

SHIPBUILDING, KNOWLEDGE, TECHNOLOGY AND HERITAGE PORTUGUESE SHIPBUILDING & LOW COUNTRIES PRACTICES: IBERIAN INFLUENCES IN THE DUTCH GOLDEN AGE

RICHARD W. UNGER

INTRODUCTION

Dutch shipbuilding established the standard for quality in seventeenth-century Europe. By any measure its example was the one to copy. The Dutch Republic in the seventeenth century was the envy of all of Europe. Most obviously to contemporaries the economy thrived on the expansion of shipping. It was Dutch shipbuilders who supplied the vessels for the success that was a cornerstone of the most prosperous economy in Europe and probably the world at the time. «The advantages gained by cheap and adaptable shipbuilding, and cheap and careful navigation, were summed up in the lowest freight rates in Europe, and the most extensive and efficient merchant marine»¹. Historians have written a great deal more about the roots of Dutch economic success since the publication of Barbour's powerful claim². There were many other sources of Dutch success, however, superior transportation on the water, whether rivers, canals, lakes or the high seas, remains critical to any explanation for the prosperity of the Golden Century and the sustained high levels of income down to the end of the eighteenth century. Even if historians raise some questions about the relative importance of shipping and shipbuilding people in seventeenth-century Europe were in no doubt. Foreigners bought Dutch ships, even entrepreneurs from a major port and long-time centre of shipbuilding as Venice. Others tried to capture Dutch ships to add those vessels

¹ BARBOUR, 1930: 285.

² For example and among many others, DE VRIES & WOUDE, 1997; ZANDEN, 1993; PRAK & WEBB, 2005.

to their merchant marines³. Other states imported Dutch shipwrights to show them how to make the best ships⁴. In the case of France, Jean-Baptiste Colbert, the finance minister of King Louis XIV, even sent spies, three of them in 1669, 1670 and 1671, to watch shipbuilders in action at home in Holland and to bring back guidelines for French shipwrights. The trio included his own son, along with two others knowledgeable in shipbuilding. The minister gave precise directions about what they were to find out. The spies went to Holland, to England and one went to Italy. Each was to compare building methods with those in France⁵. Their extensive reports along with the sketches they supplied of Dutch shipbuilding were part of the fascination with Dutch success and another sign of the superiority of the work of Low Countries construction practices.

In the late fifteenth and first half of the sixteenth century Portuguese shipbuilding was the standard for quality in Europe. It was in that way in a similar position to the one the Dutch industry was to hold in the following century and a half. Portuguese sailors made their impressive long distances voyages in the products of domestic yards. Shipbuilders launched not just small vessels that could make their way along unknown coasts and also carry paying cargoes. They produced the larger cousins of those craft with similar rigs which in turn could serve effectively in trades to the Atlantic islands and on to Brazil. The most impressive of all the ships that came down the slipways along the Tagus and elsewhere in the world were the giants able to make the long voyage around the Cape of Good Hope and across the open ocean to India. Those vessels that came from yards in Lisbon and smaller ports up the coast to the north reached sizes and levels of efficiency not seen since the Roman Empire. Foreigners were astounded by the scale of those Portuguese behemoths. The variety and quality of Portuguese ships made them vessels to imitate and Portuguese shipbuilders furnished invaluable examples of how to approach the task of constructing the most impressive vessels of the day⁶.

In both cases, first with the Portuguese and then with the Dutch, it was the ability to provide the latest and best technology that made them stand out and also made them the envy of other Europeans. For the Dutch certainly by 1600 it was also the ability to produce large numbers of ships and to do so quickly whereas for the Portuguese it was more the size of each of the massive sea-going giants rather than the number of vessels that ensured their place of prominence. In Portugal both royal shipyards and private enterprises participated in supplying effective vessels. In the Dutch Republic at least through much of the seventeenth century most of the many ships came from yards owned and operated by independent shipwrights. The difference in ownership seemed to make little difference in levels of skill. In Portugal the demands of politics

³ DAVIS, 1962: 48-54. The English followed the practice of Spanish and then French privateers based at Dunkirk. BAETENS, 1976: 50-65. The Dutch did retaliate. BRUIJN, 1979.

⁴ For example DILLEN, 1974: vol. 3, n.º 40 (1633), n.º 1312 (1655), n.º 1313 (1655), n.º 1316 (1655), n.º 1369 (1668).

⁵ COLBERT & CLÉMENT, 1864-1865: vol. 3, part 1, 132-133, 199-200, 211.

⁶ For a discussion of the products of Portuguese shipyards, DOMINGUES, 2004: 221-299.

may have impinged more on what sorts of ships were built and where the work was done and possibly been a cause of problems on the route to India in the second half of the sixteenth century. Otherwise accomplishments were similar. In both cases their superior ships led to commercial success for shippers and traders in their countries and also to international trading empires. Of course the design and construction of ships was not the only factor creating those international networks of exchange and authority. For the fledgling Dutch Republic and for the struggling Portuguese kingdom having the ability to dominate the seas was a critical factor for commercial and political success, an example imitated by one state after another in later centuries.

The Portuguese ran into difficulties, technical in shipbuilding and politically in union with the Spanish crown, in the later sixteenth century just as Dutch commercial exchange was enjoying a sharp improvement. Despite the problems, the Portuguese were able to bounce back in the course of the seventeenth century and not only endured but also prospered as a centre of commerce and shipbuilding. The Dutch ran into difficulties in the eighteenth century, faced with a multitude of political threats and increasing commercial competition, but they endured, continued to enjoy the highest standard of living possibly on the planet into the nineteenth century while also remaining a major shipping and shipbuilding country. Not incidentally Portuguese fortunes took a turn for the better in the eighteenth century. There was a revival in commerce and so in the merchant marine along with improvement in the economy which was, as in previous centuries, connected to effective transport over the ocean.

