A Brief History of Wind Powered Ships
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The Long Ship

The early medieval ships were clinker built; a term which is bastardized from "clencher" and refers to the clenching of nails, a technique for securing planks. Lapstrake is perhaps a more accurate term which literally means "over-lapping planks". In any event, the clinker design was derived from the construction of earlier skin boats in which the hides had to be overlapped to be made water tight. Such craft were in widespread use by northern European cultures as far back as 2000BC based on primitive rock scratchings. More advanced vessels, like the Irish curragh, often had a wooden frame and a hide covered wicker hull.

The earliest evidence of plank built ships is the remains of a 50 foot boat built circa 350BC using sewn planks and a central keel. The first true clinker built ship with overlapping planks held with iron nails and powered by actual oars using oarlocks, is an 82 foot vessel dated to 350AD. This "Nydam" ship was likely the type the Saxons used to reach Britain, but was not yet equipped with a sail. Like all clinker built ships, the Nydam had a wooden frame inserted to strengthen the hull after the skin was built. The "Sutton Hoo" ship of 650AD was a full 90 feet long and of more intricate design using more and narrower planks, but it too lacked a permanent mast. Speculation exists however, that these early ships could be fitted with removable masts rigged with a primitive sail. The "Kvalsund" ship dated to Norway in 700AD has a central reinforcing plank which some suggests provided the footing for a more permanent mast.

The precise date of the adoption of the sail is uncertain. But it is clear that in this period the sail was secondary to the oar. The low freeboard (distance the hull extends above the water) of these ships is ideal for oar power, but dangerous for sailing when one considers how sail powered ships tend to heave over away from the wind. The first decisive evidence of voyages made predominately by sail power dates from about 800AD. By 1000AD the famed Viking Long Ship permitted travel out of the Baltic, into the Mediterranean, and across the Atlantic. These ships were wider, and had a more advanced mast stepping design. The existence of two further strakes (the horizontal planks running the length of the ship) above the oarlocks gives evidence of a ship designed as much for sailing as rowing.

The Karv and the Knorr were ships similar to the Long Ship but designed for cargo. The Knorr (a 54 foot example of which is dated as early as 1050) had very high sides for additional cargo and only a few oarlocks indicating the ship was primarily sail driven.

It is of interest to note here the origins of the words Starboard and Larboard. Both of these early ships employed a steering oar rather than a stern mounted rudder. These oars were almost universally mounted on the right or "Steerboard" side of the ship. So as not to damage the steering oars, the ship was loaded over the left or "Lading board" side.

Another interesting note, is that iron anchors dated to this period are little different from anchors 1000 years later, shank, flukes, and all. Some period ships were equipped with "lyftings" raised platforms at bow and stern from which armed men could fight hand to hand. These structures are likely the predecessors of the "castles" of later design.

Medieval Ships

An alternative form of northern European ship design was the hulk. An example of which (the Utrecht ship) is dated to 800AD. This ship was the principle vessel of the Frisian Islands and is found on many Carolingian period coins. Its planks are flush, butted end to end and tapered so as to draw up in the sides and together at bow and stern. This ship would have a long and difficult to precisely track career.

Ships would continue to develop in northern Europe as oversea trade became more and more important, reaching their pinnacle in the cog. The cog is a general term given to a wide range of ship types which bear certain similar characteristics. As a ship it is associated with the Hanseatic League, a north eastern European trade association which would eventually include some 84 cities. The cog, appearing about 1200AD combines in one ship many features which had individually been making their appearance over the previous 200 years.

In the late 1100s, a straight sternpost was added to some ships marking the first time in northern waters a ship aft would be shaoed differently than its bow. This change was made to facilitate the hanging rudder, an advancement that significantly improved the handling characteristics of a ship. However, that advantage was almost secondary. Somewhat ironically, the chief advantage of the rudder was that it permitted larger ships to be designed. The effectiveness of the tried and true steering oar dropped dramatically when raised too high above the water. The rudder, having no such limitation, allowed for ships with increasingly higher and higher freeboards to be built.

The cog was built with a flat flush laid bottom which was ideal for the coastal islands and rivers where it was primarily used. The hull turns up sharply at the bilge (the point where the hull transitions from bottom to side) and rises from there in ever widening clinker type strakes. The nails, however, were not clenched like in Norse tradition (i.e. twisted around a cleat) but merely bent over and buried in the wood. The ship had a rather broad beam, well suited for its principle role as a merchant craft. Strangely, however, the deck planking was laid out horizontally and with gaps which intentionally allowed water to drain below decks to the cargo hold where it was pumped out by primitive bilge pumps. This deficiency was understandably hard on the cargo.

