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Dated February 8, 2001

Supply Chain Practices for Affordable Navy Systems

DATE OF SUBMISSION: November 30, 2004

FINAL REPORT

SPANS

SUPPLY-CHAIN PRACTICES FOR AFFORDABLE NAVY SYSTEMS

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Title Page

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Prepared for Office of Naval Research
Manufacturing Technology Branch under
Contract N00014-01-C-0088
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1.0 Executive Summary

This Supply chain Practices for Affordable Navy Systems (SPANS) final report is submitted to satisfy the deliverable requirements of ONR contract N00014-01-C-0088. The period of performance covered in this report is February 2001 through September 2004. This report reviews the mission of SPANS and includes a chronology of events, Strategic Direction and Project results, a financial summary, and recommendations for future projects and activities. The SPANS program is ongoing with funding under separate contracts.

The SPANS program has a strategic objective to deploy successful supply chain practices and processes in one or more Navy acquisition programs, resulting in improved affordability. The SPANS approach to this task has been to adapt promising best commercial practices in the supply chain management processes and practices developed in the civilian sector and apply them to the defense acquisition establishment. Led by ATI and Altarum, SPANS undertook five projects with industrial team members involved in the development and manufacture of a variety of weapons systems, including aircraft carriers, missiles, and aircraft.

The STAMP project is a significant success story for the SPANS Program. The objective was to develop the capability to exchange technical data packages (TDPs) electronically across the internet, between the prime and suppliers. Using an international standard format (ISO 10303), the team automated the preparation, delivery and receipt of TDPs. The process was implemented and validated at Raytheon Missile Systems (RMS) and over 20 RMS suppliers. The results for this effort determined RMS would realize an $18.6M reduction in labor costs, and RMS suppliers could realize a labor saving of $2.7M per year. Furthermore, the project demonstrated average TDP delivery cycle time reductions of 59% at RMS and 95% with RMS suppliers.

The Supply Chain Dynamics (SCD) project objective was to develop and validate an agent-based software toolkit for modeling and simulating defense supply chains to diagnose problems and help identify opportunities for improvement. Working with Northrop Grumman Newport News, the SPANS team identified process improvements that would lead to an inventory reduction of 78% for the Navy Standard 525 valve.

The Supply Chain Value Stream Management (SCVSM) Project is based on the overall concept of applying lean methods and techniques to a supply chain as a system. Through implementation of value stream mapping concepts, the team worked with Boeing to identify fourteen different multi-company opportunities where the product process could be streamlined to help shorten lead-times and lower costs for the F18 Nose Landing Gear.

The Construction History and Parametrics (CHAPS) project developed a method of exchanging Construction History and Parametric information between major CAD systems utilizing a neutral product data standard. The teaming partners included RMS, Northrop Grumman (NG), and select suppliers. The project was able to successfully translate 67% of the teams CAD models. The annual cost avoidance savings were found to be approximately $744K within NG and a savings range at the suppliers from $ 138K to $198K.

2.0 CHRONOLOGY

$4M for SPANS was authorized in the 2001 DOD Appropriations Bill. Sponsored by the Office of Naval Research (ONR), the original SPANS team included the Advanced Technology Institute (ATI), a non-profit organization and a recognized leader in consortia management; the Environmental Research Institute of Michigan (ERIM), a not-for-profit organization, and a recognized leader in supply chain research; Arthur D. Little (ADL), a leader in the consulting industry, and Andrulis Corporation, a woman-owned small business specializing in making information technology work for decision makers. A Technical Advisory Board (TAB) of commercial and government experts assisted the SPANS team in fulfilling the program goals.

5-6 February 2001 Kickoff for the SPANS program occurred in Arlington, VA at the Andrulis Company headquarters. Two initial projects were approved: Supply chain Technologies for Affordable Manufactured Products (STAMP for SPANS) and a Supply Chain Dynamics project.

10 April 2001- Initial Technical Advisory Board (TAB) meeting. The initial funding of the program was delayed, and limited funding was made available to support limited start-up of the SPANS program through 30 April 2001. Project execution could not begin until full funding was received. A simplified approval process, utilizing a technical direction letter (TDL) was instituted to speed the project approval process.

15 May 2001 $3.0 Million was received by the SPANS program from ONR MANTECH.

31 May 2001 ONR Contract Officer Technical Representative approved the TDL for Supply Chain Network Dynamics (SCD).

6 June 2001 The Supply Chain Network Dynamics (SCD) project was kicked-off on at Newport News Shipyard.

26 June 2001 The technical direction letter (TDL) for the STAMP for SPANS project was approved. The SPANS website www.spans.org became operational.

17 July 2001 Technical Advisory Board Meeting: Strategic Development Plan; Supply Chain Value Stream Management (SCVSM) project with Boeing; Construction History Project were presented to the TAB.

19 July 2001 STAMP for SPANS kickoff was held at Raytheon Missile Systems Tucson, Arizona.

26-28 November 2001 Defense Manufacturers Conference in Las Vegas NV. SPANS program was briefed.

18 December 2001 Supply Chain Value Stream Management project had its kickoff meeting at the Boeing St. Louis plant.

5 March 2002 The SPANS program was briefed to the Technology Area Readiness Assessment (TARA) Board. As a result of this briefing the SPANS program was added

to Defense Technology Objective (DTO) MP.32 Assured Supply Chain Responsiveness grouping and will be tracked by the TARA board.

25 March 2002 SPANS program was also presented to a working group of MIT's Lean Aerospace Initiative (LAI).

16 April 2002 – Construction History and Parametrics project kicked off at ATI in Charleston, SC

1 May 2002 SPANS was presented to a DoD program managers workshop at Ft. Belvoir, Virginia

22 July 2002 SPANS was presented to a NAVSEA working group at the Washington Navy Yard.

15 August 2002 SPANS projects were presented to the Advanced Manufacturing Enterprise (AME) subgroup of the Joint Defense Manufacturing Technology Panel (JDMTP) in Arlington, Virginia. The SPANS Program Manager received recognition from the Joint Defense Manufacturers Technology Panel (JDMTP) for an exceptional presentation before the Advanced Manufacturing Enterprise portfolio review team. This presentation was compared to all the hundreds of presentations given to all the subcommittees comprising the DoD JDMTP.

1 October 2002 SPANS awarded 2.0M in 2002 DOD Appropriations Bill. ONR agrees to supplement with $750K. Total contract value becomes $6,679,371.

30 October 2002 SPANS Library www.supplychainlibrary.org is operational

2-5 December 2002 SPANS supported the Defense Manufacturers Conference (DMC) in Dallas, Texas from by co-sponsoring a booth with the Defense Sustainment Consortium. STAMP for SPANS was a runner-up winner for the 2002 DMC award.

16-17 January 2003 SPANS program was presented to ShipTech 2003 Conference in Biloxi, Mississippi.

24-26 March 2003 The SCVSM project was presented at the Lean Aerospace Initiative Conference in Dayton, Ohio.

26 June 2003 Technology Refresh for Effective Navy Transformation (TRENT) project held a kickoff at ATI headquarters in Charleston, SC.

7 July 2003 The SPANS TRENT Phase 1 competed and won an award under Transition Management Technology Initiative (TMTI) with the American Competitiveness Institute (ACI). This will allow the ability for a limited pilot project to be conducted to test the TRENT architecture.

27-28 August 2003 SPANS sponsored a Performance Based Logistics (PBL) workshop for the Navy Carrier Systems Program Office, NGNN and its vendors regarding Supplier Roles in PBL. The workshop was held in Arlington, VA.

30 September 2003 Raytheon reported on its STAMP project that RMS had produced over 5600 STAMP Technical Data Packages on a variety of programs. A single engineer has produced over 943 packages. Using Raytheon's own metrics, this would equate to

nine Man-Years of labor using the pre-STAMP methods, whereas with STAMP technology, it has taken much less than a year of effort for this one engineer.

10 October 2003. Supply Chain Dynamics final report submitted.

31 October 2003 Supply Chain Value Stream Management final report submitted.

22 December 2003 Supplier *Roles in System-Level Performance Based Logistics* report is submitted to CVN 21 Office which summarizes the results and findings of the PBL supplier workshop held in August 2003.

2 January 2004 Construction History and Parametrics Final report submitted.

16 January 2004 STAMP for SPANS final Report submitted

27-28 January 2004 The SPANS Technical Director attended ShipTech 2004 conference in Biloxi, MS as chairman of the Business Processes Technologies Panel Sessions.

March 2004 SPANS Program Officer-Leo Plonsky was awarded the 2003 Department of the Navy Procurement Excellence Award for the Supply Chain Technologies for Advanced Manufactured Products (STAMP) for SPANS project due to the acknowledged success of that project. The following is an excerpt from the Secretary of the Navy's message announcing the winners of the award:

AS A RESULT OF THE HARD WORK AND DEDICATION OF THESE AWARD WINNERS AND ALL OTHERS IN THE ACQUISITION WORKFORCE, OUR SAILORS AND MARINES BENEFIT IN TERMS OF A HIGHER STATE OF MATERIAL READINESS, IN THE PURSUIT OF THE WAR ON TERRORISM AND OTHER MISSIONS. MOREOVER, COMPETITION AND INNOVATION HAS SAVED, AND WILL CONTINUE TO SAVE TAXPAYERS BILLIONS OF DOLLARS AND WILL ENHANCE THE NAVY'S REPUTATION FOR SOUND STEWARDSHIP OF PUBLIC FUNDS. THE OUTSTANDING PERFORMANCE BY ALL PERSONNEL INVOLVED IN THE ACQUISITION PROCESS IS GREATLY APPRECIATED.