There were similarities in the success of the two and in the role of shipbuilding in that success but not in the kind and type of ships they built or the methods that dominated their shipbuilding wharves. The Portuguese excelled in the construction of very large vessels for long distance travel. First it was carracks for voyages between parts of Europe especially Portugal and the Low Countries. Trade to the northern part of the continent grew as the newly expanding exchange with west Africa, a by-product of voyages of exploration, generated cargoes for sale in European ports. Second it was the giants for travel back and forth to India and parts of East Asia. At the same time shipwrights constructed smaller vessels with unique rigs for long reaches across the Atlantic. There was extensive fishing inshore and on the ocean which created demand for various boat types of different dimensions for local markets. The Dutch, on the other hand, built slow moving bulk carriers for short voyages within Europe. Costs were critical to success since the value for each unit of volume of those cargoes was much lower than for the goods in Portuguese holds. The Dutch compensated for the low unit profits by shipping large quantities of goods and not in large ships but in large numbers of ships. By the seventeenth century some Dutch captains were making extra-European voyages which placed new and more varied demands on the shipyards of the Low Countries. Despite the voyages to the East Indies and the New World it was intra-European bulk trades

which continued to be the basis for prosperity and bulk carriers remained the principal products of the booming shipbuilding wharves. The Dutch had an extensive fishery as well, the most lucrative being in the North Sea. The fishers used specific types designed to catch specific species.

The locations of the two emerging states, one a kingdom the other a republic, dictated to a great extent the character of commerce. Portugal had a lengthy coast on the Atlantic Ocean. There were many inlets and a few mouths of rivers that produced likely locations for harbours and so for shipyards. Inland navigation was difficult since, other than the Tagus, river navigation was made difficult by the narrowness and the fall of the streams that came down from the hills in the central and eastern part of the kingdom. The location in southern Europe and jutting out into the Atlantic on the western fringe of Iberia made long distance trade logical. Equally logical was taking on the role of intermediary in exchange between northern Europe and Africa as well as a supplier of New World products to the Old. The differences in topography and geography between Portugal and the Dutch Republic were reflected in differences in commercial patterns and in ships built. Largely in the delta of the Rhine River, the Low Countries were a maze of rivers and streams with lakes spread around the landscape. Over time the residents enclosed swamps and lakes to create farmland. To that end they built canals for drainage but also avenues for travel. Transportation inland was largely by water. There were no hills or fast flowing streams to worry about. The North Sea offered access to the Atlantic Ocean and to the Baltic but in both cases with seaways that needed to be negotiated, a task that could prove difficult in contrary weather conditions. The seas and the Rhine made the Low Countries the logical centre for the distribution of goods from eastern Europe and from the south to seaports in the north as well as to towns along the extensive river system in western Germany. Dutch shipbuilders and merchants in the course of the seventeenth century also made the Low Countries the entrepot for goods from Asia and the New World, using existing networks of distribution and getting goods from distant ports by expanding the scope of their shipping to all parts of the world. Vessels had to be of shallow draught to reach many Dutch ports, a problem that rarely vexed Portuguese builders. The ability to reach many different types of ports was also a requirement of Dutch ships that was not generally one in Portugal. It was often advantageous to move the colonial goods that were a central feature of Portuguese trade quickly so speed was more important than in the Netherlands where grain and fish and salt could make their way at a slow pace to their destinations.

Circumstances, economic, technological and geographical, made Portuguese and Dutch commerce different and so made the demands placed on the designers and builders of ships different in significant ways. The expectation then is that there would have been little relationship between Dutch and Portuguese shipbuilding. Any connection between the two industries and enterprises is not obvious. There is rarely any mention

of the two together. However, there were two facets of ship construction which showed ties between the building of ships in the two states. First, there was a practical connection. The Dutch relied on Portuguese and Iberian forms in general to guide them in developing a syncretic building method and then in moving on to a full imitation of southern practice. The adoption of the way Portuguese shipbuilders designed their vessels allowed the Dutch to produce the types and the range of vessels that brought them so much success. Second, there was a theoretical connection. When native writers in the late seventeenth century came to describe Dutch construction practices and, in the process, to give some theoretical basis for those practices, in general and in one specific case it was inspiration from Portugal which offered guidance.

Portuguese shipbuilders were early adopters of what emerged in the Middle Ages as the Mediterranean/Iberian/Atlantic method of construction. There were predecessors and some remnants through the late medieval centuries of more northerly designs that came from Lusitanian shipyards. Northern Europeans from Scandinavia and later from England and the Low Countries visited the Portuguese coast starting in the ninth century if not before, exposing local builders to the common design features of ships in the tradition of the German rowing barge⁷. The barks built and used along the Iberian Atlantic coast were smaller ships and may well, like keels in England and France, have descended from the sea-going cargo vessels of Vikings. Little is known about the type of vessel built in Iberia but the vessels in England and France, illustrated on town seals, show overlapping planking of the hull and a single square sail on a single mast stepped in about the middle of the ship. Barks could be serviceable open fishing vessels as well as coastal traders. Portuguese builders also generated by the fourteenth century a modified sea-going ship derived from a Mediterranean fishing boat. Caravels proved highly useful along the African coast and have enjoyed a great deal of notoriety among historians for their role in exploration in the fourteenth and fifteenth centuries.

The most impressive accomplishment and the one with the greatest impact, both in the short and long term was the Portuguese version of the carrack. It was a full-rigged ship, the exact dating of the emergence of the type with a combination of square and lateen sails is not known though probably it occurred in the late fourteenth century in or around Portugal. Hulls by that time were built frame-first. That form of construction was in common use in southern Europe by the year 1000. The method evolved from Roman practice of building hull-first with the new approach appearing in the first half of the Middle Ages and probably in the eastern Mediterranean. Portuguese shipbuilders had absorbed and embraced the way to build hulls and they quickly took up the combination rig with three masts, the one at the stern carrying a triangular lateen sail, the one in the middle carrying a large square sail and the one at the bow rigged with a small square

⁷ For a concise discussion of medieval trade relations in general see CHILDS, 2013.

sail to offer some balance to the sail at the stern as well as to aid in steering. The rig relied heavily on the single large mainsail to power the ship through the water with the other smaller sails acting as supplements and aids in shiphandling. Once the new design emerged, builders in Portugal went to work, learning to exploit the potential of the novel marriage of different design features. By the end of the fifteenth century they built carracks capable of carrying sizeable cargoes on regular voyages to northern Europe and across newly-discovered all-sea routes to the New World and to India.

