

THE *NAU* OF THE *LIVRO NAUTICO*:
RECONSTRUCTING A SIXTEENTH-CENTURY INDIAMAN FROM TEXTS

A Dissertation

by

ALEXANDER DEAN HAZLETT

Submitted to the Office of Graduate Studies of
Texas A&M University
in partial fulfillment of the requirements for the degree of

DOCTOR OF PHILOSOPHY

May 2007

Major Subject: Anthropology

THE *NAU* OF THE *LIVRO NAUTICO*:
RECONSTRUCTING A SIXTEENTH-CENTURY INDIAMAN FROM TEXTS

A Dissertation

by

ALEXANDER DEAN HAZLETT

Submitted to the Office of Graduate Studies of
Texas A&M University
in partial fulfillment of the requirements for the degree of

DOCTOR OF PHILOSOPHY

Approved by:

Chair of Committee, Luis Filipe Viera de Castro

Committee Members, Kevin Crisman

C. Wayne Smith

Gerald Vinson

Head of Department, David Carlson

May 2007

Major Subject: Anthropology

ABSTRACT

The *Nau* of the *Livro Nautico*:

Reconstructing a Sixteenth Century Indiaman From Texts. (May 2007)

Alexander Dean Hazlett, B.A., University of California at Santa Barbara;

M.A., University of Hawaii

Chair of Advisory Committee: Dr. Filipe Castro

Documents and illustrations show that the premier ship in Portugal's India trade during the 16th century was the *nau*, a beamy, three-masted ship, known in northern Europe as a “Carrack.” For decades these vessels carried passengers and cargo between Portugal and Asia. Despite the number of vessels involved, relatively little archaeological evidence of these ships exists. While 16th century shipbuilding documents predate the development of ships plans, they include theoretical treatises and scantling lists. From these documents it is possible to reconstruct the construction of a *nau* timber by timber, employing the mathematical relations and formulas used by the Portuguese shipwrights in conjunction with the timber specifications from a scantling list, creating a 3D computer model of the ship with Rhinoceros 3 modeling software. The result is an annotated and illustrated construction sequence that shows the placement of every timber in the vessel.

DEDICATION

For my wife, Karen, who came to central Texas without complaint.

ACKNOWLEDGEMENTS

A great many people have contributed to the completion of this dissertation in a variety of ways.

Before I knew anything about Texas A&M University and the Nautical Program, Dr. Hans van Tilburg got me interested in Maritime History and Archaeology while I was studying Asian History with him at the University of Hawaii, and I will be eternally grateful he redirected my attention toward maritime history and archaeology.

Early on, Dr. Filipe Castro lured me into researching Portuguese shipbuilding when he loaned me an untranslated Portuguese document that gave the scantlings and dimensions for an Indiaman when I needed a project for Dr. Crisman's course on the rigging of ships. His enthusiasm for the study of shipbuilding treatises led me to further study these documents. In addition, the experience of two years as one of Dr. Castro's teaching assistants in the Ship Reconstruction Laboratory turned drafting and the study of ships lines from the daunting challenge I faced in my first semester to the center of my research interests.

Dr. Kevin Crisman and Dr. Cemal Pulak taught me the all-important basics of our field; their courses were the foundation of all my subsequent study.

My interest in computer drafting and modeling was sparked by Dr. C. Wayne Smith, who got me started using Rhinoceros 3 software and was further strengthened by Mr. Jeffrey Otey and Dr. Gerald Vinson.

J. Barto Arnold gave me my first chance to work on an underwater excavation when he hired me as a crew chief for the summer 2002 season of the Denbigh project in Galveston Bay. This was my first experience with diving and excavating in black water, and the first practical use of my training in taking lines and drawing timbers.

In 2003 Paul Creasman gave me the opportunity to record and document timbers in a dry-land site (inside the Cairo Museum) as part of the Cairo Dashur boats project.

Taras Pevny was tremendously helpful in explaining how shipwrights conceived the shape of vessels before the graphic depiction of ships lines developed, and how the runs of planks flow over the hull of a ship.

I took great advantage of Glenn Grieco's knowledge of ships and rigging and often stood in the hallway to examine his model of the *Belle* as I puzzled over construction details in my computer model.

My fellow teaching assistant in the Ship Reconstruction Laboratory, Erik Flynn, taught me a great deal about how to analyze ships lines; both the level of and attention to detail in his drafting projects were an inspiration to me.

TABLE OF CONTENTS

	Page
ABSTRACT	iii
DEDICATION	iv
ACKNOWLEDGEMENTS	v
TABLE OF CONTENTS	vii
LIST OF FIGURES.....	viii
CHAPTER	
I INTRODUCTION	1
II HISTORICAL CONTEXT.....	6
The Legacy of the 15 th Century.....	7
Sixteenth-Century Portugal.....	12
Portugal's Overseas Empire and the <i>Carreira da India</i>	19
III THE DEVELOPMENT OF THE <i>NAU</i>	28
IV THE DEVELOPMENT OF NAVAL ARCHITECTURE.....	37
The Dawn of Naval Architecture	38
Sources on Sixteenth-Century Shipbuilding	39
Whole Molding	43
V THE <i>NAU</i> OF THE <i>LIVRO NAUTICO</i>	48
Reconstructing a <i>Nau</i> From Texts.....	48
Illustrated and Annotated Sequence of Construction.....	51
The Escoteiras That This <i>Nau</i> Takes.....	158
The Masts of This <i>Nau</i>	159
VI CONCLUSIONS.....	162

	Page
The Text and the Author	162
Portuguese Shipbuilding	164
Computer Modeling	170
Shortcomings.....	172
REFERENCES	176
APPENDIX A	180
APPENDIX B	181
APPENDIX C	187
VITA	213

LIST OF FIGURES

FIGURE		Page
1	Cog (left) and <i>Nave</i> (right).....	28
2	Fourteenth-Century <i>Cocche</i> After Friel	29
3	<i>Nau</i> After Meagher.....	30
4	<i>Mezza-luna</i> With Ruler	46
5	Graduated Ruler in Use	46
6	Rising and Narrowing Floor Timbers	47
7	Keel and Couces.....	51
8	Roda and Contra Roda	52
9	Codaste	53
10	Gio.....	54
11	Master Frame and Almogamas	56
12	Pre-designed Frames	56
13	Enchimentos and Astes	57
14	Enchimentos and Piquas and Areuessados.....	58
15	Carlinga and Trinquanis	59
16	Sobrequilhas	60
17	Dromentes and Contradromentes	61
18	Escoas.....	62
19	First Deck Beams	63
20	Cordas.....	64

FIGURE	Page
21 Bonequas	65
22 Peis de Carneiro	66
23 Paixoes and Tamboretetes	67
24 Trinquanis.....	68
25 Arreuessados and Porquas.....	69
26 First Deck Planking.....	69
27 Buçarda and Dragas	70
28 Curvas de Conves.....	71
29 Pairs of Antremichas	72
30 Knees for the Cordas	73
31 Buçarda and Dragas	74
32 Coçeiras.....	75
33 Madres das Escotilhas	76
34 First Wale	77
35 Seis Bordo and Second Aposturagẽ	78
36 Second Deck Dromente and Contradromente.....	78
37 Second Deck Beams.....	80
38 Second Deck Cordas	80
39 First Deck Curvas de Reves	81
40 Mesa for the Seis Bordo	82
41 Second Deck Paixoes and Tamboretetes.....	83

FIGURE		Page
42	Second Deck Trinquanis	84
43	Second Deck Knees for the Cordas.....	85
44	Second Deck Planking	85
45	Second Deck Peis de Carneiro	86
46	Second Deck Curvas do Conves	87
47	Second Deck Entremichas.....	87
48	Carlinga and Cunhos for the Mastro do Traquete	88
49	Second Deck Buçarda and Dragas	89
50	Second Deck Coçeirias and Madres das Escotilhas	90
51	Conchas and Curvas of the Strinqua	91
52	Eixo and Cruzetta of the Strinqua	91
53	Third Aposturagẽ.....	93
54	Third Deck Dromente and Contradromente.....	94
55	Third Deck Beams and Cuxias.....	95
56	Third Deck Cordas	96
57	Second Deck Curvas de Reves.....	97
58	Third Deck Planking	98
59	Third Deck Trinquanis	98
60	Third Deck Paixoes	99
61	Third Deck Curvas do Conves	99
62	Third Deck Entremichas.....	100