27 APR 2004 Submitted TDL for Continuous Improvement Tools Survey for DASN (L) A SPANS CI Tools team will create and execute a web-based survey to nearly 50 DoN industrial activities. The intent is to find extent of use of CI tools- Lean, 6-Sigma, Theory of Constraints, Malcolm Baldrige award criteria –at DoN industrial facilities.

30 September 2004 Completed Continuous Improvement Tool (CI Tools) survey for the Deputy Assistant Secretary of the Navy for Logistics –DASN (L). No site visits will be required. Submitted final CI Tools Survey report.

30 September 2004 The SPANS program also won a competitive award to conduct a study for Best Practices in Supplier Relations for the Defense Contract Management Agency (DCMA) in this quarter.

30 September 2004. Current SPANS contract N00014-01-C-0088 expires. SPANS is continuing operations under 4 different contract mechanisms.

3.0 SPANS Strategic Direction Plans

The SPANS program has developed several strategic plans. The revision of the initial SPANS strategic direction plan was necessary as a response to real-world issues of funding and reprioritization of the SPANS management team and the Technical Advisory

Board members. Appendix A contains the first major SPANS strategic direction plan (SDP) drafted by the team. He examined the cost drivers in a supply network and determined them to be: processes; transactions; relationships; networks; and managing the enterprise. From those cost drivers, he developed a list of strategic initiatives which would impact the cost drivers. These were:

Strategic Initiative 1. Data Quality for E-commerce
Strategic Initiative 2. Collaboration
Strategic Initiative 3. Building Trust
Strategic Initiative 4. Predicting Network Behavior
Strategic Initiative 5. Multi-company Change Processes

From these SPANS strategic initiatives came sub-initiatives: Data Quality for E-Commerce was further dissected into sub initiatives Product Data Exchange and Product Data Quality; Collaboration was broken into collaborative practices and technologies; Building Trust was subdivided into Gainsharing and Supplier Qualification; Predicting Network Behavior was broken down into Simplified Modeling of Networks and Dynamic Simulation; and Multi-company Change Processes were reduced to Turning models into action. These sub initiatives were used to screen projects to ensure that different SPANS projects were selected from different initiative and sub initiatives, that SPANS was not focusing all its efforts on one specific area. Details are in Appendix A. The niche that SPANS initially selected was focusing on the supply chain between the prime contractor and its suppliers in an *acquisition* environment, as there already was a sustainment effort in place. SPANS would not look at issues upstream of the primes as there was already an agency charged with that responsibility, namely the Acquisition Reform Office. This niche served us well for the first several years of the program, until personnel changes and funding reductions brought about the need to refocus our priorities. SPANS did not have the resources to execute projects in all sub initiative areas.

Jack White of Altarum replaced Mitch Fleischer as Technical Director of SPANS early in 2004. One of his first tasks was to revise the Strategic Direction Plan (SDP) taking into account the realities of funding and the need to focus the available funding where it would do the most good. Based on previous experience, SPANS does several different but related tasks:

- Identifies Navy manufacturing and Producibility needs
- Adapts Commercial Best Practices
- Performs Gap-filling Research
- Builds modeling Tools
- Validates technical developments through Pilot Projects

The team identified new potential areas of focus- Improve operational capability/ performance of supply chains through tools such as Lean Value Chains, Theory of Constraints (TOC), 6-Sigma, and the balanced Scorecard toolkits. Another potential area was to address the DoN supply chains desire to manage greater value chain complexity through visibility of assets, collaboration of members, organizational flexibility, and risk management. Another emphasis for SPANS could be to reflect the forward thinking of VADM (ret.) Art Cebrowski of the Office of Force Transformation on logistics

transformation efforts- to align and synchronize value chains, develop a "sense and respond" capability- to demonstrate what we want the supply network to do in the delivery of product and services and information integration. Another desired outcome of DOD Supply Chains is the ability to continuously improve end-to-end performance through adapting Value Stream Management techniques to assess value chain capability; align value chain metrics; combine TPC, Supply Chain modeling techniques, and Incentivize suppliers to participate in improving products and processes that support the Navy.

On 12 February 2004, this revised SPANS Strategic Direction Plan was presented to the SPANS TAB. After discussion, it was decided that we would look at deployment efforts of our existing projects as well as developing new technology.

SPANS initially received program support and TAB membership from James Eccleston, the Deputy Undersecretary of Defense for Logistics and Supply Chain Integration, [DUSD (L) SCI]. When Mr. Eccleston departed government service, SPANS sought additional program champions from DOD. Mr. Nicholas Kunesh was the first Deputy Assistant Secretary of the Navy for Logistics [DASN (L)]. He accepted a position on the Technical Advisory Board. From this position, he emphasized his priorities on deployment of existing projects and a focus on Department of Navy installations. This DASN (L) emphasis caused us to reevaluate the SPANS strategic position to meet pressing Navy manufacturing needs. One project that SPANS funded as a result of his interest was a survey of the continuous improvement tools (CI Tools) Lean, 6-sigma, TOC, Malcolm Baldrige Award criteria that were in use at DoN industrial sites. This survey was the result of the DASN (L) desire to find the state of CI Tool use in DoN industrial facilities. The results of the survey were turned over to the DASN (L). The results are For Official Use Only and are not allowed to be divulged by anyone outside his office by contract. This project results are not summarized in this report.

4.0 Methods Assumptions and Procedures: SPANS Projects Summaries

The SPANS project methods, assumptions and procedures were duly outlined in the individual SPANS project final reports. These final results of the completed SPANS projects: Supply Chain Dynamics; STAMP for SPANS; Supply Chain Value Stream Management; Construction History and Parametrics; and the Supplier Roles in System-Level Performance Based Logistics projects have been submitted previously- once as the individual project final report and again with the SPANS quarterly report during that period. They are available on the www.spans.org website for downloading and will not be attached again with this document. The projects will be summarized however.

4.1 STAMP for SPANS

STAMP for SPANS developed the capability to exchange Technical Data Packages electronically using the Internet between the prime and suppliers using the ISO 10303 STEP standard and replace a paper process

STAMP for SPANS has been the greatest success for the SPANS program. The project is responsible for the nomination for the 2002 Defense Manufacturing Conference Award, and the SPANS Contract Officer Representative (COR) receiving the 2003 Department of the Navy Acquisition Excellence Award. The premise of STAMP was to address a common problem between primes and their suppliers: aerospace companies and other large DoD contractors are increasingly relying on suppliers for detailed design and manufacturing. This increased reliance on outsourcing has amplified the need for primes to exchange design information and manufacturing specifications with a large number of suppliers. Substantial progress has been made to enable suppliers to read a variety of digital CAD and drawing formats through the emergence of international standards; however, until recently there has been no standard for representing the metadata associated with this manufacturing information. While most large primes use Product Data Management (PDM) systems that incorporate large amounts of metadata to manage and control their manufacturing information, most suppliers cannot exchange this information with the prime.

Building on a previous DARPA effort, the Supply-chain Technologies for Affordable Manufactured Products (STAMP) Project began in July 2001 to improve affordability of Navy missile systems. STAMP accomplished this goal by validating the technology and business case for PDM to PDM technical data exchange using the ISO 10303 standard (the STEP PDM Schema). The project team included ATI, Raytheon Missile Systems (RMS), ICF, ISS, ITI and over 20 Raytheon suppliers from various Navy weapons systems. Sponsored by the Office of Naval Research under the Supply-chain Practices for Affordable Navy Systems (SPANS) program, STAMP piloted technology that enabled Raytheon to exchange digital data packages with its suppliers. The project ran in two phases, first demonstrating prime to supplier data delivery, then demonstrating bidirectional data exchange. Using STAMP technology Raytheon and its suppliers were able to exchange data with complete configuration management information intact, even though they used two completely different PDM systems.

Phase I of the project verified that it was possible to deliver complete and accurate technical data packages (TDPs) from a large prime's PDM system to a different PDM system at the supplier site. It also demonstrated that preparing and delivering TDPs in digital form dramatically reduces labor and cycle times over paper based delivery. Phase I demonstrated that deploying STAMP across all missile programs would reduce labor costs **$18.6M per year at Raytheon and $2.7M per year at Raytheon missile suppliers.** Furthermore, the project demonstrated average **cycle time reductions of 59% at Raytheon and 95% at Raytheon missile suppliers.**

Phase II expanded the project, adding bidirectional exchange of engineering change orders, quality and test data, marked-up documents and quote packages. Phase II demonstrated a labor avoidance of $26.2M per year at Raytheon and $1.39M- $2.18M for suppliers. Cycle time reductions ranged from 96% to 99%. First year ROI estimates for bidirectional STAMP deployment range from 10 to 33, depending on the actual technology deployed at supplier sites. Five year cumulative ROI estimates range from 33 to 117. As a result of the success of this project, Raytheon has already deployed Phase I STAMP technology in production on several Navy programs and is quickly expanding

deployment throughout the entire Raytheon RMS supply chain. The results from both Phases of STAMP are expected to be widely applicable throughout DoD.

4.2 Supply Chain Dynamics (SCD)

The objective of the Supply Chain Dynamics (SCD) project was to develop and validate an agent-based software toolkit for modeling and simulating defense supply chains to diagnose problems and help identify opportunities for improvement.

The project sought to improve the accuracy of predicting supply chain performance improvements using a simulation tool to characterize and quantify the impact of supply chain parameters (lead time, variance, etc.) on cost and delivery performance. The project developed a supply chain simulation toolkit, then piloted and tested its use across the supply chain providing Navy Standard 525 valves to Northrop Grumman Newport News (NGNN) shipyard. The toolkit was then used at NGNN to analyze additional components to reduce lead time and cost to the U.S. Navy. After demonstrated success, the tool was made available for use at other shipyards and defense primes.