The Portuguese vessel types and forms of construction which made the greatest impression at the time and even now were those big carracks, the biggest being used on the India route. While archaeology has produced details of how builders formed the hull, it is contemporary images of the ships that show the rig and how sailors used the sails. The images, along with vessels excavated, also indicate the relative size of the most impressive products of Portuguese shipbuilding yards. The frames which gave shape and strength to the hull were built up from various pieces and typically linked together with lapped dovetail joints. The way of creating the frames was not really distinctive and the practice is known in other contemporary shipbuilding traditions. The shipwrights laid the keel first and then put up the frames, the principal ones followed by the rest, and then they added the abutting planks to form the watertight hull. Additional planking internally was an option to improve and enhance the integrity of the vessel. The ships ran in length to 25, 35 and even 40 metres, sizes not seen since Antiquity so the method did ensure the ability to build large ships⁸. One reason that was possible was the use of heavy framing. The number of frames per unit of length was, however, lower than was typical of Dutch ships. Indeed, one of the principal differences between Portuguese and Dutch practices was the relatively higher number of frames and lighter frames in vessels built in the Low Countries⁹.

As more wrecks, both Dutch and Portuguese, come to light, it will be possible to identify even more features, at least of hull construction, that separated the two shipbuilding traditions. The history of ship design and of nautical technology in general was until the middle of the twentieth century based on written and pictorial evidence. The mentions or descriptions of ships and navigation methods presented some problems since they were imprecise or cast in language unfamiliar to a modern reader. The problems with interpretation increased the further back in the past any research went. With illustrations ships were often incidental to what artists set out to depict. The medium often dictated distortions in portraying vessels, most obvious with the town seals that provide valuable information about high and late medieval ships in northern Europe because

⁸ On construction methods see the well-illustrated archeological report on a carrack returning from India and wrecked opposite Lisbon in 1606 by ALVES *et al.*, 1998: 194-210. For a full and careful analysis of the construction of the ship see CASTRO, 2005: 47-58, 105-88. MAARLEVELD, 1992: 158-160.

⁹ MAARLEVELD, 2013: 353-56.

the seals had to be round. Whether the ships on those seals were as round as they appear is uncertain. Manuscript illumination might also dictate a certain shape and size to the depiction of a ship. When artists added ships as decoration on maps, something they did more and more frequently in the sixteenth century, they gradually succumbed to standardization, even copying the same type and form of ship whether it accurately reflected current conditions or not¹⁰. There was the enduring problem that artists typically were not familiar with ships or sailing practices. Only in the fifteenth century when the first texts describing shipbuilding began to appear did sketches of ships and their parts come from people with experience of how to construct vessels¹¹. It was in the seventeenth century that sailors turned to drawing and painting ships. From then on works of art became more precise and more reliable. The development of conventions for scientific illustration added to the quality, in terms of transmitting an understanding of the technology involved, of pictures of ships. The limited scope and reliability of sources changed dramatically with the development of SCUBA gear in the mid twentieth century and its use in exploring the sea floor. Relatively quickly and then with greater frequency archaeologists took advantage of the ability to examine shipwrecks. The early successes, especially in the Mediterranean, generated increased interest in nautical archaeology and the perfecting of other methods to study ship remains and to preserve them. In the Netherlands in particular the completion of the enclosing dike which made the Zuider Zee into an inland lake, the IJsselmeer, and the subsequent draining of portions of the lake to create large polders created a boon for archaeologists. As farmers went to work on their newly dry fields they found the remnants of vessels lost in some 650 years that the land had been under water. The study of those more than 400 wrecks has generated a wealth of information about the evolution of Dutch shipbuilding and with an accuracy never possible before¹².

The wealth of new information, while complementing and clarifying what is known from other sources, gives a much more complete and accurate picture of the development of shipbuilding and nautical technology in medieval and early modern Europe. As archaeological investigations continue and, even more important, as the results of the careful analysis that is now typical of the field are made available to readers, a much more precise picture of both Portuguese and Dutch maritime technology will emerge. Much more is now known about the giant carracks that came from Portuguese shipyards. It seems that they did not have all the same design features as other types of vessels produced in the kingdom. Their features may not even have been typical. Knowledge of the details of construction, coming from archaeology and illustrations, strongly suggests

¹⁰ UNGER, 2010: 152-69.

¹¹ See for example MICHAEL *et al.*, 2009: vol. 1.

¹² On the early development of work in the polders and the expectations for the future of those involved see HEIDE, 1974: 363-456; HOLK, 2003: 296.

that they were not representative of Portuguese shipbuilding. From written sources, though, it seems clear that it was the very large vessels which impressed contemporaries, set Portuguese ships apart and which served as the basis for the world-spanning commercial empire of the sixteenth century¹³. Their now-documented technical features indicated the potential, in both rig and hull design, for Portuguese shipbuilding. It was the vessels which opened new avenues of intercontinental commerce and shifted the geopolitical balance which impressed contemporaries. It was the building and use of those carracks which others recognized as a pattern to follow.

In the Low Countries what the Portuguese did so impressed the ruler that he turned to Lusitanian shipwrights to introduce his people and his lands to Mediterranean/Iberian ship design. Duke Philip the Good of Burgundy, ruler of much of the Low Countries in 1439 brought Portuguese craftsmen to his emerging capital at Brussels to build a ship. The vessel, which was lost to pirates on a trip to the Mediterranean seven years later, was built all but certainly in the Iberian way with heavy frames set up first. That was not the only case of people in the Netherlands seeking out examples of the products of southern shipbuilding. Records from 1457, 1468 and 1477 show governments acquiring ships from Iberia for naval use. Though by 1460 vessels of frame-first construction in imitation of Portuguese practice were coming from Low Countries yards, it is now clear from archeological evidence that Dutch builders did not simply copy what was done in the South but that they modified those methods in light of both their own knowledge and traditions as well as the commercial and geographical circumstances¹⁴.

Traditional Dutch shipbuilding followed the norm of medieval northern Europe. Hulls were clinker-built. The overlapping external planks supplied structural integrity and watertightness. Builders put up the hull first. They added the frames and other internal strengthening after the hull was complete or at least nearly complete. There was a type with Celtic roots and features of Nordic practice which evolved in the course of the twelfth and early thirteenth century to become the major bulk carrier in the North and Baltic Seas. The cog is usually associated with the ports on the north German coast which belonged to the Hanseatic League. Archaeological as well as documentary evidence indicates that Low Countries builders produced them as well with something close to half of the known cog wrecks dating from around 1150 to the early fifteenth century found in the Low Countries¹⁵. While there has been some recent discussion about the exact character of the cog and how the name was applied and though there were certainly variations in the details of construction, over time and from one part of

¹³ An example was the *Madre de Dios*, captured by English privateers in 1592 on a return trip from India. Contemporaries were more interested in the valuable cargo than what was the largest ship ever seen in England at more than 53 metres in length. She remained at anchor at Dartmouth for some time and did draw visitors (BOVILL, 1968: 138-45; KINGSFORD, 1910: 91).

