COMPONENT ACQUISITION AND SINGLE-SOURCE VENDOR MANAGEMENT STRATEGY IN A DEFENSE APPLICATION

By

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Submitted to the Sloan School of Management and the Department of Mechanical Engineering in Partial Fulfillment of the Requirements for the Degrees of

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ABSTRACT

Building an aircraft carrier is one of the most complex manufacturing undertakings in the world. Each component must be designed, tested and manufactured to not only Northrop Grumman Shipbuilding's (NGSB) exceptionally high standards, but also to the standards, requirements and approvals of both the Navy and the US Federal Government. As a result of these standards and requirements, lead times for construction materials can exceed two years, while a similar component, purchased for industrial use may have a lead time of 90 days.

To add to the complexity, the scheduled delivery date for the carrier is fixed, and compressed so that engineering design and construction must take place concurrently. In essence, the ship is under construction years before the design is complete. As a result of concurrent engineering, a complex procurement process and a limited vendor base, some material is chronically late to the Required-in-Yard (RIY) date, causing deviations from the optimal construction schedule and impacting the cost of the ship.

This thesis analyzes the current CVN 78 valve purchasing process to identify opportunities to leverage the product model and existing process infrastructure to improve material delivery to schedule and decrease construction costs for CVN 79. It is the goal of this research to improve the supply chain to support the preferred construction schedule, while reducing cost and risk associated with component acquisition.

This thesis begins with an analysis of the current supply chain system within NGSB New Carrier Construction. It then explores the current state of vendor relations between NGSB and the supply base. The cost impact for delaying construction due to delinquent valves is identified and presented. Then specific vendor management strategies are examined. This thesis proposes a framework for improving on-time delivery of the component and lowering overall supply chain cost by (1) pursuing strategic alliances with valve vendors, (2) providing greater visibility of demand earlier in the engineering design cycle and (3) using this visibility to drive procurement timing to improve delivery to scheduled need date. The thesis presents a case study in vendor collaboration and provides recommendations. Finally, it discusses the impact of applying the framework to similar components within the New Carrier Construction Program and the potential application of the framework to NGSB's other active programs and shipbuilding locations.

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The valve supplier's names are referenced in a generic manner. "Southern Valve Company" is also a referenced name for the valve supplier who participated in the pilot study.

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So many people helped me during my internship experience at Northrop Grumman Shipbuilding that thanking each by name may very well contain more pages that the actual thesis. Shipbuilders are truly passionate about aircraft carriers, and for good reason. I would first like to thank my supervisor, Rob Gies, for his generous gift of time and perspective and my project champions, Jennifer Boykin and Tim Sweitzer, for setting the wheels of this research in motion.

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GLOSSARY

Artemis: Computer-based scheduling tool used by Data Management to lay out developmental base group schedules, perform "What-If" analysis at the base group level, and to manage the base group critical path.

Base Group: A 'building block' of the ship, increments of work that form the intermediate level construction schedule for the ship

- Includes all electrical, piping, valves, doors, systems etc components located in a physical space
- All material for the Base Group must be on-site prior to beginning any sub-component in the group

CATIA: The 3D product design software used by the CVN 21 program to simulate the shipbuilding process

Contract Delivery Date (CDD):

- Date that the vendor commits to have the component delivered to NGSB receiving
- Often compared to the RIY date to determine if the component will arrive in time to support ship build schedule

Earned Value Management System (EVMS): The system used to assess the performance of a large, complex project. EVMS compares "planned values" within a scheduled plan against "earned values" applied to work actually accomplished.

Estimated Delivery Date (EDD):

- A field in SAP where the Buyer can manually enter the date a PO line item is projected to be received at the yard
- No standard process exists to uniformly estimate or calculate the estimated delivery date – the process varies by Buyer and his/her judgment

Hardware: The physical material or component, in this case a valve

Integrated Data Environment (IDE): An interactive, secure virtual space for the sharing of information using readily available internet browser technology. Data is linked from the customer's backend systems and presented in a fashion that facilitates assimilation of the data in the supplier's systems

Required in Yard Date (RIY): Date that the material should be on site, ready to be kitted and delivered to the fabrication shop or ship

- Calculated as Base Group Start Date minusMaterial Order Lead Time (approximately 6 weeks)
- End point for the study of this thesis – goal is to have material on-site by RIY date

Software: Engineering design and quality paperwork that must accompany a valve or component

- Can be electronic or hardcopy
- Includes such things as material certifications and test results (non-destructive examination, performance/hydro, shock, vibration, visual)
- Identified though 'coded notes' in purchase order

Management Review Form (MRF): The administrative work process and management approvals needed to move a Base Group to a later (suboptimal) time in the construction schedule.

Material Order Lead Time: Internal NGSB lead time to receive material into the warehouse and then kit it and deliver it to the worksite

- Four weeks before assembly, or seven weeks before manufacturing start dates
- Acts as a supply chain buffer

Planned Independent Requirement (PIR):

- An estimate of an individual component

Platform (PF): All equipment and systems outside the nuclear reactor plant (PP)

Propulsion Plant (PP): The nuclear reactor plant and supporting equipment

1 Introduction

1.1 Northrop Grumman Newport News Shipbuilding Overview

Northrop Grumman Corporation is a global defense and technology company with 120,000 employees serving five different business areas: Information Systems, Technical Services, Electronics, Aerospace and Shipbuilding[1]. In 2007, the Shipbuilding segment accounted for 17.3% of Northrop Grumman's Revenue.

2007 SEGMENT OPERATING RESULTS[2]

$ in millions		
Sales and Service Revenues		
Information and Services		
Mission Systems	$	5,931
Information and Technology		4,486
Technical Services		2,177
Aerospace		
Integrated Systems		5,067
Space Technology		3,133
Electronics		6,906
Ships		5,788
Intersegment Eliminations		(1,470)
Sales and service revenues		32,018

Table 1: 2007 NG Revenue

Newport News is one of two primary ship construction and maintenance sites owned and operated by Northrop Grumman. In January 2008, Northrop Grumman combined its two separate sectors, Newport News and Ship Systems, into one shipbuilding sector called Northrop Grumman Shipbuilding (NGSB). NGSB at Newport News is the sole designer, supplier and refueler of nuclear-powered aircraft carriers for the US Navy. In addition, it is one of only two shipyards in the United States that build nuclear-powered submarines.

Originally founded by Collis P. Huntington in 1886 as the Newport News Shipbuilding and Dry Dock Company, the shipyard remained privately held until 1940. In 1969, the shipyard was

[1] http://www.northropgrumman.com/about_us/index.html, accessed October 6, 2008 and January 28,2009

[2] 2007 Northrop Grumman Annual Report, pg. 44

purchased by Tenneco, who then spun it off as a stand-alone company, Newport News Shipbuilding, in 1996. Northrop Grumman purchased the shipyard in 2001.

1.2 Active Programs at NGSB

NGSB currently has three active Program Offices: New Carrier Construction, Virginia Class Submarine and Carrier Overhaul.

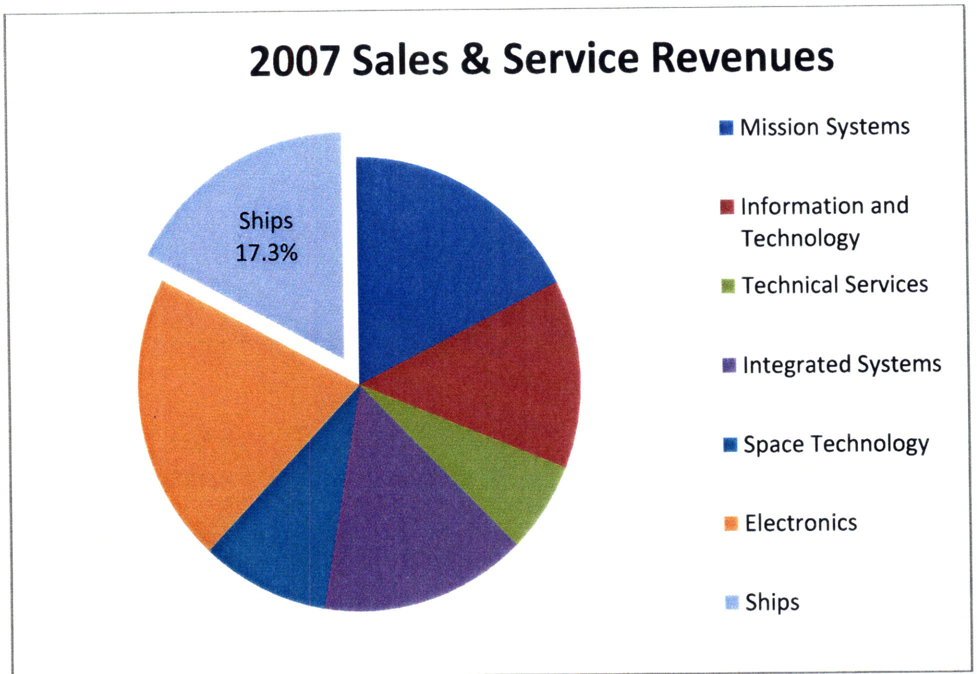

Figure 1: Shipbuilding as a Percent of NG Revenue [3]

1.2.1 New Carrier Construction

Currently, NGSBis in final stages of delivering the last Nimitz-class aircraft carrier, the GEORGE HW BUSH (CVN 77). Concurrently, Newport News is beginning construction of CVN 78 (GERALD R FORD) -- the first-in-class ship scheduled for delivery in 2015. CVN 79 will be the second of the Navy's next-generation class of nuclear aircraft carriers, and is in the advanced construction planning stage.

The various value stream information and material flows that are part of carrier construction (e.g. steel, pipe, electrical, etc) were significantly modified to accommodate the new 3-D product model design of CVN 78. In addition, new components were designed and specified, requiring extensive testing and certification prior to acceptance for installation on CVN 78. One of the most challenging areas of developmental equipment concerns the acquisition of valves. Newport News is still working through the various issues associated with long lead times, early requirement dates, limited funding and a shrinking domestic vendor base. The issue with late to schedule valves is paralleled in other materials ordered for carrier construction, such as pumps and actuators.

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[3] 2007 Northrop Grumman Annual Report, pg. 44

CVN 79 is to be a 'modified repeat' of CVN 78, taking advantage of engineering and equipment specification completed as part of the cost of development for a new class of aircraft carrier. Northrop Grumman already has very aggressive cost reduction targets to meet Navy requirements for CVN 78, and the early targets established for CVN 79 are even more aggressive. These targets will be very difficult to meet unless the CVN 79 program takes a bottom-up approach to fundamentally rethink the flow of material and information required to build an aircraft carrier on schedule and within budget.

Advanced manufacturing efforts for CVN 79 are scheduled to begin in October 2009. While there are many people engaged in trying to streamline these processes to improve execution and cost performance on CVN 78, it is necessary to take a broad, cross-functional integrated supply chain look at how the procurement process can be improved for CVN 79.

This thesis analyzes the current CVN 78 valve purchasing process to identify opportunities to leverage the product model and existing process infrastructure to improve material delivery to schedule and decrease construction costs for CVN 79. Applications of single-source valve vendor management techniques to the other programs in the shipyard is then discussed. In addition, other components that fit the single-source component framework are evaluated.

1.2.2 Virginia Class Submarines

Although the New Carrier Construction program is the primary focus of this research, it is relevant to explain the two other Project Programs active within the shipyard. The findings of this thesis are applicable to these programs since the programs share the same stringent technical and quality requirements, NGSB procurement department, procurement systems, vendor base and schedule challenges. Applicability of the framework to these programs is discussed in Section 7.2.

The Virginia Class Submarine (VCS) program began construction of the first submarine in September 1999. Currently there are four submarines that have been delivered to the Navy, and three under construction[4]. The VCS program within NGSB constructs each nuclear-powered submarine in conjunction with General Dynamic's Electric Boat sector.

Electric Boat serves as the primary engineering designer for VCS and submits material requirements for the submarine electronically through the SAP computer system. Valves that need to be procured for VCS at Newport News are processed through the Valve Buying Office. The Valve Buying Office is described in detail in Section 3.4.