The Supply Chain Dynamics (SCD) project was initiated to develop a better process and modeling tools for identifying and analyzing problems in the supply chain. The SCD project extended the Supply Network Agility & Performance (SNAP) tool, originally developed for modeling automotive supply chains, so it can also be used to analyze Navy and other defense supply chains. Studies of large system assemblies (e.g., ships, cars, planes, etc.) typically show that ***50-80%*** of the total cost comes from purchased components in the supply chain. This applies to defense weapon systems as well as commercial systems. By improving the performance and reducing the costs in supply chains, we can build weapons systems with less lead time and lower acquisition cost to the Navy.

Supply Chains are complex systems with many challenging problems. One key problem is the inability of the Prime Contractor to accurately predict how improvements in the supply chain affect their end delivery time and cost. Another problem is the difficulty of convincing suppliers that supply chain improvements will improve the whole value chain. A good tool to model the complexity and dynamics of a supply chain is needed to help address these two key problems found in all supply chains.

Detailed plans were made and finalized regarding the official SNAP toolkit hand-off and training, which was conducted at NGNN in September 2003. Data was collected for their 2nd Supply Chain to model – Electrical Breakers – and an initial model was created during the training period. Both Supply Chain models and the full SNAP toolkit were put into use at NGNN by the end of September 2003.

4.3 Supply Chain Value Stream Management SCVSM

The Supply Chain Value Stream Management (SCVSM) Project is based on the overall concept of applying lean methods and techniques to a supply chain as a system.

A supply chain is a complex system and like any system, when one of its components (companies, manufacturing sites) is analyzed and modified independently, there is a good

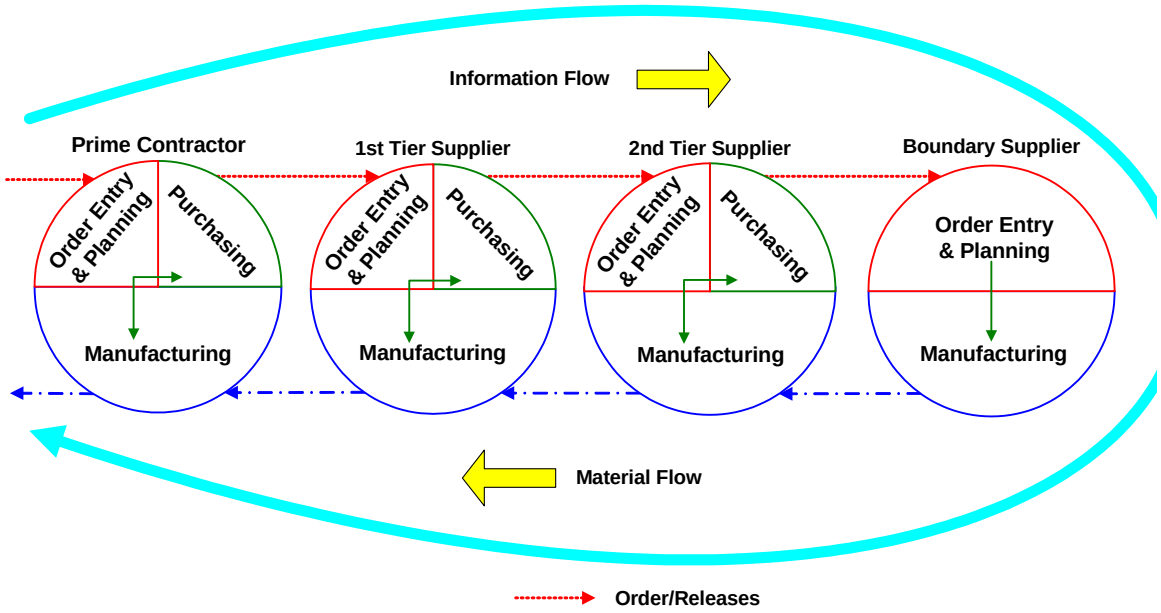

Figure 4-1: Supply Chain System – The Prime to Prime Flow of Information and Parts

possibility that the effect on the overall system will not be as good as expected. Companies stream management understand the supply chain as a system that to improve their own capabilities without the rest of the supply chain along will lead to only limited benefits. A systematic approach to addressing the supply chain is likely to have the greatest effect.

The core team concluded that existing value stream mapping concepts were useful for a very high level view of the supply chain. However, those concepts were not adequate for the broader analysis and communication requirements of the supply chain. Therefore the team created the "timeline chart," a new way to graphically describe and document the supply chain processes. In the course of the analysis, the team identified 14 different multi-company opportunities that were deemed worthy of bringing before the members of the supply chain.

The core team presented the 14 opportunities, including rough analyses of potential benefits. The team chose to undertake projects that address the top five alternatives, which included:

- Rationalizing inspections across the supply chain – Removing redundant and unnecessary inspections from the throughout the supply chain
- Rationalizing batch sizes across the supply chain – Shifting the manufacturing batch sizes at the suppliers to make the most efficient overall process
- Improving the forecasting and scheduling for the lower tiers – Reducing the variation in schedule and delivery requirements

- Shifting dressing the gear from Boeing to Messier-Dowty – Reducing the overall production lead time and cost by shifting work to suppliers
- Shifting the material capability testing off the critical path – Shortening the lead time by going ahead and shipping material rather than holding it for testing results

The lean supply chain methods and concepts have been used by the nose gear supply chain beyond these specific projects as well. For example:

- Some aspects of the forecasting and scheduling project live on, as some of the other companies are actively looking at addressing forecasting and scheduling problems through demand based ordering rather than schedule based shipments. In particular Boeing and Messier-Dowty are looking at a demand-based min/max system for shipping completed nose gear assemblies from Messier-Dowty to Boeing. Messier-Dowty is also looking at demand-based systems with some of its suppliers as well. In demand-based purchasing shipments are made as the customer needs them. The primary benefit is lower inventories across the supply chain as a whole and, hence, shorter lead times and lower costs
- Messier-Dowty has put its suppliers on notice that they expect a price reduction of 25% on purchased parts over the next five years. This covers all the parts they buy, not just F/A-18 E/F parts (hence including V-22 parts). This target has been set because Messier-Dowty believes it is achievable, in large part because of the accomplishments of the SCVSM Project.

4.4 Construction History and Parametrics (CHAPS)

The CHAPS project developed a method of exchanging Construction History and Parametric information between major CAD systems CATIA, ProE, and Unigraphics utilizing ISO 10303 STEP Standard

Complex weapon systems are frequently designed and manufactured in a collaborative environment between a prime contractor and a distributed supply chain, with 70% or more of manufacturing taking place downstream from the prime. These supply chains frequently use different CAD systems that are unable to exchange complete CAD model information due to differences in features, modeling techniques, and geometry format representation. This CAD incompatibility problem has been partially addressed by point-to-point CAD translators that use proprietary translation technology. Neutral standards have also been developed to enable primes to deliver CAD data in a format that is readable by most modern CAD systems. But in either case the current state of practice typically yields a solid structure that is not easily modified, a so-called “dumb” solid which has lost its underlying construction history, parametric relationships and design constraints.

The Construction History and Parametrics (CHAPS) project began in mid 2002 with the objective of providing an initial business case for smart CAD exchange using an emerging ISO 10303 standard, AP203-E2 (scheduled for approval in 2004). CHAPS translators provide a new method of exchanging CAD information that maps the construction history, parametric relationships and constraints of the delivering system into a neutral format, and then translates these parameters into the receiving system, essentially rebuilding the CAD model as a intelligent native file. The project was managed by ATI and included supply chains from Raytheon Missile Systems (RMS) and Northrop Grumman Electronic Systems (NG). Sponsored by the Office of Naval

Research under the Supply-chain Practices for Affordable Navy Systems (SPANS) program, CHAPS piloted technology that enabled Raytheon and Northrop Grumman to exchange intelligent CAD data with their supply chains using three different CAD systems, (Pro/E), CATIA® V4, and Unigraphics®.

The project verified that it was possible to exchange enhanced CAD information between different CAD systems using international standards for data exchange. The original goal for the pilot was a 50% translation success rate. CHAPS pilot translators successfully translated 67% of the team's CAD models, 47% with complete accuracy and 20% requiring minor rework. CHAPS pilot metrics demonstrated that using smart CAD translators can dramatically reduce labor and cycle times. Assuming perfect translations, three CHAPS team members reported business cases that would save over 4 man-years of labor, for a cost avoidance of $744,476. Using the actual pilot exchange success rates, savings would still equal 2.24 man-years and $412,598. Annual labor savings ranged from $138k to $198k per supplier, and for one supplier a savings of over $400k for a single CAD migration project. CHAPS will continue development as an official PDES, Inc. pilot project to continue development and deployment. Commercial translators will improve translation success rates dramatically and should yield labor and cycle time savings and improved product quality for any DoD supply chain that requires model exchange between different CAD systems.

4.5 Technology Refresh for Navy Transformation (TRENT)

The objective of the TRENT project is to significantly reduce the time and costs associated with Technology Management/Technology Refresh (TR).

Technology Management/Refresh is the planned upgrade of weapon systems assemblies and components to reflect improvements in reliability, performance and maintainability. It is problematic due to the high levels of COTS-based equipment within the weapons systems. This reflects the diminishing manufacturing sources and material shortages (DMSMS) issues as well for repair components for obsolete equipment. Technology Refresh is acknowledged to be one of the major problems afflicting NAVAIR/ NAVSEA and all of DoD weapons systems today due to the following:

1. Technology refresh decisions are primarily reactive and based on short term gains.
2. Current focus is primarily on electronic components, but TR applies equally to other technologies (adhesives)
3. TR tools are fragmented and incomplete
4. Solutions stand alone and are not easily integrated
5. Companies lack methods of sharing TR information across their supply chains
6. Suppliers find it difficult to communicate future technology plans to customers
7. This is a new role for the defense primes. Life Cycle management was a role that was the responsibility of the government, not the primes. Now as system integrators for major weapons systems, primes are assuming responsibility for total life cycle operations of complex weapons systems.

