

**Building Dual-Use Supply Chain Management Capabilities:
Experiences to Date of System Integrators, Original Equipment
Manufacturers & Third Party Logistics Firms**

By:

Sandor Boyson, Thomas Corsi, Lisa Harrington, and Bruce Schoolfield

**Of the Supply Chain Management Center, Robert H. Smith School
of Business, University of Maryland, College Park**



**CENTER FOR PUBLIC POLICY
AND PRIVATE ENTERPRISE**

SCHOOL OF PUBLIC POLICY

November 2008

This research was partially sponsored by a grant from
Lockheed Martin Corporation



Table of Contents

| | |
|------------------------------------------------------------------------------------|-----|
| Table of Contents | ii |
| Executive Summary | iii |
| I. Introduction..... | 1 |
| II. Principles of Dual-Use Supply Chain Management Capability | 1 |
| The Dual-Use Concept..... | 1 |
| Dual-Use Supply Chain Management Principles..... | 2 |
| The Dual-Use Supply Chain Management Working Model..... | 4 |
| III. Key Actors in Dual-Use Supply Chain Management | 8 |
| IV. Cases | 17 |
| B. Defense-Oriented System-Integrator: Northrop Grumman..... | 24 |
| B. Original Equipment Manufacturer: General Electric Aircraft Engines (GEAE) | 37 |
| C. Third Party Logistics Company: Ryder System Inc..... | 43 |
| D: Third Party Logistics Company: CAT Logistics..... | 49 |
| V. Conclusions: Challenges to Realizing Dual-Use SCM Capabilities..... | 57 |
| Acknowledgement | 59 |

Executive Summary

This Report, commissioned by the Center for Public Policy & Private Enterprise and Lockheed Martin, defines how major corporations along the DoD supply chain are re-positioning themselves to be more effective and efficient in services delivery. These actors are leveraging new technologies and management practices to develop more standardized supply chain platforms that can provide better Performance Based Logistics (PBL) & Systems Lifecycle Performance Support to DoD; and can minimize threats of disruption. We call these more standardized supply chain management approaches “Dual Use Supply Chain Management”; and we suggest that DoD can gain the benefits of scale economies and industry-supported innovations from these developments.

Specifically, the report tracks how Defense System Integrators are taking up supply chain portal technology and partnerships with third party logistics providers in order to meet the challenges of DoD’s evolving approach to supporting existing weapon systems. This shift has forced integrators to put into place lifecycle tracking and sustainment-oriented service parts networks on a global scale.

We also examine how Third Party Logistics Firms are struggling to overcome the Military/Industry Culture Divide and bring best practices into the DoD environment. In many cases, this Divide has been bridged and these companies are able to contribute agile inventory replenishment models and highly-flexible distribution grids to aid national defense.

Finally, we review the role of Original Equipment Manufacturers who are using advanced diagnostics and event-based maintenance to deliver anticipatory logistics capabilities to DoD clients but who are often prevented from taking full lifecycle stewardship over their systems because of DoD management (and/or legislative) impediments.

DoD has started down the path of supply chain reform through programmatic devices such as PBL. This report highlights the enthusiasm on the part of DoD service providers for such reform concepts and analyzes the investments they have made to comply and build internal response

capabilities. It also highlights the challenges yet to be overcome, such as the need for better collaboration incentives and information sharing.

I. Introduction

The purpose of this report is to explore the proficiency of System Integrators, Third Party Logistics Providers & Original Equipment Manufacturers in providing supply chain services aimed at both the Defense and Commercial Sectors. We call their twin sector approach “Dual-Use Supply Chain Management.”

All three actors share the common objective of revenue diversification and business risk management. Yet each of these actors has attempted to broaden its portfolio of supply chain service offerings in different ways and with differing success levels. Their experiences will be examined through the case studies of:

- A Systems Integrator (Lockheed Martin & Northrop Grumman);
- A Third Party Logistics Provider (Ryder & CAT Logistics);
- An OEM (General Electric).

II. Principles of Dual-Use Supply Chain Management Capability

The Dual-Use Concept

The traditional concept of Dual-Use Technology Management has long been promoted by DoD as a way to leverage its investments in tool/technology innovation and transfer know-how into the commercial sector to help industry gain better process efficiencies or enhanced effectiveness; as well as creating ways (and removing barriers) for DoD to take full advantage of commercial tools, technologies and practices for use by the DoD. Dual-Use Innovation, and its development environment, has been well defined by Knight as:

“Tools or techniques, developed originally for military or related purposes, which are commercially viable enough to support adaptation and production for industrial or consumer uses. In an effort to formalize the interaction between military and civilian technological innovations, DoD established the Dual-Use Science and Technology (DU S&T) Program, through which it partners with industry. As DoD officials have noted, there can be commonalities of aim between the need to maintain U.S. technological superiority on the battlefield, and the competitive edge of U.S. industry in the market place. In order to facilitate partnerships, DoD has sought to develop streamlined contracting procedures, and to implement cost sharing between its DU S&T

Program, the military services, and industry. The benefits to industry inherent in these partnerships include the leveraging of scarce science and technology funds, access to advanced technology, and the means of developing further beneficial partnerships with other firms, defense laboratories, and university research departments.¹

This paper formulates and explores a new management concept called Dual-Use Supply Chain Management (RH Smith, Supply Chain Management center, 2008) which we define as “organizing & building a common set of institutional capabilities and technologies to manage supply chains in both the military and civilian sectors at the same time.” Key benefits of this corporate approach include diversifying the customer base to reduce sole dependence on military contracts; as well as leveraging rapidly evolving industry-wide hardware, software and communications standards to lower system-development & maintenance costs for the military customer base itself.

Dual-Use Supply Chain Management Principles

In the same way that Dual-Use Technology has grown as a premier product/service development strategy for many companies who seek to encompass both military and commercial market segments, so Dual-Use Supply Chain Management (SCM) has grown as a conscious corporate strategy to leverage learning, practice sets and technology infrastructures across sectors, to diversify demand & revenue and to minimize market risk. Dual-Use Supply Chain Management is a dynamic activity, manifesting in a capability-building exercise that involves multi-year planning, resource allocations and sustained implementation efforts. In addition, a collaborative “enabling environment” must be established over time between the Military/Commercial Sectors in order to streamline business processes and increase the robustness of a shared supply chain.

There has been an increased recognition over time of the convergence of needs and many management practices/technologies across both DoD and Commercial Supply Chains.

Leiphard (2001) offered an explicit analysis and shared principles linking the needs of the two sectors and calling for greater coordination of activities between them:

“Military logistics and commercial logistics are parts of the same industry. Both are concerned with focused logistics, precision and velocity, coordinated delivery schedules, fast and flexible distribution, and good infrastructure and equipment at distribution centers. Military and commercial readiness can both be defined as the optimization of available resources to operate in a possible unforeseen event. Whether it is for a military or commercial surge scenario, carefully planned situational logistics and effective supply chain management can get the supplies to the

¹ Judson Knight, <http://www.espionageinfo.com/De-Eb/Dual-Use-Technology.html>

people in need.. Both of these hypothetical scenarios involve fundamental logistics processes, such as quickly exchanging information, identifying available supply resources, and delivering supplies. Such scenarios call for an integrated plan involving military, governmental, and commercial services and requires the achievement of the following common national goals:

Standardization of commercial and military logistics metrics and equipment. *When military cargo is to be handled by commercial and military logistics providers, common data and equipment for tracking in-transit cargo visibility become necessary for packing, identifying, shipping, and tracking shipments to the customer's door.*

Real-time stockage information. *Real time Status information is needed to improve the military's maintenance readiness and to integrate information about procurement actions and required repair parts, so there is no need to rely on equipment carcasses for spare parts.*

Minimal customer wait time. *Achieving optimal procurement, supply, maintenance, and distribution times is fundamental to creating an efficient supply chain management system. What may benefit the military is the use of real time technology to signal when supplies from authorized stockage lists reach a low point so that flights can deliver the parts reliably to forward support activities. For military surface distribution, the idea of having coordinated, scheduled truck deliveries at installations is not very different from the type of coordination that occurs between the retailers and the supply chain management system.²*

Much as it had done in promoting Dual-Use technologies, DoD has sponsored initiatives designed to promote a common SCM platform across both the military and civilian sectors. One of the most striking and recent examples is how U.S. Joint Forces Command industry partners around the world have tried to start a “paradigm shift in supply-chain management,” through the establishment in June 2004 of JxDS. This shift embraces combining joint logistics operations, with military and industry partners, through a designated logistics single point-of-contact, serving the combatant commander - which will differ from still-existing individual-service, legacy supply operations.³

Yet until now, there has been little in the way of systematic research aimed at examining the results of efforts by DoD and the companies themselves to create Dual-Use Supply Chain Management Capability.

² *Leiphart, Kristine Lee*, “Creating a Military Supply Chain Management Model”, <http://www.almc.army.mil/alog/issues/JulAug01/MS668.htm>

³ *Klinkenberger, Fred J.*, Joint Experimentation Directorate <http://www.jfcom.mil/newslink/storyarchive/2006/pa062606.htm>

Thus, the core issue this paper attempts to address is: How successful have efforts been in establishing Dual-Use Supply Chain Management capabilities, and what more can be done by DoD to help providers make this transition?

The Dual-Use Supply Chain Management Working Model

For purposes of this study, we wanted to develop an explicit model of Dual-Use Supply Chain Management that encompasses the innovations taking place in the field and the similarity of systematic management applications occurring across both the commercial and military sectors.

The Dual-Use SCM Model we envision has at its center a supply chain services platform built upon common technology, standards and management practices that can support a spectrum of activities in both sectors, as shown below:

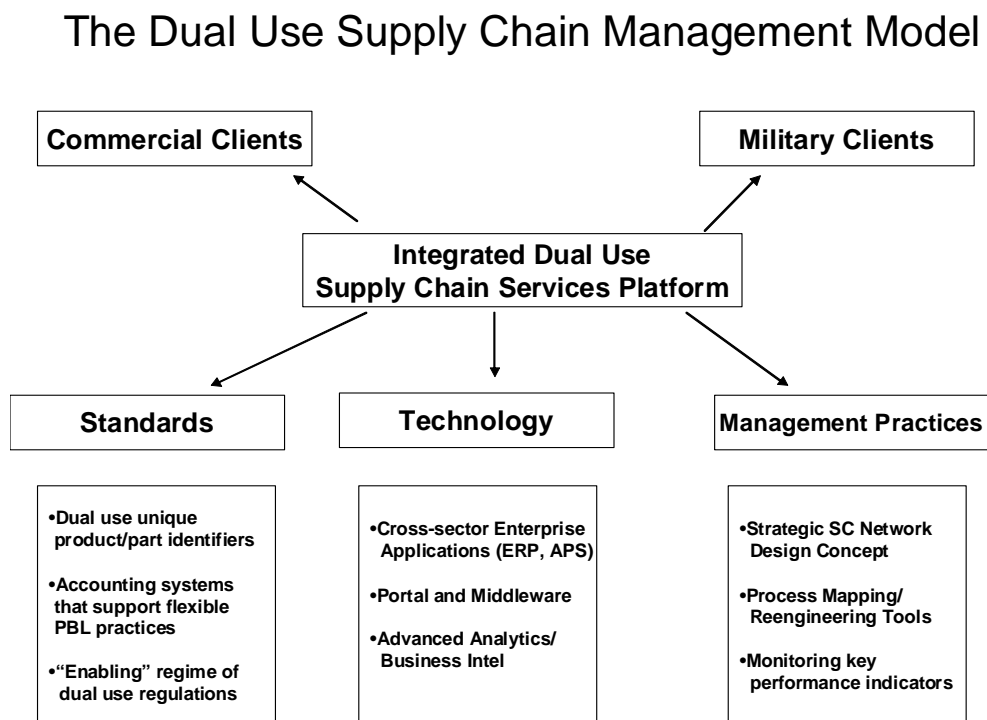


Figure 1. The Dual-Use Supply Chain Management Model (Source: Supply Chain Management Center, RH Smith School Of Business, 2008)

We have elaborated further on the specific task areas that must be addressed by this Dual-Use SCM platform, detailed below. We illustrate, with examples from our own research and work,

how these tasks are currently being met by SCM providers in both the civilian and military sectors:

Defining Dual Use Supply Chain Management

| Task Area 1: Supply Chain Strategy Services: | Civilian Applications | Military Applications |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <ul style="list-style-type: none"> •Supply Chain Network Planning/ requirements analysis •Modeling cross-border supply chains (demand/supply flows) •Optimized design for transport/warehousing assets | <p>Commercial-Off-The-Shelf Network Optimization Software used to Re-Design Corporate Customer's Consumers Goods Division Supply Network.</p> | <p>Same software used to Model Re-Design of HIMARS Missile Launch System Supply Chain Network: A Project Between U.S. Army HIMARS Program, Lockheed Martin, and the University of Maryland</p> |

| Task Area 2: Supply Chain Implementation Services: | Civilian Applications | Military Applications |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <ul style="list-style-type: none"> •Business Process Mapping/ Re-engineering support. •Building Supply Chain Performance Management Systems (Metrics-Setting/Monitoring) •Sensor-based systems for advanced diagnostics/prognostics and RFID tagging/tracking systems for inventory visibility | <ul style="list-style-type: none"> •Rapid Supply Chain Audits & Benchmarking using SCOR Methodology; •Recommendations for supply chain re-engineering. •Proctor and Gamble's average inventory of 65 days' worth of materials & product across its supply chain ties up some \$3 billion in inventory daily. •P&G's new vision: a Consumer-driven Supply Network. "No lost time, never-empty store shelves, & no stationary inventory." •Actual consumer purchasing monitored by tracking RFID-tagged product flows thru warehouses & stores triggers "real-time, simultaneous movement of relevant demand data to all network partners-store, warehouse, retailer, manufacturer, and suppliers." | <ul style="list-style-type: none"> •The F-101 Engine Collaborative Supply Chain Project between GE, USAF, and University of Maryland conducted a supply chain audit, and Benchmarked Supply Chain Systems. •The resulting prototype enabled GE to automate the gathering, synthesis & delivery of critical real time performance data from on-board aircraft engine sensors to key supply chain actors & raise to a new, commercial level Military Performance Based Logistics Monitoring. |

| Task Area 3: Ongoing Supply Chain Collaboration Services: | Civilian Applications | Military Applications |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------|
| <ul style="list-style-type: none"> •Performance-Based Logistics (PBL) •Contracting/System Lifecycle Management •Extended Enterprise Management (e.g. orchestrating external supply relationships) | <p>ExoStar Trade Exchange Supply Portal used by commercial aerospace companies to locate suppliers.</p> | <p>ExoStar Trade Exchange Supply Portal used by all the big military contractors to locate suppliers</p> |

This Dual-Use SCM strategy plays out differently among key actors in the supply chain.

