Proposed Investment Strategy to Address the First Marine International Benchmarking Study Findings

Collaboration of 11 U.S. Shipyards teaming with Navy and suppliers on Technologies and Processes to Reduce the cost of Naval Ship Acquisition and Repair

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1 Foreword

1.1 Background

The Executive Control Board of the National Shipbuilding Research Program has developed a proposed investment strategy for a future Shipbuilding Industrial Base Investment Fund (SIBIF) to be administered by SECNAV. The strategy was envisioned as a template of priority action areas suited to execution by collaborative efforts using the existing NSRP vehicle-supplemented by shipyard-specific implementations through appropriate channels. Additionally, the strategy was expected to include recommendations for changes to both shipyard and customer processes where they are tightly integrated, such as technical oversight.

The strategy responds to issues identified in the First Marine International, (January 2005), *U.S. and International Shipyard Benchmarking: Initial U.S. Industry Report (Draft)*. Many of the high-priority benchmarking report recommendations identified the business relationship between the shipbuilders and their Navy customer as a key consideration, a finding that the industry agreed with and which has been the subject of DoD and Congressional analysis in the past few years.

1.2 Problem Statement/Challenge – Benchmarks & Other Data

The First Marine International Benchmarking Study findings can be summarized by several key conclusions regarding the U.S. Naval Shipbuilding Enterprise:

- Shipyards made impressive improvements since the last round of benchmarking in 1999 and are closing the technology gap with foreign shipbuilders.
- Issues remain in some key areas of naval ship design and construction, notably:
  - High work content on increasingly complex naval ship designs – and associated high first-of-class performance drop-off and increasing labor hours.
  - Higher customer factor – additional costs due to the overhead of Navy requirements in excess of those typical of foreign navies or commercial customers.

The determination of an effective and efficient set of actions to address these findings must also consider the real world constraints that limit any solution set. A necessary complement to the FMI analysis of shipyard use of best practice is an understanding of the business factors that constrain the impact of improvements to shipyard process improvement and productivity. The intense pressure on overhead rates brought about by the lowest Navy build rate in 50 years severely limits each organization's ability to tackle major challenges on its own. Low rate production (4 ships in the FY06 budget) is complicated by the prospect of tripling the shipbuilding rate in just a few years (12 ships in the FY11 plan) – so shipyards cannot downsize to economize and reduce overhead without eroding their capability to meet the near-term future needs of their primary Navy customer.

A business relationship characterized by ***stability and predictability*** is essential to future affordability and to preserve specific critical skills in an industry struggling to maintain skilled employees and capabilities given the gaps in contract awards and low order quantities. The danger to the industrial base's capacity to design, develop and produce weapon systems posed by this instability extends beyond the shipyards to second and third tier suppliers. Stability should be the most important consideration for Pentagon planners as they try to balance combat needs, long-term strategy and budget constraints. With notice, shipyards can adapt its work force and capacity, however, they cannot size to low requirements without significantly restricting their ability to grow a skilled workforce to meet future requirements. Shipyards are encouraged by recent statements by Congress, the CNO and others that recognize the overwhelming influence of low, unstable ship orders on ship affordability and industrial base health.

An April 2002 report to Congress by the Assistant Secretary of the Navy for Research, Development and Acquisition provides a succinct assessment of critical issues that must be addressed in tandem with internal shipyard efforts. These issues include:

- Underestimated non-recurring effort for lead ship design and production startup.
- Budget reductions/rescissions.
- Growth in shipyard labor rate projections due to Navy shipbuilding procurement rates which never materialized and impacts for future direct and indirect wage disputes.
- Contractor furnished equipment & material cost due to higher inflation rates than established indices.
- Government furnished equipment cost growth due to lower than projected procurement rates and concurrent development costs.
- Requirements and configuration changes due, in part, to computer obsolescence that occurs during the five to seven year shipbuilding construction cycle.
- Change order under-funding compared to empirical execution requirements.
- System engineering cost increases to achieve combat system integration, fleet interoperability, and open systems architecture requirements.

The investment strategy recommended addresses major issues facing U.S. shipyards as identified by the FMI report and the April 2002 ASN RDA report. The industry assembled these recommendations over the course of a few weeks. The short timeframe allowed for the identification of the relative priorities for significant change, but did not allow for more detailed discussion of execution options.

The U.S. shipbuilding industry is committed to improve productivity and support the Navy's need to maintain industrial capacity and key shipbuilding skills. The FMI report demonstrated progress and pointed to actionable solutions for Industry, Navy, OSD and joint action. *The plan herein provides broad consensus on an actionable plan – and agreement that the plan merits immediate action*. We encourage readers to participate in a joint effort to strengthen this vital industry.

THE EXECUTIVE CONTROL BOARD OF THE NATIONAL SHIPBUILDING RESEARCH PROGRAM

2 Executive Summary

2.1 Purpose

This document provides recommendations from the U.S. shipbuilding industry on actions to address findings in the FMI 2005 benchmarking report. This NSRP report was developed by engaging key experts with extensive experience in building and designing both warships and commercial ships across a diverse spectrum of U.S. shipyards. The objectives of the proposed investment strategy are to:

- Frame a set of actionable approaches by which the Navy ship construction program could be made more efficient.
- Vet a set of implementable priorities for a nationally integrated effort over 5-10 years incorporating a variety of approaches that would modernize the U.S. shipbuilding infrastructure (physical facilities, critical processes, specialized labor pool and unique tools – including systems and processes), resulting in a healthier and more viable shipbuilding industrial base.
- Establish priorities for potential implementation of the approaches examined.
- Estimate the resources required to implement each of the approaches examined.
- Consider the potential for using the NSRP-ASE to implement some of the various approaches.
- Identify DoD and Navy actions, policies and contract incentives to facilitate improvements to efficiency and modernization of the U.S. shipbuilding industrial base.

The recommended strategic framework focuses on the shipbuilding enterprise front-end processes highlighted by the FMI report as the biggest levers to effect improvement. Of note, many worthwhile recommendations considered were not included in the final prioritized recommendations due to an intentional focus on the highest leverage opportunities. The recommendations are defined at a level of detail that relies on a nationally-integrated effort to execute the framework provided. The strategy presented therefore assumes:

- An execution process that would employ a rigorous down-select process of specific detailed and individually priced proposals that would address interdependencies among the issues.
- Detailed specific project proposals will provide a much more fine-grained gauge for funding levels needed in each specific area – within the general allocations recommended herein.
- Leverage of the existing NSRP organizational structure and processes where appropriate.
- Provision for multi-year, multi-shipyard team projects where appropriate to the challenges.
- Provision for shipyard-specific investment through appropriate channels and mechanisms.
- A flexible cost share structure that recognizes the barriers posed by a strict cost sharing requirement.

2.2 A Framework of Five Strategic Thrust Areas

The investment framework described provides an integrated priority list to guide the cost-effective, goal-oriented investment of an estimated $267M program. The framework contains five strategic thrust areas that provide focus for concentrating improvements-strategies that address the capabilities, concepts, and practices required to enhance the long-term infrastructure improvements needed by the Navy to build ships in the future. The five thrust areas, in investment priority order, are:

- Design, Engineering and Production Engineering
- Production Processes
- Joint Navy/DoD/Industry Action
- Organization and Operating Systems
- Shipyard Outsourcing and Supply Chain Integration

These thrust areas compose a set of strategic focus areas to be managed and budgeted under a coordinated investment umbrella. Each is structured as a set of sub-elements that map the key areas of interest within a broad area of improvement. A detailed discussion of each of the 27 proposed sub-element investment areas is provided. These critical areas provide a roadmap for effective and efficient investment.

2.3 Prioritized List of Recommendations

Table 2-1 displays the 27 investment recommendations in priority order along with the recommended level of non-shipyard-specific investment.

	Thrust Area	Investment Strategy	Inv $M	Reference
1	**Joint Navy / OSD / Industry Action**	**Acquisition Strategy Stabilization**	**$ -**	Exec Summary
2	Design, Engineering and Production Engineering	Design for Production	$ 20.0	4.4
3	Production Processes	Eliminate Non-Value Added Production Activity	$ 8.0	5.4
4	Joint Navy / OSD / Industry Action	Eliminate Disincentives & Improve Incentives	$ 0.5	6.4
5	Organization and Operating Systems	Consolidate & Streamline Production Management Information Systems	$ 5.0	7.5
6	Organization and Operating Systems	Improve Shipyard Planning & Scheduling Systems	$ 5.0	7.4
7	Joint Navy / OSD / Industry Action	Streamline Navy Technical Oversight	$ 6.0	6.5
8	Design, Engineering and Production Engineering	Improve the Naval Ship Design Process	$ 8.0	4.5
9	Design, Engineering and Production Engineering	Elevate Production Engineering	$ 8.0	4.6
10	Shipyard Outsourcing and Supply Chain Integration	Apply Lean/Six Sigma Tools to Streamline Shipbuilding Supply Chains	$ 6.0	8.4
11	Production Processes	Expand the use of Module Building (Outfitting Packages)	$ 5.0	5.5
12	Production Processes	Balance the Use of Technology in Shipyards	$ 2.0	5.6
13	Production Processes	Develop & Implement Advanced Material Handling	$ 10.0	5.7
14	Production Processes	Develop Production Process Standards	$ 2.0	5.8
15	Design, Engineering and Production Engineering	Enable Enterprise Interoperability of Design & Production Data	$ 20.0	4.7
16	Joint Navy / OSD / Industry Action	Change Weight-based Cost Estimating Relationships	$ 1.0	6.6
17	Joint Navy / OSD / Industry Action	Manage Change Orders to Reduce Productivity Impact	$ 1.5	6.7
18	Design, Engineering and Production Engineering	Format Outfit Production Information	$ 1.0	4.8
19	Design, Engineering and Production Engineering	Improve Dimensional and Quality Control Tools and Practices	$ 2.0	4.9
20	Shipyard Org & Operating Systems	Optimize Manpower and Work Organization	$ 3.0	7.6
21	Shipyard Outsourcing and Supply Chain Integration	Eliminate Outsourcing Disincentives	$ 0.5	8.5
22	Shipyard Org & Operating Systems	Improve Production Control Processes	$ 5.0	7.7
23	Joint Navy / OSD / Industry Action	Support Domestic Shipbuilding Volume other than Military Ships	$ -	6.8
24	Shipyard Outsourcing and Supply Chain Integration	Outsourcing Strategies, Including Regionalization and Process Consolidation of Shipyard Work	$ 20.0	8.6
25	Shipyard Outsourcing and Supply Chain Integration	Enable Supply Chain Data Sharing	$ 1.8	8.7
26	Design, Engineering and Production Engineering	Rationalize Design Rule Methodologies on Naval Ships	$ 5.0	4.1
27	Joint Navy / OSD / Industry Action	Enable Resource Sharing Among Private / Public Shipyards	$ 0.5	6.9

TABLE 2-1: PRIORITY OF RECOMMENDED INVESTMENTS

In addition to the largely industry wide initiatives delineated in Table 2-1, there is the potential for substantial benefits from highly focused, shipyard-specific initiatives that would target infrastructure to directly support planned Navy Programs and/or strategic industrial base objectives. While it is recognized that some project authorization and contracting mechanism distinct from NSRP would have to be employed, the industry team estimated that $100 to $150 million dollars would be necessary for these efforts. A model for such projects is described in section 9 of this document.

2.4 Acquisition Strategy Stabilization – The Most Important Action

Commercial Operators use price competition to control the cost of the ships they buy. Competition is used by the Navy on many of the ships and craft they procure each year. Experience has shown that the low order quantity and specialization that has been developed for the major combatants has made pure price competition for the procurement of these highly capable capital ships difficult to achieve. For this analysis, the present procurement model of sole source and limited competition using a variety of Fixed Price Incentive and Cost Plus Incentive contracts is assumed for discussion purposes.

Of particular note is recommendation #1: Acquisition Strategy Stabilization – universally viewed as the most important issue – and by a large margin. The FMI benchmarking report concluded that the rate of improvement in U.S. yards has recently accelerated – in fact; the recent rate of best practice improvement in the U.S. exceeds that of leading foreign yards on average. Since the number of cycles per annum in naval shipyards is usually much lower than foreign commercial shipyards, achieving a comparable rate of improvement is particularly difficult.

While the FMI report and other metrics have repeatedly proven the business case for joint efforts in industrial base investment, reductions in the cost of building ships can best be realized by stabilizing shipyard workload by building ships in series, on which infrastructure decisions optimize manpower and facilities. The remaining 26 recommended remedies for the shipbuilding enterprise can and will provide significant return on the taxpayer's investments in building ships to the Navy, but none have the potential of this first and most significant issue.

The rising costs of ships can be attributed in part to the increased capability of today's ships and on the historically low order rates of ships today. Shriveling Pentagon orders for new ships have wide ramifications – including the domino effect into the industrial base. The Navy needs a level-loaded shipbuilding investment stream and acquisition and budgeting reforms, including multi-year procurement, economic order quantity, and other measures that would help to stabilize the production path and reduce the per-unit cost of ships while increasing the shipbuilding rate. Since the Navy is driven by manpower costs of naval ships – which are manned by far larger numbers than commercial vessels, reducing the number of crews is an essential aspect of the Navy ship design strategy. The consequence is more complex, costly ship designs that further aggravate cost by reducing the shipyard throughput.

Stabilization of the shipbuilding budget will impact virtually every aspect of ship cost. CEOs have repeatedly cited this as THE most important factor in containing ship costs. The unstable business environment impedes outsourcing and hinders facility investments, just to cite two examples. The NSRP strongly agrees that stabilizing the shipbuilding program is, *by far*, the single most important factor in improving the cost effectiveness of the program and in improving the health of the infrastructure over the long term.

Even if a 260-ship navy is the new strategy, 4 ships per year only support a navy half that size. Current build rates for ships are far too low to sustain the industrial base and meet operational requirements. This calls for significant, immediate and sustained increases in SCN appropriations to build, maintain and support the force structure required by the pace of operations and national strategy.

A more stable and predictable funding environment in which sea services and Congress provide industry with definitive direction to develop strategic long-range plans would have substantial impact on costs and infrastructure vitality; specifically:

- Greater commitment from the government to define and stay on course with major programs can reasonably be expected to improve affordability and help preserve the infrastructure.
- Expanded use of advance acquisition strategies (e.g., multi-year, block-buy, multi-year priced option buys for equipments and systems) coupled with innovative funding approaches such as time-phased appropriations will stabilize the SCN account and avoid disruptive funding spikes.
- The confidence that comes with this direction will allow for the major capital investments needed to improve productivity, allow for retention of skilled labor and advance the manufacturing process.
- A stable and reasonably predictable acquisition strategy will help maintain the design skill base and promote continuous performance improvement.

2.5 Strategy Development Methodology

The investment strategy developed over a six-week period focused on identifying, prioritizing and pricing a set of effective and efficient remedies for the most significant issues identified in a set of draft FMI reports provided to NSRP on January 17, 2005. The methodology used produced a solid consensus among the representatives for the U.S. shipyards who developed this report on the highest priority actionable recommendations. Many worthwhile, but lower priority, recommendations from the FMI report were not included.

A team of experts from U.S. shipyards led the process of reviewing requirements and current investments, collecting enterprise-wide corporate knowledge, assessing gaps, and defining an action plan. A large cross-section of industry and government stakeholders assessed strengths, weaknesses, opportunities and challenges to productivity and infrastructure modernization. Participants also identified and prioritized existing process and cultural challenges that limit introduction of new processes. The stakeholders then prioritized the benchmarking gaps and mapped them to an efficient, actionable investment portfolio. Each recommendation is described in terms of the issue addressed, actionable solutions, benefits of work to be expected, anticipated difficulties in pursuing the improvements, and an estimated cost of collaborative efforts that would precede individual shipyard implementation. Industry consensus was maintained by involving the broad industry membership of NSRP's Executive Board, Major Initiative Teams, and Ship Production Panels along with internal review by public and private members of the extended enterprise.

2.6 Key Attributes

The proposed strategy exhibits the following attributes:

- Emphasizes solutions that can impact the broad industrial base while providing for unique needs of Navy programs.
- Differentiates the attractiveness of solutions with applicability across multiple ship designs.
- Balances technology transition probability with the need for appropriate risks in innovation.
- Provides a technology portfolio in which diversification mitigates individual investment risks.
- Differentiates the appropriate roles for collaborative work versus subsequent platform-specific R&D funding.
- Recommends investments that shipyards who build naval vessels would employ on future Navy shipbuilding contracts.

2.7 Execution of Collaborative and Shipyard-Specific Initiatives

The recommended investment strategy includes initiatives in each of the defined thrust areas that tie the strategic vision to one of two types of investments; 1) industry research through collaborative R&D or 2) shipyard-specific remedies. Additionally, several related recommendations are included for federal government action that may not be priced as an 'investment'.

Whereas the collaborative shipyard initiatives apply throughout the entire U.S. industry, shipyard-specific remedies are identified for resolution of individual shipyard weaknesses or to tailor application of industry wide initiatives to a specific shipyard application. Section 9 describes the proposed model for shipyard-specific investments.

NSRP Recommendations for SIBIF

The shipyards and the Navy voiced concern that the ongoing NSRP program that is producing validated ROI not be unintentionally undermined by consideration of a shipbuilding investment fund. The next two sections articulate similarities and differences between NSRP and an envisioned shipbuilding investment fund.

2.7.1 NSRP and the Potential Shipbuilding Industrial Base Investment Fund

The recommended investment program includes some overlap with the existing NSRP program – but is also marked by important differences. NSRP was created by U.S. shipyards at Navy's request in 1998 to reduce the cost of building and maintaining U.S. Navy warships. NSRP is a collaboration of 11 major U.S. shipyards focused on industry-wide implementation of solutions to common cost drivers. The program targets solutions to consensus priority issues that exhibit a compelling business case to improve the efficiency of the U.S. shipbuilding and ship repair industry. Solutions include both leverage of best commercial practices and creation of industry-wide initiatives with aggressive technology transfer to, and buy-in by, multiple U.S. shipyards. A more detailed discussion is provided in Appendix A.

2.7.1.1 NSRP Attributes

- While NSRP efforts such as the Lean Shipbuilding Initiative® and Integrated Shipbuilding Data Environment clearly played a significant role in the accelerated improvement rate noted in the FMI report, constrained NSRP funding ($10M/year) limits aggressive pursuit of large scale challenges. If a shipbuilding investment fund profile allowed for larger, multi-year initiatives, the industry could become much more aggressive in tackling grand challenges.
- NSRP's scope of activity is intentionally very broad, ranging from environmental issues and workers compensation to IT system interoperability and eBusiness. The ability of the collaboration to flexibly tackle a wide spectrum of issues on short notice is enabled by the autonomy afforded by the Navy's arms-length oversight of the Executive Control Board.
- Industry executives make funding decisions and manage the program, enabling fast response times and considerable flexibility in operations.
- Results are measured by PEO assessments of cost reductions on current Navy programs, such that longer-term infrastructure improvement efforts are difficult to fund.
- NSRP scope does not include working in areas such as Navy processes and policy. Navy acquisition practices are generally out of scope.
- NSRP strongly emphasizes extensive collaboration where large teams work on collaborative projects that impact most, if not all, shipyards.
- Shipyard-specific projects are viewed as less desirable in NSRP competitions and are therefore infrequently funded. This inhibits investment in some worthwhile areas.
- The NAVSEA NSRP funding agreement precludes buying services or equipment, thereby inhibiting developments that are hardware intensive.
- NSRP's 50% cost share requirement screens out many worthwhile projects.

2.7.1.2 Shipbuilding Industrial Base Investment Fund (SIBIF)

A new Navy investment strategy could serve to supplement NSRP over the next several years by both increasing its ability to tackle large projects and by filling in the gaps where NSRP's current structure inhibits investment. To complement the existing program without undermining its effectiveness, the SIBIF should be designed and executed under SECNAV in a manner that:

- Includes action on Navy/OSD/Congress roles.
- Provides a larger, multi-year funding profile that will enable tackling of harder problems.
- Provides for shipyard-specific infrastructure improvements.
- Focuses more on the upfront processes involved in naval ship design.
- Provides a lower and more flexible cost share provision.
- Includes more direct federal government involvement in program investment decisions.

2.7.2 NSRP Potential Shipbuilding Industrial Base Investment Fund Execution Strategies

Subsequent to the initial submission of this report, the potential execution strategies and a funding profile were developed. These are presented in Appendix B to this updated report.

3 Investment Strategy Organization and Development Methodology

3.1 Investment Strategy Organization

The top priority issues identified in the FMI report constituted several distinct, thematically-related areas. The remedies exhibit largely similar groupings, which form five top-level strategic focus areas – called "Thrust Areas" in this document – as shown in Table 3-1.

Thrust Area	*Investment Priorities*	*Investment Est. ($M)*	*Paragraph Reference*
Design, Engineering and Production Engineering	Design for Production	$ 20.0	4.4
	Improve the Naval Ship Design Process	$ 8.0	4.5
	Elevate Production Engineering	$ 8.0	4.6
	Enable Enterprise Interoperability of Design & Production Data	$ 20.0	4.7
	Format Outfit Production Information	$ 1.0	4.8
	Improve Dimensional and Quality Control Tools and Practices	$ 2.0	4.9
	Rationalize Design Rule Methodologies on Naval Ships	$ 5.0	4.10
Production Processes	Eliminate Non-Value Added Production Activity	$ 8.0	5.4
	Expand the use of Module Building (Outfitting Packages)	$ 5.0	5.5
	Balance the Use of Technology in Shipyards	$ 2.0	5.6
	Develop & Implement Advanced Material Handling	$ 10.0	5.7
	Develop Production Process Standards	$ 2.0	5.8
Joint Navy / OSD / Industry Actions	Stabilize the Navy's Ship Acquisition Strategy	$ -	Exec Summary
	Eliminate Disincentives & Improve Incentives	$ 0.5	6.4
	Streamline Navy Technical Oversight	$ 6.0	6.5
	Change Weight-based Cost Estimating Relationships	$ 1.0	6.6
	Manage Change Orders to Reduce Productivity Impact	$ 1.5	6.7
	Support Domestic Shipbuilding Volume other than Military Ships	$ -	6.8
	Enable Resource Sharing Among Private / Public Shipyards	$ 0.5	6.9
Organization and Operating Systems	Improve Shipyard Planning & Scheduling Systems	$ 5.0	7.4
	Consolidate & Streamline Production Management Information Systems	$ 5.0	7.5
	Optimize Manpower and Work Organization	$ 3.0	7.6
	Improve Production Control Processes	$ 5.0	7.7
Shipyard Outsourcing and Supply Chain Integration	Apply Lean/Six Sigma Tools to Streamline Shipbuilding Supply Chains	$ 6.0	8.4
	Eliminate Outsourcing Disincentives	$ 0.5	8.5
	Outsourcing Strategies, Including Regionalization and Process Consolidation of Shipyard Work	$ 20.0	8.6
	Enable Supply Chain Data Sharing	$ 1.8	8.7

TABLE 3-1: INVESTMENT PRIORITIES WITHIN EACH THRUST AREA

These five strategic focus areas are envisioned to be managed and budgeted as part of a coordinated investment program. Accordingly, each of the thrust areas is in turn composed of a number of constituent sub-element investment recommendations, each of which may be funded at a variable amount. A total of 27 recommended investments were identified and evaluated. The 27 recommendations are listed in integrated priority order in Table 2-1 and by priority order *within each thrust area* in Table 3-1. Each is described in subsequent sections of the document following a standard format:

- Scope/Summary – Brief description of the thrust area and its significance
- Assessment/Weakness synopsis at the top level – Generalizations across thrust area
- Investment Strategy – Priority list within the thrust area
- Issue/challenge/weakness to be addressed; As-Is condition
- Description of each actionable recommendation/potential solution

- Benefits (Importance/Impact/Business Case Logic)
- Difficulty (Viability, Risk, Implementation barriers)
- Cost Estimate and basis

3.2 Investment Strategy Development Methodology

The most valuable ingredient of any programmatic decision-making process is the professional judgment of those who will be impacted in some way by the decision. The NSRP Executive Control Board assigned a Core Team of experts from their shipyards to lead the identification and prioritization of proposed remedies to the key issues identified in the FMI reports. After consulting with others in their shipyards, these representatives down-selected the most important areas to address, added definition to each issue, developed actionable approaches, and discussed the ideas with subject matter experts and leadership in each shipyard. Where the FMI reports provided symptoms that did not identify the root causes, the core team identified the causes and proposed remedies.

The proposed remedies were then the subject of a 3-day structured decision conference designed to elicit and apply the professional judgment of the participants to find (1) the best strategy for investing resources and (2) compelling rationale to support that strategy. The decision conferencing method engaged the participants in a structured debate about relevant facts and professional judgment concerning shipbuilding investment options. Professional judgment is the informed and considered assessment of explicit values, based on the participant's education, background, and relevant knowledge, tempered by experience, about the costs and expected benefits of competing budgetary initiatives. During the debate, assertions based on this judgment were required to be justified by articulated rationale, which was then challenged by other participants. Disagreement between the participants was encouraged as a valuable resource for vetting ideas. Challenges to the estimated costs or expected benefits of competing initiatives added definition and depth to the discussion, enhanced understanding, produced insight, and strengthened rationale. The mix of experts from a variety of disciplines and from eleven shipyards with different cultures and product lines was particularly valuable in this regard. The analytical approaches used are provable from the axioms of decision theory, including (1) probability theory and utility theory, (2) cognitive and behavioral psychology, and (3) engineering analysis and design methods.

3.2.1 Evaluation Methodology

Once the list of actionable solutions was reduced to the most significant issues, the Core Team assessed each based on each of several criteria: (1) expected benefit (2) expected difficulty and (3) estimated cost. For relative benefit and relative difficulty, each candidate investment was assigned scores on a scale of 0-to-100. For relative benefit comparisons, 100 represents the most beneficial and 0 the least. For relative difficulty comparison, 100 are the most hardest and 0 the easiest.