FIGURE		Page
63	Conchas do Cabestrante	100
64	Abitas	101
65	Third Deck Buçarda and Dragas	102
66	Third Deck Coçeiras.....	102
67	Third Deck Peis de Carneiro	103
68	Quarteis	104
69	Barçolas.....	104
70	Portinholas.....	105
71	Fourth Aposturagê.....	106
72	Tolda Dromentes	108
73	Tolda Beams.....	108
74	Cuxia Dromentes.....	109
75	Cuxia Beams, Carlings, and Stanchions.....	110
76	Sterncastle Viotes.....	111
77	Tolda and Chapiteu Curvas	112
78	Tolda Entremichas.....	112
79	Tolda and Chapiteu Curvas de Reves	113
80	Abita at the Bow.....	114
81	Papoya and Curva do Falcão.....	115
82	Chapiteu Beams.....	116
83	Forecastle Dromente	117

FIGURE	Page
84 Forecastle Virotas.....	118
85 Falcão and Contrafalcão.....	119
86 Bow Structure Details	120
87 Gurita Beams.....	121
88 Forecastle Curvas do Reves	121
89 Easouvem	122
90 Contraescouvem.....	122
91 Curva do Beque.....	123
92 Forecastle Cordas and Curvas	124
93 Curvas pellas Bandas	125
94 Curvas na Arpa.....	126
95 Curvas na Alçaceua.....	127
96 Carlinga da Mezena and Curvas.....	128
97 Dala and Curvas na Dala.....	129
98 Curvas no Perpao	130
99 Gingamochoes na Bomba.....	131
100 Carregadeira	132
101 Cambotas.....	133
102 Chapiteu Cambotas	134
103 Mulinetes.....	135
104 Chapiteu Perpao and Grating	136

FIGURE	Page
105 Perpaos no Castello	137
106 Çeravioles.....	137
107 Doubled Wales	138
108 Single Wales.....	139
109 Chapiteu Dromente	140
110 Chapiteu Wales	141
111 Forecastle Wales	142
112 Forecastle Dromente	142
113 Tolda Wales.....	143
114 Chapiteu Deck Planking.....	144
115 Tolda Deck Planking.....	145
116 Forecastle Deck Planking.....	145
117 Varanda	146
118 Varanda Virotas.....	147
119 Varanda Timbers	148
120 Varanda Deck planking.....	148
121 Lower Hull Planking	149
122 Upper Hull Planking.....	150
123 Calimetas and Emendas	150
124 Stern Wales	151
125 Mesas Grandes and Apostareus.....	152

FIGURE	Page
126 Mesas de Proa and Apostareus.....	153
127 Hypothetical Upper Forecastle Deck	156
128 Bombas.....	157
129 Masts and Yards of the <i>Nau</i>	161
129 Mast Placement in the Hull	161
131 Midship Structure of <i>La Lomellina</i> After Blotti	166
132 Midship Section of <i>Mary Rose</i> After Fielding.....	167
133 Midship Section of the <i>Nau</i> of the <i>Livro Nautico</i>	168

CHAPTER I

INTRODUCTION

Five hundred years ago both Spain and Portugal established far-flung economic empires supported by fleets of merchant vessels. Spanish ships carried silver from the New World, while Portuguese ships carried pepper from India; the relative value and perishability of these cargoes may explain why so much more is known about Spanish shipwrecks today.

The Spanish trade was organized into fleets comprised of dozens of medium-sized merchant ships with warship escorts, dividing the shipments of silver between many vessels in case of loss in storms or attack. The roughly 6000-mile (9660 Km) passage across the Atlantic took about eight weeks, though the difficulties of organizing the fleets and transshipment of cargos meant the fleets made only one round trip each year. Many of the vessels lost in these voyages came to grief in the warm, shallow waters of the Caribbean, where their cargoes of gold and silver attracted salvors and archaeologists to study and excavate these vessels.

In contrast, Portugal's Asian trade was carried by a handful of large ships each year, laden with hundreds of tons of pepper. To carry these loads the small caravels used by Portuguese explorers during the 15th century were replaced by *naus*, great cargo-carrying craft developed from the mixture of Atlantic and Mediterranean maritime technology. Their passage to India took up to eight months, and the round trip typically

This dissertation follows the style and format of the *American Journal of Archaeology*.

eighteen months, often touching land only once during the 25,000-mile (40252 Km) journey (a distance equivalent to sailing around the world with only one stop). Many of these vessels were lost in the deep, cold waters off the southern end of Africa, or on its inhospitable southeast coast. With their cargo holds crammed with pepper (which is readily available as a bulk commodity in the modern world, not to mention the fact any salvaged pepper would most likely be inedible after 500 years underwater) and much less accessible wreck sites it is hardly surprising these Portuguese wrecks have failed to generate the same amount of interest as the silver-laden Spanish treasure galleons.

Although a number of Spanish vessels from this period have been archaeologically excavated, few Portuguese ships (and only one *nau*¹) have received the same treatment. Fortunately, the 16th century saw the dawn of Naval Architecture in the Iberian Peninsula as treatises were written in Portugal, Spain, and Mexico that explain how shipwrights conceived and built ships. These documents predate systems of developing ships hull designs by drawings, but their non-graphic methods for determining the shape of a vessel's hull are clearly explained.

These theoretical discussions of shipbuilding are only part of a whole corpus of sources by Portuguese and other authors that describe the materials, measurements, and methods used by 16th century shipwrights. Other documents such as scantling lists, budgets, and contracts shed additional light on the construction process. This

¹ In the 16th century the large three-masted sailing ships the English called 'carracks' were called *naos* in both Spanish and Portuguese texts, but in modern Portuguese these ships are called *naus* instead. In this dissertation I will use the modern term (*nau*) unless I am quoting a 16th-century document.

shipbuilding data can be checked against the archaeological record. Iconographic material also lends clues to the construction of these ships.

This dissertation focuses upon the “textual excavation” of a *nau* of the *Carreira da India* (the “India Route”, the Portuguese term for their trade route from India to Lisbon), describing the construction of the vessel timber by timber following the methods of the 16th-century builders and the dimensions and measurements specified in contracts and treatises, using *Rhinoceros 3* software to model the ship. Building the model has forced me to face not only the limits of our understanding of Portuguese shipbuilding nomenclature and methods but also the limits of modern graphically-based methods of design (in particular the limitations of the standard 3-view illustrations). It has also shown how useful computer modeling can be for projects like this (both for the ease of modification and for the ease of viewing the ship from any angle). The completed model is useful not only as an illustration of the parts of and construction sequence for an Indiaman, but also as the starting point for further analysis of these vessels, such as their handling characteristics, loading, and stability.

To understand the role of the India *naus* it is necessary to consider the historical context in which they were developed and the trade routes that they served. Chapter II addresses the 15th and 16th century political factors (centralization of power under the King and attempts to unify Iberia under one ruler), religious issues (crusades against Muslims in North Africa and the persecution and expulsion of Jews from Portugal), and economic factors (exploring the African coast for trade possibilities, the adaptation of a royal shopping system to larger merchant activities, land reclamation efforts, and the rise

of new trading networks) that shaped the origin of the *Carreira da India* and its operation throughout the 16th century.

Chapter III deals with the development of the *naus* themselves. Just as the *Carreira* had grown out of earlier trading systems, Portuguese India *naus* were the end result of an older evolution in ship design. The design of these ships was already mature by the time they were selected to carry pepper and Indian products back to European ports. The *nau* had developed in the 14th and 15th centuries by combining separate Atlantic and Mediterranean ship technologies: the stern rudder and square sails of the Atlantic cog were added to the lateen rig, multiple masts, and capacious hull of the Mediterranean *nave*. By the 15th century these vessels were large, typically three-masted ships, with a lateen mizzen. Their masts and yards were large multi-part assemblies and their square fore and main sails were characteristically huge as well. Fore- and stern-castles were integrated into their broad, round hulls. Because the primary function of vessels built with these characteristics was the transport of large volumes of cargo, they were perfectly suited to the *Carreira*.

Chapter IV addresses what we know about these vessels and how we know it. With limited archaeological evidence much of what we know about Portuguese Indiamen comes from iconography and from shipbuilding treatises and documents of the time. This chapter discusses the range of useful source material for the reconstruction of an India *nau*.

Chapter V focuses upon the reconstruction of one of these ships, describing and illustrating (with images from the 3D computer model) the construction sequence from

the first keel timbers to the masts, using the scantling lists and instructions in the *Livro Nautico* line-by-line, supplemented with relevant data from other treatises as well as iconographic and archaeological data.

Chapter VI concludes the dissertation with a discussion of what the reconstruction process has revealed about the *Livro Nautico* document and its author, about 16th century shipbuilding practices, and about the problems in drafting (both in conventional drafting and on the computer) a reconstruction like this.