DoD itself seeks to contain costs and is moving from a period of continuous investment in new systems’ creation & deployment to a period much more focused on existing systems’ sustainment. To implement this change in strategic focus, DoD has increasingly sponsored innovative forms of contractor-managed maintenance such as Performance Based Logistics (PBL); and has shifted toward industry-standard platforms and components.

A DoD-oriented Systems Integrator will partner with a Commercial Third Party Logistics Company to offer DoD enhanced PBL capabilities as well as wholly new services such as Supply Chain Risk Management. It would also begin to explore commercial markets jointly with the Third Party.

An Original Equipment Manufacturer (OEM) in the same supply chain focuses on up-selling its existing advanced commercial sensors and prognostics systems to its Military Maintenance Accounts; or accelerating its military engine knowledge transfer to commercial accounts and gaining scale-advantages in production and inventory management.

For all companies engaged in the effort of Dual-Use Supply Chain Management capability building, a key success factor is experimentation with processes and technologies in different settings. Thus, Dual-Use SCM is a journey, not a destination.

Along this Journey, Organizational Mileposts in Dual-Use SCM Capability-Building can be identified. These mileposts include the following:

Milepost #1: Attainments in Supply Chain-Wide Visibility

The company gains the ability to see customer demand, and match its inventory to that demand in real-time, and the ability to track inventory movements in real-time.

Milepost #2 Attainments in Supply Chain Systems' Inter-Operability

The company gains visibility not only into its own demand patterns, but also those of its partners in the supply chain ecosystem through collaborative web-based systems and a shared portal with customers and suppliers.

Milepost #3 Attainments in Supply Chain Partners' Trust & Confidence

The company moves dramatically away from transactional relationships toward strategic relationships, and fully participates in Performance Based Logistics and Lifecycle Management arrangements with key military and commercial clients.

These mileposts can help the corporate leaders to situate themselves along the Journey of Dual-Use SCM Capability-Building. But this Journey is fraught with danger.

Differences between the objectives, operating rules and supply chain cultures of the commercial and military sectors can confound efforts at delivering a cross-sector common Supply Chain Management platform of practice sets and technology infrastructure. Despite the dangers, progress is being made by key service providers in meeting the challenges of converging military and commercial supply chains.

III. Key Actors in Dual-Use Supply Chain Management

For the purposes of this study, we will focus on three categories of Dual-Use SCM Service Providers:

- Defense-Oriented System-integrators (SIs)
- Third Party Logistics Providers (3PLs)
- Original Equipment Manufacturers (OEMs)

Each of these actors has different SCM business realities, strategic objectives and core capabilities which we will review shortly. However it is important to note that, as of yet, there are no stand alone companies that provide full end-to-end supply chain capabilities.

In 2005, the RH Smith Supply Chain Management Center conducted a competitive Dual-Use SCM analysis of firms operating in the Systems Integration, OEM and Third Party Logistics spaces.

The firms studied were:

- Lockheed Martin
- General Dynamics
- Boeing
- CSC
- EDS
- SAIC
- Ryder
- UPS
- Menlo

What we found at that time (2005), and outlined below, was a relative lack of integrated SCM capabilities within and across each category of firm, with challenges in building a broad spectrum of capabilities. In fact only one firm- Lockheed Martin- was rated as having excellent integration of supply chain practices (in 2005).

In terms of supply chain IT services, some System Integrator firms have implemented systems for internal corporate use but have not translated these into external products that can be implemented at customer sites.

Also, both System Integrators and OEMs alike clearly need to acquire better physical logistics capabilities and better use of Third Party Logistics Firms to help them master supply chain management. For their part, Third Party Logistics Firms have shown a good deal of hesitation in diving into the DoD marketplace or investing in mastery of DoD contracting procedures/regulations, accounting systems and paperwork. More recently, companies have recognized these limitations and are moving to partner across categories to bid on DoD SCM contracts, increasing prospects for success; and have made significant improvements in their “Integrated SC Practices.”

| 2005 | | | | | | | | | | |
|-------------------------------|-----------|-----------|-----------|------------------|----------------|-------------|------------------|------------|------------|------------|
| Industry Evaluation Matrix | | | | | | | | | | |
| | | LMT | GD | Boeing | CSC | EDS | SAIC | Ryder | UPS | Menlo |
| External/Internal | | Int & Ext | Internal | Internal | External | External | External | External | External | External |
| IT | Portal | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| | ERP | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| | SRM | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| | CRM | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| | Software | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| 3PL | Outsource | ✗ | ✗ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Business Strength / Processes | | MANUF | MANUF | MANUF | IT Consult | IT Consult | IT Consult | Logistics | Logistics | Logistics |
| Current customers | | DoD & Gov | DoD & Gov | DoD, Gov, & Comm | Gov & Comm | Gov & Comm | Healthcare & Edu | Comm & Gov | Comm & Gov | Comm & Gov |
| Integrated SC Practices | | Excellent | Scattered | Good | Poor Execution | Vision only | Good | Good | Good | Good |

Figure 2. Industry Evaluation Matrix. (Source: Supply Chain Management Center, “Benchmarking Analysis of DoD’s Supply Chain Service Provider Market” RH Smith School of Business, 2005)

1. Defense-Oriented System-Integrators (Lockheed, Northrop, Boeing, GD, Raytheon, etc.)

The strongest players in the Defense SCM market are the System Integrators (SIs); they are the most likely leaders in bringing the Dual-Use SCM concept to Defense customers.

Integrators seek to be first movers in the market to set standards to maximize competitive advantage. Their Core Business Objectives are the following:

- To diversify into SCM services in response to DoD mandates such as Performance Based Logistics⁴ total lifecycle management and netcentric operations.
- To move practices and systems into the U.S. from corporate divisions abroad & vice-versa.
- To leverage commercial practices into DoD inventory management systems/and establish more flexible, “sense and respond” logistics models to capture bigger shares of DoD’s aftermarket logistics/maintenance business
- To slowly build up a non-DoD commercial client base as a way to move away from over-reliance on DoD clients, to help re-balance portfolio risk and to ensure revenue stability and growth.

The financial strengths of system integrators and overseas demand for military systems suggest their SCM Service Portfolios will continue to grow and diversify. Strong order backlogs, solid financial standing and streamlined operations should allow aerospace and defense companies to offset the effect of a likely wind-down of military activity in Iraq.

Jefferies & Co. analyst, Howard Rubel, said a spike in potential sales contracts to foreign militaries could provide boosts for several major companies. The Pentagon announced about \$50 billion in proposed military sales deals so by August 2008, with two months remaining in the

⁴ PBL Contractors are given freedom to determine how to meet the Government's performance objectives, that appropriate performance quality levels are achieved, and that payment is made only for services that meet these levels/The E-Government Act of 2002 authorizes federal agencies to enter gain-sharing contracts for IT (Bierce & Kenerson, P.C. *Outsourcing Law* Bierce & Kenerson, P.C. *Outsourcing Law: Insights on Effective Outsourcing*. <http://www.outsourcing-law-m/articles.htm>)

government's fiscal year. Last year, the Pentagon reported agreements worth \$22 billion. The announcements are most likely to benefit the largest military contractors, Rubel said, with Lockheed and Raytheon in the best positions, and Boeing, General Dynamics, Northrop Grumman and United Technologies likely in the mix.

Rubel noted that of the \$50 billion in potential contracts, about three-quarters of them would support the sale of weapons to Middle East nations. "A friendly administration, record oil revenues and a cheap dollar appear to make it a great time for our allies in the region to load up on U.S. military goods," he said.⁵

The Defense SIs (or Primes) are using this growth environment to diversify away from sole reliance on U.S. DoD and to reduce volatility in their supply chain service project/revenue portfolios:

*"The primes used to be much more volatile. But they learned their lessons from the most recent downturn, and now make sure they are well hedged where possible across different sectors of the industry such as the defense and civil markets, and across different areas of the business like original equipment manufacture and aftermarket support. The primes in general are well hedged and secure in the knowledge they can pass risk down the supply chain. Large prime contractors have learned the hard way they must balance their portfolios, spreading their order backlogs across the civil and military sectors to ensure that they take advantage of the peaks and cushion the troughs in each segment of the business. As lead systems integrators passing risk and financial volatility down the supply chain, the primes are "doing a very good job of sustaining constant margins", Hampson says. "The systems integration role of the primes allows them to manage their return better than a supplier." On the flip side, while the primes' margin variability may have reduced significantly, they have paid for this stability with a more modest increase in margins."*⁶

As a group, the Primes have the scope of resources and presence across DoD to help drive military supply chain transformation activities.

2. Third Party Logistics Companies

The mid-1990s saw the emergence of daring, new end-to-end logistics outsourcing providers such as Menlo Logistics, which had enough capability to assume complete coordination of the entire global supply chain of major companies such as National Semiconductor. Menlo conducted 'milk runs' to National Semiconductor suppliers around the world, picking up components, delivering them to factories, and then picking up finished goods and delivering them to distribution centers worldwide. These external strategic coordinators could help the

⁵ "Ahead of the Bell: Military contractors," Associated Press Newswire, 1 August 2008 08:55 AM- Document #APRS000020080801e481001b9

⁶ Flight International, "Climb-out continues" August 8, 2006

enterprise supply chain attain scale-efficiencies and global communications/transactions infrastructure.

*The pace is picking up across such industries as retailing, consumer goods, software, electronics, autos and medical devices. In many realms, the time it takes to bring a product to market has been cut in half during the past three or four years. At Nissan Motor Company, the development of new cars used to take 21 months. Now the company is shifting to a ten-and-half-month process. In the cell phone business, Nokia, Motorola and others used to take 12–18 months to develop basic models. Today: 6–9 months. Of course, speed has always been important in business ever since the California Gold Rush. What’s changed in recent years is that a slew of new techniques make it possible to get things done much faster. Start with global outsourcing. A vast network of suppliers around the world stands ready to do anything from manufacturing products to drawing up legal contracts. This helps companies create supply chains that are faster, more flexible and more efficient than ever before. [italics added]*⁷

More serious survey research also found that the pace of supply chain outsourcing seemed to intensify during the millennial change. For example, among corporate respondents in a 2005 Deloitte survey, 60 percent said that they had outsourced distribution/logistics functions (Deloitte 2005). In a 2005 LTD Management Group survey, 42 percent of 197 corporate respondents said that they outsourced at least half of their supply chains (LTD 2005).

Typically, a supply chain outsourcing company will enable a customer company to migrate planning and transaction systems to the Web and create instant online community hubs/enterprise portals for key supply chain trading partners. A key selling point is Supply Chain Visibility, the ability to see demand and inventory patterns in real time. It can also orchestrate operational resources to balance the two.

“Visibility and traceability are important considerations in aftermarket support for many reasons. First, traceability allows firms to choose between individual items. This is important because specific items may have different histories. Many parts in aerospace and defense are rebuilt and either returned to the aircraft from which they came or put into stock for future use. For instance, Ryder Aerospace Supply Chain Management solutions supports parts management for Bombardier/Learjet. The cycle starts with removal of a component from the aircraft and ends with the component being fitted back into the aircraft. Cycle activities during the down period of the aircraft include repair, time at the removal location where the component can wait for packaging, time waiting for repairs purchase order, time required for shipping the component to and from customers, time required for inspection of components, and time required for fitting the component into the aircraft again. Because of this potentially long cycle, Ryder developed a scheduled maintenance planning cycle (SMPC) to identify materials required before a scheduled maintenance event, satisfying the logistical flows of material requirements prior to actual maintenance. Traceability ensures that the individual components can be traced throughout the process. In addition, traceability allows the buyer to confirm that parts are authentic and, in some

⁷ ‘Speed demons’, Business week, 27 March 2006: 70

cases, aftermarket distributors can charge a premium on newer parts and/or give discounts on parts that were previously in service.”⁸

An added dimension has been the rapid rise of globalized supply chains. In response to the past decade of globalization, traditional U.S.-based logistics companies have expanded capabilities dramatically. For example, FedEx, the world’s largest express transportation company, is creating an entire ‘China Direct Strategy’; through its express hub in Shenzhen in south China’s Guangdong Province, FedEx is able to provide customers in southern China with next-day delivery of products to cities across North America. This means that in some cases multinational manufacturers can ship direct from factories to consumers’ doors and eliminate tiers of warehouses and associated inventory carrying costs.