Interestingly, this led to a unique way of measuring a ship's capacity. Because of risk of water damage, most cargo was transported in large 252 gallon barrels (35 cubic feet) called tuns. This gave rise to the term tunnage (or tonnage). Of equal interest is the use of the ships yardarm (the horizontal spar holding up the sail) as a crane to assist in loading the vessel.

Cogs were single masted ships with a single huge (and difficult to handle) sail. They were built with a large low stern castle, a small forecastle, and a top castle (basically an "armored" crows nest). The crew slept in leather bags on the deck, although the tiller was roofed in shingles and provided some cover for the ship master and passengers. This passenger space was termed the "steerage" because of its association with the tiller; a term that is still used today to refer to passenger accommodations of minimal facilities.

The first use of the cog as a war vessel came in 1234 when the city of Lubeck armed their cogs against the King of Denmark who sought to gain control of the city. A larger action came when the King of Norway, jealous of the League's financial success, began imposing tariffs and pirating League ships. The entire League mobilized to blockade the grain trade to Norway, starving the King into Armistice in 1285.

The English did not adopt the cog in any numbers until the 1300s. Prior to this the English relied on the nef, a generic term for ship used in many parts of Europe. In England

the term nef referred to a specific vessel that was a more direct descendent of the Norse karvs and knors. The English had no standing navy at this time and relied on the Cinque Ports for maritime defense. Originally 5 (hence the name) and later 7 cities along the Straights of Dover supplied ships in times of war in exchange for financial privileges. Interestingly these ports were among the first in the north to establish true tower based lighthouses as navigation aides as early as 1261.

The Hundred Years war (1337-1453) provides the first examples of the Privateer. It being very difficult for a merchant to trade when his trading partners are at war, many merchants took to raiding the commerce of thier enemy when the numerous flair ups of the "war" interrupted trade. In the largest fleet action of the period, King Edward III, in 1340, led a fleet of 200 ships to victory against the French in Flanders. It is important to note here that naval combat at the time, was essentially land combat at sea, and consisted entirely of laying along side for boarding and archery fire. In 1400, the concept of the naval convoy was introduced as armed cogs were employed to escort the Bordeaux wine ships. The most significant contribution of the English nef to future ship design was the raised fore and aft castlee as superior fighting platforms. The earliest example of ships being armed with cannon is a Hanseatic ship armed with 19 small deck guns in 1470. The earliest record of larger guns being carried below decks through pierced gun ports dates to 1493.

And now at long last we return to the hulk, which enjoyed a renaissance of sorts when it replaced the cog almost entirely between 1400 and 1450. The hulk, which had evolved significantly from its early origins had a larger, rounder, hull than the cog, and a sealed deck running the length of the ship which provided superior cargo protection. It was clinker built all the way to the keel which made for a more stable wedge shaped hull which made the ship more sea worthy than the cog's flat bottom, and also helped prevent the ship from making as much leeway (which means continuously drifting in the direction of the wind, regardless of the primary direction of travel). The hulk bore the raised fore and aft castles of the nef but these appear to be an integral part of the design rather than being mere superstructure added on afterward. It also carried a top castle like a cog, but added ratlines to facilitate access. As trade grew beyond the sheltered waters of the Baltic the hulk's sailing abilities proved superior.

It is interesting to note the unknown derivation of the term hulk. The first naval references to hulks were Greek cargo barges designed to be towed. The earliest hulks of this period seem to have been designed to be towable with a severely far forward mast placement but it is unclear if the terms are related. There is also no clear connection between this ship and the term's later use for a damaged dismasted vessel.

In the Mediterranean, ship design took a different turn. We will ignore the many derivations of the galley, for the age of sail was driven primarily by evolutions in merchant ships. In the Mediterranean the merchant ships evolved more from the giant Roman grain ships than from the long narrow galley.

The first distinctive feature of Mediterranean design was plank on frame construction. Rather than first building the skin and then inserting framing pieces for added strength, plank on frame first built the framework and attached the planks there to. This permitted much larger ships to be built in the same manner that skyscrapers which are hung on a beam and girder frame can be built much larger than buildings which rely on a skin of masonry for support.

