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Differences Between Military and Commercial Shipbuilding

Implications for the United Kingdom's Ministry of Defence

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Preface

The United Kingdom's shipbuilding industry has become progressively more reliant on the Ministry of Defence (MOD) and its Defence Procurement Agency (DPA) as customers. UK shipbuilders have largely exited the international market for commercial ships, and foreign military sales have been meagre. The MOD would prefer a more robust industry with a broader clientele, which would help sustain British shipbuilding skills over periods of low MOD demand.

With that motivation, Sir Robert Walmsley, then Chief of Defence Procurement and Chief Executive, DPA, asked the RAND Corporation to assess the prospects for the UK shipbuilding industry's diversifying its customer base, through either re-entering the commercial market or increasing its share of the military ship export market. In this document, we provide such a review, informed by the historical context of shipbuilding in the United Kingdom and potential competitor nations and by the differences between military and commercial shipbuilding.

This monograph is one of a set of three addressing related issues in UK shipbuilding. Funded by the DPA, the three studies have the common goal of contributing to understanding better the warship-building industry within the United Kingdom and to improving management processes therein. The other two monographs answer the following specific questions:

- How could greater use of advanced outfitting and of outsourcing reduce shipyard workload in the Future Aircraft

Carrier programme and thus increase the likelihood of on-schedule completion of that and other DPA programmes? (MG-198-MOD)
- What metrics would keep DPA informed of progress towards completion of ship construction projects, and why do DPA-funded programmes tend to lag commercial projects in on-time completion rates? (MG-235-MOD)

This report should be of special interest not only to the DPA but also to service and defence agency managers and policymakers involved in shipbuilding on both sides of the Atlantic. It should also be of interest to shipbuilding industrial executives in the United Kingdom.

This research was sponsored by the MOD and conducted within RAND Europe and the International Security and Defense Policy Center of the RAND National Security Research Division, which conducts research for the US Department of Defense, allied foreign governments, the intelligence community, and foundations.

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Summary

The United Kingdom's Ministry of Defence (MOD) now buys most all ships built by the country's shipyards. A shipbuilding industry relying almost entirely on a single customer will have little motivation to find more efficient ways of working or to advance the state of the art. An uncompetitive industry is unlikely to be a robust and healthy one.

The MOD is thus interested in whether the United Kingdom's shipbuilding industry might become more competitive in the commercial and foreign military marketplaces. It is our aim in this report to shed light on the prospects for the United Kingdom's re-entering the commercial market or increasing its share of the military export market. We base our conclusions on literature reviews, including detailed projections of shipbuilding by country and ship type;[1] a survey of shipbuilders in the United Kingdom, United States, and European Union[2]; and interviews with personnel at the responding shipyards.

As first and second steps in assessing the prospects for expanding UK shipbuilders' customer base, we review global shipbuilding trends and the differences between military and commercial shipbuilding. We then examine the commercial and military markets in turn and

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[1] Unless specified otherwise, data reflect trends and conditions up to early 2003.

[2] For simplicity, the authors use the term 'European Union', or 'EU', to refer to those non-UK European shipbuilders surveyed (even though the United Kingdom is an EU member). Specifically, EU countries that participated in this report consist of Denmark, Finland, France, the Netherlands, Spain, and Italy.

evaluate the potential for constructing both commercial and military ships in the same yard.

Shipbuilding Trends

The demand for commercial shipbuilding in the global marketplace has increased from a lull in the late 1980s to a peak in 2002 and 2003. Some national shipbuilding industries, notably the German and the Dutch, recovered during this period. The French shipbuilding industry took somewhat longer but eventually recovered. The US commercial shipbuilding industry, largely a protected one and uncompetitive in the global market, also recovered slowly from a similar downturn in its domestic demand. The United Kingdom's commercial industry began to recover in the early 1990s before fading again in the middle part of the decade. As of early 2003, there was only one sizable commercial ship under construction in a UK shipyard (the HMS *Anvil Point*, a roll-on/roll-off cargo ship).

The United Kingdom has, however, sustained a military shipbuilding industrial base of substantial size throughout the last quarter-century. The value of its future domestic demand is expected to be on the order of that of France and Japan and much larger than Germany's. However, UK shipbuilders are expected to export very few military ships compared with projects of the Germans and French.

Differences Between Military and Commercial Shipbuilding

If the UK commercial market is to expand, military shipbuilders will presumably have to begin building commercial ships, because the commercial industrial base is so small. The construction of all but the most complex commercial ships, however, differs dramatically from that of warships along several dimensions:

- **Ship size and complexity.** The average commercial ship is about three times as big as the average military ship and thus cannot be built in facilities sized for military ships. At the same time, the average commercial ship is much simpler (e.g., no weapon system) than the average military ship.
- **Acquisition process.** Commercial ship owners are accustomed to much simpler contracting, designing, construction, and testing processes than those that pertain in the military world.
- **Design and construction.** Commercial ships are, for the most part, large steel boxes with relatively small and simple propulsion and navigation systems. Designing military ships takes longer because of their high equipment density, the large number of sophisticated systems involved, and a desire to at least match the current state of the art. Construction of commercial ships is mostly a volume business that depends on simple steel forming and welding processes repeated over and over. The construction of warships involves the use of exotic materials, the installation of large amounts of high-value, sensitive equipment, and the satisfaction of more exacting standards. The testing process for military ships is more involved because it has to reflect the high technology and technology density of the ships and take account of multiple possibilities for mutual interference of advanced electronic systems.
- **Workforce character.** In the United Kingdom, military shipbuilding requires a much higher ratio of white- to blue-collar workers than that found in commercial shipbuilding. This is because military shipbuilding demands much more engineering support, as well as the need to interact extensively with the government oversight team. Military shipbuilding also requires more highly skilled and specialised workers. Such high overhead and high skill base cannot be sustained by any yard that expects to build typical commercial ships at competitive prices.

The differences between military and commercial shipbuilding are not as great, however, for auxiliary vessels (oilers, sealift ships, etc.) and some amphibious warfare ships as they are for surface combatants and submarines. Auxiliary vessels are similar to commercial ships and are often built to similar standards, and testing can be less rigorous where weapon and sensor systems are few.

Prospects for Market Entry and Integration

As suggested above, the United Kingdom would face strong competitors in attempting to re-enter the commercial shipbuilding market. Japan and South Korea dominate the market for ships of low and moderate complexity, mostly cargo ships and tankers of varying types. The European Union dominates the market for more-complex ships such as passenger vessels, although that market segment is also under pressure from Asian shipbuilders. The global shipbuilding market has for some years been characterised by excess capacity, so profits have been low. A newcomer would face formidable impediments to securing a meaningful market niche in such an environment. Towards the latter half of 2003, demands for certain ship types (mostly very large container ships, bulk carriers, and liquefied natural gas [LNG] tankers) suddenly soared, pressing the available builders and, we surmise, increasing profits. The United Kingdom has not been in a position to take advantage of this shift and cannot count on it lasting for long. UK shipyards attempting to enter or re-enter the commercial shipbuilding market would also have to find a way to resolve all the workforce, process, and facility issues discussed above in a niche that took advantage of their special high-skill and high-complexity capabilities. Finally, the pound has recently been strong against the dollar, which also works against the United Kingdom's export interests. We thus find prospects for re-entry of UK shipyards into the commercial market to be, on the whole, daunting.

The military export market is small in value compared with the commercial market. It nonetheless represents a tempting target for a nation with a largely military industry that is attempting to gain some ability to level the load over domestic military production lulls. Here again, UK shipbuilders face strong competitors in Germany and France, which together have more than 60 percent of the military export market. The United Kingdom certainly has a stronger industrial base to support military sales than it does in the commercial arena, but the match between most current UK military ship products and global demand is not a close one. The military export market is largely a market for modestly priced frigates and small conventionally powered attack submarines. It is not clear that a UK shipyard could build a conventional submarine at a competitive price; UK warships are, in general, too sophisticated and expensive to make them interesting to potential importers. Furthermore, export contracts often require that most ships in an order be built in the importing country, thus limiting the benefit such sales may have for the exporter's construction workforce.

As mentioned above, should the United Kingdom attempt to re-enter the commercial market, shipyards currently building military ships would have to diversify into commercial production. While some yards do have experience with naval auxiliaries or recent commercial projects, the historical trend has been more towards specialisation than integration of commercial and military production. Integration can, of course, bring the benefits of military technological advances to commercial construction, and the benefits of efficient commercial processes can feed back to the military side. However, most successful shipbuilders have found it difficult to build both military and commercial ships, of any degree of complexity, within the same operation. Certain Japanese yards constitute a possible exception, and their practices warrant further investigation.

The Way Forward

While prospects for broadening UK shipyards' customer base would appear to be poor, the shipbuilding industry is a volatile one, and events could always break unexpectedly in the United Kingdom's favour. Taking advantage of such opportunities requires some preparation, such as the development of less expensive warship designs that reflect the needs of potential buyers. Research and development directed towards a generation-skipping commercial design or dramatic technological advances in systems and materials could also be fruitful.

Of course, development of new designs and technologies would require investment on the part of shipbuilders and marine equipment suppliers and potentially on the part of government, if appropriate and if consistent with EU rules. It would require investment, for example, in sustaining core design and programme management skills through lulls in orders. These investments would be risky, because the probabilities of payoff would not be high, but externalities might accrue to domestic military shipbuilding and to other UK industries.

Acknowledgements

This work could not have been undertaken without the steadfast support and encouragement we received from Sir Robert Walmsley, then Chief of Defence Procurement and Chief Executive, DPA, and members of his staff. Many individuals in the MOD provided their time, knowledge, and information to help us perform the analyses discussed in this report. Their names and contributions would fill several pages.

If we were to single out two persons who participated in and supported this work in extraordinary ways, we would mention our action officer Andy McClelland of the DPA and Robin Boulby of the Future Aircraft Carrier programme's Integrated Project Team. Their tireless efforts on our behalf are greatly appreciated, along with their constructive comments on earlier drafts.

We are also indebted to the UK, US, and EU shipyards that participated in this study. Each gave us the opportunity to discuss a broad range of issues with the people directly involved. In addition, all the firms arranged for us to visit their facilities. The firms and government offices provided all the data we requested in a timely manner.

We are indebted to Brien Alkire of RAND and Philip Koenig of the Office of Naval Research for their formal review of the document and the many improvements and suggestions they made. Professor Thomas Lamb of the University of Michigan participated in data collection and made several helpful suggestions for the analysis—we thank him for his time and help. We are additionally indebted to

Joan Myers for her deft assistance organising and formatting the many drafts.

Abbreviations

CGT	compensated gross tonnage/tons
CVF	Future Aircraft Carrier
CVN	carrier vessel, nuclear
DCN	Direction des Constructions Navales (France)
DDG	guided-missile destroyer
DPA	Defence Procurement Agency
DWT	deadweight tonnage/tons
GRT	gross registered tonnage/tons
HDW	Howaldtswerke–Deutsche Werft
HMS	Her/His Majesty's Ship
IHI	Ishikawajima-Harima Heavy Industries
LCAC	utility landing craft
LHD	helicopter/dock landing ship
LNG	liquefied natural gas
LPG	liquefied petroleum gas
LSW	light ship weight
MARS	Military Afloat Reach and Sustainability
MEKO	Mehrzweck Kombination (system for building ships in containerised modules)
MOD	Ministry of Defence
NASSCO	National Steel and Shipbuilding Company

OECD	Organisation for Economic Co-operation and Development
OPV	offshore patrol vessel
RORO	roll-on/roll-off
SSK	conventionally powered attack submarine

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Introduction

The global shipbuilding industrial base has excess capacity. The demand for military ships in particular has been waning as the navies of major military powers have reduced force structures. Meanwhile, Asian shipbuilders have dominated large segments of the commercial market for the past two decades. Given these pressures, the shipyards of the United Kingdom have had an increasingly difficult time maintaining their viability. Some have gone into receivership, while others have shed large portions of their workforce in recent years.[1]

The United Kingdom's Ministry of Defence (MOD) needs a robust and healthy shipbuilding industrial base if it is to be provided naval ships that are technically advanced and affordable. Such a robust and healthy industrial base would, for example, offer the following advantages:

- *5ustainment through downturns in V OG demand.* Military shipbuilding activity goes through peaks and lulls as programmes ramp up and terminate and as threats erupt or subside. Shipyards need other customers if the MOD is to avoid taking in-

[1] While this report was in preparation, Harland & Wolff Shipbuilding & Heavy Industries and Appledore Shipbuilders Ltd. went into receivership.

efficient actions (e.g., suboptimal task scheduling) or risk losing skills that could be expensive and time consuming to recover.[2]

- *Increased motivation to innovate and advance the state of the art.* If the MOD is the only customer, it would benefit only from those advances in shipbuilding technology and processes that it seeks. There would be no positive externalities accruing to the MOD from innovations motivated by other customers.
- *Feedback from commercial to military shipbuilding (and vice versa).* Lessons military shipbuilders and shipbuilding officials could learn from the commercial world are perhaps most effectively absorbed by having commercial customers.

The MOD is thus interested in whether the United Kingdom's shipbuilding industry might become more competitive in commercial and foreign military marketplaces. It is our aim in this report to shed light on the prospects for the United Kingdom's re-entering the commercial market or increasing its share of the military export market. The challenges are formidable, and our conclusions are not very encouraging, but we do provide some steps that the MOD and the shipbuilding industry could consider as means to improve the industry's position.

We base our analysis on three types of information sources.[3] First, we reviewed the literature for pertinent documents. Of particular interest and value were Lloyd's Register of Ships, a database of existing ships and current commercial ship orders,[4] and Warships

[2] For a detailed discussion of future MOD demands on the UK shipbuilding industrial base and the industrial base's capacity to accommodate them, see Mark V. Arena et al. (forthcoming).

[3] Except where specified otherwise, the information presented in this report reflects trends and conditions as of early 2003.

[4] 'Register of Ships', Lloyd's Register–Fairplay, London, January 2003, www.lr.org/services_overview/shipping_information/index.htm (last accessed January 2003).

Forecast, a 10-year projection of military ship production by Forecast International/DMS.[5]

Second, we surveyed 15 major shipyards (seven in the United Kingdom, two in the United States, and six in the European Union[6]) and a consulting US ship designer for their views on the feasibility and practicality of producing a mix of commercial and military vessels at a single yard. There were six more yards sent surveys that did not respond. The full list of shipyards to be canvassed was compiled in association with MOD personnel (see Table 1.1).

Table 1.1
Firms Contacted for Survey and Responses

United Kingdom		European Union		United States	
Shipyard	**Response**	**Shipyard**	**Response**	**Shipyard**	**Response**
Vppledore	es	Blohm oss (Germany	Wo	Bath Iron or s	Wo
BV+ Systems	es	Chantiers de l'Vtlantique (France	es	+lectric Boat	Wo
Devonport Management Ltd.	es	DCW (France	Wo	Wational Steel and Ship building Company	es
kosyth	es	Fincantieri (Italy	es	vaerner Khiladelphia	Wo
Swan) unter	es	) D (Germany	Wo	Worthrop Grumman Ship Systems	es
osper hornycroft	es	I ar (Spain	es	JJMV (John J. McMullen Vssociates	es
		vaerner Masa (Finland	es		
		z dense (Denmar	es		
		koyal Schelde (he Wether lands	es		

[5] Forecast International Naval Group, 'Warships Forecast', Forecast International/DMS, March 2003, www.forecast1.com

[6] For simplicity, the authors use the term 'European Union', or 'EU', to refer to those non-UK European shipbuilders surveyed (even though the United Kingdom is an EU member). Specifically, EU countries that participated in this report consist of Denmark, Finland, France, the Netherlands, Spain, and Italy.

Third, we conducted interviews with personnel at shipyards responding to the survey to ensure that we understood the survey responses and to allow respondents to elaborate freely on the questions asked. Where helpful, we encouraged our interviewees to use our survey questions as starting points for exploring broader issues. We also interviewed experts on other aspects of the commercial and military export markets.

These sources allowed us to undertake the following tasks in support of our project aims:

- Summarise the historical context of military and commercial shipbuilding in the United Kingdom, other countries, and the world as a whole (Chapter Two).
- Identify the differences between commercial and military shipbuilding along various dimensions to give a sense of some of the challenges involved in re-entering the commercial market. We differentiate between combat ships and military auxiliaries, because production of the latter is marked by greater commonality with commercial ship production (Chapter Three).
- Identify the prospects for, and challenges to, re-entering the commercial market. Examples include the potential oversupply of ship production capacity and the extent to which the demands of commercial customers differ from those of the government customers to which UK shipyards are accustomed (Chapter Four).
- Assess opportunities in the military export market and the challenges likely to be encountered in increasing the United Kingdom's share of this market (Chapter Five).
- Examine the advantages and disadvantages of integrating commercial and military production in a single yard versus retaining the specialisation on either commercial or military shipbuilding that has evolved (Chapter Six).

Our findings should be interpreted with some caution. The survey was an important foundation for part of our analysis, and it should be kept in mind that the survey sample was small, and of those 16 firms that did respond, not all answered every question. The direct experience supporting most answers we received was often limited to a narrow range of ship types or classes, and each yard had its own understanding of what is meant by 'military' and 'commercial' shipbuilding. Some responses were not even based on experience but on planning exercises. Finally, some of our questions called on the judgment and recollection of whoever filled out the survey.

Other information sources could also not be regarded as definitive. Order book and projection databases are only as good as the data-collection effort underlying them, and that was not under our control. The literature on ship production and markets is not voluminous.

We encountered enough consistency among sources, however, to make some observations that we hope will be helpful to the MOD and to other parties invested in ship production in the United Kingdom.

C)VK +k z

Military and Commercial Shipbuilding Trends

In this chapter, we depict some historical shipbuilding trends—across the world as a whole, within the United Kingdom, and within other nations. These developments are important for providing perspective on how entrenched or volatile certain production patterns have been.

World

Naval shipbuilding since the end of World War II reflects the evolution of the Cold War until its conclusion at the end of the 1980s. The numbers and total displacement tonnage of military ships built since World War II are shown in Figures 2.1 and 2.2.[1] (For information on the different definitions of tonnage pertaining to military and to commercial ships and on the details of our methodology for comparing the two, see Appendix A.)

The Soviet Union began the Cold War with a great burst of military shipbuilding, as measured by the number of ships in the 1950s (Figure 2.1). Comparing Figures 2.1 and 2.2 reveals that the Soviet strategy changed in the 1960s, from large numbers of small ships to smaller numbers of large ships. This pattern continued through the 1970s and 1980s, but Russian shipbuilding slowed in the

[1] These data are courtesy of the Colton Company at www.coltoncompany.com.

Figure 2.1
Number of Warships Delivered Each Year Since the End of World War II

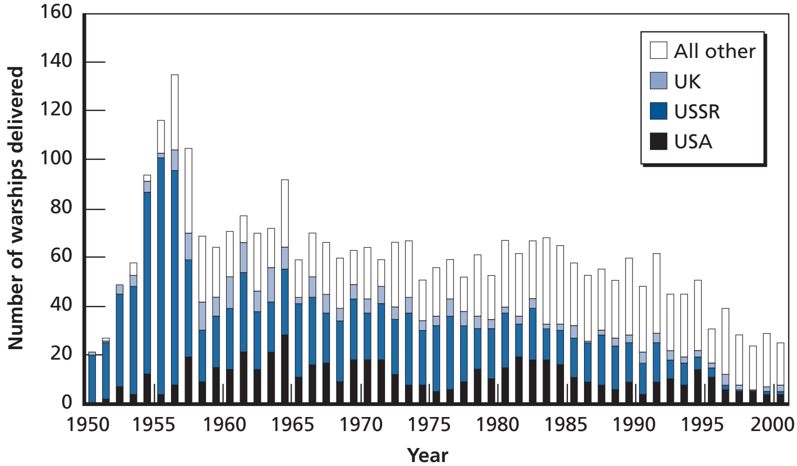

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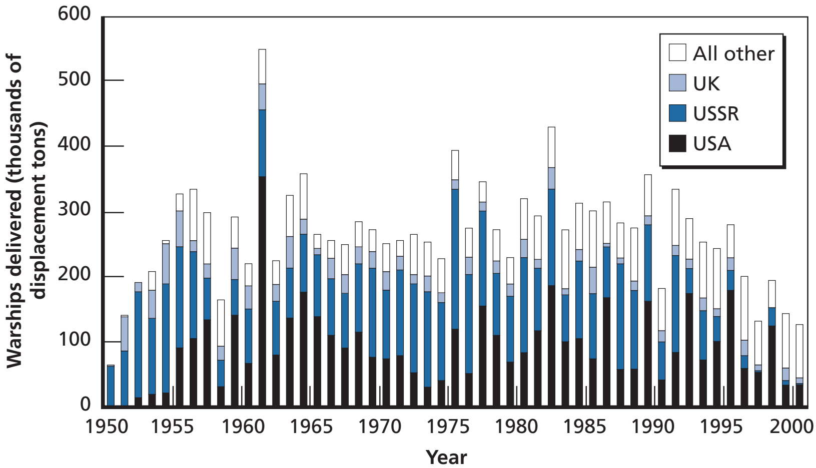
Figure 2.2
Displacement Tonnage of Warships Delivered Each Year Since the End of World War II



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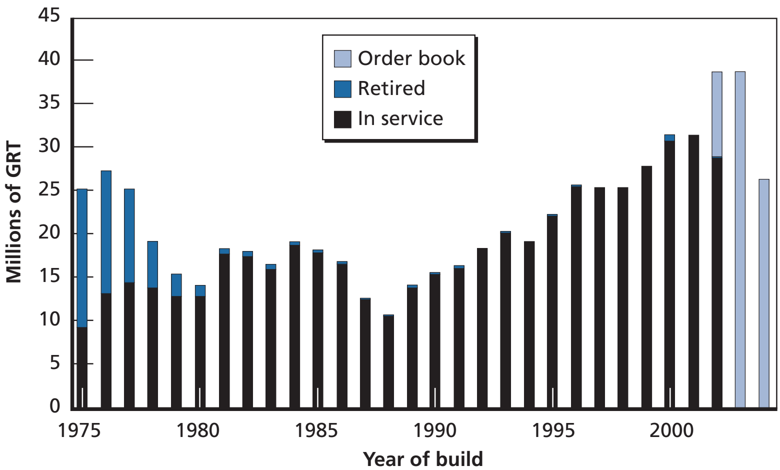
1990s and virtually ceased by the end of the century. Since 1965, military shipbuilding in the United Kingdom has oscillated somewhat in both numbers and tonnage but has remained relatively modest. The United States built a fleet of large deck carriers that are few in number but very high in displacement, as indicated by the spikes for the country's production in Figure 2.2. It also built ever-larger surface combatants and submarines, as reflected in the relatively high US tonnage totals (compare Figures 2.1 and 2.2). The numbers also suggest that the rest of the world continued at a comparatively steady pace throughout the Cold War. By the end of the century, worldwide military shipbuilding had shrunk to about 25 ships and 125,000 displacement tons per year, largely because of diminished superpower naval construction following the end of the Cold War.