3.2.1.1 Benefit

The benefit rating was a *relative* assessment of a candidate investment's expected benefit, as compared to the potential benefit from other candidates. Benefit values are assessed on a *ratio scale*, and expressed as percentages of the highest-payoff candidate, with ties permitted. For example, if participants judge that the benefit from Candidate A would be only 20% as much as the benefit from Candidate B, the assigned benefit values are: Candidate A — 20**,** Candidate B —100**.** The ratio is 2:10. Note that throughout the conference, it is the ratios that are important, and not the numerical values. Ratios have no units.

To compute the total benefit potential of each candidate investment, contributing benefit sources were ranked according to their relative potential for meeting the goals for SIBIF – specifically:

- Make the Navy ship construction program more efficient.
- Modernize the U.S. shipbuilding infrastructure (physical facilities, critical processes, specialized labor pool and unique tools – including systems and processes), resulting in a healthier and more viable shipbuilding industrial base.

Benefits were considered from a variety of mechanisms, including:

- Stability and predictability of funding process enables industry to adapt in a controlled manner

- Stability and predictability of Navy planning process enables industry to adapt in a controlled manner
- Increased throughput/amount of work enables faster improvement feedback
- Predictability that enables Capital Expenditures (CAP-X) commitment
- Preserving surge capability
- Enable One Shipyard flexibility
- Level-loading manpower
- Reduced non-value-added costs
- Reduced non-value-added design complexity
- Reduced non-value-added process complexity
- Commonality of parts, components, sub-assemblies
- Lower lifecycle costs
- Sharing overhead costs with commercial customers
- Financial ROI multiples for candidate investments
- Rewarding innovation and good performance
- Surge capacity for new construction and fleet repair
- Ability to outsource effectively; e.g., End of Quarter, just-in-time contracts
- Achievable incentives – reward for superior performance
- Commercial competitiveness in selected sectors
- Reduced manpower fluctuation – ability to retain skilled workforce

3.2.1.2 **Difficulty**

The difficulty rating was a *relative* assessment of a candidate investment's expected difficulty, as compared to that of other candidates. Difficulty values were assessed on a *ratio scale*, and expressed as percentages of the highest-difficulty candidate, with ties permitted. For example, if participants judged that the difficulty from Candidate A would be only 50% as much as the difficulty from Candidate B, the assigned difficulty values were: Candidate A — 50; Candidate B —100. The ratio is 5:10. Note that throughout the conference, it was the ratios that are important, and not the numerical values. Ratios have no units.

To compute the total difficulty, contributing barriers were considered. The barriers included enterprise-wide factors involved in making the necessary changes, starting with industry but including Navy customers, DoD decision-makers on budget and policy, and Congress.

- Industry – facility constraints, contracts, disincentives, risk, payback time
- DoD/SECNAV – acquisition policy and regulations
- NAVSEA – technical and contracting authority
- Congress – funding practices such as opposition to multi-year buys

Common sources of difficulty considered in implementing changes across the enterprise members were:

- Policy
- Regulations
- Culture
- Limited investment pools

Once the team had developed a set of actionable remedies, they examined each in terms of potential benefit, difficulties in execution, and estimated investment level requirements. They documented the findings for review within the shipyards.

3.2.1.3 **Cost Estimate**

The estimated investment requirement, or cost, was an *absolute* assessment (in millions of dollars) of the total estimated funding for a candidate investment over the period of planned investment. These estimates were based on experience in similar investments over the past 5 years and represent only the widely-applicable collaborative work leading to implementation. An overall estimate of $121M for shipyard-specific implementations was made and separately explained – again based on a list of comparable investments by shipyards in recent years.

3.3 Benchmarking Reference Terminology

The SIBIF core team generally accepted the conclusions and recommendations of the Benchmarking, since they match, for the most part, the team's own perceptions and experience. The Benchmarking results were used by the core team in formulating their investment strategies. The First Marine International (FMI) benchmarking methodology utilizes a system of related *Best Practice* assessment elements, grouped in shipyard-specific families, rated on five levels of use, assigned a “level of technology mark”. In broad terms, the levels of use of *Best Practice* correspond to the state of development of leading shipyards at different times over the past 30 years. For purpose of survey comparison, the shipyard-specific families are designated by title and as ‘A’, ‘B’ or ‘C’, etc., with the specific elements assessed assigned by title and a numeric ‘1’, ‘2’, or ‘3’, etc.. For example, the steelwork production family element titled as plate stockyard and treatment would also have the designation of ‘A1’, commonly seen as (A1) in print in the FMI Benchmarking Survey Reports.

The SIBIF document utilizes the elements of the FMI Benchmarking System. The SIBIF Core Team evaluated the FMI Benchmarking Survey, and assimilated the elements into related families, identified as SIBIF Thrust Areas. Each Thrust Area has a compact list of specific elements related to that Thrust Area, identified by the ‘A1’, ‘G3’, etc. Additionally, the SIBIF Core Team developed several other investment candidates that are similar in nature to the FMI Elements but are not covered in the FMI Benchmarking System. These were industry inputs and assigned to one of the five SIBIF Thrust Areas for development and use.

3.4 Interdependencies and Sequencing

Interdependencies refer to either synergies or unintentional duplication among recommendations within or across thrust areas, or to sequencing constraints that require one action to precede another. Interdependencies are handled in the execution phase of the envisioned SIBIF.

4 Design, Engineering and Production Engineering

4.1 Scope/Summary

The focus of the Design, Engineering and Production Engineering thrust area is to identify opportunities for improvement in the processes, tasks, tools and data associated with product definition throughout the product life cycle. For the purposes of this review, the term "product definition" included the efforts to determine and document required performance, configuration and material characteristics and the development of information/data to support construction, operation and maintenance activities. In this context, the life cycle extends from Requirements Definition through Initial Design (i.e. Concept Formulation), Functional Design (i.e., System Design), Transition Design (i.e., the transition from System-orientation to Spatial-or Product-orientation), Detail Design (i.e., the development of Production Information (PI) for manufacturing and assembly) and Test and Acceptance.

This is the largest and most complex thrust area proposed for the SIBIF program. Major emphasis areas are summarized below:

- Design for production to reduce production costs to a minimum, compatible with the requirements of the vessel to fulfill its operational functions with acceptable safety, reliability and efficiency.
- Change design processes for naval vessels to exploit the shipyards' advanced capabilities by streamlining the process to enhance productivity.
- Emphasize the Production Engineering function to define and catalog preferred production standards, so that once a production engineering solution has been arrived at, Computer-Aided Design and Engineering Systems can incorporate them as standard practice.
- Develop interoperability methods to seamlessly tie in the various systems thus facilitating the good design and allowing iteration towards the best design.
- Provide common tools and best practice for dimensional and quality control.
- Format outfit production information to produce workstation information tailored to new outsourcing strategies.
- Rationalize the definition, documentation and implementation of applicable commercial rules on naval vessels.

4.2 Assessment

FMI reported that the U.S. industry's use of best practice rating compared favorably with the international competition, coming out ahead in five of the nine sub-elements of Design, Engineering and Production Engineering. However, with an overall section rating average of 3.59, the U.S. industry is measurably behind the international shipyards that have an overall section average of 3.83. A February 2005 GAO report on shipbuilding noted that the lack of design maturity when construction begins is a key source of naval vessel cost growth.

The depth and quality of design and engineering information developed by the U.S. shipyards is equal or superior to that of the international yards. However, the man-hours expended and cycle times of the U.S. yards are substantially higher than the international competition and there is significantly less emphasis on design producibility (designing for shipyard production attributes and constraints). FMI noted that the legacy Navy designs and gaps in creating new designs that are far more complex than commercial vessels contribute to the performance differences. The extraordinary degree of customer involvement in all aspects of naval ship design makes the challenges of improving these processes dependent on multi-organization joint efforts to change traditional practices that are deeply embedded in the enterprise culture.

The design processes for today's complex ships require the ability to integrate the requirements, not only for design, but for manufacturing and life cycle. The design process for U.S. Navy ships is required by the customer to predict, early in the product development process, the life-cycle requirements of a ship design and the life cycle impacts of design changes. Ignoring these downstream issues leads to poor decisions and product designs that cause unforeseen problems and rework. Accurate predictions enable a product development team to create a superior design that performs satisfactorily in all ways.

4.3 Investment Strategy

The top investment recommendations in this thrust area are listed in priority order in the table below:

Design, Engineering and Production Engineering					
Investment Priorities	*GSIBBS Reference*	*Paragraph Reference*	*Relative Benefit*	*Relative Difficulty*	*Investment Est. ($M)*
Design for Production	F7	4.4	100	100	$ 20.0
Imrpove the Naval Ship Design Process	F1	4.5	80	100	$ 8.0
Elevate Production Engineering	F6	4.6	80	87	$ 8.0
Enable Enterprise Interoperability of Design & Production Data	--	4.7	55	67	$ 20.0
Format Outfit Production Information	F3	4.8	50	56	$ 1.0
Improve Dimensional and Quality Control Tools and Practices	F8	4.9	50	20	$ 2.0
Rationalize Design Rule Methodologies on Naval Ships	--	4.1	25	13	$ 5.0
				Total	$ 64.0

4.4 Design for Production

4.4.1 Issue/Challenge

4.4.1.1 The Design for Production (DFP) Concept

DFP comparisons relate to the degree that ship designs consider production process considerations to enable highly efficient manufacturing and assembly. The objective of focusing on producibility in the design phase is to reduce production costs to a minimum, compatible with the requirements of the vessel to fulfill its operational functions with acceptable safety, reliability and efficiency. The extension of the design process to include the DFP activity has the following objectives:

- To produce a design that represents an acceptable compromise between the demands of performance and production and, where appropriate, takes into account the needs of overhaul, repair and maintenance.
- To ensure that all design features are compatible with known characteristics of the shipyard facilities.
- To apply the individual design for production principles and procedures insofar as they are relevant to the particular vessel and to the particular shipyard where the vessel is to be built.
- To coordinate the inter-relationship between the machinery, electrical and outfitting work with the structural work, in order to create a fully integrated design model.

DFP requires formalizing the shipbuilding strategy, including subcontracting and teaming aspects. The design should facilitate the strategy and ensure that each element of the design optimizes manufacturing and outfitting processes. Optimization includes use of standard and commercial off the shelf (COTS) parts, the right amount of oversight, and establishing process control requirements. Consequently, it is vital that DFP efforts start early in the design process. The designer has the greatest influence on the cost of the vessel during the earliest design stages when primary parts, materials and equipment and the basic configuration are being decided. The influence the designer has on cost drops off quite rapidly in the later design stages.

4.4.1.2 DFP Comparisons

In the area of Design for Production, U.S. yards' average rating of 3.00 was considerably lower that the 3.93 average in international yards.

FMI concluded that it is more difficult for U.S. yards to realize the full benefits of recent advancements in their appreciation of DFP principles since most U.S. yards are currently building to legacy designs (i.e., designs developed three or more years ago). However, insufficient appreciation remains for the importance of capturing production knowledge and defining facility constraints, imbedded requirements and attributes that can be factored into design parameters to optimize production performance. Not only has the continued use of legacy designs minimized the opportunities for applying DFP principles and methods, but also the relatively high turnover of design and engineering staff in many U.S. yards means there is often a loss of DFP knowledge during lengthy gaps in design activity. As a result, U.S. shipbuilders have had limited experience in DFP, while foreign shipbuilders and other world-class manufacturing industries made great strides in the development of DFP techniques, in part through the application of lean principles. Today, typical DFP applications in foreign shipyards include emphasis on design optimization to minimize material and work content, standardization and reduction of part count, design for self-alignment, and the application of group technology. These and other approaches, coupled with experience with a large number of similar ship designs, have allowed foreign shipbuilders to significantly reduce both material and labor content in today's world-class commercial ship designs.

FMI's discussion of customer factor as a key determinant in productivity is especially relevant in comparing DFP practices and its relative priority vis-à-vis other design criteria. The benchmarking conclusion that the DFP function is a much lower priority in U.S. naval vessel designs as compared with leading foreign yards is affected by factors such as:

- Federal customer *acquisition strategy* – one program may use a cost reimbursable contract for detail design, followed by a separate contract for ship construction. Implementation of Design for Production on this program would be substantially different than on a program using a single lead ship design and construction contract.
- Federal customer *design strategy* – one program may prioritize ship's life cycle cost over construction cost; another program may prioritize a set of unique performance factors over the construction cost. DFP implementation on these programs would be substantially different than on a program with construction cost as the highest priority.
- *Multi-yard procurements* – U.S. shipyards are often participants in, whereby one shipyard is the lead yard and responsible for design development, while the follow yard is essentially limited to construction of a certain number of the ships. Design for Production indicators observed in the follow yard would, in fact, reflect on the design performed by the lead yard.

4.4.2 Actionable Solutions

4.4.2.1 Producibility Upgrades of Legacy Designs

Consider more frequent producibility reviews/upgrades of legacy designs to facilitate the development of DFP guidelines and to maintain the national design knowledge base.

4.4.2.2 Detailed Benchmarking of Navy Design or Process

Perform a more extensive benchmarking analysis of recent Navy designs and design processes. This benchmarking will identify and verify best practices to be used in future design work. Educating the customer on the impacts of DFP tradeoffs will enable them to make more informed decisions on future designs.

4.4.2.3 Adopt Product-Oriented or Activity-Based Cost Estimating Models

Develop and implement product-oriented or activity-based costing models that accurately reflect the productivity improvements associated with the application of DFP principles as well as facility and production process improvements. Current weight-based cost estimating methodologies are insensitive to DFP principles as well as facility and production process improvements, and in fact, they often result in complex designs that are expensive to produce based on the fallacy that weight reduction equates to cost reduction. The Product-Oriented Design and Construction (PODAC) cost model developed under the Navy's Mid-Term Sealift Technology Development Program offered significant promise but was discontinued prior to validation/acceptance.

4.4.2.4 Pilot DFP Implementation Program and Develop DFP Standards

Develop a pilot DFP implementation program as a collaborative effort between the Navy and the shipbuilder, to run concurrent with a naval shipbuilding program. The dedicated DFP team would be tasked to identify DFP opportunities, quantify the associated costs and benefits, and make periodic recommendations as to what changes/improvements should be implemented, when they should be implemented, and how the costs and benefits should be shared between the Navy and the shipbuilder. A function of this pilot would be to develop standards and update the NSRP DFP Manual.

4.4.2.5 Pre-Contract DFP Analysis/Assessment

Consider requiring shipyards to provide a DFP analysis/assessment as part of their proposal for a detail design and construction contract. The analysis/assessment should be required to be performed in accordance with a purpose-built DFP implementation template and checklist, to ensure that all opportunities for applying DFP principles/techniques to achieve cost and cycle time reductions have been investigated and that the resulting design reflects the value-engineered application of world-class DFP practice. Incorporate standards into the NSRP DFP Manual.

4.4.2.6 Prioritization Considerations

4.4.2.6.1 Benefit

It is generally well recognized that application of DFP principles has great leverage on overall ship production cycle time and cost. Maximum leverage is realized when DFP is applied in a thorough, rigorous, and systematic manner at the earliest stages of the ship design process, when whole-ship and functional design characteristics can be affected without incurring re-work of downstream design/engineering efforts. The importance of DFP as perhaps the single-most influential approach to reducing ship production cycle time and cost was recognized by all U.S. shipyards in making it the focal topic of the NSRP's 2004 joint all-panel meeting. Estimates of the potential benefit (on ship production cycle time and cost) of DFP, when applied throughout the design/engineering process, range from 10 to 25% (even higher in some cases). The potential benefit of applying DFP principles decreases rapidly as a design matures, but the cost-benefit typically justifies application periodically during a multi-ship production run.

4.4.2.6.2 Difficulty

For U.S. naval shipbuilding programs in which extensive design/engineering data is required to document the as-built condition and to support life-cycle operation and maintenance, the engineering re-work cost associated with applying DFP in periodic design upgrades will diminish the cost-effectiveness that would be realized on commercial shipbuilding programs. Also, the fact that ships are incrementally authorized and funded in a "long-term" naval shipbuilding program, causes the shipbuilder to justify the engineering re-work cost for a DFP upgrade over the number of ships that are assured, rather than the total number that may ultimately be built to the upgraded design.

4.4.2.6.3 Cost Estimate

$20M. Implement collaborative work that will apply to the *entire* shipbuilding industrial base. Since each shipyard utilizes its own design/production tools, much of this effort needed in DFP would be shipyard-specific implementations. Additionally, the proposed 'Production Information Systems' area is likely to lead to a common interface application thus enhancing the portability of Design for Production information without significant interface costs added to the 'Design for Production' investment line.

4.5 Improve the Naval Ship Design Process

4.5.1 Issue/Challenge

Note: Design for Production is treated separately in this document due to the particular importance of that one aspect of the overall design methodology that heavily influences production productivity. This section addresses other aspects of the design process that impact the efficiency of the broader ship design process.

U.S. shipyards scored higher (average rating of 3.92) than the international yards (3.86) in the depth and quality of design and engineering information use. Increasingly capable ship design tools (e.g., CAD/CAM systems for the creation of product models) have enabled a product model-based design process that offers considerable downstream benefit, providing the information and data required to support purchasing, manufacturing integrated outfitting, objective quality evidence and post delivery maintenance. Despite these advances, the man-hours and lead times associated with U.S. naval vessel designs are substantially higher than in leading foreign commercial shipyards. FMI concluded that U.S. design practices offer considerable opportunity for productivity improvement.

FMI concluded that the low and erratic frequency of new U.S. designs leads to atrophied design capability and high first-of-class drop off. The continuing use of legacy designs for a number of years means that new design methods and techniques aimed at reducing lead times and improving producibility are not introduced as frequently as in the international yards where even repeat designs are regularly reviewed and updated. Legacy naval designs have not been significantly modified and do not reflect the advances in production and design technology, such that the shipyards and government continue to carry the productivity burden of dated legacy designs. The combined effects of long series build programs for naval classes such as the DDG and repeated postponement of new classes (such as the Arsenal Ship-DD21-DDX progression) are long gaps in U.S. shipyard design programs. The ensuing loss of design staff makes it difficult to retain design expertise and build corporate experience. The traditional system-oriented design organization and approach used in many U.S. yards, has exacerbated the difficulty in recruiting and retaining appropriately skilled design personnel.

4.5.2 Actionable Solutions

4.5.2.1 Routine Design Upgrades of Current/Legacy Programs

Consider more frequent design upgrades to reduce the productivity burden associated with legacy designs, smooth the design load, maintain the national design capability, and promote continuous performance improvement. The partial re-design of legacy vessels to incorporate continuous productivity improvements will also serve to promote and support the implementation of modern design organization and strategy that will benefit subsequent new designs.

4.5.2.2 Acquisition Strategy Impact

Change current acquisition strategy to maintain design skill base and promote continuous performance improvement. The engineering staff of major Asian shipyards typically spend less than half of their time supporting ship-specific design development activities, with the bulk of their time devoted to improving product design standards (i.e., standard interim products aligned with target markets and the shipyards' existing or planned production processes and facilities), material standards (for purchased equipment and outsourced manufactured components), and process standards. Shortening the gap between designs not only supports the retention of experienced personnel having "corporate memory," but it also supports the focusing of those personnel resources more toward improvement efforts that will have long-term benefit over many future design projects, rather than ship-specific or class-specific design issues.

4.5.2.3 Design/Engineering Process Improvement

Create and maintain a collaborative environment for the improvement of design/engineering processes. This initiative would apply approaches such as Integrated Product and Process Development (IPPD) and NSRP's Extended Lean Enterprise model to reduce the cost and cycle time of design/engineering as well as downstream planning, material procurement, and production activities. This would build on the NAVSEA "Task Force Lean" initiative, extending it to include the entities in the design/engineering value chain for naval shipbuilding programs, e.g., NAVSEA, Military Sealift Command (MSC), SUPSHIPS, INSURV, shipbuilders, major equipment suppliers/integrators, design agents and regulatory bodies (e.g., American Bureau of Shipping and USCG). Representative processes that could be addressed and improved in this collaborative environment include: requirements definition process (including referenced specs and standards); contract/specification compliance program; equipment/material approval process, technical review and approval process, test/trials/acceptance process, and the change order process.

4.5.2.4 Design Tool Development and Validation

Create and maintain an inventory of design/engineering/analysis tools, their verification/validation status, and range of applicability. The objective of this initiative would be to ensure that those who develop design/engineering data, review the data, and approve the data are all in agreement regarding the acceptability of the methods and tools that are utilized. A secondary objective would be to identify, prioritize and support the development of new and/or improved tools and methodologies to expedite design development, integration, configuration management/control, and the synthesis of design/engineering, material procurement, cost estimating, and production planning functions.

Efforts might include the development of whole-ship and system-level parametric design models, performance prediction tools (e.g., computational fluid dynamics techniques, compilations of model test or analytical data), simulation-based design techniques capability to optimize manning, material and scheduling (including facilities), and other tools to expedite design/engineering development. Also included are the development and application of overarching design strategies such as the configure-to-order (vis-à-vis engineer-to-order) design approach and the associated development of re-usable design/engineering data for families of standard interim products, modularity/commonality and open architecture approaches.

This initiative will serve to coordinate and integrate tool development across the shipbuilding enterprise, eliminating overlapping development efforts and minimizing the number of alternative tools for a particular function or task. Common tools in areas such as lofting and accuracy control would also facilitate the Navy's One Shipyard vision for a flexible, interoperable enterprise.

4.5.2.5 Expand Design Yard Utilization

One strategy to partially compensate for gaps in design capacity utilization is to utilize design yard resources in non-traditional roles such as broad program management or task specific support including but not limited to: performance of planning yard tasks; support to Navy laboratories; performance of analysis and tradeoff studies; support Navy headquarters independent reviews of technical data, complementing the Navy's role as smart buyer/owner. Several historical examples illustrate and reinforce this concept. Design yards would be more broadly characterized as 'Centers of Expertise' and costs would be reduced through elimination of duplicate personnel facilities, and learning curves, and lower rates at the design yards, through efficiencies resulting from a stabilized technical workforce.

4.5.2.6 Prioritization Considerations

4.5.2.6.1 Benefit

The industry concurs with FMI's assertions that improvements in this area offer significant leverage, as design drives 85% of ship cost.

4.5.2.6.2 Difficulty

Significant organizational and cultural barriers associate with all actionable solutions. These areas remain particularly difficult to address because the Navy shipbuilding enterprise is a capability-driven culture composed of many layers of decision-makers.

4.5.2.6.3 Cost Estimate

$8M. For collaborative work, plus shipyard-specific implementation of common tools for areas such as such as lofting and accuracy control.

4.6 Elevate Production Engineering

4.6.1 Issue/Challenge

FMI reported that Production Engineering in U.S. shipyards lags seriously behind international yards. With an average rating of 3.33 compared with 4.07, the role of production engineering in the majority of U.S. shipyards is not as well developed as it is in the foreign yards surveyed. Leading foreign shipyards consistently place much stronger emphasis on Production Engineering, giving it the leading role in performance improvement and facility development activities to realize the best possible performance on current contracts and to achieve continuous performance improvement. Over the last 10 years U.S. shipbuilders have developed a wide variety of commercially producible ship design standards. Recognizing the potential benefit, the Navy has increasingly attempted to adopt commercial standards and performance requirements where practical. While pure combatant ship designs continue to present producibility challenges that arise as a result of mission capability requirements (i.e. speed, weight, survivability, design density, system redundancy, radar detection, etc), "hybrid" commercial / military designs have introduced some new challenges. Multi-mission ships with selective military requirements present their own unique producibility hurdles. Whether pure military or hybrid commercial/military, producibility limitations are built into the very earliest design requirements and criteria. Of primary importance in this report, is the recognition that the Production Engineering challenge for naval ship design and construction, is not one that can be solved by the shipyards alone. Significant joint industry/government cooperation will be required to make substantive gains in the production engineering arena.

4.6.1.1 Role of Production Engineering

Production Engineering is the definition and organization of preferred production standards for product, methods and industrial engineering into readily accessible libraries of best practices, so that once a production engineering solution has been arrived at, the designer can employ those standards to produce design details which can be efficiently produced.

4.6.2 Actionable Solutions

4.6.2.1 Business Case Analysis

Develop a pilot program based on more extensive benchmarking analysis and adopt best practices. Develop a detailed set of production standards and determine process reengineering requirements. Evaluate production and design tools, incorporate lessons learned and implement organizational structure.

4.6.2.2 Prioritization Considerations

4.6.2.2.1 *Benefit*

Productivity improvement through process improvement and bridging organizational boundaries provides very high leverage for minimal investment in training. The difference between no Production Engineering (benchmark score of 0) and mature/integrated Production Engineering functionality (benchmark score of 5) is estimated to represent a 20-30% difference in total production labor cost.

4.6.2.2.2 *Difficulty*

Some level of production engineering is on going in most U.S. shipyards building commercial and naval vessels. Full implementation on navy programs would require a major culture shift where the customer would require assessment of production cost as well as technical adequacy during ship design and when evaluating several possible solutions to a design problem.

4.6.2.2.3 Cost Estimate

$8M to develop a pilot program, write draft standards and test them in production.