¹⁴ BEYLEN, 1970: 7-8; UNGER, 1978: 32-33.

¹⁵ HOCKER & DALY, 2016: 187.

northern Europe to another there were certain features that usually marked vessels that can be called cogs or cog-like. By the fourteenth century the type was certainly a flat-bottomed cargo ship¹⁶. There were variations in construction, variations which appear to have increased over time, possibly under influence from southern Europe. The sides were clinker-built and the bottom had flush planking. The cog was built shell-first with strength coming from external planks and not from the frames which wrights added later to offer reinforcement and stability. The overlapping planks were typically held in place with iron nails, in many cases though not always bent over twice. Not all vessels with lapstrake construction had consistent use of nails. Some had their planks fixed to each other with roves and rivets or treenails or even with a combination of the two types of fastening though the last may have been rare. Treenails may have been typically the preferred solution for planks that would remain underwater since after launch the wooden pegs would have expanded and so created a tighter fit¹⁷. The keel was rather a bottom plank, typically light and not much thicker or heavier than the other planks that formed the flat bottom. It was more a strake holding both sides together than a spine for the ship. That gave the cog a relatively shallow draught which was an important feature in a region with shallow streams and lakes. Still it was that central plank in combination with the straight posts at stem and stern, attached to the keel with angled timbers called hooks, that formed the backbone of the ship¹⁸.

To hold the abutting bottom planks in place during construction, that is before putting on the sides and setting up the frames, builders placed small cleats on the outside and held those in place with treenails. Once work was done and the hull was sound, they took away the small pieces of wood stretched perpendicularly across the seams and then filled the holes left when they extracted the treenails with small nail-like pieces of wood called *spijkerpennen*. That was not true of all cogs though few of the wrecks excavated so far lack the remnants of the use of cleats to keep the bottom planks in place during construction. At the turn of the sides where the flat-bottom flush planking changed to curved overlapping planking at least in one case from around the 1330s there are more *spijkerpennen* than on the bottom, suggesting that extra reinforcement was needed to take the strain from the curving of the planks¹⁹. A wreck found in 1962 in Bremen harbour and dated to about 1380 is the most complete surviving example of a cog and one of the largest studied by archaeologists to date. As with all wrecks, the rigging is lost so determining the size of the sail and how it was handled is difficult. Tempted by the challenge, some shipwrights at the end of the twentieth century took on the task of

¹⁶ Some ten wrecks from the polders in the IJsselmeer are cogs or have many features of cogs. ADAMS & RÖNNBY, 2002: 176; JAHNKE & ENGLERT, 2016; JAHNKE, 2011; HOCKER, 2004; ELLMERS, 2010.

¹⁷ HOLK, 2003: 288-304.

¹⁸ MOORTELT *et al.*, 1991: 15, 27, 36; VERMEERSCH & HANECA, 2015: 127.

¹⁹ MAARLEVELD *et al.*, 1994: 19-24; ADAMS & RÖNNBY, 2002: 178; MOORTELT, 1991: 63-65, 86-88; VERMEERSCH & HANECA, 2015: 114-118; VERMEERSCH *et al.*, 2015: 331-332.

recreating the Bremen cog. Three full-scale replicas have sailed and with some success. The rig varies among them though handling the sail and the ship proved difficult in all cases²⁰.

Evidence from cog finds shows that through the Late Middle Ages Dutch building methods were similar to those in the rest of northern Europe and especially to what was done in north Germany. There was a deep divide between Mediterranean methods and northern ones, major differences in the design of hulls and rigging and in the ways shipbuilders created those designs. In the fifteenth century the injection of Portuguese practices into the Low Countries led to incomplete imitation and the emergence of a unique kind of shipbuilding which, while adhering to established traditions, created a unique and, for the better part of two centuries, highly successful approach to construction of a sea-going sailing ship.

The Dutch hybrid technique is another indication that pure systems just like pure and consistent ship types exist largely in the minds of historians. Builders developed their own approaches based on what they knew and what proved most effective. Dutch shipwrights evolved a way to take advantage of the features of Mediterranean/Iberian/Atlantic construction they learned from Portuguese examples while also employing their own established techniques²¹. A few illustrations and sparse descriptions from the late seventeenth century are the best sources for what was by then an old, outmoded and disappearing approach to the task. It recalled the ways of building a cog and the ways of building a carrack. First, as in both north and south, builders laid down the keel. They then added the garboard and bottom strakes, the progress being similar to what they did with cogs. As they built out they produced a flat bottom or something close to a flat bottom. To hold those bottom planks in place they used small cleats on the outside. The angle between the bottom and the side planks would be sharp, giving a box-like cross section though that did not come as a logical product of the method of building but rather as a matter of choice by shipwrights to improve carrying capacity. The next step was to put the frames in place though exactly at which point builders did that is not certain. Almost undoubtedly they placed the frames on the keel before the sides were completed but how much before may have varied over time and from builder to builder. Certainly by the late seventeenth century Dutch builders had adopted Portuguese practice and the frames came after the bottom and before the sides.

In a series of sixteen prints showing the life of a ship from beginning to the breakers yard dating to around 1700 the Alkmaar artist Siewert van der Meulen described the installation of the bottom strakes before including the frames and sides of the ship²². The Swedish writer Åke Rålamb, in his 1691 book on shipbuilding, offered a sketch of

²⁰ HOFFMANN & HOFFMANN, 2009.

²¹ MAARLEVELD, 1994.