Driven by different demands, the commercial shipbuilding industry followed a supply pattern different from that of the military. Figure 2.3 shows self-propelled commercial vessel deliveries occurring from 1975 onward, including the current order book.[2] The data are in thousands of gross registered tons (GRT) (see Appendix A) and include all vessels of 1,000 GRT or larger. We have excluded smaller vessels because they reflect localised markets and not necessarily the factors influencing world shipbuilding trends. The dark blue shading indicates ships that were delivered but subsequently retired, scrapped, laid up, lost, or otherwise unavailable for service. The light blue shading shows the current order book, by anticipated year of delivery, through 2004. (Anticipated deliveries beyond 2004 are omitted, because some of these data would have been incomplete at the time we collected.)

Annual commercial ship deliveries fell from roughly 25 million GRT in the mid-1970s to between 15 and 20 million GRT through the early and mid-1980s before bottoming out near 10 million GRT in 1988. The industry then underwent a vigorous recovery during the 1990s, reaching a peak of 38 million GRT in 2003. That run-up

[2] Data are from Lloyd's Register of Ships, January 2003.

Figure 2.3
World Commercial Shipbuilding Fell During the 1980s, Then Recovered in the 1990s



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amounted to an increase from 601 to 1,552 vessels. According to Lloyd's, deliveries will be off substantially in 2004, reflecting a drop in orders following the September 11, 2001, terrorist attacks. However, part way through 2003, there was a large increase in orders for certain ship types, including container ships, bulk carriers, and liquefied natural gas (LNG) tankers, filling the order books of some yards through 2005. These data are not reflected in Figure 2.3. The current commercial order book according to the Lloyd's data (83 million GRT) represents about $38 billion worth of business.[3]

It is noteworthy that the number of commercial ships over 1,000 GRT that are delivered annually is some 60 times the number of military ships. The dollar value, however, is only two or three times as much.

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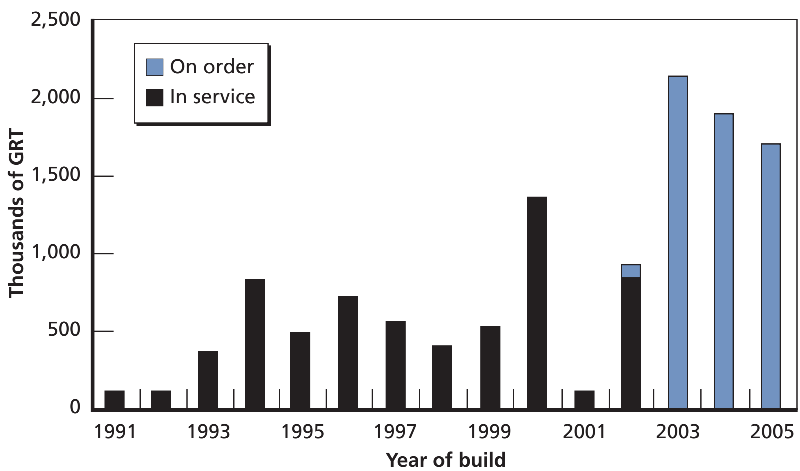
[3] Maritime Reporter, February 2003. We follow the international convention of referring to shipbuilding market value in US dollars.

The oscillations in supply shown in Figure 2.3 and reflected in very recent new orders are representative of the historical volatility of the shipbuilding market. The variable nature of the business results from cycles in world trade, the desire to take advantage of potentially profitable new shipping technologies, and other unpredictable factors. For example, in the 1970s, it was thought that LNG would be an important energy source for the foreseeable future and, therefore, a number of LNG tankers were built. Falling oil prices preempted this market until recently, when renewed LNG profitability motivated the construction of more LNG tankers (see Figure 2.4). No one can predict for sure whether the LNG trade will be sustained over the life of the ships now being built; it was not during the last cycle.

Note that, as seen in Figure 2.3, most of the tonnage built in 1975 is now out of service. Commercial ships have a short lifetime, so regardless of the volatility caused by world economic and political

Figure 2.4
There Has Been a Recent Burst of LNG Tanker Orders



RAND *MG236-2.4*

trends, there must be some minimal level of supply over the long term to sustain a commercial fleet.

In subsequent chapters, we characterise the United Kingdom's potential regional competition for commercial and military export ship sales. As a prelude to that, we now examine historical trends in the United Kingdom and in several other countries. To allow some insight into the relative importance of military and commercial shipbuilding in each country, we have reported them together in some displays in the remainder of this chapter. In these cases, we put military and commercial ships onto the same scale: GRT (by multiplying the light-ship-weight [LSW] tonnage of military ships by two; see Appendix A for more information, including caveats to the usage of this factor).

United Kingdom

The sheer size of its pre–World War II shipbuilding industry served the United Kingdom well by providing the backbone of maritime thinkers and tradesmen needed to design, build, and maintain a powerful Navy. But the UK commercial shipbuilding industry declined steadily during the latter half of the 20th century to the point where the Royal Navy has now become its major customer and, for some large shipyards, the only customer.

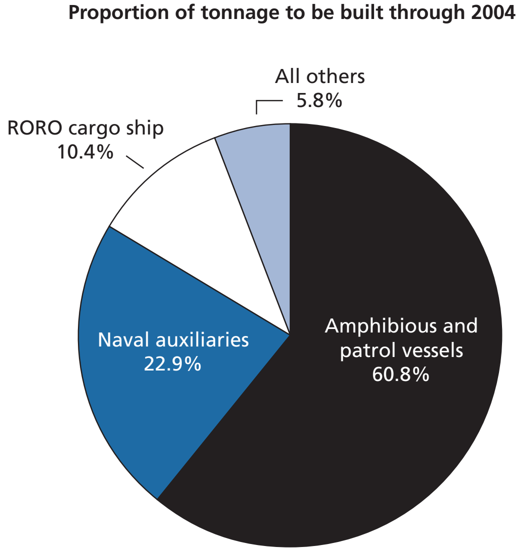
Table 2.1 shows the UK order book for commercial vessels of at least 100 GRT.[4] Because, as we will discuss in Chapter Three, they are similar to commercial ships in many ways, we include naval auxiliaries in the table but not warships. In fact, as made clear in Figure 2.5, naval ships comprise nearly 84 percent of tonnage being constructed through 2004; there is very little commercial shipbuilding left in the United Kingdom.

[4] Lloyd's Register of Ships, January 2003.

Table 2.1
The UK Commercial Order Book

Ship Name	Ship Type	GRT	Date of Build	Shipbuilder
ave Knight	Replenishment oiler	23,294	2002	ickers -T & Eng. Ltd. (Tarrow
ave Ruler	Replenishment oiler	23,294	2002	TAE -ystems Narine Ltd. (Glasgow
Enterprise	Hydrographic survey ship	3,778	2002	Appledore -hipbuilders Ltd. (Appledore
	Subtotal (naval auxiliary)	50,366		
Anvil Point	RORO cargo ship	22,900	2003	Harland & olff -hipbuilding & Heavy Industries Ltd. (Telfast
Appledore 188	Offshore supply ship	3,000	2003	Appledore -hipbuilders Ltd. (Appledore
Ferguson 712	rawler	2,999	2003	Ferguson -hipbuilders Ltd. (Port Glasgow
-cillonian I	Passenger/general cargo ship	1,800	2003	Appledore -hipbuilders Ltd. (Appledore
Appledore190	Passenger/RORO cargo ship	1,100	2003	Appledore -hipbuilders Ltd. (Appledore
FTN 2002	Passenger ship	800	2002	FTN TabcockNarine Ltd. (Rosyth
Ferguson -T 714	Fishing support vessel	800	2003	Ferguson -hipbuilders Ltd. (Port Glasgow
Pendennis 54	acht	499	2004	Pendennis -hipyard Ltd. (Falmouth
Hepworth	Oil products tanker	400	2003	Hepworth -hipyard Ltd. (Paull
NacYuff 616	Research vessel	250	2002	Nacduff -hipyards Ltd. (Nacduff
NacYuff 617	Fishing vessel	250	2002	Richards (-hipbuilders Ltd. (Lowestoft
NacYuff 620	Fishing vessel	250	2003	Richards (-hipbuilders Ltd. (Lowestoft
-mit Yee	raining ship	140	2002	FTN TabcockNarine Ltd. (Rosyth
-mit Yon	raining ship	140	2003	FTN TabcockNarine Ltd. (Rosyth
-mit Yart	raining ship	140	2003	FTN TabcockNarine Ltd. (Rosyth
NacYuff 622	Fishing vessel	138	2003	Richards (-hipbuilders Ltd. (England
NacYuff 621	Fishing vessel	120	2002	Nacduff -hipyards Ltd. (Nacduff
	Subtotal (commercial)	35,726		
	Total	86,092		

Figure 2.5
The MOD Has Become UK Shipyards' Biggest Customer[5]



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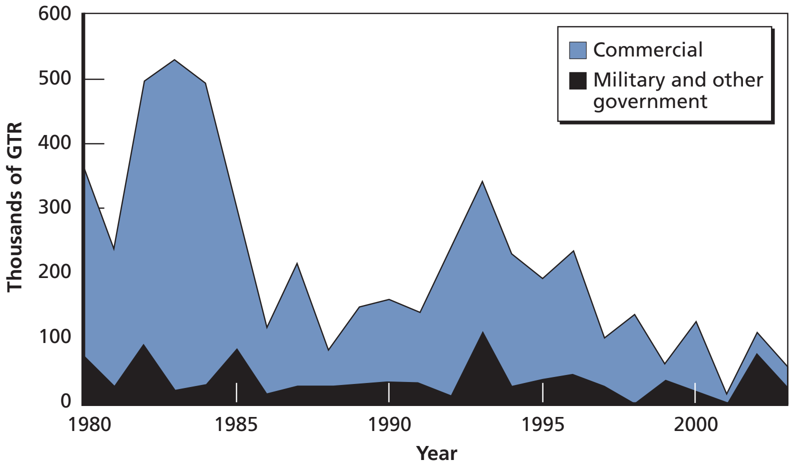
The transformation of the UK government from a minor to major customer is a recent development, as shown in Figure 2.6. The blue area represents the GRT of UK-built merchant-only ships delivered each year since 1980 and still operating today on the world's oceans. The black area shows the GRT-equivalent of UK military shipping delivered, including government commercial-like ships such as naval auxiliaries, fireboats, and standby safety vessels, along with patrol craft and other small vessels ordered by foreign governments.

[5] Data from Lloyd's Register of Ships, January 2003, supplemented by Forecast International, as of March 2003.

Figure 2.6
UK Commercial Shipbuilding Could Not Sustain a Recovery After the 1980s



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We show all ships of 100 tons or more in the figure.[6] As was the case for the world as a whole (Figure 2.3), in 1989 the UK shipbuilding industry began a recovery from the downswing of the mid- to late 1980s. However, the UK recovery began to falter in the mid-1990s, and production has steadily declined since. As recently as the early 1980s, UK commercial shipbuilding represented up to 3 percent of the world's total. This share fell to 0.3 percent by 2000 and has been virtually nothing since.

Government shipbuilding has averaged 24,000 tons per year during the 24-year span seen in Figure 2.6 but has had numerous peaks and valleys. In 1985, government shipbuilding peaked at about 90,000 tons, and again in 1993 at about 120,000 tons. Both these

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[6] Data in the figure are from Lloyd's (commercial production), Colton Company (military production through 2002), and Forecast International (military production after 2002, forecast as of March 2003). Analogous graphs for other nations in the next section draw on the same sources and represent the same products described here in the text.

peaks represented about a third of the total UK shipbuilding of those years. In future years, if commercial production remains small, the ramp-up and eventual decline of programmes such as the Type 45 destroyer will result in a much more volatile total industry than has been the case. The UK industry's inability to retain access to a load-levelling commercial market has thus become a concern for the MOD and, hence, one of the motivators of the current study.

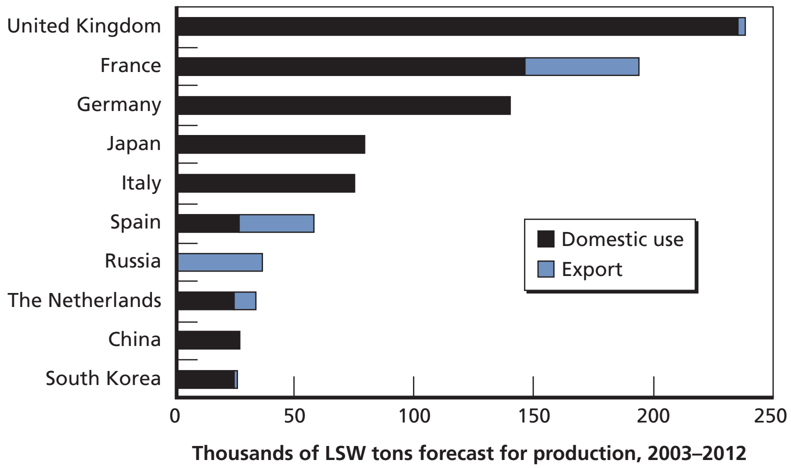
In sum, the United Kingdom's merchant shipbuilding capacity, once the biggest and most productive in the world, has faded away. Commercial shipbuilders have not been competitive with foreign yards and have gone out of business. As shown in Figure 2.6, the conversion of the UK shipbuilding industry to a largely military one has been more the result of attrition in commercial shipbuilding than the effect of a big run-up in military production. Still, the United Kingdom remains a major builder of warships, though largely for its own use (see Figure 2.7,[7] taken from Table 2.2). To shipyards, military production looks attractive, at least relative to commercial shipbuilding, for several reasons:

- Military contracts offer potentially higher profit margins than commercial contracts. Competition has driven commercial-sector profits down to just a few percent.
- Continuous military production supports large overhead structures (e.g., design teams) that yards are reluctant to dismantle (because they are difficult to reconstitute).[8] Thus, while there are incentives for yards to take up military production, there are disincentives to discourage them from going back to commercial production.
- MOD work is restricted to UK companies, so there is no need to compete against more-efficient shipbuilders from abroad.

[7] The figure shows the top 10 warship-producing countries, excluding, for reasons of scale, the United States (776,445 tons domestic use; 174 tons export).

[8] The continuous-production, high-overhead model is not the only one feasible for military production, however. We discuss an alternative in Chapter Five.

Figure 2.7
The United Kingdom Remains a Major Builder of Warships, Though Largely for Its Own Use



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Other Countries

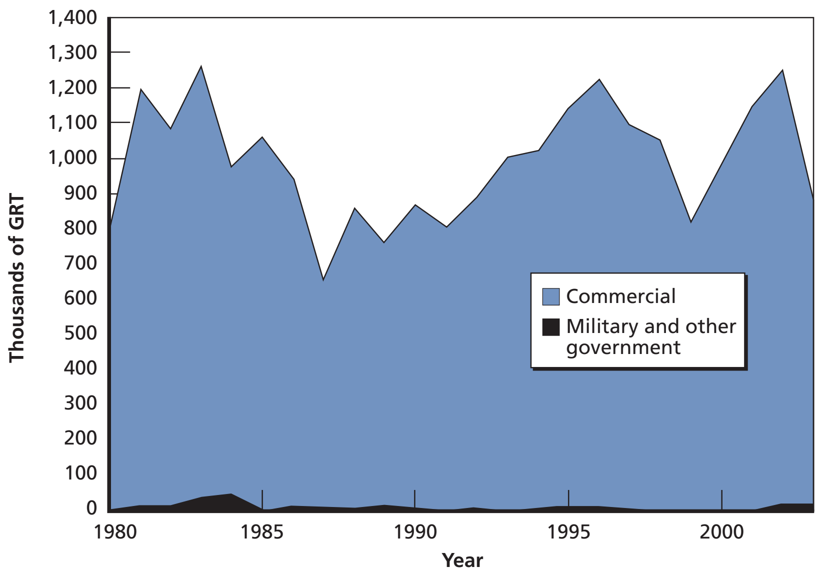
The trajectories of national shipbuilding programmes have followed many different paths during the past century. Korea and Japan, once minor players in the field, have grown to be world leaders within the past several decades. In this section, we are concerned with some of the other EU nations and the United States, which are the United Kingdom's most natural competitors in the complex-ship market for which its industry is best suited. (Korea and Japan take advantage of high-productivity, high-throughput yards developed over the decades to dominate the market in bulk carriers and other commercial ships.) We will return to the topic of market segmentation—and Asian dominance of the commercial industry—in Chapter Four.

Germany

Germany has sustained a substantial shipbuilding industry for many years, as shown in Figure 2.8. The commercial industry has averaged about 1 million GRT per year since 1975. Note the dip in the late 1980s coinciding with the dip in world shipbuilding at that time (see Figure 2.3 earlier in this chapter).

The current German commercial shipbuilding order book is substantial, totalling 1.84 million GRT,[9] or more than 50 times that of the United Kingdom (see Appendix B). Germany is the second largest commercial shipbuilder in the European Union, just behind Italy (1.86 million GRT), and ranks sixth worldwide.

Figure 2.8
German Shipbuilding Has Been Overwhelmingly Commercial



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[9] From Lloyd's Register of Ships, January 2003.

Germany is the largest of the Western European military export shipbuilders (see Table 2.2).[10] However, Germany's military ship production is a very small percentage of its commercial ship production, as measured by GRT. German military ship production peaked at about 51,000 equivalent GRT in 1984 and will reach that level again in 2006. It has averaged about 15,000 equivalent GRT per year since 1980. Recall that UK warship and auxiliary ship production has averaged about 24,000 equivalent GRT per year over roughly the same period.

Table 2.2
Projected Military Ship Production, 2003–2012

	Export			Domestic Use		
	Number	Value ($ millions)	LSW Tons	Number	Value ($ millions)	LSW Tons
Germany	56	10,713	96,040	21	5,799	44,144
France	25	6,405	47,570	17	13,015	146,302
Russia	20	5,000	36,025	0	0	0
-pain	6	2,035	31,343	7	2,195	26,735
The Wetherlands	9	1,780	8,500	4	1,585	24,759
United Kingdom	2	650	3,000	22	17,340	235,140
United -tates	2	53	174	66	56,172	776,446
-outh Korea	1	30	1,500	7	4,905	24,500
Japan	0	0	0	16	11,090	79,125
Italy	0	0	0	18	5,289	75,170
China	0	0	0	8	3,230	26,875
Australia	0	0	0	1	650	3,051
-weden	0	0	0	3	375	1,431
Taiwan	0	0	0	1	320	2,769
Israel	0	0	0	11	55	550
Total	121	26,666	224,152	202	122,020	1,466,997
Wot Reported	23 vessels valued at $13,225 million and displacing 86,291 tons L- .					

-OURCE-: Forecast International/YN-, arships Forecast, N arch 2003; displacement information from Taler (2002 .

[10] Monetary values here and elsewhere in this report are in 2003 dollars.

Thus, the shipbuilding industries of the United Kingdom and Germany are very different. The United Kingdom has maintained a larger military shipbuilding industry than Germany has but with almost no commercial ship industry, while Germany has maintained a solid commercial ship industry but a comparatively small military shipbuilding industry.

France

French commercial shipbuilding is erratic and small in scale compared with that of Germany but is far more substantial than the remaining UK commercial production (see Figure 2.9 and Table 2.3). A dip in the late 1980s coincided with the worldwide decline at that time, but the industry did not recover fully until the past few years. French commercial production is concentrated in a single shipyard, Chantiers de l'Atlantique, and almost entirely on cruise ships,

Figure 2.9
France's Commercial Industry Has Not Recovered as Well as Germany's

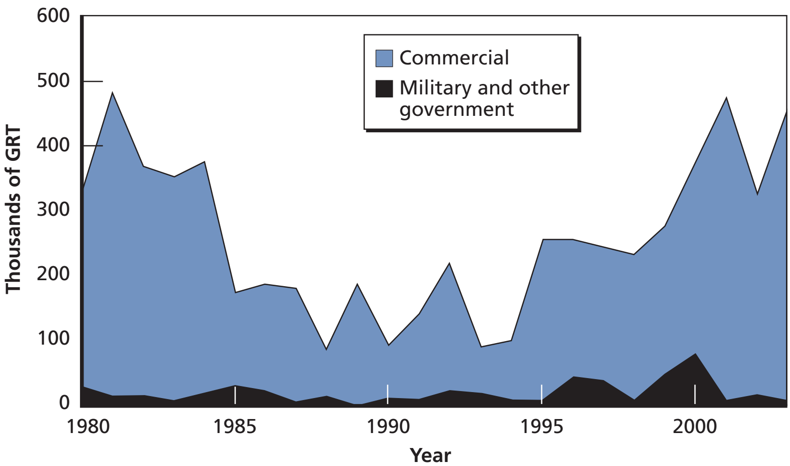

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Table 2.3
French Commercial Shipbuilding Order Book

Ship Name or Builder's Number	Type	GRT	Build Year
Queen Nary 2	Cruise	142,200	2003
Coral Princess	Cruise	88,000	2002
Island Princess	Cruise	88,000	2003
E32	Cruise	88,000	2005
F32	Cruise	88,000	2006
Crystal -erenity	Cruise	64,000	2003
K32	Cruise	58,600	2003
L32	Cruise	58,600	2004
N32	LWG tanker	49,700	2004
T32	Research	2,403	2002
Total		727,503	

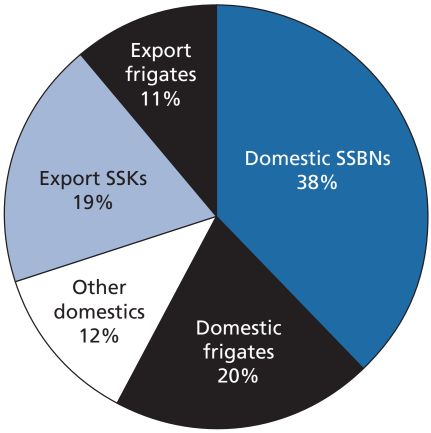
WOTE: All ships listed are built by Chantiers de l'Atlantique–-t. Wa aire.

the market for which has been depressed lately. It is likely to recover, however, and the growing LNG tanker market may also soon add to the French order book, which is currently less than half the size of Germany's.