4.7 Enable Enterprise Interoperability of Design and Production Data

4.7.1 Issue/Challenge

To move to outsourcing and streamlined inter-organizational processes, tools are needed to facilitate it. Enterprise-wide agreement and use of interoperable processes, tools, and procedures (IT format) will result in lower costs of Navy ship construction by reducing training costs, standardizing testing and certifications, and enabling the sharing of manpower, facilities and workload. Typically each program tailors its own integrated product data environments (IPDE) to its program requirements, team member work practices, and team member business relationships. Each IPDE development takes advantage of the latest hardware and software developments. Interoperability among components has been achieved by ad-hoc interfaces specific to the systems involved. The net result of this approach has been:

- Duplication of development effort
- 8-10 partially integrated systems that are not interoperable with others
- Annual integration expenses of $10M - $30M for each major program
- Multiple incompatible systems at each shipyard

Additionally, the rate of change of information technology is high. The life cycle of a major software component is typically 5-10 years versus the typical 50-year life cycle of a ship class. Because of this:

- Software components, and even operating systems, fade from common use and are no longer supported by their vendors.
- It becomes difficult to locate staff with requisite skills and background.
- Historically, shipbuilders have changed out every IPDE component every ten years.
- Programs have experienced problems with system obsolescence during class construction.
- Some shipyards have found valuable product information inaccessible for follow ship development due to its being archived in defunct formats.

Interoperability is needed to facilitate the real-time electronic access to design, configuration, modeling/simulation/visualization, scheduling, and cost information. The underlying business process which we rely upon to provide an up-to-date “model” of a ship is typically unique for each class of Navy ship, with a few common elements across classes. The business process is also typically made up of participants who operate somewhat independently, leading to redundant data and significant data configuration management and access issues.

To buy more ships and to support the ships we have within foreseeable budgets, interoperability will facilitate the elimination of redundant data, long acquisition processes, and inefficiencies in direct support of all stakeholders. The heart of the issue is the business process. The extent of the need for technical interoperability solutions will be driven by process. Fundamental enablers such as the access to information, ability to agree on open standards, and leadership of change in multi-layered processes across multiple industry and government organizations must be accomplished. Cultural resistance is, and will continue to be, great throughout many levels of these organizations.

Interoperability is also needed to facilitate the integration of lofting functions with CAD systems; there still remains some use of traditional techniques and a transfer of information between systems. All the U.S. yards appreciate the shortfalls and are actively developing their CAD systems and design methods to fully integrate lofting activities in the engineering process.

Interoperability is also needed to facilitate shipyards sharing work on Navy shipbuilding contracts by teaming or subcontracting. Since shipyards have data requirements embedded in their manufacturing and assembly processes, product model technology must be available to transfer or integrate product model data between shipyards. Common specifications/standards for electronic data (content and format) should be established. Standardization of product data will enable shipyards to develop necessary translations/applications to import design data that conforms to the specifications/standards (regardless of the origin) into their current (or future) data systems.

Finally, interoperability will also facilitate implementation of Production Management Information Systems and Supply Chain Data Sharing Requirements.

4.7.2 Actionable Solutions

4.7.2.1 Establish Enterprise-wide Access to Ship Design Data

Establish the capability to provide real-time electronic access to design and current ship configuration data throughout the life cycle. Industry and the Navy would use this capability to accomplish Life Cycle Support during any stage of a ship or combat system life cycle. NAVSEA, in cooperation with private industry, needs to establish agreed-upon criteria for Best Value Life Cycle Support. In addition, standard integrated processes must be developed that incorporate the capability and consequent knowledge gained from access to cost, schedule, design, modeling/ simulation/visualization data from requirements generation through disposal. Standard life cycle electronic data format specifications for interoperability and access to current ship configuration data throughout the life cycle of the ship must be developed. Identification of life cycle data elements and lifetime support requirements that are relevant to the design/development process must be identified to allow for the integration of those tasks. Provide a standard set of services to the Fleet through electronic connectivity to pertinent data.

- Include OPNAV, the Fleet, Program Executive Offices (PEO) and regulatory organizations in selecting the common processes.
- Leverage the common processes already in use within the Enterprise (SHAPEC, SMWG, AMP, and 688 class Submarine Factory) and identify/develop best practices.

4.7.2.2 Prioritization Considerations

4.7.2.2.1 Benefit

Benefits are as follows:

- Enables opportunities for significant business process improvement
- Allows contractor to choose the appropriate tools yet provides access and/or common format to benefit the enterprise
- Focuses resources on the adoption of a single approach and common standards data access and interchange rather than multiple independent and redundant efforts
- While credited with major cost reductions in design and manufacturing, integrated product data environments (IPDE's) pose a significant software development/integration challenge and expense IPDE cost for a major shipbuilding program can total $150M to $200M, of which 45-55% is for integration planning, information engineering and interface software development
- Reduces total ownership costs
- Enables sharing of manpower, facilities, workload

4.7.2.2.2 Difficulty

Implementation considerations are as follows:

- Requires cultural change within Navy/Industry Enterprise
- High-level leadership required
- Requires close Navy/Industry coordination to manage common architectures (definitions, process, information, technical) to guide future development
- Requires policies and guidance, with standard contractual language to enact
- IT interoperability
- Implementing and maintaining interoperable tool, process and procedures will require a significant resource commitment.
- Standardization can stifle innovation; steps should be taken to ensure that innovative new processes can still emerge.
- Complexity/scope of standardization commitment is too large.

- Scalability to suit platform type and facility requirements

4.7.2.2.3 Cost Estimate

NSRP recently completed an assessment of the resources needed for this work at the request of NAVSEA 05. Funding in the amount of $20M is required to complete the maturation of shipbuilding product data standards to the point of deployment on Navy designs, which will be funded as an element of the normal acquisition contracts. Relevant factors are as follows:

- NSRP has several related projects that provide insight into the costs of addressing these issues: Outsourcing Pilot, Shipbuilding Partners and Suppliers Supply Chain Virtual Enterprise (SPARS), Integrated Shipbuilding Environment **(**ISE), Component Factory, Standard Terms and Conditions.
- Limited activity in process via NSRP ISE and SPARS projects
- Recently completed NSRP Product Data Interoperability (PDI) study estimates $20M

4.8 Format Outfit Production Information

4.8.1 Issue/Challenge

In the area of outfit production information, the U.S. yards were fractionally better than the international yards with an average rating of 3.58 compared to 3.57. However, discussions indicated that all the U.S. shipyards adopt a block and zone-based composite format for information rather than a product-oriented concept. Most U.S. shipyards surveyed were currently mid-way or nearing the end of a long series of vessels in the same class and it is believed that, given the approach to developing production information, this may partially account for the closeness in the scores.

With respect to levels of design maturity and advanced outfitting definition, U.S. yards place a high reliance on production feedback over a series of vessels to progressively develop and improve the production information whereas the international yards achieve similar levels of production information on the first-of-class.

Traditional composite outfit production information formats are used in many yards. Outfitting methodology has tended to be driven by production from experience gained over a series of vessels rather than from a clearly defined production methodology developed and implemented in full for the first-of-class. This means that it has often not been possible to produce workstation information tailored to a predetermined outfitting strategy.

4.8.2 Actionable Solutions

4.8.2.1 Define Outfit Information Data Architecture

Develop a general methodology to reformat outfit production information to provide information specific for all stages of construction with a minimum level of information on new designs.

4.8.2.2 Prioritization Considerations

4.8.2.2.1 Benefit

Production information is considered to be one of the most important design development data requirements. First-of-class construction cost savings for fully outfitted modular construction are estimated at 20-30%.

4.8.2.2.2 Difficulty

First-of-class full-up outfitting is achievable when utilizing advanced design tools and design management methodology such as the IPPD Process Implementation will require a shifting of contract costs from acquisition account (SCN) funding to R&D funding which is not always viable for the Navy authorization process from a timing perspective, as well as a re-sequencing of design priorities. Long lead time material requirements change since parts and components are installed earlier in units than may have otherwise been installed in downstream construction where utilizing more traditional work sequencing.

4.8.2.2.3 Cost Estimate

$1M. Develop collaborative efforts and document best practices methodology to accelerate subsequent implementation by individual shipyards.

4.9 Improve Dimensional and Quality Control Tools and Practices

4.9.1 Issue/Challenge

Although there has been a recent focus on the implementation of accuracy control (AC) and quality control (QC) procedures in many U.S. shipyards, there still remains a significant gap in the use of best practice between the U.S. average of 3.50 and the international average of 4.14.

Accuracy control involves the use of statistical techniques to monitor, control, and continuously improve shipbuilding design details and work methods so as to maximize production. The focus of modern manufacturing methods is on building in quality while in process rather than attempting to inspect it into the completed product.

Accuracy control and the benefits that can be gained in terms of reducing cycle times and rework has been the subject of numerous papers and seminars in the U.S. for over 15 years. Nonetheless, there appears to be some lack of understanding of the real costs of poor accuracy and quality within the U.S. shipbuilding industry.

Although most shipyards have firmly established AC and QC departments, a low level of confidence in the statistical accuracy control techniques results in the continuing practice of added material that results in production rework. By comparison, leading international yards have adopted a total quality approach and no longer have dedicated AC and QC departments. AC and QC requirements are fully integrated into all pre-production and production activities with cross-functional teams meeting at regular intervals to discuss problem areas.

U.S. naval shipbuilders have not historically focused on the employment of dimensional control efforts to ensure dimensional accuracy at the block, module, and even pipe levels. In contrast, Asian shipyards have effectively engineered out shrinkage allowances to eliminate extra stub pipe sections at block joints or having to cut block edge steel twice (once when the panel is made, and then again when they're welding one block to the next). The lag in application of accuracy control is rather extensive. A significant disparity is in the use of statistical process control to establish process capabilities. Another major disparity is the use of work teams and organizational approaches to involve workers in the continuous improvement of shipyard processes, identifying quality issues within a workstation, and helping to identify and implement countermeasures. To a lesser degree, but still important, are specific technical tools like weld distortion prediction, dimensional control, and in process, advanced measuring techniques.

In leading foreign yards, the use of accuracy control techniques ensures that steel parts are cut to required tolerances that minimize scrap and the need for final trimming. This also significantly reduces rework and enables the building of large ship sections with minimum distortion and without the need for trimming excess material at erection. All of these advantages equate to reduced cycle time and lower material and labor costs.

4.9.2 Actionable Solution

4.9.2.1 Develop and Prove the Business Case for Accuracy Control in U.S. Yards

Develop a center of excellence that applies technology to actual cases for shipbuilders. Outside sources of technology will be utilized for developing a center of excellence for specific shipyard applications. Identify tools and processes that are well-suited to naval shipbuilding applications. This will instill in production management confidence in the capability of accuracy control procedures to successfully eliminate inherent process rework.

4.9.2.2 **Prioritization Considerations**

4.9.2.2.1 Benefit

Accuracy control information is considered to be one of the key production plan data requirements. Accuracy control facilitates manufacturing off hull components at remote locations and eliminates costly trial pairings. Large assemblies can be precut prior to installation based on as built data. First-of-class and follow on ship construction cost savings are significant for a fully integrated accuracy control measurement plan.

4.9.2.2.2 Difficulty

Must be part of the design build process with budgeting of tolerances identified and become part of the work package in the planning stage. First-of-class full-up outfitting without trial pairings and templating is achievable when utilizing advanced measuring tools. Implementation will require a shifting of shipyard trade personnel confidence in the quality and repeatability of the accuracy control data.

4.9.2.2.3 Cost Estimate

$2M. Develop common tools and processes suited to U.S. shipyards and document the value of these best practices. Separate shipyard-specific funding may be appropriate to deploy the tools to U.S. shipyards.

4.10 Rationalize Design Rule Methodologies on Naval Ships

4.10.1 Issue/Challenge

This area was not directly addressed by FMI, but is an emerging issue in U.S. naval ship design productivity.

In the present environment, numerous regulatory and classification requirements are invoked in ship design projects without due consideration of their consistency/compatibility with one another, or with the ship's mission requirements. This has resulted in requirement gaps and conflicts identified after the award of each design and construction contract to a shipyard. Related problems pertain to the lack of common understanding among the stakeholders, i.e., the Navy customers (NAVSEA and Military Sealift Command), the regulatory bodies (ABS – Americas and U.S. Coast Guard), and the shipyards, regarding:

- The content definition of functional and transition design products in order to support the efficient demonstration of compliance with requirements
- Alignment of the schedule for design product development (in accordance with the shipyard's design process) with the schedule requirements for design product review and approval
- Assignment of non-overlapping responsibility for design product review and approval

Stakeholders recognize that these problems have had significant impacts on recently completed and ongoing ship programs, and that those impacts are likely to be much greater on upcoming (near-term) multi-mission ship programs. There is a need to develop and implement improved processes for requirements definition and deployment of commercial standard use in ship design products.

4.10.2 Actionable Solutions

A collaborative effort between shipbuilders, Navy customers (NAVSEA and Military Sealift Command), and the regulatory bodies (ABS – Americas and U.S. Coast Guard) is required to address the process and product issues that will result in a significantly improved regulatory environment for use of commercial standards in future ship design and construction programs.

The technical strategy consists of three steps:

- Developing a process to assess regulatory requirements and resolve gaps or conflicts.
- Rationalizing functional and selected transition design product content against regulatory requirements.
- Aligning the data submittal schedule requirements to the design process.

4.10.2.1 Define Pre-Contract Processes

A pilot demonstration should be initiated in the first step, and continued in the second and third steps, to establish incrementally a high degree of confidence that the project results can be implemented successfully on near-term ship programs, e.g., T-AOE(X), T-AGM(R), and MPF (F).

4.10.2.2 Prioritization Considerations

4.10.2.2.1 Benefit

The benefit would be identification of commercial standard requirement gaps and conflicts.

4.10.2.2.2 Difficulty

The number of organizations involved whose tasking is risk reduction makes this a challenging task.

4.10.2.2.3 Cost Estimate

$5M

5 Production Processes

5.1 Scope/Summary

Shipyard Production Processes include steel and aluminum fabrication, sub-assembly, assembly and erection, outfit fabrication, installation and test, surface preparation and paint, process control (accuracy control and process management), industrial engineering, production control (in-yard material planning and coordination), and services (transportation and rigging).

The recommended investments focus on the application of lean manufacturing principles to:

- Systematically identify and remove sources of non-value-added activity.
- Outfit package standardization.
- Manufacture and installation.
- Balancing the use of technology in shipyards to capture the productivity potential of valuable – but isolated – improvements.
- Production control (in-yard material planning, handling and coordination).
- Improved process standardization and control.

Of note, 'downstream' production process efficiency is strongly dependent on 'upstream' activities such as design-for-production, production engineering and outsourcing strategies – each discussed elsewhere in this document. Accordingly, the scope of recommendations for shipyard production processes is limited in comparison to other thrust areas that offer more leverage in the long term.

5.2 Assessment

The FMI report and other sources assert that cycle times and cost in Navy shipbuilding programs compares unfavorably with leading foreign shipyards building commercial ships for diverse customers. FMI observed that many processes which might otherwise be more effectively sub-contracted in smaller, more focused operations continue to be performed by shipyards to protect against schedule slippages and delays.

The NSRP Strategic Investment Plan articulates a number of challenges that illustrate the issues in this thrust area:

- Construction processes and organizations established to support Navy contracts are slower, more burdensome, and more costly than those required to support commercial contracts, and once they are established, it is difficult to selectively apply them only to a yard's Navy contracts and not the commercial contracts.
- Custom construction methods, still prevalent in many U.S. yards today, have fewer repetitive tasks and more variation in processes than world-class lean manufacturing, which is based on continuous flow of standard interim products.
- U.S. ship designs tend to use more material, have larger numbers of components, less standardization, more customization of components, and consequently result in greater production process complexity
- Most U.S. shipbuilders make limited use of standard production processes, while world-class foreign shipbuilders utilize standard processes and specialized work stations based upon standard interim product designs.
- As a result of non-standardized designs and production processes, U.S. shipyards have generally done little in the field of structured statistical analysis and statistical process control emphasizing internal quality, process stability, and continuous improvement.
- Production organizations are frequently single versus multi-craft oriented; this specialization of personnel results in increased workforce turnover, and reduced shipyard flexibility, efficiency and cost effectiveness.

- Additional design and process standardization and controls are needed to effectively automate shipyard production process.
- Widespread adoption of modern manufacturing technology and processes, such as robotics, is limited by the complexity of Navy designs, low production runs, unstable backorders on which to justify capital investment for upgrades, and the degree to which production efficiency is factored into the design.
- Non-value-added activities are still prevalent in many U.S. shipyard processes due to all the reasons above.

Shipyard production processes and technologies have been a focus area of NSRP and related R&D programs such as Navy ManTech for the past several years. A number of collaborative, Industry-wide initiatives have been pursued in areas such as welding, steel processing, laser-cutting and marking, etc. The recent adoption of lean manufacturing techniques that illuminate and attack non-value added activities has proven to be a very powerful strategy for improving U.S. shipyards. FMI attributed much of the improvement they noted since the 1999/2000 benchmarking to this trend. While considerable progress has been made, a significant number of non-value added activities have yet to be engineered out of shipyard processes. Additionally, initiatives described in this section tend to be well-suited to shipyard-specific implementations due to the inherent differences in challenges faced by each shipyard.

5.3 Investment Strategy

The top investment recommendations in this thrust area are listed in priority order in the table below:

Production Processes					
Investment Priorities	*GSIBBS Reference*	*Paragraph Reference*	*Relative Benefit*	*Relative Difficulty*	*Investment Est. ($M)*
Eliminate Non-Value Added Production Activity	D5, D6	5.4	100	100	$ 8.0
Expand the use of Module Building (Outfitting Packages)	C1	5.5	75	70	$ 5.0
Balance the Use of Technology in Shipyards	--	5.6	65	40	$ 2.0
Develop & Implement Advanced Material Handling	C6	5.7	60	37.5	$ 10.0
Develop Production Process Standards	F6, F7	5.8	60	25	$ 2.0
				Total	$ 27.0

5.4 Eliminate Non-Value Added Production Activity

5.4.1 Issue/Challenge

Lean initiatives have started to identify and eliminate a number of wide-spread non-value-added shipyard activities that have evolved over many years. Within the Production area, common non-value added activities include the use of temporary staging and access (element D5), welded fairing aids and lifting lugs (A9/A10), storage costs (element B5), excessive rework (element F8), out of sequence work, movement of material from one location to another (element C6), tracking of piece parts, and numerous inspections and oversight by customer. Wait times associated with materials (element B6), tools, personnel, and information have been accepted as the norm.

U.S. shipyards and their Navy customer have realized the potential of lean manufacturing techniques to identify non-value-added activities and engineer them out of their administrative and manufacturing processes. It is hard work that requires persistence and changing deeply ingrained cultures, but the results continue to validate the merit of this approach. NSRP's Lean Shipbuilding Initiative® and NAVSEA's Task Force Lean complement the work done by individual shipyards – but much work remains to be done.

5.4.2 Actionable Solutions

- Employ value stream mapping tools and methods to develop prioritized target lists of waste activities common to shipbuilding/ship repair industry such as staging, access, temporary services, welding aids, etc. Where appropriate, use the lessons learned from prior joint efforts to accelerate the learning curves of new pilot projects.

- Take action to eliminate the waste sources by implementing changes identified in the value stream analyses.
- Expand results of previous lean projects to all shipyards in U.S. industry and further develop and implement solutions that eliminate waste.
- Evaluate customer/shipyard joint processes and eliminate non-value-added activities (inspection, testing, etc.)
- Take proactive action to share the identification of best practices that have significant impact.

5.4.2.1 **Prioritization Considerations**

5.4.2.1.1 Benefit

The ROI from recent shipyard lean initiatives offers compelling evidence of benefits. FMI comments attribute much of the improvement in U.S. shipyards since 1999 to lean initiatives. This further validates the benefits available from the proposed actions.

5.4.2.1.2 Difficulty

The industry has embraced the lean tools and methods and has begun investing in a variety of initiatives both industry-wide and internal to individual facilities. The Navy has also initiated an enterprise-wide lean initiative called Task Force Lean. The champions have thus embraced the concept, but execution requires long-term persistence and the willingness of all involved to implement changes. Actions in the overall business incentives arena discussed in section 6 of this report will facilitate barrier removal in this area.

5.4.2.1.3 Cost Estimate

$8M. Develop and expand the results of previous lean implementations in the production area that includes value stream mapping, implementation of findings, and leverage of lessons learned from previous projects.

5.5 Expand the Use of Module Building (Outfitting Packages)

5.5.1 Issue/Challenge

Although the FMI report cited a wide spread use of best practice between the U.S. yards (2.5 to 4.0) under element C-1, U.S. yards scored on average significantly less than the international yards (3.08 compared to 3.50).

The only production issue mentioned as a high priority by FMI was the recommendation to address what they termed module-building. This terminology is frequently confusing to U.S. audiences, such that the clarification of ‘outfit packages’ is used herein to describe the nature of improvements recommended. FMI reported a low level of module assembly (pre-assembled units of outfit) in many yards due primarily to legacy designs that did not incorporate reusable module design practice and the failure to capture the benefits of efficient standard interim products (preassemblies) in special design techniques for newer ships. The report further noted that U.S. yards lack dedicated module assembly facilities and that capital investment would be needed for such facilities.

The challenge is to expand the use of modular outfit construction techniques to streamline outfit installation aboard ships. A much more comprehensive investment in production engineering and design for producibility is necessary to better leverage modular construction techniques. It is further envisioned that the process of building modules can occur at regional offsite locations or be provided by vendors and be provided to ship assembly operations in a just-in-time mode consistent with lean principles, if detailed, reliable schedules are available and standard interim products are more prevalent. These modules should touch multiple trade lines, which would require better coordination across craft lines (including the use of multi-skilled teams) than presently exist in shipbuilding.

5.5.2 Actionable Solutions

- Develop a design manual for the various types of module considerations that can be easily adapted by an individual shipyard to use on a design project.
- Continue to promote industry-wide standards at common systems level incorporating modular design considerations.
- Identify cellular manufacturing techniques to streamline the construction of modules and support just-in-time delivery to ship assembly operations.
- Expand the use of standard outfit interim products in new ship designs.
- Encourage suppliers to market “integrated” packages for equipment and associated support infrastructure where possible, including electronic data for space and connection points.
- Investigate feasibility of regional module assembly (outfit packaging) facilities (discussed in the Outsourcing and Supply Chain thrust area).
- Continue to promote efforts to improve the use and effectiveness of multi-skilled production teams.
- Identify technology applications that could streamline the construction of modules (i.e. robotics).
- Investigate facility requirements to effectively construct and handle modules.
- Investigate better accuracy control solutions to facilitate use of modules.
- Improve outfit component fabrication and installation process techniques.
- Develop innovative methods to test outfit components and ultimately system tests earlier in the ship construction process.
- Improve workplace organization and point of use solutions that will eliminate waste from outfit processes.
- Improve the application of automation solutions to outfit processes.
- Increase the use of machinery packages including earlier integration into ship assembly components.
- Improve material handling techniques in order to provide outfit components and equipment more efficiently.

5.5.2.1 Prioritization Considerations

5.5.2.1.1 Benefit

The 1-3-8 ratio rule is a widely cited rule-of-thumb in shipbuilding/ship repair. The rule describes the relative costs of work performed in shops, assembly areas, and aboard ship after launch, respectively. The ratio implies that for every hour spent in a shop fabricating a component, the same task would require 3 hours if done in the ship assembly area and 8 hours if done aboard ship after launch. Accordingly, any improvement in the use of modular construction (in shops or outsourced) in lieu of downstream work in assembly areas or onboard ship would offer high leverage.

5.5.2.1.2 Difficulty

The use of modules in ship construction has been in existence since the late 1970’s to early 1980’s. The biggest barrier to further implementation is the complexity of naval vessel design and corresponding lack of production engineering/design for production. In some cases, improved facilities may be necessary to handle efficient construction of modules in shops or construction bays and lifting/handling considerations. Improvements in accuracy control are also required to facilitate the use of modules effectively without introducing higher rework costs.

5.5.2.1.3 Cost Estimate

$5M. Facilitate several collaborative workshops and potentially a detailed design project. Projects might better be incorporated with the Design Thrust Area activities.

5.6 Balance the Use of Technology in Shipyards

5.6.1 Issue/Challenge

Today in the U.S. there are few shipyards that currently build only one product type. The resulting "ability to handle" multi-ship types limit the use of specialized facilities and limits the abilities to apply greater levels of technology. For example, some shipyards have invested in facilities to better handle thin steel necessary for war ships while at the same time constructing vessels with heavier materials. Shipyards have all begun modernization but changes/upgrades are, in many cases, isolated. Additionally, tailoring improvement strategies and facilities to product lines facilitate improved technology usage and therefore provide more benefit for the industry/customer.

5.6.2 Actionable Solutions

- Develop a generic industry process for analyzing and developing solutions to benchmarking results that takes into account the individual shipyard strategy for product mix, facility development constraints, and efficient process design.
- Facilitate shipyards performing analysis and long range strategic planning to implement improvements.

5.6.2.1 Prioritization Considerations

5.6.2.1.1 Benefit

The presumption put forward by FMI and their benchmarking system is that costs come down as shipyards move up the technology rating scale generally. This initiative is geared towards improving the technology usage rating and the analysis/implementation steps necessary for each yard to do that.

5.6.2.1.2 Difficulty

With the low level of U.S. Navy shipbuilding affecting workload across the industry, the vision of gearing facilities to a single product line is probably not realistic across the industry. Many shipyards have large investments in facilities that cannot be easily converted or altered completely.

Many of the technology elements are dependent on support processes and/or customer interfaces versus investments in equipment or changes to facilities. Changes to these support processes and/or customer interfaces are generally difficult to identify and change in a manner that supports the production processes and has immediate impact. Generally, changes to support processes take effect on the next product in the cycle, which can mean years before the results are seen. Many of the customer interfaces are governed by laws and government regulations instead of company policies and directives and are usually very difficult to change.

5.6.2.1.3 Cost Estimate

$2M. Support this initiative which includes analysis, computer simulations, and pre-install analysis which is expected to be performed individually by at least 8 shipyards.