Appendix A is my own English-language translation of the *Livro Nautico* document on the construction of a 600-ton *nau*, based upon the 1892 transcription into modern Portuguese by Henrique Mendonça and checked against a copy of the original 1590 text.

CHAPTER II

HISTORICAL CONTEXT

The 16th century was the heyday of Portugal as a world power; with settlements in Africa, India, Southeast Asia, China, Japan, and Brazil, the sun hardly ever set upon the Portuguese trading network. Even at its zenith, however, the state was constrained by issues inherited from the previous century and by the tyranny of its early success. The *Carreira da India* and Portugal's Asian trading empire were affected by these factors.

This problematic inheritance included the activities and aspirations of the Portuguese crown as well as changing (and unchanging) economic and agricultural practices. Portuguese monarchs in the 15th century had attempted to unify Iberia under Portuguese rule, to reduce the power of the nobility (and centralize royal control of the country), and to establish trade with Africa and eventually with Asia. The crown also became involved in merchant activity abroad, adopting familiar medieval trading practices to new markets overseas. Religious sentiment was strong, based upon the Christian reconquest of the Iberian Peninsula, and a crusading spirit burned in the hearts of the nobility. Portuguese farmers had begun reclaiming abandoned lands for new forms of agriculture, and commercial networks were beginning to supplant the old fair- and market-based trading system. These 15th century trends would continue to affect Portugal throughout the next century and were mediated in different ways by successive rulers.

At the same time, Portugal's quick success at reaching Asia and gaining the lion's share of the extremely lucrative spice trade to Europe reduced the desire to further improve the Portuguese trading system, or to drastically modify the vessels serving on

the *Carreira da Índia*. Lack of European competition, the inclusive nature of Asian trade at the time, and the constraints of warfare in East Asian waters led to the early adoption of a trade route supported by but uninvolved with military activities. The Indiamen that carried the cargoes of the east back to Lisbon in 1505 changed only incrementally over the following century; they grew in size from two decks to four, their forecastles gradually became integrated into their hulls, their fore- and stern-castles were lowered, and their keels became longer.

THE LEGACY OF THE 15th CENTURY

In the mid-15th century King Afonso V (1438-1481) had given much of the royal patrimony away to a number of noble families, and much of the crown's political power as well. Lands were given to 15 families including the powerful Braganças, Meneses, Coutinhos, and Melos. They also received most titles, furnished most bishops and important abbots, held high offices and enjoyed special privileges. In addition to these 500 upper-level aristocrats, 2000 or so lower vassals received revenues from the crown and held feudal obligations.²

Afonso's son and successor João II (1481-1495) tried to curb the burgeoning noble power by reducing their feudal jurisdictions and cutting back on royal grants, but this drove the upper nobility to conspire against the throne. João struck back; the head of the conspiracy, the Duke of Bragança, was tried and executed, while the other ringleaders were forced to flee the country. The strongest noble families were abolished, and their

² Anderson 2000, 46-47.

properties forfeited to the crown. After quashing a second conspiracy by his cousin, the Duke of Viseu, João had eliminated or neutralized nearly all the upper nobles, and regained a considerable portion of the national territory.³

Legal experts, civil servants and other members of the lower nobility were appointed to top positions previously held only by the upper aristocracy, solidifying their support for the crown. By these ruthless actions João had achieved peace, centralized power, and enlarged the crown's patrimony, at the expense of the upper classes. It fell to his successor Manuel I (1495-1521) to find some compromise between Afonso's easygoing nature and João's ferocity to reunite and modernize the country.⁴

As the Reconquista came to a close, the kingdoms of Iberia drew closer to unification under a single ruler. The Portuguese were not aloof to the concept; Afonso V invaded Castile and Leon in 1475-6 (with the intent to rule Castile) but was forced to withdraw. In the 1479 Treaty of Alcáçovas he renounced all rights to the Castilian throne and the Canary Islands in exchange for a monopoly over the African coastal trade and over exploration south of the Canaries.⁵ Subsequent Portuguese attempts to gain control of a unified Iberian peninsula were peaceful attempts to marry into the succession. After the death in 1497 of Prince Juan, Manuel's wife Isabella of Aragon was sworn in as heir to the combined thrones of Aragon and Castile. Only two months later, however, Queen Isabella died in childbirth, and her son Miguel died two years later. Although Manuel married Isabella's younger sister Maria, and later her niece Leonor, the Portuguese were

³ Payne 1973, 225-226.

⁴ Marques 1972, 210-211.

⁵ Anderson 2000, 49.

never as close to ruling all of Iberia again. When unification finally came, it was a Spanish King, Felipe II, who was crowned Filipe I of Portugal (1580-1598).

The expulsion of Jews from Aragon and Castile in 1492 and subsequent influx of more than 50,000 Jewish immigrants to Portugal brought new problems for the Portuguese crown. Included in their midst were thousands of skilled artisans and hundreds of families of great wealth, whose presence strengthened the economy, but the sudden import of such a large group threatened the livelihood and station of native Portuguese artisans and well-to-do families.⁶ King João compromised; he allowed the Jews to enter (for a fee of eight cruzados each) but refused to allow most to stay (only the richest families were able to purchase permanent residence permits). Many who could not pay were imprisoned.⁷ These prisoners were freed when Manuel took the throne, but only a year later Queen Isabella of Spain demanded he expel all unconverted Jews from Portugal, as a prerequisite for his marriage to her eldest daughter, Princess Isabella of Asturias. In 1496 the Jews were given the choice to convert or lose their property and residence rights; in 1497 those who had not converted were ordered to Lisbon, where the 20,000 who arrived were forcibly converted.⁸ Those who resisted were finally allowed to leave the country, while the rest were assured their religious beliefs would not be investigated for at least 20 years. These persecutions were meant to convert the Jews rather than to force the departure of a productive portion of society, but many converted Jews no longer wished to remain in the country and were only kept by

⁶ Payne 1973, 229.

⁷ Marques 1972, 210-12.

⁸ Livermore 1966, 134.

new laws restricting their travel abroad. At the same time, the twenty-year protection angered the rest of the populace, who saw it as royal favoritism toward a group associated with tax collecting and money lending.⁹ In this way the crown managed to alienate much of the middle class that could have supported and participated in the developing overseas trade.

The crucial institution in Portugal's international trade in the 15th century was the *feitoria* (factory). Unlike the Italian *fondaco* who earned a salary representing a distant banking house or merchant company and carrying out their instructions, the Portuguese *feitor* (factor) was a state employee serving the financial and economic activities of the royal household. From as early as 1373 the Portuguese crown took part directly in foreign trade using royal ships to carry cargoes between Portugal, Flanders, Genoa, and even Norway. Prince Henry the Navigator even financed corsairs. This royal mercantilism was imitated by a number of nobles as well; the Duke of Beja (later crowned Manuel I) had his own *feitor* in Flanders in the 1480s.

In the 15th century, Portuguese ships organized by Henry the Navigator explored the west coast of Africa, mapping territory and pursuing trade, particularly in gold and slaves. Exploration of the African coast was done with royal ships or as royal concessions; the crown controlled the African trade in similar fashion. This 15th century trade in slaves, gold, and other African products was small enough to be administered by the king and his advisors and the products were easily absorbed into the Portuguese market. At the end of the century, however, the same limited administrative process was

⁹ Anderson 2000, 62-3.

taken to the India trade, a much more complex system for which it was not well suited. Meanwhile the persecution of the Jews and converted Jews and the destruction of the great nobles had driven many of the bankers and merchants away just at the time such people were most needed to create and support long-distance trade. From the very beginning, the crown was forced to look to bankers outside the country to build and stock its cargo ships.¹⁰

Beyond the activities of the crown, there were changes in Portugal's agriculture and economy in the 15th century that shaped 16th century developments. Two important trends of agriculture from 1450 to 1550 were organized land reclamation (primarily reclaiming lands that had been abandoned for centuries) and the introduction of new crops such as maize (which typically replaced millet and often supplanted wheat in its existing areas). Reclaimed land that had previously been sown with grain in the 12th and 13th centuries was planted with olives and vineyards, which took far less labor and brought higher profits. Olive oil and wine production increased while grain production remained constant or declined. Since the population (both in general and particularly in the urban environment) was increasing, the trade in grain from abroad was developed and regulated, and special licenses and customs exemptions were granted for grain imports to Lisbon, Porto, and the Algarve.¹¹

15th-century Portugal had few industries or craft centers; her traditional exports were agricultural produce like fruit, wine, cork, and hides. Land reclamation reduced available

¹⁰ Duffy 1955, 10-11.