Contrary to the impression given by the historical tonnage data in Figure 2.9, the greatest strength of current French shipbuilding, as measured by dollar value, is found in the military sector and, as can be seen in Figure 2.10, a substantial percentage of that is for export. In fact, France is among the largest of the European military shipbuilders, ranking second only to Germany in export production and far exceeding it in domestic military production (see Table 2.2).

The dollar equivalence of tonnage can be illustrated easily for the French industry. Typical cruise ships cost about $4,000 per GRT, and in 2003, a good year, the French output of such ships amounted to about 350,000 GRT. Thus, the French commercial market represents a potential of about $1.4 billion per year of business. France's military production, however, is forecast to average about $2 billion per year over the next decade.

Figure 2.10
A 10-Year Forecast of French Military Ship Production (by dollar value)



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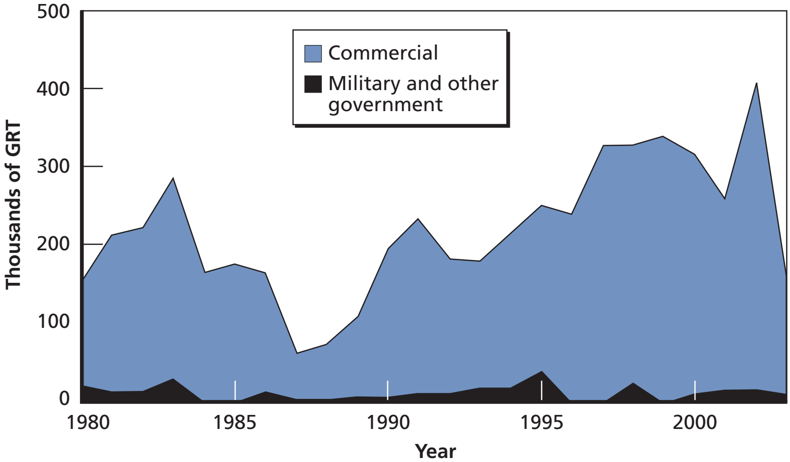
The Netherlands

The Netherlands sustains a substantial shipbuilding industry that produces at a rate of roughly a quarter to a third that of the German industry. As was the case with France, the Netherlands nearly lost its shipbuilding industry in the late 1980s but, in contrast to France, appears to have fully recovered in the 1990s, though it saw a sharp drop-off in sales in 2003 (see Figure 2.11). The Dutch market is now roughly where it was in the late 1970s. As in Germany, naval shipbuilding is a small percentage of the total.

As shown in the order book (see Appendix B), the Dutch industry concentrates on a large number of small vessels. While the German order book contains 48 vessels above 20,000 GRT, that for the Netherlands shows only two vessels above 20,000 GRT but twice as many as the Germans below 20,000 GRT.

Figure 2.11
The Dutch Shipbuilding Industry Has Been Overwhelmingly Commercial



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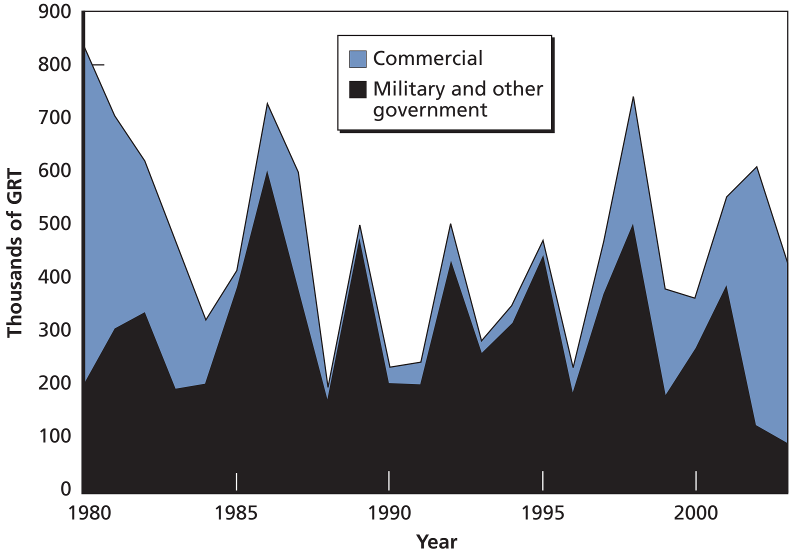
The Netherlands sustains a large number of shipyards (though one of the largest has recently closed). Naval ship production in the Netherlands is concentrated in a few yards that do little commercial production. The primary naval shipbuilder is Royal Schelde. The Rotterdam Dry Dock Company has produced some warships in recent years, although it has no current or forecast order book.

United States

We show the United States' situation in Figure 2.12.[11] It is superficially comparable to that of the United Kingdom because the United States was also once a major competitive shipbuilder but is no longer. However, there are fundamental differences. In the United

[11] The spikes appearing every three or four years in the US military output represent individual aircraft carriers on top of a steady undercurrent of smaller-scale military ship production. Military ship data are from Colton Company (2002); merchant ship data are from Lloyd's Register of Ships, October 2002.

Figure 2.12
US Commercial Ship Production Has Declined but Still Exists



RAND *MG236-2.12*

States, military shipbuilding emerged as the leading sector around 1980, whereas in the United Kingdom, it has come to dominate only within the past several years. Also, in contrast to the situation in the United Kingdom, significant commercial ship production activity remains in the United States (compare Figure 2.12 with Figure 2.6).[12]

The US commercial shipbuilding order book currently stands at about 1.4 million GRT (see Appendix B). While approaching the German order book in size, the US order book is the result of national policy, not competition. The 'Jones Act' requires ships trading at two or more US ports in series be built and flagged in the

[12] Data are from Lloyd's Register of Ships, January 2003, and include all commercial ships built (even those that have been retired) or on order. The military data are supplemented with information on naval auxiliaries from the US Maritime Administration.

United States and crewed by US citizens.[13] Large Jones Act ships, such as tankers, are built at one of two yards (NASSCO [National Steel and Shipbuilding Company] and Avondale) that also sustain the facilities and labour to produce military auxiliary and sealift ships. Prices for such vessels are strikingly higher than for comparable vessels on the international market. For example, several crude oil tankers built recently in the United States cost more than three times as much as comparable tankers built at the same time in foreign shipyards.[14]

The meaning of the Jones Act 'fleet' is sometimes unclear. The number of Jones Act self-propelled vessels in cabotage is quite small, numbering around 130 ships, including several dozen that operate on the Great Lakes. However, the Jones Act also applies to barges and barge push-pull boats that serve the many US coastal ports and the inland water system of the Mississippi River Basin. Barges and push-pull boats number in the tens of thousands and are sometimes included within the Jones Act fleet.

In sum, then, the United States has had about 20 years to reconcile itself to the fact that warships dominate the national shipbuilding market.[15] Consolidation among the yards, adjustments to shipbuilding schedules, assignment of ships to certain yards, trading of ship construction contracts among some of the yards, and other forms of accommodation to this reality have emerged. These adaptations, plus the sheer size of the US government's shipbuilding needs, have allowed sustainment of an acceptable shipbuilding industry for government requirements. To keep the commercial sector of that industry going, though, the United States has had to pay very high prices for vessels relative to those on the world market.

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[13] The Merchant Marine Act of 1920 is commonly referred to as the Jones Act after its chief sponsor in the US Congress, Senator Wesley E. Jones. It is the most recent law of its type, but such restrictions date back to the postrevolutionary 'Navigation Acts'.

[14] Data supplied by Deltamarin, from *Fairplay 5olutions*.

[15] Figure 2.12 shows this is true through 2001 in terms of tonnage. It is still true in terms of dollar value because, as is demonstrated in the next chapter, the construction cost per ton for military ships is a huge multiple of that for commercial ships.

Conclusions

Most of the nations discussed above, including the United Kingdom, maintain notable military shipbuilding programmes, largely for domestic use. In Germany and France, a large export component exists as well. The commercial shipbuilding pattern varies substantially across countries. Germany and the Netherlands maintain (with some very recent difficulties) internationally competitive industries building a wide variety of vessels that are small and specialised relative to the behemoths built in Asian yards. The French commercial industry resides in one shipyard that builds one type of ship (cruise ships) almost exclusively. And the commercial industry in the United Kingdom has completely evaporated over the past 20 years.

Other European countries follow one of these patterns but with unique variations. Italy, for example, has an active large order book like Germany's, but its major yard, Fincantieri, is government owned. Spain still has a significant commercial shipbuilding industry, but it is entirely owned by the Spanish government, which is under direction from the European Union to privatise it as soon as possible.

CHAPTER THREE

How Military and Commercial Shipbuilding Differ

In Chapters Four and Five, we will assess the United Kingdom's prospects in the commercial and military ship export markets. In those discussions, it will be useful to draw on an understanding of the differences between commercial and military ships and shipbuilding. In this chapter, we identify and elaborate on those differences. We compare and contrast commercial and military shipbuilding along the following dimensions:

- ship size and complexity
- contracting
- design
- production
- workforce demand
- client involvement
- business models.

In the following sections, for convenience, we will discuss 'military' ships versus 'commercial' ships, but it should be kept in mind that these categories overlap along most of the dimensions just listed. It cannot be said, for instance, that all military ships are more complex than all commercial ships. At one end of the spectrum are aircraft carriers, other surface combatants, and submarines, which are extraordinarily dense with large engines and high-technology systems and which are manned by large crews. At the other end are commodity carriers such as oil tankers and bulk carriers, which are essentially large steel boxes with relatively small engines at the rear and which are manned by one- or two-dozen mariners. The differences diminish when comparing military amphibious warfare and auxiliary vessels (oilers, supply ships, landing ships, etc.) and a few types of complex commercial vessels such as large research vessels, pipe layers, and LNG carriers. The less complex military vessels have many similarities to their complex commercial brethren with regard to high technology and technology density and are often built and tested to similar standards. These similarities between some subsets of military and commercial vessels should be kept in mind throughout the following discussion. In fact, we break out military auxiliary ships as a separate category.

Ship Size and Complexity

With a few exceptions (e.g., aircraft carriers), the physical dimensions and weight of warships are much smaller than those of modern merchant ships. Warships Forecast's 10-year military outlook averages to 5,137 LSW per ship, or, by the rough conversion factor we introduce in Appendix A, 10,274 GRT.[1] Lloyd's January 2003 commercial order book averaged to 32,553 GRT.

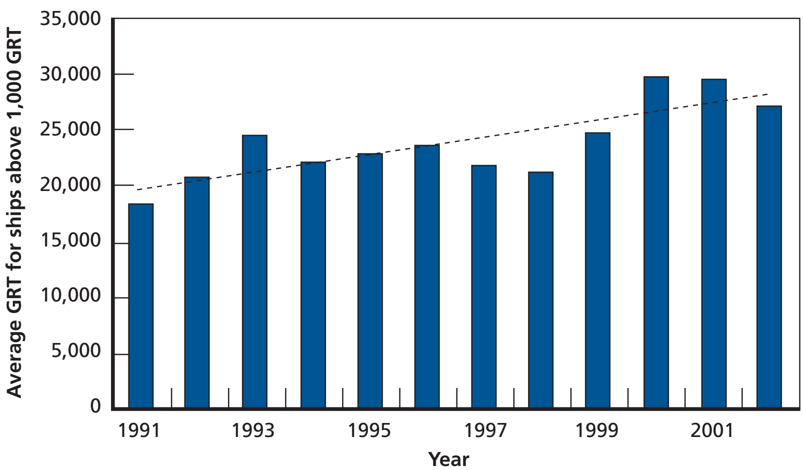
Hidden in that comparison is the fact that much of the commercial market is for truly huge ships. There are 62 ordered commercial ships measuring 150,000 GRT or more, whereas the largest ships on the European military forecast are the UK Future Aircraft Carriers (CVFs), which may displace about 60,000 tons LSW, or 120,000 GRT, and there will be only two of them. The recently built large UK replenishment oiler, HMS *Wave Knight*, is at 23,294 GRT, much smaller than the large commercial cargo-carrying ships. In fact, about 60 percent of the current commercial order book will carry more cargo than the *Wave Knight*.

[1] See Appendix A for caveats to the usage of this factor.

Commercial ships are larger than military ships—and they have been getting even bigger (see Figure 3.1[2]). Builders of modern merchant ships are under extraordinary pressure to hold down construction cost. Shipping is historically a small-margin business: 3 percent on the gross is a good return. Therefore, the cost of a new ship is a very important consideration to a ship owner. One possible response is to build larger ships, which cost less per ton to build and which deliver their goods for less cost per ton.

As a result, commercial ships have been increasing in size during the 1990s by about 2.7 percent per year, continuing a trend seen since the end of World War II. Some analysts believe that over the next few years, the need for more shipping capacity will be met by larger ships alone, not a combination of more and larger ships as in

Figure 3.1
Commercial Ships Are Growing in Size



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[2] From Lloyd's Register of Ships, January 2003.

the past. Such a trend could be realised so long as ship design, construction, and propulsion and port technology permit. If realised, this trend would put still more pressure on builders for better efficiency and more timely delivery because of the larger individual investments required by owners to procure the larger ships.

The sheer physical size of many ships on the commercial order book limits the yards that can build them. Of course, there are still hundreds of ships on the order book that would easily fit in smaller yards.

Although warships tend to be smaller than commercial ships, they are much more complex. Most commercial ships are essentially very large steel boxes with relatively small engines and small crews, sufficient only to move the ship from port to port but nothing else.[3] Warships, conversely, are compact and outfitted with complex sensors, weapons, and communication and power distribution systems (often in duplicate). This array of systems reflects the multiplicity of a warship's functions, as opposed to the single functionality (typically transport) of many commercial vessels. For example, a commercial ship needs a radar system only for navigation; a warship, however, requires such a system not only for navigation but also for detecting threats and engaging them. Military ships have complex hotel systems to serve a crew that may number in the hundreds or thousands of people, and many have structural features to enhance performance and survivability.

An important ramification of warships' complexity is that they are far more expensive to build than commercial ships. A rough sense of this effect can be gained from the data in Chapter Two. We cite a current commercial order book of 83 million GRT and $38 billion, or about $460 per GRT. We also tally the 10-year military-ship production forecast at 1.78 million LSW tons and $162 billion (Table 2.2), or $91,000 per LSW ton, which we take as equivalent to $46,000 per GRT. This amount is 100 times the commercial cost per unit of volume.

[3] Important exceptions include passenger ships and various small vessels such as tugs.

Such a comparison is dependent on the mix of ships in the order pipeline or forecast. Further insight may be obtained by comparing specific ship types. Because most of our information is on military ships, we here convert commercial ships to LSW.[4] (See Appendix A for further information on this conversion.) The resulting values are approximate but sufficient to illustrate the gulf between the costs of warships and commercial ships (see Table 3.1).

Clearly, warships are much more expensive to build per LSW ton than are commercial ships. Among commercial ships, only cruise ships come close in price per ton to the least expensive warship: a small, lightly armed MEKO[5] A-100 patrol craft. Note also the high price of the United States' Jones Act crude oil tanker, illustrating the noncompetitiveness of US commercial shipbuilding on the world market.

The gap in price between commercial ships and warships has been widening over the past two decades. The trend in prices for commercial ships has been downwards by 30 to 50 percent during this period because of fierce international competition and the increased shipyard productivity that competition has motivated. In today's world-class shipyards, a commercial ship takes half the man-hours to build that it took 20 years ago. The warship price trend, however, has been upwards by as much as 10 percent per year. Some of this inflation is a result of better and more expensive weapon systems, but competition for commercial contracts has also been more vigorous than that for naval contracts and promotes productivity.

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[4] Cruise ship cost is taken from 'Designing Cost Efficient Cruise Ships', Martin Landtman, Kvaerner-Masa Yards, undated. Container ship and bulk carrier costs are synthesised from data available in Lloyd's Register of Ships, January 2003, and cost data from the journal *Lloyd's 5hip V anager*, January/February 2003. Military ship costs are from Forecast International's Warships Forecast, March 2003.

[5] MEKO is short for Mehrzweck Kombination, a system for building ships in containerised modules.

Table 3.1
Comparison of Military and Commercial Ship Cost

		Average Cost per LSW Ton ($)
Military		
--K	Type 212A (German Wavy	346,667
	Type 214 (export	323,529
	-corpene (export	141,379
	Type 209 1400 (export	103,164
SSN	*Virginia* class	250,000
	Astute	184,615
Aircraft carriers	WASP LHD	69,767
	CVN 77	67,004
Destroyers	DDG 51 class	167,644
	Project 093 (Chinese)	153,846
	Type 45	141,343
	Project Horizon	122,000
Frigates and corvettes	Multimission Frigate (French Navy)	70,833
	MEKO ANZAK	100,156
	La Fayette (export)	122,807
Patrol	UK OPV for Brunei	216,667
	MEKO A-100 (export)	17,625
Commercial		
World Market	Cruise ship	10,000
	Chemical product tanker (small)	2,838
	Container ship	3,100
	Oil product carrier	1,630
	Bulk carrier (small)	1,259
	Bulk carrier (medium)	884
	Crude oil tanker (medium)	2,203
United States	Jones Act crude oil tanker (medium)	6,925

Contracting

About 80 percent of the cross-national sample of shipbuilders responding to our survey said that there was a difference between the types of contracts used by their military and commercial customers. As the firms pointed out, each contract has unique aspects; however, the commercial contracts are typically simple. They almost always entail a firm fixed price with payments made at a few fixed milestones, usually contract signing, start of fabrication, keel laying, launching, and delivery. Commercial contracts require penalties for late delivery. In addition, they are very competitive and leave little scope for changes, including price revisions.

Government customers are viewed as more understanding of delays, especially if there is a reason beyond the shipyard's control (as is often the case; see the discussions of contract changes and client involvement below). Generally, though, government contracts in Europe, including the United Kingdom, tend to be structured similarly to commercial contracts, with an emphasis on firm fixed prices. This structure varies somewhat from the United States, where the government relies more on incentives to induce shipbuilders to meet the schedule and budget. Even given a firm fixed price, however, European governments seek further means to insure themselves against the risk inherent when competition is limited or nonexistent; among these means are pricing conditions, profit formulas, and profit-sharing arrangements. Overall, contracting with a navy customer is much more complex than with a commercial customer, as is evident from the stack of documents that accompanies a solicitation.

With one exception, all the firms that responded to our survey indicated that contracting with military customers is more time consuming and requires more personnel resources than contracting with commercial customers. The principal reason for this disparity is that, although governments claim to have adopted best commercial practices, in reality they have not streamlined their processes.[6] For example:

- Large numbers of government personnel attend contractual meetings.
- A large number of government specialists are dedicated to each topic, whereas in the commercial world, personnel tend to be multidisciplined.
- Government bureaucratic procedures are more time consuming than the procedures of commercial firms.
- Government contracting is slowed by detailed technical specification definition, detailed joint cost analysis, and the government approval process.
- In work for the government, more documentation is required than for commercial transactions.

The fact that warships are more complex than commercial ships also contributes to the length and expense of contracting for government customers.

Survey responses indicated that contracting for military auxiliary ships was more commercial-like than contracting for warships. Three of five yards with experience in warships and military auxiliaries indicated that contracting for warships was more time consuming than contracting for auxiliaries, although three of five replied that it did not require more personnel resources.

Firms reported that because warships are more complex and cost more than military auxiliaries, demands for information from the government are greater, more rigid procedures must be followed, and navies take longer to make decisions and stabilise technical requirements. It is for these reasons that, on average, contracting takes longer

[6] An example is the construction of HMS *Ocean* and *Sea Launch Commander* at the Govan Shipyard. Both vessels are of a similar size, complexity, and value, but *Ocean* took twice as long to design, build, and commission as *Sea Launch Commander*, despite the fact that *Sea Launch* was a multinational project involving companies in the United States, Russia, Ukraine, Norway, and the United Kingdom.

and requires more personnel for warships. However, some firms noted that, although fewer personnel are involved in customer interaction for auxiliary ships, this limited interaction is offset by greater involvement by external customer support groups—banks, legal firms, etc.

Design

All the firms we interviewed agreed that, although military-commercial cost and time comparisons are highly dependent on ship types and equipment lists involved, military-ship design was more time consuming. It can take two years or more to design a military ship compared with six months for a commercial ship. Predesign work on a frigate or submarine can amount to 10 times that needed for a tanker. Developing the requirements set is more challenging for a warship—for which multiple functionalities need to be considered to meet an uncertain threat—than for a tanker, which is intended to profitably transport a fluid product of some type.

This disparity in design effort occurs for several reasons. Warships often have relatively large propulsion systems for the space available to accommodate them, and their electrical systems must be capable of greater loads. Weapon and sensor systems must be planned, and the number and placement of such heavy systems must be addressed to ensure that the ship's centre of gravity is not too high.

Partly as a result of such differences, the standards that must be met vary. Each commercial ship or group of identical such ships has a specification written for it that forms the basis of the contract. These specifications are simple documents that normally call out the essential features of the ship and the equipment to be used. Commercial ships can be built with materials that are standard across a variety of ships and that require little, if any, modification by the vendor, thus reducing the design time frame and material lead times. Some original engineering is, of course, involved, but the features of the ship that require in-depth analyses (abnormally large openings, major foundations, etc.) are far fewer than for a combatant.

Warships must meet numerous standards relating to the ship's greater complexity and multifunctionality. New classes of combatants are heavily engineered to reduce weight and to maximise available payload and space. For example, warships are typically designed with thinner plating and more numerous changes in plate thickness than would be found on any commercial vessel. The extra expense required for doing the same on a commercial vessel cannot be justified.