The earliest example of this kind of construction is a trading ship from the Eastern Mediterranean dated around the seventh century. The ship was skin built from keel to water line with a frame then inserted which rose up the side and to which the freeboard strakes were attached. Another transitional vessel has been dated to 1020. This was largely of skin based construction but demonstrates the use of a partial frame to force the skin to take a more spacious shape for cargo. These ships were loaded though a large door cut in the side of the vessel which was then sealed and caulked for the journey.

The second distinctive feature of Mediterranean ship building was the Lateen sail. The single large square sail had dominated classical ship design but appears to have completely disappeared by the ninth century. The first evidence of the Lateen sail is with Byzantine Emperor Justinian's fleet in the mid sixth century. When sailing into the wind, a sail does not push the ship ahead. Rather it acts as an airfoil, creating an area of low pressure in front of the sail, pulling the ship forward. The long triangular shape of the Lateen sail makes a far more effective airfoil than a square sail. It is likely that the widespread adoption of a type of rigging that allowed sailing in almost any direction was a direct result of the dissolution of the Roman world. Trade now occurred from nearly any port to any port and available routes changed as frequently as local politics. Thus, there was a need for a ship that could sail from anywhere to anywhere.

A crucial problem with Mediterranean ships was that they still employed steering oars. Despite their great size and the ability to sail close haulted, their shallow draft and steering oars gave little resistance to the wind. These ships made a tremendous amount of leeway (drifting with the wind) and could spend several days going nowhere, losing to leeway, what progress they made sailing. A record dated to 1183 by a ship sailing from Sicily reports passing Crete…three times. Needless to say this played havoc with navigation, and was downright dangerous in close waters. As a result the first Mediterranean lighthouse of the period was built in Genoa in 1161.

But the stage was now set. Many Crusaders familiar with the northern cog, would travel to the holy land in an Italian lateen rigged ship. In this cultural melting pot, all of the pieces were in place for the first truly full-rigged ocean capable sailing ship, the carrack.

The Dawn of the Age of Sail

The carrack was a ship of such prestige that they were frequently referred to as Great Ships and Charles the Bold used a procession of 30 for his wedding ceremony in 1468. The carrack is at once a strikingly beautiful and amazingly ungainly looking vessel. Like the great cathedrals of the time the carrack seems designed to rise as high as possible. She was truly the first of the "tall ships"

The mainmast was extended higher to make room for a newly added topsail above the gargantuan mainsail. The use of the term "main mast" is important here for the carrack was the first truly three masted ship. A forward mast carried another square sail to help propel the huge (by comparison) vessel, and the aft mast sported a lateen rig for superior sailing quality close to the wind. This aft mast would become known after 1420 as the mizzen mast, an English corruption of the Italian and Spanish word mesan, which referred to the kind of sail it carried.

The carrack appears to have its origin in Genoa in the 1300s with the design of big three decked Mediterranean vessels intended to sail north through the Atlantic to trade in the Bay of Biscay. These ships adopted some features of the cog and were called *coch*

baonesche, or Biscayne Cogs. The Moorish influence in the Iberian Peninsula seems to have corrupted this into a slang word which later came to be spelled as it was pronounced, “carrack”. This ship had only 2 masts, a single square sailed main mast and a large lateen mizzen. Bowsprits were added after 1350. In comparison to early cogs which rated 80 tons and later cogs which rated 240, these early two masted carracks rated as much as 600 tons.

These ships were almost exclusively carvel built, a type of construction that saw use in both skin and frame built ships. In a carvel design, the planks of the strakes are butted edge to edge rather than overlapping as in traditional clinker design. That this word (a bastardization of caravela which first appeared in a Portuguese manuscript in 1255) should enter the English lexicon, is a testament to how revolutionary this type of design was on English ship building. The carracks, saw the first full skeletal design with planking framed on ribs all the way to the keel.

The topsail was added to the main mast in the middle of the 1400s. And about the same time the square rigged fore mast was added. To fit this extra mast, the huge aft lateen sail was reduced drastically in size. This was actually the reason for the change because large lateen sails required far more crew to man them then large square sails did. Soon after, a fourth mast, called the bonaventure, was added with a second small lateen sail, aft of the mizzen. By 1500, all four masts carried top sails and the main and fore mast added a third sail called a top gallant. This rapid proliferation of sails results in the first evidence of crew actually being stationed in the rigging, rather than working the sails entirely from the deck. Throughout this evolution, the size of the castles continuously increased to seemingly absurd heights, with the stern castle becoming an ever rising multi-tiered structue, and the fore castle a near vertical tower. Artists renditions of carracks show a characteristic “U” shape to the hull when seen from the side..