TRENT is not a new obsolescence analysis tool, a new reliability tool, or a new sustainment tool. TRENT will produce an open language for technology refresh information, an open framework for integrating emerging TR tools, and a demonstration platform to showcase the business justification for TR tool integration and collaboration. TRENT is seeking widespread support of its TR architecture and is incorporating a Stakeholder Council made up of experts in DMSMS from the government, industry and academia to assist. TRENT will provide architecture to allow the use of existing TR tools that are currently available. TRENT provides technology for enabling supplier-managed, proactive technology refresh, but mitigates risk by providing visibility and collaboration to the entire supply chain.

TRENT is a multiphase project. Phase 0 intended to capture the JSF stakeholder requirements, develop TRENT system requirements document, document the JSF "as is" technology refresh process at LM-Aeronautics and conduct technology management tool evaluations.

TRENT is expected to speed improvements of Navy weapon systems by reducing the cycle time for introducing new technologies and enhanced capabilities by at least 25%. In addition, O&S costs should be reduced by at least 10%. These improvements will be achieved by integrating weapons system improvements and obsolescence resolution into a comprehensive TR process and tool set that can effectively manage the issues from complete system to component levels.

5.0 Results and Deployment Efforts

The SPANS pilot projects were fairly successful, with varying readiness for full deployment. This section of the final report will focus on deployment efforts for the SPANS projects. A summary of the pilot projects results is presented below:

STAMP for SPANS		Raytheon	>$26M annual savings. Cycle Time red. >95% 5 Year ROI> 30
Supply Chain Dynamics		NORTHROP GRUMMAN Newport News	Inv. Red. 78% with 99% svc lvl
Supply Chain Value Stream Management		BOEING	Inv. Red. 20%, Critical Path 62-48 wks. Costs ~16%
Construction History and Parametrics		Raytheon NORTHROP GRUMMAN	4 Man-yrs Labor/ $400K savings
Technology Refresh for Navy Transformation		LOCKHEED MARTIN	In Progress- expect 10% Savings in cost of T-R

Table 5-1 SPANS Project Results

5.1 STAMP for SPANS Deployment

Bi-Directional Exchange of Product Data produced significant labor and cycle time savings at RMS: Data package savings for Raytheon ranged from $2500-$4400 per TDP, while suppliers averaged a savings of $504 per TDP. In 2003 Raytheon delivered approximately 450 TDPs per month to its suppliers. This equates to annual savings at Raytheon ranging from ***$13.5M to $23.8M***. For suppliers, savings equaled approximately **$2.7M**. Assuming coverage of 80% of Raytheon's suppliers (based on products delivered, which corresponds directly to the number of data packages sent by Raytheon to those suppliers), savings for our ROI calculations will be 80% of the above figures. We will use Raytheon's median savings of $18.6M. 80% of Phase I savings, therefore, equals **$14.9M for Raytheon and $2.18M for suppliers.**

- $3450/TDP x 450 TDP/month x 12 month/yr x 80% = **$14.9M/yr at Raytheon**
- $504/TDP x 450 TDP/month x 12 month/yr x 80% = **$2.18M/yr at Suppliers**

Other benefits of digital exchange of product data include:

- Reducing errors caused by inaccurate data packages, manual re-keying errors, waste due to building to wrong set of plans
- Eliminating handling and shipping errors
- Providing digital data that can be electronically searched/sorted and quickly/accurately loaded into existing data management systems as well as financial management tools like Raytheon's SAP system (used to record product delivery and generate supplier payments)
- Improved collaboration and supplier/prime interaction by providing visibility of data flow and status of documentation (e.g. Engineering Change Orders (ECO) tracking)
- Long term data storage: open, international standard format enables data recovery long after current proprietary software tools are obsolete

Raytheon Missile Systems (RMS) informed their suppliers in the Fall of 2003 that they were to be STAMP compliant- An excerpt from that letter is below:

Subject: STAMP Training and Deployment

Gentlemen:

For the past three years Raytheon Missile Systems has been implementing an automated PDM data exchange process called STAMP. Your company has been engaged in this project with us either through pilot programs, training, or physical transmittal of technical data via the STAMP process. We are rapidly attempting to move this program into a production environment, so that its use and benefits can be fully realized. In order to accomplish this, we must ensure that participating suppliers are fully trained and comfortable with the process, and can confirm proceeding with this protocol for all future production requirements.

Enclosed is a training package that outlines the entire STAMP process as it relates to the supplier. We need you to review this training and confirm back to the undersigned that you are comfortable with proceeding forward with STAMP package transactions in a production environment. If, after reviewing this package, you do not feel comfortable proceeding, please contact the undersigned. A RMS Supplier Engineering or PDM Support staff member will be assigned to meet with you at your facility to review the process and answer any questions. It is anticipated that after this review, you will be able to confirm your participation going forward. …

RMS is continuing to deploy STAMP across all missile systems, but is hindered by several major issues:

1. Each RMS Weapons Program Manager has to be convinced of the merits of the system and the money they will save. RMS has embarked on a mission to train these managers, but some are nonetheless reluctant to change their processes even with the STAMP successes.

2. The weapons systems contracts are normally cost plus fixed fee, thus there is a disincentive to use labor-saving/cost saving tools. The deployment plan needs to include a Value Engineering Change Proposal (VECP) as incentive to reduce costs.

Raytheon is proceeding with the deployment, at its own cost. It is being accomplished at a slower pace than the SPANS team would like however.

5.2 Construction History and Parametrics (CHAPS) deployment

It was initially believed that the 67% success rate of 3-D CAD file transfers between the three major CAD systems- CATIA, ProENGINEER, and Unigraphics shown in the pilot CHAPS project would not be commercially viable. Although the pilot project showed a potential direct labor cost avoidance of $400K, it was estimated that more work would be required including: Enhance the CHAPS standard (~20K-50K); Update Software (~100K-200K for each translator x 3); and Pilot the software tools to prove the BCA (~200K) for a grand total ~$550-$850K. The CHAPS project and business case analysis was evaluated by the PDES Inc. body that saw commercial merit in the CHAPS tool as it exists. 67% initial success rate would still have a favorable impact on the exchange of 3D CAD models. Here is an excerpt from a press release concerning the CHAPS tool (attached in its entirety in Appendix B) from Tony Ranger of Theorem Solutions from the UK:

> "The CHAPS report showed that there is a tremendous benefit to be gained from the CHAPS STEP processors even at the success rate of the pilot. We want to make those processors available to engineering users so that they can begin to benefit now. The cost will be low for features and history technology and, based on the estimates of the CHAPS participants, will provide a massive ROI. As businesses begin to use the translators we will work with them and with the ISO process to extend the scope of the STEP coverage to increase the success rate and increase the ROI."

Theorem Solutions is currently marketing these CHAPS translators to engineering firms in Europe and the U.S. Future development of the CHAPS translators and processes will be conducted under the PDES Inc. Consortium.

5.3 Supply Chain Dynamics Deployment

The SCD technology is be used at NGNN for additional supply chains including electric circuit breaker supply chains. Mr. Veasey Wilson is a SPANS TAB member and VP for Logistics and Supply Chains at NGNN. He plans on using this SCD tool throughout NGNN to reduce the costs of inventory with the new carrier CVN-77 and the new design CVN-21. SCD showed the potential to greatly reduce on hand inventories by 79% while keeping service levels over 99%. Reduction of inventory at NGNN translates into real dollar savings. The logisticians at NGNN always suspected they had more Navy Standard 525 valves on hand than needed, but they had no tool to prove that they could not only reduce inventory and still meet demand, but they could positively *optimize their inventory holdings* with this SCD tool.

The SNAP toolkit and SCD processes are being used in other programs, specifically the Defense Sustainment Consortium (DSC) efforts in the Robust Lean Supply Network (RLSN) project, where a missile system supply chain is modeled utilizing the SNAP tools. The supply chain can then be war gamed to determine the optimal response to surge and disruptive events. RLSN is also quantifying the risks associated with each of the disruptive events. This has seen further application in a Defense Reutilization and Material Supply (DRMS) Material Security Risk Assessment project to quantify specific risks associated with chemical-biological warfare production equipment.

5.4 Supply Chain Value Stream Management (SCVSM) Project Deployment

The SCVSM project had a Lean Pathways program member on the SCVSM team member. Lean Pathways has received training on the tool and may incorporate the technology into their own Lean interventions. The SCVSM tool was shown to executives in the Boeing aircraft commercial division who embraced it. They plan on using that tool in their internal Lean efforts. The SCVSM Lean tool was recently successfully deployed in 2004 at a AN/SLQ-32A (V)3 repair shop at NSWC Crane by Altarum in an effort to utilize continuous improvement tools to increase the efficiency and effectiveness of the facility. Here is a graphic which describes the before and after effectiveness of the SCVSM tool.