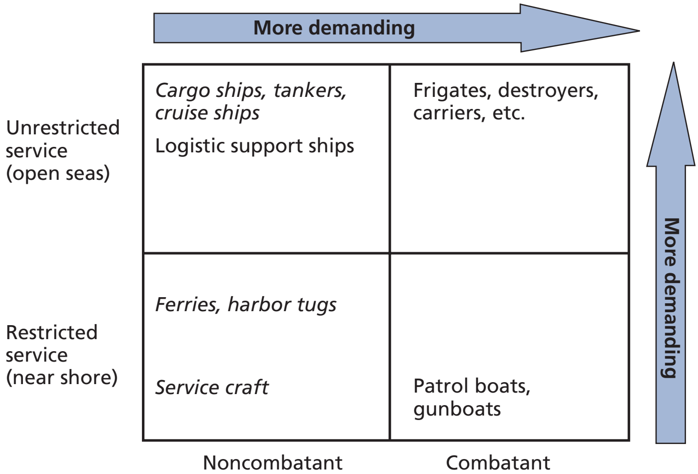
Many reviews and revisions to a military ship's design are typically made prior to the start of construction. Usually, contracts for long-lead-time materials have to be awarded during design to keep the build time from reaching unacceptable lengths.

Military ships must also meet more demanding standards because they operate not only on the open seas but also in combat zones (see Figure 3.2, which classifies ship types according to both open-sea service and combat demands). Many military ships thus have specifications for structure and shock; nuclear, biological, and chemical protection; signature; fire fighting; damage control; and weapon storage and movement. Furthermore, all such aspects of ship design must be integrated with weapon and sensor systems that commercial ships lack.

Differences in complexity between military and commercial ships thus give rise to differences in design effort. More broadly, the Royal Navy is engaged in a technological competition with adversary navies, thus involving the need to be responsive to evolving requirements and technological opportunities. Shipbuilders thus have to be patient and responsive to work this market successfully. Furthermore, although more development work is required for a warship design, the customer is typically willing to pay for most, if not all, of that development and allow time to get the job done right. Most work supporting the development of new commercial designs must be funded by the shipbuilder.

The need for interaction among a number of stakeholders also drives up military design time. It is often the case that, when a shipyard works for a commercial owner, it may be interacting with as few

Figure 3.2
Military Ships Must Be Designed for Open Seas *and* Combat Duty



SOURCE: US Naval Sea Systems Command.
NOTE: Commercial ships are in italics.
RAND *MG236-3.2*

as three people, partly because the project may well be just a modification of a previous design. Typically, a commercial owner's representatives have the responsibility and authority to make all decisions regarding their project. This is less likely to be the case when working with the MOD's Defence Procurement Agency, where significantly more people are involved.

Inevitably, the greater the number of people involved, the greater the problems of communication and the less defined the responsibilities and authority for decisionmaking. This is exacerbated by the tendency of the government to fragment authority. Differences may have to be worked out between the Integrated Project Team and naval authorities that must approve specific elements such as ship handling or magazines; sometimes differences *within* the authorities may have to be worked out. All this places a significantly greater demand on resources and time for ship definition.

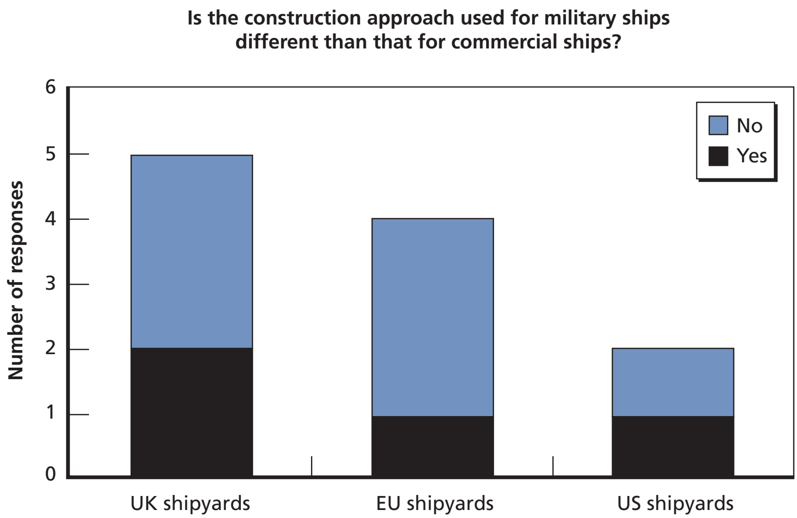
Again, military auxiliaries occupy a middle ground. Shipbuilders responding to our survey unanimously agreed that warship design was generally more time consuming and specification driven than auxiliary design. Specifying the cost and time differentials is difficult because all ship designs and requirements are unique, depending on the type and role of the ship. At the design stage, 20–60 percent more design time might be expended for a warship than a military auxiliary ship, again depending on the types and roles of the ships. At the detail stage, 20 percent more design time could be required. For simple auxiliary vessels such as tankers and roll-on/roll-off (RORO) ships, standards and specifications are similar to those in the commercial world and therefore quite different from those for constructing a frigate, for example. However, when constructing an auxiliary vessel to carry munitions and other dangerous cargoes, there are additional military standards and design requirements, although not equivalent to those required for a front-line warship. In the United Kingdom, for example, naval auxiliaries must meet standards set by the Department of Trade and Industry and the Maritime Coastguard Agency.

Although our comments here are based on experience with the current auxiliary fleet, they are likely to prevail for the upcoming Military Afloat Reach and Sustainability (MARS) ships, which are still in conceptual design. These ships are intended to replace the current auxiliary tankers, replenishment oilers (AORs), and fleet support ships (AFSHs). Most likely, MARS ships will have many commercial-ship characteristics but will be capable of afloat commodity transfer; will carry ammunition, so magazine protection will be important; and will have some self-defence capability. MARS ships will also carry helicopters for inter-ship goods transfer and insertion and support of commandos ashore. Thus, as with other auxiliary ships, design challenges will apparently be intermediate between those associated with commercial ships and those associated with warships.

Production

There was not unanimity among respondents to our shipbuilder survey regarding the difference between the construction approaches used for military and commercial ships (see Figure 3.3). Most responded that the general approach did not differ.[7] In some cases, the response reflected whether the yard had experience with warships ('yes' = 'different') or military auxiliaries ('no'). However, the 'no' conclusion was buttressed by yards that had built both warships and commercial-like military auxiliaries, which responded that these two ship types did not differ much in general construction *approach* (except for their integration and testing).

Figure 3.3
No Broad Consensus on Similarity of Construction Between Military and Commercial Ships



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[7] While the approaches taken do not differ, the labour forces deployed do. See 'Workforce Demand' below.

Despite the sense that military and commercial ship construction do not differ in the general approach taken, shipbuilders also conveyed to us a number of specific differences, especially where warships are concerned. There is, for example, the perception that Navy ships are constructed to higher standards of quality, though that gap may be closing. The difference in quality may be partly related to the attention to detail required in military ships, which, as mentioned above, are denser with systems requiring installation and integration. The internal complexity also warrants more sophisticated construction planning, especially considering the potential for change and the fact that construction requirements can differ significantly by class, sometimes even by hull within a class. In commercial yards, the tasks are more routinised and the emphasis is on construction productivity, because maximising net revenue requires maximising throughput, given the small profit margins prevailing in the commercial sector. With these considerations in mind, it should not be surprising that commercial ships are often built much more quickly than military ships. Commercial shipbuilders are accustomed to spending perhaps nine months to finish a ship of substantial size, whereas it could take three years or more for a military yard to get a ship out.

The materials used in warship production are typically lighter in weight to allow for more speed. The lightness requires the use of more construction jigs and fixtures than is typical for commercial production, together with differences in welding and greater use of unit erection approaches.

One aspect of production does not appear to differ consistently between commercial and military shipbuilding: outsourcing. In the European Union as a whole, for example, shipbuilders concentrate on steel fabrication and rely on subcontractors for most other shipbuilding functions. This generalization applies for both shipyards that build military ships and those that build commercial ships (Schank et al., forthcoming).

There are two other areas in which production-phase requirements, if not construction itself, differ markedly between military and commercial shipbuilding: security and quality control (including testing). These differences warrant some elaboration.

Security

More than 80 percent of the firms responding to our survey asserted that military projects demand a higher level of security to prevent unauthorised access to the ships and any information, material, or equipment that is at the site. The latter includes weapons, ammunition, secure communications links, and encryption equipment, as well as layouts that might give potential enemies key data with which to attack the craft and disable it. Because of these concerns, all personnel granted access to the site require clearance.

Firms finding little security difference between military and commercial projects primarily construct auxiliary vessels. They pointed out that commercial owners also have concerns about the loss of sensitive information. This near-equation of military auxiliary and commercial projects was consistent with the view expressed by all respondents that warships and auxiliaries differ substantially in the level of security required during construction. Even if security concerns are somewhat higher during the construction of auxiliaries than of commercial ships, it is not nearly as great as the difference between warships and auxiliaries because of the distinctive characteristics of warships mentioned above. Also, security requirements in auxiliary construction tend to be ship- or warehouse-specific rather than applicable to the entire site.

Quality Control

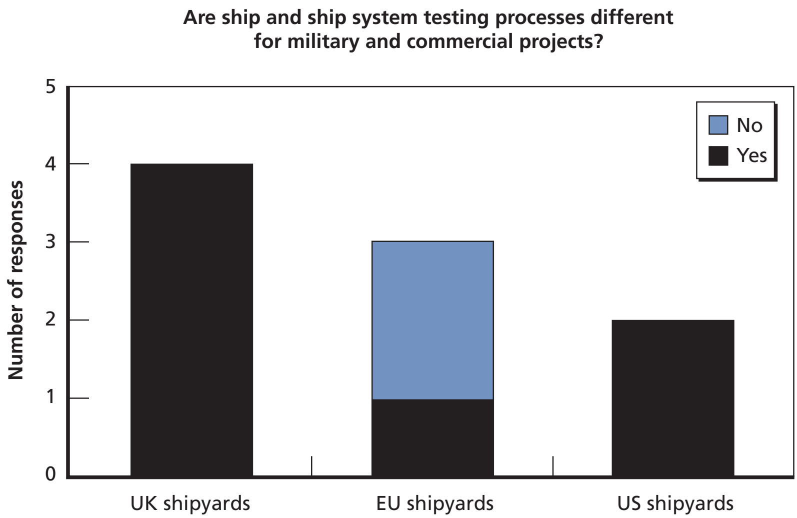
Naval military standards are, understandably, much more onerous than civilian standards and in many cases involve more exotic materials whose life histories must be documented. Quality control is more rigorous in military shipbuilding than in commercial for reasons largely given already: the need to maximise ship life and survivability, provide for crew safety in a challenging work environment, control damage in the event of system failure or attack, and minimise maintenance time. As a result, more materials must be certified as meeting a standard, e.g., shock resistance, than is the case in commercial shipbuilding. Some materials must have a traceable 'pedigree' so that manufacturing practices can be verified back through the supply chain if necessary. Because of the complexities of the issues involved in manufacturing speciality components for naval vessels, the base of suppliers has contracted. Finding and verifying quality materials place a greater burden on the shipyard's purchasing, receipt, and inspection staffs than would be the case for a commercial project.

For commercial ships of the most common types (i.e., tankers, bulk cargo carriers, and container ships), builders utilise off-the-shelf components from established marine manufacturers; prices and availability are reliable. The standards to which the components must be built are set by the regulatory body of the flag state and the classification society and are well known and typically involve widely available materials.

Testing. While the use of exotic materials and thin plates, among other things, requires more extensive training and more comprehensive inspections during construction, it is at the end of the construction phase, during testing, when military shipbuilding differs most from commercial. The great majority of our survey respondents agreed that commercial and military shipbuilding differ in testing requirements (see Figure 3.4). On military vessels, there is a greater requirement for testing and commissioning of systems prior to delivery of the vessel, although the degree of difference is dependent on the ship type. This greater emphasis on testing in military construction is a reflection of two factors:

- There is more nonstandard or specially developed equipment, including weapons and more-sophisticated electronics, on military vessels than on commercial vessels, leading the customer to want assurance that all these systems will work together before accepting the ship into service.
- On military ships, there is usually multiagency involvement, which requires a greater level of paperwork and bureaucracy.

Figure 3.4
Military and Commercial Shipbuilding Vary in the Testing Required



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The first of these two factors is particularly important. For example, electromagnetic interference is disproportionately high on warships and can compromise sensitive equipment that is often state of the art or at the forefront of technology. The testing routine for such interference is thus often much more involved and lengthy than on commercial ships. The potential for radiation hazards from aerials is disproportionately high, and they must be checked for. Military communication systems require extensive testing to verify security.

Testing and acceptance *processes* are fundamentally the same across military and commercial ships. The differences occur in the following areas:

- *Scope of testing and trials, i.e., whether they are at the component, equipment, or full system level.* Military projects, including auxiliary ships, require test and verification procedures for every component of the ship. However, for auxiliaries that have fewer

components to test—e.g., fewer weapon systems and sophisticated sensors—the testing goes more quickly.
- *Test specifications, including safety, quality, and environmental standards.* Military testing and acceptance criteria are more detailed than commercial. Military projects have been slow to move away from rigid adherence to design standard testing. Currently, commercial projects are relying more on in-service or functional testing.
- *Inspection, acceptance, and certification authorities.* Military-commercial differences among these authorities lead to varying acceptance processes, criteria, and standards. Customer oversight and witnessing requirements are much greater for military contracts than for commercial projects.
- *Test documentation.* Military projects tend to be prescriptive with volumes of test procedures approved for use by an all-party test authorisation group. Commercial practice is based on certification and capability demonstration.

The focus of testing differs between military and commercial ships, because with a military ship, maintenance of combat capability is the priority, whereas with a commercial ship, the safety of the civilian crew takes precedence. When a project involves in-service passengers, there are further major differences in test requirements and class certification. That said, military inspection authorities require a high level of confidence that the ship is safe and all risks are as low as reasonably practical.

Sea Trials. There was consensus among survey respondents that military and commercial ships differ in the extent of sea trials required. Sea trials of military ships often cover all aspects of manoeuvring, endurance, ship handling, machinery space operation, and weapon and sensor testing and operation. Such trials are carried out as an activity separate from testing, prior to a final demonstration after rectification of defects. The entire testing, commissioning, and acceptance process can take up to a year—sometimes even longer—and can often involve other warships and aircraft.

Commercial vessels typically undergo a single sea trial, usually conducted by the shipbuilder. It is generally less complex than that for a military vessel and requires very little in expensive assets (e.g., ranging facilities, aircraft, and other vessels) to complete. Final testing and commissioning can occur in a matter of weeks; commercial ships can sometimes even be tested on their delivery voyages.

The primary reason for these differences is, again, that warships are more complex. A merchant ship is not designed to enter combat, so it has no weapon systems and has only navigation-related sensor systems. It is not subject to combat survivability testing for shock and vibration, and there are no detection issues.

In the complexity and rigour of sea trials and acceptance, military auxiliaries fall somewhere between warships and commercial ships. Auxiliaries often go through all the same procedures as a warship, but for those more commercial-like in character, the time and effort involved can be much less than for a warship, because not as many systems need be demonstrated.

Workforce Demand

As might be expected from the big differences in cost per ton between warships and commercial ships, warship construction is much more labour-intensive than commercial.

Figure 3.5 compares the labour expended in building a warship with that required to build a large bulk carrier.[8] In every category of work, the military ship required many times the labour required by the commercial ship.

Moreover, the types of skills needed vary considerably between the two types of shipbuilding (see Figure 3.6). Only about 30 percent of the effort on a military ship goes into the hull, whereas the hull accounts for half the effort on a bulk carrier.

[8] Both estimates are for construction in the United States, first ship of a class.

Figure 3.5
Military Ship Construction Requires a Much Larger Workforce

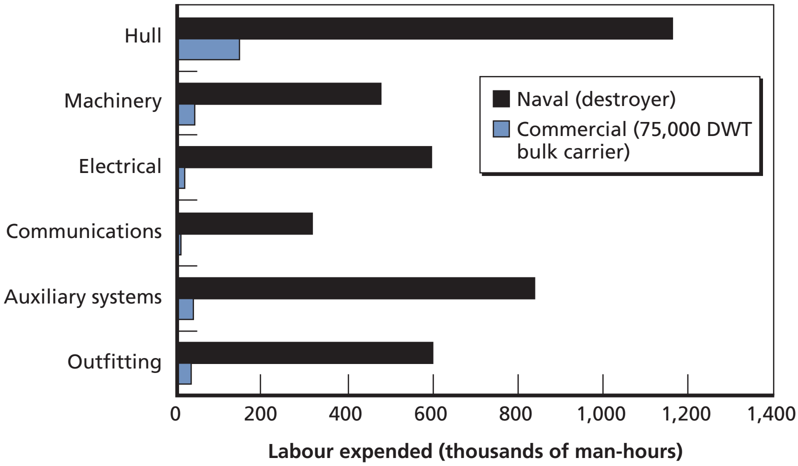

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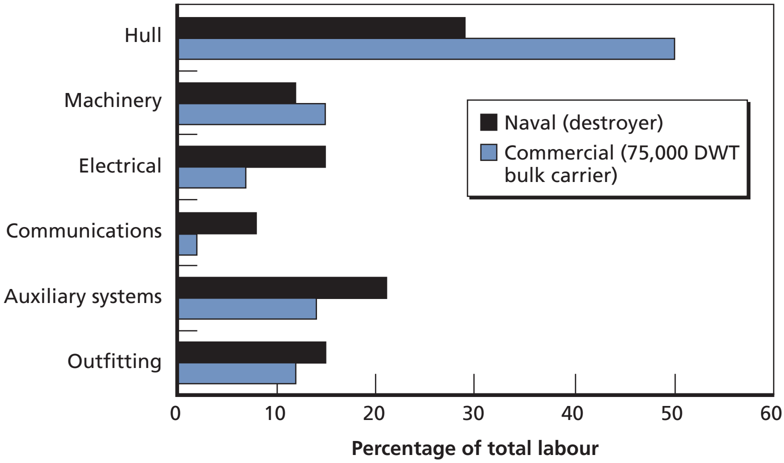
Figure 3.6
A Greater Percentage of Commercial Shipbuilding Labour Is Expended on the Hull

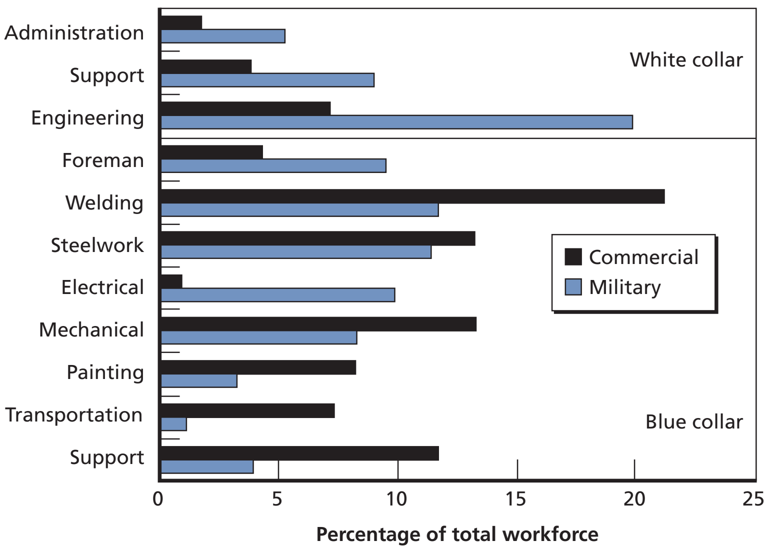


RAND *MG236-3.6*

Another way of looking at the skill differences between military and commercial shipbuilding is to examine the nature of the workforce at any given time for yards specialising in one or the other type of ship. Figure 3.7 compares the skill makeup of UK military and commercial specialist yards.[9]

The difference in the ratio of white- to blue-collar workers is particularly noteworthy: In the commercial yards, it is about 1:6, whereas in the military construction yards, it is about 1:1.7. There are several reasons for the differences in these ratios (most of them are mentioned throughout this chapter). Briefly, however, the government customer places a greater emphasis on milestones and contract

Figure 3.7
Distribution of Skills Available Differs Between Commercial and Military Construction Yards



RAND *MG236-3.7*

[9] The data shown are provided by the yards, although we have made some adjustments in an attempt to enforce consistency.

compliance; on quality control, including testing; and on project planning, management, and reporting. Thus, for a military yard, more engineering and other professional support is required than would be the case for a commercial yard, and overhead is also higher—at least 175 percent, versus no more than 100 percent for a commercial shipbuilder.

Other differences of interest in Figure 3.7 include the following:

- The ratio of foremen (blue-collar supervisors) to workers is about 1:20 at the commercial yards versus about 1:6 at the military yards. Apparently, the complexity of military ship construction requires more waterfront supervision.
- The data do not show as great a divergence in the steel fabrication trades between commercial and military yards as would be expected from the difference in allocation of work to the hull (compare Figures 3.6 and 3.7). About 57 percent of the commercial yard blue-collar workers are involved in steel fabrication, welding, and mechanical work, versus about 49 percent at the military yards. However, the three UK commercial yards represented in Figure 3.7 are all builders of small and relatively complex commercial or naval auxiliary ships. None of these yards fabricates the large bulk carriers reflected in Figure 3.6.
- Commercial yards have a much lower proportion of electricians (about 1 percent of blue-collar workers) than do military yards (about 16 percent), due in part to the practice of outsourcing electrical work at the commercial yards and in part to the larger amount of electrical work needed in warships.

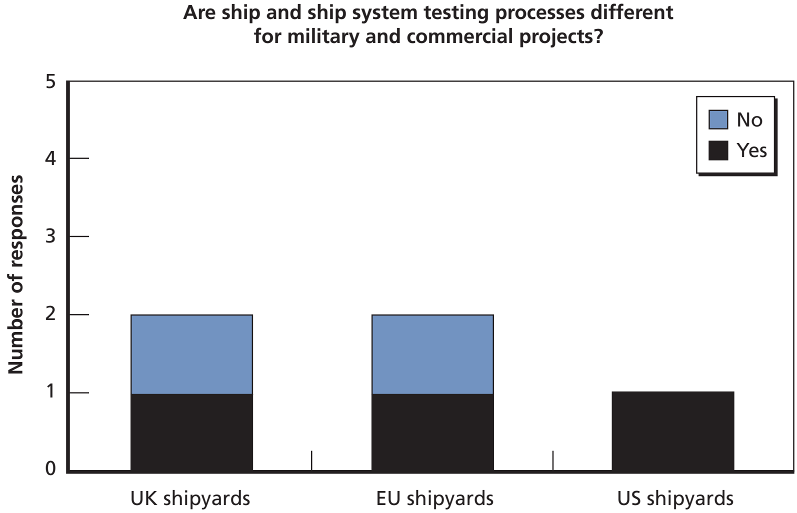
Our survey verified the differences in skill mix between military and commercial builders. The firms' responses to the relevant question again reflected the types of ships each constructs. Firms that primarily build surface combatants and submarines responded that the skill mix is different, whereas those that construct auxiliaries indicated the skill mix was similar.