²² GROOT & VORSTMAN, 1980: 138-39.

work in a shipyard giving two approaches, a standard one consistent with Portuguese practice and, off in a corner, a way the Dutch built ships. He said it was a *fluit*, the very successful type that served to carry bulk cargoes, being built with small cleats which he called *klampar*²³. One of the spies Louis XIV's minister, Jean-Baptiste Colbert, sent to the Republic to find out about Dutch building methods was Nicolas Arnoul, the son of the Marseilles Intendant des Galères and the future administrator of the naval shipyard in that port. His time there combined with an earlier trip to Italy to examine shipbuilding practice guaranteed he had an experienced eye. His report along with a sketch that he supplied to his superiors in Versailles confirms what turns up in the Swedish and Dutch illustrations, that the Dutch, unlike the French and English and Portuguese for that matter, put bottom planks up first and then moved on to the frames and the rest of the hull planking²⁴. Construction of a replica of a seventeenth century Dutch Eastindiaman at the Bataviawerf in Lelystad where efforts were made to recreate original methods, within limitations, also tends to confirm that the Dutch built ships, or at least their cargo ships, differently from others in Europe. The same can be said for a ship excavated in the Noordoostpolder between 1957 and 1961 and conserved at what was the museum of the archaeological service at Ketelhaven²⁵.

There were some advantages to the hybrid approach which borrowed from but did not slavishly imitate Portuguese practice. The frames did not need to be built up with great care in advance. They did not need to be as heavy as with Portuguese construction. The Dutch apparently did not use lapped dovetail construction in frames but by the end of the sixteenth century the Portuguese had given up that extra work anyway. The shape of the principal frames did not have to be as strictly controlled perhaps in the Netherlands as with methods of building which predominated in Portugal and elsewhere in southern and western Europe²⁶. Dutch builders had considerably more flexibility in the kind and shape of wood they used in building the frames. They could work on hull planking and frames at the same time and were not typically delayed waiting for heavy frames to be finished and fitted nor delayed by waiting for just the right piece of wood. It could be that the Dutch way meant that they could build ships more quickly²⁷. Whether or not the method was the reason, it was certainly true that the Dutch were able to build ships faster and more cheaply than other Europeans. There is evidence that sailing ships in the Late Middle Ages through to the nineteenth century cost more to build for each unit of carrying capacity as they got bigger²⁸. There is every reason to believe that was true of the carracks the Portuguese sent to Asia. The risk of loss may have been greater

²³ RÅLAMB, 1691: 34-44.

²⁴ HASSLÖF, 1972; UNGER, 1985.

²⁵ Wreck E81NOP.

²⁶ SLEESWYK & SLEESWYK, 1998: 7-12.

²⁷ MAARLEVELD, 1992: 158, 165-69.

²⁸ SLEESWYK, 2003.

with larger ships and certainly the stories of Portuguese shipwrecks in trade to India from 1550 to 1650 would tend to support that assumption²⁹. With larger ships the sheer size and complexity of the vessels increased the likelihood that something would go wrong. Dutch shippers avoided going to the building and using of very large ships in part, presumably, to control costs and also in part because the middle-range ships they deployed on intra-European voyages could be built more quickly. Equally important the slower, smaller ships were adequate for delivering the bulk goods which they carried. With vessels in an intermediate range Dutch shipwrights did not face the problems presented to Portuguese builders who had to make stronger ships with heavier planking for their long distance voyages when they were fully loaded or, as in many cases, more than fully loaded.

The archaeological and iconographic evidence indicates that the Dutch system of construction which emerged in the sixteenth century was unique. The way of building ships depended on well-established traditional northern practices and also on the knowledge gained from Portuguese imports of ships and of shipwrights. It also depended on how Low Countries builders adapted those foreign practices to what they knew and what they had done for centuries. It depended as well on the character of the trades Dutch merchants and shippers were involved in. Acquiring knowledge of alternate methods, adapting them, integrating them with existing practice creating some syncretic way of working and then finally to abandon the compromise and to accept fully the imported system proved to be a slow process. Over time Dutch building became ever more like Portuguese and the two increasingly fit into a more universal European and even global way of building a sea-going sailing ship.

Theory and practice merged. Dutch builders did not have need of a theoretical articulation of what they did. Because their method was a hybrid, describing it would have proven, and indeed did prove, difficult. In other parts of Europe, especially in the Mediterranean and notably in Portugal, there were theoreticians who wrote about how shipbuilders should think about what they were doing³⁰. Importing ideas from southern Europe in maritime matters had a proven pedigree in the Low Countries. There was a well-established tradition of Portuguese influence on navigational thinking and practice. As pioneers in celestial navigation, forced on them by long north-south voyages out of sight of land and voyages to the Azores which were islands in the open sea, the Portuguese had a deep influence on practices throughout Europe. Series of sailing instruction, roteiros, were known and a model for books produced in the Low Countries like the so-called *leeskaart* of Jan Severszoon, the first of its type produced in Amsterdam in 1532, and the subsequent 1558 *Onderwijsinge van der zee* by Cornelis Anthonisz. That was the beginning of a tradition of the adoption of Iberian practices among

²⁹ BRITO & BOXER, 1959: 24-27.

³⁰ MAARLEVELD, 1994: 154, 159.

northern sailors in the Low Countries and in, for example, England as well³¹. As Dutch cartographers started to produce maps in the sixteenth century, they borrowed from Portuguese practices, most obviously in the decoration of the seas and the lands they depicted. This may have come through direct knowledge of what went on in Iberia from the personal experience of Dutchmen working there or through seeing the maps that came from Iberia or through the intermediary of practices in France, specifically in Dieppe where in the mid sixteenth century a small group of men made impressive maps very much in the Portuguese style³². The Low Countries map maker Gerard Kramer, better known by his Latinized name of Mercator, developed a projection for maps which created loxodromes, lines which intersect all meridians at the same angle and so show the true course of a ship. He first produced that projection in 1541, just four years after the Portuguese mathematician Pedro Nunes had discussed how to carry out the calculations to get Mercator's result³³.