5.7 Develop & Implement Advanced Material Handling

5.7.1 Issue/Challenge

The U.S. shipyards had an average score of 3.00 which was significantly less than the 3.57 average in the international yards in the 2004 benchmarking study (element C6). There are few yards either in the U.S. or overseas where transport distances are short and therefore the majority of movement is in "unit loads" by road. There is little use in U.S. yards of integrated conveyor systems and numerically controlled transport systems as is found in some leading international yards.

In all U.S. shipyards there is a notable lack of purpose designed pallets and trestles for the transport and storage of storage of parts, batches of steel and outfit components. While storage areas are generally well defined, pallets and trestles are stored at a single level and there is very little use of high density multi-level pallet stacking.

The extent of inefficient materials handling is significantly higher in U.S. shipyards and results in high levels of non-added value effort. Shipyard layouts and resulting material flows are constrained by the site and the ad hoc manner in which the yards have developed over the years.

5.7.2 Actionable Solutions

There are many advances in the handling of materials in shipyard conditions that can and should be pursued despite the challenges posed by the size, variation, and complexity of naval ship components. The initial focus should be to minimize and eliminate as much movement as possible but beyond that effort, implementing innovative techniques and equipment to reduce waste and streamline material handling operations. Specific recommendations include:

- Investigate industry-wide best practices associated with in-yard material handling and storage techniques and produce a state-of-the-art report to include the design of specialized equipment.
- Develop guidance for design input on part movement constraints/techniques.
- Develop improved methods for palletizing systems, automated material handling systems, material handling fixtures (pipe, cable, modules, and foundations/tanks).
- Standardize material tracking systems (see Organization and Operating Systems Section).
- Standardize material marking/coding (see Organization and Operating Systems Section).

Implementation of advanced material handling techniques varies widely across the shipyards since each yard is laid out differently and faces different challenges. Implementation projects will likely have to be pursued individually, but the following areas of concern are common to the industry: palletizing systems, automated material handling systems, fixtures, etc.

5.7.2.1 Prioritization Considerations

5.7.2.1.1 Benefit

Material handling expenses generally fall into an “overhead” category in most shipyards, which are generally viewed as excessive. More detailed analysis would be required to quantify a more accurate assessment of this savings and could be done in conjunction with state-of-art reports.

5.7.2.1.2 Difficulty

Variation in design and component parts has contributed to slow pace of implementation in this area. Advances in part standardization will still be a pre-cursor to advancement. Additionally, capital investment will likely be required in individual shipyards to enact meaningful changes which typically take time to implement.

5.7.2.1.3 Cost Estimate

$10M. Facilitate development of improved techniques in palletizing systems, automated material handling systems, and material handling fixtures that includes analysis and pilot projects at various shipyards including the purchase of some equipment, hardware, and potentially software development.

5.8 Develop Production Process Standards

5.8.1 Issue/Challenge

These issues are related to design for production (F7) and production engineering (F6) elements. Relative to leading foreign yards in higher volume commercial markets, many U.S. shipbuilders are underdeveloped in their definition and application of standard production processes. Over the past several years, many U.S. yards have begun standardizing their building processes. Standard interim products, group technology techniques, and specialized work stations are examples of areas where improvements in use have every potential to lead to lower construction costs and improved construction cycle times. The use of standard production processes supports improved planning, workload balancing, cost predictability, learning, quality, and employee moral. Additionally, standard production processes make it possible to expand existing production capabilities into production of new vessel types with a degree of predictability and lower business risk.

Standard production processes do not exist in a form that is easily understood by support functions. Typically, ship design is considered a primary function while the actual ship construction is considered a secondary function (i.e., “build what I’ve designed” versus “let me create a design that you can build”). This leads to highly inefficient production processes or delays in a ship construction project to facilitate a re-design, which are generally not cost effective.

5.8.2 Actionable Solutions

- Leverage the previously developed Design for Production Manual created by the NSRP to develop production process standards.
- Develop a maintenance procedure for upgrading standards when new technology or new processes become available.

5.8.2.1 **Prioritization Considerations**

5.8.2.1.1 Benefit

Work in this area would enhance communications and feedback to the design community and other supporting processes, which will in turn lead to higher quality inputs into the production process (i.e., more producible designs, better components, and more accurate schedules/budgets). This will provide a foundation for more advancement in design for producibility and production engineering which were cited as two of the major discrepancies in the shipbuilding industry.

5.8.2.1.2 Difficulty

There will be an inherent debate between design requirements and production standards that will continually have to be balanced. Rigorous designs are necessary to create some of the most capable warships in the world, which is often in conflict with a simple, producible design. Along the same lines, constant changes introduced during the construction phase will challenge the ability to execute standard production processes.

5.8.2.1.3 Cost Estimate

$2M. To be used to develop production process standards. A majority of this effort is viewed as collaborative in nature with some follow up at the individual shipyard level to develop specific facility constraints and challenges.

6 Joint Navy/OSD/Industry Action

6.1 Scope/Summary

According to FMI, the productivity of naval vessel construction can be improved by:

- Improving shipyard processes and practices.
- Reducing the shipbuilder's work content associated with DoD acquisition processes and practices.
- Reducing the designed-in work content.
- Making contractual arrangements that promote higher levels of performance.

Earlier sections of this report deal with the first of these four improvement pathways. This section discusses the remaining three, covered generally here and has specific examples cited in other areas of the document as the Department of the Navy is tightly interwoven into the fabric of the core shipbuilding shipyard processes.

Business drivers offer the highest leverage, but are the most difficult to change due to the number of people involved and culture, Federal Acquisition Regulations (FAR), risk tolerance, etc. The tools by which the Administration and Congress control the shipbuilding enterprise – such as budgeting practices and influence on shipbuilding work allocation – are among the most important drivers of ship cost and are addressed in this section.

6.2 Assessment

The FMI report identifies work content reduction as a key strategy to reduce Navy shipbuilding costs. The ship designer and the customer both have an influence on the work content and hence the compensation coefficient.

An earlier FMI paper asserts that fundamental differences between the two sectors will mean naval shipbuilders will inherently exhibit a lower level of productivity than commercial yards of similar technology. FMI studies have documented a wide variation in the work content associated with the acquisition practices of different customers. A 2001 FMI study estimated that UK MOD practices added a 12% premium to ship costs independent of the ship's design complexity, and FMI believes the U.S. DoD customer factor is significantly higher – perhaps 18%! This means that acquisition practices add $180M to the cost of each $1B DD(X) for example. This 18% "customer factor" corrects the ship complexity production comparison multiplier, known as Compensated Gross Tonnage (CGT), for the additional effort required by the shipbuilder which is over and above that which would be usual in a normal commercial contract. The FMI report concludes that "The U.S. customer factor may account for part of the apparent productivity gap between U.S. and European combatant builders."

An April 2002 report to Congress by the ASN RDA 2002 provides a succinct assessment of critical issues that must be addressed in tandem with internal shipyard efforts. These factors include, in Secretary Young's words:

- Underestimated non-recurring effort for lead ship design and production startup.
- Budget reductions/rescissions.
- Growth in shipyard labor rate projections due to:
  - Navy shipbuilding procurement rates which never materialized.
  - Impacts for future direct and indirect wage disputes.
  - Contractor furnished equipment and material cost due to higher inflation rates than established indices.
  - Government furnished equipment cost growth due to lower than projected procurement rates and concurrent development costs.
  - Requirements and configuration changes due, in part, to computer obsolescence that occurs during the five to seven year shipbuilding construction cycle.

- o Change order under funding compared to empirical execution requirements.
- o System engineering cost increases to achieve combat system integration, fleet interoperability, and open systems architecture requirements.

6.3 Investment Strategy

The top investment recommendations in this thrust area are listed in priority order in the table below:

Joint Navy / OSD / Industry Actions					
Investment Priorities	*GSIBBS Reference*	*Paragraph Reference*	*Relative Benefit*	*Relative Difficulty*	*Investment Est. ($M)*
Stabilize the Navy's Ship Acquisition Strategy	--	2.4	High	High	$ -
Eliminate Disincentives & Improve Incentives	--	6.4	100	100	$ 0.5
Streamline Navy Technical Oversight	--	6.5	95	73.75	$ 6.0
Change Weight-based Cost Estimating Relationships	--	6.6	60	60	$ 1.0
Manage Change Orders to Reduce Productivity Impact	ASN 2002	6.7	58	55	$ 1.5
Support Domestic Shipbuilding other than Military Ships	NSRP	6.8	47	31.25	$ -
Enable Resource Sharing Among Private / Public Shipyards	G1	6.9	13	18.75	$ 0.5
				Total	$ 9.5

A common technique for addressing many of the issues identified in this section is prototyping to flesh-out the cost reduction solutions that work and those that don't.

6.4 Eliminate Disincentives & Improve Incentives

6.4.1 Issue/Challenge

The FMI report documents the impact of customer incentives and disincentives as an element of productivity. The threat to the shipbuilding industrial base posed by the record low Navy shipbuilding rate provides a powerful motivator for the industry to work with the Navy customer in controlling costs. The reported cost reductions from NSRP alone provide openly accessible evidence that cost reduction incentives do exist. Nonetheless, a major issue in this regard is the short-to-medium term disincentives to cost savings that need to be eliminated. The determination and administration of contract fees and incentives have a direct impact on the health of the Navy shipyards. Providing an environment that enables shipbuilders to make a reasonable return contributes to process improvements which should result in cost savings and increased ship capability.

The pervasive adverse effect of disincentives across the spectrum of opportunities to improve the shipbuilding program efficiency and improve the infrastructure can be overcome by creating a process that permits sharing of future savings without increasing costs. Incremental funding has provided significant challenges for material procurements.

Currently, the Navy does not use a value engineering clause that truly rewards and provides an incentive to the shipbuilder to vigilantly seek and implement design or process changes that would be more cost effective or enhance ship performance, as opposed to strictly building to meet the specifications. In short, if a profit basically remains unchanged with or without value engineering changes, and a contractor is not rewarded for the extra time and resources that it takes to validate innovative value engineering changes, not only is there no positive incentive, but there may be a negative incentive associated with the existing value engineering clauses.

6.4.2 Actionable Solutions

6.4.2.1 Profit/Fee Policy

- Support incentives to cut costs and reward those companies that achieve significant savings, thus creating an environment in which high-performing companies can achieve returns on capital comparable to commercial enterprises of similar risk and capitalization.
- Establish a policy for profit/fee determination that takes into consideration cash flow, ROI, and current regulatory requirements.

- Develop a revised profit determination process to more accurately determine appropriate fee and profit levels that reflect current business conditions.
- Review the award fee and incentive fee criteria used principally for repair and overhaul contracts to remove what appears to be an arbitrary and less effective 10% fee cap.
- Establish a method for longer term sharing of cost savings, resulting in an effective incentive to generate larger future savings, efficiencies, and process and facility improvements.

6.4.2.2 **Value Engineering Change Proposal**

Jointly develop a long-term benefit-sharing clause modeled on the Value Engineering Change Proposal (VECP) Clause (FAR 48). It will allow the Navy to achieve cost improvements and reward contractors over a longer period of time. The expanded use of the VECP concept enjoys the support of the USD (A, T&L). In testimony before the Senate Armed Services Committee (SASC) March 22, 2000, Dr. Jacques Gansler testified that there was a need to develop a VECP-type savings program to recognize government savings resulting from industry consolidations. It is only a small extension to utilize the methods in this application. Establishing a VECP-type share arrangement and raising the fee limits will require changes in the FAR and possibly in the law.

6.4.2.3 **Correct FAR Provisions that Limit Outsourcing**

U.S. Navy shipbuilding subcontractors are required to comply with the "flow-downs" of the FAR and the Defense Federal Acquisition Regulations (DFAR), some of which are costly to implement and require substantial changes to their business processes. An example with significant proportions is the requirement to employ an Earned Value Management System.

6.4.2.4 **Dynamic Incentives Program**

Too many of the existing contract incentives are backward-looking, e.g., we did it, or we didn't. By the time we evaluate, it's too late to achieve the originally desired result. They have historically tended towards inflexibility, and offer very little insight into the different phases and/or maturity of a program. For example, there may be time frames in a program when cost reduction or performance enhancing changes are very good and should be encouraged. There are other times when configuration stability is a high priority. A good incentive program needs to recognize both.

6.4.2.5 **Incentives Account**

Retentions should be used in a systematic manner to fund an incentives account. PEOs could use the retentions to incentivize contractors that demonstrate cost savings beyond those anticipated in the contract process.

Establish an account above PEO level that annually accumulates productivity savings from prior Navy approved cost savings by shipbuilder (prime contractor). On an annual basis, according to a negotiated rate, award an incentive payment to the shipbuilder reflecting the prime vendor’s share of the continuing savings enjoyed by the Navy for the shipbuilders cost improvement efforts.

6.4.2.6 **Prioritization Considerations**

6.4.2.6.1 Benefit

Elimination of disincentives would be a significant enabler to cost savings in the Navy shipbuilding and ship repair industry. The determination and administration of contract fees and incentives have a direct impact on the health of the Navy shipbuilding/ship repair industrial base. The benefit of the improvements to government program managers and contracting officers will be an enhanced tool set to determine appropriate fee and profit levels and share in cost savings that reflect current business conditions. Another benefit of the process change and training is it will provide standard methodologies for government use across a competitive manufacturing segment. But the largest benefit to the Navy will be removing disincentives, which could lead to overall less cost in the shipbuilding/ship repair industry. Improved incentives along with sharing in future cost savings could reinvigorate the industry, increase its ability to compete in financial markets, enhance the ability to hire and retain the best and the brightest staff, as well as improve its capacity to attract capital from sources other than government operations. All of these will lessen the ultimate burden on Navy funding.

6.4.2.6.2 Difficulty

- Navy culture with regards to profit/fee determinations
- Navy Comptroller support
- Authorization/Appropriations changes
- Removes disincentives to cost reductions
- Higher returns which result in increased private investments
- VECP concept allows a sharing of future savings
- Lower total cost to Navy

6.4.2.6.3 Cost Estimate

$500k. The work to execute this actionable solution could set the foundation for significant ROI down stream and establish a more cooperative business culture.

6.5 Streamline Navy Technical Oversight

6.5.1 Issue/Challenge

The FMI report emphasizes the need for U.S. yards to reduce the designed-in work content. The Navy business model's extraordinary degree of customer involvement means that this issue can only be solved with a significant change by both industry and the Navy customer, as this is another area where customer factor for warships is much larger than for commercial markets.

Technical oversight on modern warship designs is currently carried out through a hierarchical decision structure that starts with the core customer (PEOs) and executed by a huge pyramid of technical 'customers' for each of the major technical areas (e.g., hull, electrical, shock, acoustics, etc). The various technical requirements that are driven by each area at each level all contribute to a huge snowball of iterative studies and analyses that drive the cost of design increasingly higher and significantly lengthen the design schedule. The customer needs to streamline his technical approval process and eliminate non-value added requirements, studies and analyses. In addition, a move to more performance-based (rather than specification driven) focus will help decrease the cost and shorten the product design time.

6.5.2 Actionable Solutions

6.5.2.1 **Reduce Government Furnished Equipment (GFE) in Favor of Contractor Furnished Equipment (CFE)**

According to ASN RDA, Government Furnished Equipment (GFE) systems have historically been major drivers of engineering change orders and cost growth for Navy warships. This condition is attributable to Diminishing Material Sources (DMS), technology obsolescence, and the need for highly integrated, complex combat systems to meet emerging mission requirements.

CFE creates savings by allowing the prime contractor to deal directly with the supplier base, and to use a streamlined procedure to consolidate purchases. It facilitates an increased use of commercial-off-the-shelf (COTS) purchasing, which can reduce costs, and it allows the prime contractor to achieve quantity of scale savings when a multi-year procurement is used on all ship systems.

The effect of reduced shipbuilding procurement rates is an equally profound cause for higher than expected GFE cost. When the average unit costs for GFE systems were projected for ship budgets, they were based on higher ship procurement rates in future budgets that never materialized. As the Department of the Navy (DON) transitions from 12-15 new construction ships per year to five to seven ships per year in the current FYDP, GFE system unit costs have increased. GFE costs for ships and systems in production for an extended period are increasing due to production inefficiencies and lack of competition from DMS. As a result, the DON pays a premium to procure this equipment and sustain the vendor base during ship production.

Contractor Furnished Equipment (CFE) cost growth is also predominately due to low rate procurement due to very low rates of ship production. The cost growth is also due to decreased quantities from reduced shipbuilding profiles, production changes from developmental testing, and DMS.

The evolution from GFE to CFE procurements will help leverage new commercial off the shelf technologies and provide industry with increased configuration control. In the interim, fewer quantities result in higher unit costs for GFE, and the DON is incurring more costs to transition to newer, more capable CFE.

6.5.2.2 **Specifications**

As the Navy moves more and more into the "commercialization" of their fleet, the complex topic of requirements definition, rules applicability, Safety of Life at Sea (SOLAS) exemptions, Access and Crew Protection (ACP) applicability, and classification society certifications needs a thorough vetting and evaluation.

Require ABS Certification on more production standards. The Navy has established a method to carry on the old general specification requirements through the implementation of the ABS NVR's. The NVR's effectively invoke the old Mil Specification and NAVSEA standards. This practice inhibits innovative cost savings ideas by dictating old standards and practices that in some cases go back over 50 years. The Navy should be providing incentives that foster creative ideas that are used effectively in the commercial market. ABS is well versed in reviewing and accepting these solutions through their standard review process. Providing for new innovation in the Navy shipbuilding industry would help reduce costs and allow for new designs to be developed quicker.

6.5.2.3 **Remove Transactional Waste from Navy-Shipyard Customer Processes**

Task Force Lean (TF Lean) is a NAVSEA-wide initiative to promote the application of lean principles across NAVSEA and track the results of these efforts and savings generated. The two primary goals of TF Lean are to improve mission productivity through more efficient practices and return the savings gained to fleet recapitalization and funding the Navy's 21st century readiness. NAVSEA Lean is applicable to all lines of business, product lines, and processes across the HQ/PEO/Field Activity enterprise. It is NAVSEA’s overarching business strategy/approach for continuous improvement incorporating Lean, Six Sigma, Theory of Constraints, Critical Chain Project Management, and Business Process Re-engineering.

6.5.2.4 **Perform Lean Value Chain Analysis of a Navy Ship Acquisition Program to Promote Awareness of the True Costs (FMI report element G8)**

- Minimize design/analysis workload and schedule perturbation with an improved approval process.
- Identify areas of customer over-involvement and customer-internal conflicts and propose process changes to resolve.
- Identify and validate those construction and repair business processes that yield the greatest leverage of driving mutual naval and industry success.
- Develop the value stream focused standard work for the identified business and information processes using lean principles.
- Create the model of operation that integrates these multiple value streams of standard work into a synchronized approach for all value chain members to operate.

The NSRP SHIPWAY Project is an example of how government and industry are working together to streamline technical oversight of Navy work. This project focuses on the development of the highest performing business processes (lowest total cost, shortest cycle time) for accomplishing naval ship new construction and repair. These processes are defined as Lean Best Practice Value Stream Focused Standard Work Elements (SHIPWAY). They are executable and repeatable in a reliable manner. Defining the DoD New Construction and Repair value chains, understanding the value streams within those chains, and attacking the waste in a prioritized, collaborative manner represents the structured approach used to drive improvement along the value streams.

6.5.2.5 Demonstration Project of Lean Manufacturing on a Navy Shipbuilding Program (Senate)

Armed with the information from value chain analysis, apply the changes identified as needed to increase the emphasis placed on lean manufacturing technologies and processes in acquisition programs, and the potential for broader application of such technologies and processes in ship repair.

Consistent with the Senate Armed Services Committee interests [Senate Report 108-260 that accompanies S.2400 (NATIONAL DEFENSE AUTHORIZATION ACT FOR FISCAL YEAR 2005)], DoD and DON should place greater emphasis on lean manufacturing technologies and processes. Specifically, the Navy should consider experimentation with the wholesale adoption of such technologies and processes across the spectrum of an entire ship acquisition program as a demonstration of the merits of this approach.

A commitment to change the current practices of the Navy and Industry is required. Recent language in the Senate Defense Acquisition Act FY 05, as well as a recent correspondence from NAVSEA, provides evidence of this commitment.

6.5.2.6 Prioritization Considerations

6.5.2.6.1 Benefit

Evidence of the importance can be derived from the impact of recent efforts in Lean by NSRP.

- Business Process Technologies is an area rich in opportunities for cost and cycle time reductions, regardless of whether the business area in question is marketing and sales, pre-contract activity, or contracting. One significant ongoing activity under this initiative involves a collaboration of five U.S. shipyards working with IBM to reengineer and web-enable shipyard-supplier-SUPSHIPS business processes for electric commerce on the NSRP ASE SPARS project.
- The NSRP ASE World Class Manufacturing Model, Ultra-High Pressure Water Blasting, Knowledge Based Modular Repair, Five-S (Sorting, Simplifying, Systematic Cleaning, Standardizing, and Sustaining) Applications, and Lean Enterprise projects are providing significant insight and understanding into the changes required to effectively implement world-class or Lean-manufacturing practices. These process-oriented projects are currently in the implementation phase, and are demonstrating significant bottom line improvements in product quality, cost, and cycle time.

6.5.2.6.2 Difficulty

NSRP has demonstrated the viability to the degree that its lean efforts proceeded. Additionally, each shipyard has been pursuing its own efforts in this area. NSRP's newest efforts involve attempts to work directly with multiple Navy organizations and have gotten good response to date (but, not from the acquisition community.) Since it is in the best interest of all the members of each value chain to collaborate and improve, the limitations are few. The tools are simple and reliable although new perspectives and applications will be developed. The major limitation is the ability of the customer to engage in rapid improvement.

Organizational change will be at the core of successful Lean implementation. Modifying the culture of individual shipyards and the industry as a whole to embrace and sustain Lean principles is critical to the Lean Shipbuilding Initiative's success. Acceptance of changes in production and business processes, relationships to suppliers and customers (both internal and external), and standardization of methods and procedures will be necessary.

6.5.2.6.3 Cost Estimate

Lean Manufacturing pilot improvement projects and best practice forums to share lessons learned provide a model of execution with an historical price basis. Demonstration projects can assess a series of shipyard-Navy processes at sample locations. Repeating this at multiple locations – or in parallel – would cost ~$6M.

6.6 Change Weight-based Cost Estimating Relationships

6.6.1 Issue/Challenge

The FMI report identified ship design complexity as a major factor in Navy ship compensation factor elevation above commercial ships. For example, FMI found that as the compartment size increased, the CGT coefficient reduced – resulting in lower costs per ton. The FMI recommendation to reduce designed-in work content is squarely on target when considering the Navy's primary ship program cost estimating algorithms.

The Navy's legacy weight-based cost estimating relationships exert a significant negative impact on ship design complexity, construction cost and time, and life cycle cost. Since the Navy uses weight as the principle indicator of cost, there are artificial decisions imposed in the design phase to minimize weight regardless of the trade-offs. While weight does provide a measure of cost and impacts such issues as fuel consumption, it sub-optimizes weight at the expense of smaller compartment size and deck heights, which in turn makes design more difficult, requires more expensive components, and adds significant extra downstream fabrication and outfitting work content.

It is interesting to note, when comparing U.S. Navy shipbuilders to leading world class commercial yards, the striking difference in the top-level drivers of ship design and which yards win the contracts. One of the reasons that commercial shipbuilding has a much lower cost than Navy construction is competitive designs developed from performance versus detailed specifications. Commercial contracts are largely awarded on the basis of cost to the owner, who exerts far less direction on ship design as long as it meets the functional requirements. On Navy contracts, the actual cost is perceived by many to be secondary to not only the complexity imposed with factors such as weight-based estimating, but by political and non-cost considerations such as ability to build the type of ship, balancing workloads, capability and experience with the particular type of ship, and Congressional influences on what gets built and funding, etc.

6.6.2 Actionable Solutions

6.6.2.1 Ship Design Impact Study

- Develop an alternative cost estimating model. Conduct simulations to verify and validate the method.
- Study a new ship design program to identify the ongoing costly design aspects that result from weight-based cost estimating relationships. Develop future programs cost reduction recommendations report.

6.6.2.2 Pilot DFP Implementation

Institute a formal review of design trade-offs for each new Navy ship program. Review/modify existing Navy process for conducting design trade-offs and specification development. The pre-contract DFP analysis discussed in the Design thrust area discusses this in additional detail.

6.6.2.3 Fix the Cost Estimating Process to Factor in the Lessons Learned

Include both cost estimating and specification development. Metrics definition could include some combination of geometry, density, complexity, etc.

6.6.2.4 Prioritization Considerations

6.6.2.4.1 Benefit

Productivity of each shipbuilding program is reduced when non-value-added complexity is added to the process. FMI's report identified the U.S. ship design process as comparatively expensive to foreign yards despite a higher level of best practice.

6.6.2.4.2 Difficulty

The Navy culture is strongly entrenched in the existing methodology; and will be concerned over the inherent risks of changing from a known methodology.

6.6.2.4.3 Cost Estimate

$1M. Platform specific studies could lead to significant cost reductions once applied to all new platforms industry-wide.

6.7 Manage Change Orders to Reduce Productivity Impact

6.7.1 Issue/Challenge

Both FMI and the ASN 2002 Assessment comment on change orders as a factor in U.S. Navy shipbuilding program cost growth. Commercial shipbuilders are able to build complex ships, such as cruise ships and deepwater drilling rigs, for significantly less cost and in significantly less time than naval shipbuilders require to build naval ships of comparable size and complexity. One of the many reasons for this is that in the commercial world, the shipbuilder and his customer work closely together, starting before the contract is executed, to do everything possible to avoid change orders. The primary mechanism for this is to freeze the design before production is begun, even on the first ship of a new class. The ship-owner wants the ship as soon as he can get it so that he can begin to pay back the money he has spent in getting the ship built: extended delivery times cost him significant sums of money. The shipbuilder wants to deliver the ship as soon as possible in order to free up his capacity for the next contract. He also knows that the adjustment to the contract price designed to cover the cost associated with a change order is rarely enough to compensate him for the disruption caused by that change. In addition, reduced construction times reduce overall cost to the job. The question is: Why can a commercial customer do without a huge volume of change orders but the Government plans from the very beginning of every project for large numbers of major changes throughout the building process?