1.2.3 Carrier Overhaul

Every 25 years, each carrier must return to port for refueling and complex overhaul. This process takes over three years, and the Carrier Overhaul office is responsible for the advance planning, engineering, procurement of material and repair of the carrier while it is in port. In general, there is one carrier in port undergoing repairs, while advance planning is underway for the next carrier overhaul. Carrier Overhaul has the most variable demand for components, because, in general, it is an open-inspect-repair contract. Often it is not known in advance which

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[4] Northrop Grumman Corporation, "VCS - Our Ships" http://www.nn.northropgrumman.com/vcs/our_ships.html , accessed January 20, 2009

valves and equipment must be replaced. Valves for Overhaul are procured through the Valve Buying Office, which is described in detail in Section 3.4.

1.3 Thesis Overview

The structure of the thesis is as follows:

Chapter 1: General overview of Northrop Grumman and the Shipbuilding segment of the business, with descriptions of the major programs at the site.

Chapter 2: Discussion of project motivation, scope, goals, objectives and approach

Chapter 3: Description of the existing supply chain

Chapter 4: Discussion on the marine valve market, including description of types of valves, a summary of existing suppliers, challenges to the market, problems within the existing supply chain system and cost impact

Chapter 5: Discussion of alternatives to the existing supply chain process and recommendation for NGSB to pursue a strategic alliance with key suppliers

Chapter 6: Presentation of a case study between NGSB and Southern Valve Company to test the viability of a strategic alliance

Chapter 7: Conclusions, recommendations and areas of further research are presented

2 Problem Statement

2.1 Project Motivation and Scope

Building an aircraft carrier is also one of the most complex manufacturing undertakings in the world. Each component must be designed, tested and manufactured to not only Northrop Grumman's exceptionally high standards, but also to the standards, requirements and approvals of both the Navy and the US Federal Government. As a result of these standards and requirements, lead times for construction materials can exceed two years, while a similar component, purchased for industrial use may have a lead time of 90 days.

To add to the complexity, the scheduled delivery date for the carrier is fixed, and compressed so that engineering, procurement and construction must take place concurrently. In essence, the ship is under construction years before the design is complete.

NGSB can only issue purchase orders if adequate Navy funding exists. Due to the complexity of design and high quality of the components, as well as timing of funding, a single supply chain system of identifying, engineering, releasing, purchasing and receiving material has been developed to account for long lead times and prioritized funding releases, with the end goal of having the correct construction material on-site by the Required in Yard (RIY) date.

Yet despite best efforts of all involved, some material is chronically late to the RIY date, impacting the optimal ship construction schedule and increasing construction costs. It is the goal of this research to improve the supply chain to support the preferred construction schedule, while reducing cost and risk associated with component acquisition.

Sourcing components for a nuclear-powered aircraft carrier is a complex undertaking, and is described in detail in Section 3. The scope of the project includes evaluating the current state of the valve sourcing process for CVN 78, starting with system engineering design and terminating with the delivery of the valve to Shipping and Receiving.

An analysis of the development and current state of the marine valve market is provided to establish the existing state of the purchasing environment (Section 4). In Section 5, vendor management strategies are evaluated, including fostering competition by qualifying additional vendors for a valve type, establishing a Vendor Managed Inventory strategy, expanding "Outline Agreements" or developing a single-sourced strategic alliance. Leveraging the existing vendor base and product model knowledge into true vendor partnerships is ultimately recommended to improve the material supply chain for CVN 79.

The scope also includes developing a cost estimate of the impact of delinquent materials to the construction cost of the carrier. Developmental valve delinquencies for CVN 78 are used as a baseline to determine the cost impact of deferring work due to late-to-schedule components.

2.2 Goals and Objectives

It is the goal of this project to improve the supply chain to support the preferred construction schedule, while reducing cost and risk associated with component acquisition. This is accomplished by developing a framework for managing the existing vendor base and valve acquisition.

A matrix of valve specifications versus supply base capabilities will be developed. The supply base capabilities will then be matched with the valve specifications and each group will be examined separately. The case for managing valves as single-sourced partnerships as opposed to openly-competed commodity items will be discussed.

The existing sourcing model case will be examined using historical data from CVN 78 to develop a baseline for the valve supply chain design and cost impact to construction.

A framework will be developed to identify actions with the highest impact and greatest likelihood of success to the CVN 79 program, and strategies to improve the overall valve value chain will be recommended. The results of these specific cases will then be used to extrapolate the potential impact on the valve class.

New strategies will be assessed on using cost/benefit ratio, following the methodology described above. Costs will not only include monetary impact, but also an analysis of the difficulty of implementation with respect to changing the existing sourcing model, vendor relationships, customer relationship, and cultural beliefs for a given recommendation or set of recommendations. Benefits will be judged on adherence to schedule (ability to procure items by the Required in Yard date) and cost impact. Quality of valve is the number one most important factor to building either the Plant or Platform, so it is recognized that any recommendation cannot impact quality.

2.3 Project Approach

This thesis will begin with an analysis of the current supply chain system of releasing requirements for purchase. It will also detail the current state of vendor relations between NGSB and its valve supply base. Then, specific examples of valve purchases will be examined and a framework developed for improving on-time delivery of the component and lowering cost. Next, the feasibility of applying the framework to other similar components will be discussed. Finally, potential applications of the framework, both internal to Newport News, and throughout Grumman Shipbuilding, will be identified.

The advanced construction procurement contract for CVN 79 was awarded in January 2009, so the project timing is appropriate to have significant positive impact on the procurement process for and construction of CVN 79.

3 Existing Supply Chain – New Carrier Construction

This section explains the key groups within the New Carrier Construction procurement process and defines the existing process of management, design, procurement and construction for CVN 78.

3.1 The Program Management Office & Program Management Team

The NGSB CVN 79 Program Management and Business Management organizations include resources from Contract Management, Cost Engineering and Pricing, and Program and Operations Finance. The NGSB Program and Business Management organizations provide the following services to the CVN 79 Program:

- Establishes program objectives based on corporate goals and customer requirements;
- Controls and oversees CVN 79 Program work authorization and its associated funding;
- Manages the program Earned Value Management System (EVMS) process and provides the contract deliverables for contract cost reporting;
- Provides NGSB program and functional management with internal cost visibility to ensure compliance with program cost and schedule targets.

Within the Program Office, there are two sub-groups: Propulsion Plant (PP) and Platform. The Propulsion Plant group focuses on the reactor design and construction, while the Platform group is responsible for the remainder of the ship design and construction.

A key feature of the Program Management approach includes the utilization of a Program Management Team (PMT) to ensure effective communication and awareness between NGSB and the Navy. The PMT is comprised of NGSB functional/value stream leaders and Navy representatives whose purpose is to collectively and effectively manage the design, construction and delivery of the carrier to the Navy. The PMT is chartered with the following objectives:

- Review, discuss and make consistent management actions affecting all aspects of the design and construction contract effort
- Communicate and manage expectations of Navy customers
- Address the cost and risk topics as required by the contract.

3.2 The Engineering Department

The Engineering Department is comprised of system engineers, production engineers and designers. The engineering process is a multi-stage, iterative process. During this process, the Engineering Department works with the Navy, Planning, Sourcing and Construction to drive the design development of the carrier. The integrated engineering process was developed to ensure that technical data is scheduled in the proper sequence to support ship design and construction. The process described herein is the current process for engineering design and material procurement for CVN 78, the first-in-class ship.

The engineering process is broken down into three "Design Phases." These design phases are: Concept, Arrangement and Detail. Within the duration of each phase, the engineers work with a computer system called CATIA, sometimes referred to as "the product model." CATIA is a three dimensional design software package that enables the designers to lay out each piece of equipment within each compartment space. This enables different systems to be routed within the model to create a holistic view of each compartment, and when complete, the entire ship. The power of CATIA is the ability of designers to breakdown the system into specific and accurate assemblies, details and loose parts. Once the system break down at the assembly level is complete, assemblies are further broken down into details and then details are broken down into parts.

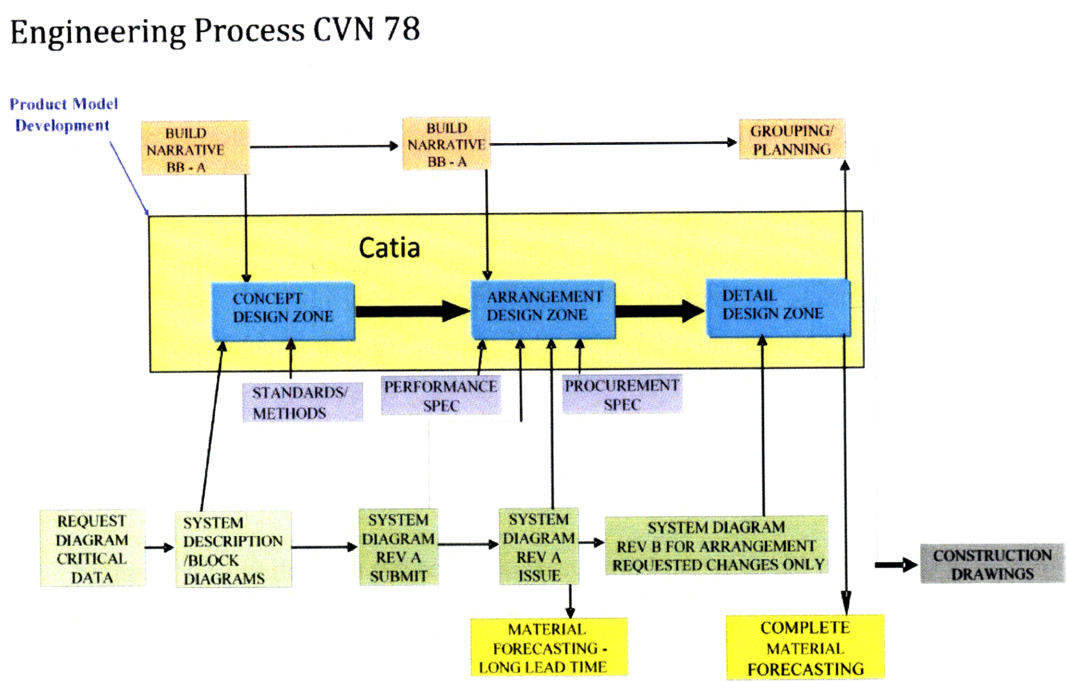

Figure 2: Simplified Engineering Design Process

3.2.1 Concept Design Phase

During this design time, system engineers initiate the development of the carrier on the system level. They work closely with the Navy customer to define the specification and configuration of each system on board the carrier (i.e. jet fuel, potable water, steam distribution). The conceptual design effort results in a set of two-dimensional block diagrams for each system.

3.2.2 Arrangement Design Phase

At this stage, major pieces of equipment (including valves), sizes and materials of construction are identified. Performance and procurement specifications are completed. System engineers work with vendors to obtain vendor equipment drawings based on the requirements captured in the system diagrams. Equipment layout and ship compartment drawings are completed.

3.2.3 Detail Design Zone

Once the system arrangement design zone is completed, it is released to the detail design zone. At this stage, production engineers use their shop fabrication and ship experience to assist the design engineers in optimizing the system design for efficient fabrication and erection. They group parts into assemblies and details and provide a sequence sheet with the description of group boundaries to designers who then create engineering bills of material (EBOM).

At the end of this stage of engineering, the CATIA model of the ship design is complete. Detailed information can be extracted to develop construction and erection drawings. Since the actual construction of the ship is outside the scope of the study, it is not discussed in detail.

3.2.4 PIR Creation

Additionally, Engineering must specify each component to be ordered by creating a Planned Independent Requirement (PIR) within the computer system (SAP). Engineering controls the release schedule of each PIR. The schedule is determined by taking the construction need date (determined by Planning) and then subtracting the Book Lead Time for that particular component or piece of material. Engineering's goal is to release the PIR to Sourcing one standard lead time ahead of the need date.

Material requirements are developed concurrently with the design. During the Concept and Arrangement Design Zones, long, medium and short lead time material forecasts are created 160, 124, and 94 weeks respectively before the construction start dates. These stage gates have been developed to ensure that the PIR's are placed with enough lead time to procure the material, even if the design is not complete for the area.

3.3 New Carrier Planning Department

The New Carrier Planning Department is responsible for developing and maintaining the integrated master construction schedule for the aircraft carrier and consists of Area Planning, Detail Planning and Data Management.

3.3.1 Area Planning

Area Planning is responsible for laying out the overall build strategy for construction of the carrier. The Area Planners work with the engineering design organizations during the Product Model phase, and utilize the design tool, CATIA, to document and capture the intended build strategy.

