# LPD 17 ON THE SHIPBUILDING FRONTIER: INTEGRATED PRODUCT & PROCESS DEVELOPMENT

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## Abstract

In the April 1996 words of Secretary of the Navy Dalton, "LPD 17 is a first. The Navy is on the frontier of a new way of doing things through teaming with our industry partners and streamlining the administration and acquisition processes." Truly, in the months since that prophetic statement, the LPD 17 program has crossed the shipbuilding frontier and through its Integrated Product Process Development (IPPD) tools has developed its innovative acquisition strategy - a strategy that has application to many other programs as well. The LPD 17, the first amphibious ship designed for 21st Century, is therefore on the leading edge of new product and process innovations in Naval shipbuilding.

This paper provides a synopsis of the IPPD strategy as implemented by the LPD 17 Government and Industry Team. In addition, it details the steps in establishing the baseline for IPPD implementation and relates specific examples of early successes. This will be addressed in terms of goals, people, processes, and tools. Written by members of the LPD 17 team it concludes by conveying lessons learned on how this edition of IPPD would enhance other applications and programs.

## Introduction

As the 20th Century comes to a close, few industries are undergoing as many challenges as the Naval Shipbuilding industry. The Cold War victory ended the single, superpower threat while replacing it with the potential for dozens of hot spots and minor conflicts, necessitating doing more with fewer ships. The requisite need to divert military financial resources to other programs and to better manage available resources demanded new acquisition techniques. Meanwhile the explosion of technology, information and otherwise, demanded improved systems integrated to maximize efficiencies and to "Engineer once, use many." Of course more sophisticated technology required fully qualified and knowledgeable Sailors and Marines to operate them, drawn from a pool of diminishing, but expensive manpower.

Given these challenges, the collective naval shipbuilding community needed to change and change it did. Yet, the LPD 17 program was caught in the middle of this transitory, revolutionary effort. Conceived in the Cold War 1980s and begun in 1988, the LPD 17 program became both a tool of these changes and sometimes a victim. No longer could a learning curve be afforded. The program would have to plan, design, and produce a combat-ready ship and in the words of the Assistant Commandant of the Marine Corps, General Neal, "Get it right the first time."

Modifications to acquisition guidance created the first hurdle. LPD 17's Request for Proposal was issued without mandatory Military Specifications and Standards, allowing the Full Service Contractor to initiate smarter, more effective solutions to design requirements. Only the Military Standards that addressed technical specifications where industry did not have direct commercial equivalents were retained. Although an improved method for acquisition, it still necessitated variation and transformation from traditional processes. Then the ship procurement was advanced two years!

Concern for costs also dominated much of the planning. Total Ownership Costs (TOC) combined the planning, design and inherent traditional ship construction costs with life cycle operating and support costs. This TOC perspective quickly led to the realization that two thirds of the cost of the LPD 17 class would be incurred after delivery and throughout the 40-year life expectancy of the class - based on current dollar costs. Therefore saving money in construction was less critical than avoiding Total Ownership Costs.

The changing military threat also entered into the LPD 17 equation. With no other superpowers on the horizon for the moment, the ship required flexibility, survivability, and endurance to be the right tool for the 21st Century expeditionary warriors. Forward presence and missions of state required new focus even as designers patterned the ship to accomplish the traditional tasks of transporting and landing Marine Corps assault forces where needed. In some cases the multi-faceted missions facing LPD 17 created potential design dichotomies where an Advanced Enclosed Mast design conflicted with traditional signal flag display or how to accommodate ship's boats and still reduce radar cross section. Above all new technology had to support the goal of delivering a combat ready ship for the Navy-Marine Corps team.

Building LPD 17 right the first time also recognized the need for a sustained dialogue with the ship's ultimate owners, the Sailors and Marines. Ideas, suggestions and recommendations from the operators, maintainers, and trainers needed to be solicited to ensure the process stayed on track. Product development is not successful if the customer is not satisfied and LPD 17 needed to maintain continuous interaction with those customers.

Finally, the Program quickly recognized the value of cooperating and collaborating with industry. By challenging the best minds and most experienced experts from an Industry team, shared technologies and innovative efficiencies would more likely be integrated into the process. Industrial solutions, often proven effective in the world of profit and loss, could be made directly applicable to LPD 17. The promotion of Contractor Furnished Equipment where appropriate provided an environment for potential cost savings. In addition, industrial teaming was not only encouraged, but became a practical necessity. The successful offeror recognized this and created the Avondale Alliance, a team of proven shipbuilders from Avondale and Bath Iron Works, of combat systems artisans from Raytheon, and of seasoned system integrators from Intergraph. Partnering with these experts also enabled the

Government to evolve from detailed guidance into overall strategic management.