Additionally, non-traditional Third Party Logistics Companies have also entered the marketplace. In June 2005, as part of a ‘flurry’ of recent activity by IT outsourcers, IBM added a new supply chain outsourcing unit to its business process transformation division, bringing together its existing 8,500 supply chain consultants and another 15,000 IBM employees who had worked on building IBM’s own internal outsourcing arm.

Generally, Third Party Logistics Companies seeking Dual-Use SCM capabilities have these core business objectives:

- To develop new markets in DoD through Supply Chain Management (SCM) Alliances with DoD-oriented System Integrators (e.g. the Ryder Logistics /Northrop Grumman Partnership).
- To harness DoD’s massive commercial shipment & commodity volumes to gain leverage in the marketplace against carriers and drive down overall carrier costs.
- To help re-balance a SCM Services Portfolio heavily weighted toward commercial clients.

3. Original Equipment Manufacturers (General Electric, etc.)

⁸ *Farris, Theodore M, Wittmann Michael, Hasty Ron* “Aftermarket support and the supply chain: Exemplars and implications from the aerospace industry”, *International Journal of Physical Distribution & Logistics Management*, Vol 35 No.1, 2005 pp6-19 ISSN: 0960-0035

Aerospace OEMs are constantly trying to anticipate the needs of the aircraft industry and its operators. This allows the OEM and its suppliers to react to operational needs, be they parts, repairs or modifications. Although the commercial sector is far ahead of the military sector in enabling real time sensor and engine diagnostics, OEMs can nevertheless still reduce the operational costs to the military sector through more efficient parts management and provision of higher levels of aircraft availability.

OEMs are actively pursuing aftermarket support opportunities in both the military and civilian sectors and building alliances to do so via multi-year contracted services. Engine OEMs have constructed facilities around the world to provide aftermarket support to their own and competitors' products. An often cited example is Rolls Royce, which is handling engine maintenance, repair and overhaul through regional-based alliances. Among these alliances have been efforts to partner with third party logistics providers and outsource key supply chain activities to these specialized firms.

Another example is Honeywell, which has outsourced parts support through a strategic alliance with Caterpillar Logistics Service, a third party company we will examine through a case study later in this report:

Honeywell's "fill rate" was 90 percent and the company was seeking to increase that to 95 percent. Caterpillar developed information systems and modeling techniques to forecast on a real-time basis customers' demands for product availability as well as competences in warehouse management and transportation capabilities. Caterpillar Logistics typically has a 100 percent fill rate on orders on behalf of such customers as Chrysler, Saab and Sun Computer. Honeywell predicts the enhanced capability Caterpillar Logistics brings to the process "will help reduce flight delays, decrease aircraft downtime, and save millions of dollars spent annually for excess inventory stock and for chasing critical parts shortages. With the Caterpillar alliance, Honeywell will have a more efficient system in place to get a larger volume of aftermarket products to

customers when they want them.”⁹ These types of OEM/Third Party Logistics Provider arrangements have been promoted by Honeywell in the military space as well.

Conversely, some OEMS have successfully leveraged military advantages into commercial success: Thales Avionics - the world’s third largest avionics firm and Europe’s largest avionics manufacturer - is doing well with its program to efficiently adapt to market change and has effectively broadened its product breadth to encompass both commercial and military business. *Avionics Magazine* interviewed François Quentin, chief executive officer (CEO) of Thales Avionics and senior vice president of the Thales’ Avionics Systems Business Group. He oversees Thales’ activities in civil and military avionics, aircraft electrical systems, and in-flight entertainment (IFE). Their business used to be primarily military; by 2002 their business was 70 percent commercial and 30 percent military.

The company supports 200 airlines and 40 different armed forces and has enjoyed significant growth in recent years. It has a major supply chain management initiative within Top Avionics. “In the past we provided our customers with boxes—one by one—and customers had to run huge inventories. Now we are delivering complete ship sets, on time, within a very short time frame. This is something we do with Bombardier, Airbus and Dassault.”¹⁰

This has enabled Bombardier to utilize engine parameters for diagnostics and communicate them in real time to the engine supplier.

OEMs seeking to build Dual-Use SCM capabilities typically have these core Business Objectives:

- To gain inventory visibility, demand forecasting/ordering control in key client accounts and move to get DoD to allocate flexible programmatic funds for ordering what inventory is actually needed rather than wasteful inventory orders de-linked from real time facts on

⁹ *Farris, Theodore M., Wittmann, Michael & Hasty, Ron*, “Aftermarket support and the supply chain: Exemplars and implications from the aerospace industry,” *International Journal of Physical Distribution & Logistics Management*, Volume 35 No.1, 2005 pp6-19 ISSN: 0960-0035.

¹⁰ <http://www.aviationtoday.com/av/categories/commercial/12898.html> Tuesday, October 1, 2002

the ground; and to streamline acquisition processes and compress time to respond to need.

- To gain maximum inroads into after-market support & PBL opportunities at client accounts.
- To keep balance in the SCM Service Portfolio to better manage risk and to leverage efficiencies/scale economies across a client base of both commercial and military accounts.

IV. Cases

A. Defense-Oriented System-Integrator: Lockheed Martin

Lockheed Martin is the largest global defense integrator, with reported 2007 sales of \$41.9 billion and a workforce of almost 140,000. It has built an extremely robust supply chain capability to support the sustainment of systems for Departments of Defense around the world.

As noted earlier, the RH Smith School Benchmarking Study in 2005 rated Lockheed's integrated supply chain practices as excellent, the only firm in the sample rated so highly. More recently, this view was corroborated by AMR research, which announced that Lockheed's supply chain was among the top 25 supply chains in the world (AMR, "Supply Chain Top 25: A Cash-to-Cash Lens," Monday, July 21, 2008).

The cash-to-cash cycle was one of the metrics used to determine the rankings, along with inventory turns data. Cash-to-cash provides a good view "into supply chain throughput, or how quickly raw materials can get through supply chain operations and be converted into cash". The table below highlights the fact that Lockheed has done a good job in balancing the needs of its military customers, external suppliers and internal divisions in terms of managing inventory and accounts payable and receivable. This is particularly impressive given the nature of government contracts and the financial constraints to productivity often embedded in them. It is also a testimony to the degree of horizontal integration across its extended supply chain that Lockheed has achieved, and its ability to synchronize supply with demand across its client and supplier base.

The integration of Lockheed Martin's supply chain has been a struggle. It has been necessary to overcome a history of being a confederation of companies with different cultures and processes brought together through mergers and acquisitions. For example, Unisys Defense Systems was first sold to Loral in 1988 then to Lockheed in 1995; for a long time after the 1995 merger, it maintained its own set of supply chain systems distinct from those run by Lockheed.

Lockheed's own supply chain organization was largely oriented to the production floor because of its tradition of building systems. Adding to the stovepiping of supply chain systems was the

historical dominance of Programs as supreme profit centers inside Lockheed, with each program employing its own tools even when the end customer is the same. For example, the F-22 aero tools are different than those used in the F-35 because of differences in the program project cycles and the lack of a mandate by the customer to leverage tools across programs.

Table 1: A Cash-to-Cash Lens on The Top 25

| 2008 Rank | Company | AR Days | Inventory Days | AP Days | Cash-to-Cash Days |
|-------------------------|--------------------|---------|----------------|---------|-------------------|
| 1 | Apple | 61.3 | 8.0 | 114.4 | -45.2 |
| 2 | Nokia | 80.1 | 31.1 | 76.5 | 34.7 |
| 3 | Dell | 45.9 | 8.7 | 84.8 | -30.2 |
| 4 | P&G | 31.6 | 67.8 | 56.8 | 42.7 |
| 5 | IBM | 106.4 | 17.0 | 51.5 | 71.9 |
| 6 | Wal-Mart | 3.5 | 44.8 | 38.7 | 9.6 |
| 7 | Toyota | 30.8 | 44.0 | 44.0 | 30.8 |
| 8 | Cisco Systems | 41.7 | 38.3 | 22.8 | 57.2 |
| 9 | Samsung Electronic | 10.3 | 26.0 | 15.1 | 21.2 |
| 10 | Anheuser-Busch | 17.6 | 24.4 | 49.3 | -7.3 |
| 11 | Pepsi | 40.6 | 46.3 | 51.8 | 35.1 |
| 12 | Tesco | 10.1 | 20.3 | 33.9 | -3.4 |
| 13 | Coca-Cola | 42.0 | 77.9 | 48.4 | 71.4 |
| 14 | Best Buy | 5.6 | 54.1 | 52.9 | 6.8 |
| 15 | Nike | 55.8 | 84.5 | 41.4 | 98.8 |
| 16 | Sony Ericsson | 52.8 | 17.8 | 51.5 | 19.2 |
| 17 | Walt Disney | 47.4 | 8.1 | 50.8 | 4.7 |
| 18 | Hewlett-Packard | 47.0 | 37.3 | 54.7 | 29.5 |
| 19 | Johnson & Johnson | 56.4 | 105.1 | 142.1 | 19.4 |
| 20 | Schlumberger | 84.1 | 38.6 | 107.3 | 15.4 |
| 21 | Texas Instruments | 46.0 | 79.6 | 36.9 | 88.7 |
| 22 | Lockheed Martin | 42.9 | 16.7 | 21.0 | 38.6 |
| 23 | Johnson Controls | 69.6 | 24.3 | 66.3 | 27.6 |
| 24 | Royal Ahold | 12.2 | 22.1 | 39.2 | -4.9 |
| 25 | Publix | 5.7 | 27.8 | 21.2 | 12.3 |
| Median (without retail) | | 46.0 | 31.1 | 51.5 | 29.5 |

Data is sourced from company financial statements, supplemented by Google Finance and Hoover's

Source: AMR Research, 2008

Calculations:

Accounts Receivable (AR) Days: $(AR * 365) / Revenue$
 Inventory Days: $(Inventory * 365) / Cost of Goods Sold$
 Accounts Payable (AP) Days: $(AP * 365) / Cost of Goods Sold$
 Cash to Cash Days: $AR Days + Inventory Days - AP Days$

 [Download Larger Version](#)

There were a few catalytic developments that enabled Lockheed to overcome these hurdles and achieve a level of excellence in supply chain integration:

1. An Internal Integration Initiative

Under the leadership of a new CEO, Robert Stevens, a “C-Suite” Supply Chain function was strengthened. John Hatch was appointed VP of Supply Chain Management reporting to the CEO, and his organization acted as a shared service to Lockheed’s business units.

The SCM Corporate Shared Service provided the following:

- set policies and procedures
- achieved corporate scale economies in purchasing
- gave assistance to business units in working with a network of suppliers and helped with supplier due diligence and auditing
- established corporate-wide process standards

Each of Lockheed’s business units (Aeronautics in Fort Worth; Space Systems in Denver; Electronics Systems in Bethesda; and Information Systems & Global Services in Bethesda) continued to produce its own products and have its own procurement/sourcing/supplier network. But the VP of Supply Chain for each unit reported up to the Corporate VP of Supply Chain, John Hatch, which lent a greater coordination and coherence to the whole Lockheed supply chain integration effort.

2. An External Integration Initiative

As noted earlier, the U.S. Department of Defense has shifted its focus and fiscal resources over time to sustainment of systems and has required its contractors to align with its shift in priorities. These long-term support challenges are causing Lockheed Martin to create mechanisms such as second tier supplier collaboration and preparation for parts obsolescence that have not previously been as vital to its profitability. Under the umbrella concept of Performance Based Logistics, Lockheed is developing a variety of lifetime product support programs and assuming lifecycle management responsibilities in some 25 DoD PBL Projects. As a senior DLA executive stated to Lockheed, upon the award of a large automotive outsourcing contract (the ten year long, \$5.6 billion Fleet Automotive Support Initiative (FASI-G)) in which the company now manages many-parts from brake shoes to transmissions for DLA: “You are now DLA”.

In the FASI-G Program, Lockheed will manage the entire supply chain for the sourcing of 1200 maintenance and replacement parts from more than 350 suppliers and will provide total asset visibility, information and progress metrics.¹¹

The complexity of logistics involved in such PBL initiatives has caused Lockheed to augment its capabilities through supply chain strategic alliances.

At a strategic level, Lockheed entered into an alliance with HP in November, 2004 wherein HP provided “ global supply chain best practices” to enable Lockheed to streamline internal operations and to use their combined expertise to provide end to end enterprise logistics solutions.¹²

At a tactical level, Lockheed has bolstered its relationships with third party logistics companies. For example, EGL Eagle Global Logistics, a leading global heavy-weight freight transportation and logistics company, opened an Aerospace & Defense supply chain management center at Alliance Texas in January 2006 to handle parts and equipment for Lockheed Martin’s Fort Worth production facility.,

A major lesson learned so far from these PBL efforts is the need to find ways to incentivize all players. If Lockheed places work for sustainment of second generation Army HIMARS weapons systems with the Oklahoma City Depot, how does it align incentives with that Depot, since that Depot may not prioritize efficiency or profitability? The Depot may care more about job creation. How are incentives aligned across the supply chain so that all players are working toward the same objectives? This is an ongoing struggle in the conduct of PBL contracts.