During the design phase, the Area Planners will identify each part in CATIA to an installation group through the use of CATIA classification fields. The Area Planner will load the group number for the group that has been determined to be the proper installation group to support the overall build strategy. The application of the base group to the component classification in CATIA is the first opportunity for the actual component need schedule to be determined, and is called "attribution".

3.3.2 Detail Planning

The Detail Planning team is responsible for taking the build strategy, as laid out by the Area Planners, and turning it into an actionable construction plan by creating work packages and product structured bills of material (PBOM).

This level of the planning process is iterative and does not complete until shortly before the delivery of the ship. As such it is an inaccurate predictor of material use. Conversely, the Area

Planning effort completes relatively early by comparison and its results have significantly greater potential for use in forecasting component usage.

3.3.3 Data Management

The Data Management team's primary responsibility is to manage the integrity of the program's schedule development tool (Artemis) and its execution tool (SAP). The Artemis tool is used by Data Management to lay out developmental base group schedules, perform "What-If" analysis at the base group level, and to manage the base group critical path. When complete, the Artemis construction schedule will contain approximately 20,000 activities.

The SAP tool is used as the New Carrier Construction program's, and the sector's, primary execution tool. All schedules, including Engineering, Planning, Manufacturing, Construction, and Material Ordering are all stored and managed in the SAP system.

With the Area Planners attributing the base groups to the components in CATIA, and the base group schedule residing in SAP, a material requirement schedule can be developed and utilized long before the formal PIR process contributes information to Supply Chain Management.

3.4 The Sourcing Department

Sourcing ensures delivery of specified materials of sufficient quality, supporting the construction schedule and at the lowest cost. The first, and most important, priority is to source components compliant with the exceptionally high quality standards required not only by Northrop Grumman itself, but also by the Navy and the US Federal Government.

Sourcing is unique when compared to the Program Offices, Engineering and Planning departments within the shipyard. Each Program Office has its own Engineering and Planning departments that are assigned to work specifically with each Program. For example, New Carrier Planning works only with CVN 77, CVN 78 & CNV 79 and reports in a matrix fashion to the Program Office for New Carrier Construction. In contrast, Sourcing supports all programs. The Valve Buying Office purchases valves for all programs: New Carrier Construction, VCS and Overhaul.

The Valve Buying Office is further broken down into a group of Buyers. Each Buyer is responsible for 1 to 5 different suppliers. The Buyers act like account managers, managing the relationship between the specific vendor and the shipyard. Buyers are responsible for acting as the point-source of contact for the vendor. All requests and communications from the vendors go through the Buyers. They communicate Vendor Inquiries and Vendor Notifications to Engineering and Program Management as necessary. Althoughthe role of Buyer has employee turnover, several Buyers have stayed in the job to form significant strategic relationships with the supplier accounts that they manage.

3.5 The Receiving and Supplier Quality Departments

Supplier Quality

The Supplier Quality (SQ) Department ensures the high quality of material, components and equipment to NGSB. Primary responsibilities of SQ with respect to the supply chain include analyzing and reporting suppliers' quality performance, auditing the suppliers' quality systems and procedures and conducting inspections of components under manufacture at supplier facilities. SQ also assists with the selection, qualification, and approval of new suppliers.

Receiving

The Receiving Department accepts inbound material and is responsible for ensuring that ordered equipment exactly meets the specifications of the purchase order. Once the material is received and checked in, the software (the document package of test and quality reports) is reviewed and approved. Depending on the complexity of the material, this can take anywhere from an hour to several hours for initial software review. Material with software discrepancies are flagged in the SAP system and placed in a holding area for SQ and Sourcing to rectify.

After passing through software review, a detailed physical (or hardware) review is conducted. Once the material successfully passes both Hardware and Software reviews, it is accepted and checked into the stores warehouse to await kitting.

The goal of this thesis is to suggest ways to improve material availability with respect to material delivery dates. Therefore the analysis of the supply chain in this thesis stops ends with the Receiving Department.

3.6 Sourcing System Imperatives

Priorities for sourcing any component include quality, schedule and cost. The most important aspect is that the valves are of uncompromised quality. Complex systems exist to redundantly ensure the integrity of any component used in the operation of a nuclear aircraft carrier. Second to quality is that the ship construction schedule has to be supported by material availability. The ship is promised to be delivered to the Navy by a certain date and slipping the construction schedule or delivery date is not a feasible option to either NGSB management or the Navy. Finally, reducing cost of the individual components is a goal of the Navy and NGSB.

Quality

Quality is ensured by the development of a documentation package (called 'software' by NGSB) that is reviewed and approved by NGSB engineering and the Navy. These quality components include, but are not limited to:

- Traceability of all components and subcomponents back to the original raw materials acquisition (can be 4^{th} tier suppliers or lower).
- Proof of shock and vibration testing
- Proof of compliance with all manufacturing procedures, weld procedures and assembly procedures.
- Proof of correct packaging, storage and material handling
- Non-destructive test records
- Performance test records (including hydrostatic testing)

Schedule

The second priority for the Sourcing group is to support the ship build schedule. Sourcing gauges its support of construction by whether or not the material procured is in the warehouse (available to the trades) by the Required in Yard (RIY) date. At this level, Sourcing will monitor the Contract Delivery Dates (CDD) and compare them to the RIY dates. If the CDD date appears to be after the RIY date, the Buyer must take action. The first option is to expedite the item, at no additional cost. The second option is to incur additional cost. Not only is this cost monetary, but also a disruption to the vendor's operations.

The second option is to flag a material disconnect to management and look deeper into the production planning schedule. A cross functional team must evaluate whether or not estimated delivery date of the component will allow the item to be installed before the Base Group is complete. This step takes approximately 24 manhours per valve to estimate (discussed in Section 4.5). With over 150,000 components and over 15,000 valves comprising an aircraft carrier, this review is a cost NGSB would like to avoid. If the material is still needed before the CDD, engineering institutes a work-around in the engineering drawings. For valves, a work-around generally consists of a placeholder, or spool piece, installed in the piping where the valve should be. This moves the piping work from the shops to downstream in the assembly steps. Finally, if a suitable work-around cannot be determined, the base group will be deferred, which can result in costly delays. Rescheduling work because of a valve delinquency is estimated to increase construction effort by a significant amount. This cost estimate is discussed in Section 4.5.

Price

The third priority for Sourcing is to procure items at the most economical price. Having said that, price will always be negotiated to support construction schedule. The ship must sail on schedule.

"We shall build good ships here at a profit – if we can – at a loss – if we must – but always good ships."

- Collis P Huntington.

3.7 Sourcing System Design

Sourcing works in a collaborative team with Engineering, Program Planning, and Construction to develop and maintain material lists and schedules for both PP and PF components, valves and equipment. This team structure spans multiple internal and external stakeholders.

As the arrangement of the design geometry of the ship develops, Planning develops the Base Group sequence and master schedule for ship construction. This critical path management system generates schedule start and complete dates for each Base Group. As material item descriptions and ship locations are identified by Engineering, Planning connects the material items to the consuming Base Group. The consuming Base Group provides the schedule for the material RIY date.

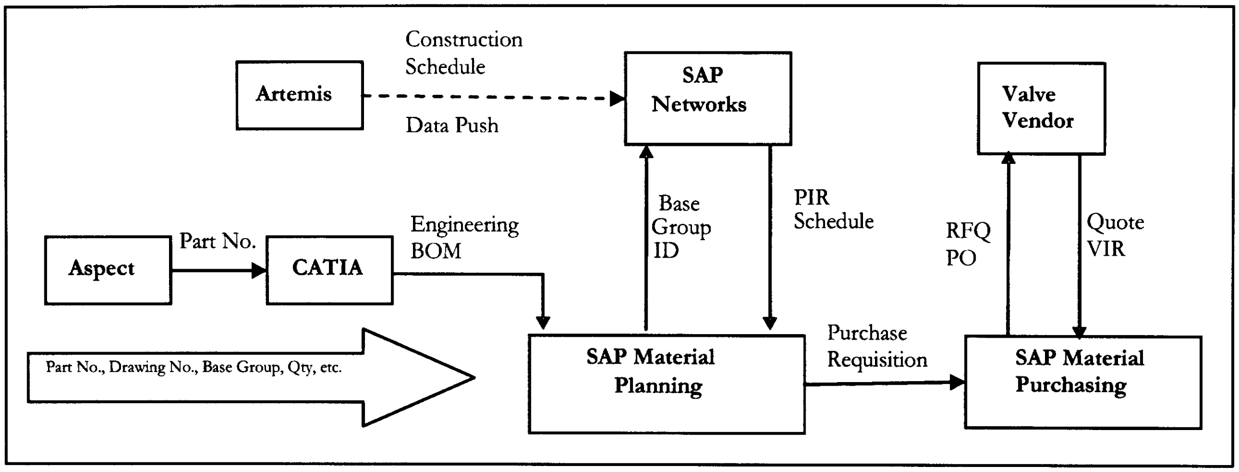

Figure 3: Material Purchase Process Information Flow

Based on lead times that are associated with the part number, the system will generate a Planned Independent Requirement (PIR) schedule by subtracting the lead times from the RIY date. A PIR is used to notify Sourcing of what to buy and when it is needed. Once the PIR schedule is established, Design Engineering then prioritizes its detailed design work schedule within the Detail Design Phase to coincide with the construction start dates and PIR schedule.
Once Engineering has created a PIR, it is routed in SAP to the Material Planning Controller. The Controller (called a Planner at the shipyard, but for clarity, will be referred to here as a "Controller") reviews the available funding stream within the program and the material delivery schedule and then will manually convert the PIR to a purchase requisition. This moves the material requirement into the appropriate Buying Office queue.

The Controller is a program oriented position within Sourcing, he or she is responsible to the specific shipbuilding program (New Carrier Construction, Overhaul, VCS). On the other hand, the Buying Offices are organized by commodity stream. A requirement for a valve will be routed to the Valve Buying Office, which procures all valves for the shipyard, regardless of program. So the Buying Offices will have multiple Controllers from the three different programs feeding requirements into the requisition queue.

Buyers have two means of converting a requisition into a PO. The first is to complete the request for quotation (RFQ) for any particular valve and collect pricing and delivery data. Once the quotation is received from the vendor, the Buyer can issue a PO. The second is to release a PO against an "outline agreement." Outline agreements are pricing and lead time contracts with specific vendors for specific products. These agreements are discussed further in Section 5.2.

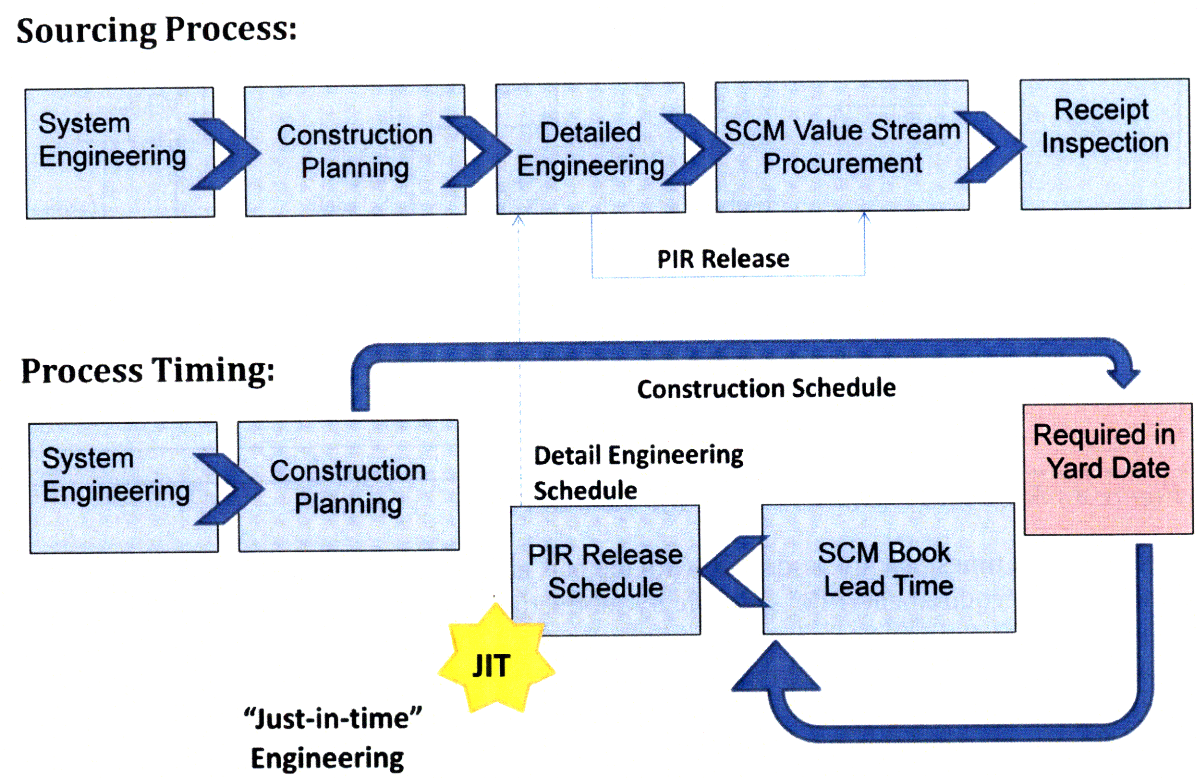

Figure 4: Existing NGSB Supply Chain Process Flow

Buyers are responsible for issuing PO's (subject to proper financial approvals) and ensuring the delivery of the software and hardware to schedule. Once a PO is issued, the Buyer is responsible for working with Engineering and Supplier Quality to attain software approvals. The Buyer is the primary contact between NGSB and the vendor, and facilitates resolution of all business and technical issues associated with valve purchase. The Buyer is also responsible for managing the valve delivery schedule to the RIY date.