Writers in the Dutch Republic, when they did turn to the theory of shipbuilding in the late seventeenth century, relied on Portuguese work as well. A practice emerged in the fifteenth century in Italy of writing about shipbuilding. The few books produced were highly descriptive and probably not very useful as practical manuals for workers on wharves. Once the practice started and a language developed for writing about shipbuilding, works appeared in Spanish, Portuguese, French and Dutch which were increasingly accurate, precise and of value in developing the skills of shipbuilders³⁴. In the Netherlands the progression was from a work by a wealthy amateur observer to a practitioner with extensive experience building ships. Nicolas Witsen came from a well-off Amsterdam family and the book he published in 1671 incorporated information from what he learned from men on wharves. Cornelis van Yk, whose book came out in 1697, had spent a lifetime as a professional shipbuilder. Both books indicate that there was considerable variety in the kinds of ships that came from Dutch yards. Their works, largely empirical, lacked signs of the systematic approach that was becoming common in works by writers coming from an Iberian or even an English shipbuilding tradition. Witsen's book which, in its first edition, was largely a catalogue of practices, indicates that shipbuilding in the Netherlands used a hybrid system. He did feel the obligation to offer some theoretical framework and for that he turned to a book, probably in the hands of the Dutch humanist Isaak Vossius at the time, written by the Portuguese man of letters and character of a number of careers, Fernando Oliveira. His *Ars Nautica*, written in the 1550s, had an unfinished but still extensive middle section which dealt with shipbuilding, a topic he would treat more completely in his *Liuro da*

³¹ KEUNING, 1952: 57-59; WARD, 2009: 147-150.

³² UNGER, 2010: 84, 118-124, 144-146.

³³ ASH, 2007: 513-14, 520-22; KYEWSKI, 1962: 116-17; UNGER, 2011.

³⁴ BONDIOLI, 2009: 261-66, 271-80; UNGER, 2013: 187-91.

Fabrica das Naos of 1580³⁵. Relying on the Portuguese work, Witsen thought he was describing the way ships were built in the distant past, that is in the 1520s. He used Oliveira's drawings of the progress of ship construction verbatim and then, dropping the nod to theory, moved on to his description of contemporary practices. It would seem that Witsen was aware that Dutch builders did not follow the Portuguese pattern and that he knew Dutch hull design was different. At the same time his use of Oliveira suggests that he, and others, thought there were different notable and effective ways to think about sailing ships and about how to build them. It also suggests that he revered Portuguese practice as superior, at least as it was back 150 years before he was writing.

Dutch designs and construction procedures changed in the seventeenth and even more in the eighteenth century. Rembrandt's 1633 painting of a shipbuilder handing his wife a drawing of the principal frame of a ship, suggesting that the sketch was critical to the execution of his trade, meant that builders were already thinking like their counterparts in Iberia. Van Yk, in describing construction, talks about putting up the frames first in contrast to Witsen who showed the older system³⁶. As Dutch trading connections spread around the world in the seventeenth century, shippers needed vessels more like those in use in Portugal. The eighteenth-century East Indiamen of the Dutch East India Company were like the heavily-built, large, defensible ships of all other European states trading to the Far East³⁷. Dutch vessels used within Europe increasingly shared characteristics of the ships and boats of other parts of the continent. The decision to bring English shipwrights to the Amsterdam Admiralty wharf to train Dutch builders in the latest techniques in 1727, as a way to meet criticism of the poor quality of Dutch warships compared to French and British ones, was just another sign of falling in line with general European methods³⁸.

Archaeology will certainly over time add more knowledge about how Portuguese and Dutch shipwrights built their ships. Speculation about the shape and extent of the effects of one on the other depends heavily on archaeological finds. Relying only on contemporary descriptions and surviving images would not have revealed the extent and character of potential influence that most likely existed. It could well be that the flow of technical knowledge and practices was not just in one direction. It may be that cross-fertilization travelled south as well as north. Working at Red Bay in Labrador, Robert Grenier and his team of underwater archaeologists from Parks Canada excavated sixteenth-century Basque whaling ships. Having learned that Dutch builders made small holes in hull planks to hold cleats in place and then, when done, filled the small holes

³⁵ VOGEL, 1911. The book is now in the Leiden University Library. I am indebted to Richard Barker for his pointing out my earlier oversight in describing the book. On the life and works of Oliveira see DOMINGUES, 2008.

³⁶ HOVING, 2012: 8-11.

³⁷ MAARLEVELD, 2013: 350.

³⁸ BRUIJN, 1972. The experiment, despite some successes, failed in its purpose, and criticism of Dutch warships continued.

with *spijkerpennen*, he looked for signs of similar remnants on the hull of the large ship he was then diving on. He found evidence of something very similar to the use of *spijkerpennen*. The plugs were all at strategic points, which indicates that some temporary pieces of wood served to outline the shape of parts of the hull during construction³⁹. The conception of the building process and its progression were different on Basque wharves from those on Dutch ones. Filling small holes with dowels does not show that Iberian builders used temporary cleats in constructions nor that they picked up practices from the Low Countries. The presence of plugs may show nothing more than a practical way for all builders to deal with nail holes that were temporary. On the other hand the consistency of practice in Iberia and the Netherlands strongly suggests that shipbuilders in those two parts of Europe were familiar with what their counterparts were doing and that, even if slowly, were willing to exploit what they learned from others. There is promise to learn much more about how contact among shipbuilders, directly through migration and indirectly through seeing the products of other practitioners, affected practices. Experimental archaeology, the construction of replicas in all sizes of historic vessels based on what is learned from digs and from the classic sources of texts and images, together will lead to a better understanding of how and why and to what degree technology got transferred and how Europeans came to build the very effective ships that they put together in the early modern era.

SOURCES

- ADAMS, Jonathan; RÖNNBY Johan (2002) — *Kuggmaren 1: The First Cog Find in the Stockholm Archipelago, Sweden*. «International Journal of Nautical Archaeology», vol. 31, n.º 2, p. 172-181.
- ALVES, Francisco *et al.* (1998) — *Archaeology of a Shipwreck*. In MARTINS, António Alves, *ed.* — *Nossa Senhora dos Mártires: The Last Voyage*. Lisbon: Editorial Verbo, p. 183-215.
- ASH, Eric H. (2007) — *Navigation Techniques and Practice in the Renaissance*. In WOODWARD, D. — *The History of Cartography: Cartography in the Renaissance*. Chicago: University of Chicago Press, p. 509-527.
- BAETENS, R. (1976) — *The Organization and Effects of Flemish Privateering in the Seventeenth Century*. In BAETENS, R. *et al.* — *Acta Historiae Neerlandica IX: Studies on the History of the Netherlands*. Leiden: [s.n.], p. 45-75.
- BARBOUR, Violet (1930) — *Dutch and English Merchant Shipping in the Seventeenth Century*. «Economic History Review», n.º 2, p. 261-290.
- BEYLEN, Jan van (1970) — *Schepen Van De Nederlanden*. Amsterdam: P. N. Van Kampen & Zoon N. V.
- BONDIOLI, Mauro (2009) — *Early Shipbuilding Records and the Book of Michael of Rhodes*. In O. LONG, Pamela; MCGEE, David; STAHL, Alan M.; ROSSI, Franco — *The Book of Michael of Rhodes: A Fifteenth-Century Maritime Manuscript*. Cambridge, Mass.: MIT Press, p. 243-280.
- BOVILL, E. W. (1968) — *The Madre de Dios*. «The Mariner's Mirror», vol. 54, n.º 2, p. 129-152.
- BRITO, Bernardo Gomes de; BOXER, C. R. (1959) — *The Tragic History of the Sea, 1589-1622; Narratives of the Shipwrecks of the Portuguese East Indiamen São Thomé (1589), Santo Alberto (1593), São João*