Our interviewees made some observations that expanded on the lessons from the data above. They pointed out that military ship construction is more outfit-intensive than commercial ship construction, so military yards employ a greater percentage of outfitters than commercial yards do. Military projects require a greater number of people with skills related to weapons and to electronics and communication equipment, along with a knowledge of military standards. Technicians involved in weapon systems are not directly required on commercial craft, although their skills could be used, for example, on radio and radar systems. However, on commercial ships, any work required on such systems during construction tends to be done by the supplier as a result of purchase or support agreements or guarantee requirements. The requirements for greater quality control and testing also give rise to a different skill profile for blue-collar workers, as do the use of distinctive materials and the importance of shock and damage resistance and recovery.

Although there is strong evidence for a difference in skill mix between commercial and warship projects, it is less clear that military auxiliary and warship projects differ as strongly and consistently in their required skill mix. There was not a consensus among our survey respondents in this regard (see Figure 3.8). The mix of responses reflects the types of auxiliary ships with which the firms have had experience. Some auxiliary ships differ little from commercial ships, whereas others are armed and, like warships, must be able to go into harm's way. Even ships in the latter category, however, do not usually have the same sophisticated communications, sensors, and weapon systems as do warships. The need to install and integrate such systems is an important reason why warship construction can require a different skill mix, e.g., more electronics and testing personnel. The skill mix of workers on warship and auxiliary projects is similar for the construction of the vessel hull and the ship systems.

From the preceding discussion, it can be inferred that, if current UK military shipyards were to undertake major commercial projects, the workforce would have to change. For example, the white-collar workforce would be much too large for such a project and would lead to high, uncompetitive overhead costs. Conversely, if commercial yards were to undertake complex military projects, they may well

Figure 3.8
There Was Not a Strong Consensus as to Whether Warship and Auxiliary Construction Varies in the Skill Mix Required



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need more white-collar workers than they now have. Appledore, a commercial specialist, found that, in constructing Lloyd's-classed military survey vessels, the information demands of its government customer were much more than the firm was accustomed to and severely stressed its white-collar staff. Swan Hunter, essentially configured as a commercial yard, may be confronting a similar situation. Its white-collar staff already numbers the highest, as a proportion of total workforce, among the three commercial yards but is only about half the proportion in the military yards. Thus, Swan Hunter could come under pressure for more white-collar workers if customer demands escalate.

Client Involvement

In our interviews, shipyard personnel elaborated on the additional burdens imposed by their interaction with the government. The MOD is perceived as process- and procedure-driven, requiring progress reports of far greater scope and detail than a commercial customer would. Furthermore, questions posed by the contractor and issues requiring specialist attention take a long time to resolve. When decisions are made, they are subject to change. Different inspectors may interpret standards differently, leading to inconsistencies over the course of time or even rework. Changes can also result from turnover in the MOD staff. This process is in sharp contrast to work for the commercial sector, in which very few changes are typically requested by the owner once a contract has been signed.

Some shipbuilders also find MOD work more burdensome because the government is concerned with aspects of the business that a commercial customer is not. Cash flow is a big concern of the MOD, as is 'excess' profit; the government may even demand a share of the profit over some threshold. A commercial customer cares only that a quality product is delivered on time for the price agreed upon; how much of this price is realised as profit is irrelevant. Of course, a pattern of 'excess' is unlikely to be sustained in the face of competition, and indeed profits for MOD work can be higher than for commercial work.

Interaction with the customer is viewed as less onerous in the case of military auxiliaries than with warships. Decisions are often made by a local government superintendent, someone with a master engineering background, like a marine engineering officer on a warship. The overall mode of interaction is closer to that on a commercial product, although, as indicated above, there are significant differences between the quantity of information required by the MOD and that necessitated by commercial owners.

Business Models

A final point of difference between military and commercial shipbuilders is that, particularly in recent years, military shipbuilders have evolved towards a different type of business model. The great majority of shipyards have developed as independent companies and include small yards such as Appledore in the United Kingdom, Bollinger in the United States, and Hakata in Japan. They also include intermediate yards, such as the military specialist Vosper Thornycroft in the United Kingdom, and very large builders, such as the eight-yard conglomerate Fincantieri in Italy and the Japanese shipbuilder Imabari, whose four-year-old shipyard is the newest in Asia (Koenig, Narita, and Baba, 2001). Some yards (e.g., Appledore) are privately owned, whereas others (e.g., Fincantieri) are government owned.

Over the years, however, some successful military shipbuilders have begun to look less like traditional, independent shipyards and more like elements of high-technology defence production firms. BAE Systems in the United Kingdom and Northrop Grumman in the United States are representative of this model. Apparently, both these companies see in military shipbuilding, with its high-technology content, a natural alliance with their high-technology systems integration skills as well as a natural customer for products of some of their other divisions. Nearly all UK and US warships and auxiliaries are now built in such shipyards.[10] Practitioners of this model focus on military or military-like ships and rarely offer strictly commercial products. While the Avondale and Ingalls shipyards of Northrop Grumman also offer commercial ships, they do so largely because of the Jones Act. Thus, the fact that such an industry exists in the United States is a consequence of domestic policy rather than of a successful international business model. The high-technology model characterising the UK and US military shipbuilders is a relative new-

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[10] There are always exceptions. For example, Appledore Shipbuilders is finishing the construction of two hydrographic survey vessels for lease to the MOD, but they are being built under subcontract to Vosper Thornycroft, a military specialist.

comer. It remains to be seen whether, over the long haul, the management and organisational skills of high-technology defence-focused conglomerates match well with what is needed for shipbuilding. The latter remains a difficult heavy industrial task despite its high-technology content.

At the same time that this high-technology defence production military shipbuilding business model has been developing, other commercial builders have been departing from the traditional, independent model, though in a different direction. These builders have either been absorbed by or have been established as or grown into more generalised heavy industrial firms. Such builders include the shipbuilding arms of Kawasaki Heavy Industries in Japan, Hyundai Heavy Industries in Korea, and ThyssenKrupp in Germany. Kawasaki and Daewoo are also builders of products such as machine tools, industrial vehicles, and industrial engines. ThyssenKrupp builds a wide range of industrial products and manages two shipyards, Thyssen Noordsea and Blohm + Voss. The heavy industry model offers several advantages:

- There is the economy of scale for material acquisition. Material orders can be so large as to influence the provider, such as a steel mill, to produce materials that best fit the quality and dimension needs of the yards at favourable cost.
- There may be synergy among the trade and professional skills needed for heavy industrial activities, including shipbuilding.
- As with the high-technology model, shipbuilding may represent a customer for some of the parent companies' other divisions, such as producers of diesel engines.
- Heavy industrial production methods can be applied to shipbuilding to achieve efficiencies.
- The very large parent company may be better able to influence government policies in ways that are favourable to shipbuilding.

This model has been successfully applied in Korea and Japan to produce very large and simple ships such as crude-oil tankers and box carriers.[11] ThyssenKrupp uses the model for the construction of smaller, complex ships, including some warships. The heavy industrial model may be expanding in Europe. In 2000, the Spanish government formed a new company, Izar, from eight shipyards and allied industries formerly under the management of AESA and Bazan. In addition to ships, Izar produces diesel engines, steam turbines, and other products for marine as well as land applications. In some instances, however, Asian heavy industrial conglomerates are trying to make their shipbuilding operations more independent. In the case of Daewoo, the shipyard was recently set up as an independent shipbuilding-specialist company following the failure and split-up of its former corporate parent. In Japan, Kawasaki Heavy Industries and Ishikawajima-Harima Heavy Industries (IHI) reorganised their shipbuilding divisions effective October 2002. They set up their shipbuilders as subsidiary companies to gain managerial flexibility.

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[11] Drewry Shipping Consultants and Silberston (2001). Asian producers are not restricted to the simplest of ships. They deliver some complex products such as LNG tankers.

CHAPTER FOUR

The Potential for Re-Entering the Commercial Market

In this chapter, we assess the United Kingdom's prospects for re-entering the commercial shipbuilding market. We find these prospects to be limited by Asian dominance of the market as a whole and by EU dominance of the higher-value market segment. Not only would UK shipbuilders face strong competition in a market characterised by excess supply, but other challenges loom—e.g., the need to satisfy the demands of a very different class of customers. Nonetheless, the vagaries of the market could swing in the United Kingdom's favour, so we conclude by suggesting a path to re-enter the market and making clear the risks involved.

A Profile of the Competition

If the United Kingdom chooses to enter the commercial market, it faces a situation strongly dominated by two countries. As shown in Table 4.1 (some key data are also graphed in Figure 4.1), South Korea and Japan lead the industry.[1] Worldwide, South Korea leads in

[1] Taken from the Lloyd's Register of Ships, January 2003, the data in Table 4.1 reflect ships scheduled for delivery from the latter half of 2002 through 2007. (Almost all, however, are for delivery before 2006. The order book thus represents two-and-a-half to three years of commercial deliveries: all of 2003, perhaps all of 2004, parts of 2002 and 2005, and little bits of 2006 and 2007.)

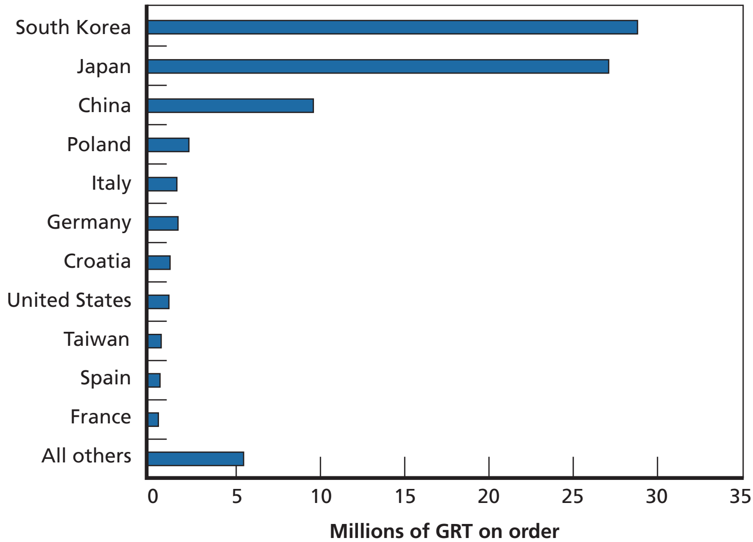
Table 4.1
World Commercial Shipbuilding Order Book, January 2003

		Greater Than 99 GRT		Greater Than 999 GRT	
Rank	Country	Number	Total GRT	Number	Total GRT
1	South Korea	504	28,763,329	493	28,759,769
2	Japan	646	27,110,720	617	27,096,703
3	China	420	9,816,473	394	9,808,050
4	Poland	116	2,475,701	91	2,465,057
5	Italy	93	1,863,884	60	1,848,303
6	Germany	88	1,842,374	86	1,841,771
7	Croatia	56	1,479,135	56	1,479,135
8	United States	156	1,375,515	96	1,353,253
9	Taiwan	26	911,067	20	907,765
10	Spain	129	886,690	42	851,964
11	France	15	729,055	10	727,503
12	Romania	99	676,678	86	673,707
13	Ukraine	55	557,773	51	556,161
14	The Philippines	20	520,820	17	520,400
15	The Netherlands	221	509,072	88	474,913
16	Finland	7	464,776	7	464,776
17	Brazil	36	450,183	30	446,455
18	Denmark	11	431,541	10	431,360
19	Singapore	47	411,214	23	402,159
20	Russia	84	352,662	61	341,568
21	Turkey	76	291,269	67	287,472
22	Bulgaria	17	168,098	17	168,098
23	Norway	43	133,206	30	126,974
24	India	47	118,048	19	105,596
25	United Kingdom	20	86,092	8	82,165
26	Indonesia	26	74,147	6	68,450
27	Portugal	18	61,491	6	57,720
28	Greece	7	56,243	5	56,000
29	Slovakia	20	54,487	20	54,487
30	Vietnam	11	50,972	9	49,799
31	Australia	38	34,789	5	18,660
32	Sweden	3	22,934	3	22,934
33	Argentina	4	20,009	2	19,585
34	Iran	13	18,948	5	16,386
35	Egypt	19	15,125	5	10,800
36	Yugoslavia	5	13,487	4	13,187
37	Malaysia	34	9,529	1	1,440
38	Canada	6	6,720	2	5,000
39	Peru	10	5,274	1	1,000
40	Czech Republic	3	5,254	3	5,254
41	Chile	7	4,431	1	2,664
42	Latvia	3	2,989	2	2,490
43	South Africa	6	2,944	1	1,200

Table 4.1—Continued

		Greater Than 99 GRT		Greater Than 999 GRT	
Rank	**Country**	**Number**	**Total GRT**	**Number**	**Total GRT**
44	Mexico	5	2,608	0	0
45	New Zealand	5	1,801	0	0
46	United Arab Emirates	3	1,513	0	0
47	Myanmar	1	1,094	1	1,094
48	Hong Kong (China)	2	1,014	0	0
49	Pakistan	2	580	0	0
50	Cuba	3	420	0	0
51	Fiji	1	154	0	0
	Not Reported	11	6,503	0	0
	Total	3,310	83,031,490	2,567	82,759,227

Figure 4.1
South Korea and Japan Dominate the Commercial Market



NOTE: The United Kingdom is 25th, with 0.09 million GRT.
RAND *MG236-4.1*

GRT and Japan produces the highest number of vessels. Among European shipbuilders, Poland produces the most tonnage, followed closely by Italy and Germany. Worldwide, the United Kingdom trails far behind these countries, in 25th place. In fact, the United Kingdom could triple its commercial tonnage production and still lag Turkey, which is in 21st place.

Competition by Region

While the worldwide data are of some interest in comparing the performance of national industries, shipbuilders do not really compete in an undifferentiated worldwide market. Rather, they specialise and compete for segments of the market. These segments are also dominated by one or two nations or regions.

To convey this market segmentation, we follow the Association of Western European Shipbuilders in dividing ship types into three groups based on their complexity:[2]

- **Group 1:** oil tankers, bulk carriers, and combination carriers
- **Group 2:** multipurpose ships, refrigerated cargo ships, container ships, RORO ships, car carriers, product and chemical tankers, liquefied petroleum gas (LPG) carriers, and LNG carriers.
- **Group 3:** ferries, passenger vessels, fishing vessels, and non-cargo vessels.

Table 4.2 shows the commercial ship production of Europe, Japan, and South Korea, as well as the world as a whole, for 1999, 2000, and 2001, broken down by compensated gross tonnage (CGT)[3] and value (in then-year dollars). The percentages shown are for value and, for the first three rows in each complexity group panel, their sum falls short of the world total by the percentage produced by

[2] Information on groups and group markets is from Drewry Shipping Consultants and Silberston (2001).

[3] CGT is a measure of ship size and complexity adjusted by ship type to reflect differences in value per ton. (See Appendix A for details.)

all nations other than those specified. For example, in 2001, Europe, Japan, and South Korea accounted for 87.9 percent (1.6, 54.3, and 32.0 percent, respectively) of global group 1 production, implying that all other areas accounted for 12.1 percent of world production. Percentages given in the 'world' rows are the proportion of world production represented by the given ship complexity group; i.e., they add up to the 100 percent at the bottom of each column. The regional percentages in the last column of the table are graphed in Figure 4.2, where the proportions produced by all nations outside of Europe, Japan, and South Korea are also shown.

The patterns shown in Table 4.2 and Figure 4.2 are the product of historical investment strategies. In the 1950s, shipbuilders in Japan began to focus their facilities, technology, and supporting contractors on the construction of group 1 ships. This concentration proved a good match with Japan's excellent organisational skills and heavy industries. South Korea followed suit, and China has more recently adopted the same practice. Japan and South Korea alone have now succeeded in capturing 86 percent of the group 1 market. It is noteworthy (see Figure 4.2) that South Korean yards have passed up the Japanese in product complexity, as reflected in their greater share of the group 2 market.

Asian firms were able to establish command of the market in building group 1 and 2 ships because, in large measure, their labour rates were so competitive. Commercial shipbuilding is a labour-intensive heavy industry. Labour accounts for about 25–35 percent of the cost of merchant shipbuilders' operations and around 65–70 percent of the value added at the shipyard (Koenig, 2002; Koenig, Narita, and Baba, 2003). Thus, labour cost is a critical competitive driver. Competitive total labour cost can be achieved via low unit labour cost (China), high productivity (Japan), or a middle position in both (Korea).

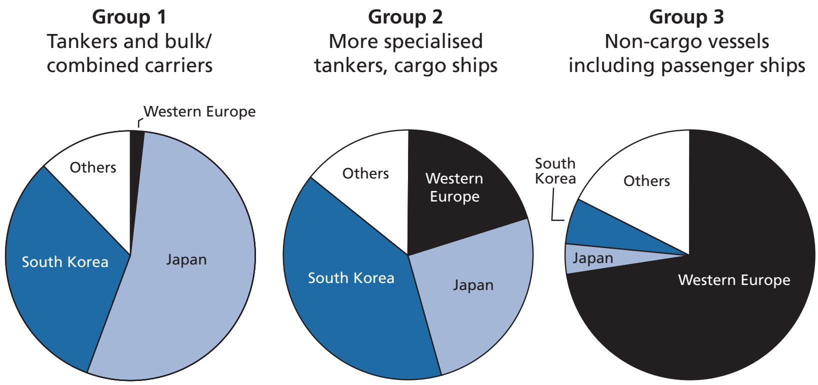
At the same time the Japanese were starting to focus on group 1, Western European shipyards turned their attention to developing efficient production schemes for group 3 ships to keep them ahead of

Table 4.2
Ships Recently Completed by Europe, Japan, and South Korea, Categorised by Complexity

	1999			2000			2001		
	Completions (1,000 CGT)	Value ($Millions)	%	Completions (1,000 CGT)	Value ($Military)	%	Completions (1,000 CGT)	Value ($Millions)	%
Group 1									
+urope	149	247	3.1	90	123	1.4	121	191	1.6
ʻapan	3,311	4,294	54.5	3,385	4,627	52.6	4,019	6,338	54.3
South qorea	2,187	2,838	36.0	2,439	3,335	37.9	2,368	3,734	32.0
World	6,078	7,883	23.5	6,440	8,804	25.3	7,368	11,666	31.4
Group 2									
+urope	1,925	3,199	23.9	2,268	3,523	23.3	1,692	2,729	20.1
ʻapan	2,548	4,235	31.6	2,461	3,821	25.3	2,173	3,505	25.8
South qorea	1,874	3,115	23.3	3,526	5,475	36.3	3,369	5,435	40.0
World	8,058	13,392	39.9	9,720	15,096	43.4	8,434	13,604	36.6
Group 3									
+urope	2,026	7,395	60.1	2,423	7,716	70.8	2,852	8,703	72.9
ʻapan	206	753	6.1	213	678	6.2	148	450	3.8
South qorea	294	1,074	8.7	384	1,223	11.2	223	680	5.7
World	3,373	12,312	36.7	3,424	10,903	31.3	3,910	11,934	32.1
Total									
+urope	4,100	10,841	32.3	4,781	11,362	32.6	4,665	11,623	31.2
ʻapan	6,065	9,282	27.6	6,059	9,126	26.2	6,340	10,294	27.7
South qorea	4,355	7,027	20.9	6,349	10,033	28.8	5,960	9,849	26.5
World	17,509	33,587	100.0	19,584	34,803	100.0	19,712	37,204	100.0

NOT+: For each group's elements, see text.
CGT = compensated gross tons (GRT adjusted for value).

Figure 4.2
Dominant Countries Vary with the Market Segment



NOTE: Each pie represents the value of completed ships in that group for 2001.
RAND *MG236-4.2*

potential competitors. They have largely succeeded. Western European shipyards have almost abandoned the tanker market because of their inability to compete with Asian countries. They hold 73 percent of the group 3 market and compete with one another for group 1 ships. The group 2 market is, like the group 1 market, dominated by Asian countries, but Western Europe has made further inroads into this market, an incursion that reflects the greater complexity of the products than those in group 1. In fact, although Western European nations are less productive than either Japan or Korea in GRT, in terms of value they are in the lead, a position that reflects their dominance of the high-value market segment.

Competition Among Nations

The commercial shipbuilding market is segmented not only by generalised ship type at the regional level but by specific type at the national level. As shown in Table 4.3, more than 80 percent of the European Union's container ships are built by Germany and about

Table 4.3
Commercial Order Book by EU Nations: Number on Order for Selected Ship Types

Ship Type	Average KGRT[a]	France	Germany	Greece	Italy	The Netherlands	Spain	All Others	Total Number
Container	25	0	42	0	0	2	0	6	50
General cargo	4	0	6	1	0	41	1	2	51
Cruise	80	8	8	1	12	0	0	4	33
Passenger/ RORO	22	0	2	3	8	2	7	4	26
All others	15	2	28	1	36	34	32	23	156
Total	22	10	86	6	56	79	40	39	316

[a]Thousands of GRT. The number in the last row is the average across all 316 ships.
NOT+: Ship types broken out in this table are those numbering more than 25.

80 percent of the general cargo ships by the Netherlands. Production of cruise ships and passenger/RORO vessels is less concentrated.

It is noteworthy that the average vessel on the EU order book is about 22,000 GRT, compared with the average Japanese vessel at 43,425 GRT and the average South Korean vessel at 59,587 GRT. This is consistent with the European Union's concentration on higher-value vessels, which tend to be smaller.

The industrial culture of the United Kingdom is likely to be better suited to producing group 3 ships rather than group 1 or 2 ships. In so doing, it would be competing against other EU ship producers. Some of these countries are far ahead of the United Kingdom in penetrating the commercial market. European shipbuilders have been focusing on the group 3 market over the course of time, and many of their skills, facilities, and long-range plans revolve around higher-value vessels rather than simpler ships. If the United Kingdom chose to enter this market, it would face tough competition from neighbouring shipyards.