Meanwhile, in England, things were taking a slightly different turn. England’s first attempt at designing large ships resulted in the 540 ton *Trinity Royal* and the 760 ton *Holigost* which were the largest clinker hulled ships ever built (predecessors of which had simply foundered and sunk). Following the capture of 8 Genoese carracks in the service of King Charles of France in 1416, the English began their own carrack building program. One recovered example of English Carracks is the Mary Rose. The details of this ship provide a fair picture of a period carrack.

Built in 1510, she was extensively refitted in 1536 before sinking in 1545. She was 105 feet long with a 37 foot beam (width) and a draft of 14.8 feet (distance below the water line) Records indicate that she was regarded as a huge ship in her time of about 1500 tons. The masts and most of the superstructure did not survive intact; but it is likely that her main mast was around 114 feet high with a 9 foot circumference, the yard holding the mainsail some 31 feet long, with a forecastle that rose about 52 feet above the waterline. She was pierced for cannon below decks, and the wreckage sight revealed a “bewildering array of guns of different sizes and calibres”. Some were iron, others bronze, and some seem to have been bored as scatter guns. Also recovered were bows and arrows indicating that even by 1545, gunpowder had not entirely replaced those ancient naval mainstays. While a typical carrack carried 1 crew for every 5-8 tons of burthen (cargo capacity), English ships carried more. When the Mary Rose sank, she went down with 500 hands aboard, about 1 man for every 3 tons. The cost of ships similar to the Mary Rose, was in the neighborhood of 1650 pounds with annual costs of 100 pounds or more.

The carrack was a culmination of both northern and Mediterranean ship building arts. They were among the first ships where evidence is seen of specialization in design

for war or trade and they dominated the seas, politics, and budgets of their day. But for all of that they were slow, ponderous, and poor handlers.

The carracks were the Great Ships of the day, but in the days before naval standardization there were literally dozens of different types and sizes of small craft: Some of the more common included:

Ballinger: A distinctly English craft, the ballinger was a small clinker built double ended ship capable of being rowed or sailed with a single mast and square sail. A contemporary of the cog, by the late 1400s they were used as scouting and raiding ships attached to the fleet.

Barque: Bearing little resemblance to the nineteenth century vessel of the same name, the barque of this period was a Mediterranean, and particularly Iberian craft mounting three lateen rigged masts and noted for speed.

Galliot (Galiote): In the Mediterranean a Galliot referred to a small single masted, single sailed galley type vessel with 20 oars. Northern Europe (and particularly Dutch usage) refers to a small 1 or 2 masted ship with main and mizzen mast lateen rigged and a square topsail and possibly a top gallant on the main. The hull was characterized by a bluff (steeply sloped) rounded bow, a characteristic of many northern (and especially Dutch) ships.

Balener (Baleinier): A predominately Mediterranean ship, the balener was a shallow draft vessel equipped with oars as well as 1 or 2 lateen masts. In the late 1400s it was listed as being larger than galliots, barques, or caravels.

Deserving greater attention here, as being a ship as important as if not as large as the carrack, is the caravel. A direct descendent of a line of ships that includes the thirteenth century caravela (an open decked fishing boat) and the smaller barque, the caravel was the outstanding wind-ward sailing ship of the period. As a comparison in size. Columbus' beloved Nina was a caravel rated 60 tons.

The hull of the caravel was distinctive and elegant by comparison to the clumsier carrack design. Her lines swept back from a very bluff but sharp bow to a revolutionary stern design. Rather than a single stern post at which the side strakes would meet, the stern was transom built. It had two stern posts, one at each side resulting in the squared off aft characteristic of later ships. The stern castle was long and low, and overhung the aft of the ship in a graceful poop deck. This configuration owed much to Moorish ships such as the dhow, and proved very buoyant and resistant to leeway.

While the hull of the caravel was a defining feature, the rigging showed much variety. The *caravela latina* was an early design having 2 or three masts, all rigged with large lateen sails. She had less draft than the barque and generally better performance to windward. But the large lateen sails required a large crew and were dangerous to work in rough seas. The *caravela redonda* was a much more stable and flexible rig. The first versions mounted square sails on the fore mast, and when this proved successful square rigged the main mast too. This rigging became very popular and most carracks would adopt redonda rigging as well.

When Columbus sailed on his first voyage, the Pinta was a redonda rigged caravel, and the Nina a latina rigged caravel. While the redonda rig could not sail as closely to the wind, the Pinta's better all around performance prompted him to change the Nina's rigging for future voyages. As an interesting side note: No one is sure exactly what type of ship the Santa Maria was. The best guess is that she was a small carrack.