Given the significant number of change orders on Navy shipbuilding programs, it is axiomatic that the longer the ship is in the shipyard, the more it costs, such that change orders increase the cost of the Navy's ships and delay their completion. Any reduction in the volume of change orders may, therefore, result in a reduction in both the cost of ships and the time required to build them. The major contributor to the need for contract changes is the looseness of the design when the shipbuilding contract is signed. To the extent practicable, the firmer the design at contract signing and fewer numbers of changes will result in lowering contract cost and construction times.

Balancing the benefits of reducing change orders are several realities in Navy shipbuilding programs:

- It is probably impossible to eliminate changes entirely. For example, spiral development of weapons systems will inevitably necessitate some number of change orders. In the event change orders are necessary, careful management and negotiation will mitigate the potential negative impacts.
- It is harder to eliminate changes on some types of ship than on others.
- Not all change orders are disruptive.
- Not all change orders result in delay to delivery.

6.7.2 Actionable Solutions

There are several approaches that the Navy might try, either singly or in combination. Options to reduce change orders include incentives for change reduction, more frequent use of post shipyard availability (PSA) to accomplish changes, substituting performance specs for detail specs, and change ceilings.

- Stabilize the ship design earlier in the process, and complete as much of the detail design as the need for the ship allows before construction begins.
- Conduct a detailed analysis of the change order process and best practices in a surface ship, carrier and submarine program using the NSRP SHIPWAY model.
- When change orders are required, there are numerous examples of initiatives to speed up the change adjudication process. Processing of small dollar value changes through limited scope “waterfront contracting authority” is particularly beneficial in the testing and pre-delivery phases of new construction contracts and for overhaul/repair work. Use of a “banking process” where changes are

authorized on the basis of rough order of cost estimates with periodic final adjudication can markedly accelerate change implementation.

- Document change management best practices and implement. Testing of deck plate authorizations has been done and implementation is in process.
- Postpone changes with significant potential impact on cost and schedule until after delivery, e.g., in a PSA, or in the next flight of ships. This approach requires a procedure for determining (by someone responsible) which changes can be postponed and which cannot.
- Incentivize the PEO (or equivalent) to minimize changes.
- Legislate or otherwise set in concrete a ceiling on the allowable percentage increase in the total value of a shipbuilding contract.
- NAVSEA should take the lead in identifying and documenting current "best practices" as well as planned improvements and provide them to industry for comment and incorporation into local contract administration practices as appropriate.
- NAVSEA should consider several means of reducing change orders, including incentivizing change reduction, more frequent use of PSA to accomplish changes, substituting performance specs for detail specs, and ceilings on change values in shipbuilding contracts.
- Perform a study of all major shipbuilding contracts over the past five years to determine the costs and benefits that would have been incurred if changes had been (1) eliminated entirely, (2) held arbitrarily to not more than 5% of base contract value, and (3) performed only on the basis of a determination of criticality, regardless of value, made by an experienced ex-Ship Acquisition Program Manager (SHAPM).
- Draft the regulations and procurement clauses that would be required to implement change volume control.

6.7.2.1 **Prioritization Considerations**

6.7.2.1.1 Benefit

If the Navy's increase in ship contract values is caused by change orders that are in the region of 5%, total elimination would save hundreds of millions a year in the annual shipbuilding budget. Significant additional savings would accrue from the concomitant earlier deliveries (in O&MN as well as in SCN) and from the reduction in overall cost resulting from shorter construction times.

Any reduction in the volume of change orders may result in a reduction of the cost of ships and potentially the time required building them.

Cost savings would result from the elimination of most of the large number of estimators, accountants, engineers and other technical and administrative personnel involved in change order scoping, estimating, reviewing, negotiating and tracking. In commercial shipyards, change order administration departments are virtually non-existent: the owner usually has only one or two on-site personnel in total, to ensure (along with the regulatory body personnel, who also usually only number one or two people) that the ship owner's interests are protected.

6.7.2.1.2 Difficulty

The underlying reasons for the large number of changes on Navy vessels will continue to make change order reduction problematic:

- The electronics and weapon suites are continuously improving, and the Navy wants the latest and most useful equipment aboard when the ship is delivered.
- The Navy buys to MILSPECS, which are very specific as to what the contractor is to provide. Any change in a MILSPEC automatically triggers a contract change order.
- Both the contractor and the government have built up large constituencies who are dependent on a significant volume of change order traffic: change orders are part of the culture of naval shipbuilding.

- Contract disincentives regarding change orders can make the culture resistant to changing.
- The only significant cost to the Navy would be some delay in the introduction of new technology.

6.7.2.1.3 Cost Estimate

Assessments in surface ship, carrier and submarine programs totaling $1.5M.

6.8 Support Domestic Shipbuilding Volume other than Military Ships

6.8.1 Issue/Challenge

The FMI report, and virtually every other recent analysis of U.S. shipbuilding, identifies low throughput as a critical peril for U.S. shipyards. FMI comments that since the number of cycles per annum in naval shipyards is usually much lower than foreign commercial shipyards, achieving a comparable rate of improvement is particularly difficult.

Recent and out-year budget plans fall far short of meeting national requirements and, coupled with previous deep cuts in shipbuilding, are continuing to exacerbate severe erosion of America's shipbuilding infrastructure. Congressional actions on the shipbuilding accounts in recent years were important steps to address the lowest Navy build rate in 50 years.

The industrial base is increasingly concerned over the deteriorating health of the nation's vital defense industrial base, on which the Navy relies to produce defense systems and weaponry. The U.S. defense industry plays a key role in the sea enterprise as well as in providing critical surge capability. It is an integral partner in defending America's national security interests and must be kept both technologically innovative and economically competitive.

Congressional authorization for shipbuilding programs other than military ships can aid domestic yards by added volume of ships.

6.8.2 Actionable Solutions

Urge the Administration and Congress to:

- Act on the erosion of our domestic ship repair industrial base that results from commercially-operated MSC ship repair work being conducted in foreign shipyards. Performing MSC repair in U.S. yards would benefit the U.S. ship repair base and improve quality of life for Sailors.
- Improve and reauthorize the Maritime Security Program (MSP), including Maritime Administration reimbursement to MSP operators for the cost differential between U.S. and foreign shipyards to encourage vessels to use U.S. shipyards for maintenance and repair. With continued reductions and reorganizations in Navy repair capacity, it is vital that sufficient commercial work be available to U.S. repair yards to maintain the ship repair industrial base that we need in emergencies.
- Expand the Capital Construction Fund to allow the $1.9 billion in accounts already on deposit to be used to build much-needed ships for the coastwise trades.
- Support the Jones Act and the Passenger Vessel Services Act, urging opposition to any legislative initiatives, trade agreements or other efforts that would weaken vital industry support.
- The NSRP SHIPWAY Project is an example of how government and industry are working together to streamline technical oversight of Navy work. This project focuses on the development of the, highest performing business processes (lowest total cost, shortest cycle time) for accomplishing naval Ship New Construction and Repair. These processes are defined as Lean Best Practice Value Stream Focused Standard Work elements (SHIPWAY). They are executable and repeatable in a reliable manner. Defining the DoD New Construction and Repair value chains, understanding the value streams within those chains, and attacking the waste in a prioritized, collaborative manner represents the structured approach used to drive improvement along the value streams.

6.8.2.1 Prioritization Considerations

6.8.2.1.1 Benefit

Additional work for the shipbuilding and ship repair industrial base will enable faster improvements and additional sources of capital investment from commercial customers.

6.8.2.1.2 Difficulty

Varied interests and budgetary pressures are in play for these items, but they have been supported by Congress in recent years.

6.8.2.1.3 Cost Estimate

There are no direct costs estimated for this policy item.

6.9 Enable Resource Sharing Among Private and Public Shipyards

6.9.1 Issue/Challenge

The FMI report recommended the development of methods to more effectively share work/labor among shipyards (item G1). This is consistent with NAVSEA's One Shipyard vision and the prevalent multi-yard build strategy used in new ship acquisitions. The ship maintenance demands imposed by the Navy's Fleet Response Plan also demands greater resource sharing among shipyards and other organizations.

Enterprise Sharing would appear to improve facility utilization at naval shipyards, with a simultaneous reduction in facility requirements among the private yards. The Naval Sea Systems Command launched an initiative to address this need called "One National Shipyard." Fully realized, the One National Shipyard concept would allow more sharing and better coordination of individual yards' resources and capabilities. Furthermore, centralized workloading of the nation's ship repair industrial base would ensure more level loading and would tend to dampen the radical swings in a yard's level of activity over time.

VADM Balisle stresses that one key step in effecting such a change to an integrated enterprise lies in surmounting organizational boundaries that, while administratively convenient, can too often impair efficiency. He exhorts the entire enterprise to "work across…normal organizational boundaries, collaborate with other organizations and with our industry partners to the maximum extent possible, and raise our standards to the highest level."

6.9.2 Actionable Solutions

Enterprise Sharing solutions will vary from region to region based on the public and private sector facilities, ship types, and Navy fleet concentrations. Additionally, in many cases the solutions will be affected by the platforms; for example, aircraft carriers, submarines, surface combatant, or commercial, as well as by the system and component to be repaired, maintained, or altered.

6.9.2.1 Skill Standards

The shipyard workforce is both the most important sharable resource and a key to the sharing of any other resources. Workforce mobility will require compatible skill standards and interoperable tools and processes. Industry specific skill standards can provide shipyard workers portability of their skills. This will allow the shipyard worker to remain industry focused while working at various yards, due to industry business cycles. Additionally, shipyards can be assured of the skill level that a certified shipyard worker will bring with them to a job.

NSRP has sponsored several projects addressing the need for industry skill standards. Past efforts include establishing a baseline for industry skill standards by expanding an initial industry skills database, prototyping a skills assessment and certification approach, and developing a curriculum guidance approach for apprenticeships and schools. Through these efforts, a relationship was established with the National Skills Standard Board and the Manufacturing Skill Standards Council.

NSRP Recommendations for SIBIF

A recent NSRP survey revealed that employee sources and skills are falling behind requirements to replace aging workers and cover workplace turnover in shipyards as well as manufacturing in general. U.S. manufacturing is in competition with other industries in the U.S. and in other nations. There is strong demographic evidence of a gap in required skills and interest in shipbuilding and manufacturing in general. National efforts to revitalize American manufacturing require collaborative efforts. NSRP is sponsoring an Employee Sources & Skills Summit to further connect shipbuilding and repair workforce development and skills initiatives with other national manufacturing and professional-technical education initiatives to achieve a more consolidated understanding and action plan. The summit will share specific manufacturing industry, workforce board and related education provider new employee needs, common problems and best practice solutions to achieve greater national, regional and local unity; and will apply resulting recommendations toward improving shipbuilding and repair efficiencies including cost reduction.

The model being used successfully in the nuclear skills between private and public yards should be used as a model to build on.

6.9.2.2 **Tools**

The nuclear shipyards developed a mechanism to track approximately 9,000 nuclear trades. This sort of tool should be expanded. Actions taken by the Navy and Industry in recent years have already started the U.S. Naval Ship Repair Enterprise down this path. Since 1999, NSRP has facilitated migration toward an integrated national ship repair enterprise by providing capabilities and tools which the Navy and Industry are able to bring to bear, to surmount organizational boundaries in improving interaction and interoperability across the shipbuilding and ship repair industry. NSRP project results in such areas as web-enabled eBusiness innovations and improved interoperability among CAD systems and other information technology areas have catalyzed formation of unprecedented, valuable links across a previously stove-piped ship repair enterprise.

The kind of teaming envisioned under One National Shipyard is already happening, as evidenced by teaming arrangements between Electric Boat and Northrop Grumman Newport News on VIRGINIA-class submarines, and between Northrop Grumman Ship Systems and Bath Iron Works on the DD(X) contract. Teaming within the repair industry is just as prevalent, as when Todd Pacific Shipyards joined with Puget Sound Naval Shipyard for an under-budget, on-time maintenance availability on the USS CARL VINSON. Additionally, Atlantic Marine is currently engaged with the public sector repair establishment on a major overhaul of another carrier, the USS JOHN F. KENNEDY.

6.9.2.3 **Workload Sharing**

An enterprise-wide workload/resource review would lead to the identification of opportunities to optimize the match of resources to requirements. Coupled with the capability to schedule the use of critical facilities and equipment, investments in infrastructure could be optimized and any excess infrastructure could be targeted for accomplishing new business or considered for elimination. The nuclear shipyard 2-year advance planning-by-quarter methodology currently in place should be used as a model.

6.9.2.4 **Prioritization Considerations**

6.9.2.4.1 Benefit

Proven return on investment from early NSRP projects shows promise for continued and increasing benefits – including less costly and less lengthy repair and overhaul periods for Navy ships - from continued collaboration and more seamless interaction among the nation’s shipyards. Challenges such as preserving a commercially competitive environment and accommodating the concerns of organized labor will need to be addressed, but the efficiencies to be realized argue for the necessity of migrating to the One National Shipyard concept. The Navy’s Force Response Plan also demands the capability for such interoperability.

6.9.2.4.2 Difficulty

- Maintain competition as appropriate.
- A means of accurately capturing and redefining requirements and capacity.
- Applying the information to reduce the cost of design, build, and repair of ships.
- No enterprise-wide scheduling tool currently exists.
- Striking an equitable balance between national, regional, participant, and customer optimization.
- Competition in contracting act, Small Business Administration (SBA) set asides, and FAR.
- In place multi-year contracts.
- Public/private competition rules.

6.9.2.4.3 Cost Estimate

500k. This comprehensive skills "database" and work sharing initiation would reduce several industry overhead costs and sustain an accurate and current industry-wide pool of specific skills and trades, enabling a fully exportable and readily available labor force for any shipyard need.

7 Organization and Operating Systems

7.1 Scope/Summary

The Organization and Operating Systems thrust area includes all of the processes, tasks, tools, and data associated with master planning, manpower and work organization, scheduling, production control, performance feedback, management information systems, and quality feedback.

7.2 Assessment

The primary conclusions from the FMI benchmarking report regarding planning, organization, manpower, and operating systems focused on the following:

- Simplification of the underlying processes.
- Use of the appropriate level of detail for the given point in the life cycle of a design or construction contract.
- Provide a predictable and level workload for the industry (see Section 6, Joint Navy/OSD /Industry Action, for discussion).

Planning systems and methodologies applied in the U.S. yards are much more complex and require more operational effort than those in the international yards. The U.S. yards have complicated, hierarchical methods that breed too much detail too early which in turn causes multiple schedule changes.

Lack of schedule adherence at U.S. yards causes numerous compounding schedule adjustments, rescheduling of labor, and many other problems.

7.3 Investment Strategy

The top investment recommendations in this thrust area are listed in priority order in the table below:

Organization and Operating Systems					
Investment Priorities	*GSIBBS Reference*	*Paragraph Reference*	*Relative Benefit*	*Relative Difficulty*	*Investment Est. ($M)*
Improve Shipyard Planning & Scheduling Systems	G2, G4	7.4	100	100	$ 5.0
Consolidate & Streamline Production Management Information Systems	G9	7.5	100	71	$ 5.0
Optimize Manpower and Work Organization	G1	7.6	53	45	$ 3.0
Improve Production Control Processes	G5	7.7	53	40	$ 5.0
				Total	$ 18.0

7.4 Improve Shipyard Planning and Scheduling Systems

7.4.1 Issue/Challenge

FMI concluded that the planning systems and methodologies applied in the U.S. are complex and require more operational effort than those in the international yards.

In addition, FMI found that the U.S. shipyards have some complicated systems that often require too much detail too early in the planning process. The processes being used are often labor intensive, requiring a disproportionately high number of people involved resulting in excessive time required for schedule changes. FMI observed poor schedule adherence in many yards, but this is compounded by Navy change orders. Many legacy-planning systems are not responsive to change and often create excessive inventory.

As compared to world-class competitors, many U.S. shipbuilders are underdeveloped in their definition and application of standard production processes. Over the past several years, many U.S. yards have begun standardizing their building processes, while foreign yards practice continuous process improvement. Standard interim products, group technology techniques, and specialized work stations are examples of areas where improvements in use have every potential to lead to lower construction costs and improved construction cycle times. The use of standard production processes supports improved planning, workload balancing, cost predictability, learning, quality, and employee morale. Additionally, standard production processes make it possible to expand existing production capabilities into production of new vessel types with a degree of predictability and lower business risk.

While addressed in a separate section of the FMI report, Outfit Scheduling as it relates to the integration of construction, test, and Navy acceptance/inspection and the relationship to Master Planning is an area of considerable opportunity for both schedule and cost savings.

Another topic area identified that falls under the general thrust area of master planning is simulation-based production planning. Simulation-based planning is an area that will provide major benefits in controlling shipbuilding costs. Accurate simulation-based design and manufacturing applications need to be developed to allow planners to construct and evaluate manufacturing and construction plans and manpower forecasting. This will enhance the planning process and optimize manpower, scheduling, and facility use.

7.4.2 Actionable Solutions

Develop a model planning process centrally to provide guidance for those in industry that are currently developing new systems and/or wish to upgrade current systems. This model would address both the process and the underlying tools and systems used in the broad topic of planning systems.

Consider funding a series of joint Navy/Industry change implementation pilots with the objective of developing a less costly and disruptive methodology for incorporation of change into the design and construction cycles. This may include incorporating groups of changes into smaller baseline upgrades to allow more efficient learning on a series of ships.

Develop a business model that improves detailed planning and scheduling by developing physical and procedural standards that integrate suppliers earlier in the engineering process. Material standards and standardization criteria developed should have direct application to either commercial or navy ships.

7.4.2.1 Prioritization Considerations

7.4.2.1.1 Benefit

Improvements in planning systems have the potential of improving schedule adherence, manpower loading, and the overall cost of ships.

7.4.2.1.2 Difficulty

While the change and workload related issues would require challenging joint Industry/Navy solutions, process changes related to more efficient planning processes are relatively easier to pilot and implement.

7.4.2.1.3 Cost Estimate

The cost associated with the proposed solutions will vary depending on the size and number of pilots undertaken. $5M would allow significant progress to be made in this thrust area.

7.5 Consolidate and Streamline Production Management Information Systems

7.5.1 Issue/Challenge

FMI did not question that the appropriate information was available. However, they observed that potentially too much data was available which had the tendency to increase support costs with no additional benefit to the shipyards.

Additional challenges identified in this thrust area include the simplification of production management processes and tools, and streamlining and standardizing reporting requirements to the U.S. Navy.

7.5.2 Actionable Solutions

Consider funding a series of pilot projects related to the application of lean principles focused on improving the flow of information and delivery to the shipyard manager's desktop.

Consider funding a series of pilot projects addressed at the Navy/Shipyard interface related to production management information systems.

7.5.2.1 Prioritization Considerations

7.5.2.1.1 Benefit

Improvements in this thrust area have significant potential for streamlining the process used to manage and deliver production management information.

7.5.2.1.2 Difficulty

No substantial barriers exist for the implementation of results in this area.

7.5.2.1.3 Cost Estimate

It is anticipated that $5M would be required to execute the actionable solutions described above.

7.6 Optimize Manpower and Work Organization

7.6.1 Issue/Challenge

FMI concluded that there has been a notable change in HR policy over the last few years with yards making much more effort to retain and get the best out of their people. The importance of the stable workforce is understood. While the use of best practice applied across the industry is variable but with some very good examples, the industry generally lags behind the international group. In addition, FMI found that the yards feature some or all of the following: hire and fire policy, difficult labor relations, strong blame culture, trade demarcation, limited multi-skilling and limited training for flexibility. The public image is generally poor. Some yards are not attractive places to work. There has been a serious reduction in new entries into higher education for shipbuilding. Workstation organization is not fully implemented. There is a lack of full area management controlling multi-disciplinary teams.

The shipbuilding industry faces some unique challenges regarding the fairly broad topic area of manpower and work organization covered by the FMI report. Stability or predictability of the workload is a significant enabler to avoiding the “hire and fire policy" noted by FMI and one which the industry and the Navy can work together to improve.

Working conditions and their relationship to safety and health also present challenges to be solved by both the Navy and, more broadly the Government along with the shipyards. Strides have been made in improving shipyard safety and ergonomic conditions, but further improvements are needed.

The industry lacks methods for handling a diverse workforce, including understanding multiple cultures and addressing workplace literacy and language requirements. Trades and management personnel alike are recognized as specialists in a particular field, and processes and management systems have been put into place accordingly. Education and training programs in most shipyards are equipped to provide conventional classroom or hands-on training for their employees via on-site training programs. Across the industry, however, these on-site training programs are often specifically tailored for the specific company conducting the training, and are not shared with the rest of the industry. Considering the overlap in training requirements and needs that must exist across shipyards performing similar work, these separate training endeavors may be draining individual shipyards, and the industry as a whole, of much needed resources. Training technology options generally have not been widely adopted.

The industry lacks implemented skills standards needed to support shipyard operations and the "One Yard" concept. Industry specific skill standards can provide shipyard workers portability of their skills. This will allow the shipyard worker to remain industry focused while working at various yards, due to industry business cycles. Additionally, shipyards can be assured of the skill level that a certified shipyard worker will bring with him to a job.

7.6.2 Actionable Solutions

Safety/Health

Consider funding a comprehensive review of regulations, practices, standard procedures, and processes related to safety/health, concluding with specific recommendations that would improve shipyard safety and reduce safety and health care related costs across the industry.

Schedule Stabilization

Establish a more stable design and construction schedule cycle for U.S. Navy vessels to allow better level loading of the workforce. U.S. Navy should consider using industry for additional technical and design work to allow retention of core skills. (See Section 6, Joint Navy/ OSD/Industry Action for discussion.)

Special Skills Training

Consider establishing centers for specialized skills training to reduce start-up and training for implementation of new technologies and materials. This would include the continuation of work accomplished to date in developing a standard definition of skills across the industry.

7.6.2.1 Prioritization Considerations

7.6.2.1.1 Benefit

Improvements in safety, quality of life, and other human resource aspects of the industry are somewhat difficult to quantify. Clearly, savings related to safety/health have the potential for significant direct and indirect savings to both industry and the Navy.

7.6.2.1.2 Difficulty

With a focus on the three actionable solutions, the only significant potential barriers to implementation are charged to safety/health related laws and regulations.

7.6.2.1.3 Cost Estimate

A relatively modest investment of $3M would provide a significant opportunity for improvements in this area.

7.7 Improve Production Control Processes

7.7.1 Issue/Challenge

FMI concluded that there are weaknesses in the planning systems in some yards that are being compensated to some extent by a huge effort in production control and, that in many cases, improvements in the planning processes would reduce the effort.

Production control encompasses the processes related to each shipyard's material movement, schedules, work instructions and other associated activities within a daily, weekly or possibly monthly time horizon. Production control activities must fit into the larger planning and scheduling framework outlined in Section 7.4 (Improve Shipyard Planning and Scheduling Systems) and must be well integrated with those higher level planning processes and systems in order to avoid the application of additional resources in production control as pointed out in the FMI report.

7.7.2 Actionable Solutions

Define, pilot, and provide to the industry, production control methodologies that support improvements to the detail planning and management of material, labor, production information, facilities, and tooling. This may involve cost saving methodologies/technologies being exploited by other industries in addition to:

- Increased use of standardized piece/parts
- Innovative techniques for computerized control and tracking of interim parts and products
- Automated part markings
- Increased use of Just-In-Time practices
- Reduction of inventory of raw materials/components and in-process products
- Visual material control systems

Consider funding specific efforts aimed at the reduction of cost and schedule in the onboard construction and testing time frames for different ship types across the repair and new construction industry.

7.7.2.1 Prioritization Considerations

7.7.2.1.1 Benefit

The relative impact of improvements in this thrust area are modest in regards to cost savings, however, the potential for reduced lead times in the construction cycle will amplify the cost savings.

7.7.2.1.2 Difficulty

No significant barriers to implementation exist.

7.7.2.1.3 Cost Estimate

An investment of $5M would provide the ability to make excellent progress in this thrust area.

7.8 Other Topics

A number of related topic areas were identified by FMI and the industry experts. The topic areas identified included:

- Performance and Efficiency Calculations
- Quality Assurance
- Pull vs. Push Production (MRP2)

These topic areas, while important, were deemed to be of a lesser priority than the topic areas addressed in sections 7.4 – 7.7.

Performance and Efficiency Calculations and Production Management Information Systems were identified as probable candidates for shipyard-specific topic areas.

8 Shipyard Outsourcing and Supply Chain Integration

8.1 Scope/Summary

This thrust area addresses the structure and operations of shipbuilding supply chains. Specifically, the recommendations includes actions to streamline shipyard-supplier interactions, improve the flow of information to enable more aggressive and more efficient outsourcing, remove barriers to outsourcing, and to assess the adaptability of outsourcing strategies that work well for foreign shipyards building less complex ships for commercial customers.

The FMI report recommendations illustrate the scope of potential activity considered in this area:

- The coordination of purchases of treated plate steel (A1) and profile steel (A2).
- The outsourcing of purchases of fabricated metal outfitting components (A11) and pipe spools in a reduced variety and degree of complication (B1).
- Centralization of machining work to increase throughput (B2), sheet metal manufacturing facilities (B3), electrical component manufacturing facilities (B4), and module assembly (pre-assembled units for outfitting) (C1) .
- Investigation of palletized stores system (B5), outfit parts marshalling (C2) and material handling and storage alternatives (C6).
- Institute Just-In-Time deliveries of large/heavy items (B6).