Consider the case of Germany. German shipyards build a wide variety of commercial ships. Within the past five years, German shipyards have built 80 of the 112 ship types on Lloyd's Register. Since 1997, 16 German yards have produced ships totalling 100,000 GRT or more, and seven of these yards topped the half-million-GRT mark.[4] The United Kingdom has only one yard, Harland and Wolff, that has produced commercial ships totalling over 100,000 tons in the past six years. That yard has restructured and is pursuing repair and design work. Fourteen German yards have built ships greater than 10,000 tons in the past five years, compared with three in the United Kingdom; thirty-two have built ships of 1,000 tons or larger, compared with nine in the United Kingdom. Looking to the Netherlands, we also find a rich array of shipbuilding resources: five yards having produced over 100,000 GRT in the past six years and more than twice as many yards total as have been operating in the United Kingdom.

In re-entering the commercial market, the United Kingdom might also face increasing competition from non-EU yards, which are winning a greater percentage of the complex-ship market. In 2001, EU shipbuilders received only 54 percent of the new orders for group 3 ships, down from their 73 percent market share for ships completed that year. In fact, the EU industry itself is discussing the need for consolidation in order to survive.

With regard to commercial ship production, we have not so far mentioned the United States. Is it a possible competitor with the United Kingdom for commercial shipbuilding contracts? Probably not. Like Germany, the United States sustains a rather large variety of builders of vessels of many sizes and types. A total of 121 yards have produced commercial ships during the past five years, about five times as many yards as in the United Kingdom. However, only six of the 121 yards have experience building ships above 10,000 tons, and those are Jones Act vessels. It is unlikely that shipyards accustomed to building in a protected market would have the ability, or perhaps even the motivation, to compete internationally.

Even Jones Act protection has been no guarantee of success. Given that the United Kingdom's shipbuilding industry is largely dedicated to military production, it may be instructive that two US military shipbuilders could not profitably build merchant ships;

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[4] Lloyd's Register of Ships (2002). Some of the yards counted separately here may have closed or merged.

Newport News did not profit at building product tankers, and Ingalls was unsuccessful at building cruise ships.

Other Challenges in Re-Entering the Commercial Market

UK shipyards will face an array of established, successful competitors if they re-enter the commercial shipbuilding market. The presence of tough competition, though, is only one of a number of challenges. In this section, we summarise the others, some of which have their roots in the differences discussed in Chapter Three.

Market Saturation

The presence of strong competitors by itself need not be a deterrent if demand exceeded supply. Instead, the opposite is the case. Overcapacity in the shipbuilding sector is acknowledged as one of the industry's major problems. The Organisation for Economic Co-operation and Development estimates that, as of 2001, capacity was more than 30 percent higher than future demand.[5] The 2003 Platou Report has a slightly less pessimistic estimate of 11 percent excess capacity.[6] Despite this excess, world capacity is expected to grow by around 2 percent in the future, fed by growth in Korea and China and offset partly by declines in Japan and Europe.[7] During the latter half of 2003, trade journals reported a sudden surge in orders for container ships, bulk carriers, and LNG tankers, which, for the moment, has saturated the world capacity for these ship types. Should these orders continue, the excess capacity problem, at least for some ship types, might be resolved for now. However, supplier adjustments have already begun. Hyundai Heavy Industries announced in November 2003 that it was converting an offshore yard to

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[5] Association of Western European Shipbuilders (2002, p. 29).

[6] R. S. Platou Shipbrokers (2003, p. 7).

[7] R. S. Platou Shipbrokers (2003, p. 11).

shipbuilding to help meet this demand.[8] Thus, for the long haul, should the UK warship yards decide to compete for commercial shipping, they might only be adding further excess capacity to an already full market.

Commercial Client Demands

In working for the government, UK warship-building yards may have become accustomed to production scheduling requirements that are not as strict as they are in the commercial sector. These demands could make an expansion to commercial shipbuilding difficult. As pointed out in Chapter Three, commercial build-times are typically shorter than those for warships, and penalties for late delivery can be large. One EU commercial shipbuilder said that cost penalties could be as high as $100,000 per day, although there is generally a grace period before this type of penalty is imposed. With low profit margins, shipbuilders cannot afford to deliver a ship behind schedule. Furthermore, delaying one ship can have secondary effects on follow-on ship schedules because of the nonavailability of labour and facilities. To enter this environment, the UK warship yards would need to be absolutely confident of their ability to deliver a ship on schedule, or they could face significant financial losses.[9]

Different Workforce and Process Needs

If the United Kingdom's military shipbuilders enter the commercial market, they will face demands for skills different from those needed in military shipbuilding. For example, commercial standards for welding and surface flatness are less strict than military requirements. Shipyards employing workers able to meet the exacting military standards pay a premium for these specialised skills; however, such costly skills are not needed in commercial ship construction. Shipbuilders

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[8] Anyone entering the commercial shipbuilding market has to be prepared to cope with the market's chronic volatility. 'Shipbuilders are constantly under pressure to expand or contract their output' (quote from Stopford, 1997).

[9] This may further dissuade publicly listed shipyards (such as BAE Systems) from fully entering the commercial market; their shareholders would likely express concern over the enhanced financial risk.

that plan to use their military shipbuilding resources for commercial ships must change the culture of their workforce to accept these lesser requirements, especially if they plan to use the same workforce to build both military and commercial ships.[10] Shipbuilders moving to commercial contracts may also need to subcontract more work than they are accustomed to in order to keep a more stably employed workforce in the yard and build more efficiently.

In addition to changing the culture of the workforce, UK shipbuilders would have to change their processes. Their current processes have been developed to meet the Royal Navy's requirements for documentation, traceability, and configuration management, which are required for highly complex advanced surface combatants and submarines. These very expensive processes would need to be replaced by streamlined procedures that are sufficient to meet commercial standards for simpler ships and that cost less money.

Facility Constraints

Three principal UK shipyards—Swan Hunter and the BAE Systems yards at Barrow and Glasgow—have recent experience in building large commercial or commercial-like ships. These yards could serve as the nucleus of a regenerated UK commercial shipbuilding industry. However, the facilities at these yards are being adjusted to meet requirements for military shipbuilding work. Such adjustments could complicate profitable entry into commercial shipbuilding at those yards.

UK shipyards are generally not sized to build the very large commercial ships that are common today, and some are located on waterways that are not wide or deep enough anyway. This situation is problematic because a large ship facility can build smaller ships when its traditional market declines, whereas small facilities do not have the complementary option. Thus, competitive pressures will at times be

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[10] We have been told by firms with military experience that the transition to 'lower-quality' work (e.g., welds meeting lower standards) would be difficult for their workforce to achieve after years of quality-oriented training. Note that in moving to commercial shipbuilding, it is not necessary to pay the workforce less per hour, but the workforce must be able to complete more tasks (e.g., more welds) in a given amount of time.

greater for yards limited to building small ships. South Korea's large facilities, in contrast, can take whatever the market offers to fill their shipbuilding capacity. In fact, it is not unusual to see up to five ships of different sizes and even types under construction in a Korean shipyard's large dry docks.

It is noteworthy that when we asked shipbuilders (in the United Kingdom and elsewhere) what type of ship they would build if they were to enter a new market segment, most identified types that were the closest to what they were currently building. Factors such as yard capacity, river width and depth, and skill mix and locations weighed heavily in their choices.

Strong Currency

In competing with other countries, the United Kingdom would at least in the short term have to deal with the strength of its pound against the dollar, which is the standard for international trade. Because a strong currency has the effect of raising export prices relative to those from other countries, UK shipbuilders would have to keep costs to a minimum to be competitive. This would be particularly challenging for shipbuilders trying to enter a new market because their costs would, other things equal, be higher than the costs incurred by shipbuilders that have established themselves in the market. Current exchange rate trends, however, are likely to be reversed at some point. US interest rates are expected to rise, which will likely weaken the pound. In that event, the United Kingdom's labour prices, which are lower than those of some European competitors, could give it an advantage.

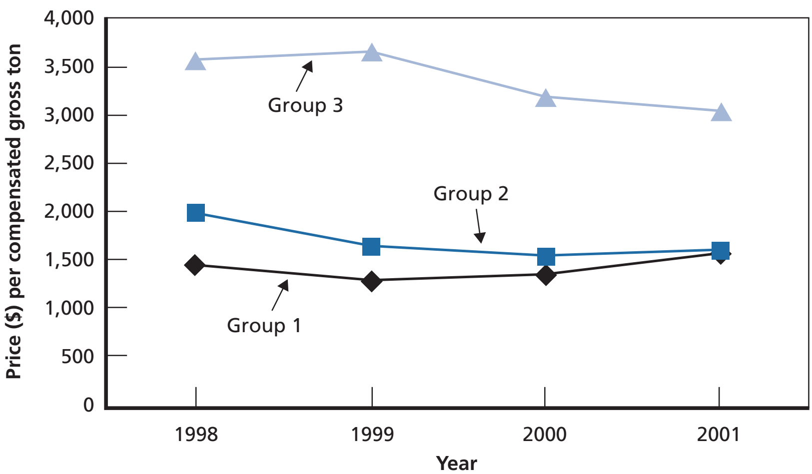
Falling Prices

Overcapacity, improved productivity, lower demand, alleged Korean price-cutting, and increased Asian shipyard productivity have caused the price of new ships to drop substantially in the past five years. This price drop may be in the process of correction as this is written, but only time will tell. But prices in 2002 for new build ships were 19 percent lower than in 1997. This presents a significant challenge to shipbuilders that must already wrestle with low profit margins and demanding delivery conditions. The largest price drops in the last three years were for the group 2 and 3 ships (see Table 4.4, graphed in Figure 4.3), the type of ships that EU shipyards generally build and the types for which Asian competition is increasingly being brought to bear.

Table 4.4
Average Price of Commercial Ships by Complexity Group, 1998–2001

	1998		1999		2000		2001	
Ship Type	Number	$/CGT	Number	$/CGT	Number	$/CGT	Number	$/CGT
Group 1	229	1,476	439	1,297	411	1,367	299	1,577
Group 2	318	1,984	319	1,662	478	1,553	598	1,613
Group 3	169	3,569	166	3,650	129	3,184	99	3,052

Figure 4.3
Prices for Complex Ships Have Fallen More Than for Simple Ships



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Opportunities and Risks

To summarise this chapter so far, conditions indicate that it will be a challenge for UK warship yards to successfully enter the commercial market, even that for highly complex ships where they might be able to develop an advantage over Asian builders. Market overcapacity has led to a highly competitive environment characterised by price deflation and a focus by established European shipbuilders on the most remunerative market sectors.

Although the most likely extension of current trends thus leads us to a pessimistic outlook regarding the United Kingdom's re-entering the commercial shipbuilding market, other futures are possible. The shipbuilding industry is a volatile one, and unpredictable events can give rise to unexpected opportunities. There might be an economywide boom, early retirement of a class of ships (as occurred with single-hulled oil tankers), shifts in other aspects of goods transport (e.g., the propagation of containers), or explosions of demand (as for cruise vacations). Any of these events could cut the current excess of supply and open avenues for new entrants into the market.

There are indications that there may be good times ahead. The demand for LNG tankers as well as container ships and bulk carriers has been rapidly growing. The depressed cruise-ship market appears to be turning around as well. There are current shortages in larger container ships, forcing some shippers to hire two smaller ships to serve their routes at a higher cost than one larger ship, and there appears to be a coming surge in tanker demand.[11]

If it is to take advantage of any market opportunities, successfully enter the commercial shipbuilding industry, and develop a healthy industrial base, the United Kingdom should act deliberately and be prepared to accept a substantial degree of risk. The government could consult with the shipbuilding industry to identify investment options that might motivate the desired outcomes, although the constraints imposed by the European Union's Ship-

[11] *Trade Winds: The International 5hipping Paper* (2003).

building Framework should not be underestimated.[12] The choice of any option could include a recognition and allocation of the risks involved. Shipbuilders should define the product range, in both ship type and size, that they feel presents their best opportunity for success, given their facilities, experience, and skills. Once they define this target, the shipbuilders could 'buy in' to the market by investing in the management, organisational development, and worker skills that it requires.

The shipyards must be prepared for the drawbacks of being market newcomers. Commercial ship owners are reluctant to become test cases and hesitate to contract with inexperienced shipbuilders when the price difference between the experienced shipyard and the inexperienced one is small.

It is possible to enter a new market, but the cost may be great. For example, when Mitsubishi produced its first large cruise ship, it lost 100 percent of the contract price (i.e., its cost was twice what it was paid). Ingalls anticipated a loss between 25 and 50 percent with its cruise-ship programme that ultimately failed, and Newport News lost 100 percent of the contract price on five product tankers when it re-entered the commercial shipbuilding market. These losses occurred even though the companies hired expert assistance from experienced designers and builders of the ship types involved. In the case of Mitsubishi, some loss was expected because the company was buying into the market. This risk eventually paid off when Princess Cruise Lines offered Mitsubishi contracts for two large ships. Small shipbuilders do not have the financial depth to sustain such losses, and in all the above three cases most individual shipbuilders would have been put out of business.

Should the United Kingdom wish to succeed in the commercial market, its shipyards would have to be prepared to weather initial losses of this magnitude. This preparation would include extensive planning and, to the extent possible within EU rules, support from

[12] The Framework sets tight definitions and limits to public-sector investments in capital projects in the merchant shipbuilding sector and expressly prohibits the underwriting of losses incurred by shipyards.

the government. Given the lower profits in commercial work, it is doubtful that the shipyards would be motivated to fund their own reentry into the commercial market. It might take both private- and public-sector commitment to make the United Kingdom's shipbuilding capabilities competitive in the commercial market.

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The Potential for Foreign Military Sales

Given that the United Kingdom faces a formidable challenge in re-entering the commercial market, would it find better prospects in foreign sales by playing to its strengths in military shipbuilding? To answer this question, we describe the competition in the military export market and how this market is segmented. We examine other challenges that UK shipbuilders would have to overcome and conclude that foreign military sales are not likely to be a major source of revenue for them.

Competition and Market Potential

A quick examination of Table 5.1 (p. 75) reveals that Germany, France, and Russia dominate the military export market. The table shows the number, tonnage, and value of newly constructed warships, including amphibious ships, projected to be exported from 2003 through 2012.[1] Ships are listed by shipyard, ship type, and buyer (operator). We have identified the shipyards that build only military ships (indicated by 'Yes' in the 'Mil Spec?' column) and those that build (or may build) commercial ships too ('No' in the same

[1] The table does not include auxiliary ships, but few of these are likely to be exported. They are required principally by nations with blue-water navies, and they can build their own.

column).[2] As elsewhere, we follow the international convention of denoting value in US dollars.

When we tally the projection data from Table 5.1, the dominance of the three primary military ship exporters becomes even clearer (see Table 2.2 [reproduced here as Table 5.2 for the reader's convenience] and Figure 5.1). It is noteworthy that, in contrast to the commercial market, the military export market is dominated by European countries. This dominance partly reflects the greater complexity of military ships and partly stems from Japanese policy against foreign military sales. However, as is clear from Table 5.2, the United Kingdom is not one of the European military export powers. We only know for certain of one contract for two offshore patrol vessels (OPVs) for sale to Brunei.

The export market is big enough to make a tempting target for sales intended to help sustain the United Kingdom's shipbuilding industry. If British shipbuilders could take a share half the size of Russia's, that could be a useful step towards sustaining the industry and levelling the load across time and yards.

However, the United Kingdom faces some daunting challenges in attempting to make inroads into the military export market. The French, Germans, and Russians are well entrenched, and there are already multiple sellers for most buyers. (See Table 5.3, where we show potential sellers to each of a number of buyers, based on an analysis by the Defence Export Service Organisation.)

The United Kingdom does have the advantage of having a robust military shipbuilding industry, dedicated at present to domestic needs, to serve as a foundation for foreign military sales. In fact, as Table 5.2 shows, the United Kingdom's projected domestic military production exceeds that for export by a larger amount than is the case for any other European nation. It thus might be viewed as having a large capacity or foundation for supporting foreign military sales.

[2] The designation is by shipyard. A shipbuilder may have more than one yard, and these may vary in their specialisation.

Table 5.1
Projected Military Ship Export Market, 2003–2012

Shipyard	Mil Spec?	Programme	Ship Type (operator)	LSW (tons)[a]	Cost ($M)	Number	Total LSW[a]	Total Cost
France								
DCN International	Yes	F3000S	Frigate (Saudi Arabia)	2,850	350	2	5,700	700
DCN International	Yes	Um Al Maradim	Patrol boat (quwait)	225	70	?	?	?
DCN International	Yes	La Fayette	Frigate (Singapore)	2,850	350	6	17,100	2,100
DCN International	Yes	Tripartite Minehunter	Mine warfare (Pakistan)	535	75	?	?	?
Alstom (Chantier)	No	Floreal	OPV (Morocco)	2,600	165	?	?	?
DCN/Bazan	Yes	Scorpene	SSq (Chile)	1,450	205	2	2,900	410
[Not reported]	?	Scorpene	SSq (India)	1,450	205	5	7,250	1,025
DCN/Bazan	Yes	Scorpene	SSq (Malaysia)	1,450	205	2	2,900	410
DCN International	Yes	AgostaX90B	SSq (Pakistan)	1,570	325	1	1,570	325
DCN/Bazan	Yes	Scorpene	SSq (Portugal)	1,470	205	3	4,350	615
DCN/Bazan	Yes	Scorpene	SSq (Spain)	1,470	205	4	5,800	820
Germany								
[Not reported]	?	M+qO AX200	Frigate (Saudi Arabia)	3,195	320	4	12,780	1,280
M+qO Consortium	No	ANZAC	Frigate (Australia)	3,195	320	4	12,780	1,280
M+qO Consortium	No	M+qO AX100	OPV (Malaysia)	1,617	29	12	19,404	342
Lurssenwerft	Yes	M'X332	Mine warfare (Turkey)	590	112	6	3,540	669
[Not reported]	?	M+qO AX100	OPV (Turkey)	1,617	29	12	19,404	342
HDW	Yes	Type 209X1400	SSq (Brazil)	1,454	150	1	1,454	150
HDW	Yes	Type 214	SSq (Greece)	1,700	550	3	5,100	1,650
HDW	Yes	UX2121	SSq (Italy)	1,350	450	2	2,700	900
HDW	Yes	Type 209X1200	SSq (qorea)	1,100	186	?	?	?

Table 5.1—Continued

Shipyard	Mil Spec?	Programme	Ship Type (operator)	LSW (tons)[a]	Cost ($M)	Number	Total LSW[a]	Total Cost
Germany (cont.)								
HDW	Yes	Viking	SSq (RDN)	1,800	325	2	3,600	650
HDW	Yes	Type 214	SSq (qorea)	1,700	550	3	5,100	1,650
HDW	Yes	Type 209X1400	SSq (South Africa)	1,454	300	3	4,362	900
HDW	Yes	Type 209X1400	SSq (Turkey)	1,454	225	4	5,816	900
Israel								
Israel Aircraft Industries Ltd.	Yes	Super Dvora	Patrol boat (Sri Lanka)	50	5	?	?	?
The Netherlands								
qvaerner	No	Skjold	Patrol boat (Norway)	260	100	5	1,300	500
Rotterdamse Droogdok MI'	No	Moray	SSq (+gypt)	1,800	320	2	3,600	640
Rotterdamse Droogdok MI'	No	Moray	SSq (Malaysia)	1,800	320	2	3,600	640
Russia								
Severnoe Design Bureau	Yes	Project 1241	Patrol boat (various)	385	60	?	?	?
Severnoe Design Bureau	Yes	Sovremenny	Destroyer (China)	6,500[b]	800	2	13,000[b]	1,600
Severnoe Design Bureau	Yes	Project 1241	Patrol boat (Vietnam)	385	60	1	385	60
Baltiisky Zavod Shipyard	No	Project 1135.6	Frigate (India)	3,100	300	5	15,500	1,500
Severnoe Design Bureau	Yes	Abhay/Veer	Patrol boat (India)	385	60	4	1,540	240

Table 5.1—Continued

Shipyard	Mil Spec?	Programme	Ship Type (operator)	LSW (tons)[a]	Cost ($M)	Number	Total LSW[a]	Total Cost
Russia (cont.)								
Rubin Design Bureau	Yes	Project 877	SSq (India)	2,325	282	?	?	?
Rubin Design Bureau	Yes	Project 636	SSq (China)	2,325	200	8	18,600	1,600
South Korea								
Daewoo Heavy Industries	Yes	Modified Ulsan	Frigate (Bangladesh)	1,600	20	?	?	?
Daewoo Heavy Industries	Yes	Samar	OPV (India)	1,500	30	1	1,500	30
Spain								
Izar Shipbuilding (mil yard)	Yes	FX100	Frigate (Norway)	4,500	350	5	22,500	1,750
Izar Shipbuilding (mil yard)	Yes	Principe de Asturias	Aircraft carrier (unknown user)	8,843	285	1	8,843	285
United Kingdom								
BA+ Systems	Yes	OPV	OPV (Brunei)	1,500	325	2	3,000	650
United States								
Textron	No	LCACX1	Amphibious warfare ('apan)	87	26	2	174	53
Intermarine	Yes	Lerici/Gaeta	Mine warfare (Thailand)	488	60	?	?	?

SOURC+S: Forecast International/DMS Warships Forecast, March 2003, and discussions with Stuart Slade, Senior Naval Analyst, Forecast International/DMS, during the week of March 31, 2003. Displacement information is from Baker (2002).

[a]Displacement information is LSW where available. Where only fullXoad displacement was available, the LSW was determined by using a factor of 0.77. This is representative of destroyerXsized vessels.

[b]Not in source data. Assumed to be the same as for other *Sovremenny*Xclass ships, from Baker (2002, p. 629).