The *caravela da armada* was a sixteenth century refinement of the caravel's rigging. It consisted of a forward raked (leaning) foremast with two large square sails, the lower one anchored to the upper above and the bowsprit below, called a spritsail (an innovation of the late fifteenth century). The main, mizzen, and (most often) bonaventure masts were all rigged with progressively smaller lateen sails.

The caravel was the original pathfinder of European ship design. It was caravels that first doubled the Cape of Good Hope, and first sailed to the West Indies. But as voyages of exploration became longer her small size became a liability. By the end of the sixteenth century the caravel had lost its place as an internationally recognized symbol of naval achievement. But for all that, the design was so successful, and so perfectly suited to certain uses, that the caravel and its descendents would survive for centuries as fishing boats, small cargo carriers and escort craft. In fact, small, fast, seaworthy caravels were often used as scouts and messengers for the fleet. It is interesting to note, that a direct descendent of the caravel, the Portuguese Frigata, would eventually lend its name to British and French ships specifically designed for just that purpose.

By the late sixteenth century, the early Portuguese naval lead had been surrendered to Spain. Spain was not interested in exploration for the sake of exploration, Spain was interested in loot. The small caravels were limited in the amount of plunder and raw materials they could carry from the new world. So in 1552, Spain banned any ship smaller than 100 tons from sailing to the West Indies. In 1587 this ban was increased to 300 tons. By the mid 1500s a new larger vessel was replacing both the caravel and the carrack, the galleon.

The first reference to a galleon comes from a Venetian document in 1550, which mentions a "galleon moved by oars". The term probably derived from the Italian gallioni which was a traditional galley that had particularly superior (for a galley) sailing qualities (for a galley). One thing is certain, however, the term never had any standardized meaning. Although it would come to be applied most closely to the Spanish Treasure Galleons, the term, like caravel, carrack, and cog before it was actually a generic label applied to a wide range of craft bearing certain similarities.

The galleons had a lower profile than the carrack. Gone was the towering forecastle to be replaced by a much lower structure which included a beak projecting out under the bowsprit. This development was likely a direct result of the sprit sail becoming standard and the need for a more effective means of handling it. The ship was also slimmer. The proportion of the length of hull to keel, to beam was 3:2:1 in the carrack but only 4:3:1 in the Galleon. The long low stern castle of the caravel became an integrated raised section of deck called the quarterdeck. The stern itself was transom built and above were often several overhanging decks, culminating in the high, sloping, narrow tiers of the characteristic galleon poop deck. This feature led to another innovation of the Galleon. With the ship's upper decks so high above the rudder, the tiller was actually inside the ship. In order to steer from the upper deck, the tiller was extended by means of whipstaff and tackle to the quarter deck. It would still be some years before ships mounted an actual wheel.

Like the caravel the galleon had a largely flat bottom which curved outward up the sides. But, the galleon's side continued up, curving sharply back in to a much narrower deck. This bulge, called a tumblehome (a term still used by auto makers to describe similar bulges in cars and particularly SUVs) created a very low center of gravity. This low center of gravity made the galleons a superior gun platform, and enabled them to carry guns in multiple decks increasingly higher on the ship. Galleons typically mounted two

continuous gun decks below, with lighter cannon set on the raised castles on the upper deck.

The larger galleons were almost universally four masted. The fore mast was set well forward, close to the bowsprit. It was square rigged with a square topsail. Unlike the caravela da armada, the lower sail was not anchored to the bowsprit which now carried its own spritsail. The main mast was very tall and rigged with square main sail, top sail, and top gallant. These upper sails were “wide footed, and narrow headed” meaning they were wide but narrow. It is important to note that they were not a very efficient design, and the main courses provided most of the driving power for the ship. The short mizzen mast, set on the quarter deck, and the very short bonaventure, set on the poop deck, were both lateen rigged. There is some evidence of lateen topsails on both of these masts, but the unlikely sailing qualities of such sails probably limited them to being flamboyant displays.

