Skip all front matter: Jump to Page 1

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REPORT

# Shared Modular Build of Warships

## How a Shared Build Can Support Future Shipbuilding

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Prepared for the United States Navy



RAND NATIONAL DEFENSE RESEARCH INSTITUTE

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*Cover photo by DCNS: The bow section of the* Mistral *is brought into position with the stern section in Brest, France, July 2004.*



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# Summary

Why would a warship program follow a multiple-yard, modular-build strategy? And how might such a program be managed to deliver those warships? This report sets out to answer these questions by considering the theoretical cost advantages, benefits, and challenges of building warships in modules at multiple yards with final assembly at a single shipyard: the shared-build approach. The basis for this analysis is the case studies of recent shared-build warship programs in the United States, France, and the United Kingdom (UK). We do not prescribe specific steps to take; rather, we draw out key points and themes from the case studies and analyze these. In this way, decision makers and future program managers can draw on the experiences of others who might have faced similar challenges.

There are three circumstances under which a multiple-shipyard, modular-build strategy might be adopted: A customer might specify the requirement; a prime-contracting shipyard might plan to outsource elements of construction; or an event in a build shipyard might lead to unplanned outsourcing of some of the work. Shared build might be required for political reasons, such as to provide work to more than one geographic region or maintain a shipbuilding industrial base, or it might be needed to access skills available only at different shipyards or to overcome capacity constraints. In some circumstances, it might be hoped that shared build could reduce costs.

The case studies are used to investigate such factors, and we use these to describe the key elements that decision makers might wish to consider as they contemplate the available strategies for delivering a class of warship. It might be that lawmakers direct the requirement for sharing build to maintain work and support an industrial base. Program managers and the potential shipyards will want to carefully plan the workload allocations to deliver the vessels within budget. Choices will need to be made about the contractual structure that will best meet the program's needs, and those involved will need to consider how they will work together, both in design and production, so that their collaboration helps and does not hinder the program. Table S.1 summarizes the attributes of the different shared- or modular-build cases.

There are no irresolvable technical obstacles to a shared-build strategy. Although shared build can work, it might not always deliver the outcome expected when the decision to adopt it is first made. For example, it might not maintain skills at all shipyards equally. Also, there are likely to be extra costs associated with such duplicated capability if hull numbers and drumbeat are not carefully managed.[1] Further, it is not clear that shared build is an effective means of preserving competition. This is because success in a shared-build program, particularly for

[1] *Drumbeat* is the build-schedule periodicity and is usually measured by the start of construction of each hull.

**Table S.1**
**Characteristics of Shared-Build Programs Studied**

| Characteristic | *Virginia* Class | DDG-1000 | LPD-17 | DDG-51 Deckhouse | Type 45 | QEC | *Mistral* Class |
|---|---|---|---|---|---|---|---|
| Number of units | 30 | 3 | 9 | 1 | 6 | 2 | 3 |
| Choice of shared build | Maintain industrial base | Access specialist skills | Event-constrained capacity | Event-constrained capacity | Maintain industrial base | Overcome capacity restrictions | Overcome capacity restrictions and reduce costs |
| Capability constraints | Ring construction; sustain two yards' ability to integrate and deliver alternate assembly and delivery, alternate construction of nuclear reactor, and split rest of modules evenly | Composite deckhouse to NGSB-GC; rest to BIW | Reduced capability (loss of labor and facilities) after Hurricane Katrina; outsource some steel work and minor outfitting to small companies | Build yard had no "spare" deckhouse modules; use deckhouse already being built in BIW | N/A; distribute work to minimize cost | QEC project too large for single shipyard; distribute work to minimize cost | DCN yard could not build whole ship. Chantiers de l'Atlantique yard is skilled at large-accommodation construction: living spaces to Chantiers; combat systems and other military functions to DCN; some outsourcing of DCN steel work to Polish yard |
| Contractual arrangements | Intimate teaming, prime-sub | GFE | Prime-sub | GFE | Prime-sub | Alliance | Prime-sub |
| Design software and IT | Shared design system, separate business systems | Shared design systems | N/A | N/A | Separate design systems | Shared data warehouse, two separate design systems | Separate |
| Cost implications | Transportation costs; IT infrastructure costs; additional design-translation cost | Transportation costs; IT infrastructure costs for common data systems | Transportation costs | Transportation costs | Transportation costs | Transportation costs; IT infrastructure costs; infrastructure-modification costs | Transportation costs |

**Table S.1—Continued**

| Characteristic | *Virginia* Class | DDG-1000 | LPD-17 | DDG-51 Deckhouse | Type 45 | QEC | *Mistral* Class |
|---|---|---|---|---|---|---|---|
| Shipyard collaboration | Extensive collaboration at all levels of management and production | Integration-yard QA personnel at supply yards | Minimal collaboration | Some collaboration | Integration-yard QA personnel at supply yard | Fully integrated program management; integration-yard QA personnel at supply yard | None |