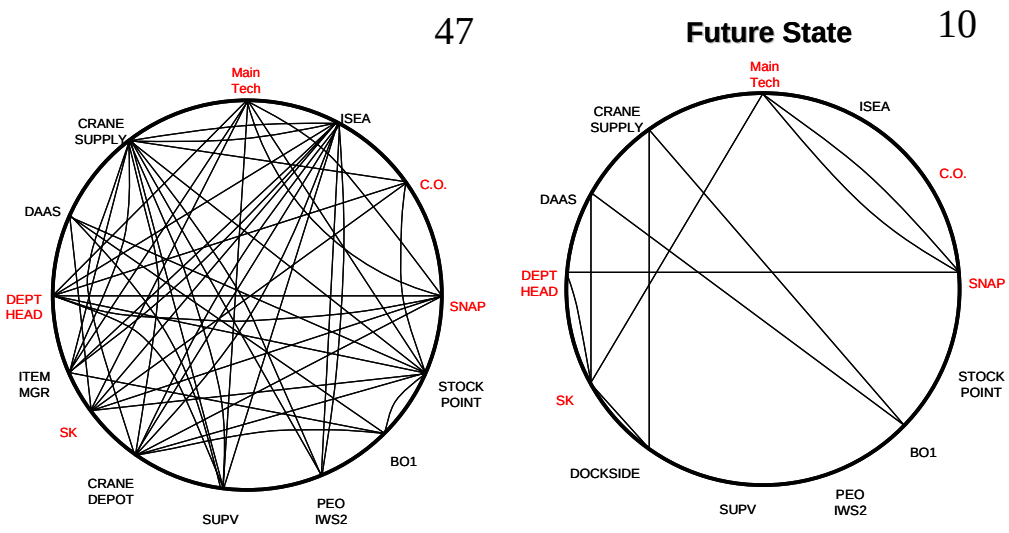

Figure 5-1 AN/SLQ32A (V)3 Lean Intervention

It is predicted that the SCVSM efforts pioneered with the F/A-18 Super Hornet E/F Nose Landing Gear will have far-reaching effects across the DOD industrial base.

6.0 Financials

This section shows the cost of each project by phases and the total funding received.

Projects	Phase 1	Phase 2	Total Funding
Supply Chain Dynamics	$ 700,081	$ 745,905	$ 1,445,986
STAMP	$ 517,773	$ 515,216	$ 1,032,989
SCVSM	$ 325,509	$ 405,523	$ 731,032
CHAPS	$ 151,604	$ 401,693	$ 553,297
CITUNE	$ -	$ 99,996	$ 99,996
TRENT	$ -	$ 197,226	$ 197,226

7.0 Conclusions: SPANS Metrics

The metric of success for SPANS projects has always been deployment of SPANS technology in two or more Navy Weapons systems programs. Actual deployment of

SPANS technology for our program is defined as use of the technology or process in production or sustainment of Navy Weapons systems beyond the pilot project phase.

TECHNOLOGY	PILOT PROJECT PLATFORM	DEPLOYMENT PLATFORM
STAMP FOR SPANS	AIM 9X /TACTICAL TOMAHAWK	EKV; ALL RMS MISSILE SYS.
SCD	NGNN 525 STANDARD NAVY VALVE SUPPLY CHAIN	NGNN BREAKER SHOP; SM3 FOR DSC RLSN
SCVSM	F/A -18 E/F NOSE LANDING GEAR (NLG)	AN/SLQ-32 BOEING COMMERCIAL A/C
CHAPS	NAVY STANDARD MISSILE	TBD

TABLE 7-1 SPANS Projects Deployment Summary

It can be quickly concluded that 75% of the SPANS projects has led to deployment by the above definition of deployment: use in a production or sustainment environment beyond the initial pilot phase. CHAPS may yet be successful in a deployment effort that is led by the PDES Inc. Consortium. In that sense, the SPANS program has been successful.

SPANS has also been attempting to present a good image to the DOD community for Navy MANTECH. SPANS has received awards from the JDMTP for best program presentation, was selected as runner-up for the DMC award in 2002, and received the DON Acquisition Excellence Award for 2003. The DASN (L) has briefed SPANS project results to PEO's and other flag officers. In bringing positive visibility to the Navy MANTECH organization, SPANS has definitely been a success.

8.0 Recommendations: SPANS Future Direction

SPANS has performed remarkable, successful work on behalf of MANTECH and the Navy. An excerpt from the DOD Appropriations Bill Report for Fiscal Year 2005 (p. 293) is pertinent:

SUPPLY CHAIN PRACTICES FOR AFFORDABLE NAVY SYSTEMS (SPANS)

The Committee recommends an additional $2,000,000 for the development and adoption of industrial and logistics best business and management practices among government and industry in support of Department of Defense systems. The Committee is aware of the significantly higher costs for supply chain management in the Defense sector than that for commercial companies, and recognizes the significant savings that the

SPANS program has already demonstrated by gains in efficiency and cycle time reduction. The Committee encourages the Office of Naval research to fully fund this program in future budget requests.

It is recommended that ONR follow the encouragement offered by the US House of Representatives Appropriations Committee.

SPANS will continue to select and execute DoN/ DoD supply chain projects in the coming years. Potential future SPANS projects include:

Continued Technology Refresh (TRENT) efforts: JSF TRENT Phase I will allow more detailed evaluation of the T-R approaches at Lockheed Martin Aero JSF. The steps involved are: define requirements and solution architecture, design TR solution, develop interconnects & collaboration tools, pilot limited TR process to test the operational feasibility, and develop the initial business case.

The efforts outlined in the current phase of Technology Refresh for Standard Missile Three (TR-SM3) Phase I is preliminary work to be conducted prior to piloting the TRENT architecture with the Navy Standard Missile in succeeding project phases.

TRENT Phase II- The purpose of the Technology Refresh (TRENT) Phase II project is to develop and test the TRENT common architecture and process in two separate weapons systems- the F-35 Joint Strike Fighter and the Standard Missile 3.

CFRAME The success of Supply Chain Operations Reference (SCOR) model and its limitations is a topic of interest among supply chain enthusiasts. The Collaboration Framework (CFRAME) project combines the Supply Chain Operations Reference (SCOR) model, and the Collaboration, Planning, Forecasting and Replenishment (CPFR) models to identify points of collaboration in a reverse logistics (repairable) environment. There was initial interest from the Air Force in the F-15 PDM line at Warner Robins with such a project, but no funding was available. The potential SPANS project will focus on repairable carcass turn-ins with the CH-46 Sea Knight Helicopter. This repairable issue is a major concern for aging weapons systems, as the continuing was in Iraq and Afghanistan are putting tremendous strains on these aging aircraft and the replacement V-22 Osprey is well behind schedule. This CFRAME project would be another departure from the traditional SPANS projects in that this is the second sustainment effort being addressed- the first was a survey of DON industrial sites. Our first projects focused more on the acquisition efforts of the DON.

Virtual Intelligent Enterprise Warehouse (VIEW) At the end of the TRANSCOM AOR, a supply depot/dump gets a lot of small containers with parts for different deployed USMC units. In order to find where their particular unit's supplies, the Marines will open the containers, sift through the contents and invalidate the container inventory integrity. A method is needed to track the container and its location, and provide the supply logistician the location of that particular container wanted by a particular unit quickly

Solution: What is needed is a Virtual Intelligent Enterprise Warehouse (VIEW)
- one that can be erected quickly to provide order and accountability for all the containers randomly deposited in a supply "dump". The system will provide order from chaos:

1. Container Supply visibility external to the unit
2. Locating information for the particular container.
3. Inventory for a particular container through its attached RFID tag
4. Hand- held RFID transponder/ locator
5. Optional location for particular container

The system uses the RFID transponders that are shipped on the outside of USMC shipping containers. Four poles with transponder receivers surround the supply depot. The pile of containers is virtually grouped into a virtual warehouse with locations for the shipping containers RFID tags. Once keyed the sensors pickup the signal from the RFID source and use the signal generated to locate the container tag in 3-D space based on time difference from each different sensor. That container location is given to the logistician in terms of ft, yards, inches, from the origin to a particular container. For large supply dumps, the signal form the RFID tag can be amplified from a handheld transponder and the transponder location is used for the location of the particular container.

VIEW would provide total asset visibility for the items delivered to the location. It would also provide exact locating data on the specific containers.

This is another sustainment issue that looks at a real-time problem faced by expeditionary forces today. Marines and soldiers attacking a shipping container with cutters to discover its contents is an inefficient way to maintain asset visibility. This again is not an acquisition effort; it is more a sustainment solution.

Risk Evaluation and Modeling Risk Management in supply chains is another issue that SPANS can address utilizing the previous efforts of the SNAP toolkit and the war gaming experience already in place as a result of the RLSN efforts. SPANS can quantify risks in a modeled supply chain and war-game results. The Navy wishes to reduce the lead-time associated with construction of DDX and CVN-21 ships. The government does not wish to pay for long-lead items necessary to support a Lean build schedule. The Risk Evaluation and Modeling project could detail which components could rapidly turn around a needed assembly, and which could not. The REM tool could examine which supply chains need to be funded in order to support an aggressive build schedule. REM would give the shipbuilder the tool necessary to make that sort of decision with a numerical confidence grade.

9.0 Summary

This report has sought to provide a chronology of the projects and successes enjoyed by the SPANS program to this point. It is interesting to note the changes that have occurred since this program started. We have gone from peacetime priorities to wartime necessities with the attack on the WTC. Acquisition issues seem to be secondary to sustainment issues associated with military operations thousands of miles from home base in a harsh desert environment in the current war on terrorism.

Of the 4 partner companies which began this SPANS program, all have renamed themselves and one is merged with other entities. Advanced Technology Institute is ATI; ERIM has merged and become Altarum, Andrulis merged to become DRC, and Arthur D. Little, one of the oldest consulting companies in America, became ICF Consulting.

What has not changed is the need to reduce costs associated with major weapons systems. Indeed it is more crucial as all extra DoD funding is being used for Iraqi operations. With increased outsourcing of design and testing, more of the weapon system costs are in the supply chain below the prime. It makes even more sense in these days of supplier consolidation to have the most flexible, agile and capable suppliers in the supply chain. Getting suppliers and some primes to that professional competence level of seamless data exchange, lean manufacturing and supply chain sophistication is still an incentive for supply chain operations. Having an MRP system in place does not mean effective and efficient supply chain operations, regardless of the marketing hype. Getting small businesses to that point where they can get the data they need to bid on contracts is still extremely difficult. Recent directives leading to an integrated digital data environment (IDDE) may be painless for tier one and tier two suppliers, but not for the entire supply chain. From TOC theory if a small supplier is the constraint in the supply chain, it must be identified as such, and the constraint rectified or the entire value chain will suffer. It is just good business practice to invest in Supply Chain technology, and SPANS has so far turned that investment into improved efficiency and real savings for the Navy.