¹¹ Marques 1972, 168-70.

grazing area and stockbreeding declined. The only important industries were shipbuilding and biscuit making; both required great amounts of capital, employed large numbers of workers, and both belonged to the crown.

Late in the century overseas commodities (gold, sugar, spices, slaves, ivory, wood, and dyestuffs) became the most important and valuable exports.¹² Most large commercial enterprises became concentrated in the port cities as overseas trade developed, but local markets and trading cities along the border with Spain also expanded, making the medieval trade fairs obsolete and tying national trade together. Imports included textiles, grain, and industrial products (which included metalwork in copper and tin for African trading). Traditional exports (wine, salt, fruit, and cork) were still shipped in significant amounts but this trade network had little overlap with the overseas trade (which belonged to the king, a small group of powerful lords, and a few traders, most foreign or working for foreign investors).¹³

SIXTEENTH-CENTURY PORTUGAL

The reign of Manuel I (1495-1521) was the golden era of Portuguese exploration and discovery. He sponsored the expedition of Vasco da Gama, who opened the sea route to India around the Cape of Good Hope; the voyage of Pedro Álvares Cabral, who claimed Brazil for Portugal, and then sailed westward to India; the exploration of Gaspar Corte-

¹² Livermore 1966, 136.

¹³ Marques 1972, 170-74.

Real of the coasts of Labrador and Newfoundland; and the expedition of Afonso de Albuquerque, who established the Portuguese empire in the Far East.

Manuel made his court a center of the arts and sciences and issued a code of laws that bears his name. Under his direction a single standard set of weights and measures was established, with the reference pieces kept in the Lisbon city hall.¹⁴ His great religious zeal led him to sponsor missionary enterprises in his overseas possessions, to construct religious buildings like the Monastery of Jeronimos, and to promote a crusade against the Turks.

Manuel I inherited a difficult position; João II had torn the country apart as he centralized and enlarged the Crown's patrimony by crushing the largest feudal nobles and confiscating their property. Manuel's task was to reunite the nobles, a task he was able to accomplish with the fruits of overseas expansion. The Braganças and other banished families were restored to their former dignities and privileges but royal authority remained supreme.¹⁵ Instead, military command in Africa and Asia allowed the nobility the chance to enrich and affirm themselves without reducing the royal patrimony. Nobles also found new positions in the expanding royal administration.¹⁶

Manuel's administration and reforms helped to centralize power under the crown. The nobility was distracted by the chance to crusade in Africa and the populace was constrained by legal reforms. In 1515 Manuel sought to establish the Inquisition in Portugal. This would have given the crown great secular control of the Church since all

¹⁴ Marques 1972, 174-6.

¹⁵ Payne 1973, 226.

¹⁶ Marques 1972, 211-12.

of the judges and officials of the Inquisition (although clergy) would have been appointed by the king. The papacy was slow to grant the king's request; the Inquisition was not established in Portugal until 1536 (under Manuel's successor, João III) and its full exercise was restricted until 1547.¹⁷

Foreign trade flourished during Manuel I's reign.¹⁸ Previously a supplier of raw materials and limited industrial goods, Portugal became an intermediary between Europe and Africa (and the Atlantic islands), and later, between Europe and Asia. By the early 16th century the bulk of Portuguese foreign trade was the sale of African and Asian spices.

Manuel's son, João III (1521-1557), became king at the height of the Portuguese empire's commercial and colonial power. In the later years of his reign, Portugal fell into the stagnation that would also characterize the reign of his grandson and successor, Sebastian, who succeeded him in 1557.

In terms of international relations, the reign of João III was filled with a flurry of diplomatic activity. With Spain, he made alliances through marriage that assured peace in the Iberian Peninsula for years, and he strengthened relations with Rome. He attempted to remain neutral during the war between France and Spain, but stood firm against French corsairs. Commercial relations were intensified with England, the countries of the Baltic, and with Flanders. The colonization of Brazil began during João III's reign.¹⁹ In the Far East, commercial relations were established with China and

¹⁷ Payne 1973, 230.

¹⁸ Payne 1973, 232.

¹⁹ Livermore 1966, 133.

Japan and the Portuguese gained a monopoly over the trade in cloves from the Moluccas and nutmeg from the Banda Islands. In 1553 João raised (at great cost) an armada to join the Genoese under Andrea Doria in a successful attack on the Muslim pirate fleet at Tunis.²⁰

These accomplishments, however, were offset by pressure from the strengthening Ottoman Empire, especially in the Indian Ocean. The expense of defending Indian interests was huge, and to pay for it, João was forced to abandon some of his North African strongholds (Safim and Azamor in 1541, Alcacer Ceguer and Arzila in 1549) and to strengthen others (Ceuta, Tangiers, and Mazagan).²¹

Like his father before him, João was deeply religious; he sent missionaries to the Far East (as well as to the new colony of Brazil), including the Society of Jesus (the Jesuits). Unfortunately, the Jesuits and the Inquisition had disastrous effects on the commercial prosperity and social stability of the nation and the overseas empire. The Society of Jesus had an extremely important role overseas in evangelizing native populations, yet within Portugal it had a devastating impact; the gold of the Empire was squandered upon the construction of a great number of religious buildings and maintaining a large, very expensive, and unproductive class. The Jesuits also created an environment of instability within the nobility and the other religious orders. João spent enormous quantities of gold in embassies to the Papacy seeking the authority to establish the Inquisition in Portugal. Once it was finally established, there was a direct and very negative effect upon the

²⁰ Anderson 2000, 81-2.

²¹ Marques 1972, 214-15.

Portuguese economy from the Inquisition's persecution of important Jewish merchants, many of whom were killed or fled the country.²²

Sebastião (1557-1578) inherited the throne at the age of three when his grandfather João III died in 1557. His grandmother, Catarina of Austria, acted as regent for five years, followed by his great-uncle, Cardinal Henrique (archbishop of Lisbon and Inquisitor-General). Sebastião took the throne in 1568. The fourteen-year-old ruler preferred religion and war to affairs of state; for the next decade he made plans and preparations to recover all of Morocco in a crusade against the Muslims.²³ In 1574, he made an alliance with the ousted sultan of Morocco, solicited support for his crusade from the papacy and Castile, and in 1578, with financial aid from the church, he led an expeditionary force of mercenaries and a great number of Portuguese aristocrats to Morocco. The expedition was an unmitigated disaster for Portugal; at the battle of Ksar el Kabir, the king and the cream of the Portuguese nobility were slaughtered after engaging a much larger Muslim force. Joao's body was never recovered from the battlefield.²⁴

The end of Joao's reign marked the beginning of a shift in the crown's involvement in trading, as pro-Spanish influence from João's widow Catarina (a sister of Charles V) and from Portuguese agents of the Spanish court began to be felt on the court, the nobles, and the merchant class. The first change to the established royal monopolies took place during Catarina's regency; in 1562-3 private merchants were given the right to

²² Payne 1973, 231.

²³ Livermore 1966, 153-154.

²⁴ Anderson 2000, 94-98.

trade in pepper and spices (although the monopolies returned in 1564).²⁵ In 1570 Sebastião allowed private persons to trade freely in pepper, spices, and other royally-monopolized goods, though they were required to buy them from Portuguese factories in Asia at fixed prices. Luca Giraldi, an Italian, was granted a five-year contract to provide three ships per year for the *Carreira*. After he failed, a contract for five ships per year was granted to a second Italian, Antonio Calvo. In 1576, a five-year contract on the pepper trade itself was granted to a joint German and Italian venture.²⁶ This was the first time the entire monopoly (the purchase of spices in Asia, their shipment to India and on to Europe, the provisioning of carracks in Lisbon and Goa, and the distribution of pepper and spices in Europe) was granted to private investors.²⁷

Sebastião died without an heir; in his place the aged Cardinal Henrique, sole surviving son of Manuel I, was called to the throne. Henrique's (1578-80) attempt to gain a dispensation in order to marry was unsuccessful and he died before a successor was named.²⁸ With no clear heir to the throne, the populace was split over who should rule Portugal; the common people preferred Antonio, the Prior of Crato, but the clergy and nobles supported Felipe II of Spain. After a short military campaign against Antonio, Felipe took control of the country in December 1580; he was crowned Filipe I of Portugal in March 1581.²⁹

²⁵ Newitt 2005, 164.

²⁶ Subrahmanyam 1993, 112-113.

²⁷ Boyajian 1993, 18.

²⁸ Livermore 1966, 166.

²⁹ Anderson 2000, 99-103.