³⁹ LOEWEN, 2007: vol. 3, 79, 82.

- Baptista (1622), and the *Journeys of the Survivors in South East Africa*. Cambridge: Hakluyt Society at the University Press.
- BRUIJN, J. R. (1972) — *Engelse Scheepsbouwers Op De Amsterdamse Admiraliteitswerf in De Achttiende Eeuw: Enige Aspecten*. «Mededelingen van de Nederlandse Vereniging voor Zeegechiedenis», n.º 25, p. 18-24.
- (1979) — *Dutch Privateering During the Second and Third Anglo-Dutch Wars*. In *The Low Countries History Yearbook 1978: Acta Historicae Neerlandicae*. [S.l.]: Springer, p. 79-93.
- CASTRO, Filipe (2005) — *The Pepper Wreck: A Portuguese Indiaman at the Mouth of the Tagus River*. Texas: Texas A&M University Press.
- CHILDS, Wendy R. (2013) — *Trade and Shipping in the Medieval West: Portugal, Castile and England: A Series of Lectures in Memoriam of Professor Armindo de Sousa, Given in the University of Porto, November 2009. Textes et Études du Moyen Âge*. Porto: Fédération internationale des instituts d'études médiévales.
- COLBERT, Jean Baptiste; CLÉMENT, Pierre (1864-1865) — *Lettres, Instructions Et Mémoires De Colbert*. Paris: Imprimerie impériale, vol. 3, part. 1.
- DAVIS, Ralph (1962) — *The Rise of the English Shipping Industry in the Seventeenth and Eighteenth Centuries*. London; New York: Macmillan; St. Martin's Press.
- DE VRIES, Jan; WOUDE, A. M. van der (1997) — *The First Modern Economy: Success, Failure, and Perseverance of the Dutch Economy, 1500-1815*. Cambridge; New York: Cambridge University Press.
- DILLEN, J. G. van (1974) — *Bronnen Tot De Geschiedenis Van Het Bedrijfsleven En Het Gildewezen Van Amsterdam*. 's-Gravenhage: Nijhoff. 3 vols.
- DOMINGUES, Francisco Contento (2004) — *Os Navios do Mar Oceano. Teoria e Empíria na Arquitetura Naval Portuguesa dos Séculos XVI e XVII*. Lisboa: Centro de História da Universidade de Lisboa.
- (2008) — *Experiência e Conhecimento na Construção Naval Portuguesa do Século XVI. Os Tratados de Fernando Oliveira*. In *Navios E Viagens: A Experiência Portuguesa dos Séculos XV a XVIII*. Lisbon: Tribuna da História, p. 49-83.
- ELLMERS, Detlev (2010) — *Koggen Kontrovers*. «Hansische Geschichtsblätter», n.º 128, p. 113-40.
- GROOT, Irene de; VORSTMAN, Robert (1980) — *Sailing Ships. Prints by the Dutch Masters from the Sixteenth to the Nineteenth Century*. New York: Uitgeverij G. Schwartz; Viking Press.
- HASSLÖF, Olof (1972) — *Main Principles in the Technology of Ship-Building*. In HENNINGSEN, Henning, et al. — *Ships and Shipyards, Sailors and Fishermen; Introduction to Maritime Ethnology*. Copenhagen: Copenhagen University Press, p. 27-72.
- HEIDE, G. D. van der (1974) — *Scheepsarcheologie Scheepsopgavingen in Nederland En Elders in De Wereld*. Naarden: A. G. J. Strengholt's Boeken.
- HOCKER, F. M. (2004) — *Bottom-Based Shipbuilding in Northwestern Europe*. In HOCKER, F. M.; WARD, Cheryl A. — *The Philosophy of Shipbuilding: Conceptual Approaches to the Study of Wooden Ships*. College Station: Texas A&M University Press, p. 65-93.
- HOCKER, F.; DALY, Aoife (2016) — *Early Cogs, Jutland Boat builders and the Connection between East and West before AD 1250*. In BLUE, Lucy Katherine; HOCKER, F. M.; ENGLERT, Anton — *Connected by the Sea: Proceedings of the Tenth International Symposium on Boat and Ship Archaeology, Roskilde 2003*. Oxford: Oxbow Books, p. 187-94.
- HOFFMANN, Gabriele; HOFFMANN, Per (2009) — *Sailing the Bremen Cog*. «International Journal of Nautical Archaeology», vol. 38, n.º 2, p. 281-96.
- HOLK, André van (2003) — *Clenched Lap-Strake Boat Finds from the Netherlands between 1200 and 1600*. In BELTRAME, Carlo — *Boats, Ships and Shipyards: Proceedings of the Ninth International Symposium on Boat and Ship Archaeology, Venice 2000*. Oxford: Oxbow Books, 296-305.