Appendix A: SPANS Strategic Direction Plan

Introduction

The purpose of the Supply Chain Practices for Affordable Navy Systems (SPANS) is to develop, pilot and deploy supply chain practices that will result in improved affordability of Navy systems. SPANS will be considered successful when it has led to the deployment of changes in supply chain processes and/or technologies within one or more Navy weapon system procurement programs that have resulted in improved affordability.

Development of a Strategic Direction Plan

The SPANS program is in the process of developing a Strategic Direction Plan (SDP). This plan will include both a conceptual direction for the program and a statement of priorities regarding the expenditure of program funds. The purpose of this paper is to describe a tentative conceptual direction. That conceptual direction will provide the basis for a survey of members of the Technical Advisory Board and others to get their input on priorities. Based on the results of that survey and other input from the ONR MANTECH program, the SPANS program will issue a final SDP document.

Scope

For purposes of SPANS, a *supply chain* starts with a Navy prime contractor and extends to its first-tier suppliers, to their (second-tier) suppliers, and as far down the chain as necessary to raw material suppliers. We have deliberately excluded the link between the Navy and its prime contractors since that is part of the Navy acquisition process. The Navy acquisition process is the subject of its own Navy Center of Excellence and we have no desire to duplicate their efforts. Nonetheless, it is quite clear that the Navy acquisition process has a significant impact on the operations of the entire supply chain, and thus SPANS must keep aware of the acquisition process and how it may change.

We also exclude from our scope the logistics systems that keep the Navy supplied with "beans and bullets" or that are designed to keep Navy weapon systems operational. Thus, the logistics of keeping repair parts in the pipeline, while vitally important to the Navy, is not within the scope of SPANS. This issue can get fuzzy very easily since a major affordability concern for the Navy is total life cycle cost. The ongoing ability of the supply chain to provide repair parts is part of total life cycle cost. We believe that designing a supply chain from the beginning that can provide repair parts, at low cost, can be part of SPANS. But, the operation of those supply chains to provide repair parts directly to the Navy, as well as Navy systems for ordering and dealing with those supply chains is out of scope.

The Business Case for SPANS

The business case for SPANS is driven by the long-term tightening of defense spending on conventional weapons that has resulted in a need to reduce the cost of procuring new

Navy weapon systems[1]. The Navy has an ongoing need to replace and upgrade its existing systems, yet it must do so with only limited increases in funding.

If we look at the total value of any given weapon system delivered by a prime to the Navy, typically anywhere from 70 to 85% (occasionally more) of the value of that system is created by suppliers, hence a comparable portion of the cost is also generated by those suppliers. If we are going to reduce the cost of new weapon systems we have to look at the weapon system supply chain in order to do so.

The core metric for any SPANS project therefore must be that it leads to reduced cost to the prime for a weapon system[2]. However, there are many paths to reduced cost. In this document we will describe what we believe to be the key cost drivers in the supply chain for Navy weapon systems (Figure 1). The fundamental drivers are:

- **Transactions** – the actual transactions that occur between members of the supply chain;
- **Processes** – the processes that define and support those transactions;
- **Relationships** – the relationships between companies that cause supply chain processes to form the way they do; and
- **Network Effects** – characteristics of the supply chain as a whole that affect the other three drivers.
- **Managing the Enterprise** – this is how the whole supply chain is managed and achieves change. Although this is not a cost driver in itself, it has a significant impact on the how the system as a whole operates.

The cost of a Weapon System consists of two major elements (Figure 1): parts and material cost and the costs of integrating those parts into a whole system. Both of these are a direct function of transactions in the supply chain and supply chain processes. Supply chain relationships have a direct impact on supply chain processes. Network effects (by definition) have an impact on transactions, processes, and relationships. Finally, how the enterprise is managed covers the whole system[3]. We will explain each of these cost drivers in the section below, and then define a set of strategic initiatives that we derive from them.

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[1] Despite the events of September 11, discussions about new defense spending suggest that there will not be a huge buildup in conventional forces.

[2] A core assumption of SPANS is that those reductions in cost will over time result in reduced price to the Navy. How the Navy achieves those reductions is a function of the Navy's contracts with its primes and the whole acquisition system.

[3] We have not attempted to draw arrows from Managing the Enterprise to the other boxes since it is so pervasive.

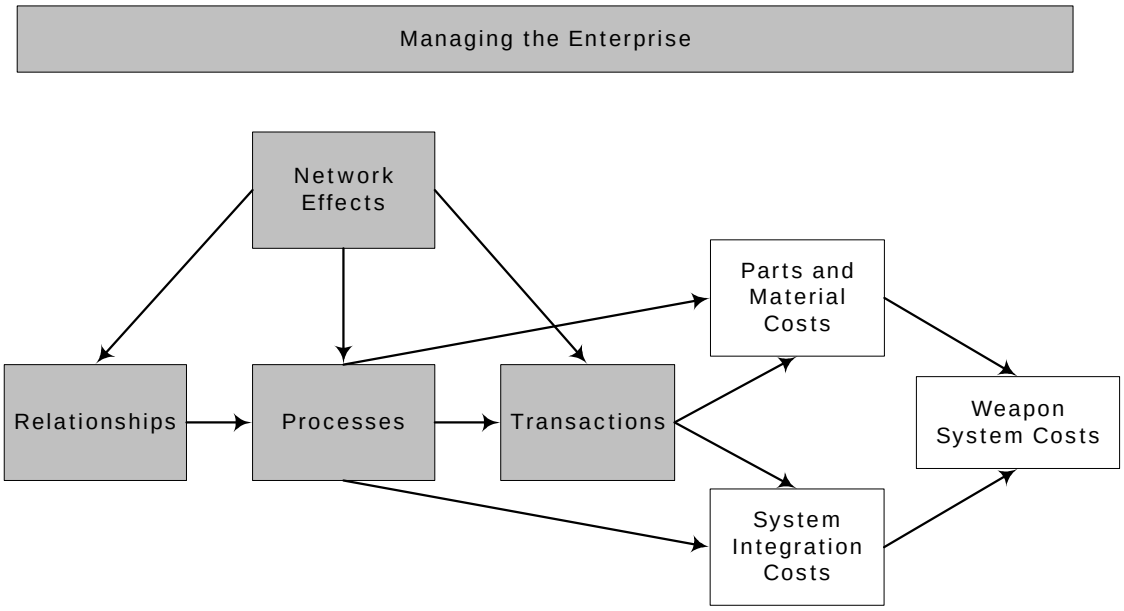

Figure 1. Cost Drivers in Supply Chains

Supply Chain Cost Drivers

The 5 supply chain cost drivers obviously do not drive all the costs for a weapon system. For example, raw material costs are driven not only by the costs of supply chains but by the worldwide supply and demand for the commodities involved. Equally, there are many internal company costs that have a major impact on total system cost. Nonetheless, these factors do drive a significant amount of the cost of a weapon system.

- **Transactions** – Every supply network bilateral pairing is founded on the need to have a transaction – buying and selling something. These fundamentally involve the movement of a product from the seller to the buyer. There are also other transactions that take place, e.g., placing an order, requesting bids, sending design information. The cost of these transactions (in both money and time) is a significant part of the price of doing business with a supplier. Indeed, the high cost of engaging in transactions with other organizations is a fundamental driver to keep activities in-house.
    - *The key management task regarding transactions is to make them faster and more efficient – reduce the cost and the time that they take.*
- **Processes** – These transactions take place within the context of one or more processes. Each company has internal processes for doing its work, some of which explicitly address interorganizational activities. These systems of transactions need to be as efficient and effective as possible – so that a task one person is performing doesn't cause additional, and non-value added work

somewhere else. In addition, there is concern not only that processes are efficient, but that they are doing all that needs to be done[4].

- *The key management task regarding processes is to make sure that the right things are being done, in the right way, and in the right order.*

- **Relationships** – Everything that takes place between two organizations is representative of the *relationship* between them (Figure 1). For example, we often speak of a *partnering* relationship when two companies work very closely together and have a sense of common fate between them. While we can explicitly define transactions and processes, relationships are often a bit fuzzier. Nonetheless, they drive much of the behavior that takes place between organizations.

  - *The key management task here is to establish and maintain relationships that enable the development of efficient and effective processes and the ability to learn from the other organization so that new markets can be entered and new products created.*

- **Networks** – Up to this point we've been concerned with *bilateral* relations. Here the focus shifts to the whole supply network. The concern is with the overall pattern of relationships among the members of the network. For example, there may be patterns of relationships that are causing the macro-process to be inefficient. An example of this can be found in the US automotive industry. Toyota actively promotes interaction among suppliers in order to encourage joint problem solving. In contrast, most US companies either ignore such relationships, or actively discourage them. As a result, Toyota's network as a whole is better at solving problems with its vehicles, one source of its consistently higher quality.

  - *The key management task regarding networks is for the "managing partner" (usually the customer) of the network to understand the behavior of the whole network in order to be able to discover these patterns and work to improve them.*

- **Managing the Enterprise** – In addition to the cost drivers we've discussed so far, it is also essential to provide a *structure* for managing the whole enterprise. For example, as changes are proposed in the way the supply network does business, how are those proposed changes propagated throughout the network?

SPANS Strategic Initiative Areas

Each of the supply chain cost drivers has enormous implications for the operation of the overall enterprise. For each cost driver we have identified a single Strategic Initiative, each of which has (or will have) multiple sub-initiatives (Figure 2).