3. A Supply Chain Technology Initiative

Over time, Lockheed has built a spectrum of supply chain technological capabilities. On the Demand Side, it has built its own Inventory Forecasting And Transportation/Delivery Management Systems as part of an integrated suite it calls SCM+. On the Supply Side, it

¹¹ [www.global security.org/military/library/news/2008/09/mil-080912-lockheed-marti...](http://www.globalsecurity.org/military/library/news/2008/09/mil-080912-lockheed-marti...) “Lockheed Martin awarded contract to manage supply chain for all U.S. Military Automotive Parts” September 26, 2008

¹² www.hp.com/hpinfo/newsroom/press/2004/041103b.html “HP, Lockheed to deliver supply chain solutions to government customers”, November 3, 2004

has built SupplierNet, a secure portal for its supplier community that also acts as a gateway out to the Exostar Global Aerospace & Defense trading Exchange.

This combined technology capability is demonstrated in Michelin/Lockheed's Aviation Tire PBL with the DLA, Air Force and NAV ICP. Michelin is the prime on the PBL and hired Lockheed to pick up and consolidate all the customer demand signals, process them with Lockheed demand forecasting software and translate those requirements into sourcing requests and coordinate movements with third party logistics companies.

More recently, Lockheed has purchased the RFID company SAVI and rolled its global real time shipment tracking capabilities into its supply chain portfolio.

Finally, Lockheed is now pioneering an ambitious "Product Support Framework" that will serve as the corporate end-to-end supply chain platform. This framework includes a single secure web portal interface to all internal backend systems, client DoD systems and COTs systems. A middleware or bus layer processes and exchanges data feeds between internal and external systems and will also monitor processes and issue business alerts to key decision makers.

The stated objectives of this unified web-based supply chain architecture are the following:

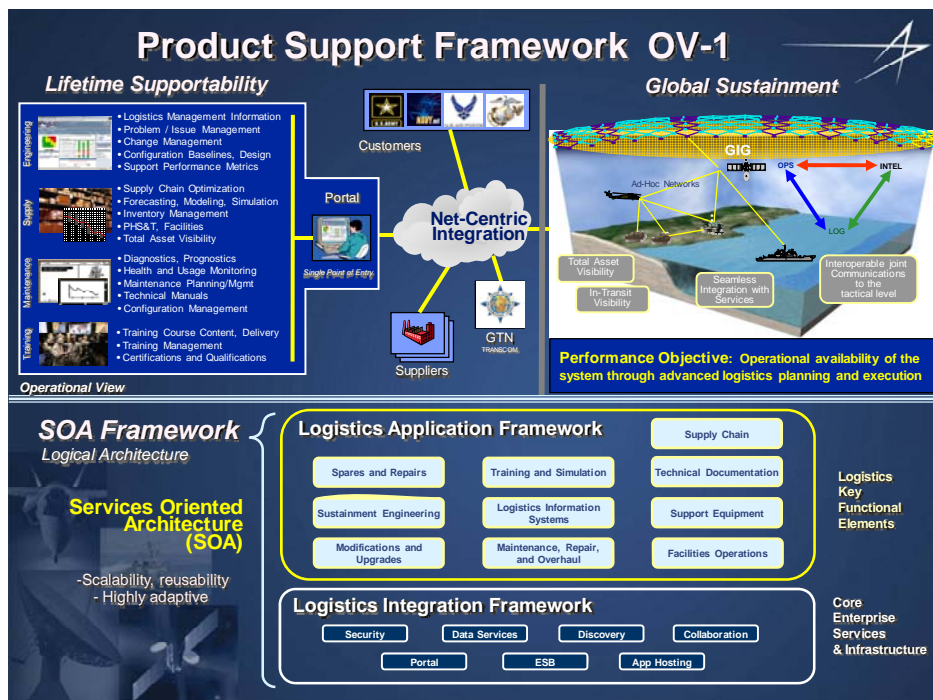
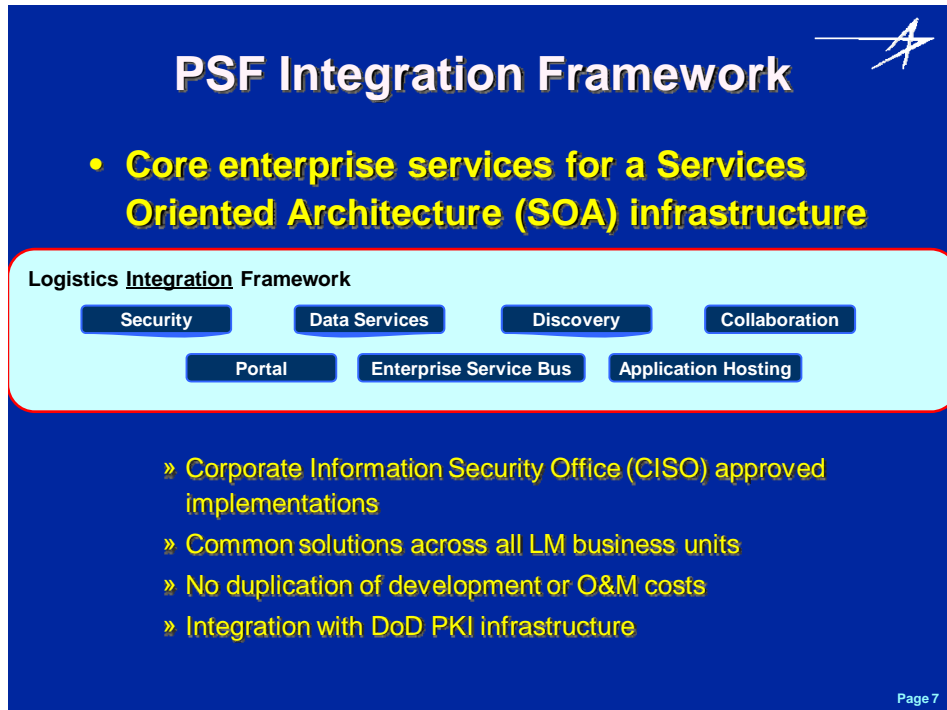
- The Product Support Framework enables agile, cost effective production & sustainment solutions, via Corporate IT infrastructure and Common EBS Services
- Positions Lockheed Martin as the leading provider of logistics and sustainment in the Aerospace and Defense market
- Provides business areas efficient access to an enterprise architecture, capable of interacting with current and future internal and external IT solutions in the logistics domain
- Reduces program risk through the implementation of enterprise-class, accredited services
- Enhances horizontal integration and adoption of best practices across Lockheed Martin¹³

¹³ Delahanty, William, *Architect Product Support Framework & Chief Engineer, Lockheed Martin Integrated Logistics Solutions*. "Product Support Framework: an Enterprise SOA Framework for Logistics" November 4, 2008

The PSF is an extremely important initiative in that it offers a new service-oriented architecture that can grow over time with the needs of its clients and can incorporate a multiplicity of existing systems in a “virtual integration” process that enables client system-owners to maintain and extend the lives of their systems. This platform will effectively buttress and enable the current and next generation of PBL Contracts and offer a powerful competitive advantage given its scope and flexibility. The PSF was deployed in June, 2008 and is now used in four programs across Lockheed and was put into the bid for the Joint Lite Tactical Vehicle.

Currently PSF is based on the commercial open standards provided by SAP Netweaver technology which will enable it to align with the diverse ERP initiatives in the DLA Transformation Program, the Army Modernization Program and the Air Force ECSS Program. Nevertheless, a challenge remains in the negotiations between system owners over data feeds and security policies which can sometimes vary not only from service to service but also from facility to facility. A Data warehouse and Business Intelligence system will be incorporated and rolled out in 2009.

The PSF architecture is distilled in the following Lockheed Martin charts¹⁴:



¹⁴ Delahanty, William, Architect Product Support Framework & Chief Engineer, Lockheed Martin Integrated Logistics Solutions. "Product Support Framework: an Enterprise SOA Framework for Logistics" November 4, 2008

The PSF must be understood in the context of Lockheed's vision for a next generation logistics system. On October 5th, 2006, during a press briefing at the National Press Club in Washington, D.C., Lou Kratz, vice president of Lockheed Martin's Focused Logistics, presented Lockheed's vision of logistics that will anticipate support requirements and increase customer effectiveness through extended life cycles and global supply networks.

"Our approach is to create integrated solutions that support our customers, maximize mission effectiveness, and improve operational efficiencies. Our integrated approach to logistics covers the entire gamut of military operations," said Kratz. "Our system integration expertise and deep customer knowledge enable Lockheed Martin to design and support platforms that need less maintenance. This enables platforms to last longer and creates global supply networks that extend from the factory to the warfighter."

B. Defense-Oriented System-Integrator: Northrop Grumman

Northrop Grumman Corporation is a \$32 billion global defense and technology company, whose 120,000 employees provide innovative systems, products and solutions in information and services, electronics, aerospace and shipbuilding to government and commercial customers worldwide.

According to Ron Sugar, CEO of Northrop Grumman:

"We have a four-part strategy to grow revenues. First, we intend to capture an increasing share of business in our core markets. The things we do today -- we are putting more emphasis on the set of very large competitive opportunities which we see in the near-term and in the future. Secondly, we intend to take the core capabilities we have inside the Company and leverage them into that area I referred to earlier as securing the commons. This can be thought of as near adjacencies from our current lines of business, taking advantage of the core capabilities which were excellent and the furtherance of our vision to be the most trusted provider to ensure broad security capability for our nation.

Third, we intend to pursue some of these large opportunities through what we call asset light partnerships where we act as a systems integrator or provider of some specialized technology that greatly enhances the chances of success. An example of this is the Joint Light Tactical Vehicle program for which we have teamed with Oshkosh which is a highly respected manufacturer of extreme duty vehicles. And of course, Northrop is a well-respected provider of defense systems and integrated electronics."¹⁵

These overriding strategic corporate objectives guide the formation of Northrop's core SCM objectives:

¹⁵ *Fair Disclosure Wire*, "Northrop Grumman at Sanford C. Bernstein & Co. Strategic Decisions Conference - Final." Voxant, May 30, 2008

- To focus on retaining and growing core military business.
- To transfer in SCM technologies from its UK Defense Department contracts into the U.S. DoD as a service/revenue expander.
- To build after-market services to stabilize margins, particularly as current US military systems are increasingly sold to Mideast clients.

Although its commercial activity has been largely peripheral to military business, NG's state and local government and private sector accounts are growing. Over a period of years, NG has been developing capability in servicing complex supply chain system lifecycle management projects ranging from systems-requirements-gathering & design to fielding and sustaining logistics and distribution networks.

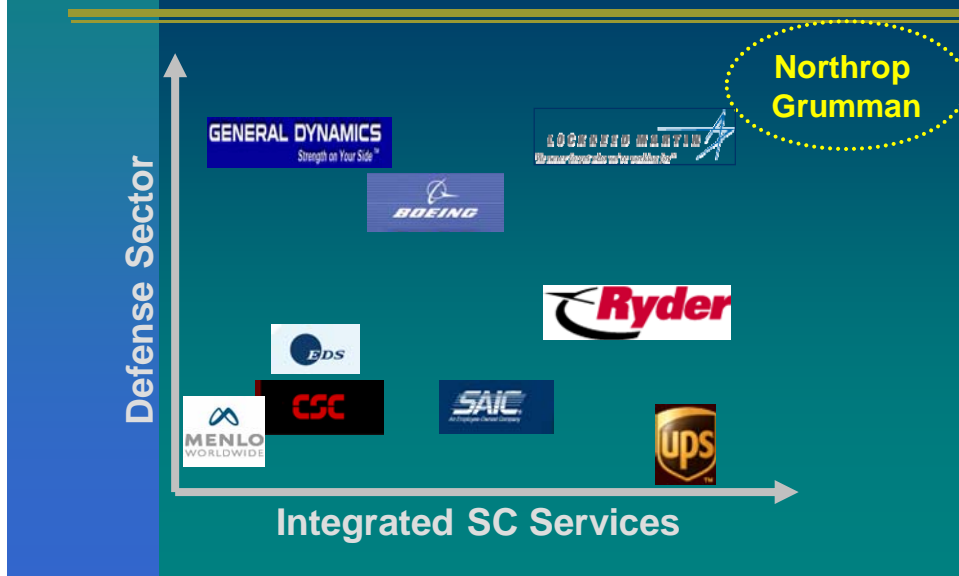
Northrop's primary Dual-Use SCM Capability Building Activities to date have been:

- Transferred in to the military a range of commercial best technology/SCM practices: from enterprise applications (ERP) practice development to SCM portal creation and deployment.
- Implemented Strategic partnerships with Ryder Logistics and other Third Party Logistics Companies to bring in new competencies to its own DoD SCM Service Offering Mix.
- Initiated Performance based Logistics/Lifecycle Management Projects with core DoD customers as demonstrators of increasing corporate SCM Mastery.

A 2005 RH Smith benchmarking analysis showed NG as *a challenger* to Lockheed in both the integrated SCM service space and related IT spaces as shown in the charts below:¹⁶

¹⁶ Source: Supply Chain Management Center, RH Smith School Of Business, 2005

Competitor Positioning (1)



Competitor Positioning (2)



This assessment was echoed by Gartner, which recognized Northrop's integrated SCM capability in its 2006 Magic Quadrant for North American Supply Chain Management Consulting and Integration Service Providers, placing Northrop in the challenger's position.

Like us, Gartner also defines supply chain initiatives as evolving among information technology (IT) service providers. According to the Gartner report, IT services providers are repositioning and refining their supply chain portfolios. Clearly, this is a strategic area for Northrop: "We consider supply chain management services a strategic business and will make the necessary investments and apply our industry expertise to continue delivering effective solutions to our customers' increasingly complex challenges," said David Zolet, president of Northrop Grumman IT's Defense group.

Northrop's Vision of Dual-Use SCM Capability-Building

NG has attempted to respond in a comprehensive way to DoD's intention to benefit from an integrated life-cycle system management and total equipment uptime management approach. Such a system would integrate information and logistics support systems to provide full-scale cradle-to-grave system and equipment service to DoD.