Filipe I (1580- 1598) swore to maintain the Portuguese system of government; Spain and Portugal remained separate countries, as did their empires. The language and currency remained separate, and no Spaniard could be appointed to any post in the civil, military, or religious establishments. A number of reforms were made to the administration, treasury, and judiciary based upon Spanish patterns but were carried out by Portuguese officials.³⁰ Filipe returned to Spain in 1583, leaving a nephew and three Portuguese regents to govern in his stead.

Political unification with Spain ended centuries of border skirmishing and provided new arenas for advancement for the clergy and nobles. Portuguese merchants also gained new commercial opportunities. Only the peasants lost out; open borders reduced their traditional roles as smugglers, cross-border traders, and soldiers in border fortresses.³¹

This new opportunity came at a great price, however. With Spain came all the Spanish political, economic, and religious entanglements.³² France (engaged in off-and-on war with Spain) supported Antonio in his struggle for the Portuguese throne, both before Filipe took the crown and afterwards. The English had long supported the Dutch revolt against Spanish rule; in return, Filipe barred English ships from Portuguese ports in 1583 and Dutch ships in 1594. Both actions devastated Portuguese commerce. Part of the Spanish Armada (later called the 'Invincible Armada') was launched from Lisbon in 1588; in response an English Counter-Armada of 30 warships under Francis Drake attacked Coruña and Lisbon in 1589. English ships under the Earl of Cumberland raided

³⁰ Marques 1972, 315-316.

³¹ Birmingham 1993, 34.

³² Livermore 1966, 167.

the Azores in 1591, and the Earl of Essex led an attack on Cadiz in Spain, then sacked Faro and nearly took Lagos in Portugal. The situation was no different in the Far East; cutting off the Portuguese spice trade with Holland and England forced those countries to seek their own route to the east, cutting into Portugal's income from the India Route.

Filipe I's heir, Filipe II (1598-1621) broke the agreement to leave Portugal to handle its own affairs, although he ruled from Madrid and only visited Portugal late in his reign. Spanish auditors were appointed to oversee the Portuguese Treasury and the *Casa da India*. Spanish truce terms signed with the Netherlands in 1609 allowed the Dutch to make trade agreements outside Europe, which in turn allowed them to trade in the Portuguese Far East.³³

PORTUGAL'S OVERSEAS EMPIRE AND THE *CARREIRA DA INDIA*

During the 15th century expansion into the Atlantic and down the African coast the Portuguese adapted their organizations and methods to meet and exploit different opportunities. In North Africa Portuguese nobles carried on a constant crusade against the Muslims, supported by a network of coastal fortresses.³⁴ On the Atlantic islands (Madeira, Porto Santo, the Azores and Cape Verde Islands) settlement and agrarian development were the chosen models. Along the Gulf of Guinea, and further south, the Portuguese established peaceful commerce through a network of trading ports with a minimum of Portuguese settlement.

³³ Anderson 2000, 100-107.

³⁴ Newitt 2005, 71.

By 1487, Bartolomeu Dias rounded the Cape of Good Hope, and in 1498 Vasco da Gama reached India and established the first Portuguese outposts there. The discovery of this sea route around Africa to India and the rest of Asia opened enormous opportunities to trade for Portugal, which it aggressively pursued with the establishment of trading posts and fortified bases.

From these first encounters with Muslims in the Indian Ocean, the Portuguese treated Islamic traders as enemies to be conquered. Portuguese fleets attacked Muslim ships and fortresses along the Eastern coast of Africa, in the Red Sea and Persian Gulf.³⁵ East Africans who were not Muslim, on the other hand, were treated as trading partners in the same manner as West Africans. In the 16th century the Portuguese adopted similar patterns of contact with other native groups in the Indian Ocean, Far East, and Brazil.

The Portuguese took advantage of the multiplicity of states in the Indian Ocean and Far Eastern areas to play one against another for (Portuguese) political and economic gain. Settlements and fortresses were established at Cochin, Goa, Melaka, and other important trading cities, but large-scale settlement along the line of the settlements on the Atlantic islands was never undertaken. Lacking the population to undertake large scale colonization, and facing well-established native civilizations, the Portuguese never attempted to establish the sort of large colonies the Spanish were creating in Central and south America. The Portuguese strategy focused instead upon commanding Indian Ocean trade by controlling the most important seaports.³⁶

³⁵ Newitt 2005, 72-73.

³⁶ Newitt 2005, 64.

During the 16th century the interests of successive monarchs shaped these general approaches to contact and trade. As mentioned above, King Manuel (1495-1521) supported exploration and commerce, for example the expedition of Vasco da Gama, which opened the sea route to India around the Cape of Good Hope; Pedro Álvares Cabral's voyage to Brazil; Gaspar Corte-Real's exploration of the coasts of Labrador and Newfoundland; and Afonso de Albuquerque's establishment of the Portuguese empire in the Indian Ocean. New wealth from the India trade helped to make his court a center of the arts and sciences. At the same time, Manuel's religious zeal (fueled in part by dynastic ties to Spain) led him to persecute the Jews in his country, crusade against Muslims overseas, and establish missionary efforts in his overseas possessions. Historians like Subrahmanyam and Thomaz assert that these were two sides of the same coin; that Manuel plotted to do nothing less than retake Jerusalem and the Holy Land from the Muslims, striking both from the west and the south.³⁷

Portuguese *naus* sailed in the *Carreira da India* almost from its inception at the end of the 15th century (as early as 1505, less than a decade after the first Portuguese vessels returned from the Indian Ocean, a fleet sailing to India included a 600-ton *nau*).³⁸ A variety of political, economic, navigational, geographical, and technological factors acted together to shape the Portuguese India trade and the ships that carried it.

For much of the 16th century Portugal was at peace with its Christian neighbors, maintaining political and trade contact with England and Northern Europe. Trade

³⁷ Subrahmanyam and Thomaz 1991, 301.

³⁸ Newitt 2005, 73.

competition between Portugal and Spain was minimized by the divergence of their exploration efforts and the development of thriving overseas empires well separated from each other, as defined by their division of the globe in 1494 with the Treaty of Tordesillas. Only after 1580, when the throne passed to the Spanish King, did Portugal become embroiled in European conflicts. Unfortunately for Portugal, however, Spanish rule hurt the India trade in at least four different ways. It led the English and Dutch (enemies of Spain) to attack Portuguese shipping (Indiamen laden with goods from the east were particularly prized), and it hurt the trade in Asian commodities that had previously existed between Portugal and those states. The cessation of Portuguese trade with England and the Netherlands led those countries to start their own India trade, leading to wars between them in the Indian Ocean and the diminishment of the Portuguese trading empire.³⁹ Finally, under Spanish rule, Portugal's India profits were siphoned off to support Spain's wars in Europe.

Like Spain's monarchs, the rulers of Portugal were driven by the urge to reconquer lands ruled by Islam; both countries carried the crusading spirit developed in their own unification abroad. Portuguese exploration of Africa in the 15th century and the Indian Ocean region in the 15th century developed as much from a desire to defeat Islam as it did to generate income.⁴⁰ The most direct Portuguese crusading efforts in the 16th century were the ongoing effort to conquer Morocco and the attacks on Muslim shipping and cities around the Indian Ocean. Suppression of Islamic ports and commerce cost

³⁹ Livermore 1966, 167.

⁴⁰ Livermore 1966, 140.

money but did help Portuguese trade by eliminating a rival. The crusades in Morocco on the other hand had no good effect and many ills, as they siphoned off a great deal of money with no return, and the death of King Sebastião and many of the Portuguese nobles led directly to Spanish rule.

Social stratification played a part in shaping the India trade as well; Portuguese society was divided against itself at many levels. The nobles and the king struggled for more autonomy vis-à-vis each other, inland nobles with land-holdings strove against newly-created court nobles who made their wealth from trade, peasants sought advancement while nobles sought to keep them servile.⁴¹ The Church was a major player as well, with substantial landholdings and monies, and with its own interests to advance and protect. Jews driven from Spain in 1492 were persecuted, forcibly converted, and milked of their earnings in exchange for being allowed to live in Portugal (and forbidden to leave the country). This struggle between classes and institutions hampered trade; money was siphoned off to buy land or into Church coffers and lavish constructions, and much of the artisan class was unable to join the middle class.⁴² Without a strong middle class investing in trade, local networks and distribution of wealth languished, and much of the trade income flowed out of the country.

In the East, Portuguese trade was helped by the political diversity of the area; they were able to play one ruler against another to gain entry into the Indian Ocean trading realm.⁴³ They also took advantage of ongoing strife in the region. For example, the

⁴¹ Birmingham 1993, 31.

⁴² Payne 1973, 231.

⁴³ Newitt 2005, 85-86.