NOTE: DDG-1000 = *Zumwalt*-class destroyer. LPD-17 = *San Antonio*–class dock. DDG-51 = *Arleigh Burke*–class destroyer. Type 45 = *Daring*-class destroyer (UK). QEC = *Queen Elizabeth*–class aircraft carrier. NGSB-GC = Northrop Grumman Shipbuilding—Gulf Coast. BIW = Bath Iron Works. DCN = Direction des Constructions Navales. GFE = government-furnished equipment. IT = information technology. QA = quality assurance.

complex vessels, requires the cooperating shipyards to set aside any competitive tendencies and help each other to the overall benefit of the program. The prospect of future competition will inhibit such a process, as was seen in the early stages of the UK's Type 45 program. Conversely, shipyards in a successful shared-build program seem keen to remain in such a structure for subsequent work. The teaming arrangement delivering the *Virginia*-class submarines reinforces this observation; the UK's alliance structure for delivering the future carriers evolved from multiple shipyards via a joint venture to a single shipyard. We conclude that the government (or Navy) needs to decide what it wants from a shared-build strategy before embarking on it. Once a decision is made, the program manager must then monitor and manage the program to ensure that it delivers the required outcome, as well as the vessels called for in the program.

Although our case studies do not allow direct comparison between different programs, we group our findings into four areas in which risk reduction is important. Reducing risk will give greater assurance that a program can deliver the required vessels, that they will be delivered on time, that they will be of the required quality, and that the program will meet its cost targets. Our four risk reduction areas are as follows:

- Motivating cooperation. Contractual requirements are only the first stage of cooperation between shared-build shipyards. For the more-complex warships, a higher level of trust and openness is needed between the involved shipyards. This can be difficult when there is an underlying and continuing shipbuilding competition. Strong collaboration can lead to shared best practices and reduced costs. The government (or Navy) has a role to play in bringing shared-build yards together and can encourage cooperation with, for example, contracting structures and profit share.
- Design completion. Detailed design is a key step in mitigating rework requirements during module integration because it allows better quality control and ensures accurate and timely stock delivery to the production process. This becomes even more important when those modules are to be built at two or more locations. In particular, the design at the module interfaces needs to be fully understood and, therefore, practically complete for modules to integrate easily and at less cost.
- Design and design-to-production organization. Shipyards involved in a shared-build strategy need to reach a detailed and common understanding of what affects the module interfaces and their integration. Such commonality requires either common design software or compatible software linked to a common design data bank.
- Aligning production practices and schedules. Aligning production practices requires each yard—in particular, the integration yard—to understand differences in production processes. This is of vital importance at the interfaces of complex, outfitted modules. Aligning the production schedules also requires pacing module construction to the same completion drumbeat.

A failure in the earlier stages of this progression is more likely to be catastrophic to the program than is a failure later on. The importance of these risk-reduction areas increases with the complexity of the modular-build process, which, in turn, is linked to the complexity of the vessel to be built. In other words, shared-build risks are likely much higher for more-complex vessels than are traditional-build risks of such vessels.

These risks could lead to increased program costs apportioned according to the shared management structure and contractual requirements. There is a further set of costs linked directly to the shared-build decision. The key shared-build costs are as follows:

- Demarcation of block completion. Shared build places a requirement for the supplying and receiving yards to agree on the completeness or otherwise of the supplied blocks. To mitigate the impact of unfinished or late blocks and to reduce overall program costs, both yards will endeavor to monitor and agree block progress. Such steps will add costs.
- Design for transportation. Structural and stability requirements to allow for open-ocean transport of blocks will increase design and production costs.
- Transportation. Moving completed modules from the supplying yard to the integration yard will add cost to the program.
- IT infrastructure. Especially in shipyards with very different IT systems, linking those systems or adopting a uniform system is a necessary cost.
- Resource management. Block build places particular demands on build manning with, for example, a block move coinciding with peak manning. The facilities in the yards are similarly affected. Shared build might require specific investment in delivering- and receiving-yard facilities to allow transfer of the modules.

The potential benefits to the cost of a program that follows a shared-build strategy include the following:

- Maximizing the learning curve. A shared-build strategy, in which the same modules are fabricated at the same yard for a relatively small number of hulls, can offer more opportunities to derive learning-curve efficiencies than an alternating, whole-hull schedule would offer.
- Cross-yard learning. In some circumstances, such as the *Virginia*-class program, the sharing of lessons learned and the collective innovation of more-efficient processes can reduce cost. In the case of the *Virginia* class, the motivation for cross-yard learning was underpinned by the agreement for equal share of profit.
- Outsourcing benefits. Assigning modules to shipyards with a specific specialization or lower manpower costs can lower the costs of an overall program. For example, the French *Mistral* class achieved cost reduction by outsourcing some steel work to a less costly Polish yard and by assigning the habitability modules to Chantiers. Assigning specific modules to specialized shipyards to reduce cost needs to be carefully balanced against other build strategy goals, such as the desire to maintain specialized skills at both shipyards. As seen in the *Mistral* class, outsourcing can also relieve existing or emerging capacity problems in the primary yards and keep a project on schedule, thereby avoiding any penalties for late delivery.