NG's service vision appears to be about achieving a seamless flow of operational status data about a military system from its initial deployment to its final disposal. Its vision focuses around the information and actions taken, based on pre-established business rules, to ensure maximum readiness for the equipment's lifespan. To realize this objective, the information flow is synchronized with an optimized flow of goods and material that satisfies headquarters' need for asset planning; the logistician's need for on-time, cost-efficient deliveries; and the war fighter's need for maximum equipment readiness. The vision has two major pillars:

- E-supply chain portal and enterprise applications.
- Strategic business alliances.

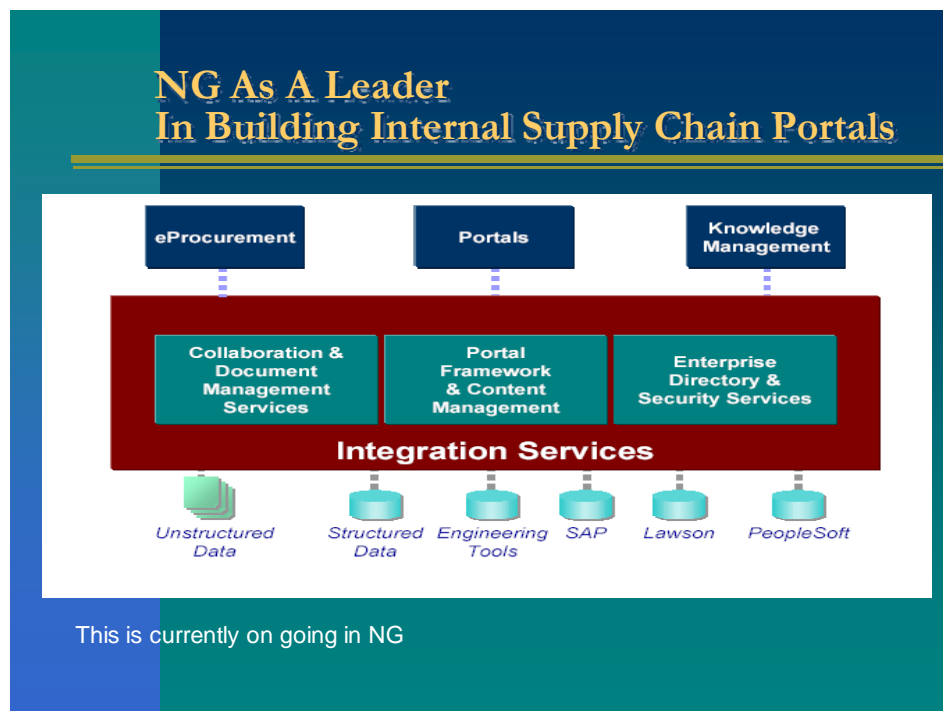
Northrop Grumman already has expertise in these two areas. The challenge to accomplish this vision is to consolidate their individual areas of expertise into an integrated service.

Building E-Supply Chain Portals & Enterprise Applications

We define portal as the completely integrated and web-enabled supply chain information hub. It is not only the web – the presentation and user interface layer – but also includes the integration and application layers of the whole system. Northrop Grumman has grasped the initial concepts needed to automate supply chain integration through the portal. This type of portal allows all players along the supply chain to have proper access to real time logistics data. The integrated systems and predefined business rules enforce the process and enable the seamless information flow.

Northrop Grumman's strength is that it already has plenty of these types of portals in place. These are very specialized portals that focus on key areas within the supply chain. They enable all players within that specialized area access to their area via the Internet.

The flow diagram of the e-supply chain displayed below (based on data supplied by NG) shows the integrated web services that NG has provided to highly distributed supply chain actors¹⁷:



¹⁷ Source: R.H. Smith School, Supply Chain Management Center 2006

NG As A Leader In Building Internal Seamless Information Flow

| | |
|-------------------------------|----------------------------------------------------------------------------------------------------------------|
| Customer Portals | Reaching Customers Online > Tech Data, Program Libraries, Spares Catalogs |
| Transportation Portals | Utilizing efficiencies of 3PL Transportation Providers > Shipment Consolidation, Tracking Visibility |
| Supplier Portals | Extending the Back Office to our Suppliers > e- Procurement, Auctioning, Shared Services |
| ERP | Integrating the back office > PP, MM, SD, FI, CO, HR, QM, PM, etc. |
| Engineering Tools | Collaborating for Design Excellence > CSM, PDM, SDE/IDE |

...through Business Tool Innovation

NORTHROP GRUMMAN

NG has leveraged its internal SC portal and enterprise applications capabilities over time into external business with its core military clients. In 2003, Northrop Grumman and Intergraph Solutions Group, a division of Intergraph Corporation (NASDAQ: INGR), received an award of a \$3.3 million delivery order to extend and enhance the U.S. Air Force Supply Chain Common Operating Picture (SCCOP). The software environment was intended to provide 200,000 Air Force users a common operational view of the supply chain and deliver details on factors that affected aircraft availability. SCCOP was a scalable, collaborative logistics Web space that integrated Air Force supply chain processes, including fleet status, program management, technical data management, storage and distribution and e-business connectivity to commercial suppliers. The Intergraph-Northrop Grumman Team supports continued integration of SCCOP with the Air Force Portal and Global Combat Support System-Air Force (GCSS-AF) Integration Framework, and scales the application to support up to 200,000 users at 350 locations worldwide and integrate additional applications and devices identified by the Air Force.¹⁸

¹⁸ Business Wire, "Intergraph, Northrop Grumman to Extend Supply Chain Common Operating Picture Throughout Air Force," Feb 13, 2003

More recently, NG has moved up the SC IT Value Chain defined in the Dual-Use Supply Chain Management Model defined in an earlier section. It is now providing strategic supply chain advisory services and an execution platform for advanced analytics.

In 2007, under an \$8.8 million contract with the Transportation Command, Northrop Grumman helped establish a joint supply chain distribution process analysis center to integrate analytic capabilities across the organization and support joint operations. Northrop Grumman's Information Technology Division and its subcontractors will handle distribution performance analysis, organizational design and supply chain risk and analysis. Northrop Grumman's team included: Logistics Management Institute Government Contracting; Pittiglio, Rabin, Todd, McGrath; Stanley Associates; Ryder System Inc., FedEx Corp. and Washington University. The team built a Joint Distribution Process Analysis Center to support cooperative operations among a handful of agencies responsible for military transportation.¹⁹

This should help Northrop to diversify beyond its DoD supply chain transactions support business, to move up the value chain beyond providing portal and application integration products to DoD into providing real time analytics and business intelligence.

Success in providing strategic supply chain services does not mean Northrop will abandon its core business of portal-based systems-integration.

On March 13, 2008 Northrop Grumman said it won a U.S. Army task order worth up to \$267 million to develop Defense Knowledge Online, which it said was "the largest portal task order ever awarded in the federal government." The task order will help expand the portal, which currently connects 1.8 million DoD personnel and service members through intranets supporting operations, missions and critical support processes, and link it to other federal agencies, growing to as many as 8 million users across the federal government. This "would be the first time where multiple services and potentially federal civilian agencies adopted an enterprise-wide best practice" as their portal.²⁰

¹⁹ *Beizer, Doug*, Government Computer News, "Transportation Command Analysis center to be built by Northrop Grumman" January, 2007

²⁰ <http://www.wdif.net/latest/northrop-grumman-gets-267m-dod>

In conjunction with its DoD successes, NG has made increasing inroads into the commercial sector as well.

In 2005, Northrop Grumman Corporation (NYSE:NOC) announced the company's OpenTrac (TM) software and e-commerce system would assist Millennium Steel Service's expansion to San Antonio, Texas. OpenTrac software for the metals industry is an enterprise resource planning solution that enhances communication between supply chain trading partners. Under the five-year, follow-on contract, Northrop Grumman agreed to provide supply-chain management capabilities for better transaction management between Millennium Steel's suppliers and customers. In addition, Northrop Grumman IT will upgrade Millennium Steel's Princeton, Ind., service center with an enterprise resource planning system accessible to the entire corporation.²¹

These supply chain portal & advanced application build-outs in both the commercial and military space have enabled NG to accumulate significant Dual-Use Supply Chain Management capability.

Building Supply Chain Strategic Alliances

The second key separate element that is needed to make NG's vision complete is a series of strategic alliances with a) key global suppliers, b) key Third Party Logistics Providers: supply chain industry service experts such as Ryder, UPS, Schneider, FedEx, etc. and c) OEMs (e.g. Caterpillar). These alliances are required to realize the vision of being an integrated supply chain services provider to both military and commercial sectors.

Alliances with Key Suppliers

NG has made a major push to globalize its aerospace industry Supply Base, and to establish second source suppliers capable of providing redundancy and resiliency. For example, in April, 2008, NG hosted composite manufacturing training for engineers and manufacturing specialists from the Danish firm Terma and Turkish Aerospace Industries (TAI) at the company's Advanced Composites Center in El Segundo, California. This was in support of the F-35 Lightning II, a

²¹ Press release: Northrop Grumman Brings Supply Chain Management to Millennium Steel, 2005 Contact: Juli Ballesteros, APR (703) 713-4675 juli.ballesteros@ngc.com

stealthy, supersonic multi-role fighter designed to replace a wide range of aging fighter and strike aircraft.²²

“This hands-on training is a critical step toward ensuring the successful implementation of high-quality, composite manufacturing processes by our international F-35 suppliers,” said Mark Tucker, vice president and F-35 program manager for Northrop Grumman's Integrated Systems sector. “Creating an effective global supply chain is one of many ways we're helping ensure the successful production, delivery and sustainment of the world's most advanced multi-role combat aircraft.”

According to Tucker, the plan to create this global supply chain was put in motion in 2006 when Northrop Grumman helped its F-35 customers – Lockheed Martin and the F-35 Lightning II Joint Program Office – secure commitments from eight countries to purchase approximately 25 percent of the more than 3,000 projected F-35 aircraft sales. In return, the F-35 partner countries were offered an opportunity to participate in a plan that would establish viable second sources for F-35 parts in their home countries.²³

Alliances with OEMS

Northrop has made a determined effort to work with commercial engine OEMs and provide high end maintenance and modification support to their products. This enables NG to bundle products from several OEMs with its own advanced services to create integrate-able supply chain systems for its core military customers.

Dave Werkheiser, vice-president and general manager of the Life Cycle Optimization and Engineering Group at Northrop Grumman Technical Services sector since March 2006, discussed this emerging set of value added services provided in partnerships with OEMs:

“Northrop Grumman is a really large company. Today, we provide supply chain management on some of our major programs like the B-2, for example, we do all the low observable supply chain support. In addition to AWACs and JSTARS, we team with the supply chain provider. We are teamed with AAR Corp. on U.K. AWACs as well as JSTARS to provide that supply chain function, and I think you will see a lot of these large companies like Northrop Grumman that will have an extensive team to supports third-party and even our OEM products.

We are going to apply the things that we learned out of Lake Charles from the JSTARS and even the U.K. AWACs [program], where we have a lot of Lean/Six Sigma activity I think we are going to leverage both the lessons learned out of JSTARS and even U.K. AWACs. On both of those programs, we didn't build the airplane. On JSTARS, we built the mission equipment that goes in

²² International Suppliers to Make Composite Parts...Mon Apr 7, 2008 8:01am EDT

²³ Prime Newswire,” Northrop Grumman Begins Training International Suppliers to Make Composite Parts for F-35 Lightning II Aircraft,” April 7, 2008

the airplane, but, with AWACs, basically the entire mission equipment and the airplane now are being maintained by Northrop Grumman as a third-party provider -- and we have learned a lot on how you manage third-party products. So, our ability to take that experience [and] leverage it to maintain the KC-10, I think, will be very valuable to our Air Force customer.

You will notice that the platforms we are talking about -- JSTARS, U.K. AWACs and KC-10 -- are pretty much commercial derivatives. There is a lot of experience in the marketplace for maintaining these kinds of airplanes, but I think what we add to the mix is the fact that we have a good track record on JSTARS and U.K. AWAC in maintaining and modifying legacy commercial airliners in a very efficient way.”²⁴

Alliances with Third Party Logistics Companies

These supply chain industry experts have distinct advantages that Northrop Grumman needs to capitalize on in order to reach its vision. They have thorough knowledge of the logistics systems and integrated business rules that support highly efficient, complex supply chains. These systems include both the IT hardware and software that need to be integrated to support real-time decision-making.

Northrop/TRW has already established itself as an authorized GSA LOGWORLD provider of supply chain services in a confederation with Artel, Lesco and Ryder. Ryder is of crucial possible importance given its role in the industry.