4 The Existing Marine Valve Market and its Effect on Construction

4.1 Categories of Valves

An aircraft carrier contains over 50,000 individual valves. The valves can be broken into categories. For NGSB, valves are first categorized by Nuclear (Plant - PP) and Non-nuclear (Platform - PF) then by valve type and specification. The next category level is valve type, which has to do with body style and configuration of the valve. Typical categories are: gate, globe, check, butterfly, stop, in-line stop and are presented in Table 2. The next important determination is material type. Typical materials in use in marine shipbuilding are: steel, bronze, brass, stainless steel and titanium. In addition, various alloys of stainless steel are used. Once usage, valve type and material are determined, individual valve specifications (end preparation, seat, pressure rating) and sizes are specified.

Each individual valve has a specific use and installation location defined in CATIA. In addition, each valve has a part number that is defined in Aspect, the part catalogue used by NGSB. Valve part numbers are unique by configuration of the valve. This requires that even a small change to an existing valve configuration requires an entirely new part number. For example, if the material in an O-ring is modified by a design engineer, an entirely new part number will be created in Aspect.

The three major programs buy similar valves from the same vendor, but the part numbers are unique by program. For the new FORD class carrier, every part on the ship was given a new part number, including all valves.

4.2 Supplier Base for Marine Valves

The modern Navy marine valve market traces its roots back to the 1960s, when the cold war expanded the defense industry. There was an explosion in valve shops that opened in multiple states throughout America and began offering marine and commercial valves for sale. Some of the surviving companies today that began in this way are: Velan, Dante, Edwards, Leslie Controls and Southern Valve. These companies were typically private and sold valves in relatively low volume. Many of the companies competed directly against each other in different valve markets and valve metals.

Over the next twenty years, the market changed. The small companies found certain types of valves they were more competent at designing and manufacturing, not only for NGSB, but for the Standard Navy Valve Yard (SNVY). Having a design/manufacture competency in a particular area of valve design led the small companies to specialize and expand their capabilities in that niche market. This specialization of the market was reinforced by the ever increasing burden of quality paperwork and engineering approvals (software) required with each valve. As the standards and requirements for Navy marine valves increased, the profitability of keeping a vast line of products decreased because of the overhead engineering and design costs. This led the market to self-select. Companies that did not consistently win a contract for a certain type of Navy valve stopped offering that valve.

In the 1980's and 1990's there was consolidation in the valve market. Although many companies remained private, some were taken public. Even the private companies purchased competitors to enhance their product line with existing design and manufacture capability.

Although certain companies grew in size, the market capacity and capability shrunk, as the small shops were consolidated into larger operations. This led to a further reduction in competition in the market.

Categories of Valves	
Ball	Free Design, Multi-port
	Free Design, Str. & Angle
	Motor Operated
	Non-deviational
Butterfly	Aluminum/bronze, Electric Motor Operated
	Aluminum/bronze
	Bronze
	Stainless, Motor Operated
	Steel
Check	Aluminum/bronze
	Vent Check
Gate	Bronze
	Bronze, Motor Operated
	Cast Steel
	Forged Steel
	Steel Alloys
	Steel Alloys , Motor Operated
Globe	Bronze
	Cast Steel
	Forged Steel
	Steel, Alloys
Hose	Gate & Globe
Needle	Needle
Reducing	Bronze & Steel Alloys Unloading
	Steel Unloading
Relief	Bronze
	Hi-Velocity Pressure/Vacuum
	Steel Alloys - Cast
	Steel Alloys - Forged
	Steel Alloys
	Steel
Stop and Check	Bronze
	Cast Steel
	Forged Steel
	Steel Alloys
Swing Check	Steel
	Bronze
Temp Control	Steel Alloys; Steel
	Bronze

Table 2: Categories of Valves Used in Shipbuilding

Today, there are approximately 20 key valve suppliers that NGSB at Newport News purchases valves from.

4.3 Supply Base Challenges

One of the most significant challenges to the Valve Buying Office of NGSB is the erosion of the supply base. Over time, there have been fewer vendors willing and able to sell valves to the nuclear shipyard. The main reason for lack of capacity is that many vendors have chosen to exit the Navy marine market.

The decision to exit the market is based on many different factors. One key reason is the "hassle factor" involved with nuclear defense construction. The quality requirements are prohibitively high for some vendors. Government and NGSB inspection requirements frequently stop manufacturing lines for inspection and rework. These production interruptions can impact the vendor's commercial business. Software requirements and re-submissions take engineering administrative time, even for products frequently supplied. Even small changes require the creation of a new part number, and the vendor has to provide additional paperwork and submissions for engineering approval.

Financial challenges exist as well. The demand for valves in shipbuilding is cyclical. The cycle time on an aircraft carrier exceeds six years, with the construction of the ship progressing from the bottom of the keel upwards to the flight deck. The first years of construction are focused on the PP, located in the bottom of the ship. The more complex nuclear valves are needed first with the less complex, but higher volume PF valves needed later in the process. The result, from the vendor's point of view, is that the production demands for both PP and PF valves are cyclical and uncertain. Even when the government awards contracts for a new carrier, it is uncertain to many vendors when they will see demand for their products. Financial impacts include: uncertainty of financial forecasting to shareholders/banks, difficulty in long-term production and capacity planning, and unanticipated swings in income.

The current trend in manufacturing is to move facilities out of the United States to lower cost areas of manufacturing, such as India and China. This is not feasible for defense application. Over time, many vendors have chosen to move their operations overseas to stay competitive in the commercial market, sacrificing the Navy marine portion of their portfolio. This is a particular concern for casting houses, where the domestic market has grown particularly thin.

The barrier to entry into the market is high. Engineering design, prototyping and shock and vibration qualification costs are significant for a single product line. Add the technical challenges to the financial challenges and the market for Navy Marine valves is a difficult one to sustain.

One recent example of market flight is Vendor F. Once a key supplier to the yard, Vendor F has recently declined to supply valves, citing difficulties in the material inspection process that make it untenable for the company to continue to do business with the shipyard.

Another reason for the shrinking vendor base is consolidation, typical of manufacturing industries in the last two decades. Vendor F also serves as example in this category. The parent company Vendor F purchased three companies. Even though the valve lines retain their particular branding, the valves are manufactured and sold by one company. Loss of Vendor F as a supplier will impact several brands of valve. Another important vendor comprised of the consolidation of different smaller valve companies is Vendor J, who provides two other brands of valves. One of these two is a critical valve supplier. If the yard were to lose this vendor, it would present valve supply problems to the yard.

The marine market also has the unique aspect of self-segmentation. The market base is small, and over time, suppliers have gained expertise in a particular area. Smaller companies are reluctant to expand their current scope of supply into a segment of the market with a proven preferred supplier. Two cases in point are Vendor V and Southern Valve. Vendor V is the market leader for high pressure steel valves, and Southern Valve provides bronze valves.
In addition to the challenges above, traceability of raw materials must be maintained throughout the supply chain to the source. All sub-components must be procured through approved sources,

all of the way back to the mines that provide the ore for the valve bodies. The traceability requirements are especially difficult for titanium and stainless steel alloys to meet. This creates a limited raw material supply base. Coupled with a limited number of domestic casting houses, the result is a very long lead time for valve bodies, sometimes in excess of one year. As a result of limited raw material supply and long production lead times, most casting houses are now quoting “price upon delivery,” which means that the price of the valve body will be determined at the time of shipment. Under the "price upon delivery" quoting process the valve customer accepts and absorbs the cost risk and schedule risk is generally absorbed by the customer not the supplier. This dynamic injects additional uncertainty that the supplier base has to deal with.

The vendor base has serious challenges to deal with in the Navy Marine Valve market. These challenges include: high quality and technical requirements, extensive inspections and paperwork, industry consolidation, high barriers to entry, and limited raw material supply. The result is that there are limited willing and capable participants in the valve market.

4.4 Problem Identification

The goal of this research is to understand the existing sourcing system of defining and procuring valves for aircraft carrier construction and to suggest improvements to increase on time delivery of valves and lower construction costs.

Each supplier was evaluated for this study on the basis of “Preferred” and “Capable” for each category of valve. A “Preferred” supplier is NGSB’s primary choice for supplying that particular category of valve. A “Capable” supplier is one that either has shown manufacturing capability in that category, or has actively bid on that category of valve for NGSB. This Supplier Capability Matrix is attached in the Appendix.

There are several issues with the existing valve supply base and sourcing methodology. These problems can be divided into three general areas: Technical Capability, Pricing Practices and in Supply Chain Issues.

Technical Capabilities

Many of the valve designs are highly intricate and involve very close manufacturing tolerances. Some suppliers have been removed from the supplier pool because they do not have the technical capability to manufacture to the standards required of NGSB. Even some of those that choose to stay in the marine valve market are currently having trouble providing valve designs and prototypes that pass the design, manufacturing and testing requirements of the FORD class carrier designs. These issues are currently being worked through with the developmental valves teams.

The technical capabilities of producing one type of valve are not identically transferable to another type of valve. For example, companies that have expertise in gate valve design can not readily transfer their design and manufacturing capabilities. The casting and sealing technologies between ball valves and gate valves are different. The cost to attain this technical knowledge and skill level to sell in the marine market is high, and is considered a barrier to entering another segment of the market. This further reinforces the divisions in the market.

Pricing Practices

In addition to technical challenges, NGSB is facing cost escalation challenges. Cost escalation can come from various sources: increases in the cost of raw material, energy or labor rates. Cost escalation can also be a derivative of the pricing plan of the vendor. In several cases, vendors that have been down-selected to be the single-source supplier are taking strategic advantage of their technical capabilities and single-source status. These vendors appear to understand the fixed cost of qualifying another supplier for their product and are increasing prices on the second-generation set of valves. These escalations can be significant. These challenges for NGSB stem from the pricing and marketing strategy of their suppliers.

These key suppliers have leverage over NGSB with respect to increasing prices. These valves require a high degree of specialization and customization, and have a high "hassle factor" with regard to engineering approvals and quality documentation required. Since these vendors are the only ones qualified for their design, no substitutes are available and the cost of switching is high. NGSB also makes up very little of these vendors' revenue streams, generally less than 5 percent. A high requirement, low volume customer such as NGSB has relatively little market power with suppliers who choose to raise prices.

<u>Supply Chain Issues</u>

The sub-set of suppliers who have technical competence. These problems are supply chain issues and are the focus of this thesis.

During interviews of different valve vendors several issues were identified.