Table 5.2
Projected Military Ship Production, 2003–2012

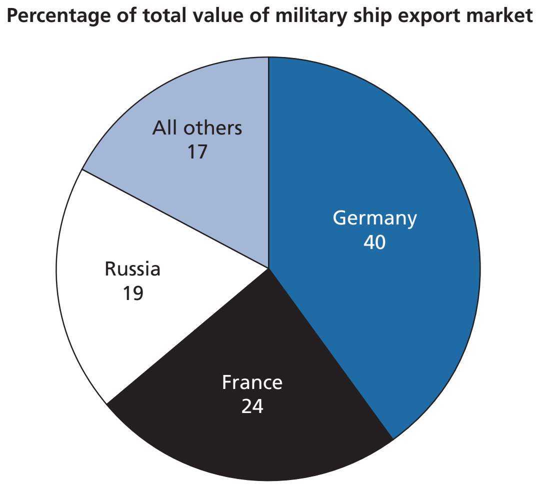
	Export			Domestic Use		
	Number	Value ($ millions)	LSW Tons	Number	Value ($ millions)	LSW Tons
Germany	56	10,713	96,040	21	5,799	44,144
France	25	6,405	47,570	17	13,015	146,302
Russia	20	5,000	36,025	0	0	0
Spain	6	2,035	31,343	7	2,195	26,735
The Netherlands	9	1,780	8,500	4	1,585	24,759
United qingdom	2	650	3,000	22	17,340	235,140
United States	2	53	174	66	56,172	776,446
South qorea	1	30	1,500	7	4,905	24,500
ʼapan	0	0	0	16	11,090	79,125
Italy	0	0	0	18	5,289	75,170
China	0	0	0	8	3,230	26,875
Australia	0	0	0	1	650	3,051
Sweden	0	0	0	3	375	1,431
Taiwan	0	0	0	1	320	2,769
Israel	0	0	0	11	55	550
Total	121	26,666	224,152	202	122,020	1,466,997
Not Reported	23 vessels valued at $13,225 million and displacing 86,291 tons LSW.					

SOURC+S: See Table 5.1.

Table 5.3
Potential Sellers for Each Military-Ship Buyer

	Potential Exporter				
Potential Importer	France	Germany	Spain	United States	Other
Australia		÷		÷	
Brazil	÷		÷		
Chile	÷	÷	÷		
Greece		÷		÷	÷
quwait	÷	÷			
Malaysia	÷				
Oman	÷	÷			÷
Saudi Arabia	÷				
Turkey		÷			

Figure 5.1
Germany, France, and Russia Dominate the Projected Military Ship Export Market



RAND *MG236-5.1*

Matching Supply with Demand[3]

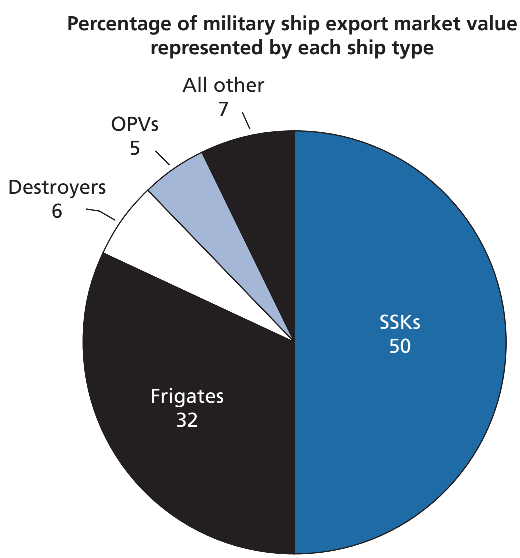
But is the United Kingdom's industry the right one for the customers? Germany and France give us some perspective here. The importing countries in Table 5.3 are not first-tier naval powers looking for cutting-edge weapon systems. Germany and France succeed in the military ship export market and are expected to continue that success because they have developed designs specifically for export in the lower size and price range that second-tier naval powers can afford. Howaldtswerke–Deutsche Werft (HDW) and ThyssenKrupp in Germany (the Blohm + Voss and Thyssen Noordsea shipyards) have cultivated the export market for conventionally powered attack submarines (SSKs) with their Type 2XX and U-212 boats. France has

[3] Some of the ideas in this section are taken from an informal paper prepared for us by the Defence Export Services Organisation.

recently introduced the small *Scorpene* SSK to compete with Germany in this market segment and appears to have been successful. Table 5.1 shows 16 *Scorpene* submarines compared with perhaps 20 German SSKs. (The Netherlands has tried to build an export SSK business with the Moray project but has had less success.) Germany's MEKO modular frigates have also done well in the market. These ships are easy and inexpensive to build and adaptable to the customer's system requirements. France is also cultivating the *La Fayette* frigate for export in competition with the German MEKO vessels and may be considering export of the *Mistral* LHD (helicopter/dock landing ship) as well.

In fact, the export market is largely an SSK/frigate market (see Figure 5.2 and Table 5.4). SSKs make up about half the market and frigates another third. These data are somewhat biased against the smaller sectors because those account for more than their share of

Figure 5.2
SSKs and Frigates Dominate the Military Ship Export Market



RAND *MG236-5.2*

Table 5.4
Projected Value of Military Ship Export Market, 2003–2012, by Exporter and Ship Type (in $ millions)

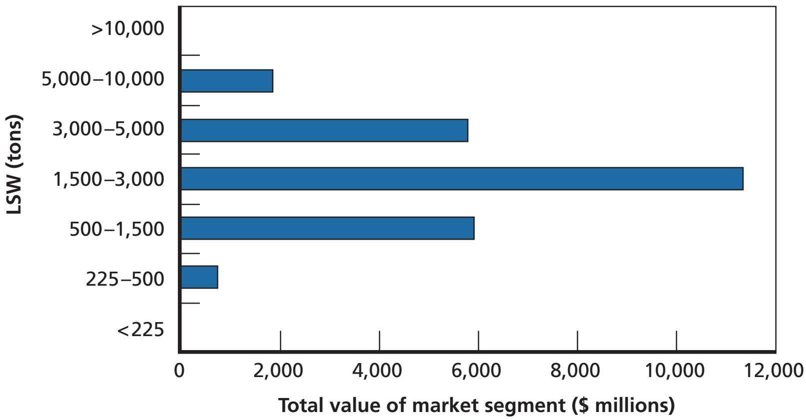
	Germany	France	Russia	Spain	The Netherlands	UK	US	South Korea	Total
SSqs	6,800	3,605	1,600		1,280				13,285
Frigates	2,560	2,800	1,500	1,750					8,610
Destroyers			1,600						1,600
OPVs[a]	684					650		30	1,364
Patrol craft[a]			300		500				800
Minehunters	669								669
Carriers				285					285
Amphibious vessels							53		53
Total	10,713	6,405	5,000	2,035	1,780	650	53	30	25,066

SOURC+: Table 5.1. Orders of unknown quantity are omitted.
[a]Offshore patrol vessels are taken here to be ships of roughly 1,500 tons LSW; 'patrol craft' are vessels of 200–400 tons.

orders of unknown number in Table 5.1, and such orders are excluded from Table 5.4 and Figure 5.2. If typical order numbers specific to the various ship classes are assumed for the unknown quantities, SSKs and frigates still dominate the market, with about three-quarters of the total. However, the OPV quantity approximately doubles and thus accounts for a somewhat more important niche than appears to be the case in the data shown.

The market is dominated by small ships because the buyers are interested only in coastal or regional defence, not a blue-water navy. Only about ten countries have a blue-water navy, and seven of those can build their own ships. As shown in Figure 5.3, almost all the money in the military ship export business is in ships under 5,000 tons, and most of it is in ships under 3,000 tons. The *5corpene* submarines, for example, displace about 1,500 LSW tons, and the German SSKs a little more. Because basic, no-frills versions of these ships are available, they are affordable to developing countries. The basic

Figure 5.3
Almost All the Money in the Military Ship Export Business Is in Ships Under 5,000 Tons



RAND *MG236-5.3*

French or German SSK costs around $200 million; some customers have asked for added capabilities that have run the price up into the half-billion-dollar range.

By comparison, UK naval vessels tend to be large, sophisticated, and expensive. The *Astute*-class attack submarine will displace about 6,700 tons (fully loaded) when on the surface and will cost around $1.2 billion. It would be pointless to design a conventionally powered variant of that ship for export. New designs specific to the export market would be required. However, it is unclear whether UK shipbuilders have the ability to design and build an inexpensive, small, conventionally powered submarine that can compete with German and French products. As for surface combatants, even the Type 23 destroyer—a good value towards the end of its production run—did not arouse interest in the export market.[4]

[4] In implementing 'Smart Acquisition', the MOD has been moving away from military towards commercial standards where feasible, thus in some degree simplifying the design and production of military ships. The MOD's performance requirements, however, will always lead to designs costlier to produce than those for lower-performance surface combatants and submarines, other things equal.

Market Limitations

At some point, a seller desiring to expand its military ship exports must face the reality that there is only so much potential in the market. The export market is less than a fifth the value of the total military ship production market (about $16 billion a year over the next eight years), which in turn is only about a third of a total shipbuilding market of very roughly $50 billion a year.

The export market's size is limited for several reasons. Most navies are small, and naval vessels last for many years, so turnover is limited. Ships retiring from first-tier navies, particularly that of the United States, are often good enough for second-tier navies and can be bought inexpensively. And as is obvious from the data just cited, the overwhelming preference is for domestic production of naval ships.[5] In fact, the export numbers are somewhat exaggerated for this reason. We count the sales of six French frigates to Singapore and three German SSKs to Greece as exports, but the arrangements in each case call for only the first ship to be built in the exporting country and the remainder by the importer. Such arrangements allow the exporter to sustain its design and integration skills but are not of great worth in sustaining its shipbuilding skills if there is not other demand for them. Such requirements for local construction under license are particularly likely to be encountered in the market for OPVs and smaller boats, whose construction presents lesser challenges for shipbuilders in second-tier naval powers. In fact, surface combatants of 1,250–1,750 tons LSW have been built or are being built by Brazil, China, India, Italy, Malaysia, Norway, Poland, Romania, South Korea, Spain, Thailand, and Yugoslavia, in addition to all the principal builders of military ships (Baker, 2002). Some of these ships have not only been built locally but have also been designed in country, a practice that cuts exporters out of the picture entirely.

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[5] These reasons are taken from an informal paper by the Defence Export Services Organisation.

Conclusion

It does not seem to us that exports of UK warships represent a realistic means of sustaining a competitive shipbuilding industry. The reasons for this conclusion are as follows:

- UK warships tend to be more complex and expensive than second-tier countries require.
- International competition is intense; many governments strongly support foreign sales.
- Competing for export orders is a long process with no guarantees of success.
- The trend in export orders is towards design and integration, with construction itself undertaken in the 'importing' country.

Our pessimism must be tempered by the precedent of France's penetration of the SSK market with its *5corpene* design in direct competition with well-established German SSK exports. However, it might be best if the United Kingdom considered military exports as an option for filling short-term gaps in demand or for responding to specific opportunities. Less-expensive versions of a ship like the Type 45 destroyer might find a market niche, but there appears to be greater demand for ships like the OPVs the United Kingdom is supplying to Brunei.

If export sales become a key component of UK naval industrial policy, the Royal Navy should, of course, continue to consider adaptability for export or simultaneous design of an export version in the process of developing new platforms. The government might consider playing a role in supporting the sustainment of design and programme management core teams between lulls in orders. The government might also consider the possibility of financing foreign military sales through very-low-cost loans, to the extent that is permitted by EU rules.

CHAPT+R SI

Integration Versus Specialisation at the Shipyard Level

To this point, we have dealt with the issue of industrial expansion at the national level. But if the United Kingdom were to re-enter the commercial shipbuilding market or the military export market, who would build the ships? The United Kingdom's commercial shipbuilding industry is small and fragmented. For only eight currently operating yards has the average commercial or naval auxiliary vessel exceeded 1,000 GRT over the past six years. The commercial industry would thus not appear to be a major player, at least in the short term. Could military shipyards begin building commercial vessels? Some have recently done so. Might builders of naval auxiliaries be particularly well positioned to enter the commercial market?

In this chapter, we review the history of military versus commercial specialisation and current practice across major shipbuilding countries. We conclude that integration of commercial and military shipbuilding in a single yard is rare and elicit some of the reasons why.

A Historical Perspective

In the days of wooden ships, military vessels were much like their commercial counterparts. While the biggest warships were larger, heavier, and more sturdily constructed than commercial ships, the skills needed to build both kinds were nearly identical. The history of military shipbuilding in England goes back to Alfred the Great, who ordered ships from private builders to defend against the Vikings. In 1496, Henry VII established the first royal dockyard at Portsmouth to ensure a suitable facility for the British navy. Thereafter, many royal dockyards were developed to provide the government a permanent source of ships and ship repair services as well as convenient locations for fleet homeports.

The royal dockyards took most of the shipbuilding load but by no means all of it. The involvement of private shipyards waxed and waned with the war situation; it was they, for instance, that built much of Lord Nelson's navy (Burton, 1994). Royal dockyards served as outfitting facilities for military ship hulls built in private yards. The private builders relied on subcontractors to provide masts and yards, standing and running rigging, sails and awnings, blocks, anchor, chain, and many other goods as well as such services as caulking and painting (Heinrich, 1997). These subcontracted products and services were widely used elsewhere in the economy of the times; this external demand helped temper the swings in order quantities that have always typified commercial shipbuilding. This business model enabled almost any private shipyard to focus on constructing the hull to whatever requirements the customer demanded—military or commercial—leaving the outfitting to others. The Royal Navy recently resurrected this pattern for acquiring the assault helicopter carrier HMS *Ocean,* for which the commercially oriented Kvaerner Govan shipyard assembled the hull and machinery, while military specialist BAE Systems Barrow performed the outfitting.

When iron, and later steel, shipbuilding emerged early in the 19th century, commercial shipyards started to vertically integrate, taking to themselves more and more of the tasks needed to build ships from the new material. The pioneer among such vertically integrated commercial shipyards was, perhaps, Palmer's Shipyard at Jarrow on the Tyne, which by the late 19th century had its own coal mines, a fleet of colliers, and an engineering works where engines and other machinery were made (Heinrich, 1997). For the royal dockyards, this was not a new model, but for whatever reasons, they found it difficult to keep up with the advancing technology and began to assign responsibility for engines and other auxiliaries to private companies.

Soon, difficulties began to emerge as navies made greater performance demands on the suppliers of iron warships. The large and prosperous Cramp Shipyard in Philadelphia exemplified these difficulties. In the 1890s, Cramp received contracts to build US warships that employed new high-strength nickel-iron armour that was over a foot thick. This order forced the yard to abandon its commercial shipbuilding preference for a time and make significant facility investments in larger slipways and cranes and special metal-forming machinery. When the government programme ended, the investments were of no commercial value. Cramp attempted to move back into commercial work with limited success. Towards the end of the government programme, as one commentator has noted,

> there were five slips, each capable of building a [passenger liner or battleship]; on one was a tug, on another was a battleship, on another was a ferryboat, on another a yacht and on another a revenue cutter. It is absolutely impossible to practice economies under such circumstances and build the ship so that they would compare favorably in cost with ships built abroad. (Heinrich, 1997)

The 'ships built abroad' were at the time made by dozens of highly specialised modern commercial British yards, each building a narrow range of commercial ships for specialised (largely British) shipping firms (Johnman and Murphy, 2002).

As World War I loomed, the turn-of-the-century gun maker, Vickers, bought the privately owned Naval Construction Works at Barrow in Furness (now owned by BAE Systems) and considered merging with Cramp and Bethlehem Steel, also in Pennsylvania, to form a US-UK military ship specialist conglomerate.[1] This merger never took place. Cramp, crippled by unproductive investments and without a productive niche, ultimately closed.

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[1] See Heinrich (1997).

Tensions created by steadily diverging technology demands of commercial and naval shipbuilding continued as steel ships evolved. While many shipyards during the 20th century continued to build both military and commercial ships, the trend towards specialisation continued perhaps even more strongly than previously, and it has not yet ended. One of the larger German shipyards has been HDW in Kiel. Over the past six years, HDW has been the sixth-largest builder of commercial ships in Germany (in terms of total tonnage produced), but it has recently decided to focus on military sales only. Its last commercial ships are being built this year. And as a representative of one UK military shipbuilder told us, it is becoming increasingly difficult to win work in commercial markets while retaining the capability to execute warship contracts.

The Predominance of Specialisation

The result of the historical trends is that two-thirds of the world's shipyards building military ships are military specialists (this is reflected in those yards building military ships for export, as shown in Table 5.1). European, including UK, naval shipyards have tended to specialise in military shipbuilding, although some of the shipbuilding groups have multiple shipyards, and naval and commercial shipbuilding are kept separate. For example, Fincantieri has two yards devoted primarily to naval vessels (Muggiano and Riva Trigosa) and six to commercial ships.[2] An exception is the French Chantiers de l'Atlantique, which builds both commercial cruise ships and frigates for the French navy.

In Japan, all the companies involved in naval shipbuilding have multiple yards, although they take different approaches to isolating their naval work. Mitsubishi begins the construction of its naval ships in a small dedicated yard and does so in relatively small blocks that are pre-outfitted only with piping. After traditional, inclined launch,

[2] From the Fincantieri Web site, www.fincantieri.com.

the ship is towed about 8 miles to Mitsubishi's Nagasaki shipyard and machine works where it is completed. IHI, Kawasaki, and Mitsui also build naval ships in their smaller (and older) yards, although they do attempt to use modern shipbuilding methods such as block construction and advanced outfitting. None of these shipbuilders has sufficient continuous naval ship work to keep its naval shipyards busy; they build commercial ships in the same facility. Profitable operations on the commercial side motivate the shipbuilder to strive for quick turnaround on both commercial and naval work. IHI builds small bulk carriers and RORO ships at its dual-use shipyard, and Kawasaki has recently begun building 50,000-ton bulk carriers at its commercial/naval yard. Employment data from these shipyards suggest they are able to build commercial ships at competitive prices by keeping overhead rates lower than those at UK military yards. This discontinuous, low-overhead, dual-use model of ship production is worth further study by the MOD.[3]

Korean naval ships are built by Hyundai and Daewoo. Both companies keep the complete operations separate, even though Daewoo's naval shipyard is inside its commercial yard. The naval component in each shipyard has its own management, design, and production departments with minimum crossover of employees from one area to the other. (The latter is not necessarily typical, however, as indicated by our survey of US and EU shipbuilders. Most respondents stated that although they recognise that military and commercial projects require different worker skills, they regard the skills as generally portable, except for work on submarines and combat systems.)

Not only has specialisation driven military and commercial shipbuilding to different facilities, but commercial shipyards also tend to further specialise by both ship complexity and size. For example, Oshima of Japan specialises in bulk carriers between 30,000 and 90,000 deadweight tons—nothing larger, nothing smaller, no different ship types. Mitsubishi Heavy Industries specialises in moderate-

[3] We are indebted to Philip C. Koenig for calling this model to our attention.

sized, very complex ships such as LNG and LPG carriers and, recently, cruise ships. Gydnia of Poland specialises in container, vehicle, and bulk carriers up to 57,000 deadweight tons.[4] Kvaerner Masa in Finland focuses on cruise ships. Of Fincantieri's six commercial shipyards, three (Monfalcone, Margheria, and Sestri Ponente) are dedicated to cruise ships and three (Palmero, Castellammare, and Ancona) to other merchant ships, with subspecialties within each.

The results of our shipbuilder survey confirmed this picture. Most firms had just one shipyard that concentrated on either military or commercial work. For firms with multiple shipyards, commercial and military work was not usually mixed at individual yards other than to level a yard's workload.

In sum, then, most shipyards have a history of constructing a certain type, size, and complexity of ship for either the military or commercial market, but usually not both. Firms that do build both military and commercial ships are usually building military auxiliaries, not combatants, that are very much similar in size and complexity to commercial ships. Each yard's facilities, workforce, processes, and experiences have become optimised over time for its market segment. Moreover, as we discussed in Chapter Three, to the extent that military and commercial shipbuilders are evolving towards new business models, they are going in different directions. Our survey of shipbuilders indicated, however, that most yards are opportunistic and will, from time to time, move out of their market segment—military to commercial and commercial to military—if an opportunity arises to either make a profit or sustain their workforce. Unless driven by sustained changes in market conditions, such moves, at least for military specialists, are usually of short duration. A possible exception is the Japanese shipbuilding industry, which appears to have achieved some success in mixing commercial and military production.

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[4] *Fairplay 5olutions* (2003).

Costs and Benefits of Integration

It would thus appear that there is not much precedent for military shipbuilders moving aggressively into commercial competition. Still less are both types of ships to be built in the same yard, and establishing new commercial yards or expanding current ones to competitive scope would require a major investment. Why are dual-purpose shipyards, or even shipbuilders, so rare?

Firms that reported building both commercial and military ships are now focusing more and more on military products, because there is less demand for domestically built commercial ships and those yards have the specialised skills required for military construction. Also in play are the numerous differences between commercial and military ships and shipbuilding cited in Chapter Three. To summarise a few of these differentiations, the average commercial ship on order is about three times the size of the average military ship but takes only one-quarter the design and one-fifth the build duration and is only one-quarter the value. It may be too much of a challenge to run an integrated facility with such different processes and products. And then there is the matter of the large white-collar workforce that is essential to military shipbuilding but uncompetitive in the commercial market. Firms also report that military construction contracts, while more challenging and demanding, are more stable than commercial ones.

Every shipbuilder that builds both naval and commercial ships in the same facility acknowledges that it cannot attain the productivity of a pure commercial shipbuilding facility. One Japanese builder claims that the productivity on a commercial ship built after a naval ship is 25 percent lower than that achieved in a purely commercial yard.

Nonetheless, with one exception, all the dual-purpose respondents to our shipbuilder survey could see benefits to their commercial work from their military shipbuilding experience or, less often, vice versa. However, it was pointed out that benefits would largely depend on the ship type. In particular, where warships are involved, the benefits are marginal. Sharing of best practices is more likely where there are greater similarities between ship types—for example, military auxiliary vessels and similar commercial vessels. Among the benefits that military practice can draw from commercial experience are knowledge of purchasing and cost-reducing practices through modern shipbuilding methods. From military experience, the commercial side of the yard can learn about arrangement of tight, complicated compartments; management and control of complex projects; and higher-quality requirements and, in particular, high-technology products where those meet owner requirements within cost constraints. Of course, the yard as a whole benefits from the broader business base, considering the constraints on sales in the increasingly competitive commercial market and in the shrinking defence market. Sometimes yards that specialise in one category of ship have turned to the other to fill gaps in demand and thus retain trained, skilled workers.

CHAPT+R S+V+N

Conclusion

Given that the MOD is responsible for more than 80 percent of the demand for the products of the UK shipbuilding industry, it would appear prudent to coax the industry into attaining competitive status in a broader market. Formidable impediments stand in the way of achieving such a goal, however. For one thing, warship design and production are different from commercial counterparts in most respects. From concept and design to testing and sea trials, military shipbuilding proceeds at a slower pace, to more exacting standards, monitored by a larger white-collar staff and a broader array of interested parties. The more demanding standards to which military shipyards are accustomed and their need to carry higher office overhead will not well support attempts by them to enter the commercial market. Such endeavours would also fly in the face of a historical trend towards greater specialisation by shipbuilders in military or commercial markets only.