8.2 Assessment

The FMI Benchmarking Report identified a clear distinction between the make/buy philosophies of U.S. shipbuilders and that of foreign shipbuilders, particularly in the choices of what the major shipyards consider core competencies and strengths. Although the traditional sub-contractor model continues to be employed for many of the ship's components, the industry perceives that, in order to remain cost effective, the majority of the work required to assemble and test a major warship still requires a single business entity to perform the work. Changing that cultural mindset requires increased confidence that outsourcing can meet the demands of Navy shipbuilding. Accordingly, the recommendations proposed address the steps needed to make outsourcing strategies viable.

Materials costs are a significant factor in U.S. shipbuilding. The shipbuilding supply chain is an area rich in opportunities for reductions in both cost and cycle time, as identified in both FMI report and the 2002 ASN RDA "Report to Congress on Prior Year Shipbuilding Account Management". Since the FMI benchmarking methodology does not explicitly assess supply chain issues, there are no numerical scores to compare. Nonetheless, the report does identify outsourcing as a key recommendation for U.S. shipyards.

The ability to reliably estimate and control materials cost, quality, and delivery is a major challenge – especially in light of the instability of U.S. Navy shipbuilding plans. In addition to inflation, a limited supplier base for highly specialized and unique materials makes ship materials susceptible to price increases. The low rate of ship production has affected the stability of the supplier base – some businesses have closed or merged, leading to reduced competition for the services they once produced. As a result, remaining suppliers were able to raise prices. In some cases, the Navy lost its position as a preferred customer and the shipbuilder had to wait longer to receive materials. With a declining number of suppliers, more ship materials contracts have gone to single and sole source vendors. Over 75 percent of the materials for the VIRGINIA Class submarines – which were reduced in number from 14 to 9 ships over a 10-year period – are produced by single source vendors.

Materials cost estimates are based, in part, on the number of units produced and learning curves – the more units produced, the less expensive each unit is expected to be. Thus, if contractors and subcontractors are assured a high, consistent level of business, they are able to produce the ship and ship parts at a lower cost. Conversely, if purchases are erratic or dip to historically low levels, the ship and ship parts will be more expensive to produce.

It is estimated that over 60% of the ship's cost is purchased material, with the trend increasing. This is due in part to the legacy of Navy construction with its emphasis on military specification compliance and the FARs, as well as the continued trend of increased complexity in the vessel design, resulting in an overburden of material and parts. U.S. shipyards, like most companies, have allowed their supply chains to develop largely without intervention.

8.3 Investment Strategy

The top investment recommendations in this thrust area are listed in priority order in the table below:

Shipyard Outsourcing and Supply Chain Priorities					
Investment Priorities	*GSIBBS Reference*	*Paragraph Reference*	*Relative Benefit*	*Relative Difficulty*	*Investment Est. ($M)*
Apply Lean/Six Sigma Tools to Streamline Shipbuilding Supply Chains	--	8.4	100	100	$ 6.0
Eliminate Outsourcing Disincentives	A1, A2, A11, B1-B6	8.5	60	89	$ 0.5
Outsourcing Strategies, incl Regionalization and Process Consolidation of Shipyard Work	A1, A2, A11, B1-B6	8.6	55	51	$ 20.0
Enable Supply Chain Data Sharing	C1-C3	8.7	50	44	$ 1.8
				Total	$ 28.3

8.4 Apply Lean/Six Sigma Tools to Streamline Shipbuilding Supply Chains

8.4.1 Issue/Challenge

The first step in improving the efficiency of existing supply chains and enhancing the viability of more aggressive outsourcing strategies is to streamline current supply chain processes. This requires a deeper understanding of the supply chains in which suppliers/subcontractors can number in the tens of thousands. Many industries have found Lean/Six Sigma approaches to be particularly valuable in providing these insights and implementing solutions to eliminate non-value-added waste in the supply chains. For example, the current mix of suppliers contains duplications and inconsistencies that fail to take advantage of economies of scale. In addition to the compounded waste that exists within these multiple entities, there is the waste of unnecessarily managing so many of them.

Comprehensive understanding of the supply chain (jointly with the Navy customer) is the first and most important step of designing a supply chain management program/strategy that employs the principles of Lean manufacturing. In designing such a strategy it is important to understand and identify the different kinds of waste found in the supply chain:

- Operational waste - internal to individual members of the supply chain.
- Transactional waste - caused by the transactions between members of the supply chain.
- Structural waste - waste due to the current value chain structural design of value streams, activities, and responsibilities.
- Systemic waste - waste resulting from the way members are organized in relationship to each other.

8.4.2 Actionable Solutions

- Perform a lean supply chain analysis of the collaborative ship construction environment within the unique Naval Shipbuilding Enterprise. This step is critical to understand the key areas where changes are needed. This effort will complement much of the lean work that is underway in many shipyards and the NAVSEA Task Force Lean Initiative. Based on this analysis, an efficient collaborative process can be designed and implemented.
- Select pilot acquisition areas for Lean Supply Chain implementation on a Navy shipbuilding program.

- To address the trend of increased material costs and increased overburden of material and parts, the industry needs to implement proactive procurement methods and strategies that reduce waste, shorten cycle times and reduce the total cost for material and services employed in the shipbuilding process. Some examples of these methods include just-in-time delivery, vendor stocking, material standardization, and utilizing commercial specification material in lieu of military spec material whenever feasible. Currently, key members of the carrier and submarine supply base are collaborating through consortiums to address similar supply chain issues (Submarine and Aircraft Carrier Industrial Base Councils).

8.4.2.1 Prioritization Considerations

8.4.2.1.1 Benefit

- Streamlining existing supply chains is expected to be the most beneficial of all recommendations within this thrust area because the recent gains from the deployment of Lean/Six Sigma in other areas of shipbuilding are tangible and widely appreciated. The existence of waste in the as-is processes is a widely-accepted given, and the probability of near-term improvement from a concerted, joint effort is considered high. The benefits would accrue to both Navy and Industry both in the near and long term.

8.4.2.1.2 Difficulty

- If this were easy, it would have been already accomplished. Acquisition programs are typically designed to fabricate and purchase critical components years before installation is planned. The lack of focus across an entire value stream results in a high level of transactional waste that drives the total cost of the program, regardless of gains produced by local efficiencies.
- Culture to include politics and unions
- Infrastructure issues to include facilities shortcomings and distance between facilities.
- Impact of reverse auctioning (long term) on quality and the supply base
- Market barriers to include the uncertainty of Navy workload
- Lack of standardization to include inconsistency in schedule adherence
- Regulatory barriers – MILSPEC and FAR requirements
- Foreign exchange rates (someone has to accept the risk)
- World market for raw material (steel - a continuing concern for everyone)
- Sole source restrictions and the prevention of long term supplier partnerships
- Government's challenge in directing desired sources

8.4.2.1.3 Cost Estimate

The NSRP Extended Lean Enterprise Project performed similar work on a very limited scale that averaged $400k per major supplier. Each supplier served as a pilot for improved processes, and the ROI from just the first few suppliers returned the investment quickly. Assuming 20 major suppliers per shipyard enterprise over 8 Navy Programs/Shipyards, the total investment in this area is estimated at approximately $6 million.

8.5 Eliminate Outsourcing Disincentives

8.5.1 Issue/Challenge

The Navy shipbuilding environment poses numerous barriers and disincentives to outsourcing. Examples include labor union rules, overhead allocation constraints, low order rates and unstable workload. Suppliers are reluctant to engage in complex federal contracts and continued re-competition, while shipyards view many tasks that might otherwise be outsourced as opportunities to control overhead by applying idled in-house labor on direct-charge work.

U.S. Navy shipbuilding suppliers and subcontractors are also required to comply with burdensome "flow-downs" of the Federal Acquisition Regulations (FAR) and the Defense Federal Acquisition Regulations (DFAR), some of which are costly to implement and require substantial changes to their business processes. An example with significant impact is the requirement to employ an Earned Value Management System.

8.5.2 Actionable Solutions

8.5.2.1 Identify and Eliminate Outsourcing Disincentives in Navy Contracts

- Identify and eliminate disincentives and improve incentives to encourage "prime" shipyards to engage turnkey suppliers; other prime yards, tier two yards, and non-shipbuilding entities in construction projects in a manner that results in overall savings to the Navy.
- Eliminate the competitive bid requirement that impedes the development of strategic long-term relationships with high value suppliers.
- Correct FAR provisions that inhibit outsourcing.
- Improve determination and administration of fees and incentives to maintain a healthy shipbuilding industrial base.
- Consider specific, targeted incentives that reward effective outsourcing to suppliers or partnered shipyards.

8.5.2.2 Prioritization Considerations

8.5.2.2.1 Benefit

- Reduces total costs through innovation and specialization (provided overhead costs can be reduced /offset by the Prime shipyards).
- Navy prime shipyard can focus on complex aspects of warship construction and repair when the non-core activities of construction and repair are eliminated from their primary scope of work.
- Stabilizes small yard business base and expands the pool of workers familiar with warships and arrangements and systems.

8.5.2.2.2 Difficulty

- Adequate incentives for prime contractor yards to outsource.
- Ability of prime contractor yards to reduce/reapply infrastructure to offset adverse impact on rates.
- Interoperable processes, procedures and tools; IT maturity.
- Resistance from labor unions.
- Regional advantages/disadvantages due to different labor rates and proximities of yards.
- Aged procurement systems may not be sufficiently flexible.

8.5.2.2.3 Cost Estimate

Much of the action needed in this arena is within the aegis of the federal government. The estimate of $500k is based on industry participation such as pilots, best practice determination, etc.

8.6 Outsourcing Strategies, Including Regionalization and Process Consolidation of Shipyard Work

8.6.1 Issue/Challenges

The FMI report recommended that U.S. shipyards adopt the outsourcing practices that are so effective in foreign commercial yards. This variety of consolidation/aggregation strategies to shift low volume work of individual yards to a higher volume provider could include increased reliance on existing suppliers, new make-buy decisions, or more sophisticated enterprise restructuring involving combinations of new facilities with coordination and reconfiguration of existing facilities. The supply sources could be partner yards, third-party yards, or any of a variety of non-shipyard entities. Many of the activities included in this discussion can be performed outside of the prime shipyards and are not considered core competencies of the prime yards.

FMI and other sources report that the outsourcing practices of U.S. shipbuilders are generally less extensive than those of leading foreign shipyards and of other U.S. auto and aerospace industries – due largely to the limited volume of unique specification components used in complex naval warship designs. Instead of relying on less structured collaborative processes and supplier design expertise, most U.S. shipbuilders tend to follow government acquisition practices and continue to submit detailed design specifications for bid, following the typical Engineer-to-Order model. This mode of doing business results in short-term, distant relationships between shipyards and suppliers instead of utilizing full supplier value contributions.

Foreign shipyards, typified by much higher throughput of simpler and more repeatable ship designs for a diverse commercial customer base, more fully involve their suppliers in the business of shipbuilding, depend almost wholly on a small group of tier one suppliers and develop long-term, close relationships with those key suppliers with which they do business.

While most Navy vessel design detail is developed within the shipyard, the automotive, and aircraft industries (among others) have shifted much of the detail work upstream to the suppliers. Shifting design workload through supplier integration utilizes their technical knowledge and expertise. This shift leverages the technical expertise of the suppliers and has been extremely beneficial in terms of reducing both cost and time. Supplier integration will reduce cost and cycle time by tasking them to meet criteria for performance, production installation, testing through to overall ship life cycle maintenance. Achieving such a shift depends on establishing solid business relationships, implementing electronic data exchange protocols, and changing the paradigm of current design and value integration practices.

Outsourcing by the prime shipbuilders can be done to other prime shipyards, tier two yards, or other non-shipyard suppliers/contractors. This action affords the prime yards the ability to eliminate these non-core activities and focus on the complex aspects of warship construction. There are recent examples of outsourcing by prime shipyards. One example is the work performed by Northrop Grumman Newport News Industrial Products Program supplying products from the Newport News foundry operation. The products have been furnished, on a competitive bid basis, to Bath Iron Works, Electric Boat, Northrop Grumman Ship Systems (Ingalls Operations) and Northrop Grumman Ship Systems (Avondale Operations) in support of SSGN, DDG, SEAWOLF, LHD, LPD, and USCG Programs. Additionally, during the past year two prime Gulf Coast yards have outsourced the fabrication of panels and units, some with outfitting, to a second tier yard and a non-shipyard fabricator. While these examples are relatively small in terms of the overall potential, they are examples that there has been some movement in the direction of outsourcing by the prime yards.

8.6.2 Actionable Solutions

- The industry should examine strategic outsourcing decisions to determine the best candidates for outsourcing to achieve lower costs and greater assembly productivity. A 2002 NSRP study by Altarum Institute with Northrop Grumman Newport News developed a process to identify key areas for U.S. shipbuilders to explore those tasks that were outside the shipyards core competencies, for the potential of outsourcing those activities.
- Develop and implement effective outsourcing strategies to facilitate standardization, to reduce lead times and to achieve greater economies of scale. The concept could include the development of consolidated specialized centers to provide interim products to the shipyard. These centers could be operated by prime shipyards, second tier shipyards, or by non-shipyard suppliers/contractors. These opportunities were identified as clearly significant factors in the 2005 FMI Report. The concept of an enterprise with shared capacity is also consistent with the Navy's "One Shipyard Concept".
- Assess the viability of various forms of increased outsourcing in each of the following areas:
  - Fabricated metal outfitting components

- Pipe spools
- Centralized machining work
- Sheet metal manufacturing facilities
- Shipboard electrical component manufacturing facilities
- Module assembly (pre-assembled units for outfitting)

8.6.2.1 **Prioritization Considerations**

8.6.2.1.1 Benefit

- Outsourcing non-core activities enables focus on core competencies of shipbuilders.
- Reduce cost of materials through contracting with lower cost producers.
- Burdened labor costs of suppliers with a broader, more diverse business base may be lower than that of the prime yards with low Navy order rates.

8.6.2.1.2 Difficulty

While this initiative has the potential to provide significant benefit to the industry, there are numerous barriers that should be addressed and eliminated prior to implementation. To achieve the long-term desired benefit that regionalized outsourcing should provide the industry must be diligent in mitigating the risks associated with implementation.

- Organized labor strongly opposes any programmatic effort to subcontract more work outside of their facilities.
- Prime shipyards are reluctant to outsource work without sufficient incentive.
- Widely varying wage rates across the country make subcontracting less attractive in some areas.
- The total cost impact associated with subcontracting of low volume, highly engineered naval warship work exceeds that of simpler commercial components. Purchasing, quality, engineering all incur added costs removed from the operations cost center. Loss of control and the waste of overproduction is an associated risk with this concept, due to the historical volatility in shipyard schedules.
- Training issues would occur when prime shipyards subcontract for labor. The augmenting work force would need training in the work processes and procedures of the prime shipyard.
- Suppliers and subcontractors for navy vessels are required to comply with "flow-downs" of the FAR and the DFAR, some of which are costly to implement and require substantial changes to their business processes. An example with significant proportions is the requirement to employ an Earned Value Management System. Additionally, foreign subcontractors are limited in their ability to support Navy contracts due to stringent International Traffic in Arms Regulations (ITAR) requirements.
- In the case of subcontracting deliverable-based work, there may be situations where the subcontractor would need to train its workforce on Navy security requirements, particularly NOFORN.
- Transportation and shipping of deliverable components from the supplier/contractor to the prime yards could pose some limited problems. While this proximity issue concern that must be addressed, it is not insurmountable.
- Potential erosion of critical prime shipbuilding infrastructure/capacity through outsourcing to non-shipbuilding enterprises.
- Continued bearing of overhead burden of prime shipyards across a smaller labor base. This may tend to increase overhead costs at those shipyards thereby increasing the man-day rate, which would erode potential savings to the Navy.
- Incentives or sharing of cost savings offered to prime shipyards to offset the impacts of subcontracting would result in less net savings to the Navy.
- From the prime shipyard perspective, there is risk of loss of work and loss of capability to do specific types of work that is subcontracted.

- There is a risk associated with potential schedule impacts in the event subcontractors are unable to perform to the required schedule. An area of paramount importance to all critical supply chain initiatives and executions is the need for a realistic and dependable plan and schedule. This plan and schedule must be both executable and reliable since the entire procurement and material logistical plan for the acquired materials will fail if the schedule is not accurate.

8.6.2.1.3 Cost Estimate

The proposed investment level envisions some level of infrastructure development; however, it did not assume there would be a need to develop a greenfield manufacturing facility given the current capabilities available to the industry. The costs would include process development, infrastructure improvements, and support to de-establish existing shipyard infrastructure to remove the overhead burden. This investment candidate is budgeted for $20M.

8.7 Enable Supply Chain Data Sharing

8.7.1 Issue/Challenge

Best practices from high volume industries such as automotive, aerospace and even foreign commercial shipyards offer valuable models – but they are a point of departure for the low volume, highly-engineered ships that distinguish the U.S. Navy market sector. The complexity of an SSN, for example, is estimated by FMI to require over 200 times the work content of a similar-sized commercial vessel. Effective and efficient management of supply chains for ships such as DDX, CVN, SSN, LPD, LCS, LHA(R) and the other programs on the horizon necessitates the sharing of production process and ship construction data. This includes the designed materials and the plan and schedule required to support a collaborative naval shipbuilding program across an extended enterprise. This issue includes the interface from the Navy to the shipyard, internal shipyard processes, and multiple tiers in the supply chain.

Current processes related to shipyard material acquisition are typified as manual, labor intensive, paper oriented, and differing from yard to yard and from program to program. This is true for shipyard to supplier processes as well as intra-yard processes. Current process tracking and management are often manual and ad-hoc resulting in high labor costs, long cycle time, and errors due to manual data entry/data exchange. These facts are substantiated by the 2003 Purchasing and Purchasing-Related Benchmarking Study sponsored by the National Shipbuilding Research Program.

The shipyards also face a myriad of NAVSEA/government processes that vary between ship classes. This challenge is compounded for suppliers, who are faced with a myriad of processes that vary not only between shipyards, but may vary within a single shipyard for different classes of ships. In addition, business processes are "stove-piped" to an individual class of ships that results in the time and expense of reformulating processes from class to class. The variation is these processes adds cost and complexity but does not add value. Success in rationalizing and automating some of these practices across shipyards, navy programs and suppliers through NSRP over the past several years has proven the merits of work in this area.

8.7.2 Actionable Solutions

- Establish joint Navy/Industry projects to define the content and methodology (including standards, processes and tools) for exchanging production process and construction support information required for a collaborative construction program.
- Provide funds to accelerate several proven vehicles (Shipbuilding Partners and Suppliers (SPARS), Common Parts Catalog (CPC), and Integrated Shipbuilding Environment (ISE) initiatives as described below) to effectively integrate requisite business processes and information between shipyards and suppliers that will support a shipbuilding collaborative Integrated Supply Chain process.

  - A model for investment in this regard is the SPARS Initiative sponsored by NSRP. U.S. shipbuilders and suppliers are working together through a series of incrementally funded SPARS tasks to address U.S. shipbuilding supply chain integration issues. A key objective of this effort is to have the participating shipyards define the extent to which data needs to be shared to support the collaborative construction environment while maximizing each shipyard's ability to continue to differentiate themselves and promote a competitive environment. The SPARS goal is to enable shipbuilders and suppliers to operate as a single integrated virtual enterprise. Independently, industry and Naval Supply Systems Command (NAVSUP) have initiatives addressing supply chain integration. The objective is to integrate the full range of shipbuilding business processes from concept design through disposal. The "Virtual Shipbuilding Enterprise" is enabling sourcing and supply chain integration to provide business process interactions among shipyards and suppliers that is transparent of the underlying processes and computing environments of the participants.
  - Another NSRP model is the Common Parts Catalog. NSRP and the shipyards have co-funded the development and full-scale testing of this capability at 4 shipyards, with more to follow calendar year 2005. This capability greatly enhances outsourcing efficiency and life-cycle logistics. NSRP's funding constraints, however, preclude extension of this capability to Northrop Grumman Newport News and NASSCO, which provides an opportunity for SIBIF to invest.
  - A final NSRP model called the Integrated Shipbuilding Environment is working to complete the product data interoperability standards described in the Design and Engineering thrust area. Progress is steady and portions of the architecture have been deployed, but limited NSRP funding constrains the rate at which these solutions can be developed. These standards will further enhance the capability and reliability of transmitting design and manufacturing data to geographically disbursed suppliers.
- Continue developing and testing interoperability standards supporting the information needs of a collaborative shipbuilding supply chain. The current NSRP projects ISE, SPARS and CPC have defined and tested many in this area already. The interoperability standards would not only define the exchange methodology, but would also define the level to which construction process data would be exchanged. This would define the extent to which construction process data would be shared among shipyards and the degree to which shipyards would be able to protect their proprietary shipyard processes. The development of interoperability standards would allow each business entity to implement a construction process optimized for their business yet allow the shipyard to participate in a number of collaborative construction programs without incurring the significant cost of building an environment for each program.
- Enable business processes through which shipyard-supplier design, procurement and production functions can be managed, thereby reducing the total cycle time and cost of ship design and construction.
- Enable the implementation of pre-contract business processes that integrate the supply chain with the shipyard design/engineering organization to support build strategies, master scheduling, resource allocation, capacity analysis; improved bidding, estimating, and costing systems.
- Share production process information and product data to support increasing co-production contracts and permit wider industry participation in defense work.
- Leverage the work done by others. First Marine International (FMI) and the Marine Machinery Association (MMA) have shown that the supply chain integration can be of benefit in the domestic industry. Furthermore, The Office of Naval Research (ONR) has developed Supply Chain Practices for Affordable Navy Systems (SPANS) and Lean-Pathways Programs to address supply chain integration in the aerospace and shipbuilding industries.

8.7.2.1 Prioritization Considerations

8.7.2.1.1 Benefit

- The naval shipbuilding environment is heavily dependent on timely, accurate information for all facets of the process. The growing complexity of ships such as the LPD 17 – which was designed to replace 4 previous classes of specialized ships – demands that the supply chain share detailed information in real time
- Real time business information flow is essential to achieving greater productivity in business process arenas.
- Elimination of manual, paper-driven processes reduces the probability for errors and improves the timeliness of completing transactions that can affect the productivity and ability to maintain production schedules during all phases of ship material acquisition.

8.7.2.1.2 Difficulty

- The actions identified in this document will require cultural change within the Navy Shipbuilding Enterprise, which can only be achieved with an appropriate level of leadership focus.
- Effective solutions will require close coordination of the shipbuilding and repair industry in order to develop and manage common architectures (process, information, and technical) and to guide past and future Navy Shipbuilding Enterprise information exchange developments. This coordination will support the Navy's commitment to Life Cycle Management of the fleet.
- Effective solutions will also require issuing appropriate policy and guidance and incorporating appropriate clauses in NAVSEA contracts.
- Processes are often interdependent. Overarching framework for process, product and organizational changes must be developed to achieve sufficient savings to buy more ships.

8.7.2.1.3 Cost Estimate

NSRP has several related projects that provide insight into the costs of addressing these issues: Outsourcing Pilot, SPARS, ISE, Component Factory, and Standard Terms and Conditions. Based on the cost of these past projects, as well as the forecast of work remaining, $1.8M should be budgeted for investment in this area. Note: Shipyard-specific investments such as CPC deployment at Northrop Grumman Newport News or NASSCO are not included in this estimate of collaborative work.

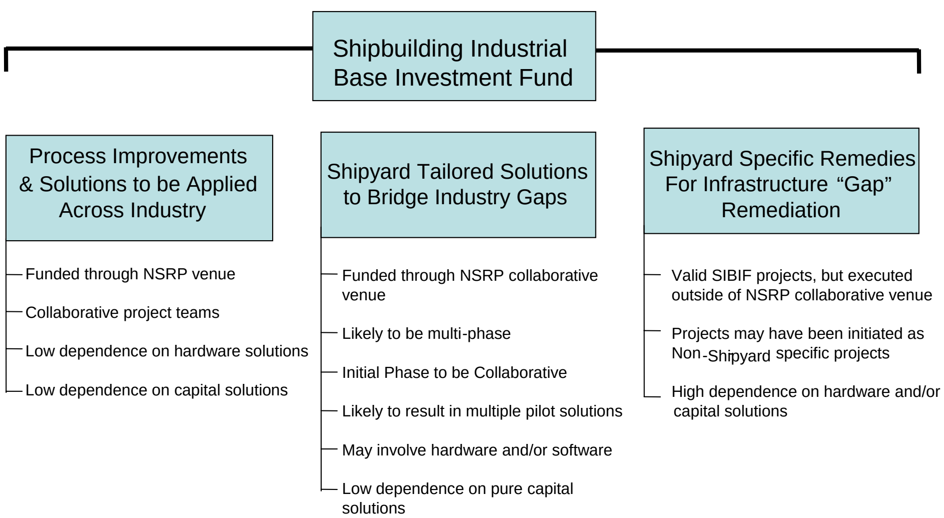
9 Shipyard-Specific Productivity Engineering

9.1 Complementary Execution Strategies

The FMI benchmarking report indicates that the use of best practice in the U.S. shipbuilding community is behind international standards in a number of areas. The report also shows a large variance of scores among U.S. yards in many areas. This performance spread (or variance) is the natural result of the degree to which individual shipyards have developed specific areas of their operations based on their business priorities, and on factors such as facility constraints and market sectors served. FMI rightly asserts that it is not cost effective for shipyards (or their customers) to seek best practice level for all benchmarking elements. These realities lead to a three-pronged investment strategy:

1. Joint efforts in raising the use of best practice across the industry in areas where the U.S. yards are generally behind by developing solutions with R&D applicability.
2. Joint efforts in raising the use of best practice across the industry in areas where the U.S. yards are generally behind by developing baseline solutions that must then be tailored to implementation specifics in individual yards – but are generally not capital-intensive.
3. Closing the spread (variance) of best practice use in areas where some U.S. yards compare favorably with leading foreign yards while others are further behind – using strategies that tend to be better suited to shipyard-specific investments.