The Northrop/ Ryder Systems Alliance

On Feb. 5, 2001, Northrop embarked upon an ambitious supply chain alliance with Ryder Systems and announced that Ryder had been selected to implement a transportation management program for its Electronic Sensors and Systems Sector (ES3) and Integrated Systems Sector (ISS) divisions. Ryder would provide shipment and carrier management functions through its Transportation Management Center (TMC) in Fort Worth, Texas, for several of Northrop Grumman's business locations, including Baltimore, Md.; El Segundo, Calif.; Rolling Meadows, Ill.; and Melbourne, Fla.²⁵

Ryder System, Inc. is a provider of integrated logistics, supply chain management and transportation solutions headquartered in Miami. Ryder is one of the largest third-party logistics providers in the United States. The company's services result in faster order-cycle

²⁴ Interview with Elyse Moody/Overhaul & Maintenance Overhaul & Maintenance, March 2008 issue

²⁵ Business Wire, “Ryder Selected to Implement Transportation Management Program for Select Northrop Grumman” Monday, February 5, 2001

times, reduced inventory expense, fewer facilities and greater flexibility for its customers. Ryder System is headquartered in Miami, Florida. Its 75 years of experience & reputation have helped Ryder to continually rank among the industry's leading companies in many publications, including *Fortune's* Most Admired Companies, the InformationWeek 500 of leading business users of information technology and *Internet Week's* top 100 U.S. companies for effectiveness in using the Internet to achieve tangible business benefits.²⁶ In 2005, Ryder announced it had been named the number one third-party logistics (3PL) provider in the annual Inbound Logistics Top 10 3PL Excellence Awards. This was the second consecutive year Ryder has been awarded the top spot by this leading publication and the eleventh consecutive year Ryder has been recognized as a top-five 3PL.

"Companies of all sizes rely on world-class logistics performance to stay competitive in today's global economy," said Felecia Stratton, Editor of Inbound Logistics. "Ryder provides the flexible, innovative supply chain solutions that companies large and small demand. Ryder is responsive to customer needs, and offers strategic solutions designed to drive business process improvement and change. Inbound Logistics editors are proud to recognize Ryder as a recipient of the 2008 Top 10 3PL Excellence Awards." This year's Top 10 3PL Excellence Awards were based on faxed, mailed, and emailed ballots received by Inbound Logistics from December 2007 to June 2008. Readers ranging from transportation managers and CEOs to small retailers and Fortune 10 companies nominated more than 325 companies and cast 5,100 votes (some were disqualified).²⁷

In the aerospace sector, Ryder provides supply chain and global parts distribution, transportation management, and ground fleet solutions. Clients include the largest airlines and aerospace companies, such as Northrop Grumman²⁸.

Northrop Grumman used Ryder's Supply Chain Active Tracking System (SCATS) to track supplier shipments from time of pickup through final delivery to the Northrop Grumman location. Northrop Grumman users were able to access shipping data through its website. Under the transportation management contract, Ryder was supposed to provide end-to-end supply chain visibility, order management, negotiation of carrier pricing/service agreement, shipment planning and execution, freight bill, audit, payment and management reporting services for Northrop Grumman. Ryder was contracted to provide these services for both inbound and outbound transportation of air, small package, truckload, less-than-truckload and classified shipments. Through the TMC, Ryder optimized shipments, developed the transportation schedule with carriers, and orchestrated the pick-up and delivery of loads. Ryder enhanced the ES3/ISS supply

²⁶ Market Wire, Aug 12, 2008 via Comtex News Network

²⁷ *ibid*

²⁸ *Datamonitor Industry Market Research*, Global Truck Leasing, Industry Overview Feb 1, 2005 pNA

chain by providing web visibility through Ryder's SCATS, accessible seven days a week, 24 hours a day, in order to capture and validate critical shipping data being provided by ES3/ISS' suppliers. Ryder also provided the functionality for suppliers to obtain bar-coded labels through SCATS to ensure authorized shipping.²⁹

At the time of this partnership's initiation, Ryder was "eager to develop a more efficient supply chain for Northrop Grumman that begins with connectivity and ends in superior reliability and customer service," said Miles Raper, senior vice president of Global Transportation Management Services for Ryder. "Our contract with Northrop Grumman is a strong validation of Ryder's transportation and logistics expertise. Working with Northrop Grumman provides Ryder a tremendous, high-visibility opportunity to provide a major defense contractor excellence and profitability throughout its supply chain."

Ryder's experience in the alliance with Northrop Grumman is discussed further in the Ryder case later in this report.

Reaching a Dual-Use SCM Milestone: Northrop's Success in Performance Based Logistics

As mentioned in the introduction, a critical milepost on the journey to Dual-Use SCM capability is the expanding presence of Performance Based Logistics and Lifecycle Management arrangements that demonstrate the company's shift away from transactional relationships to more holistic strategic relationships.

Northrop Grumman has attained this milepost, winning several large scale PBL awards from its DoD clients: in January, 2007, the U.S. Air Force awarded Northrop Grumman a \$200 million contract to manage logistics for the B-2 stealth bomber program in a unique outsourcing arrangement. Under the one-year deal, Northrop Grumman supplied the Air Force's Oklahoma Air Logistics Center with full spectrum SCM Support - all the hardware and software, maintenance, and the supply-chain management tools and services needed to keep B-2s fully deployed in the Iraq theater and other global hot spots.

²⁹ Market Wire, Aug 12, 2008 via Comtex News Network

“What's unique about the contract is that it employs a relatively new Department of Defense contracting model known as performance based logistics (PBL).” Basically, the customer tells us what we need to deliver as an end result, and we have the freedom to find the best way to deliver it,” says a Northrop Grumman spokesman. In more traditional outsourcing contracts, funds are allocated for numerous line item products and services, limiting contractor flexibility. The B-2 support contract consolidates multiple funding sources dedicated to various support activities into just three accounts. “It allows us to address the most critical B-2 availability issues quickly and cost effectively,” says Gary Roehrig, director of PBL for the company's B-2 program. DoD's push for PBL contracting began earlier this decade as defense planners sought to improve contractor efficiency at a time when the Bush White House began outsourcing a greater range of military-related activities to the private sector. The DoD's Fiscal 2003-2007 Defense Planning Guidance report requires each department of the military “to be aggressive in their PBL efforts,” according to the report. The B-2 program was included in six PBL pilot programs launched by DoD in 2005. The stealth bombers, which can fly for more than 6,000 miles unrefueled, were instrumental in the initial U.S. invasion of Iraq in 2003 and continue to draw heavy mission duty over the country.”³⁰

In 2008, Northrop was awarded the Fast Project: one of eight companies awarded a U.S. Air Force Flexible Acquisition and Sustainment Program Contract with a Ceiling Value of \$6.9 Billion. This was an indefinite quantity/indefinite delivery (ID/IQ) contract to provide development, modification and depot maintenance of any U.S. Air Force system, including support systems, subsystems and components.³¹

It is apparent that, in trying to achieve integrated SCM capabilities, Northrop's progression has been swift.

Dating back to 2001, Northrop has maintained a long term push to solidify its role as a leading end-to-end supply chain services provider to the military sector. This push has been highlighted by its alliances with Ryder and other logistics providers; the success of its supply chain portal practice in solidifying its core supply chain transaction support business; and its shift up the value chain to provide advanced supply chain analytics. These accumulated capabilities in the military sector are enabling Northrop to target “adjacency opportunities” in the commercial sector and attain some early wins in diversifying its customer base.

³⁰ January 12, 2007, Newswire, Copyright 2007 CMP Media LLC

³¹ Northrop Grumman, news release distributed by Prime Newswire, www.primenewswire.com, July 28, 2008

B. Original Equipment Manufacturer: General Electric Aircraft Engines (GEAE)

GEAE: A Focus on Commercial Accounts

General Electric is a \$150 billion a year business and is being reorganized from six business segments to four segments, with GE Aircraft Engines and Aviation merged under the Technology segment. The Aviation business is one of purchased and leased aircraft. The volume of aircraft purchased by GE from aircraft suppliers makes it the largest single owner/leser of aircraft in the world. This success is the result of GE's Finance Division resources and leasing acumen. GE Aircraft Engines is the largest supplier of aircraft engines in the world as well. The GE 90 is the largest, highest thrust engine in commercial service. The CFM 56 is the most popular aircraft engine in use today.

Total Lifecycle Management Support Contracts have been a major vehicle for GEAE to improve the design of parts, accessories and functions for commercial clients and to keep engines on wing longer. GEAE sells the engines and associated 10 year service contracts that include initial provisioning, spare parts, services & leased modules and engines needed to maintain aircraft availability. Commercial airlines are experiencing more than 10,000 hours on wing for GE engines through incremental repairs, services and design incorporations.

Modularized engines enable as-needed removals of modules and parts without complete engine overhauls, which allows GE to guarantee high levels of engine availability to commercial customers. This process has not been implemented in the military as extensively as it could be. This deficiency in the transfer of commercial practice to the military has served to increase costs for the military and limit service contracting to GEAE.

It is important to note that the GE aircraft business is the only military business in the corporation, indicative of the military sector's minimal revenue contribution to GE and the effects of the military's bureaucratic constraint on commercial practices. Within this context, GEAE's core Dual-Use SCM business objectives are these:

- To maintain a focus on commercial business whose ROI exceeds the military business's.

- To effectively manage a diminished volume of demand for aircraft and engines by DoD, a decline that has persisted since the Vietnam War.
- To lower DoD support costs through technology (advanced real time sensor-based diagnostics) and multi-year service lifecycle management contracts wherever and whenever possible.

GEAE's Commercial Sector Best Practices

In commercial practice, GEAE is responsible for design/development; product support; service; and management. We will discuss each in turn:

Design/Development Responsibility

Requirements for GE aircraft engines are derived from the operators and aircraft manufacturers. GE is the authority for the design and configuration control of the end item. This is not a trivial point because it means GEAE has an inherent responsibility/stewardship for the life of the engine in service. This includes legal liability and financial accountability. One hundred percent of new engines (CFM 56, CF6-80 engines, etc) are sold to airline passenger industry clients bundled with multi-year lifecycle management service contracts to assure reliability and minimize liability. These service support plans are customized for the client as determined by logistical and reliability analyses of customer needs.

Product Support/Service

The product support management plan covers life limited parts vulnerable to low cycle fatigue sensitivity, and enhances spare parts availability through real time engine monitoring. Aircraft dispatch availability is supported by spare engine quick change and incremental on wing repairs.

Traditional, wholly company-owned overhaul has been replaced by repairs and module replacements utilizing GE manpower, methods, tools and facilities. Southwest Airlines was the first airline to contract GEAE for both engines and multi-year service contracts to reduce costs of operations. This enabled Southwest, as a brand new airline, to forego the sunk costs of its own overhaul facilities.

Contract /Project Management

In the management of lifecycle contracts, GEAE has the authority to improve product performance, reduce costs and improve reliability with the incorporation of FAA-approved

changes. By observing all operational aspects of engine performance under aircraft operation, GE can enhance profit maximization/expense control for all parties.

A comprehensive account management structure has been implemented across GEAE's worldwide unified customer base, including both commercial and military sectors. It is a *three tiered Logistics Management/Customer Oversight System* with the following designated lines of authority:

1. *The Technical Representative*- The Tech Rep role is site-specific and product-specific. This role acts as the "floor-level" GE technical resource used by commercial airline personnel to achieve or improve repairs to GE products. In the commercial sector, these representatives are funded by GE itself as a way to address overall project stewardship issues and liabilities.

2, *The Customer Account Manager*- This manager is assigned to an engine-type or program-type and is the key interface between the customer and GEAE. He/she monitors operational conditions at the customer sites, handles all products and spare parts orders and facilitates problem-solving interactions between GE and the customer. He/she maintains a constant dialogue with the customer, assisting with orders/projected needs; listening to customer and responding; and acting as the customer advocate in plant. Thus, the United Airlines customer account manager is supposed to act as the UAL representative/advocate in interface meetings with GE. This manager is funded by GE and is a necessary requirement in commercial accounts.

3. *The Country Manager*-GEAE has a country-specific manager in all the countries with which it does business. For example, the French GEAE country manager would interface with all the airlines flying into France and act as "the manager of last resort" in backstopping GEAE operations in the country.

GEAE has implemented this three tiered management system across its consolidated customer base. It covers the initiation of a critical operations plan for GEAE product support and service of all engines both commercial and military.

Supplier Management

For over a decade, GEAE has used a Strategic Supplier Alliance Contract to achieve the following goals:

- reduce total cost to the end-user
- improve supplier product quality
- get faster delivery to the end user
- reduce total cost of ownership
- reduce inventory levels for suppliers
- improve strategic supplier satisfaction

This Contract is a buyer/seller agreement that transcends purchasing transactions. It defines strategies for sharing information and working together that fully leverage the buying power of the customer and take advantage of supplier capabilities to deliver superior value. It is an agreement to collaborate.

Every major supplier of engine parts (rotating parts, disks, controls & accessories, etc.) to GEAE - a total of 50 core suppliers in all - have signed an Alliance contract. To incentivize participation, GEAE pays core suppliers on receipt of invoice, not on a 30/60/90 day basis. This is a reward to suppliers who participate in the Alliance program. Also, if there is a discrepancy between a supplier's invoice and GEAE's receivables, GEAE corrects it on the next invoice. The results of the Alliance have been improvement in on time delivery & quality. It has facilitated the implementation of design changes when needed as opposed to when inventory is reduced or depleted.

GEAE's Military Practices

Unlike with commercial accounts, GEAE has been limited in its implementation of design improvements and lifecycle support contracting in the military.

GEAE commercial accounts are multi-year in scope with 10 years as the normal duration of service contracts. Military accounts can be multi-year as well, but are often under-funded by DoD. This causes critical spares, services, etc. to be eliminated in order to save money.

Given the long term nature and revenue value of its commercial contracts, GEAE invests more in fielding technical representatives to smooth account relations and acquire vital

information/operational data than it does on the military side of business. For its part, the military chooses not to fund additional GEAE technical representatives, resulting in a lack of information and collaboration.

The Lifecycle Management approach is contingent in the commercial space on flexibility and trust between parties. This permits GEAE to make effective real time decisions, execute optimized inventory/spares management actions and launch targeted, effective maintenance actions.