The resultant LPD 17-management approach to meet these challenges and to take advantage of attributes is Integrated Product and Process Development. This emphasis on product and process is not only starting to achieve small victories in the LPD 17 program, but is also demonstrating potential application on other fronts that will lead to mutual 21st Century benefits.

## IPPD Results to Date

IPPD is more than vu-graph technology. For the LPD 17 program it has become a process that not only works, but also has been the key to meeting many of the initial challenges of a new way of doing business. Co-location, for instance, streamlined the administration of the government-industry interface. Traditionally, the Full Service Contractor would formally draft and forward questions about the specifications to the Program Office. Typically, after 60 days or so the Program Office would respond in letter filled with contractual syntax. More time would elapse and then the FSC would request clarification in another letter. The Program Office would response again formally, usually in about 30 days and this would resolve the issue. Until, of course the actual production team encountered further questions or requested a change for improvement. Then the process might start all over again; culminating in a Change Request that would invoke more time and money.

Historically, such back and forth efforts might consist of over 100 letters in the first three months. For LPD 17 and IPPD, no contractual letters have been generated in the first three months. In fact day-to-day and face-to-face interaction has completely eliminated previous cycle time delays. Decisions are made and solutions obtained within days instead of the months that often slowed traditional programs.

**Pre-contract Acquisition Strategy.** Other results are equally impressive. Early in the acquisition process, IPPD characteristics were applied to the older methods of acquiring ships and systems.

TEAM 17 developed an innovative acquisition strategy that for the first time in a major naval ship program blends shipbuilding firms and system integrator companies in the same contract. Most previous shipbuilding programs separated the entities contractually with the Navy managing the interface. The LPD 17 acquisition methodology directs the Full Service Contractor to manage these interactions while the Navy management team focuses on top level strategic direction.

There are several advantages to this stratagem. First the program office can itself be spared the work-intensive efforts of refereeing between the prime contractor and its sub-contractor integrators – government talent can be relegated to more decision-making and top level management. This process also recognizes the value of concurrent engineering where design and integration occur simultaneously. Gone are the days when designed systems could not interact within the ship or interface with other naval systems, ships or vehicles. The new working relationships between prime, sub-contractor and government team incorporate efficiencies and facilitate process execution that will ensure successful integration.

Process integration is also enhanced by the unique dual sourcing venue in the LPD 17 strategy. Rather that direct two shipyards to build LPD 17 independently, the contract calls for a lead building yard at Avondale to build 8 ships and the follow-on yard, Bath Iron Works, to build the other four. Shipbuilding teams share all aspects of planning, designing and management. Raytheon, and Intergraph, responsible for combat systems and system integration respectively, are equally part of the teams, providing common inputs and development to both yards. One contract, one plan and one design, with shared management teams, schedules and data elements fit all.

The LPD 17 program approved acquisition strategy also envisions a long-term relationship with the Full Service Contractor. “Full Service” does not just end when that last of the initial 3 ships is delivered, but continues through the subsequent construction under two separate contracts for follow-on ships. Further, the contract structure includes tasking the FSC with life-cycle support and planning yard responsibilities of the entire class for the duration of the LPD 17’s lifetime. Overall, this element will both substantially reduce Navy infrastructure and avoid costly interface documentation requirements inherent in traditional processes.

Acquisition reform has also played a part in IPPD. LPD 17 employed a completely electronic Request for Proposal and proposal evaluation process to evaluate responses to the solicitation. The RFP was published on the Internet and proposals were received in digital format and reviewed using state-of-the-art selection tools. In addition hundreds of paper contract data requirements were reduced to six non-electronic deliverables.

The results of this new pre-contract acquisition strategy will be forthcoming throughout the 40-year life of the LPD 17 class. However, this effort is expected to avoid $1 billion dollars in acquisition costs compared to traditional dual source strategies.

**Fleet Input.** Another indication of IPPD success is the sustained and continuous dialog with the future owners of LPD 17. Traditional shipbuilding programs have relied upon periodic interaction with Sailors and Marines, but this was sometimes not early enough in the design process to make a difference. In other instances, not all-relevant information was accessible or incorporated in the design. Finally, by the time the pre-commissioning crew arrived to take delivery of the ship and make recommendations, the cost of change was exorbitant

Fleet and Marine Corps personnel are constant sources of ideas, suggestions and recommendations for LPD 17. Reflecting the aspect of IPPD that the ship is being designed for the Owners, individuals, individual ships, and commands have been provided an opportunity to impact design and planning. The forum for Design for Ownership has been a series of 27 conferences and workshops and an interactive issues database on the LPD 17 Home Page (lpd17.nswc.navy.mil). These provide a device for input as well as feedback from the Program Office to the interested Sailors and Marines.