The graphic below illustrates these execution options.



The investment levels cited in each of the preceding sections of this document refer primarily to the first execution strategy described above - collaborative projects. This section describes the second option in more detail and suggests an appropriate investment level.

9.2 The Case for Shipyard-Specific Investment

Since a process implemented in one yard is not necessarily applicable to another yard, the facility with less developed processes cannot simply copy the solution applied elsewhere. Similarly, a particular shipyard may not be able to apply the solutions of every industry-wide development due to unique limitations in their current processes and capital constraints. A specific process improvement may also include a change in hardware and infrastructure to support the process. The method and form of implementation of advanced processes will be unique to each yard and therefore require its own development path to at least some degree.

These situations imply investments tailored to individual shipyards. Since each shipyard received an individual benchmarking report on their use of best practice in all fifty sub-elements of ship production, their individual improvement strategies can identify areas where they would look to collaborative solutions as well as those areas where their needs would be most effectively accomplished by focused, shipyard-specific work.

9.3 Shipyard-Specific Investment Issues

Two issues will inevitably arise as shipyard-specific investments are considered:

- Funding individual yards for development work that is specific to them (and potentially of limited benefit to other yards) may run into objections by those who have already invested in developing these areas of production on their own.
- Government funding of capital projects for individual yards may be difficult under government contracting rules.

These two issues potentially reduce the viability of successfully conducting shipyard-specific projects as an element of a future Shipbuilding Industrial Base Investment Fund. There are, however, precedents on which model such a project is proposed.

9.4 A Shipyard-Specific Investment Model

Investment in shipyard-specific initiatives should be considered particularly appropriate for those sub-elements that have a large variance in benchmarking scores and are not prioritized targets of opportunity for the industry-wide initiatives as described in the proposed thrust areas. This strategy will accomplish two objectives; it will raise overall industry averages and it will improve the least developed processes throughout the industry. This may also have the added benefit of enabling participating U.S. shipyards to more readily take advantage of the industry-wide solutions implemented by the other project work.

Although the particular capital projects undertaken by the shipyards may be specific to each, the *process* for developing those projects is not shipyard-specific and may qualify for program funding. The proposed process follows the structure first developed and successfully deployed under the Air Force Technology Modernization Program and later under the Navy and Army sponsored Industrial Modernization Incentives Program (IMIP), established by DoD Directive 5000.44. Using the IMIP model, each shipyard-specific project would involve three distinct phases:

Phase 1- Process Analysis/Project Identification, this phase includes the following tasks:

- Structured analysis of current processes and identification of cost drivers.
- Identification of project opportunities and prioritization of productivity improvements.
- Conceptual design of new processes.
- Preliminary cost/benefit analysis.
- Preliminary project plan, capital investment plan and schedule.
- Proposal development for Phases 2 and 3.
- Assessment of risk in not implementing the new process.

Phase 2- Project Design/Development, this phase includes the following tasks:

- Define system requirements.
- Detailed design and development of new systems or processes.
- Prototyping, modeling, method demonstrations and validation testing.
- Finalize capital requirements, update cost/benefit analysis, implementation planning.

Phase 3 - Production Implementation, this phase includes the following tasks:

- Capital equipment and/or system acquisition, installation and construction.
- Production proofing, integration and implementation.

- Performance improvement measurement and confirmation.
- Technology transfer to the industry.

Phases 1 and 2 can be characterized as "shipyard productivity engineering efforts." The envisioned SIBIF would fund Phases 1 and 2 of selected projects.

Cost sharing for Phase 3 (capitalization) between DoD and the individual shipyard is envisioned to vary by project and would affect the negotiated benefit sharing. The decision to go forward with the capital investment and production implementation at the end of Phase 2 comes from the final evaluation of the impact on production programs by shipyard management and Navy production program representatives. There may be cases where the yard determines that there is insufficient benefit to warrant the continuation of the project. The key input for that review is the updated cost/benefit analysis performed by the shipyard's finance department.

This structure would provide each shipyard with an incentive to perform a structured process analysis culminating in a strategic plan and conceptual design to modernize particular areas of their ship production processes that were identified in the benchmarking report. If the results of the analysis performed during Phase 1 and the validation testing in Phase 2 substantiate the viability of the planned capital investment, the shipyard would go forward with the Implementation Phase with a reduced risk of failure.

Cost, quality and capacity improvements will naturally be variable across the industry and dependent on the types of shipyard-specific projects that are completed through the Implementation Phase. Since the first two phases of these projects include cost/benefits analyses that are *specifically* directed at current or near term Navy ship production programs, the structure is in place to validate the potential benefits to the shipyards and the Navy as the investments in development are made. The key point here is that the validated benefits would exceed the investments made by the Navy and the shipyards.

Examples of the types of projects that might be identified as shipyard-specific initiatives are provided in Table 9.1, which lists recent and current capital projects undertaken by U.S. shipyards:

Capital Investment	Shipyard	Approximate Cost
Automated Sheet Metal Shop	GDEB	$11M
Automated Profile Fabrication Line	NASSCO	>$10M
First Operations Center (steel processing)	Bender	$5M
Block Assembly Line	NASSCO	>$20M

Table 9.1 – Recent Shipyard Capital Projects Resulting from Shipyard Process Analysis

9.4.1 Actionable Solutions

- Shipyards assess their needs for development work specific to their operations.
- OSD reviews the feasibility of funding shipyard-specific work under the 3-phase structure described.
- OSD confirms the method to make funding available through Navy Production Program PEO's.
- A confirmed method for supporting this type of work is documented .

9.4.1.1 Prioritization Considerations

9.4.1.1.1 Benefit

Each shipyard's priorities will be different. The nature of their processes, the types of ships being produced and their particular contract technical demands result in a different "as is" condition. However, the Benchmarking Report reveals a potential ranking for those sub-elements that have a significant range of scores across the industry and are not currently ranked as high priority (top 10) for development work under the NSRP structure. The sub-elements ranking are as follows:

Sub Elements with a High Variance of "Use of Best Practice" Across the Industry

C3	Pre-erection Outfitting	F5	Parts Listing Procedure
D1	Ship Construction	B4	Electrical
D6	Outfit Installation	B6	Large Heavy Item Storage
A4	Profile Cutting	A11	Outfit Steel
A9	Curved & 3D Assembly	A7	Sub-Assembly
C4	Block Assembly	A8	Flat Unit Assembly
D2	Erection & Fairing	C5	Unit & Block Storage
E2	General Environment	D7	Painting
D4	Onboard Services	F2	Steelwork Production Information

Sub Elements with a Moderate Variance of "Use of Best Practice" Across the Industry

E1	Layout & Material	B3	Sheet Metal Working
B2	Machine Shop	C6	Materials Handling
F9	Lofting Methods	A2	Profile Stockyard
A6	Minor Assembly	A10	Superstructure Assembly
B1	Pipe Shop	D5	Staging & Access
C2	Outfit Parts Marshalling	G9	Production Management Information Systems
G8	Quality Assurance	A5	Plate & Profile Forming

Sub Elements with a Low Variance of "Use of Best Practice" Across the Industry

A1	Plate Stockyard	G3	Steelwork Scheduling
D3	Welding	A3	Plate Cutting
F4	Steelwork Coding System	B5	General Storage & Warehousing
G7	Perform. & Efficiency Calculations	G6	Stores Control

The SIBIF Program may evaluate proposals for shipyard-specific work with this ranking as a guide to determine the overall potential impact to industry capabilities.

9.4.1.1.2 Difficulty

One significant issue with applying this model to NSRP-managed work is that the Industrial Modernization Incentives Program model incorporated a distinctly different business arrangement between the government and DoD prime contractors engaged in that program. For this reason, contracting and management of some (or possibly all) phases of shipyard-specific projects may not be viable under the NSRP Program structure and may be better performed directly through Navy PEOs. The potential for PEO funding may be different for projects that affect a single Navy program and those that affect multiple programs. The method for allocating SIBIF budget to the PEOs to fund proposed shipyard-specific projects is currently unknown. This needs to be evaluated by the government.

9.4.1.1.3 Cost Estimate

Total costs for Shipyard-specific projects are unknown at this time, as it is highly dependent on the projects proposed after the completion of the process analyses by the individual shipyards. The work preformed during the Process Analysis (Phase 1) for each shipyard is expected to take approximately 6 months to complete. Typical manning and labor expenditures during this time would require project funding on the order of $100K per participating shipyard. Costs for Phases 2 and 3 for each proposed project is to be determined but an estimate for the entire program is provided below:

Program funding levels (industry-wide) by phase based on the examples provided in Table 9.1:

Phase 1 - $1M

Phase 2 - $20M

Phase 3 – $100M

10 Appendix A – The National Shipbuilding Research Program

10.1 NSRP Overview

The NSRP ASE collaboration of 11 shipyards with Navy and other federal agencies was initially established in 1998. R&D projects began in late 1999 based on a Navy-approved Requirements Document - *a discrete, bounded statement of work* that is defined by consensus national priorities of the platform-independent manufacturing cost drivers. This document, the Strategic Investment Plan, provides close alignment with SECNAV/CNO goals for current and future readiness and prior year shipbuilding cost growth control. Navy benefits accrue from direct payback to Navy programs and Fleet maintenance PLUS the long-term payback from infrastructure and process improvements, a more robust commercial supply base, and the accelerated adoption of commercial practices in a defense-oriented enterprise. Since the Navy is the dominant customer for U.S. shipyards, Navy leaders who conceived of NSRP appropriately viewed sponsorship as a cost-effective customer investment.

10.2 NSRP Focus Areas

- Lean manufacturing for warship construction & repair
- Common parts catalogs, supply chain eBusiness network, standardization of parts and engineering/design processes
- Common cost drivers: e.g., Workers' Compensation
- Boost Navy ROI on ManTech & Small Business programs
- Interoperability of tools, design & manufacturing data, processes and skilled workers across public/private enterprise

10.3 NSRP Operations

Annual Navy seed funding acts as a catalyst, while NSRP organizational constructs provide the legal safeguards that enable shipyards to collaborate extensively across corporate boundaries. Industry investment exceeds Navy funding because large teams share in the initial costs of joint evaluation and experimentation. Each yard pays the more substantial costs of implementation and capital investment after the risk is reduced. Additionally, projects that would have been carried out by individual yards at a much slower pace and in isolation are accelerated by the multi-yard effort.

10.4 Implementation of NSRP Projects

NSRP's hallmark is rapid, widespread implementation of R&D results on Navy programs: cross-yard and cross-tier, across varied technology areas, and long before projects complete – even at yards that were not on the project team. Over 65% of ASE projects have already been implemented in at LEAST one yard – most at multiple yards, and CEOs assert that NSRP enables them to make improvements for a fraction of the cost of going it alone.

10.5 NSRP Results

Identification of specific cost reduction benefits to the Navy through warship acquisition and repair contracts is a key NSRP metric. Recent detailed reporting by shipyards to Navy PEOs is summarized as follows:

- ✓ **Positive Navy cash flow: 2003 cost reductions > 4x investment.**
- ✓ **Payback Period – Navy break even point: 2002.**
- ✓ **Solid ROI Multiple using *measured* cost data on limited subset of NSRP benefits.**

Execution with follow-thru implementation at many yards

High transition rate

Focus on common cost driver priorities

Cost & Risk sharing; Joint experimentation & learning curve

Critical mass for vetting process and product advances and effective regulator interaction

Proactive, industry-wide approach for enterprise solutions

Cost reductions in overhead and product / maintenance cost elements			
1998 - 2002	Savings	$	13,740,002
	Avoidance	$	59,433,571
	subtotal	**$**	**73,173,573**
2003	Savings	$	8,369,296
	Avoidance	$	36,718,554
	subtotal	**$**	**45,087,850**
2004 - 2009	Savings	$	102,990,249
	Avoidance	$	152,294,595
	subtotal	**$**	**255,284,844**
Total 1998-2009	**Savings**	**$**	**125,099,547**
	Avoidance	$	248,446,720
	Total	**$**	**373,546,267**
Funds recv'd by Industry (FY '99 - Feb 04)		**$**	**74,111,137**

Metrics process developed in late 2003 to measure a subset of NSRP Value

(Does not include Naval Yards, Suppliers, etc.)

NSRP's strong focus on collaboration has also created an unmistakable, rapid cultural change in industry. The collaborative operations strongly incentivize broad project teams of multiple shipyards, suppliers, academia, and others, such that results are typically implemented in multiple shipyards simultaneously. Cross-tier teaming enables smaller, agile Second Tier yards to debug and prototype technologies that are then deployed by both First and Second Tier yards.

10.6 NSRP Rationale/Value Proposition

NSRP has earned strong CEO-level support from across the industry because it is also aligned with economic reality from the shipyard perspective. The intense pressure on overhead rates brought about by the lowest Navy build rate in 50 years severely limits each organization's ability to tackle major challenges on its own. In a business environment where defense R&D is not profitable and capital is scarce despite the anticipation of sharply increased demand during this decade, NSRP enables firms to make improvements for a fraction of the cost of going it alone.

The NSRP framework efficiently coordinates collaborative R&D among all segments of the ship construction and repair enterprise to reduce the cost and time required for both Navy and commercial ship construction, conversion, and repair. NSRP spreads financial risk by matching each yard's investment with funds from other yards, other private firms, and Navy - such that individual risk is substantially reduced.

Annual NSRP seed funding, legal provisions and vast knowledge network act as a catalyst to accelerate cost-effective, reduced-risk R&D. In the aggregate, industry investment *more than doubles* the federal funds because large teams share in the initial costs of joint evaluation and experimentation. Each yard pays the more substantial costs of implementation and capital investment *after* the risk is reduced. These dynamics are particularly apparent in the areas of laser-enabled steel processing, Lean manufacturing, eBusiness, and elimination of common non-value-added cost drivers in such areas as workers compensation. Additionally, projects that would have been carried out by individual yards at a much slower pace and in isolation from other yards are accelerated by the multi-yard effort. The economic and other benefits gained from the projects is realized much sooner. Vendors and regulatory agencies are eager to engage through NSRP because they are afforded an efficient and effective avenue of access to the industry. The nationwide, real-time, on-going technology and knowledge transfer between geographically and market-separated yards coupled with subsequent widespread R&D implementation provides the Navy a large return on its seed funding.

10.7 NSRP Origins

Fleet ownership costs (design, acquisition and life cycle) are directly impacted by shipyard production and repair technologies and processes. NSRP was created in response to a specific Navy request for industry to develop and manage a cost-effective, cross-program vehicle for rapid and effective implementation of cost-avoidance processes and technologies. Created as an innovative complement to stove-piped platform-specific R&D, NSRP was purpose-built as a highly leveraged program to drive industry-wide improvements applicable to ALL Navy ship programs on a scale and pace needed to impact SCN and Maintenance accounts.

11 Appendix B - Potential Shipbuilding Industrial Base Investment Fund Execution Strategies and Funding Profile

11.1 References

(a) NSRP ASE Strategic Investment Plan; Revision 4 dated June 8, 2005
(b) NSRP Proposed Investment Strategy to Address Findings of the 2004 First Marine International Benchmarking Study
(c) National Defense Authorization Act for FY2006 (H.R. 1815), Sec. 225; and House Report 109-89 (House Armed Services Committee), Sec. 225

11.2 Purpose

In light of Reference (c), recent discussions on the future of NSRP and the Shipbuilding Industrial Base Investment Fund (SIBIF) concept identified a need to define a set of execution strategies for the Navy to implement all or parts of the two work plans (References (a) and (b)). Balancing the merits for SIBIF execution by NSRP as a single, integrated national effort are aspects of NSRP's current structure that limit utility for executing the shipyard-specific and Navy policy aspects of SIBIF. This Appendix proposes an execution framework that accounts for the key issues.

Section 225(c) of Ref (c) states that "*An entity requesting assistance under [SIBIF] to develop new design or production technologies or processes for naval vessels or to improve shipbuilding infrastructure shall submit to the Secretary of the Navy an application that describes the proposal of the entity and provides evidence of its capability to meet program intent.*"

Accordingly, the NSRP Executive Control Board (ECB) proposes herein a top-level plan to execute Ref (c). If the Department of Defense and Congress agree, the ECB will develop a more detailed proposal for Navy, OSD and / or Congressional discussion.

- Short Term – If FY06 funds are available, portions of the SIBIF which are appropriately carried out with the as-is NSRP structure can begin on short notice. To that end, the ECB included specific interest areas (DFP, Product Data Interoperability, Design) in the FY06 Pre-solicitation Announcement and could execute with more funding via the existing JFA for the 1st year of SIBIF.
- Long-Term – The ECB will develop a more complete proposal if needed for (1) FY07 start if not appropriated in FY06, or (2) to provide a longer term solution if an FY06 start occurs.

The uncertainty concerning NSRP's FY06 funding threatens the execution plan described herein. While authorized by both HASC and SASC for FY06 based on the Navy's inclusion of NSRP on the Unfunded Priority List, House Appropriators did not restore funding and the cognizant Senate Appropriations committee will not mark the bill until September.

11.3 Background

11.3.1 Shipbuilding Industrial Base Investment Fund (SIBIF)

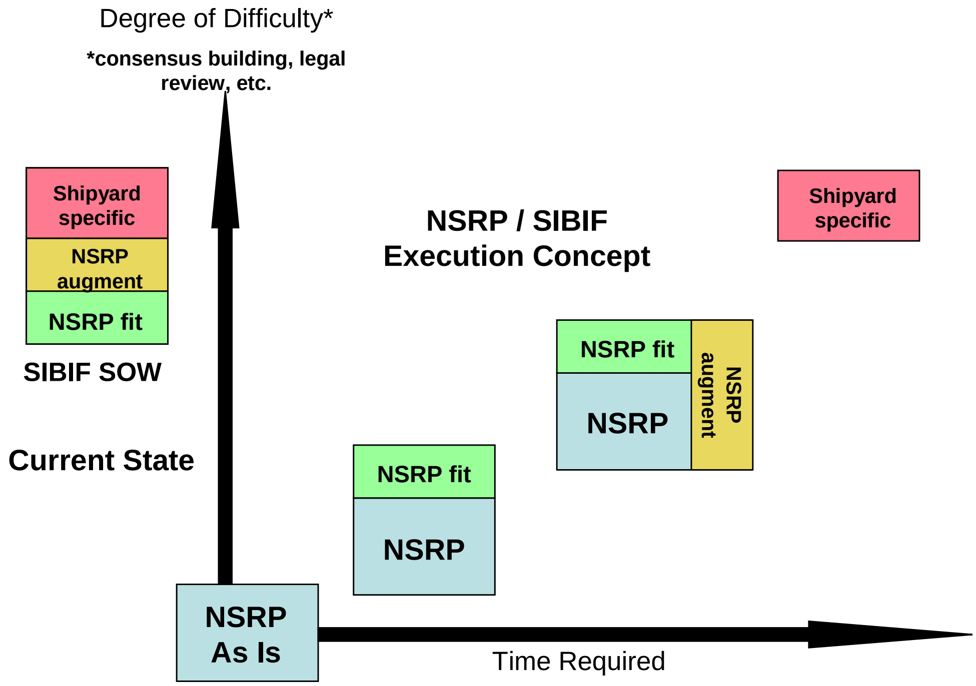
The 2006 HASC Bill (Ref (c)) defines a SIBIF to make the Navy ship construction program more efficient and to modernize the U.S. shipbuilding infrastructure. The specific improvements cited therein were extracted from the NSRP response (Ref (b)) to a 2004 industrial base benchmarking study. As requested by OSD, the industry collaboration (NSRP) developed recommendations using only those issues assessed by the scope of the benchmarking analysis – which highlighted design and production engineering issues. By comparison, the NSRP SIP includes both these issues and a broader scope of cost drivers such as Workers Comp, Environmental, etc. Constraints of the existing NSRP (cost share, data rights, preclusion of equipment purchasing, shared projects) were intentionally not considered in order to provide a greenfield plan.

Per section 225(b) of Ref (c), the *"Shipbuilding Industrial Base Improvement Program for Development of Innovative Shipbuilding Technologies, Processes, and Facilities is intended to improve the efficiency and cost-effectiveness of the construction of U. S. naval vessels and to promote the international competitiveness of United States shipyards for the construction of commercial ships and naval ships intended for sale to foreign governments."* The fund would seek shipbuilding infrastructure modernization (physical facilities, critical processes, specialized labor pool, unique tools, and the associated systems and processes) through investments in both shipyard facilities and in collaborative work in several key thrust areas: design-for-production, ship design/engineering processes, production engineering methodology, enhanced supply chain integration, organization and operating system optimization, associated with Navy ship construction programs.

11.4 Discussion

Figures 1 depicts a set of mutually supportive strategies to execute NSRP and various aspects of the SIBIF concept as described in Ref (c)

- NSRP As-Is: Continue funding NSRP Strategic Investment Plan with current structure and out-year budget plans
- NSRP Extension: Add funds and scope to execute additional tasks on SIBIF scope under existing NSRP structures.
- Modified 'NSRP Augment': Modify NSRP structure, or award new contract, as needed for limited aspects of SIBIF collaborative work otherwise problematic due to scale, scope or legal concerns.
- Shipyard-Specific: Create new vehicle for direct Navy-Shipyard investments.



Each of these elements is further summarized in Figure 2 and Table 1, then described in the text that follows.

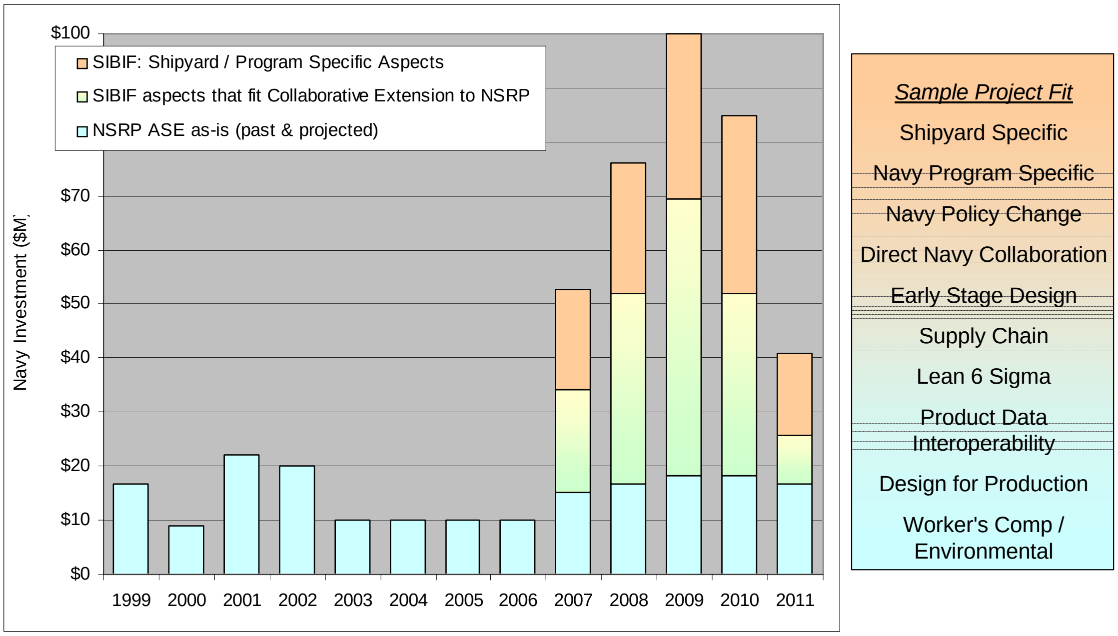


Figure 2: Funding Profile Options for NSRP and SIBIF Work

Note: Funding level sources: NSRP: History plus minimum sustainment level for NSRP viability; SIBIF Strategies 1 & 2 derived from the $148M collaborative investment cited in Ref (a) and (c); SIBIF Strategy 3 from Ref (b) and (c). As shown, strategies are additive, although precise differentiation of strategies is not yet complete. The dollar split between columns 2 and 3 is NOTIONAL pending a more detailed review. Total funds required will be less than the sum of current SIP + SIBIF due to overlap. Example: DFP is 100% overlap.