- HOVING, A. J. (2012) — *Nicolaes Witsen and Shipbuilding in the Dutch Golden Age*. College Station: Texas A&M University Press.
- JAHNKE, Carsten (2011) — *Koggen Und Kein Ende Anmerkungen Zu Den Thesen Von Reinhard Paulsen Und Detlev Ellmers*. «Zeitschrift für Lübeckische Geschichte», n.º 91, p. 305-20.
- JAHNKE, Carsten; ENGLERT, Anton (2016) — *Historical Research on Merchant Sea-faring in Danish Waters and in the Western Baltic Sea 1000-1250*. In ENGLERT, Anton — *Large Cargo Ships in Danish Waters 1000-1250. Evidence of Specialised Merchant Seafaring Prior to the Hanseatic Period*. Roskilde: The Viking Ship Museum, p. 30-75.
- KEUNING, Johannes (1952) — *XVIth Century Cartography in the Netherlands*. «Imago Mundi», n.º 9, p. 35-63.
- KINGSFORD, C. Lethbridge (1910) — *The Taking of the Madre de Dios, Anno 1592*. In LAUGHTON, John Knox; Navy Records Society, eds. — *The Naval Miscellany II*. London: Navy Records Society, vol. 40, p. 85-121.
- KYEWSKI, Bruno (1962) — *Über Die Mercatorprojektion*. In STADTARCHIV DUISBURG — *Duisburger Forschungen Schriftreihe für Geschichte und Heimatkunde Duisburgs*. Duisburg-Ruhrort: Verlag für Kultur Werner Renckhoff KG, 115-30.
- LOEWEN, Brad (2007) — *The Hull: Of Ship Design and Carpentry*. In BERNIER, Marc A.; GRENIER, Robert; STEVENS, Willis — *The Underwater Archaeology of Red Bay: Basque Shipbuilding and Whaling in the 16th Century*. Ottawa: Parks Canada, vol. III, 25-148.
- LONG, Pamela O.; MCGEE, David; STAHL, Alan M.; ROSSI, Franco (2009) — *The Book of Michael of Rhodes: A Fifteenth-Century Maritime Manuscript*. Cambridge, Mass.: MIT Press, 3 vols.
- MAARLEVELD, Thijs J. (1992) — *Archaeology and Early Modern Merchant Ships, Building Sequence and Consequences. An Introductory Review*. In CARMIGGELT, Arnold — *Rotterdam Papers VII: A Contribution to Medieval Archaeology. Teksten Van Lezingen Gehouden Tijdens Het Symposium 'Handel, Handelsplaatsen En Handelswaar Vanaf De Vroege Middeleeuwen in De Lage Landen' Te Rotterdam, Van 2 T/M 3 November 1990*. Rotterdam: Coördinatie Commissie van Advies Inzake Archeologisch Onderzoek Binnen het Ressort Rotterdam, 155-173.
- (1994) — *Double Dutch Solutions in Flush-Planked Shipbuilding*. In WESTER-DAHL, Christer — *Crossroads in Ancient Shipbuilding: Proceedings of the Sixth International Symposium on Boat and Ship Archaeology, Roskilde, 1991, ISBSA 6*. Oxford: Oxbow Books, 153-163.
- (2013) — *Early Modern Merchant Ships, Nicolaes Witsen and a Dutch-Flush Index*. «International Journal of Nautical Archaeology», vol. 42, n.º 2, p. 348-57.
- MAARLEVELD, Thijs J.; GOUDSWAARD, B.; OOSTING., R. (1994) — *New Data on Early Modern Dutch-Flush Shipbuilding: Scheurrak T24 and Inshot/Zuidoostrak*. «International Journal of Nautical Archaeology», vol. 23, n.º 1, p. 13-25.
- MOORTEL, Aleydis van de et al. (1991) — *A Cog-Like Vessel from the Netherlands*. Lelystad: Rijkswaterstaat Directie Flevoland.
- PRAK, Maarten Roy; WEBB, Diane (2005) — *The Dutch Republic in the Seventeenth Century: The Golden Age*. Cambridge; New York: Cambridge University Press.
- RÅLAMB, A. (1691) — *Skepps Byggerij Eller Adelig Öfrings*. [n.s.: n.p.].
- SLEESWYK, André Wegener (2003) — *Building Costs and Carrying Capacity of European Merchant Ships, 1400-1800*. «Tijdschrift voor zeeschiedenis», vol. 22, n.º 2, p. 137-146.
- SLEESWYK, André Wegener; SLEESWYK, M. Wegener (1998) — *Joseph Furttenbach En De 'Holländische Nave'*. «Tijdschrift voor zeeschiedenis», vol. 17, n.º 1, p. 3-14.
- UNGER, Richard W. (1978) — *Dutch Shipbuilding before 1800: Ships and Guilds. Aspects of Economic History. The Low Countries*. Assen: Van Gorcum.

- (1985) — *Dutch Design Specialization and Building Methods in the Seventeenth Century*. In CEDERLUND, Carl Olof — *Postmedieval Boat and Ship Archaeology*. Oxford: B. A. R., p. 153-164.
- (2010) — *Ships on Maps: Pictures of Power in Renaissance Europe*. Houndsmills, Basingstoke, Hampshire; New York: Palgrave Macmillan, 2010.
- (2011) — *Dutch Nautical Sciences in the Golden Age: The Portuguese Influence*. «E-Journal of Portuguese History», vol. 9, n.º 2, p. 68-83.
- (2013) — *The Technology and Teaching of Shipbuilding, 1300-1800*. In EPSTEIN, Stephan R.; PRAK, Maarten Roy; ZANDEN, J. L. van — *Technology, Skills and the Pre-Modern Economy in the East and the West Essays Dedicated to the Memory of S.R. Epstein. Global Economics History Series*. Leiden: Brill, vol. 10, p. 161-204.
- VERMEERSCH, Jeroen; HANECA, Kristof (2015) — *Construction Features of Doel 1, a 14th-Century Cog Found in Flanders*. «The International Journal of Nautical Archaeology», vol. 44, n.º 1, p. 111-131.
- VERMEERSCH, Jeroen; HANECA, Kristof; DALY, Aoife (2015) — *Doel 2: A Second 14th-Century Cog Wrecked in Den Deurganck, Doel, Belgium*. «The International Journal of Nautical Archaeology», vol. 44, n.º 2, p. 327-348.
- VOGEL, Walther (1911) — *Ein Neu entdecktes Lehrbuch der Navigation und Des Schiffbaues aus Der Mitte Des 16. Jahrhunderts*. «Hansische Geschichtsblätter», n.º XVII, p. 370-374.
- WARD, Robin (2009) — *The World of the Medieval Shipmaster: Law, Business and the Sea c.1350-c.1450*. Woodbridge; Rochester: Boydell Press.
- ZANDEN, J. L. van (1993) — *The Rise and Decline of Holland's Economy: Merchant Capitalism and the Labour Market*. Manchester; New York: Manchester University Press.