Moreover, there is more construction capacity worldwide than is needed to meet the demands for both commercial and military ships. All the market segments, too, are filled with multiple competitors vying for a modest number of contracts. While there appears to be some relief to the commercial overcapacity problem with recent orders, the industry is erratic, and if the past is prologue, a downturn will soon follow.

Given the United Kingdom's industrial infrastructure and culture, it would seem most likely to find success in the commercial market in building cruise ships and other complex vessels. However, these market segments are already dominated by competing shipbuilders elsewhere in Europe, and those industry leaders are themselves being challenged by lower-cost competitors in Asia.

Successful commercial builders are thus looking to military export markets for a more secure flow of profits. The United Kingdom, one of Europe's leaders in military ship production, might appear to have an advantage there. However, the ships that UK builders are used to producing are much larger, more complex, and more expensive than desired by the second-tier navies that are the principal importers. The United Kingdom's European competitors have already designed and produced the modular frigates and small, conventionally powered submarines that are the mainstays of the export market. Moreover, the export market is limited in scope. Importers are at least as interested in local licensed construction to a foreign design as they are in buying ships constructed elsewhere.

While prospects for broadening UK shipyards' customer base appear to be poor, the shipbuilding industry is a volatile one, and events could always break unexpectedly in the United Kingdom's favour. Taking advantage of such opportunities requires some preparation, such as the development of less-expensive warship designs that reflect the needs of potential buyers.

There is the possibility that UK shipbuilders could create some of their own opportunities by developing designs, both military and commercial, that would be attractive enough to lure buyers away from established suppliers. The United Kingdom may be able to manoeuvre around continental business models if these models tend to ossify with success. A generation-skipping design or dramatic technological advances in systems or materials could compensate for a lack of market position, particularly given the United Kingdom's reputation for military technology and systems integration. In particular, about 70 percent of the value of many commercial ships is in installed equipment, so research and development directed towards advances in such equipment could also be fruitful. While not necessarily benefiting shipbuilding per se, such a programme could enlarge the UK marine equipment industrial base and might make use of some shipyard shore-side design, engineering, and production capability.

Development of new designs and technologies requires investment, of course, on the part of shipbuilders and potentially on the part of the government if appropriate and consistent with EU rules. Any such investments will be risky because the probabilities of payoff will not be high, but externalities might accrue to domestic military shipbuilding and to other UK industries.

APP+NDI A

Commercial and Military Ship Tonnage Definitions and Comparisons

We use measures of ship size frequently throughout this report. The sizes of commercial and military ships are measured with different systems. Warships are typically measured in *displacement tonnage*—the volume of water displaced by the hull beneath the waterline, multiplied by 1 ton per 35 cubic feet, the density of sea water. Displacement tonnage may be reported in terms of light ship weight (LSW) or full load (FL), where the difference represents the weight of fuel, ordnance, crew, water, food, and other transported items. Commercial ships are usually measured in *gross registered tonnage* (GRT)—not a measure of the ship's weight but of the internal capacity of most of the enclosed space on the ship, figured at 1 ton per 100 cubic feet. Tankers and bulk cargo ships are also measured in *deadweight tonnage*—a measure of the total weight of cargo, stores, etc., that can be carried.

There are reasons for the use of these different measures. LSW is not reported in available commercial shipping databases because the information is of no value to commercial interests until the ship is sold for scrap. Of course, volume is not typically of interest in characterising a warship. However, to compute total industrial output, we need a common measure. Typically, we convert military ship LSW to 'equivalent GRT' by multiplying LSW by two, an equivalence factor derived from instances in which both displacement and GRT are reported for commercial ships (they are not both reported for military ships). The factor is roughly correct only in aggregate. This is a weight-to-volume conversion and could work for all ships only if all were equally ‘dense’, and that is obviously wrong. Submarines are much denser than landing ships. However, a rough, aggregate factor is sufficient for our purposes.

For Table 3.1 in Chapter Three, we convert commercial ship size data to LSW. Where data are available, commercial LSW can be determined by subtracting reported values for ship deadweight tonnage from full load displacement tons. The difference must then be multiplied by a factor (we chose 0.97[1]) to account for crew, food, water, and other non-cargo loads. However, Lloyd’s provides these data for only about a third of all the ships in its database and not for ships in all classes. It is not possible to impute the others from the average relationships among the third that are known because deadweight tonnage per LSW ton increases sharply with ship size. We have thus restricted LSW inferences to commercial ships that are close in deadweight tonnage to ship types for which we have cost information (we do not have deadweight, displacement tonnage, and cost for any commercial ship).

In Chapter Four, Table 4.2 and Figure 4.2, we reported results based on *compensated gross tonnage*, a measure of ship size and complexity adjusted by ship type to reflect differences in value per ton. It was devised by the Organisation for Economic Co-operation and Development (OECD). We were told by Danny Scorpecci,[2] OECD’s Principal Administrator for Maritime Transport, that the factors were not derived analytically but rather represent agreements among OECD shipbuilders as to relative shipbuilding costs. Compensation factors range from 1.85 to 0.30 on deadweight tonnage for small to large crude oil tankers and from 6.00 to 1.25 on GRT for small to large passenger ships. The factors reflect the larger construction cost per ton for a small ship than a large ship and for a complex passenger ship than a simple cargo ship.

[1] We can only cite expert judgment here as a basis, but this adjustment is in any event lost in the uncertainty attending the overall GRT-to-LSW conversion and does not affect the conclusion we draw.

[2] Interviewed October 24, 2002.

APP+NDI B

Selected National Commercial Shipbuilding Order Books

Table B.1
German Commercial Shipbuilding Order Book

Ship Name or Builder's Designation	Type	Number Ordered	GRT	Build Year	Builder (Short Name)
Norwegian Dawn	Cruise	1	92,250	2002	Meyer
Serenade of the Seas	Cruise	1	90,090	2003	Meyer
’ewel of the Seas	Cruise	1	90,090	2003	Meyer
659	Cruise	1	90,090	2005	Meyer
660	Cruise	1	90,090	2005	Meyer
Aidaaura	Cruise	1	42,600	2003	Aker
PontXAven	Passenger/ RORO cargo	1	39,600	2004	Meyer
Norrona	Passenger/ RORO cargo	1	39,600	2003	Flender
444–446	Container	3	34,000	2003	Volkswerft
721–722	RORO cargo	2	30,800	2003	Flensburger
723–724	RORO cargo	2	30,800	2004	Flensburger
725	RORO cargo	2	30,800	2005	Flensburger
Wehr Oste	Container	1	25,705	2002	qvaerner
30–34	Container	5	25,705	2003	qvaerner
35	Container	1	25,705	2004	qvaerner
[Unknown]	Container	4	25,369	2003	Aker
[Unknown]	Container	2	25,369	2004	qvaerner
16–19	Container	4	25,368	2003	Aker
P&O Nedlloyd Hunter Valley	Container	1	25,286	2002	Aker
15	Container	1	25,286	2002	Aker
Beechy Head	RORO cargo	1	22,900	2003	Flensburger
Longstone	RORO cargo	1	22,900	2003	Flensburger
+berhard Arctic	Chemical/ oil products tanker	1	22,422	2002	Lindenau
Sealeng	Chemical/ oil products tanker	1	21,353	2003	Lindenau
251	Chemical/oil products tanker	1	21,353	2003	Lindenau

Table B.1—Continued

Ship Name or Builder's Designation	Type	Number Ordered	GRT	Build Year	Builder (Short Name)
254, 258	Chemical/ oil products tanker	1	21,353	2004	Lindenau
255	Chemical/ oil products tanker	1	21,353	2005	Lindenau
663	Passenger ship	1	15,200	2004	Meyer
Taurus ′	Container	1	14,062	2002	Peene
Cape Falcon	Container	1	14,000	2003	Peene
Cape Ferro	Container	1	14,000	2003	Peene
Cape Fox	Container	1	14,000	2003	Peene
Cape Frio	Container	1	14,000	2003	Peene
[Unknown]	Container	2	14,000	2004	Peene
Platinum Project 01	Yacht	1	11,600	2004	Blohm Voss
Pachuca	RORO cargo	1	10,000	2003	Hegemann
Lina	Container	1	9,995	2002	Sietas
Pioneer Lake	Container	1	9,995	2003	Sietas
Maria	Container	1	9,995	2003	Sietas
1070, 1140–1142	Container	4	9,990	2004	Sietas
Octopus	Yacht	1	9,700	2003	Howaldtswerke
Panchino	Vehicle carrier	1	9,230	2003	Hegemann
Parnavera	Vehicle carrier	1	9,230	2003	Hegemann
1137, 1138	General cargo	2	8,397	2003	Sietas
1159, 1160, 1165, 1166	Container	4	7,600	2003	Sietas
442	Offshore tug/ supply	1	6,536	2003	Volkswerft
443	Offshore tug/ supply	1	6,530	2003	Volkswerft
447, 448	Offshore tug/ supply	2	6,500	2004	Volkswerft
Corvus ′	Container	1	6,470	2003	Hegemann

Table B.1—Continued

Ship Name or Builder's Designation	Type	Number Ordered	GRT	Build Year	Builder (Short Name)
[Unknown]	Container	1	6,384	2003	Hegemann
+uro Snow	Container	1	5,900	2002	Peters
Maria S. Merian	Research	1	5,300	2004	qroeger
[Unknown]	Oil products tanker	1	4,200	2002	Cassens
Orion	Cruise	1	4,000	2003	Cassens
Ocean +xplorer	Cruise	1	3,900	2004	Cassens
537	Research	1	3,800	2004	Thyssen
337–339	General cargo	3	2,500	2003	Ferus Smit
13626	Yacht	1	1,100	2003	Lürssen
Total			1,840,771		

Aker: Aker MTW Werft GmbH–Wismar
Cassens: Schiffswerft u. Maschinenfabrik GmbH Cassens–+mden
Blohm Voss: Blohm Voss AG–Hamburg
Ferus Smit: Ferus Smit Leer GmbH
Flender: Flender Werft AG–Lübeck
Flensburger: Flensburger Schiffbau–GmbH & Co. qG–Flensburg
Hegemann: Detleff Hegemann Rolandwerft GmbH & Co. qG–Berne
Howaldtswerke: Howaldtswerke–Deutsche Werft AG–qiel
qroeger: qroeger Werft GmbH & Co. qG–SchachtXAudorf
qvaerner Warnow: qvaerner Warnow Werft GmbH–Warnemünde
Lindenau: Lindenau GmbH Schiffswerft u. Maschinenfabrik–qiel
Lürssen: Fr. Lürssen Werft GmbH & Co.–Bremen
Meyer: ’os. L. Meyer GmbH–Papenburg
Peene: PeeneXWerft GmbH–Wolgast
Peters: Peters Schiffbau AG–Wewelsfleth
Sietas: ’. ’. Sietas qG Schiffswerft GmbH & Co. qG–Hamburg
Thyssen: Thyssen Nordseewerke GmbH–+mden
Volkswerft: Volkswerft GmbH Stralsund

Table B.2
Dutch Commercial Shipbuilding Order Book

Ship Name or Builder's Designation	Type	Number Ordered	GRT	Build Year	Builder (Short Name)
988	Passenger/ RORO cargo	1	37,000	2003	Giessen– de Noord
989	Hopper dredger	1	28,000	2003	Giessen– de Noord
in Hai Long	Hopper dredger	1	15,400	2002	IHC Holland
9101, 9102	HeavyXload carrier	2	15,069	2003	Damen Hoogezand
695, 696	Hopper dredger	2	14,000	2004	Merwede
824	General cargo	1	13,767	2002	Damen Hoogezand
Uilenspiegel	Hopper dredger	1	12,958	2002	Merwede
CO1234	Dredger	1	10,000	2003	IHC Holland
MutzelfeldtX werft 244, 245	Container	2	9,500	2004	Damen Hoogezand
Toisa Proteus	Offshore support	1	7,950	2002	YVC Ysselwerf
Natasha C	General cargo	1	7,752	2002	Damen Hoogezand
Vanessa C	General cargo	1	7,752	2002	Damen Hoogezand
Ile de Reunion	General cargo	1	7,460	2002	Damen Hoogezand
[Unknown]	General cargo	6	7,460	2002	Damen Hoogezand
enia	General cargo	1	7,406	2002	Damen Hoogezand
990	Hopper dredger	1	8,500	2003	Giessen– de Noord
991	Hopper dredger	1	8,500	2004	Giessen– de Noord
350	General cargo	1	6,350	2003	Bodewes Volharding
821, 822	General cargo	2	6,305	2002	Damen Hoogezand
Chandra qirana	General cargo	1	6,301	2002	Bodewes Volharding
694	Bitumen tanker	1	5,000	2003	Bijlsma
618	General cargo	1	4,983	2003	Bodewes Volharding
Scan Runner	General cargo	1	4,941	2002	Bodewes Hoogezand

Table B.2—Continued

Ship Name or Builder's Designation	Type	Number Ordered	GRT	Build Year	Builder (Short Name)
CO1233	Hopper dredger	1	4,515	2003	IHC Holland
340–342	Oil products tanker	3	4,300	2003	Ferus Smit
343, 344	Oil products tanker	2	4,300	2004	Ferus Smit
380	Other nonmerchant	1	3,900	2003	Schelde
381	Other nonmerchant	1	3,900	2004	Schelde
Caballo de Trabajo	Offshore supply	1	3,500	2002	Hoop
392	Offshore support	1	3,500	2002	Hoop
Mellina	Dredger	1	3,434	2002	IHC Holland
Trinitas	General cargo	1	3,214	2003	Peters
804–806	General cargo	3	3,214	2003	Peters
807–810	General cargo	4	3,214	2004	Peters
761, 762	General cargo	2	3,000	2002	Damen Hoogezand
521	General cargo	1	2,829	2003	Bodewes Volharding
477	General cargo	1	2,785	2002	Peters
481	General cargo	1	2,780	2002	Peters
Orisant	Hopper dredger	1	2,744	2002	Barkmeijer
Arklow River	General cargo	1	2,700	2003	Barkmeijer
790	Yacht	1	2,650	2004	Van Lent
Celtic +xplorer	Research	1	2,500	2002	Damen Gorinchem
+spero	General cargo	1	2,400	2002	Damen Bergum
9346	General cargo	1	2,400	2002	Damen Bergum
9348, 9349	General cargo	2	2,400	2003	Damen Bergum
Oerd	Passenger/RORO cargo	1	2,286	2003	Bijlsma
Smaragd	General cargo	1	2,200	2003	Barkmeijer
8312, 8313	General cargo	2	2,100	2002	Damen Bergum

Table B.2—Continued

Ship Name or Builder's Designation	Type	Number Ordered	GRT	Build Year	Builder (Short Name)
469	General cargo	1	2,056	2002	Peters
474	General cargo	1	2,056	2003	Damen Bergum
9109	Hopper dredger	1	2,000	2003	Damen Hoogezand
[Unknown]	Tug	2	2,000	2003	Damen Hoogezand
9987	General cargo	1	1,768	2002	Damen Bergum
9329, 9332	General cargo	2	1,700	2002	Damen Bergum
9326	General cargo	1	1,700	2003	Damen Bergum
Sepia	General cargo	1	1,500	2002	Pattje
442	General cargo	1	1,500	2002	Pattje
9324, 9325, 9327, 9328	General cargo	4	1,400	2003	Damen Bergum
705	LNG tanker	1	1,200	2003	Bijlsma
Total			470,543		

Barkmeijer: Barkmeijer Stroobos B. V.
Bijlsma: Scheepswerf Bijlsma Lemmer B. V.
Bodewes Hoogezand: Bodewes' Scheepswerven B. V.–Hoogezand
Bodewes Volharding: Bodewes Scheepswerf 'Volharding' Foxhol B. V.
Damen Bergum: B. V. Scheepswerf Damen Bergum
Damen Gorinchem: B. V. Scheepswerf Damen–Gorinchem
Damen Hoogezand: B. V. Scheepswerf Damen Hoogezand–Foxhol
Ferus Smit: Scheepswerf Ferus Smit B. V.–Westerbroek
Giessen–de Noord: van der Giessen–de Noord B. V.–qrimpen a/d I'ssel
Hoop: Scheepswerf de Hoop Lobith B. V.
IHC Holland: IHC Holland N. V. Dredgers–qinderdijk
Merwede: B. V. Schps & Mfbk 'De Merwede' v/h van Vliet & Co.–Hardinxveld
Pattje: Scheepswerf Pattje B. V.–Waterhuisen
Peters: Scheepswerf Peters B. V.–qampen
Schelde: Schelde Scheepsnieuwbouw B. V.–Vlissingen
Van Lent: 'achtXen Scheepswerf C. van Lent & Zonen B. V.–qaag
YVC Ysselwerf: YVC Ysselwerf B. V.–Capelle a/d Ijssel

Table B.3
US Commercial Shipbuilding Order Book

Ship Name or Builder's Designation	Type	Number Ordered	GRT	Build Year	Builder (Short Name)
484	CrudeXoil tanker	1	96,000	2003	NASSCO
485	CrudeXoil tanker	1	96,000	2004	NASSCO
486	CrudeXoil tanker	1	96,000	2005	NASSCO
Polar Adventure	CrudeXoil tanker	1	85,387	2003	Avondale
Polar +nterprise	CrudeXoil tanker	1	85,387	2004	Avondale
Polar Discovery	CrudeXoil tanker	1	85,099	2002	Avondale
487	CrudeXoil tanker	1	79,000	2006	NASSCO
7671, 7672	Cruise	2	72,000	2004	Ingalls
Midnight Sun	RORO cargo	1	60,864	2002	NASSCO
North Star	RORO cargo	1	60,864	2003	NASSCO
[Unknown]	Cruise	2	42,000	2002	Ingalls
'ean Ann	Vehicle carrier	1	40,000	2002	HalterX Pascagoula
[Unknown]	Vehicle carrier	1	40,000	2002	HalterX Pascagoula
001	Container	1	32,000	2003	qvaerner
002	Container	1	32,000	2004	qvaerner
[Unknown]	Container	2	31,600	2005	qvaerner
471, 472	General cargo	2	7,000	2005	NASSCO
[Unknown]	General cargo	1	7,000	2005	NASSCO
7260	Container	1	6,000	2002	Bender
7255	Container	1	6,000	2003	Bender
[Unknown]	Hopper dredger	1	4,000	2004	Bender
Laney Chouest	Tug	1	4,000	2002	North American
+mpress of the North	Cruise	1	3,388	2003	Nichols
Paul W. Murrill	Offshore supply	1	3,200	2002	Quality
1234	Offshore supply	1	3,200	2002	Quality
1235–1238	Offshore supply	4	3,200	2003	Quality
Damon B. Bankston	Offshore supply	1	3,183	2002	Quality

Table B.3—Continued

Ship Name or Builder's Designation	Type	Number Ordered	GRT	Build Year	Builder (Short Name)
Mackinaw	Icebreaker	1	2,700	2005	Marinette
Chenga	Passenger/RORO cargo	1	2,500	2004	Derecktor
Fairweather	Passenger/RORO cargo	1	2,500	2005	Derecktor
750	Dredger	1	2,500	2002	Marinette
211,213, 214	Offshore supply	3	2,500	2002	North American
218, 219	Offshore tug/supply	2	2,500	2003	North American
146	General cargo	1	2,500	2002	Portier
[Unknown]	Offshore supply	7	2,000	2004	Bender
[Unknown]	Offshore supply	2	2,000	2005	Bender
MNM Boats	Offshore supply	1	2,000	2002	Bollinger
IBOM	Offshore supply	1	2,000	2002	Horizon
+d qyle	Offshore supply	1	1,931	2002	Bender
Oak	Buoy/lighthouse	1	1,930	2002	Marinette
Fir	Buoy/lighthouse	1	1,930	2003	Marinette
Hickory	Buoy/lighthouse	1	1,930	2003	Marinette
Sequoia	Buoy/lighthouse	1	1,930	2003	Marinette
Alder	Buoy/lighthouse	1	1,930	2004	Marinette
Hollyhock	Buoy/lighthouse	1	1,930	2004	Marinette
Collins Tide	Supply	1	1,882	2002	Bender
[Unknown]	Offshore supply	4	1,815	2003	Leevac
[Unknown]	Offshore supply	2	1,800	2002	Leevac
[Unknown]	Supply	1	1,600	2003	HalterX Gulfport
Miss Sarah ’ane	Offshore supply	1	1,599	2003	Bollinger
Cape Cod Light	Cruise	1	1,564	2002	Atlantic
777, 778	Offshore supply	2	1,500	2002	+astern
[Unknown]	Offshore supply	4	1,500	2003	+astern
Oscar Dyson	Research	1	1,500	2004	HalterX Gulfport

Table B.3—Continued

Ship Name or Builder's Designation	Type	Number Ordered	GRT	Build Year	Builder (Short Name)
[Unknown]	Offshore supply	4	1,375	2003	Bollinger
[Unknown]	Supply	1	1,200	2004	Bender
[Unknown]	Crewboat	1	1,200	2002	C&G
[Unknown]	Crewboat	3	1,200	2003	C&G
[Unknown]	Passenger	1	1,200	2004	Chesapeake
130	Offshore supply	1	1,200	2002	Houma
131–133	Offshore supply	3	1,200	2003	Houma
134, 135	Offshore supply	2	1,200	2004	Houma
Cloud	Passenger	1	1,025	2002	Nichols
Total			1,363,253		

Atlantic: Atlantic Marine Inc.
Avondale: Avondale Industries Inc., Shipyards Division
Bender: Bender Shipbuilding & Repair Co. Inc.
Bollinger: Bollinger Machine Shop & Shipyard Inc.
C&G: C&G Boat Works Inc.
Chesapeake: Chesapeake Shipbuilding Inc.
Derecktor: Derecktor Shipyards (Robert +. Derecktor Inc.)
+astern: +astern Shipbuilding Group
HalterXGulfport: Halter Marine Gulfport Inc.
HalterXPascagoula: Halter Marine Pascagoula, Inc.
Houma: Houma Fabricators Inc.
Ingalls: Ingalls SB. Division of Litton Systems Inc.
qvaerner: qvaerner Philadelphia Shipyard Inc.
Marinette: Marinette Marine Corp.
NASSCO: National Steel & Shipbuilding Co.
Nichols: Nichols Bros. Boat Builders Inc.
North American: North American Shipbuilding
Portier: Russell Portier Inc.
Quality: Quality Shipyards LLC

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