1. <u>There is an incomplete picture of demand forecast on the buyer/vendor level.</u> The current "Just-In-Time" detailed engineering model (see Figure 4) releases component requirements individually to Purchasing. The buyers (and by extension, the vendors) have no prior knowledge of what valve (if any) will be released for purchase today or tomorrow, much less be able to forecast requirements for the next year. This makes it very difficult for the vendors to plan engineering labor, purchases of raw materials (which are highly regulated for Navy applications), piece parts (which can have long lead times themselves), manufacturing capacity and production schedules.
2. <u>Vendors do not have a picture of the required ship-set volume.</u> In years past, the vendor used the PO numbering system from the previous hull to forecast (with high accuracy the vendors reported), the volume and timing of product they would provide for the next hull. PO's were organized and numbered by work area, and the PO number from one hull to the next was identical, except for the prefix, which was the hull number. Vendors recognized the new hull number when the first PO was issued to them, and could pull the record of PO's for the last hull to forecast. This functionality was lost in 2000 with the implementation of SAP. Now, PO's are numbered sequentially, with no logic readily apparent to the vendor. This is a problem because vendors can no longer forecast NGSB new carrier construction demand, vendors are simply reacting to PO's placed by the Buyer.
3. <u>There is high variability in demand to valve vendor</u>. Another unintended consequence of "JIT" engineering is that orders presently come sporadically to the vendor and then cease altogether with no warning or could double over the next two months. Vendors reported that they are simply reacting to orders, and are unable to plan raw materials, labor, capacity and scheduling. This is compounded by the long

period (over six years) for the design and construction of a single aircraft carrier. The long construction schedule makes it difficult for vendors to use actual purchase data to forecast future usage quantity and delivery timing.

4. Valve lead times are treated as deterministic within the existing supply chain system. Some vendors have entered into fixed "Outline Agreements" for cost and delivery schedules for valves (see Section 5.2). While there are benefits to these agreements, vendors have indicated that the lead times cited in the existing contracts are fixed and do not take into account order volume. For example, a vendor might agree to manufacture a certain valve with a lead time of six months and a capacity of 50 valves per month, expecting a typical order size to be 30 valves. Depending on the construction schedule, the computer system might release requirements (issue PIR's for) 250 valves in one month, exceeding the vendor's capability to deliver on schedule. Order quantity and vendor manufacturing capacity are not fully taken into account in the existing NGSB procurement model.

   This is a problem for the vendor when NGSB's just-in-time purchasing model calls for more valves than the supplier is prepared to manufacture within the contractually obligated lead time. The vendor might have agreed to a static lead time, but the dynamics of the current procurement system can at times catch the vendor unprepared for a large order and make it difficult, if not impossible for the vendor to perform on time.

5. New part numbers are identified early in the engineering processes, but not communicated to vendors until late in the purchasing process. Every valve for the FORD class carrier was given a new part number, even if the valve is identical to one specified for the NIMITZ class. This requires extensive engineering work for the vendor to provide design detail, manufacturing process and specifications for approval by NGSB and the Navy (which must be approved before manufacturing can begin). This is a problem when the vendor gets an order for a part number never provided before without advance warning. The vendor's engineering department (sometimes only a few people deep) is then left scrambling to complete the paperwork so the vendor can ship the valve on the required schedule.

4.5 Cost Impact Analysis

For the basis of this research it was necessary to understand the impact of delinquent valves on overall ship construction costs. The CVN 78 developmental valve mitigation effort currently underway was chosen for a case study of the cost impact of material not being available at the preferred, or optimal, time during the construction schedule. For simplicity, the impact is was determined in manhours instead of dollars. Wages will change from year to year, but the impact of moving construction will stay the same when evaluated on a manhour basis. It is simple enough to multiply the manhour estimate by the present wage rate to get the present cost impact of a delinquent valve.

The developmental valve disconnects were chosen for several reasons. First, the scope of the disconnects were large enough that NGSB instituted teams and processes to mitigate the schedule impacts before construction was impacted due to shortage of material. This results in data that is available for items such as additional manhours for re-engineering, re-scheduling, administrative, fabrication and construction.

In addition, it can be argued that the cost of moving work to a later (and less optimal) time in the construction schedule for a developmental valve is the same as moving work due to a missing or late non-developmental valve. Developmental valves are basically new valve designs, specific to the FORD class of carrier. Failures during the Engineering and Procurement processes simply provide the cause for the delinquency, but do not change the fact that the material is late. Ultimately, the impact is the same whether the valve is late due to developmental issues, a lack of capacity at the supplier, or insufficient lead time to manufacture.

During the course of design of CVN 78 and procurement of material over the last three years, valves have been identified that will not arrive by the scheduled need date. This lack of construction material is termed a "valve disconnect." There are two mitigation strategies currently employed at NGSB: Expediting through Sourcing or moving the construction schedule to coincide with valve availability. Of these disconnects, greater than one third were resolved by Sourcing. No definitive material price increases have been passed through to NGSB from the vendors as of December 2008. So the cost to NGSB to mitigate a valve through changing the sourcing strategy is estimated to be very low on a per valve basis.

Valve schedule disconnects that cannot be mitigated through Sourcing must be evaluated on a case by case basis. There are several possible impacts to construction of varying severity. These strategies include:

1. Moving the work from one period of time in a platen assembly window to later in the same platen construction.
2. Moving the work from shop fabrication to platen or shipboard installation.
3. Moving the work from shop fabrication or platen installation to shipboard assembly, so late in the schedule that it requires a spool piece to be installed to hydrostatically test the system.

The cost breakdown for a schedule impact can be divided into three categories: administrative costs to implement a Management Review Form (MRF), engineering and construction planning re-work (including Disconnect Team efforts), and construction installation impacts. The administrative manhour requirements of the MRF were estimated by Planning. Engineering and construction planning re-work manhours were also estimated. The construction impact was also estimated using the original detailed plan estimate. If the work was moved to a different construction location, the manhour effort was scaled up by using factors for increased congestion and complexity. If the work was moved later in the same location (platen or ship), an installation difficulty factor was used to estimate the impact of congestion and space limitations on construction efficiency.

Since the mitigation effort is still in process, the total impact was estimated by taking the ratio of disconnected valves by sourcing versus construction schedule and applying that to the unresolved population of disconnected valves.

For the basis of estimating cost impact for construction schedule delays PP and PF valves are estimated separately. In general, the PP is lower in the ship and installation is earlier in the schedule, so a delinquency in that area is more difficult and costly to mitigate. Construction impacts for both late PP and PF valves are significant. This analysis is proposed to be valid for any valve requiring schedule mitigation, regardless of cause of delay. Eliminating schedule changes and deferred work due to delinquent valves reduces the construction cost.

5 Analysis

5.1 Overview

In this section alternatives for vendor management strategies are examined. The first alternative is to continue with the existing policy of qualifying one preferred vendor for each type of valve. Under the alternative of keeping a single qualified vendor for each valve, the existing vendor management strategies employed at NGSB will be discussed and evaluated for sourcing valves for CVN 79. The alternate idea of leveraging existing single-source relationships into strategic alliances is then discussed as a strategy for the long-term management of key valve vendors. The other alternative is to qualify additional suppliers for each type of valve.

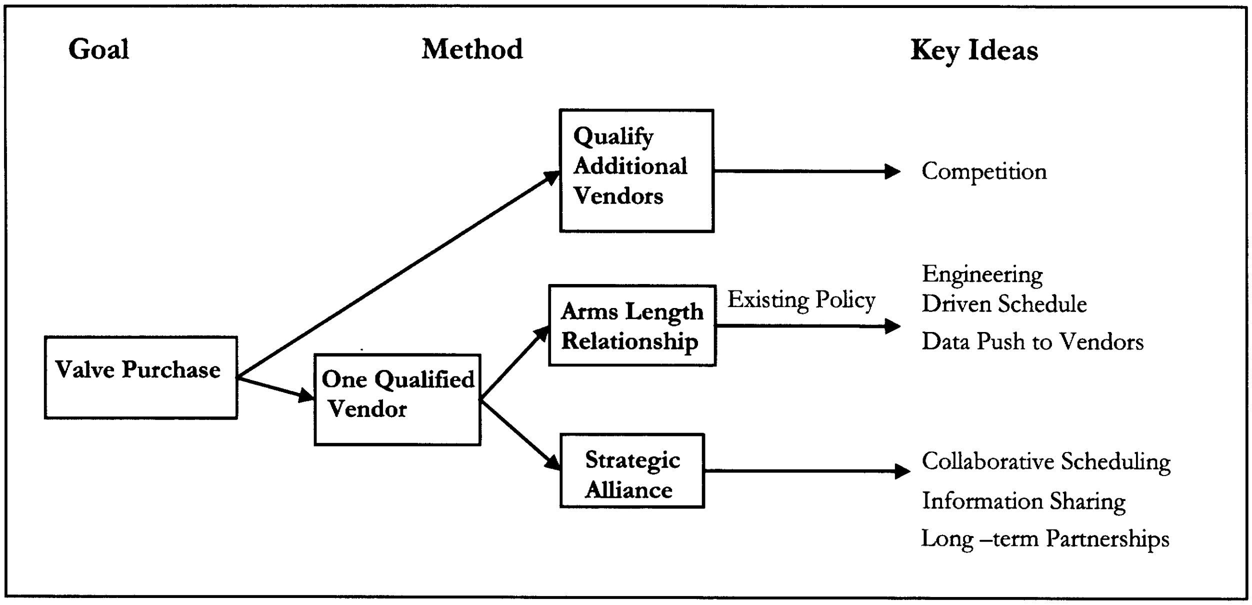

Figure 5: Options for Vendor Management for CVN 79

These evaluations will take into account the existing market conditions and supplier capabilities for manufacturing valves required for new aircraft carrier construction. Once this analysis has been completed, the problem areas for NGSB and the vendors will be identified. Specific construction and cost impacts associated with schedule delays due to delinquent valves will be detailed and quantified, using existing data from the CVN 78 program.

A recommendation of this analysis is to develop a pilot program with one vendor to determine the scope and feasibility of applying an integrated vendor partnership framework to valve procurement.

5.2 Existing NGSB Vendor Strategy – One Qualified Vendor

NGSB is not a stranger to contractual agreements with vendors. The most prevalent existing partnerships fall into two categories: Vendor Managed Inventory (VMI) and fixed price/lead time agreements, referred to as Outline Agreements.

<u>Vendor Managed Inventory Agreements</u>

VMI, as applied at NGSB, allows several distributors to control inventory levels and replenishment patterns. The existing VMI partnerships are for non-nuclear commodity items:

nuts, bolts, pipe, gaskets, fittings, steel plate and wire. These items are kept in inventory on a maximum/minimum stock level managed by the vendor. Generally VMI partners are distributors and not the manufacturer of the item. The items that are particularly prone to VMI at the shipyard include these commodity items with highly uncertain demand. One reason for this uncertainty is that it is difficult to estimate from engineering drawings how many of the item are required. They are generally low cost, have high consumption rates or are used within various work packages. In addition, these items are not location specific. The engineering specifications are static and not prone to change. VMI partnerships have been successful at the shipyard in lowering the required inventory on hand, reducing stockouts and reducing per item costs.

However, the VMI model of vendor partnerships is an incompatible candidate for managing components such as PP and PF valves. PP and PF valves are generally higher cost and with lower consumption rates than the items currently under VMI agreements. Valves are purchased directly from the manufacturer and custom manufactured to order. They have specifically identified location assignments, and using the CATIA product model, the quantity and locations of these valves can be forecast with high accuracy (especially the second-in-class ship, which is CVN79). In addition, the specifications of the valves can change, either by the engineering 'churn' associated with a new class of carrier, or through evolving Navy requirements and improvements to existing product lines. Utilizing a VMI model for PP and PF valves is not expected to improve the delivery timing and is projected to increase inventory carrying costs and decrease material availability because of the risk of specification obsolescence.

Outline Agreements

A second type of contract vehicle has been used by the Valve Sourcing Office for valves in the NIMITZ class carrier construction program, and is referred to as an Outline Agreement. A preferred vendor is qualified and a contract is entered into over a period of time for fixed pricing and lead times for each type/size/material of valve. This is especially useful for PF valves, which have higher and more variable usage rates than the nuclear PP valves. The Valve Buying Office finds this type of contract useful because the Buyer does not have to generate a Request for Proposal (RFP) for each individual valve. This allows the Buyer to immediately place a PO using the Outline Agreement. While the buyer finds this type of agreement convenient, valve vendors have identified problems with the existing one-off purchase model (see Section 4.4).

5.3 Alternative - Increase Competition by Qualifying Additional Vendors

A different option that has been discussed at NGSB is to reduce risk and cost in the supply chain by encouraging more open competition in the Navy marine valve market. The theory is to identify key valves and openly bid these valves out on the spot market, therefore encouraging competition and driving the cost of the component down. It is expected to reduce risk by developing a secondary supply chain for the valves.