Despite the seeming preciseness of this description it is important to mention again that there was really no such thing as a “standard galleon”. Ships were never built to plan or with any sense of engineering principles. “What looked right, was right”. Ships floated because they were made of wood. An enormous galleon built in 1514, by King Henry Viii of England, founder of the Royal Navy, still maintained the towering forecastle of the earlier carrack. After her refit in 1536, the *Henri Grace a Dieu*, or Great Henry, carried 21 heavy bronze guns, and 130 small iron guns. She was the first ship known from records to have an orlop deck, i.e. a deck below the lowest gun deck. The orlop was essentially the ceiling of the ship’s hold. Pictures of the Great Henry show grappling hooks at the ends of her yards, if accurate they were likely intended to aid in fouling an enemy vessel prior to boarding action.

The Great Henry is typical of an English ship that would have fought the Spanish Armada in 1588. While the English never referred to their ships as galleons, they were as much galleons as those of their Spanish enemies. It is interesting to note that out of the 130 ships in the Armada, only 20 were true galleons.

Of Ships Practical and Impractical
And the Evolution of Tactics

The Great Henry was the first ship built for the sole purpose of being a political instrument of intimidation. This trend was continued in later centuries with several interesting results. First warships continued to become larger and larger and carry increasing numbers of guns. Second, warship and merchant ship design parted ways as merchants were too practical to get caught up in the grandiose inefficiencies of monarchal whim, and true warship design began to have specialized requirements of its own. Third many fortunes were spent on singular awe inspiring monstrous vessels, that rarely lived up to their reputation.

During this period, the first standardizations of ship construction were seen. As early as 1400, Venetian galley building had begun to be codified and precise proportions for the most efficient combination of speed and size were laid down in “rules”. Italian experts became sought after in other courts and in 1587 the first manual for ocean going ship design was written in Mexico City, followed up by more comprehensive documents in 1611 in Seville, and 1616 in Portugal. These manuals concentrated on galleons and naos (a term literally meaning ship and used to refer to any ocean crossing vessel that was not a galleon), and agreed that the proper proportion for hull to keel to beam for a nao was 3:2:1. From 1629 through 1646 similar works were appearing in France, Germany, and

Italy. While England continued to rely on the “rule of thumb” for ship design, France in 1663 began to develop the “rule of measure”. As a result, French ships began to recognized as superior sailors, riding higher in the water as the result of a greater beam. This made them more nimble and more stable gun platforms. British advances in galleion design came largely from copying captured French ships, much as their advances in carrack design came from copying captured Genoese ships. These manuals were primarily concerned with military ships and aimed at the growing bureaucracy surrounding the navy. Merchants were left to their own devices

Portugal and Italy were not the only places in Europe where revolutions in ship design were taking place. The Dutch had hit upon several innovations which had previously been confined to the Baltic trade but which soon would become standard the world over.

The Boyer (boeijers) was a small vessel of under 100 tons used to ply the Baltic and coastal waterways of the north. In such an environment, the ability to sail to windward was crucial, but the cumbersome, capricious, and difficult to control lateen sail was not the ideal solution. Their innovation would revolutionize sail rigging. Rather than hanging a lateen sail from a yard beside the mast, where it was difficult to bring around for tacking, a tall square sail was hung from a spar set behind the mast. The Dutch called this spar a sprit and hence the sail a sprit sail. To avoid confusion with the spritsails hung from the bowsprit, I herein use the term gaff sail, based on a more common term for this type of spar. This gaff sail, projecting behind the mast like a fin could swing freely to either the right or left tack and so could be handled with a minimal number of crew. It could be easily furled by simply drawing it towards the mast like a curtain. This arrangement freed up a lot of space in front of the mast. Already there were a series of lines, called stays anchoring the mast, and now, from those stay lines, stay sails were set. On the main forestay, running from fore mast to bowsprit, a large triangular staysail called a jib was set.

The Buss was a fishing boat which had the useful feature of allowing its main and foremast to be lowered towards the stern. This reduced leeway and rolling while working the nets. It also called for ships to be designed with a very long hull with a hull to beam ratio of 4:1 and more. This was to become a defining feature of Dutch ships.

A particularly successful merchant design, was the Dutch Flute (or Fluit). The flute represents perhaps the first application of design by specification in the history of sail. The Dutch, who were still embroiled with their never ending conflict with Spain, relied on overseas trade to fund their war effort. They sought a ship that was reliable, and safe, cheap to build, cheap to rig, and cheap to operate. It had to have ample cargo space. That cargo space had to be well protected from the weather, and easily carry any form of cargo.