Maintaining a viewpoint of working side by side with the owners, LPD 17 designers have cooperated with inspection activities to take an early, detailed look at the ship. In two Early Operational Assessments, a team from Commander Operational Test and Evaluation Force reviewed drawings and simulations of the ship. They provided a wide variety of useful comments and recommendations down to the detail of discovering a topside ladder positioned to interfere with underway replenishment - safety hazard easily rectified 3 years before steel is cut.

The direct participation by the Fleet and Marine Corps will continue throughout IPPD. Most recently a “Virtual crew” of operator, maintainer and trainer experts is being employed for real-time support. One example is the Advanced Enclosed Mast/Sensor (AEM/S)

The innovative AEM/S helps reduce radar cross section signature while facilitating maintenance of ship systems normally exposed to weather. With many advantages, the basic mast design conflicts with the operational requirement for the visual display of signal flags, international signals and day shapes. Presenting a series of eight AEM/S design options, TEAM 17 design team members met with Fleet representatives to choose the best design. Working together, the Fleet operators and ship designers produced a ninth design option that appeared to meet the needs of all concerned.

Then as a follow up as the detailed design progressed, TEAM 17 members in Maine directly interfaced with Fleet Signalmen in Little Creek, VA via Video Teleconferencing. Technical and specific operational issues were resolved during the design process instead of after ship delivery.

Fleet input has also brought port engineers and experienced warfighters face to face with the Avondale Alliance and will continue. These sessions serve as constant reminders that the ultimate goal for the LPD 17 class is to serve as the right tool for Naval Expeditionary Warfare forces. Fleet input remains a viable, critical implement for IPPD as well.

**Equipment Selection.** IPPD is succeeding for LPD 17 and some successes are already being realized. One potent example has been with the ship’s boats.

During Phase I, Preliminary and Contract Design, the LPD 17 designers were faced with intricate challenges. Amphibious ships have traditionally carried boats in addition to their prescribed landing craft These were used for transportation between ships and ports when the ship was at anchor and sometimes used as liberty boats. Operationally, boats were essential in serving as boat group or wave group boats for embarked commanders to guide traditional landing craft ashore. These boats were also prescribed as safety boats whenever Marine Amphibious Assault Vehicles were water-borne. Such boats were a documented requirement for LPD 17 as well.

Yet in LPD 17 a primary consideration in the littoral is survivability. The ship can not afford to appear to be an inviting target so requirements demanded that its radar detection signature be reduced. Boats on boat decks with adjacent ponderous Boat and Aircraft Cranes hovering over them seemed to directly contradict radar cross section reduction efforts.

Product was the first target of this IPPD team. Working to resolve the boat deck problem, the ship designers and engineers recognized the need to place the boat deck behind bulwarks, hidden from probing radar detection from the side. Access to the boats would then still be feasible, by lifting the boats up and over the bulwarks. However, the next challenge was what to do with the crane?

The government next took the design problem to industry. Instead of the large, maintenance-intensive B&A cranes, something better was needed. Rather than design, build and develop a life-cycle infrastructure for a Government Furnished device, the LPD 17 team found a solution commercially. A single, knuckle boom crane already proven in industry not only provided a minimum profile, but could effectively launch and recover the ship's boats.

Everything looked good on paper. However, when key Navy operators were approached, they questioned the ability for the crane to place boats in the water during actual operations. Speed, manpower, and safety were paramount to a successful evolution and these had to be demonstrated. If the demonstration was to wait until delivery or a physical mock up was created, negative results would be extremely costly. It was time for Process to be reworked.

Instead of relying on drawings or waiting for physical mockups, an electronic modeling and simulation process was added. Animation duplicated form, fit and function in realistic scales, vividly portraying launching and recovering boats. Reviewed by fleet operators, the evolution worked.

Before the designers could relax and move onto other projects, the next question arose. Could the crane operate and the boats be safely launched and recovered in various sea states? Again the modelers went to work adding realism by specifying certain pitch and roll dynamics for the animated LPD 17 under defined sea conditions. Again the evolution worked and boats could be placed in the water or picked up in sea state three.