It can be argued that this theory of open competition will not be successful in driving down risk and cost. First of all, open competition is not a strategic fit for this market. The history of self-selection and specialization within the vendor base in the market has led to a small, fragmented, but technically capable existing supply base (see Sections 4.2 and 4.3). This dynamic of specialization is reinforced by the low volume of demand over time (less than 10% of vendors' sales). Another difficulty is the limited capacity of the domestic supply base that is required for defense work. The high fixed cost of developing a new product line to compete with an incumbent vendor causes the challenger's product to be more expensive and is therefore highly unlikely to be chosen over the less expensive and proven supplier. The result is that there is a limited domestic supply base with little incentive for vendors to venture outside of their proven capability zone, even if every Navy valve was openly competed. In short, the spot market for Navy valves does not exist.

In addition, NGSB's strategic organizational design structure and policies make it difficult to successfully implement such a program. The existing policy of "downselect" openly competes valves during the early engineering phases. For detailed design, manufacturing and qualification, only one vendor is selected and paid to develop the valve design. Due to the extent of engineering required in the unpaid, early phases of competition, and the high knowledge base of the incumbent vendor, the valve manufacturers tend to compete primarily within areas of their established expertise.

The existing NGSB strategic organizational design of the Valve Buying Office and Supplier Quality Departments would also make open competition difficult to implement. At a high level, Sourcing is aligned into Buying Offices by commodity streams (Valve Buying Office, Pipe Buying Office, etc). At the Buying Office level, the buyers are organized by vendor (i.e. Southern and Vendor L) and not by commodity category (gate valve, ball valve, etc), which reflects the market. In the Valve Buying Office, the buyer functions as an account representative, assigned to manage specific vendors. Material requirements flow through the system to a specific buyer by identifying the preferred vendor. The buyer is responsible for pricing, delivery and vendor management. It would be very difficult to manage RFQ for valves with several different vendors within the existing structure of the Valve Buying Office.

The Supplier Quality Office is staffed in much the same manner, and would face the same challenges. However, the Supplier Quality Office is responsible for all vendors, so increasing the vendor pool of suppliers to be qualified would mean an increase in workload to this department with additional site visits to inspect production lines for new products.

In short, the Navy marine valve market is not large enough to support multiple vendors for each category of valve, nor is it structured to do so. To change the Navy marine valve supply base to open competition would require changing the structure and dynamics of the existing market, which is outside NGSB's control. If open competition really made sense, NGSB would have to look closely at restructuring internal organizations and computer systems, which are not currently strategically designed to support an open-competition commodity sourcing model.

5.4 Preferred Solution - Develop Strategic Alliances

Strategic Alliances

Even if VMI and open competition are not appropriate sourcing models for NGSB to pursue with respect to valve purchase, there are still courses of action that will improve delivery and lower construction costs within the constraints of the existing systems and relationships.

In the valve supply chain, NGSB is acting as an Original Equipment Manufacturer (OEM) purchasing components (valves) from distributors or directly from the manufacturer. In this sequential supply chain, information in the form of RFQ's and PO's flows from the OEM to the distributers and manufacturers. Internal to NGSB, the demand is signaled with the PIR issue from engineering. Then the PIR is converted into a requisition by the Material Planner, and finally into a placed PO by the buyer. Manufacturers receive the PO, issue their own PO's for raw materials and piece parts and make-to-order. In this system, each party (including those internal to NGSB) is optimizing its own decisions.

In this system, all parties involved are operating in a risk-adverse environment. NGSB only purchases valves when government funding is approved and available. In addition the specific, individual component must be completely through the engineering system (see Figure 2). The valve must be identified as required for the system during the Concept Engineering phase, specified and scheduled for installation during the Arrangement phase, and *all detail design completed* in the Detail Design Phase before being released for purchase. This is indicitave of a new design aircraft carrier, like CVN 78. However, for CVN 79, this process is expected to be streamlined. NGSB does not purchase valves until the certainty of the use, specification, location and installation plan of the valve approaches 100 percent.

Valves are generally make-to-order, so the distributers do not stock them, and assume no inventory risk. Manufacturers wait until the order is placed to begin engineering and procuring raw materials. In some instances, manufacturers wait until late in the assembly process to order piece parts for final assembly of the valves. The result is long lead times for valves, many times in excess of a year.

Strategic alliances are defined as "multifaceted, goal-oriented, long term partnerships between two companies in which both risks and rewards are shared.[5]" Alliances enable "global optimization" of the supply chain and in successful implementations both the purchaser and supplier share the risks and benefits of the alliance. Alliances come in many forms and can be viewed as a continuum. The low end of the scale involves some information sharing and collaborative forecasting. More complex agreements (VMI) involve a high degree of information sharing (point-of-sale or point-of-use data) and vendor involvement.

Todetermine which type of alliance is most beneficial, it is worth considering how the potential alliance will impact the following key issues:

1. Strengthening operations.
2. Adding technological strength.
3. Enhancing strategic growth.
4. Enhancing organizational skills.

These impacts should be considered with respect to NGSB and its existing valve vendor base, to recommend appropriate Strategic Alliances and corresponding supply contracts that globally optimize the supply chain. In assessing these items, particular attention will be given to leverage the existing vendor base to address the challenges identified in the "Supply Chain Issues" described in Section 4.4.

5.5 Development of Strategic Alliances at NGSB

In analyzing the existing purchasing system (described in Section 3.7), valve market conditions (described in Section 4.3) and construction cost impacts (described in Section 4.5) several preliminary observations can be made. These include:

- Delayed valves have an impact to ship construction costs when the work needs to be rescheduled to later in the build cycle.

[5] Simchi-Levi, D. *Designing and Managing the Supply Chain*, Boston: McGraw Hill Irwin, 2008.

- The existing strategy of "downselecting" valve vendors has led to a majority of single-sourced valves.
- The existing Navy valve market is not conducive to open commodity-style competition or spot-purchase.
- The procurement system is currently a one-off, make-to-order purchasing model.
- The "JIT" engineering model has adverse impact further down in the supply chain.
- Supply chain process changes are currently being developed for CVN 79 to take advantage of second-in-class engineering design knowledge.
- There are existing strong supplier relationships that might be improved through developing a strategic alliance approach to vendor management.

The current sourcing system is designed for concurrent engineering, which is appropriate for a completely new design of carrier, but is not the most effective model for construction of subsequent ships. The work process and computer networks are not currently configured to take advantage of prior engineering knowledge. To leverage the product model (CATIA model) for CVN 79 construction, new processes and methodologies need to be put in place to globally optimize the valve supply chain.

There are several key items that may be leveraged for the second-in-class ship construction:

- Extensive computer systems and networks within NGSB that capture a vast amount of data
- Certainty of engineering design – only change orders are expected be incorporated on future FORD class carriers
- High degree of accuracy in the CATIA model – forecast certainty will be high from the early stages of the project
- The estimated need dates for valves for CVN 79 can be estimated using CVN 78's construction schedule
- Valve design contracts give the Navy ownership of the design – valves can be manufactured by different vendors if necessary
- Existing single-source supplier relationships are strong with some vendors
- Existing vendors have a high degree of technical design skill and manufacturing capability
- Some vendors have advanced IT systems
- Some vendors have strong, long-term relationships with NGSB and the particular buyer in charge of their account.

It is possible to apply Strategic Alliance methodologies (see Section 5.4) to NGSB and its existing valve vendor base, to recommend appropriate supplier partnerships and corresponding supply contracts that globally optimize the supply chain. In assessing this framework, particular attention will be given to leverage the existing vendor base to address the problems identified Section 4.

6 Pilot Program – Southern Valve Company

After identifying the benefits, strategic alignments and cost impacts of single-source partnerships, the next step is to present a case study to evaluate the validity of applying the framework to an existing valve vendor. This framework will take into account the feasibility and impact of developing new means and techniques of creating true long-term alliances with component (valve) suppliers as opposed to continuing the existing arms-length relationships.

6.1 Southern Valve Overview

Southern Valve Company (SVC) was founded in 1901 and is a privately held company. Since the early 1960's, SVC has been supplying valves to the Navy shipbuilding industry; including NGSB, General Dynamics, Electric Boat, Bath Iron Works and NASSCO, as well as Marinette Marine. Southern Valve also sells direct to the US Government groups DSCC and NAVICP and through distribution channels to commercial marine enterprises.

SVC serves four primary markets with an annual sales volume of US$105,000,000. NGSB is considered a marine customer and accounts for approximately half of the marine market sales.

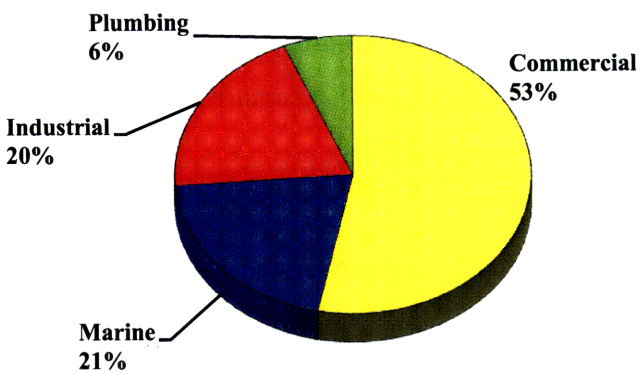

Figure 6: Southern Valve Company Sales by Market Segment[6]

SVC operates two facilities in the United States.. One location houses corporate headquarters and the distribution center. The other is the domestic manufacturing operation and includes a foundry, machining and assembly operations. Southern Valve is in the unique position of being almost completely vertically integrated. Every bronze product manufactured is cast in the company's foundry, with two state-of-the-art automated foundry processes. After the valve body is cast, all of the machining and assembly is done in the same factory. Other vendors are less vertically integrated, and must rely on domestic casting houses and foundries for valve bodies.

Southern Valve Company is a good candidate for developing a strategic alliance with for several reasons:

1. Both NGSB and SVC have a strong financial incentive to work together. SVC is one of the largest suppliers of valves at NGSB, supplying more than 25% of the valves

necessary for a new carrier. In addition, NGSB makes up greater than 10% of SVC sales revenues.

2. SVC has highly regarded technical capabilities in both engineering and manufacturing. The companies quality rating has been high, and SVC is regarded by NGSB Sourcing to be one of the most competent suppliers.
3. SVC had advanced IT systems, including MRP and production planning systems and a strong business infrastructure that will facilitate information sharing.
4. The SVC management team has a strong relationship with the Buyer and the Valve Buying Office and has expressed willingness to share information.
5. SVC has shown interest in expanding their offering into other valve categories in a time when most valve suppliers are scaling back interest in the Navy marine market.

In short, SVC is a competent supplier, with a good existing relationship with the Valve Buying Office. The company would like to expand its relationship with NGSB and is open to information sharing. Choosing a vendor with strengths such as these will test whether a Strategic Alliance is possible within NGSB.

6.2 Step 1 – Assess Within the Strategic Alliance Framework

To assess the practicality of creating a formal Strategic Alliance with SVC, the company was evaluated on the following key issues:

1. Strengthening operations.
2. Adding technological strength.
3. Enhancing strategic growth.
4. Enhancing organizational skills.

The true value of the Strategic Alliance can be seen as "*strengthening operations*." The first goal of the alliance is to support the optimal ship build schedule. The second goal of the alliance is to drive cost out of the valve supply chain. This will be the key item to leverage.

An alliance is not projected to impact *technological strength*, as the supplier is highly capable, and the components are highly specified, engineered, and quality assured. However, through an alliance there is possibility to improve communication flow and facilitate best practice information sharing.

SVC would benefit from an alliance with respect to *enhancing strategic growth*. A stronger alliance with NGSB would facilitate the vendor's entry into the ball and/or butterfly valve market (see Appendix 1).

Both NGSB and SVC would benefit from *enhancing organizational skills*. For NGSB, appropriate and thoughtful expansion of this relationship will ensure supply of highly technical components and improve delivery to schedule. Once this framework is identified, and the NGSB Sourcing Office becomes competent in using the model, it may be possible to expand the scope of partnerships to other valve vendors, or to other components.