Portuguese entered the Sino-Japanese trade when Japanese pirate activity led the Chinese to ban overseas trade by Chinese vessels and restricted Japanese entry into China. Portuguese merchants became the new middlemen in the trade of Japanese silver for Chinese gold, silks, and other products.

Unlike the Spanish experience in the Americas however, the Portuguese were seldom culturally superior to their trading partners, and did not conquer and rule colonies in Asia as the Spanish had in the Americas. In Brazil, where such conditions existed, Portuguese colonies did resemble the Spanish model.

As an economy the Portuguese empire was based upon a system of royal monopolies and on income derived from rents of monopoly rights by commodity or region. This system had been developed during the exploration and exploitation of Africa⁴⁴ and while it served its purpose in the short term, it hampered Portuguese economic development in the long run. In a sense, the early successes of the India trade hurt its development, since the inefficient, almost medieval system generated acceptable profits and hampered any drive to modernize or improve it. Moreover, the ideology of the Counter Reformation favored a medieval political organization in which power was ascribed to a rural, land based aristocracy, and the rise of cities and middle classes was not encouraged.⁴⁵ In this context the crown maintained a total monopoly on gold, slaves, spices, and other goods from Africa and the Far East, and taxed all goods brought into the country.⁴⁶ The *Casa da India* was established in a royal palace on the waterfront to oversee all imports (in the

⁴⁴ Newitt 2005, 68.

⁴⁵ Birmingham 2003, 31.

⁴⁶ Payne 1973, 232.

same manner as the Spanish *Casa de la Contratación*). Although private vessels were sometimes allowed to sail with the royal ships until the 1520s, the *Carreira* remained a royal monopoly. Between 1521 and the 1570s nearly all Indiamen (with rare exceptions) were owned by the crown. Subsequent rulers, King Sebastian and the Spanish kings, did allow private individuals or combines to invest in the *Carreira*, but the distribution of Eastern goods was still controlled by the *Casa da India*. The king's vessels were built and equipped at the *Ribeira das Naus*, a vast complex that included shipyards, warehouses, a foundry and a powder factory. Eventually other shipyards were built in Asia at Goa, Cochin, Bassein, and Daman. Lisbon became the single most important port in Portugal, hampering development of all others, and the dominant cultural and economic center.

Unlike Spanish silver and gold, however, Portuguese pepper (by far the biggest portion of every Indiaman's cargo) had to be sold to generate income, and traders closer to the point of consumption often made the final profits. Dutch traders, for instance, bought pepper right off the ship at the *Casa da India*, and then shipped it on to the major markets in Amsterdam and around Europe where was sold with a substantial markup, after the Portuguese had done the lion's share of the work to get the product to market.

Even worse, since profits from the India trade reached port in just a few large installments each year, many Portuguese including the court were forced to borrow against future income both for local needs and for bigger causes such as crusading in

Africa.⁴⁷ The result again was that profits left the country as interest payments on loans.⁴⁸

Spanish silver imported from the New World mines was money, or could easily be minted and disbursed where it was needed. It was intrinsically valuable, although the value of silver did decline during the 16th century as Spanish treasure flooded the European economy. It was carried in a great number of vessels, averaging from 100 to more than 200 tons burden.⁴⁹ Distributing valuable cargoes in this manner meant that individual vessel losses were seldom catastrophic. In contrast Portuguese pepper was a bulk agricultural commodity that had less intrinsic value and was subject to both seasonality and deterioration. It was carried in great quantity by a handful of exceptionally large ships each year, so any loss was significant. Furthermore its price was directly related to its scarcity; successive vessels to reach port made less for their loads than the first. This led captains to take independent courses and to make decisions for economic reasons rather than for safety, which undoubtedly contributed to losses.⁵⁰

In order to keep the India trade flowing, the crown established and maintained a number of fortresses and fleets around Africa and the Indian Ocean. The Indiamen were ill suited to military tasks in these waters, so purpose-built warships – *caravelas de armada*, galleons and oared ships – were built in Portugal and in Eastern yards.⁵¹ This military establishment was a constant drain on the royal profits from the India Trade.

⁴⁷ Newitt 2005, 99.

⁴⁸ Payne 1973, 232.

⁴⁹ Perez-Mallaina 1998, 93.

⁵⁰ Payne 1973, 234.

⁵¹ Newitt 2005, 109.

It was also a drain on the manpower of Portugal; while it took a relatively limited number of Portuguese to man these forts and fleets it was a drain of qualified manpower that might have been more useful in other roles.⁵²

Like the *India naus* that served it, the *Carreira da India* in the 16th century was the end result of a complex mixture of political, economic, religious, and cultural factors that had their origins deep in the previous century.

⁵² Payne 1973, 233.

CHAPTER III

THE DEVELOPMENT OF THE *NAU*

The Renaissance carrack, which the Portuguese called the *nau*, was developed in the 14th and 15th centuries from the blending of separate Atlantic and Mediterranean ship technologies. In the European waters of the Atlantic the cog (Figure 1) was the typical cargo carrier; a clinker-sided, flat-bottomed vessel with straight, raking stem and sternposts, rigged with a single square sail and steered by a stern rudder. The Mediterranean *nave* (Figure 1), in contrast, was a much larger, round-hulled vessel; built skeleton-first with flush-laid planking, high curved endposts, and two or more great and unwieldy lateen sails, steered by a pair of large side rudders.⁵³

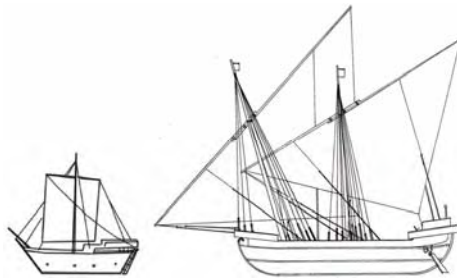


Figure 1. Cog (left) and *Nave* (right)

During the 14th century Venetian and Genoese shipwrights began to build vessels called *cocche* that shared the capacious hull form, square sail, and eventually the stern

⁵³ Unger 1994, 77-78.

rudder of the cog, while being built skeleton-first in the Mediterranean tradition. These ships were cheaper to operate and more capacious than their predecessors and became increasingly commonplace.⁵⁴ In England ships of this sort were called carracks, while in Italy, France and Iberia they were simply called “ships” – *naves* in Italian, *nefs* in French, *Naus* in Spanish and Portuguese. By the mid-14th century *cocche* had begun to carry two masts⁵⁵, a square-rigged main mast and a lateen-rigged mizzenmast (Figure 2).

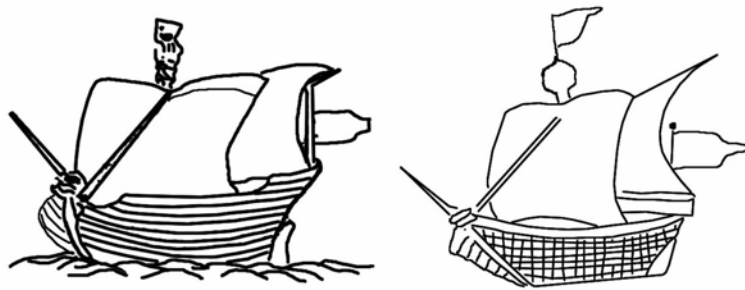


Figure 2. Fourteenth-Century *Cocche* after Friel

The three-masted rig with square sails on a foremast and mainmast along with a lateen mizzen appeared early in the 15th century, and iconographic sources show the three-masted rig had spread to Northern and Southern Europe before the mid century.

By the end of the 15th century additional topsails and even topgallants were in use, along with a lateen-rigged Bonaventure mast located at the stern to assist the mizzen.⁵⁶

⁵⁴ Lane 1934, 39-40.

⁵⁵ Friel 1994, 78.

⁵⁶ Unger 1994, 79-81.

By the 16th century this design was mature. *Naus* (Figure 3) were large, typically three-masted ships, square-rigged except on the mizzen (and on the Bonaventure mast, if a fourth mast was present), with keels only twice as long as the ship's beam. Their masts and yards were gigantic assemblies of multiple timbers, and their main sails were characteristically huge as well, with bonnets added at their lower edges when more sail was needed. Large fighting tops joined the main and topmasts, but higher topgallant masts and sails were uncommon on Portuguese *naus*, though period illustrations show some *naus* did carry topgallant masts.⁵⁷ The lower hull shape was broad and round (the curve of the hull section was often drawn from a single arc) with high fore- and stern-castles well integrated into the hull.⁵⁸ Their primary function was the carriage of large volumes of cargo.