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[4] An example might be when we begin to look to a supplier for new technical ideas, rather than just low prices. In that case we need a process in place that provides for a flow of ideas, as opposed to just a flow of parts.

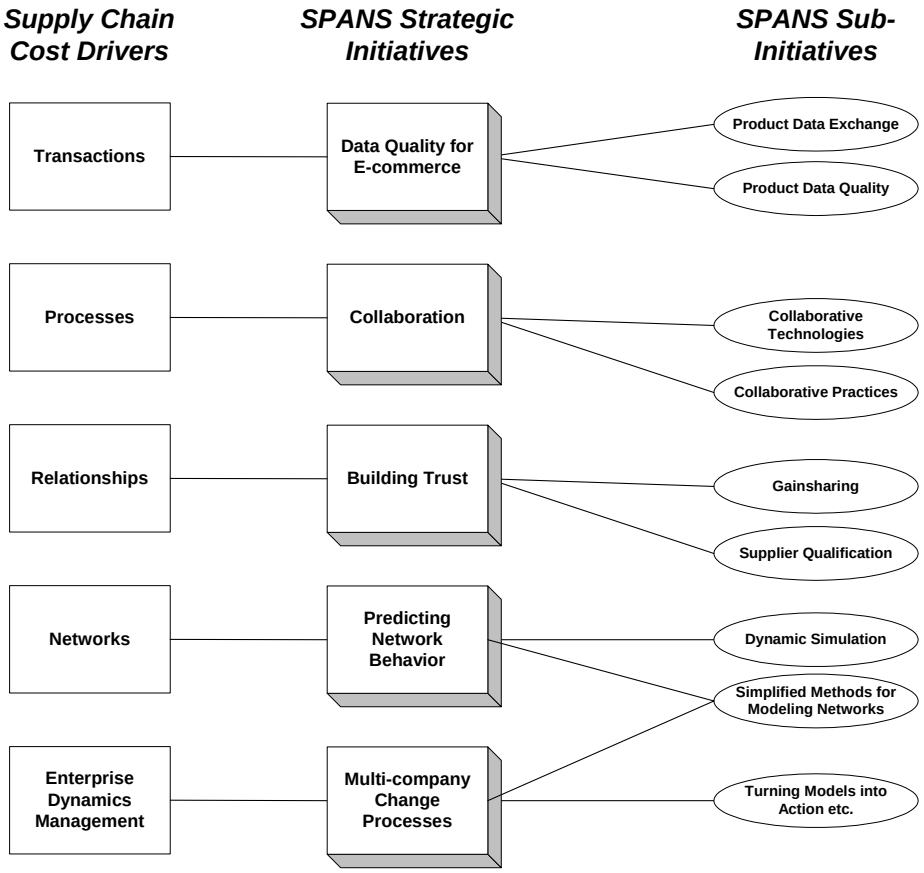

Figure 2. SPANS Strategic Initiative and Subinitiatives

Strategic Initiative 1. Data Quality for E-commerce

The key concern under Transactions is to reduce their cost. The primary approach in industry to directly attacking this today is *E-commerce*, defined broadly as the conduct of business over the Internet. E-commerce technologies include the use of email to exchange files; electronic data interchange (EDI) for the exchanges of business data, and the use of business to business (b2b) exchanges (such as Covisint, Exostar, and SPARS) for ordering, schedule release and many other applications. While there is considerable development still taking place in this area, the fundamental technologies are already relatively mature and in commercial use. However, most of the commercial work in E-commerce is on the application side – finding things users can do with the Internet and developing systems for those purposes. For example, the SPARS and ISE-EC programs have developed systems for shipbuilders and their suppliers to exchange information about engineering changes, requests for information, and much else. But, there is a more fundamental, underlying issue that is not well addressed yet, and that is the *quality* of the information passing through these media.

Without quality information, E-commerce applications will not achieve their full promise to reduce transaction costs. The most complex E-commerce transactions are those involving product data – information that defines the product in some way, such as CAD or PDM data. We therefore define two sub initiatives in this area:

1.1. Product Data Exchange. One difficulty with this type of data is that, in a supply chain, it often must be translated between different systems. This can be done in three ways: direct translators, IGES, and STEP. Most Navy primes are reasonably advanced in their ability to do this, but there is much data that still cannot be effectively translated. In addition, most subcontractors are much less advanced than their customers. A priority then is to adapt state of the art technologies and practices so they can be used by the sub tier suppliers.

1.2. Product Data Quality. Even when an effective translation mechanism is in place there are still often significant problems with the data that are apparent to the downstream user. Some of these problems concern preparation of the data so an effective translation can be made (e.g., some types of geometry translate better than others between specific systems); others relate to the construction of the geometry in such a way that it is of greater use downstream and doesn't have to be redone. A recent report from the Automotive Industry Action Group[5] defined a growing list of such problems for the auto industry.

Strategic Initiative 2. Collaboration

While there is a wide range of processes involved in a supply network, most of them have evolved over a long period of time and work reasonably well. What is relatively new in Navy supply chains is *collaboration*, the need to work closely together across company boundaries. We will define *collaborative processes* to mean processes that involve sets of tasks in which people from different companies must work very closely together. An example of a collaborative process is a design process in which a team composed of members from different companies must work together to develop a new product. In a collaborative process, tasks, milestones, goals and infrastructure are established to make it easy and effective to exchange information and to iterate through the design.

We can define two sub initiatives under collaborative processes: collaborative practices and collaborative technologies.

2.1. Collaborative Practices. Some of the best examples of collaborative practices can be found at Toyota, which uses dedicated supplier resources, long term relations, target costing, supplier associations, supplier development, cyclic process, and target events to keep their internal processes aligned with those of their suppliers and to make suppliers' processes more efficient. Collaborative practices are not restricted to design. As an example, vendor managed inventory is a collaborative practice in production.

2.2. Collaborative Technologies. There is increasing development of technologies that enable people and groups to collaborate from a distance. In effect, these permit discussions and sharing of a wide range of information. Telephone and video conferencing are fairly primitive versions of this, as are Internet discussion groups. Microsoft's Netmeeting is a somewhat more sophisticated approach since it allows some interactivity regarding documents between individuals. More sophisticated technologies provide a higher level of interactivity, but at the expense of a more difficult to learn user interface.

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[5] Automotive Industry Action Group (1999). *Defining Product Data Quality*, Southfield, MI: AIAG.

Strategic Initiative 3. Building Trust

A fundamental part of collaboration is the *closeness* of the relationship, and a key concern in any relationship is *trust*. "Closeness" means each company is relying on the other in relatively undefined ways – ways that are not always specified in a contract. For example, Toyota relies on its suppliers to help it to reduce costs and to find new technology. These are not specified in the contract between the two companies. Equally, Toyota's suppliers rely on Toyota to provide them with a certain level of business and to help them when necessary to find ways to reduce costs. This too is not specified in a contract. The primary reason this works is that there is a high level of trust between Toyota and its suppliers. This trust is based on two things: the belief that the other party will fulfill its promises and the belief that the other party will not exploit its vulnerabilities (Dyer, 2000)[6].

Note that trust in this case is not blind – it is based on a long trail of past and current behavior. For example, a supplier may learn to trust its customer because the buyer has always been reliable and helpful, and has not attempted to take advantage of the supplier when he learned information that the supplier accidentally told him.

The reason trust is so important as a relationship issue is that trust leads directly to types of processes that can lead to reductions in transaction costs. Dyer defines four types of transaction costs: search costs, contracting costs, monitoring costs, and enforcement costs. Consider contracting costs – if two organizations spend a long period of time and lots of expensive person-time negotiating a legal agreement, costs have been increased and timing delayed. None of this is value-added. Equally, all monitoring and enforcement costs are non-value-added. If a high level of trust is in place, the time spent negotiating the contract is significantly reduced, as are monitoring and enforcement costs.

Navy supply networks have relatively low levels of trust – and with good reason – most relationships are as arm's length as possible. While we would never expect Navy supply networks to achieve the same high levels of trust as Toyota's, trust could be significantly increased – and that could lower costs. Since trust takes a long time to build we have to begin with relatively simple, concrete approaches to building, saving the more subtle ways of building trust to later efforts. We define two sub initiatives under Building Trust, Gainsharing and Supplier Qualification.

3.1. Gainsharing. One example of a major mechanism for increasing trust in Navy supply networks is gainsharing mechanisms. Gainsharing mechanisms are explicit, contractual approaches that enhance trust because they encourage greater sharing of information and an explicit reduction in the willingness of the other party to take advantage of the other's vulnerability. Consider that under a gainsharing agreement, the supplier (or prime if the relationship is with the Navy) might agree to share information about potential cost reduction, while the customer agrees to not seek the full potential of the cost reduction. This is far from Toyota's situation, but it goes a long way to building trust.

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[6] J. Dwyer (2000). *Collaborative Advantage*, New York, Oxford University Press.

3.2. Supplier Qualification. Another possible mechanism for building trust is Supplier Qualification. While all companies attempt to qualify their suppliers in some ways, most rely on a combination of self-statements by the supplier and costly personal visits. Because of the cost of personal visits, supplier qualification in many cases is a hit or miss process. The result of poorly done supplier qualification can be significant problems with communication, quality and delivery. Efforts to verify supplier qualifications in a more systematic, less expensive manner could result in a far greater level of this work being performed, with significant improvements in supplier relations.

Strategic Initiative 4. Predicting Network Behavior

The most difficult problem with trying to manage a network is understanding what's going on within it at the system level. In other words, it's currently possible (although most managers don't know even this) to know who is sending what to whom in the network, but it's very difficult to understand what the sources of problems are and what the opportunities are for improvement, i.e., predicting how the system as a whole will behave. We have defined two subinitiatives under Predicting Network Behavior: Processes for Modeling Networks and Dynamic Simulation.