6.3 Step 2 – Define Business Needs to Engage in a Better Alliance with SVC

Success for the NGSB Valve Buying Office is to receive 100% of the valves on time to RIY date, with all quality paperwork (software) completed and for a reduced cost. SVC is willing to supply valves, however, there are communication and supply chain inefficiencies that impact SVC's ability to perform.

Some of these factors include:

1. No forecast of demand, requirements trickle in by one and two at a time.
2. Difficulty in knowing how much raw material to procure.
3. Inefficient use of administration/engineering time, since the paperwork requirements for each PO is high.
4. Incomplete or changing specifications and part numbers.
5. PO's placed after lead times have eroded.
6. Difficulty/delays in receiving "Released to Manufacturer" approval from NGSB's Engineering Department.
7. Changing scheduled need dates.
8. New part numbers ordered with no prior warning of an impending change.
9. When capacity is a limiting factor, there is difficulty in determining the priority of which valves to deliver first, especially if multiple ship programs are involved.
10. Other marine builder's place multiple-shipset orders to be manufactured and placed in inventory, reserving available vendor capacity.
11. Disruption/change over of the commercial lines to manufacture military specification equipment.
12. Disruption of the commercial lines to hold work-in-progress for government and NGSB inspection.

In general, SVC relates well to the shipyard, is responsive to changing circumstances and delivers quality products. But both the Valve Buyer and SVC are operating in reactionary modes. Neither party has advance warning of demand, and both are simply reacting to signals of need as those signals come down the pipeline. In this case, it is recommended to begin an alliance by generating a demand forecast over time. This can be accomplished by better information sharing during the engineering phase of the new carrier. Information sharing is on the less complex end of the alliance scale, and is a basic need for any strategic alliance. Beyond that, collaborative forecasting is necessary.

6.4 Step 3 – Develop the Forecast Tool

In the case of SVC, it was desired to define the NGSB forecast structure to align with the vendor's manufacturing and business processes. This information was gathered during meetings with the author, the Buyer, and SVC representatives. The SVC representatives included: the Marine Valve Sales and Marketing Manager in charge of the NGSB account, Manufacturing Plant Manager, and the Production Scheduling Manager. Over the course of the study, this framework of forecasting and information sharing grew support within NGSB and SVC, including high-level collaboration with the Valve Sourcing Manager, Strategic Sourcing Manger, and SVC's President and CEO.

One of the first items was to explain the sourcing processes (Covered in Section 3) to SVC. Although SVC has supplied valves to NGSB for almost 40 years, they had no visibility to, or understanding of, the internal complexity of the shipyard. This was a key piece of information to share since the vendor now had an understanding of the requirements and challenges faced by Sourcing.

The next step was to determine which forecasting information was most important and useful to SVC. This included: size, type and material of valve, Navy drawing number, quantity and delivery date. SVC also wanted advanced warning of times when NGSB will be ordering new part numbers, so that advance engineering work on these new parts can be scheduled within the existing SVC engineering department capabilities. It was desired by both sourcing and SVC to aggregate the demand data over the construction span of the carrier – to generate a shipset view instead of demand.

Although this data seems simple enough, there were several technical challenges to developing a holistic forecast. First off, data for New Carrier construction resides in several computer systems (CATIA, Aspect, Artemis, SAP). Data in the sourcing supply chain flows through, or cross-references, each computer system during the design and procurement process (See Figure 7). This data resided in separate systems until PIR's were compiled and issued by Engineering. Early in the sourcing process, there was no one location that contained forecast data.

In addition, SVC supplies valves for all programs at the shipyard. Even though New Carrier Construction is the majority consumer for valves at the yard, any forecast generated for the outside vendor would be incomplete without considering demand from VCS and Carrier Overhaul. The overall usage of valves as one shipyard is the most important to SVC, they are not as concerned with program break-down.

The Buyer is also responsible for valve purchase for these other NGSB programs, and is responsible for purchasing valves for the entire shipyard. Therefore, demand data for VCS (through SAP) and Carrier Overhaul (through their system, called AAMP) had to be included. In short, it was determined that a program-specific approach would be of less benefit to the supplier than an integrated, yard-wide forecast estimate. VCS and Overhaul program members became strong members of the forecast development team.

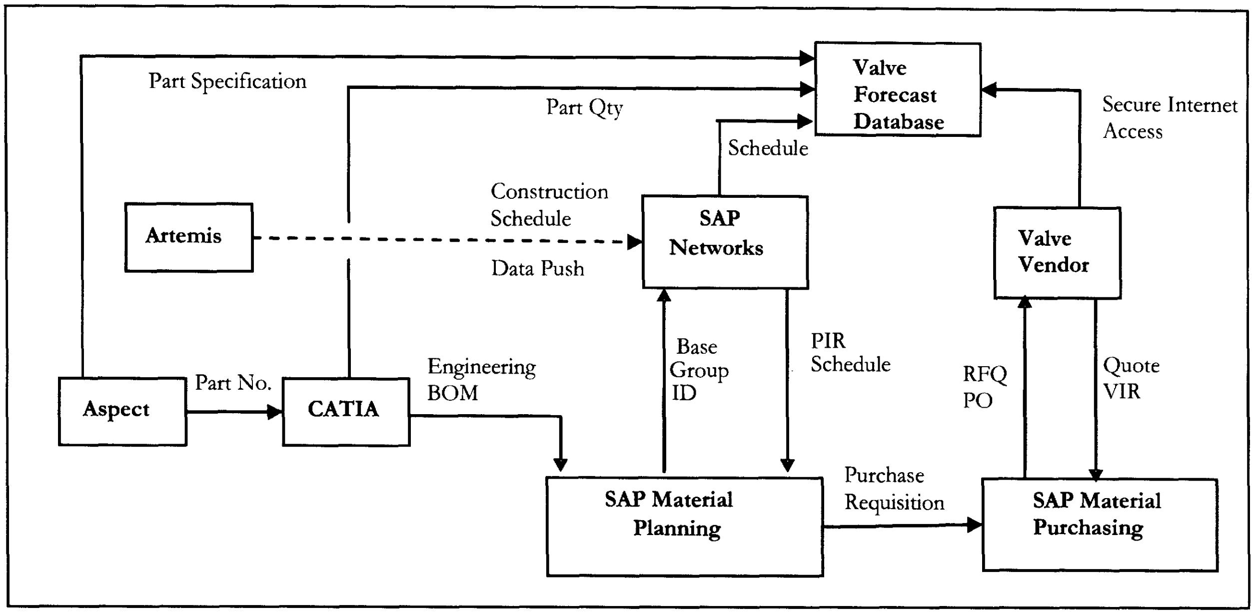

Figure 7: Valve Forecast Database Process Information Flow

Working with Strategic Sourcing, a methodology to aggregate data using the yard's existing COGNOS reporting tool was developed. First, the individual usage of the valve was data-mined from the existing CATIA product model. Then, the scheduled need date was determined by cross-referencing the base group material order start date in CATIA with the base group schedule in SAP. Specifications and preferred vendor data was then pulled from the Aspect part catalogue.

This data was pooled into multiple Microsoft Access databases and finally aggregated into a demand forecast through 2013 (See Appendix 4). One of the benefits of MSAccess is that the demand data is in the database by specific day required in the yard. The vendor can then 'roll up' the demand into weekly, monthly or yearly demand as desired. In addition, specific size ranges, or drawing types can be pulled out of the forecast for material planning purposes.

Once the demand data was pulled, a key aspect to collaborative forecasting with SVC is to understand the certainty of the forecast. In many manufacturing and retail sales supply chains, the certainty is time-based. As the usage date gets closer, the demand can be estimated with growing certainty. The 'firmness' of demand can be evaluated based on engineering stage - where in the engineering process the design of the valve is (see Figure 2). For typical consumable construction material (piping, elbows, steel, paint, cable, lighting fixtures, etc) the amount used is highly uncertain in the Concept and Arrangement Design Phase. It is not until the Detailed Design Phase is complete that the quantity necessary for construction is known.

For example, a simple system might consist of a pump, valve and tank. During the Concept Phase, a block flow diagram will be drawn to detail the system. During Arrangement, the location of the pump and tank will be determined. During these two phases, it is unclear as to exactly how much piping, elbows and pipe hangers will be required. The piping is a function of how far away the pump is from the tank, and this is not readily apparent until the Arrangement has been finalized. The final amount of piping and elbows necessary is not known with certainty until the detailed piping design is completed.

Engineering Certainty – Typical Material				
Detail	High			
Arrangement	Medium			
Concept	Low			
Time Horizon		6 months	12 months	18 months

Table 3: Engineering Design Phase vs Consumable Material Forecast Certainty

For CVN 78, the relationship of engineering certainty to lead time available is presented in Table 3. Items that have passed through the Detailed Design Phase are highly certain, and are likely to be procured on time. These are coded green over the time horizon. Items in the Arrangement Phase are less certain, are not released to Sourcing, and are increasingly likely to be late to schedule. Materials in the Concept Design Phase are highly uncertain (see Table 3), regardless of how soon the scheduled need date is. The conclusion from this analysis is that the forecast quality does not necessarily improve as the RIY date draws closer (a function of time), but as the engineering design matures (a function of engineering work linked to the construction need date). The implications of this means that it is possible for items to be needed within a short time window, but the specifications and exact quantities are still vague or undetermined, if they are still being developed. Represented by red squares in Table 3, lead time is being eroded, design is immature, and/or usage is uncertain. The red zone shows areas where components have a high possibility of being late to schedule. This is unique to CVN 78, since it is the lead ship. It is projected by the CVN 79 Program Office that this issue will lessen with the construction of subsequent ships.

Valves, however, are components that have unique characteristics enabling more advanced forecasting than typical material. Valves are different – unlike cable and piping, valves are individually diagram identifiable and uniquely located. This means that the specification and quantity of each individual valve are system design driven. The need and specification of the valve is highly certain before the detail design zone is complete. This enables the development of a forecasting framework that reaches into the earlier engineering design zones (Concept/Arrangement) and forecast with reasonably high accuracy.

Table 4 shows the implications of reaching into the Concept and Arrangement Zones for valve forecasting. Items in the red zone are at risk of being late to scheduled need date. However, this risk is more limited than typical consumable construction materials (Table 3). In this framework, NGSB Sourcing and Engineering can focus on red areas with the vendors help.

6.5 Step 4 – Develop On-going Dialogue and Lead-time Feedback

This creates a specific opportunity for advanced and accurate forecasting of valve usage. Understanding the drivers of valve certainty can help both NGSB Sourcing and SVC determine accurate decision/ordering timeframes. The valve forecast allows for NGSB and SVC to begin an on-going supply chain dialogue based on projected demand data. SVC can evaluate the demand forecast with respect to:

- Lead times sensitive to volume/product mix
- Early identification of new part numbers

Engineering Certainty - Valves				
Detail	High			
Arrangement	Medium/High			
Concept	Medium			
Time Horizon		6 months	12 months	18 months

Table 4: Engineering Design Phase vs Valve (Component) Forecast Certainty

Once the demand patterns are understood, Sourcing and SVC can work together to determine PO placement dates that both support scheduled need dates and are feasible for the vendor to perform to (Figure 6). These optimal PO placement dates can be compared with the existing Engineering PIR schedule. If it appears that the Engineering PIR schedule will not support the actual vendor projected lead times, then the Program Office can proactively make a determination as to whether to accelerate Engineering, accept the late delivery date, or delay construction. The Program Office can use the cost analysis developed in Section 4.5 to determine what the most cost effective course of action is.