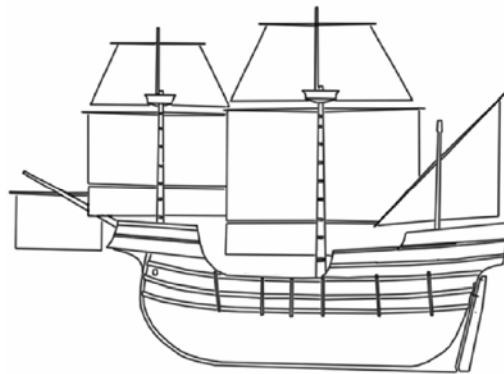


Figure 3. *Nau* After Meagher

⁵⁷ Castro 2005b, 112, 115.

⁵⁸ Boxer 1969, 207.

Galleons appeared in the early 16th century⁵⁹, and although typically defined today as purpose-built warships, they probably differed only slightly from *naus*; most notably their castles were lower, their structure sturdier (to support the larger weight and firing stresses of their greater armament), and they commonly mounted four masts that were generally lower and thicker than those of *naus*.⁶⁰

All in all, however, the ships of the *Carreira* changed only incrementally during the 16th century, developing wider sterns and lower fore castles, increasing in size (17th century Indiamen commonly had four decks and a broader relative beam) and gradually increasing in armament.⁶¹

These great ships carried the bulk of Portugal's overseas cargo and carried it quite efficiently; between 1497 and 1520 ships of the *Carreira* averaged only two voyages to and from India in their careers but by mid-century the average was more than five voyages apiece, and fifteen *naus* actually made more than nine voyages per ship.⁶² The total number of India Route shipwrecks is problematic; different authors list differing numbers and percentages of ships sailing and of ships lost. According to T. Bentley Duncan, between 1497 and 1590, total losses were 120 ships out of 1220 sailings, a loss ratio of only 9.8% on a voyage of close to 16 months round trip.⁶³ Guinote, Frutuoso, and Lopes cite losses of 143 ships out of 1183 for the period from 1497 to 1600, a loss rate of 12%, although they estimate losses of around 20% for the *Carreira* over its entire

⁵⁹ Phillips 1994, 98-99.

⁶⁰ Kirsch 1990, 9-11.

⁶¹ Castro 2005b, 111.

⁶² Duncan 1986, 7.

⁶³ Duncan 1986, 14.

lifespan.⁶⁴ Notwithstanding the great epics of Portuguese literature that describe the tragic losses of the *Carreira*, during the 16th and 17th centuries most Indiamen made the round trip successfully, except for a brief period at the turn of the century (from 1590 to 1620) when losses to privateering increased dramatically and more vessels were lost to late departures (because of the shifting monsoons in the Indian Ocean, ships that left Lisbon at the end of July or later faced the choice of waiting out the monsoon season in fever-ridden African ports such as Mozambique or taking a long, slow course sailing well east of Madagascar that greatly increased the chance for mortality aboard from scurvy⁶⁵) as well.⁶⁶ These ships truly were the supertankers of the 15th century, hauling a bulky but valuable cargo over great distances of open sea, built for capacity more than maneuverability or speed.

It is not completely clear why the design of Portuguese Indiamen did not change more drastically over the 16th century. The Dutch and English vessels that began to appear in the Indian Ocean at the century's end were quite different; small, sleek, and well armed, they were everything an India *nau* was not. While the Portuguese ships built for the *Carreira* changed over time, they do not seem to have emulated their enemies' models.

For most of the century the majority of *naus* were around 600 tons burden, although a few, much larger (some in excess of 1000 tons burden), were built from the middle of the 16th century on. This standardization was due, no doubt, to the royal monopoly on

⁶⁴ Guinote, Frutuoso, and Lopes 1998, 106.

⁶⁵ Duncan 1986, 5.

⁶⁶ Castro 2005a, 25-26.

Indiamen – having established a working design which could be predictably reproduced and built to pre-specified dimensions (through the use of the Mediterranean ‘whole-molding’ system of design and construction), there was little incentive to change the vessels. It is possible that the stagnant intellectual environment brought on by the Counter Reformation in the Iberian Peninsula also had an effect on the development of naval architecture in Portugal during this period, causing a corresponding stagnation in ship design.⁶⁷

Unlike the Spanish voyages to the New World, which made passages measured in weeks, Portuguese Indiamen spent months at sea, often touching land only at Goa and again at Lisbon, a 25,000-mile (40250 Km) round trip. To go this far the vessels needed to be very large just to carry enough provisions and water for the passengers and crew, let alone the cargo. This need for great quantities of provisions and water was exacerbated by the large complements of men (at times hundreds of passengers sailed on each *nau*) that shipped out on these ships to serve in the Portuguese fortresses and trading establishments scattered that made up the Portuguese Asian trading network. Smaller vessels would have had to make landfall more often, risking the shallows and reefs of African waters. Indiamen avoided such waters, following deepwater routes well away from land. The vessels of the *Carreira* also had to be sturdy to withstand the rigors of the long trips and the hazards of sailing around the southern tip of Africa. Safety through strength was much more important than speed for these craft.

⁶⁷ Castro, personal communication, 14 August 2006.

The weather patterns in the Indian Ocean, combined with a general lack of deepwater ports, led to the establishment of a monsoon-based sailing calendar, where ships left Lisbon in late March to reach the Indian Ocean in time to catch the monsoon winds, which blew toward the northeast, towards India. Harbors and anchorages were safer for the large Indiamen at this time. The *torna-viagem* (“return-voyage”) required that ships left India for Lisbon in the fall, when the winds shifted to blow southwest and monsoon storms made the ports along India’s western coast inaccessible to large vessels.

Since Indiamen couldn’t safely remain in the ports along India’s western coast (where the pepper was to be found) over the winter, there was little incentive to modify their design in order to better fit the intra-Asian trade. Instead, that commerce was carried out with other craft. Similarly, Indiamen (with their deep draft and cumbersome sailing rigs) were ill suited to naval duty in these waters, so smaller ships and galleys were built or adapted to military tasks.

At the European end of the route, the crown stationed warships to suppress piracy, although for most of the 16th century Portuguese Indiamen were little bothered by attacks from other ships. Cannon were heavy, expensive, and took up valuable cargo space; until their costs came down – with the general adoption of iron artillery in the beginning of the seventeenth century – the best defense the giant Indiamen could muster was their size. They were so big and sturdy that most pirates couldn’t sink or overpower them, and they carried great numbers of crew and passengers who could fight off pirates who got aboard.

The bulk nature of the cargo also helped shape the vessels chosen for the trade; economics of ship operation mandated the use of a handful of large carriers rather than a variety of medium-sized vessels each voyage. Smaller vessels would have meant more crew to feed and pay, and crewman were another resource in short supply.

Portuguese carracks were capacious and sturdy, well suited to carrying bulky cargo long distances without touching land. The design of these ships had reached maturity before the India route was established and little change to their form and assembly was called for to meet their pepper-carrying mission. For most of the century they were built almost exclusively in one shipyard (the *Ribeira das Naus* in Lisbon), for one owner (the King of Portugal). In addition, for much of the century they faced no major predators; even late in the century the only time Indiamen faced danger from other ships was at the end of their voyage in the waters between the Azores and Portugal. All of these factors (a design that worked from the start, limited production by very few shipyards, and little need to develop defenses) militated against any major changes in the design of the *Nau*. They could do this because for much of the 16th century they weren't threatened by external foes, they could follow routes well away from shoals and reefs, and most importantly because they were built by one shipyard for most of the period, and operated for that purpose alone. Limitations on the India trade such as debt and the lack of a middle-class as well held back innovation and expansion, and the design that had worked in the beginning of the century was never seriously changed. In the 17th century, other nations without such limits would develop new, more utilitarian ship designs that

could be used with equal facility for exploration, commerce, and war. These supplanted the Portuguese *naus* in the India trade.

CHAPTER IV

THE DEVELOPMENT OF NAVAL ARCHITECTURE

Although a number of 16th-century Spanish vessels have been archaeologically excavated, few Portuguese ships (and only one *nau*) have received the same treatment. Making up for this lack of physical evidence, however, is a corpus of written sources by Portuguese and other authors that describe the materials, measurements, and methods used by 16th century shipwrights. These documents were written before the modern systems of defining ships hulls with drawings was conceived, but the sequence of construction and the non-graphic tools used to control the shape of the vessel are clearly explained. This shipbuilding data can be tested by comparison to what little is available in the archaeological record (for example, Basque and Portuguese contracts that specify the dimensions and the size of important ships timbers can be compared to an excavated Basque shipwreck in Labrador).