			SIBIF Execution Concept		
		Baseline	**Strategy 1: Expand NSRP As-Is**	**Strategy 2: Modified NSRP (Augment)**	**Strategy 3: Create Direct Channel**
Description		Current NSRP	Investments well-suited to existing NSRP structure - add resources via JFA	Areas where NSRP structure mods (Org, Contract, processes) MAY be required	Shipyard/Program Specific Aspects (Including equipment purchase/lease)
Nature of Particpation / Roles		Collaborative	same as NSRP	Collaborative with more direct Navy involvement	Non-Collaborative
Structure/ Workforce		Current NSRP	same as NSRP	TBD	New
Contract		NSRP Joint Funding Agreement (JFA)	use existing contract with minor, if any, changes	Modified NSRP JFA or New Contract	New contract(s) direct to yards - not via collaboration
Strategic Guidance		NSRP Sstrategic Investment Plan (SIP)	NSRP SIP updated with SIBIF info	NSRP SIBIF Plan with Navy modifications	TBD by yards and PEOs
Funding levels	FY06	$ 10,000,000	$ 18,900,000	$ -	$ -
	FY07	$ 10,000,000	$ 26,000,000	$ 9,400,000	$ 18,500,000
	FY08	$ 10,000,000	$ 30,000,000	$ 21,300,000	$ 24,000,000
	FY09	$ 10,000,000	$ 20,000,000	$ 13,600,000	$ 30,500,000
	FY10	$ 10,000,000	$ 5,000,000	$ 4,000,000	$ 33,000,000
	FY11	$ 10,000,000	$ -	$ -	$ 15,000,000
	total	**$ 60,000,000**	**$ 99,900,000**	**$ 48,300,000**	**$ 121,000,000**
Cost Share		50% High Quality	same as NSRP	Relief needed based on nature of work and/or cost share sources	Much lower
Metrics		Extensive	same as NSRP	TBD	Shipyard specific
Start-Up / Execution Difficulty		**Very Low**	**Very Low**	Moderate	High

Table 1: NSRP and SIBIF Funding Strategy Descriptions

11.5 SIBIF Execution Strategies

11.5.1 Baseline NSRP ASE Program

NSRP ASE operates under a Joint Funding Agreement (JFA) between NAVSEA and the shipyard collaboration. A 5-year extension signed in Aug 2004 continues the as-is program using the existing Strategic Investment Plan (SIP) and a well-established, effective organizational structure composed of an Executive Control Board, Major Initiative Team Leaders, Panel Chairs, Blue Ribbon Panel, etc. NAVSEA, OPNAV N7, ASN RDA, Congress and Industry leadership support NSRP ASE continuation.

11.5.2 Expand NSRP's As-Is Structure with Funds to Focus More on Design / Production Engineering

Much of the SIBIF plan (Ref (b)) is consistent with execution via the existing NSRP structure with low risk and little difficulty. In fact, the SIBIF plan was developed knowing that there was considerable overlap with the SIP. If Congress and the Department are ready to invest at levels greater than NSRP's recent / planned funding, the ECB would be enabled to act on these areas much more vigorously. In fact, the ready-for-issue NSRP solicitation for FY06 projects has already incorporated key SIBIF Year 1 recommendations (Design for Production, Interoperability/Integrated Shipbuilding Environment, and Lean/Six Sigma) as highlighted interest areas since these were already present in the SIP.

The existing structure and process have a track-record of flexibility, credibility and results to build on. While NSRP has operated at the $10M level for the past few years, its structure was designed for a $40M annual funding target, and Figure 1 shows that it worked at levels as high as $22M and for large, multi-year projects (e.g., ISE2 was 52 months and $34M). The ECB is confident that NSRP can readily adapt to $30M as early as FY06, and ramp up as high as $60M within 3 years while avoiding the overhead of duplication by adapting / expanding as needed rather than reinventing. Because of the topical similarities in focus and function, the enhanced program would be executed using existing NSRP structures. While few if any changes are anticipated, the NSRP SIP and Major Initiative Team/Panel structure would be amended as appropriate to more explicitly address the SIBIF plan. (The Shipyard-specific and more direct Navy involvement scenarios, however, pose challenges to this structure, such that a variant is discussed in the next 2 sections for those aspects).

Section 225(a)(1) of Ref (c) directs SECNAV to establish a program for private shipyards to fund qualified applicants to facilitate the development of innovative design and production technologies and processes for naval vessels and the development of modernized shipbuilding infrastructure. It goes on to state that *"a key near term initiative would be design optimization projects of several ship classes – a mix of those classes in production as well as new design classes – including a coordinated effort to collect lessons learned across ship platforms and share productive methods among the programs."* NSRP is ideally suited to execute this emphasis area, as DFP is already covered in the existing NSRP SIP and Draft 2006 Research Announcement, so the ECB can execute cleanly if funds become available. NSRP's credentials as a 'qualified applicant' should be evident from past work such as Common Parts Catalog, Integrated Shipbuilding [Digital Product Data] Environment, an industry eBusiness network, and other areas. Finally, NSRP's existing metrics mechanisms are well-suited for the periodic assessments specified in subsection (f) of Ref (c).

NSRP Extension: NSRP expanded to add focus on Design / Production Engineering	
Organizational Structure/Process	Identical to current NSRP structure and process including Executive Control Board, Major Initiative Team Leaders, Panel Chairs, Technical Evaluation Review Panel, Blue Ribbon Panel, etc.
Contract/Cost Share	Use existing NSRP contractual agreements/vehicles, including the use of the current Joint Funding Agreement. Shipbuilding and ship repair industry participants would be expected to jointly fund projects with the Navy on a near 50/50 basis.
Collaboration	Collaborative/team-based projects would be strongly emphasized.
Examples	Design for Production Optimization, PDI acceleration, Lean / 6 Sigma, Supply Chain tools
Difficulty	**Low**
Execution Risk	**Low**

Table 2: NSRP Extension Characteristics

11.5.3 Modify NSRP Structure to Enable New Collaboration Areas and/or More Direct Navy Participation

This is the least defined of the three approaches, since the easier and harder pieces are each much clearer. Activities would entail a funding level and/or range of topics for which there is some added degree of execution uncertainty under the current NSRP structure, but it is not clear that the more radical departure from the status quo appropriate for the shipyard-specific work (next section) would be necessary. The ‘Modified NSRP’ alternative requires further analysis to assess projects of interest to the Navy customer whose scale or topical coverage is beyond the existing structure. Once such issues are identified and resolved, funding levels could grow consistent with the number and magnitude of SIBIF projects to be added to the NSRP Strategic Investment Plan (SIP) up to an estimated ceiling of $50M-$60M. Because of the topical expansion from the current NSRP SIP and projected costs above the level which industry can cost share on a 50/50 basis, this alternative would require some modifications to the current contracts, organization and processes. However, there should be significant similarities to the extant terms and conditions of the current NSRP ASE agreements. The NSRP SIP could be modified (e.g., Navy concurrence to reduce ‘practicable cost share’) and the Research Announcement scope broadened as necessary. Some prospective topics *might* be determined to be outside the scope of a collaborative Navy-industry agreement due to potential legal issues (FACA, Anti-trust). It may be determined that a new contract would be required.

Collaborative Extension 2: New Collaboration Areas & Increased Direct Navy Participation	
Organizational Structure/Process	Similar to current NSRP structure and process including Executive Control Board, Major Initiative Team Leaders, Panel Chairs, Technical Evaluation Review Panel, Blue Ribbon Panel, etc.
Contract/Cost Share	Modified NSRP contractual agreements/vehicles, including the Joint Funding Agreement. Shipbuilding and ship repair industry participants would be expected to jointly fund some projects, although the level would not likely meet the current 50/50 goal. If JFA cost share 'practicability' criteria can be modified - or specified in legislation - to be lower than the current 50%, the need for a new agreement is much less. A new type agreement will necesitate either (1) ECB incorporation to meet FAR 'entity' requirements or (2) concurrence for a 3rd party such as ATI to fulfill that role.
Collaboration	Collaborative/team-based projects will continue to be strongly emphasized, but shipyard-specific projects would also be considered for funding.
Examples	Concept/Functional Design Optimization projects, Early stage Design Tools (more Navy and other stakeholders), Navy policy review
Difficulty	Moderate, due to potential for (1) renegotiating contracts with multiple parties and (2) legal issues (FACA, Anti-trust, etc.) and inevitability of protracted negotiation process.
Execution Risk	Moderate in the short-term for same reasons as difficulty; Low once up and running

Table 3: Modified ‘NSRP Augment’ Characteristics

11.5.4 Create Direct Navy-Shipyard Investment Method for Shipyard / Program-Specific

Ref (c), Section 225 (a)(2) and (e) include provision for shipyard specific investments called “Shipyard Use of Developed Technologies, Processes, and Infrastructure.” The language states that “upon making a determination that a technology, process, or infrastructure improvement developed using funds provided under subsection (a)(1) [e.g., collaborative projects] will improve the productivity and cost-effectiveness of naval vessel construction, [SECNAV] may provide funds to a shipyard to facilitate the purchase of such technology, process, or infrastructure improvement.”

Section 9 of Ref (b) describes the logic for and concept of shipyard-specific aspects of SIBIF that fit the Congressional intent. *Since a process implemented* in one yard is not necessarily applicable to another yard, the facility with less developed processes cannot simply copy the solution applied elsewhere. Similarly, a particular shipyard may not be able to apply the solutions of every industry-wide development due to unique limitations in their current processes and capital constraints. A specific process improvement may also include a change in hardware and infrastructure to support the process. The method and form of implementation of advanced processes will be unique to each yard and therefore require its own development path to at least some degree.

These situations imply investments tailored to individual shipyards. Since each shipyard received an individual benchmarking report on their use of best practice in all fifty sub-elements of ship production, their individual improvement strategies can identify areas where they would look to collaborative solutions as well as those areas where their needs would be most effectively accomplished by focused, shipyard-specific work. Investment in shipyard-specific initiatives should be considered particularly appropriate for those sub-elements that have a large variance in benchmarking scores and are not prioritized targets of opportunity for the industry-wide initiatives as described in the proposed thrust areas. This strategy will accomplish two objectives; it will raise overall industry performance and improve the least developed processes throughout the industry. This may also have the added benefit of enabling participating U.S. shipyards to more readily take advantage of the industry-wide solutions implemented by the other project work.

The SIBIF aspects regarding shipyard/program specific projects and purchases of equipment and services are NOT suited to collaborative execution. Because this execution strategy is beyond the scope of the NSRP JFA and other existing NSRP contracting vehicles, a new contract would be required with markedly different terms and parties. The required level of funding for this plan would also necessitate a different cost sharing formula and metrics methodology.

Shipyard / Program-Specific SIBIF Elements	
Organizational Structure/Process	The Navy would define a structure between PEOs and shipyards (extract HASC language)
Contract/Cost Share	The Navy would use existing contracts with the individual shipyards or issue new ones directly to the yards. Cost share requirements contained in the NSRP are not expected to be part of the SIBIF execution plan.
Collaboration	Relatively little collaboration would be appropriate at this stage due to the nature of shipyard unique-requirements. Much of the groundwork leading to proposals under this arrangement is expected to be the result of collaboration, such that the remaining implementation requires unique follow thru. On a case basis, the Navy and shipyards could agree to sharing information developed under this approach, and NSRP could be used as an efficient vehicle for that sharing.
Examples	Shipyard implementation of capital equipment, Program-specific industrial capability, etc
Difficulty	**HIGH**, due to the legal concerns of federal investment in individual private firms.
Risk	**HIGH**, due to the legal concerns of federal investment in individual private firms.

Table 4: Shipyard/Program Specific Aspects

11.6 Initial NSRP-SIBIF Comparison

The NSRP Major Initiative Teams and Panels are mapping the SIBIF recommendations to the NSRP Strategic Investment Plan to define the degree of overlap / similarity and to highlight areas of SIBIF with little fit (e.g., Navy customer actions and shipyard/program specific implementation). For those elements common to both, recommended funding levels will be compared. Preliminary feedback indicates that there is much similarity with existing NSRP SIP (e.g., the DFP scope is more completely described in the SIBIF plan, but is wholly contained within the SIP sub-initiatives). Nonetheless, some obvious differences exist in SY-Specific and Navy policy areas. These similarities and differences are manifested in the three execution strategies.

11.7 Contract Options / Issues

A preliminary assessment of the JFA and other contracting options was completed by ATI to determine if the current agreement should be modified or if a separate agreement should be developed to handle SIBIF. Much of the SIBIF work scope can be executed without the need for a new agreement, some aspects are not a good fit for the existing JFA. Table 5 summarizes the key issues associated with contracting the various SIBIF elements.

Note that modifying the cost share requirement in the existing agreement is limited by statutory issues for this form of agreement. Management of yard-specific issues, should probably be managed directly between NAVSEA program offices and the shipyards; but this is something that requires discussion and agreement by the ECB.

	NSRP ASE	NSRP expanded	New Collaboration Areas / Increased Direct Navy Participation		Shipyard / Program-Specific
	Existing JFA		*Revised "JFA"*	*FAR Collaborative Agreement*	*FAR Individual Agreements*
Authority	Other Transaction (10 U.S.C. § 2371)		???	*FAR/DFARS*	*FAR/DFARS*
Type of Contractual Vehicle	Joint Funding Agreement		???	*FAR/DFARS*	*FAR/DFARS*
Legal Entity Parties to Agreement	NAVSEA and the ECB		???	*FAR/DFARS*	*FAR/DFARS*
Cost Share Requirement	Goal is 50% (unless impracticable) for technology development and technology transfer		Consider that share be "encouraged", but not mandated		Consider that share be "encouraged", but not mandated
Management of Projects	Collaboration (with formal Articles of Collaboration) via Program Administrator		Collaboration (with formal Articles of Collaboration) via Program Administrator	TBD	Individual Shipyard
Government Payment	Quarterly Advanced Payments				As negotiated
Data rights	Article IX of current JFA				As negotiated
Patent Rights	Program Participant(s) IAW 35 U.S.C. § 202; With respect to any subject invention in which the Program Participant(s) retains title, the Government shall have a nonexclusive, nontransferable, irrevocable, paid-up license				As negotiated
Disputes	Article VII of existing JFA (FAR clause)				As negotiated
Intellectual Property Rights					As negotiated
Audits	Subject to examination or audit by the Government for a period not to exceed three (3) years after expiration of the term of the Agreement			As negotiated	As negotiated
Metrics / Reporting	Existing JFA provisions for Project Metrics, Impl Reporting and periodic Cost Reduction Reports			As negotiated	As negotiated
Technology Transfer / Sharing Requirements	Aggressive technology transfer to, and buy-in by, multiple U.S. shipyards is a requirement of all funded efforts.			Encouraged	Encouraged
Anti-Trust Provision	Maintainable via Articles of Collaboration and Core NSRP JFA				N/A
Foreign Access to Technology	Export Administration Regulation (15 CFR 730-774) (the EAR) or the International Traffic in Arms Regulation (22 CFR 120- 130) (the ITAR), and the National Industrial Security Program Operating Manual (DOD 5220.22-M) (the NISPOM)				As negotiated
Equipment Procurement	< OR = $50K			As negotiated	As negotiated
Title and Disposition of Property	Acquisition value of $50,000 or less shall vest in the Collaboration			As negotiated	As negotiated

Table 5: SIBIF Contracting Comparisons

11.8 Initial Focus Priorities for SIBIF Funds

Prepare for the possibility of FY06 funds by establishing consensus on first year SIBIF priorities. The FY06 NSRP Research Announcement added emphasis to the three key areas cited in the SIBIF plan's year 1 profile (Design For Production, Interoperability, and Lean / Six Sigma), such that the RA is suited both by topic and scale to accommodate $30M in FY06 funds. HASC language emphasizing Design Optimization pilots requires some further definition, however. Initial discussions with NAVSEA 05DM indicates NAVSEA is interested in addressing early stage design optimization tools to complement the producibility-focused optimization work.

11.9 Comparison of Work Scope with HASC Language

The extent of commonality between the two plans is being evaluated separately, but three execution philosophies are presented below for consideration. Although presented separately, the lines of distinction between each are not clear. The final execution strategy may be a progressive hybrid of any or all of the approaches presented dependent on funding level and Congressional / DoD / Navy direction.

FY06 HASC Section 225 Focus Areas	NSRP Baseline + NSRP Extension	NSRP Augment	Shipyard Specific
Processes *- Novel techniques and processes designed to improve shipbuilding quality, productivity, and practice on a broad and sustained basis, including in such areas as: engineering design, quality assurance, concurrent engineering, continuous process production technology, employee skills enhancement, and management of customers and suppliers.*	Design for Production	Outsourcing Strategies: Regionalization, Process Consolidation of S/Y Work	Solutions to unique aspects due to product line (Subs, Carriers, Surface Combatants)
	Improve Dimensional and Quality Control Tools and Practices	Develop & Implement Advanced Material Handling	
	Develop Production Process Standards	Elevate Production Engineering	
	Enable Supply Chain Data Sharing	Supply Chain coordination	
	Apply Lean/Six Sigma Tools to Streamline Shipbuilding Supply Chains	Navy-Shipyard interface processes / contracting	
Technologies *- Numerically controlled machine tools, robots, automated process control equipment, computerized flexible manufacturing systems, associated computer software, and other technology designed to improve shipbuilding and related industrial productivity.*	Enable Enterprise Interoperability of Design & Production Data	Improve Shipyard Planning & Scheduling Systems	Internal shipyard IT system interfaces
	Lasers, Lasox, Autogen, Steel distortion, Welding, Ship Design Tool Enhancements …		Shipyard-unique adaptations of new technologies
	CAD, CAM, CAE		
Infrastructure Modernization *- Technology, techniques, and processes appropriate to enhancing the productivity of shipyard infrastructure.*	Lean Shipbuilding Initiative projects, Wireless communications for Material Handling systems		Equiupment leasing / purchase

Table 6: Example Project Fit to Each Strategy

11.10 Potential SIBIF Investment Roadmap

Table 7 provides a recommended funding profile for the investments described in this report.

Thrust Area	Remedies	Year 1	Year 2	Year 3	Year 4	Year 5
Design, Engineering, Production Engineering	Design for Production	$ 3.0	$ 4.0	$ 10.0	$ 3.0	
	Improve the Naval Ship Design Process		$ 2.0	$ 4.0	$ 2.0	
	Elevate Production Engineering			$ 1.6	$ 4.0	$ 2.4
	Enable Enterprise Interoperability of Design & Production Data	$ 6.0	$ 10.0	$ 4.0		
	Format Outfit Production Information		$ 0.1	$ 0.2	$ 0.5	$ 0.2
	Improve Dimensional and Quality Control Tools and Practices		$ 0.2	$ 0.4	$ 1.0	$ 0.4
	Rationalize Design Rule Methodologies on Naval Ships		$ 1.3	$ 2.5	$ 1.3	
Production Processes	Eliminate Non-Value Added Production Activity	$ 1.2	$ 1.6	$ 4.0	$ 1.2	
	Expand the use of Module Building (Outfitting Packages)	$ 0.8	$ 1.0	$ 2.5	$ 0.8	
	Balancing the Use of Technology in the Shipyard	$ 0.6	$ 1.0	$ 0.4		
	Develop & Implement Advanced Material Handling		$ 1.0	$ 2.0	$ 5.0	$ 2.0
	Develop Production Process Standards	$ 0.6	$ 1.0	$ 0.4		
Joint Navy/OSD/Industry Actions	Stabilize the Navy's Ship Acquisition Strategy					
	Eliminate Disincentives & Improve Incentives	$ 0.1	$ 0.1	$ 0.3	$ 0.1	
	Streamline Navy Technical Oversight	$ 0.9	$ 1.2	$ 3.0	$ 0.9	
	Change Weight-based Cost Estimating Relationships	$ 0.3	$ 0.5	$ 0.3		
	Manage Change Orders to Reduce Productivity Impact	$ 0.2	$ 0.3	$ 0.8	$ 0.2	
	Support Domestic Shipbuilding Volume other than Military Ships					
	Enable Resource Sharing Among Private / Public Shipyards	$ 0.1	$ 0.1	$ 0.3	$ 0.1	
Organization & Operating Systems	Improve Shipyard Planning & Scheduling Systems	$ 0.8	$ 1.0	$ 2.5	$ 0.8	
	Consolidate & Streamline Production Management Information Systems		$ 1.3	$ 2.5	$ 1.3	
	Optimize Manpower and Work Organization		$ 0.8	$ 1.5	$ 0.8	
	Improve Production Control Processes	$ 0.8	$ 1.0	$ 2.5	$ 0.8	
Shipyard Outsourcing & Supply Chain Integration	Apply Lean/Six Sigma Tools to Streamline Shipbuilding Supply Chains	$ 1.8	$ 3.0	$ 1.2		
	Eliminate Outsourcing Disincentives		$ 0.1	$ 0.3	$ 0.1	
	Outsourcing Strategies, Including Regionalization and Process Consolidation of Shipyard Work		$ 2.0	$ 4.0	$ 10.0	$ 4.0
	Enable Supply Chain Data Sharing	$ 0.5	$ 0.9	$ 0.4		
	Collaborative Projects subtotal	**$ 17.5**	**$ 35.4**	**$ 51.3**	**$ 33.6**	**$ 9.0**
Shipyard-Specific Projects		$ 18.5	$ 24.0	$ 30.5	$ 33.0	$ 15.0
	Total	**$ 36.0**	**$ 59.4**	**$ 81.8**	**$ 66.6**	**$ 24.0**

Table 7 Recommended SIBIF Funding Profile

11.11 Summary

Reference (c) expresses Congressional interest in taking advantage of NSRP as an execution vehicle for a prospective national, integrated effort to act on shipbuilding costs and infrastructure.

"The committee is encouraged that the United States Shipbuilders have embraced the National Shipbuilding Research Program as an effective and efficient means to collaborate on innovation in shipbuilding and ship repair. The committee believes that the Department can take advantage of this existing collaboration as an effective vehicle to address shipyard productivity issues related primarily to naval ship design practices."

The nation's shipyards stand ready to build on the momentum of the existing NSRP structures and agreements to execute a first phase of the SIBIF as early as FY06. If the Congress, and Navy concur, the shipyard collaboration will more fully develop plans to identify the subset of SIBIF that requires changes to the existing structure and jointly explore options to execute the shipyard specific aspects of Ref (c).

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13 Acronym List

ABS – American Bureau of Shipping

AC – Accuracy Control

ACP – Access and Crew Protection

AMP – Alteration Management Planning

ASN RDA – Assistant Secretary of the Navy for Research, Development and Acquisition

CAD – Computer-Aided Design

CAM – Computer-Aided Manufacturing

CAP-X – Capital Expenditures

CEO – Chief Executive Officer

CFE – Contractor Furnished Equipment

CNO – Chief of Naval Operations

COTS – Commercial off the Shelf

CPC – Common Parts Catalog

DFP – Design for Production

DFR – Defense Federal Acquisition Regulation

DMS – Diminishing Materials Sources

DoD – Department of Defense

DON – Department of the Navy

ECB – Executive Control Board

FAR – Federal Acquisition Regulation

Five S – Sorting, Simplifying, Systematic Cleaning, Standardizing and Sustaining

FMI - First Marine International FMI

FY – Fiscal Year

FYDP – Five Year Defense Plan

GDEB – General Dynamics Electric Boat

GFE – Government Furnished Equipment

GSIBBS - 2004 Global Shipbuilding Industrial Base Benchmarking Study

HQ – Headquarters

HR – Human Resources

IMIP – Industrial Modernization Incentives Program

INSERV – In-Service Inspection

IPDE - Integrated Product Data Environments

IPPD - Integrated Product and Process Development

ISE - Integrated Shipbuilding Environment

IT – Information Technology

ITAR – International Traffic in Arms Regulations

ManTech – Navy Manufacturing Program

MILSPEC – Military Specifications

MMA – Marine Machinery Association

MSC – Military Sealift Command

MSP – Maritime Security Program

NASSCO - National Steel and Shipbuilding Company

NAVSEA – Naval Sea Systems Command

NAVSUP – Naval Supply Systems Command

NG – Northrop Grumman

NOFORN – No Foreign Nationals

NSRP – National Shipbuilding Research Program

NSRP ASE - National Shipbuilding Research Program Advanced Shipbuilding Enterprise

NVR – Naval Vessel Rules

O&MN – Operations and Maintenance, Navy

ONR – Office of Naval Research

OSD – Office of the Secretary of Defense

PDI – Product Data Interoperability

PEO – Program Executive Office

PI – Production Information

PM – Program Manager

PODAC - Product-Oriented Design and Construction

PSA – Post Shipyard Availability

QC – Quality Control

R & D – Research and Development

ROI – Return on Investment

SASC – Senate Armed Services Committee

SBA – Small Business Administration

SCN – Shipping and Conversion, Navy

SECNAV – Secretary of the Navy

SHAPEC - Ship Alteration Planning and Engineering Center

SHAPM - Ship Acquisition Program

SHIPWAY - Developing Lean Best Practice (Value Stream Focused Standard Work Elements) for Naval New Construction and Ship Repair Business & Information Processes

SIBIF - Shipbuilding Industrial Base Investment Fund

SMWG – Standardization Management Working Group

SOLAS – Safety of Live at Sea

SPANS – Supply Chain Practices for Affordable Navy Systems

SPARS – Shipbuilding Partners and Suppliers

SUPSHIPS – Supervisor of Shipbuilding

TF Lean – Task Force Lean

UK MOD – United Kingdom Ministry of Defence

USCG – United States Coast Guard

VADM – Vice Admiral

VECP – Value Engineering Change Proposal

U.S. Navy Ship Classes

AGM(R), CGX, CVN, DDG, DDX, LCS, LHA(R), LHD, LPD, MPF (F), SEAWOLF, SSGN, SSN, T-T-AOE(X), VIRGINIA

NORTHROP GRUMMAN
Ship Systems
Ingalls Operations

NASSCO
National Steel and Shipbuilding Company
A GENERAL DYNAMICS COMPANY

BATH IRON WORKS CORPORATION
A GENERAL DYNAMICS COMPANY

Bollinger
Shipyards, Inc.

NSRP ASE

TODD
PACIFIC SHIPYARDS

NORTHROP GRUMMAN
NEWPORT NEWS

NORTHROP GRUMMAN
Ship Systems
Avondale Operations

VT Halter Marine, Inc.
Vision Technologies Systems

GENERAL DYNAMICS
Electric Boat

An industry collaboration working with government and academia to manage and focus a national technology strategy for shipbuilding and ship repair

For more information on NSRP ASE activities:

- Common Parts Catalog
- Research & Development Programs
- eBusiness Solutions
- Lean Shipbuilding Initiative®
- Standards Coordination
- Technology Transfer
- Conferences/Seminars
- Industry Analysis & Planning

Contact the NSRP Program Administrator:

ATI
843-760-3591(phone)
843-760-4098 (fax)
5300 International Blvd
Charleston, SC 29418
nsrp@aticorp.org

ATI