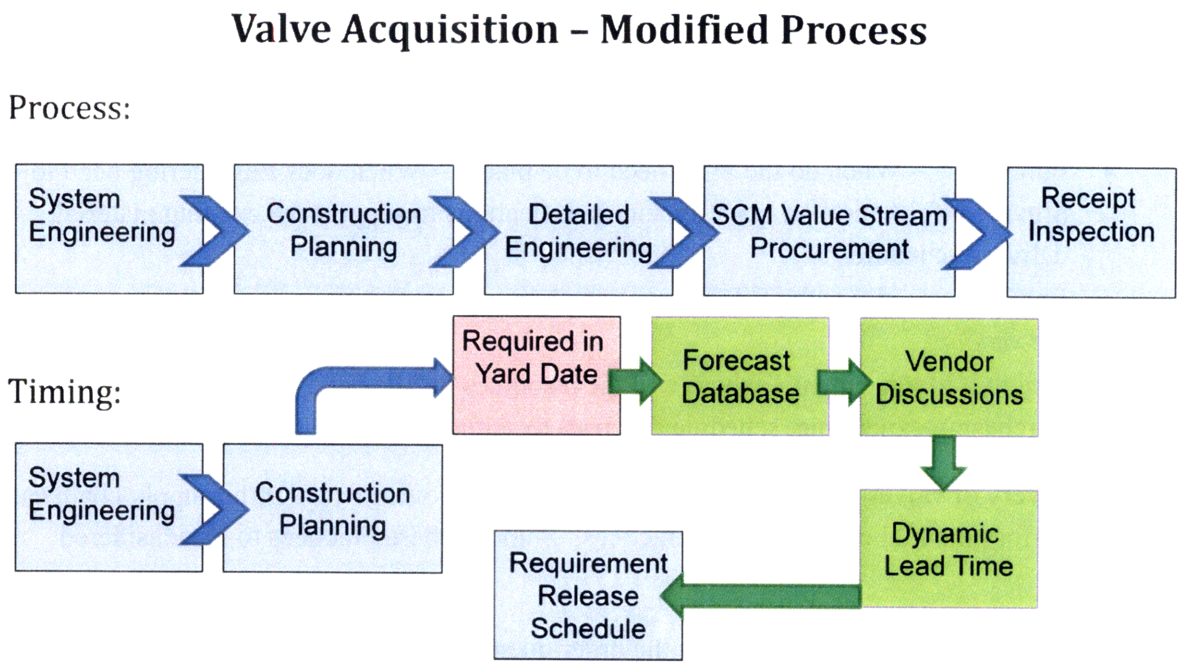

Figure 8: Proposed Sourcing Process, Integrating the Forecast

6.6 Leveraging the Forecast

Key components to forging an OEM – Supplier Alliance are increased communication and information sharing. It is recommended to first increase information sharing between NGSB and the valve vendor. The second step is to begin to develop shared decision making as to the timing of the PO's and delivery schedules. Once valves are flowing into the shipyard to schedule, the next step will be to work with the supplier to globally optimize the supply chain with respect to cost.

Creation of a forecast database is a key first step for NGSB to begin to proactively manage its existing single-source valve vendor supply base. With the creation and implementation of the database, NGSB brings the knowledge of valve demand and usage schedule in an integrated, easy to understand and secure format. This will be particularly useful for the second-in-class ship, where the design maturity will be high from inception. The supplier will share knowledge of lead times and production capabilities. This information sharing creates tremendous potential for both NGSB and the vendor to accurately understand what and when these materials will be needed.

The forecast databases for SVC were created manually. For full implementation, IT support will be required to automate the collection of data and creation of the usage curves. Due to the sheer volume of part numbers for valves (over 1,000 for FORD class alone), the database must be updated automatically to ensure accuracy and timeliness.

Once the information is stored and updated in a secure environment, further discussions and information sharing are necessary between NGSB and the vendor to improve material delivery to schedule. These discussions will include key internal and external stakeholders:

- Vendor – What are the actual valve lead times, with respect to current factory conditions?
- Purchasing – When do the PO's need to be placed? When does Engineering need to provide information on quantity and specifications to support the existing material delivery schedule?
- Engineering – Does the PIR release schedule support PO place dates that are *requested by the vendor*?
- Program Management – where will the resources be allocated (engineering overtime, purchasing expediting, schedule deferral) to support ship construction?

Once delivery of valves is optimized to schedule, then the overall cost of the supply chain can be examined for potential cost reduction practices. Some of these practices to be considered include:

- Optimal batch sizing – aligning the order quantities for certain valves to globally optimize processing time and costs considering Sourcing, Supplier Quality, the vendor, and Receiving.
- Lowering lead times – purchasing and pre-positioning raw material and precious metals in advance of demand.
- Delaying differentiation – assessing which parts (valve bodies?) can be used for multiple applications and developing economic quantities to inventory.

The overall goal of this collaborative alliance is to first improve valve deliveries to schedule and then to lower the overall cost of the supply chain.

7 Conclusions and Recommendations

7.1 Conclusions

The valve sourcing process for New Aircraft Carrier Construction at NGSB is complex and spans many internal and external stakeholders. Internal stakeholders include the CVN 21 Program Office, Engineering, Construction Planning, Sourcing and Vendor Quality. External stakeholders include the Navy and the valve suppliers.

The current process is an engineering-schedule driven release of material requirements to purchasing based on a static lead time estimate with the goal of supporting construction need date. This system is a one-way purchasing information flow from NGSB (the OEM) to the supplier. The vendors are kept at arms length and requirements are passed "just-in-time" for the vendor to supply the valve. The unintended consequence of this system is a "one-off" purchasing model, in which each component or valve is purchased to its own schedule, a schedule the supplier has no advance visibility of. In addition, the demand schedule for valves is driven by construction group start schedules, leading to significant demand swings. This lack of forecast and demand variability causes valves to be late to schedule.

Valves arriving late to schedule impact ship construction by deferring the valve installation from the shops to the platen and ship outfitting, where the spaces are more congested and more difficult to work in. Delayed valves increase construction cost to work around.

In addition, the vendor base for Navy Marine valves has consolidated and contracted over the last 20 years. At the present time, NGSB has basically one qualified vendor for each type of valve it purchases, and vendor capabilities to provide different categories of valves are limited.

With the high cost of delinquent valves and the limited supply base for valves, it is recommended to change the existing sourcing process. Instead of keeping supplies at arm's length, NGSB should begin to develop strategic relationships with suppliers.

A four step process is proposed to begin to develop long-term strategic alliances. These steps include:

1. Evaluate the supplier for suitability to, and strengths and weaknesses of, forming an alliance.
2. Define the specific business needs and capabilities of the supplier.
3. Develop a collaborative forecast with the supplier.
4. Leverage the forecast with respect to delivery to the construction schedule by creating on-going dialogue between the supplier, buyer, Engineering and the Program Office in order to determine quantity, actual lead time and specification need date.

Providing an accurate and useful forecast of demand to the supplier is a key first step in creating a strategic alliance. Creation of this forecast can be particularly timely and accurate for New Carrier Construction, by reaching earlier into the engineering design process to extract data on valve specifications and scheduled need dates. The existing product model will be particularly powerful for CVN 79 to use as a forecast basis. Currently, data from CVN 78 can be used and offset 4 years for projected valve demand. Since CVN 79 is to be a 'modified repeat' of CVN 78, there is projected to be a limited amount of engineering changes.

In a similar manner, data can be pulled for the other major programs at the shipyard: Virginia Class Submarine and Carrier Overhaul. The demand data for VCS, and Overhaul can be aggregated into a demand time-line that spans the next five years. Demand data for CVN 79 will reach beyond that time, creating a long term forecast.

It is recommended to automate the collection and processing of the data and use a secure internet portal to allow suppliers to view the forecast. Then suppliers can have on-going dialogue with the Buyer on when the forecast needs to be solidified in the form of accurate need dates from Planning and specifications from Engineering, culminating in a purchase order for a valve, or economic quantity of valves.

This will improve schedule compliance by providing visibility of demand to Purchasing and the supplier. The suppliers will have the ability to give early warning to NGSB on such issues as capacity constraints in light of overall demand to the supplier. Suppliers will also be able to more proactively manage their raw materials and piece-parts purchase. The most powerful aspect of the forecast is the ability of the supplier to accurately tell NGSB what the actual lead times for valves are at a given point in time, versus the current method of using an estimate generated internally at NGSB.

The key characteristics of the proposed Strategic Alliance Model include:

- Aggregate shipset forecasting across all major programs
- Reach earlier into the engineering and design process for valve demand
- Create a demand forecast over the life of the construction cycle
- Engage the vendor in capacity and lead time discussions
- Create real-time dialogue between Engineering/Sourcing/Supplier
- Determine the true latest release date of requirements from Engineering to support Sourcing and Construction

7.2 Additional Applications of the Framework

<u>Yard-wide Application</u>

As previously discussed, to successfully create a strategic alliance with valve suppliers, it is necessary to consider the demand for valves from all of the major programs at the shipyard. This prevents "cannibalism," or one program benefiting at the expense of another. It also opens the opportunity to explore leveraged buys, where a group of valves are purchased at a discount. It is recommend to manage vendors as 'one yard.' This 'one yard' philosophy can be extended in the future to include other NGSB sites within the sector.

It must be noted, however, that the future viability of these suggestions is dependent upon, and directly related to, the Navy's contracting and funding strategies. This will directly impact these kinds of decisions. Navy funding and contracts were not explored as part of this thesis.

Components with Similar Criteria

Valve suppliers are not the only material vendors that can benefit from aggregate forecasting and strategic alliances. It would be feasible to extend this framework into other engineered components. Characteristics of components that fit the framework include:

- Single-sourced
- Diagram-identifiable
- Moderately complex
- Long lead times
- Variable demand
- Potential for part number changes

Components that have the potential to fit into this framework include pumps, electrical distribution equipment (starters, motors), manholes and ventilation equipment (fans, coamings).

7.3 Future Research

Contract Opportunities

Once open information sharing is completed with a valve vendor, the next logical step for NGSB is to formalize the alliance with a business contract. Further research should be done on which type of contract is most appropriate for strategic components, such as nuclear valves. Indeed, this situation may call for the development of a new type of supply chain contract.

Some existing contracts used in general manufacturing include:

1. Cost-Sharing Contracts – NGSB would pay some portion of the manufacturers cost. In practice, NGSB would buy some raw materials or piece parts that the supplier needs.
2. Capacity Reservation Contracts – NGSB would pay to reserve a certain amount of capacity with the supplier.
3. Advance Purchase Contracts – NGSB would contract a certain quantity at an advance purchase price (discounted) and schedule then pay additional for the final order quantity.
4. Option Contract – NGSB would provide an initial payment, a reservation price, to reserve a certain quantity of valves. Then NGSB would pay the execution price when the order is placed with certainty. The drawback for NGSB would be to forfeit the reservation price if NGSB does not exercise the option. The total price is the reservation plus execution prices. The benefit is that NGSB can adjust the order quantity based on actual demand.

5. Flexible Contract – A fixed order quantity and price are determined when the contract is signed and the actual delivery can vary no more that a certain percent from agreed order quantity. Any additional demand would have a higher per-unit price.

Each of these would have to be assessed versus the contracting and funding environment resident within the government and US Navy acquisition programs.

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Appendix

Appendix 1: Valve Supplier Capability Matrix

Categories of Valves		Valve Suppliers - New Carrier Construction								
		Vendor A	Vendor B	Vendor C	Vendor D	Distributor 1			Vendor V	Southern Valve Co
Type	Material					Vendor C	Vendor D	Vendor F		
Ball	Bronze	P	P							
	Brass			P						
	Steel Alloys		P	P	P					
Butterfly	Aluminum/bronze					P				
	Steel					P		P		
Check	Aluminum/bronze								P	
	Bronze			P						P
	Brass									
	Steel Alloys		P	P			P		P	P
	Vent Check									
Gate	Aluminum/bronze									P
	Bronze			P						P
	Steel Alloys			P					P	P
Globe	Bronze									P
	Steel Alloys		P	P	P	C			P	P
Hose	Gate & Globe									P
Needle	Bronze									P
	Steel Alloys			P						
Reducing	Bronze					P				
	Brass						P			
	Steel Alloys					P			P	
Relief	Bronze							P		
	Steel Alloys									
Stop and Check	Bronze									P
	Steel Alloys									P
Swing Check	Steel		P	P					P	
	Bronze									P

P Preferred Supplier

C Capable Supplier

Steel Globe Valves		Valve Suppliers								
Material	**Size Range/Type**	Vendor B	Vendor C	Vendor D	Vendor M	Vendor F	Vendor V	Southern Valve Co	Vendor J	Vendor E
Stainless Steel	< = 1/2"	P	P	P	P					
	< = 2"		P			P				
	1/2" Ball Tip Stem			P						
	6"						P			
Nickel/Copper /Stainless	1"							P		
Steel	< = 4"		P				P			
	< = 6"						P			
	< = 10"					P				
	Globe Stop Check						P		P	
	1/4" Angle Globe								P	
	1 1/2" Globe Needle								P	
	10" Y - Globe					P				
	1" Globe Reducing									C

P — Preferred Supplier   C — Capable Supplier

Appendix 3: Aggregated Valve Forecast