4.1. Simplified Methods for Modeling Networks. The development of models and then exercising or simulating those models are often the only method we currently have to really understand what is going on in a complex network and to do what-if analyses of changes in the network. Modeling and simulation approaches to these types of problems do exist and in some cases are available as commercial or near commercial packages. However, they require significant expertise to operate and a significant time commitment to set up if one is starting just from the commercial package. Custom toolkits can be developed, which wrap around the commercial package, that can make the tool easier to use and much less time consuming. In addition, evidence is needed about the utility of these tools since most senior management has not been educated about their value or their accuracy.

4.2. Dynamic Simulation. Research over the past decade has shown that, even in a simple supply chain consisting of a few companies, information and material flow can often reaches a state of formal chaos, where small (and unpredictable) changes in inputs to the system result in large (and equally unpredictable) changes in the behavior of the system. In other words, it is sometimes impossible to effectively top-down manage these systems using traditional methods. Although traditional modeling tools cannot accurately predict the behavior of such supply networks, these highly complex networks can be modeled using agent-based dynamic simulations. These simulations can be used to predict emergent patterns of behavior from the system. Emergent behavior is a pattern of behavior that develops as a direct result of the underlying, non-linear relationships present in the system. Analysis of these models can indicate structural drivers that are at the root of supply network problems. From this understanding, changes are proposed to mitigate the problem. Many changes can be made which are relatively minor modification of information flows and behaviors at individual nodes. Finally the changes can be tested in the simulation, as a first step prior to pilot deployment of the recommended changes.

These two sub initiatives have a degree of overlap. Dynamic simulation is a relatively new approach to modeling supply chains that fills a gap in existing methods. The Dynamic Simulation sub initiative therefore will develop new methods that can be used in the Simplified Methods for Modeling Networks sub initiative over time.

Strategic Initiative 5. Multi-company Change Processes

Once we have gained some understanding (and predictive ability) of how the supply chain as a whole behaves, we run into the problem of how to *change* large pieces of the supply chain, rather than just single companies or one on one relationships. Naturally, members of the supply chain (individual companies) have to be responsible for their own change processes. However, when a supply chain changes, some level of coordination is required so they all change together. For example, when a new communication technology is introduced to a supply chain, multiple members of the network have to adopt it, more or less at the same time. Unless this is done, costs will increase due to the new technology, rather than decrease. Similarly, when Lean production methods are introduced in one member of a supply chain, all the others are affected – unless they too adopt a number of specific changes the efficiency of the whole network may not be improved. We have only defined a single sub initiative in this area at this time: Turning Models into Action.

5.1. Turning Models into Action. The problem of how to effectively create change in individual companies is reasonably well understood, even if it can still be extraordinarily difficult to accomplish. The problem of changing multi-company networks is much less well understood, and potentially more difficult to accomplish. There are a number of software companies that provide software for "managing the supply chain," but these do not address the types of issues we have included here. New methods need to be developed to understand how supply chains change.

The distinction between this strategic initiative and the previous one (Predicting Network Behavior) is the difference between knowledge and action. Predicting Network Behavior is focused on knowledge – what will a network do under different sets of circumstances? Multi-company Change Processes is concerned with action – what do we have to do in order to achieve some type of new process or set of relationships?

A question may also be raised about how this initiative differs from the stated intent of SPANS to deploy all of its results in Navy weapon systems. That might argue that project that are part of the other four initiatives include this because they will introduce change in their supply chains. However, the purpose of this initiative is to develop new methods for turning models into action – hence it feeds the deployment efforts in the other four strategic initiatives.

Example SPANS Projects

SPANS currently has 3 formally approved projects (STAMP for SPANS, Supply Chain Dynamics, and Supply Chain Value Stream Management) and a set of proposed projects in various stages of development. While many projects meet the objectives of multiple sub initiatives, Figure 3 shows the strongest connections between sub initiatives and projects/proposals.

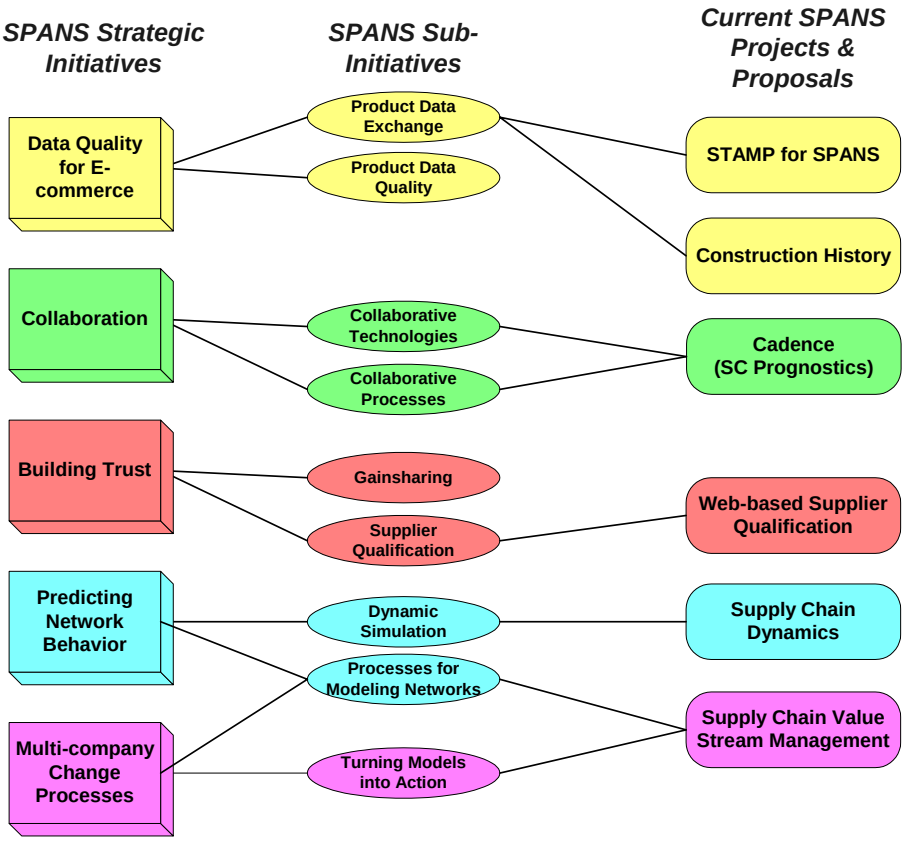

Figure 3. Example SPANS Projects

Appendix B: PDES CHAPS Press Release

FOR IMMEDIATE RELEASE

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PDES, Inc. Consortium Announces Availability of Three New "Smart" CAD Translators

Charleston, SC, USA – November 15, 2004

PDES, Inc. is pleased to announce the availability of three new "smart" CAD translators for STEP. The translators were developed as a part of the CHAPS (Construction History and ParametricS) project, which piloted a new method of exchanging CAD information that maps the construction history, parametric relationships, and constraints of the delivering system into the ISO STEP format and translates these definitions into the receiving system—essentially rebuilding the CAD model as an intelligent native file.

The CHAPS translators were developed under a program jointly sponsored by PDES, Inc. and the Office of Naval Research Supply-chain Practices for Affordable Navy Systems (SPANS) program. Raytheon and Northrop Grumman piloted the translators with their supply chains, exchanging intelligent CAD data using three different CAD systems—Pro/ENGINEER (Pro/E), CATIA V4, and Unigraphics. The original goal for the pilot was to successfully translate at least 50% of typical production parts. The CHAPS pilot translators exceeded that goal, successfully translating 67% of the team's CAD models and demonstrating that using smart CAD translators can dramatically reduce labor and cycle times. Using the pilot's actual exchange success rates, the primes (Raytheon and Northrop Grumman) saved over 2 man-years and over $400K in just three exchange scenarios—a large DoD prime might have hundreds of CAD exchange scenarios and could realize far greater savings. At the supplier level, the CHAPS translation provided a savings of over $400K for a single CAD migration project. (See www.SPANS.org for the CHAPS Program final report and business case.)

CHAPS translators for Pro/ENGINEER (Pro/E), CATIA V4, and Unigraphics, all supporting construction history and features, will be commercially marketed by Theorem Solutions Ltd., a UK company recognized as one of the world leaders in CAD/CAM product data exchange. According to Tony Ranger, Technical Director for Theorem Solutions:

> "The CHAPS report showed that there is a tremendous benefit to be gained from the CHAPS STEP processors even at the success rate of the pilot. We want to make those processors available to engineering users so that they can begin to benefit now. The cost will be low for features and history technology and, based on the estimates of the CHAPS participants, will provide a massive ROI. As businesses begin to use the

translators we will work with them and with the ISO process to extend the scope of the STEP coverage to increase the success rate and increase the ROI."

Information on the new CHAPS translators and all of Theorem's products and services can be found at www.theorem.co.uk or by contacting sales@theorem.co.uk.

PDES, Inc. industry members—which include AIRBUS, BAE Systems, Boeing, Electric Boat, General Motors, Lockheed Martin, Northrop Grumman, PTC, Raytheon, Rockwell Collins, and UTC/Pratt & Whitney—together represent over $500 billion in annual revenue. The consortium's government members (NASA, NIST, the National Archives and Records Administration, U.S. Army, and U.S. Dept. of Energy/National Nuclear Security Administration) and university associates enrich the consortium's capabilities with their expertise and unique perspective on user requirements and validity of solutions. Vendors of STEP software that are members of PDES, Inc. include IBM, EPM Technology, LKSoft, International TechneGroup, and Theorem Solutions.

For more information about membership in PDES, Inc., visit http://pdesinc.aticorp.org or contact Lynn Crane, PDES, Inc. Operations Manager, at +1-843-760-3783 or cranel@aticorp.org.

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