The original flute design is attributed to Pieter Jansz Liorne in 1595. The original flute had a hull to beam ration of 5:1 making her long and slender like the wine glass from which she takes her name. Like a galleon she had a low forecastle and high and narrow stern resulting in half, quarter, and poop decks Unlike the galleon or caravel which carried a transom stern, the flute returned to a single vertical sternpost which drew the sides together sharply like a box. The stern castle above the rudder had a transom aft. Larger flutes had a second deck and mounted a few guns, but since guns require additional crew to work, and took weight and space more profitably used for cargo, flutes were almost always lightly armed or unarmed.

Flutes ranged in size from 100 to 800 tons, but the middle range seemed to be the most common and could enter and exit any port without delay. They occasionally reached

rations of length to beam of 6:1. This length made them slow to turn, and they were ponderous sailors (although stable and with good control). Their greatest feature, from a merchant perspective, was how few crew they required. Fewer crew meant fewer expenses, and less cargo space dedicated to supplies. Typically the Dutch flute could be manned with 1/3 or less of the crew required by other vessels of similar size. Seven men and a boy were listed as the compliment of a 150 ton flute in Norway, and in 1603 Sir Walter Raleigh complained 10 Dutchman in a flute could do the job of 30 English sailors.

The principle crew savings came from greater efficiencies in the rigging. As ships got larger, the main sail on each mast grew progressively larger as well (these main sails were called courses, the term main sail came to be reserved for the course on the main mast only). By the days of the carrack and galleon they were ridiculously huge and hard to manage. They were particularly hard to sail in the close quarters of a port or river, where waterfront buildings would block the wind to the low set courses. The flute carried 3 masts. Ironically the mizzen mast carried a small lateen sail rather than the more effective gaff sail of the boyer. The main and foremast were square rigged with topsails but no top gallants. Of particular interest here is that the topsails were much wider in the head (taller) than on other ships of the day. As a result, the main course was smaller and more manageable. The new topsail design was also far more effective as a driver, and in rough weather the ship could be more safely managed by topsails alone. This had other applications as well. The top sails typically projected above the level where the wind was blocked by waterfront buildings allowing for superior maneuverability in harbors. In combat, ships flying only topsails had better control, better field of vision and less cloth to be damaged by enemy fire. This sail state would become the standard “fighting sail” of a later age.

In addition to crew savings, the flute was significantly cheaper to build, largely because it was built to somewhat standardized specifications. A flute cost a mere 40% of an equivalent Nao. Some of the cost savings were the result of substituting pine for oak. Pine was much less durable, giving the flute a career of only 20 years or so, but to the profit maximizing eye of the merchant trader, she was the most wonderful ship afloat. By 1669 there were over 10,000 Dutch flutes at sea. These large numbers were made possible by the first mass production ship yard at Zaanstreek near Amsterdam. Windmill powered saws and efficient cranes helped speed construction with little waste.

Such a successful ship as the flute spawned many variants after 1650.

Northern Flute: This larger flute’s cargo holds were so water tight that they could carry grain in bulk rather than sacks or barrels.

Timber Flute: The long length of the flute made it naturally easy to adapt to carrying long timbers such as those used for masts. Ports were cut in their stern to allow the excess length of the timber to project out. This was a common end for many older ship nearing the end of their useful life.

Katchip (ketch): A smaller flute with a gaff sail mizzen mast and no topsails.

Hekboot (hack boat): A larger flute with a gaff sail mizzen mast and no topsails.

Straetsvaeder: More heavily constructed and armed against Barbary Corsairs for passing through the Straights of Gibralter, the Straetsvaeder had a projecting beak and a more complex rig including main and fore top gallants, a mizzen topsail and a second spritsail at the bow. This was the only flute design to carry heavy armament with its resulting greater cost in crew and maintenance. Even so the ship could bring northern trade goods to the Mediterranean cheaper than the Italians.

The United Provinces of the Netherlands also provided escort craft for their flutes in the form of the fast, armed, full rigged single deck pinnas (or pinnace in England). The pinnace served the role of a light frigate or corvette and was built like a miniature galleon.

An even lighter warship used to pursue small enemy vessels was the jachtschip, or hunting ship. A particularly lavish and well appointed jacht was presented to King Charles II, and ensured that the term jacht, which comes to us today as yacht would ever after refer primarily to a pleasure craft.