GEAE has provided multi-year support contracts at predictable costs to commercial operators by managing the improvements and configurations of the engines via operational data. Supplying engines and modules to meet the fleet readiness requirements on a “just in time” basis can only happen under such contractual arrangements.

In the military space, the government has required extremely close oversight, participation and approval. Funds allocated in military accounts are highly directive and specify types, quantities and schedules for parts ordering. The military has struggled with spare parts purchase, delivery, shipment and funding. It is not necessary to recite the frailties of the system that have led to no parts, wrong parts, no funding and aircraft on the ground. (Note: GAO found that about 65 percent (\$18.7 billion) of on-hand Air Force inventory was not needed to support required inventory levels.)³²

Yet DoD continues to allocate funds not to provide flexibility in inventory purchasing but rather for a specified inventory mix regardless of changing demand and needs.

A rare success in this regard has been the GEAE/US Air Force Program for the F-110 engine on the F-16 Fighter initiated in 2005. This program allocated funds to GE not to buy a set of identified parts with specified volumes, but rather to buy parts that were actually needed at catalogue pricing. The parts are delivered under this program and funding is debited.

³² GAO, *Defense Logistics: Efforts to Improve Distribution and Supply Support for Joint Military Operations Could Benefit from a Coordinated Management Approach*, GAO-07-807 (Washington, D.C.: June 29, 2007).

In order to overcome constraints in military support contracts, GE interviewees have suggested the following:

- Hold the OEM liable for fleet readiness, including spares, modules, engines and support services.
- Incentivize the OEM to manage the design and configuration of the life of the engine through a ten year renewable services contract.
- Make real time service/operational data a contract requirement for the government; or contract with the OEM to get it.
- “Make the factory the depot” (General Fain, Advanced Tactical Fighter). Such a concept would send engines back to the OEM’s factory for maintenance and repairs rather than sending them to duplicative military facilities. Currently GEAE is managing GE engine overhaul services at Navy Jacksonville and Army Corpus Christi depot facilities which is a first step in this direction.
- Use the OEM accounting system and audit depending upon the phase of the program.

C. Third Party Logistics Company: Ryder System Inc.

Commercial Supply Chains: State of the Art

The state-of-the-art for large commercial supply chains is real-time visibility for a part or a product no matter where it is, whether at rest or in motion. At the same time, these commercial supply chains have very well-defined and precise event management capabilities layered in; which enable real-time views of what's transpiring in the supply chain and alert reviewers of any anomalies.

For example, Ryder System Inc. delivers 4,000 auto parts per second to automotive production plants in the United States. Ryder and the automakers have complete visibility into what is happening to those 4,000 parts per second.

Ryder serves in this fashion for the 40-some automotive customers. Any system user with appropriate permissions can look at an individual part and see what is happening with it. No one does that, however, because no one needs to. This is because Ryder has a very disciplined process and a business rules engine that overlays all of the supply chain flow activities, which highlights exceptions only i.e., delayed shipment, early shipment, wrong count, mismatched part number on pick-up, etc. The business rules engine, in effect, alerts Ryder and its commercial client to an exception, and tells both parties how to handle the exception. In many cases, system intelligence automatically takes action to handle an issue – again based on pre-defined business rules set by the client and Ryder.

In the automotive example, there are approximately 80 business rules built into Ryder System's rules engine. Of these rules, 30 are generic (i.e., they represent solutions to occurrences common to any automotive supply chain) and 50 or so are individualized down to the particular production plant level.

The automotive example illustrates state-of-the-art practice for inbound manufacturing operations. Ryder applies its real-time management solutions to outbound, customer-facing supply chains as well.

Philips Consumer Electronics serves as the perfect illustration of an outsourced, outbound commercial supply chain. Ryder applies the same visibility layer and supply chain management disciplines to Philips that it applies to its automotive customers. These include inbound and/or outbound order management capabilities. Ryder's information management systems reach up into Philips' raw demand information, and parse this demand into order quantities. Ryder at this point becomes the custodian for fulfilling Philips' customer demand.

Ryder can dynamically optimize customer shipments based on demand information. This dynamic optimization is necessary because, unlike the automotive sector which serves a planned, highly synchronized manufacturing production schedule, consumer goods and retail businesses are based on rapidly fluctuating demand conditions.

For example, on a Friday morning, Ryder's information system accesses Philips' system to see what needs to be shipped for Monday, Tuesday and Wednesday. By noon on Friday, Ryder's systems automatically optimize the Philips customer orders. Ryder may re-optimize Philips' outbound loads several times before they actually ship because there may be allocation issues or order changes that pop up on the fly.

Philips may not have as many flat panel televisions as Wal-Mart wants, for instance. To build up the less-than-truckload shipment, Ryder may add some Circuit City orders to the freight mix. That less-than-truckload shipment then moves from the Ryder facility to a pool distribution point, where the orders are consolidated with orders for Best Buy.

At the last minute, however, Ryder finds out that Circuit City is on a credit hold, so those orders must be pulled off the truck. This means that the entire shipment, which includes Wal-Mart and Best Buy orders, must be re-optimized to take out the Circuit City freight. Ryder can do all of this in a matter of minutes – before a truck is ever finally loaded.

The dynamic nature of commercial and especially retail/consumer goods orders requires more frequent optimization. Although it's highly unusual and seldom necessary, Ryder can optimize 10 times a day. It's not uncommon, however, for customers to require re-optimization four times daily. State-of-the-art IT makes this possible.

The Emergency Response Supply Chain

A violent outbreak in Darfur shares supply chain response characteristics to a hurricane in Florida in terms of inventory availability, immediacy of need, instant reaction time and readiness requirements. In turn, both types of events resemble the military surge situations of rapid & urgent deployments of material. Equipment and manpower are required to manage crises. To respond to such crisis/surge events, seamless coordination is required between organizations. This coordination is illustrated in the case below which highlights how Ryder and Florida Power & Light act in unison to overcome a natural disaster.

Florida Power & Light, which is one of the largest utilities in the United States, has one of the best crisis management centers in the country. The center is tasked with the mission of restoring power in the event of a hurricane or other natural disaster as quickly and effectively as possible. In power generation, Florida Power & Light's up-time requirement is 99.999 percent. The utility's supply chain is built around delivering that up-time as efficiently as possible. FPL works with Ryder to manage its emergency response supply chain effectively, controlling costs while providing unmatched response and recovery time.

FPL has developed an efficient process that helps prioritize restoration efforts, starting with facilities that provide the most critical services:

- Damaged FPL power plants and power lines from the plants since these must be fixed before service can be restored anywhere.
- Organizations that provide critical infrastructure functions to the community, such as hospitals, police and fire stations.
- Major power lines that serve large numbers of customers.
- Smaller power lines such as service to a single street.
- Individual homes or businesses still without power.

When storms strike, FPL responds with an experienced emergency preparedness organization. The purpose of the organization is to execute FPL's comprehensive restoration plan. The plan was developed to be flexible and self-sustaining, and includes multiple sites, out-of-state crews and virtually all FPL employees. When storms threaten to strike, the organization is activated and stays active 24 hours a day until every customer has their service restored.



Storm Command Center. From this location, FPL manages the restoration efforts throughout its 35-county service area, working through various service centers and a number of staging sites. The command center serves as the brain of the operation, communicating restoration and logistics planning to staging sites and service centers to best restore power to communities.

Staging sites. When a storm threatens, FPL sets up working sites to house the thousands of restoration and support personnel who are executing the restoration plan. These sites are pre-selected before the storm depending on its projected path.

Arrangements are made to prepare the site to be self-sustaining with the necessary technology and logistics for restoration workers. Ryder supports FPL in setting up and managing these staging sites.



Service centers. Similar to the staging sites, FPL uses its own facilities to house hundreds of workers. However, due to the limited space at the service centers, FPL uses staging sites to house the majority of its restoration personnel. FPL follows and executes a three-phase Emergency Preparedness Plan – preparedness, restoration and recovery – which

allows for an effective execution of the plan and efficient deployment of personnel, resources and materials.

In the preparedness phase, FPL’s workforce is trained, resources are secured, and systems are tested. Prior to the start of the hurricane season, FPL prepares and trains its workforce with a storm dry run, where employees practice their storm assignments and test new systems in order

to utilize the tools and knowledge to perform safe and speedy power restoration in the aftermath of a hurricane. Also during this phase, FPL coordinates assistance agreements with other utilities for out-of-state support, and supplies/equipment are ordered and stored.

FPL's priority in the aftermath of a hurricane is to restore service to affected customers as soon as possible. Here is how the restoration works:

- FPL uses a damage forecast model in conjunction with storm tracking systems to create a detailed estimate of the storm damage and based on that, a preliminary restoration plan is developed.
- Based on the restoration plan, field crews are pre-stationed and staging sites are selected within the vicinity of the communities likely to be affected by the storm. Once the storm passes, FPL makes an assessment of the damage, refines the restoration plan and directs its field crews to work at the affected areas.
- Once the restoration phase is complete and every customer who can receive power has restored service, FPL enters into a recovery phase that focuses its attention on bringing the system to its pre-storm state. A detailed patrol or post-restoration assessment is conducted and FPL then establishes a plan to complete the repairs in a timely fashion. Staging sites used during the restoration phase might stay operational for an extended period of time to support the effort.

While power restoration is FPL's number one priority in the event of a storm, the utility must manage its costs throughout the entire process. Throughout all of its storm response efforts, FPL is concerned with managing costs – from an inventory/warehousing standpoint and from a transportation standpoint. FPL has outsourced warehousing and fleet management responsibilities to Ryder for this purpose.

Defense Supply Chains: Ryder Practices

Ryder supports supply chain operations for a number of aerospace and defense companies. As noted above, the 3PL works with Northrop Grumman to provide supply chain support for a number of the integrator's defense-related business units. Specifically, Ryder supports inbound operations for seven different business sectors within Northrop Grumman.

Ryder's task with Northrop Grumman is to provide the lowest cost solution to meet the on-dock requirements for those seven facilities. Ryder handles all carrier management and rate negotiation to get the best service and price.

Ryder also works closely with Northrop Grumman to support aircraft on-ground emergency shipment requirements. In these cases, execution is critical. At the same time, cost is important – there is still a need to utilize the lowest cost solution. At times, these two factors conflict. There are trade-off management issues which need to be addressed, and are not always handled most effectively. These issues are discussed in more detail in the CAT Logistics segment of this report.

DoD has many different supply chains, but the overriding motivation for these supply chains is to support missions. In that environment, the defense supply chain 'feels' and acts more like a service parts/service support supply chain than a manufacturing or retail supply chain.

Control tower planning and real time event management capabilities are critical in the defense supply chain. However, the characteristics of the way inventory is obtained and prepared are vastly different. In the fast moving consumer goods sector, the object is to get inventory levels down as low as possible -- to about three weeks. This is not appropriate for many DoD mission events.

D: Third Party Logistics Company: CAT Logistics

CAT Logistics and Service Parts Supply Chain Management in the Commercial World

CAT Logistics expertly manages service parts supply chains, and performs this service not only for its parent company, Caterpillar Inc., but also for some of the leading automakers and equipment manufacturers around the world. CAT Logistics also provides similar services in the aerospace and defense sector.

The following is a summary of the challenges CAT Logistics faces in managing a service parts supply chain in the commercial world. This information was obtained from interviews with three different executives who have asked for confidentiality.

Managing service parts logistics is quite different from managing manufacturing requirements. Manufacturing logistics builds out of an enterprise resource planning (ERP) focus, which concentrates on planning and supporting new product production — i.e., deciding which plant to produce the product, and which tools to manage production, planning and execution.

As companies introduce new products, service parts proliferate through the market. Companies cannot afford to stock every product in every location. So how do they determine how much of a given part must be brought into the network initially, and where those parts should be positioned in the network? To make these decisions, companies use computer models that factor in product demand demographics and locations, product failure rates and so on.

The nature of demand. There are two types of demand in any given manufacturing setting – dependent and independent demand. A description of dependent demand follows: an auto manufacturer can project demand for tires by simply calculating that every car has five tires, and because they are making 1,000 cars they'll need 5,000 tires. In this scenario, demand is dependent on how many cars are produced.

By contrast, in the service parts environment, demand is generated by problems or service requirements. Historically, companies viewed all service parts demand as independent. But there has been a realization that a portion of demand from time to time is actually dependent. For example, a major undercarriage overhaul in a Caterpillar tractor typically requires 70 different

parts. The dealer can predict how many tractors it will repair each month based on its knowledge of the localized tractor population together with customer usage patterns and product lifecycles. With this information, the dealer should be able to predict the number of parts it will require, procure the needed items and keep them out of the independent demand forecast.

How then does one forecast true independent demand? How are safety stock, economic order quantity and other characteristics for a product with variable demand calculated? The first step is to apply logic and history to the demand forecasting process.

In the automotive sector, for instance, dealers can estimate the typical number of miles a customer drives on a daily basis based on that customer's early usage history. Using this information, the dealer can predict when that customer will show up for an oil change. Extrapolate this data out for the dealer's entire customer base, and the dealer can do a fairly good job of predicting how many oil filters to buy from the OEM and when to buy them.

The other metric driving service parts logistics is inventory cost. The goal is to achieve the best service level with the optimal inventory turn rate.

Inventory cost must be balanced against total supply chain cost. One may have a high rate of inventory efficiency — i.e., a high rate of turns — but spend too much on transportation. Leading companies are therefore adopting a supply chain view that balances trade-offs to provide optimum service while minimizing total supply chain cost.

Robust System Requirements

Inventory management systems must be robust enough to recognize and manage all forms of inventory, based on a set of governing parameters. A system is needed that will automatically consume old parts before the new, or manage the choice of remanufactured parts versus new depending on customer requirements.