Still this did not establish absolute success. Next potential operators and maintainers from the Fleet were invited to validate the operation. Sailors viewed the boat evolution and the single boom crane in simulations and in drawings. The sea state demonstration was rerun. The audience validated the design, but more concurrence was sought. The Navy's Operational Test and Evaluation Force (COMOPTEVFOR) viewed the drawings, models, and simulations through two Early Operational Assessments, verifying safety and operability. They validated the new crane technology and boat viability in 1996, six years before actual delivery.

With the preliminary and contract design phase completed, IPPD entered Phase II. Teamwork was equally essential for Detailed Design and Construction. The Integrated Product Team, the Hull Team, assumed the lead on the crane and ship's boats part of the ship. A joint Avondale Alliance and government team combination, they began outlining resources, plans, and integration requirements for the final design and building. Costs and actual manning needed for these segments were quantified. Total Ownership Costs in terms of manpower to operate and maintain the crane, as well as associated maintenance and support requirements were factored into planning equations. Liaison with the other Integrated Product Teams, such as the Distributive and Machinery Teams ensured service compatibility. Interaction with the Topside Engineering Cross Product Team also assured integration with other systems and topside considerations. IPPD was facilitating product development.

Another process entered the effort at this time. Input from the Design for Ownership database, provided by an amphibious deck evolution naval officer, provided a positive recommendation. LPD 17 already possessed a Rigid Hull Inflatable Boat to be used for man overboard and other rapid, emergent requirements. Carried on the side of ship with a single arm davit, the RHIB was the only boat of its type onboard. At the same time it was a durable, speedy boat with minimal maintenance compared to traditional ship's boats. The recommendation from the potential owners was to replace all of the ship's boats with RHIBs.

The advantages were significant. Boat engineers would only have to be trained for one type of engine. Maintenance and upkeep were considerable less. A single parts allowance would service all ship's boats. Plus if the man overboard RHIB was out of commission one of these boats could be moved to that davit. Finally, since they weighed less the RHIBs could be even more easily launched and recovered from the boat crane.

This input started the change process. The LPD 17 Ownership Team reviewed the suggestion, discussing pros and cons. As one possible drawback, an all-RHIB LPD 17 would not be able to provide viable liberty boats for port visits, but the tendency during recent years has been to hire water taxis. Boat and Wave group commanders no longer operate from small boats since LCACs and LCUs have sufficient navigation resources to find the beach, so this requirement is not realistic. Traditionally ship's boats could still be employed as safety boats, but the older boats would not be able to keep up with the new high speed Advanced Amphibious Assault Vehicles that the Marines will operate from LPD 17. The RHIBs' speed provides a better chance of accompanying the AAAVs if safety boats are still required or rescue helicopters already in the force could satisfy the need. The all-RHIB suggestion was supportable.

Next in the process was the TOC team. Measuring costs in procurement and upkeep differences they discovered significant savings. Even without completely estimating maintenance, upkeep, manpower or training savings, the change to all-RHIBs would save $6,000,000 in life cycle costs for the 12 ships of the class. From the TOC perspective the advantage was clear.

The process continued as the design engineers and production experts from the Hull Team determined technical feasibility. Changes made now would have some cost, but certainly less than if the change was inserted in 2002 or later. Long-term support of current types of ship's boats could be tenuous, further highlighting the need for something better. Of course fit on the boat deck and operation with the crane would require further demonstration. Still, the lighter RHIBs would be more easily handled by the crane and would save about two tons. And every pound saved in overall ship weight is deemed to save about $200 in life cycle costs.

Other members of the IPTs/CPTs will also participate in the analysis. Training and ILS members of the Ownership Team will play a part. In addition Topside, Machinery, Distributive System, and Mission team members will help contribute a comprehensive perspective. The change appeared to have every aspect of proving technically feasible.

The final step in the approval process is the overall Production Management Team. This group oversees the IPPD and owns final approval. Incorporating ownership desirability, TOC avoidance, and technical feasibility into their criteria for confirming changes, the PMT is the final step in making LPD 17 an all-RHIB ship.

IPPD will not end with a new design and revised product. Indeed, new electronic mockups will represent the new boat operations as their merit is further evaluated. Fleet representatives either from COMOPTEVFOR or from the LPD 17 "virtual crew" (fleet operators, maintainers and trainers specifically invited to review design and electronic models) will have another chance to participate during the detailed design process. These last reviews should further enhance the confidence that the steel being cut and materials being ordered will successfully meet the owner's needs in 2002.

IPPD will not stop then either, as it continues to support the ship class for the following 40 years.