England during this period was undergoing a civil war. One of the root causes of that war was King Charles I highly unpopular ship tax. While several effective English men-of-war were built as the result of this tax, it is interesting to note that, in the spirit of the monstrous great ship discussed at the open of this section, King Charles' dream was to build the "largest ship in the world". The Sovereign of the Seas was launched in 1637 with a tonnage of over 1500, and some of the most extravagant decorative carvings to-date. The ship's rigging was to carry royals above the top gallants on main and foremast, and a top sail and top gallant above the lateen mizzen course. With 100 guns on three decks, she truly was the largest ship afloat. Where a typical 40-50 gun galleon cost some 6-7000 pounds (including 1,000 pounds worth of decoration), the Sovereign of the Seas (renamed Royal Sovereign in 1660) cost over 65,000. An interesting historical note. As a result of the excessiveness of the Sovereign and the role it played in inciting the puritanical revolution, British ships thereafter carried far fewer decorative carvings, forcing the entire industry of ship carvers to turn to carving country churches.

The French answer to the Sovereign was the La Couronne of 1636. While larger at 2000 tons, she boasted only 2 gun decks and hence only 72 guns. Even so, she was the more effective warship. In fact, so effective was La Couronne's basic design, that the most successful wooden warship of the nineteenth century would be the 2 deck, 74-gun ship of the line.

One of the key problems with such experimentation lay with the stability of the ship once built. The Mary Rose discussed earlier was one of the first English ships to be outfitted with cannon. As a result of the builder's inexperience at this sort of thing, the lower gun ports were cut too close to the water line, and the ship flooded and sank when heaved over by a strong wind. In 1628, the Swedish monster ship Vasa met the same fate on her maiden voyage. She was to be an 800 ton 2 decked galleon. In order to carry more guns in her broadside she was lengthened to the dimensions of a flute.

But such experiments continued. While some were more successful than others, all were a result of how naval ships came to represent royal prestige, and the effort of monarchs to claim the sea as they claimed territory. The Dutch claimed the Helsingor Sound and levied taxes on ships passing through it (since the tax was based on a formula using the ship's beam, the narrow Dutch flute paid far less than its foreign competitors). To keep her southern coast secure, the English king required foreign ships in the channel to lower their topsails when confronted with an English vessel (thus reducing their ability to fight or run considerably). This act was preserved in the Royal Navy tradition of dipping the ensign (flag) as a show of respect.

Naval tactics also evolved greatly during this period. The medieval fleet battle was an action of boarding, a land battle fought at sea. The engagement of the Armada proved the effectiveness of gunfire over boarding. It also proved the effectiveness of harassing large ponderous ships with many smaller more nimble ones. In something of a follow-up to the Armada, the English ship Revenge in 1591 held off 53 Spanish ships until she ran

out of powder (sinking two of them) in a battle that decisively proved the superiority of gunnery over boarding.

The hundred years from 1590 to 1690 can be seen as the gradual evolution of the line of battle; where ships would line up stem to stern “following the motions of the admiral”. This formation brought the most guns to bear on the enemy and helped protect a fleet from being picked apart piecemeal. Many battles of the Dutch Wars were still chaotic running fights of individual ship duels; but others, like the Battle of the Gabard in 1653, were fought broadside to broadside. The Battle of Beachy Head involved a line of battle of 56 Anglo-Dutch ships opposing a line of 84 French ships in an engagement over twice as large as the famed battle of Trafalgar (60 ships total) 115 years later.

The line took 100 years to adopt because it required ship design and standardization to catch up with tactical application. To stay in a close line formation without falling behind or becoming entangled requires a fleet of ships of approximately equivalent sailing characteristics. Like the proverb about a chain’s weakest link, ships in a line of battle had to be able to dish out enough punishment to harm the enemy and to withstand the same. Throughout this period a national fleet consisted of some royal ships at the core and a number of commandeered merchantmen. It was soon discovered that this mixture proved inadequate to the maintaining of an effective line formation.

The tactical needs of the line of battle would give rise to national navies of dedicated warships rated by their ability to stand in such a line. The number of guns was the most convenient and most accurate way of rating such ships. The number of guns served as a proxy not only for firepower, but also size, and crew complement. The ever increasing size of ships of war can be seen in the constant revision of this rating system.

In 1651:

First Rate: 60 guns and more
Second Rate: 50-60 guns
Third Rate: 40-50 guns
Fourth Rate: 30-40 guns

In 1680:

First Rate: 80 guns and more
Second Rate: 60-70 guns
Third Rate: 50-60 guns
Fourth Rate: 40-50 guns

In 1700:

First Rate: 100 guns
Second Rate: 80-100 guns
Third Rate: 70-80 guns
Fourth Rate: 50-60 guns

Note the Primary Reference for this work was:

The History of the Ship, Richard Woodman
Conway Maritime Press; London, 1997