The system must be able to manage reverse logistics and provide visibility into that return flow in order to adjust the vendor procurement accordingly.

To manage all of this, real-time execution and decision-making capabilities must be available. The underlying theme in service parts logistics management is inventory visibility across the entire network, to see what's sitting on the dock, in the warehouse or in the truck. Can a

customer's rush order be filled and shipped out to the customer that same day? Or must the part be procured from a distribution center, packaged away, and then mailed, forcing the customer to wait two days for the part?

This is the world of service parts inventory management. It's a world that works seven days a week, 24 hours a day because somewhere in the world, a customer requires parts.

Convergence of People and Parts

In the after-sale service and support business, there has been a convergence between people and parts. Companies are looking at service and service management as more than just parts planning. They're integrating the parts supply aspect of the equation with the labor/technician portion to provide full service. They're not just shipping a part to a site.

To manage this integrated approach, companies are investing in service parts IT solutions that enable them to optimize the provisioning and planning for the field labor force. At the end of the day, if there is optimization and planning for the right part, but the Service Level Agreement (SLA) is still violated because a field technician is not in the right place, that's still a service failure.

While a lot of companies realize the potential of integrated service/support, they also recognize that they may not be the best party to execute on that service. As a result, outsourcing continues to grow strongly in the after-sale service arena. More OEMs see service as an opportunity to leverage other people's expertise. They're contracting for the field service labor and using third party logistics service providers to manage the service parts supply chain.

Supply-base Performance

Five or six years ago, inventory management expertise was seen as a differentiator. But life has moved on, and systems have moved on as well. Inventory management per se is not a competitive advantage.

What does distinguish companies today is the combination of inventory management in addition to a high-performing supply base. Supply base performance has a tremendous impact on parts availability. In the past, however, most OEMs focused their purchasing expertise on production procurement. The aftermarket was not seen as warranting much attention because the cost of a

manufacturing line going down was much greater —with much more immediate consequences for managers and the company. So the primary mission of purchasing was to feed the OEM line.

Companies are beginning to pay more attention to managing their aftermarket suppliers. They are applying the same kind of performance measurements and requirements to their aftermarket suppliers as they do to their production line suppliers. After all, underperforming suppliers can only be combated with increased inventory. The hidden costs of a poorly performing supply base are very high.

But if there is better management of aftermarket purchasing, companies experience better parts availability and reduced costs. For some automotive customers, purchasing from second tier suppliers is handled at the company level. Parts availability has been increased, in addition to reducing costs and the time burden of managing the supply chain for the client.

Caterpillar's perspective on service parts logistics is focused on three industry sectors — consumer retail (appliances, etc.), aerospace and defense. Each of these three sectors has unique needs when it comes to service parts logistics.

Mobile Inventory

In consumer retail, service parts management takes the shape of a large field force of highly mobile technicians that need to be supplied with an inventory of parts which they keep on their trucks. Because an inventory solution may be propagated across hundreds or thousands of trucks, profiling what should be on these vehicles and in the supply depots is critical.

In determining truck inventory, a couple of things come into play. First, one must take into account a product's geographic distribution. This allows a profile of need for types of parts, demand, and failures for the installed population within a certain geography. These profiles change based on various factors. For example, if air conditioning units require servicing in Texas and Chicago, there will be different repair profiles for each location. There will be a much higher demand for parts in the warmer climate because of significantly higher usage.

Lifecycle Management and Shifting Demand

Aerospace is a whole different animal. Aerospace has two types of products: airframe and components/systems. Boeing, Embraer, Bombardier, and Airbus all make airframes.

Components can range from GE or Pratt & Whitney engines all the way to the electronics that go into products, made by companies like Rockwell Collins, Raytheon and Honeywell. For example, every gauge in an aircraft cockpit is a module that slides in and out. These modules, as is the case with all aircraft parts and components, are subject to stringent regulations regarding usage and repair history tracking.

The gauge modules are designed to be swapped out. If the gauge fails, a light goes on; a repair technician pulls the module out of the dashboard and pops in a new one. The old module has to be returned for remanufacturing. The returned part or module is triaged, diagnosed, repaired, turned into a serviceable part, recertified and fed back into the forward supply chain.

Because many aerospace components are very high in value, there are a large volume of returns. The OEM has to have depots strategically located so it can get a replacement part on an airplane and to the customer quickly. It has to be able to track that part everywhere it goes, throughout its whole lifecycle.

From a demographic perspective, the profile of aerospace product in the world has shifted. Specifically, regional jets have changed everything, opening up new markets. In Asia for example, every manufacturer of regional jets or product going into regional jets is blazing into the market because there is tremendous current and future demand for air travel. And the nature of the travel has changed. There is no longer a corporate struggle to fit 500 people on a single international flight from Tokyo to Singapore. Now flying smaller connecting flights between rural places in mainland China help to ease constraints on space and create a more efficient system.

Given this trend, a company such as Embraer needs not only to be able to produce aircraft in Brazil, but support these aircraft anywhere in the world. Embraer needs to be able to move parts very quickly to far away, strange places. They additionally require a system that fully leverages the best available transportation infrastructure in the region the aircraft resides. This presents a big challenge.

Supporting “Platforms” and “Programs”

The defense industry must choose to support either a “platform” or a “program.” A platform might be an aircraft like the Joint Strike Fighter (the J-35).

A program revolves around operational capability, supporting assets globally at a given level of readiness. For example, a program might involve supporting a fleet of ships such that they can sustain a certain number of marines deployed in a theater for a specific period of time. In this kind of program, the fleet would come into port, dock for 45 days, and within that time frame, suppliers would provide all the supplies, parts, etc. needed to sustain the fleet at 100 percent readiness.

In the defense sector, it's increasingly common to set up a set of services under a performance-based logistics (PBL) contract. This kind of contract specifies that product support will be provided to guarantee a certain level of capability or readiness for a system or platform. Payment is tied directly to product availability or usage.

Essentially, the customer outlines an outcome. It is the job of the contractor to determine the most efficient manner in which the outcome can be achieved.

Issues in the Defense Supply Chain

The defense supply chain is in the same business of supporting products all over the world, much like the commercial services parts supply chain. The Defense Department approaches supply chain from three avenues: through the Defense Logistics Agency or through individual Service supply chains on weapon systems, or supply chain services embedded in the purchase of the product (PBL).

PBL contracts, in many cases, end up being parts acquisition programs along with someone running a warehouse for quick delivery; the vendor puts a warehouse near a military depot to ensure quick delivery. While this does mean parts get delivered when needed to the service operation, there are often 10 different warehouses next door to a repair depot – a warehouse for power units, avionics, APUs, fuel controls, actuators and so on. So PBL creates multiple infrastructures and IT systems clustered around the repair depot operation. These clusters are repeated wherever there are repair depots. They are managed by the OEM, which is expert at designing and making parts or products, but not necessarily expert at managing an efficient product support supply chain.

There is no single view or overarching visibility into inventory across this discrete network of service support warehouses, making it very difficult for the service operation to see what is available, what is inbound and so on.

One of the critical differentiators between commercial and DoD supply chains is finances. The Defense Logistics Agency, for example, has a budget and its activities are all driven by that budget. At the same time, however, its employees are not required to report vital information to anyone about how efficiently they are managing costs.

In the commercial world of 2008, 3PLs are expected to do forecasting, lineside deliveries and surge control. DoD information systems often do not facilitate communication between different service units or between the military services and their external suppliers. This puts DoD at a significant disadvantage when it comes to improving total efficiency in supply chain operations.

Lack of systems capability and integration, for example, makes it extremely difficult to track parts that are returned for repair. It is not unusual for a part to be shipped out in a mislabeled package due to an information system gap. Thus, when the mechanic opens up the box on a part needed to repair a jet fighter engine, he finds the wrong part and cannot repair the aircraft in a timely manner.

One of the issues that the best practice commercial supply chains have spent a lot of time addressing -- with relatively high level of success -- is organizational silos. For example, when an order needs to be expedited, that fact is visible across the various operational departments that handle the order. Order Processing is able to process the order quickly; Warehousing knows to pick it and stage it for shipment quickly; Transportation knows to arrange expedited carrier service; and so on. The order reaches its destination at the required date and time.

This ability to expedite an order is enabled by horizontal integration across the organization.

Such horizontal integration is lacking in the military supply chain. Thus an order may be expedited in one section of the supply chain, but bogged down in another, so it does not get to the warfighter when he needs it.

Each branch of the service has its own enterprise application and sets of software to manage their supply activities. These IT infrastructures cannot "talk" to one another. Thus, the Navy and the

Air Force may fly the aircraft and use interchangeable parts, but one service's aircraft will be grounded for lack of a part, even though that part is available in the other service.

With the military, it may take as long as three years to get a contract. GM and many other big companies will typically be under contract for other projects within six months.

However, when contracts with the military are obtained and best practices are applied, they are wildly successful.

There is no doubt that PBL can work, and it can be efficient; and the warfighters love it because it gets their planes flying and their tanks running. The Honeywell contract, for example, has been amended six times; the warfighter keeps adding to it because it works so well. But without the warfighters putting pressure on the system, optimum PBL is not going to happen.

CAT Logistics is a large transporter of very heavy stuff. They have contracts with customers that require CAT Logistics to deliver a replacement part to fix a malfunctioning machine anywhere in world within 96 hours. If this is applied that to a defense scenario, when a Colonel in Iraq has a plane on ground, would it be preferable to pay CAT Logistics a premium to get the needed part to the Iraq location in 96 hours? Or would it be better to save that premium and ship the part by boat, which may take up to 60 days, and have the plane sit on ground for the duration? To the Colonel in Iraq, the answer is easy.

There are tremendous bureaucratic, organizational and structural roadblocks to overcome in order to realize the potential of PBL. Unfortunately, many of these remain to be addressed.

V. Conclusions: Challenges to Realizing Dual-Use SCM Capabilities

Building Dual-Use SCM capabilities have been hampered by DoD's reluctance or inability (including legislative barriers) to adapt to best commercial practices, particularly those employed by Third Party Logistics Providers and OEMs. These companies do not share the same level of DoD-related revenues, critical mass of DoD-installed resources or "strategic patience" of the System Integrators. This has raised barriers to the seamless transfer of capabilities across sectors.

Ironically, unlike in the Dual-Use Technology movement, DoD has not been the engine exporting innovations to the commercial world but the seemingly resistant recipient of supply chain innovations from the commercial sector. There is a huge cultural dislocation between a DoD supply chain culture conditioned by sequential, bureaucratic procedures and the real time simultaneous supply chain decision making environment in the best-practice commercial sector.

Other factors also impede Dual-Use Supply Chain Management development. Regulatory Compliance with overseas transfer of Dual-Use technology has complicated international Dual-Use SCM capabilities development.³³

On an even more basic level, differences between the military/commercial sectors in parts' serial numbers, descriptions & nomenclature also complicate Dual-Use SCM capabilities development.

Regardless of these challenges, we believe Dual-Use Supply Chain Management will continue to grow as commercial opportunities expand for key actors in an era of high-growth global markets; and as the military sector increasingly requires the process cost-savings and sunk capital cost-avoidance promised by leveraging commercial supply chain innovations and infrastructures.

Finally, both commercial and military sectors will continue to share a strong desire to minimize supply chain risk profiles. When the Aberdeen Group conducted a survey of 180 global

³³ http://www.securitymagazine.com//Articles/Industry_News/BNP_GUID_9-5-006_A_, June 18, 2008

enterprises, eighty per cent reported supply disruptions in the previous 24 months. Most expected risks to increase.³⁴

Against this backdrop of supply chain disruption, attempts have already been made to define more effective strategies and practices for managing global supply chain risk. The Aberdeen Study found that best-practice companies are taking a variety of measures to counteract risks – including the adoption of balanced sourcing methods. Supply chain risk management leaders, such as Wal-Mart and FedEx, have created Global Situation Rooms led by Directors of Business Continuity to track and respond to emerging threats.

The combined supply chain resources of the commercial and military sectors will have to be increasingly pooled and shared to gain overall supply chain resiliency in the face of heightened global risks.

Ultimately, DoD can only accelerate the transition to Dual-Use SCM by its key providers through continuous and systematic review & removal of barriers to cross-sector sharing of standards, practices and technologies.

³⁴ Aberdeen Group (2005) 'Supply risk management benchmark: Assuring supply and mitigating risks in an uncertain economy', Boston MA: Aberdeen Group

Acknowledgement

The Lockheed Case was based largely on interviews with Mr. James Conn, Senior Manager Logistics & Sustainment, Corporate Engineering & Technology Lockheed Martin Corporation; and Mr. William Delahanty, Chief, Architect Product Support Framework & Chief Engineer, Lockheed Martin Integrated Logistics Solutions. The GE case was based on interviews with Bruce Schoolfield , GEAE Manager Advanced Logistics Support (retired); Karl Matson, GEAE Master Black Belt For Military Engines, Larry Trowel, GEAE Director of Contracts for Military Engines. This research was sponsored in part by the Lockheed Martin Corporation.

The Center for Public Policy and Private Enterprise provides the strategic linkage between the public and private sector to develop and improve solutions to increasingly complex problems associated with the delivery of public services — a responsibility increasingly shared by both sectors. Operating at the nexus of public and private interests, the Center researches, develops, and promotes best practices; develops policy recommendations; and strives to influence senior decision-makers toward improved government and industry results. The Center for Public Policy and Private Enterprise is a research Center within the University of Maryland's School of Public Policy.