**Manning reductions to date.** No facet of LPD 17 attracts more attention than the eventual crew size. Each sailor represents a significant cost investment that when multiplied by 12 ships and by 40 years becomes a significant cost. Given a price tag of about $50K each, every person deducted from the final crew reflects $24M in Total Ownership Costs.

IPPD has been a factor in addressing crew size. Advancing technologies, innovative efficiencies, and close in examination of manning criteria have already led to reductions. From a planned size of 450, the LPD 17's crew size has dropped to 386, while efforts continue to find even more savings.

First IPPD is providing feedback to the Navy manning activities to reexamine manning models and processes. Workload paradigms may need to be revised to incorporate increased shipboard training emphasis. Procedures and doctrine may also need to be changed as traditional and routine functions are performed smarter and more efficiently. New initiatives from Navy testing and evaluation on Smart Ship and Gator 17 are also expected to provide manning conservation recommendations.

If LPD 17 can reach to a crew size of 360, over $2 billion in costs may be saved. Toward this goal, remaining billets and watch stations are under scrutiny for future savings. Recently 24 watch stations were identified that could be candidates for savings if Wireless communications supplemented the need for sound powered phone talkers, and computers could replace manual damage control plotting. However, these watch stations do not represent immediate savings. Each Sailor in a watch station must also have associated reductions in maintenance and workload, in own unit support tasks, and routine watch standing chores. Only when there are savings in all areas, may a billet be reduced.

Fleet and Marine Corps involvement remains mandatory to ensure that the ship may still be tactically operated. The LPD 17 IPPD theme in manning is "Do No Harm" and so combat readiness remains a priority over cost. Still, replacing a dedicated phone talker inefficiently pass information at 100 words per minute between decision nodes may be a process improvement on LPD 17.

**Streamlining the Process.** Total Ownership Cost avoidance remains of paramount importance in IPPD. Team members are constantly striving to identify and implement cost cutting, but such exertions may be futile if processes are not streamlined. IPPD facilitates changes that will save costs.

Traditionally, the ship design process was all consuming. As detailed design progressed, it became increasingly difficult to make changes even if the change made greater sense or saved money. Design and engineering changes often reached a stage where they were too expensive to implement. In fact, outmoded systems were sometimes designed and installed on a new ship, although never operated because everyone knew that shortly after delivery it would be replaced. Discrepancies discovered on the first of the class, which might preclude system certification, were sometimes left intact until after delivery of each of the ships - again because change cost was higher than late removal. Learning curves where team members learned from mistakes were also thought to be positive, despite the initial error costs.

Recognizing that learning curves and changes to the final product could be ill afforded, IPPD addressed accelerating the process to incorporate changes early. Through Design for Ownership, through using the good ideas and suggestions from industry and through an open mindset, LPD 17 design is conducive to designing smarter. One sample is in the ship's surface ship radar system.

LPD 17 initial design included two surface search radar systems - a military standard SPS - 67 radar, and a backup military version of a commercial radar, a SPS -64. Both radars were proven in the fleet, but TEAM 17 thought that the SPS-73 radar, a system available commercially, could do the function better and at less coast. A cost and benefit analysis provided the life cycle comparison shown below:

| Area | SPS-67/64 | SPS-73 |
|---|---|---|
| Acquisition Costs | $29.9M | $2.2M |
| MTBF | 1600/3800 hours | 4800 hours |
| MTTR | 15/3 hours | .4 hours |
| Preventive Maintenance | 22/14 hours per year | 3 hours per year |
| Manning | 1 ET/1 ET | 1 ET |
| Training Costs | $11K per ET | $3K per ET |

Notes: MTBF is Mean Time Between Failure
MTTR is Mean Time to Repair
ET is a Navy Electronic Technician

The advantages appear obvious, but in the past formal time-consuming correspondence, in depth feasibility studies, design analysis, and the lead times of government furnished material would all have figured into the time-schedule and costs. The result might very well have led to a post-delivery rip out and installation of the better system, directly impacting any acquisition cost savings.

Through IPPD, TEAM 17 has already started the process to incorporate this three-week-old suggestion into detailed design. By eliminating formal review correspondence, delegating studies to Cross-product teams with cognizant empowered experts from the full scope of required activities, and utilizing on-site government decision makers, the incorporation of the SPS-73 radar will occur months before design deadlines and years before delivery.

Still, TEAM 17 has a long way to go before the first ship is delivered, and certainly a long way to go before the last ship is decommissioned around the year 2050. Yet, IPPD will remain not only a valuable tool, but also an evolving, constantly improving implement for reshaping the shipbuilding frontier. We will continue to learn and to share our lessons as Integrated Product and Process Development and LPD 17 unfold.