Nearly a dozen Spanish shipwrecks with significant hull remains have been at least partially archaeologically recorded. Most of the Spanish remains were found in the Caribbean, these include the Emanuel Point, Fuxa, Highborn Key, Molasses Reef, Saint John's Bahamas, and Western Ledge Reef wrecks, and the *San Esteban*. Others were found in Labrador (*San Juan* and three more galleons), Portugal (the Angra D wreck), and England (the Cattewater and Studland Bay wrecks). Unfortunately there is little archaeological evidence for 16th century Portuguese Indiamen. Excavated Portuguese

vessels include *Nossa Senhora dos Martires*, the Aveiro A, Corpo Santo, Arade 1, and Cais do Sodre ships.⁶⁸

The only Portuguese *Nau* that has been archaeologically excavated, *Nossa Senhora dos Martires*, has been dated to 1606. Like many of the Spanish wrecks, just a small fraction of the hull of *Nossa Senhora dos Martires* survives to be analyzed; some 50 m² of the ship's bottom, including portions of the keel, apron, 11 frames, and 26 strakes of hull planking.⁶⁹

These Spanish and Portuguese wrecks provide nautical archaeologists with invaluable evidence of 16th century shipbuilding techniques, including information not discussed in the treatises, such as fastening patterns, details of mast step construction, and frame joinery.⁷⁰ They also serve to verify the methods, materials, proportions and dimensions found in shipbuilding documents from the period.

THE DAWN OF NAVAL ARCHITECTURE

The 16th century is a fascinating period in the development of the documentation of ship construction. A handful of earlier texts from Venice, described the process of building Mediterranean galleys and round ships in the 15th century. These include the “Fabrica di galere” or “Libro di marineria” (a collection of texts by several authors, dated to the 15th century, though the original text, authored by an *amiraglio* of the Venetian Arsenal, Michael of Rhodes, can be dated to around 1434); the Timbotta

⁶⁸ Oertling 2004, 129.

⁶⁹ Castro 2005a, 106-107.

⁷⁰ Chapman 1998, 60.

manuscript (dated to 1441-1449); and the “Ragione antique spettanti all’arte del mare et fabriche de vasselli” (written by multiple authors, dated from the mid-15th to the first half of the 16th century).⁷¹ These texts included information on many topics of interest to the urban bourgeoisie including data on ship construction, and do not appear to have been the works of shipbuilders themselves.⁷² Some may have been copied from real shipbuilding documents, however, perhaps from the Venetian Arsenal.⁷³ The second half of the 16th century saw the beginning of naval architecture in Spain and Portugal, as methods, materials, and measurements began to be written down for their own sake. These Iberian shipbuilding documents took a variety of forms: theoretical treatises on shipbuilding, descriptions of ships and their construction by interested outsiders, contracts for vessels, budgets for construction and maintenance of ships and fleets, and scantling lists for different-sized vessels. Like their Venetian predecessors, the 16th-century Iberian shipwrights still relied upon simple proportions and non-graphic methods to conceptualize the vessel to be built. Not until the following century did techniques of illustration arise to show ship lines and how they could be used to envision and then create a vessel.

SOURCES ON SIXTEENTH-CENTURY SHIPBUILDING

In his “Report on 16th Century Spanish Basque Shipbuilding c.1500 to c.1600”

Michael Barkham cited Basque contracts that described ships built from 1575 to 1625,

⁷¹ Bellabarba 1993, 291.

⁷² McManamon 2001, 25.

⁷³ Mauro Bondioli, personal communication, 2005.

specifying dimensions, ratios of keel length, beam, and depth in hull, timber choices, prices and so forth. Basque wrecks such as the *San Juan* at Red Bay fit these specifications. Two similar contracts for Portuguese ships (dated to 1598) were included with the manuscript of João Baptista Lavanha's early 17th-century treatise *Livro Primeiro de Arquitectura Naval*.⁷⁴ The remains of the *Nossa Senhora dos Martires* appear to fit these contracts; though little of the hull is left to be studied (and compared to the vessel illustrated by Lavanha, *Nossa Senhora dos Martires* appears to be shallower and older).⁷⁵ This lends confidence in the other specifications these contracts provide.

The *Livro Nautico*, Codex 2257 in the Reserves of the Biblioteca Nacional of Lisbon, is a collection of documents on the construction and fitting of Portuguese ships and galleys dated to the end of the 16th century (between 1575 and 1625). In 1892 Henrique Lopes de Mendonça published six selected texts and a list of the codex's entire contents transcribed into modern Portuguese. All but three of the documents in the *Livro Nautico* pertain to the arming, maintenance, staffing, or construction of ships. They include measurements and scantling lists for various vessels (including a 600-ton *nau*), ammunition requirements for ships, budgets for soldiers and sailors both for single ships and for fleets of vessels, construction, maintenance, and arming budgets for fleets, the value of prizes, the value of various items that might be found in prizes, and the costs of crews, provisions, and materials for various ships.

⁷⁴ Lavanha 1610, 237-241.

⁷⁵ Filipe Castro, personal communication, 15 Sept 2006.

Fernando Oliveira's 1580 *Livro da fabrica das naus* was republished in facsimile (with a transcription and translation into English) in 1991. This text might best be described as a theoretical treatise written by an interested outsider rather than a shipbuilder. It is incomplete; the last folio ends abruptly in mid-sentence and there is no discussion of sails or rigging (topics found in other treatises of this sort). The surviving chapters include a brief discussion of the antiquity of shipbuilding, the types of timber suitable for shipbuilding, when and how to cut timbers, the other materials necessary for a ship, the names and types of ships, the role of art in shipbuilding, and a brief note on the way ships imitated the shapes of fish. The largest chapter relates the construction and measurements of *naus*. This chapter describes the relation of the vessel's length of keel to its breadth, height, and other relevant dimensions. It gives a list of relevant terminology such as the parts of the ship and the definitions of dimensions. It describes the methods and tools used to determine and mark the rising and narrowing of the floor timbers (the heart of a non-graphic system for determining hull shape), and the shape of the master frame. Beams, decks, and planking are also addressed. The last, incomplete chapter focuses upon rudders.

Diego García de Palacio's 1587 *Instrucción nauthica para el buen uso y regimiento de las naos, su traza y gobierno* is the first treatise on shipbuilding ever published. It is a general work on navigation that includes a treatise on shipbuilding, with sections on the design of hulls, masts and spars, rigging, sails, ship's boats, artillery, victuals, and crews, detailing the functions and obligations of the captains, masters, and pilots. For examples

Palacio describes two ships (of 400 and 150 toneladas burden) in detail (although the drawings he presents do not appear to match the description in the text).⁷⁶

Written only 30 years after Oliveira's *Livro da fabrica das naus*, João Baptista Lavanha's *Livro Primeiro de Arquitectura Naval* (ca. 1608-1615) is also the theoretical work of a scholar rather than the practical text of a shipwright. In this treatise Lavanha focuses solely upon the four-decked India *nau*. Like Oliveira, Lavanha calls for the need to pre-design a central portion of the hull, although in this case for only 5 frames on either side of the master frame where Oliveira prescribed 18 frames forward and aft.⁷⁷ This treatise is most useful for its accurate description of construction techniques and its detailed illustrations. It is clearly more modern than Oliveira's *Livro da fabrica das naus* in its basing the construction of hulls upon drawings.

By the 17th century this new technique of illustration (seen also in Manoel Fernandez' *Livro de traças de carpintaria*) had arisen to show ships lines with drawings and how they were used to first conceive and then create a vessel, replacing the older non-graphic method. By the 18th century, shipwrights typically used lines drawings or models to visualize the vessel's shape before construction and to preserve that information after the vessel had been built. This was a fundamental departure from the simpler (and more conservative) non-graphic method used by 16th-century shipbuilders.

⁷⁶ Palacio 1587, 115-141.

⁷⁷ Oliveira 1580, 175.

WHOLE MOLDING

Modern shipwrights design and build ships from drawings, either the old-fashioned way with pen and ink or by computer-assisted-design (CAD) programs such as *Rhinoceros*. In the 18th and 19th centuries designers used hand-carved models to define a ship's hull before building. To build their *naus* 16th-century builders adapted the 'whole-molding' method the Venetians had used to control the shape and size of their galleys. With this non-graphic tool they could conceive the vessel before construction and control its shape, build a vessel that fit desired specifications and consistently reproduce it.

From ancient times until the Middle Ages ships had been constructed 'shell-first' by assembling the planks of the hull before adding internal frames to support the hull. Northern Europeans like the Vikings overlapped each strake and joined the strakes with iron nails driven through both. Mediterranean builders joined each strake along its edge, with tenons inserted into slots cut into each edge. In either case, however, the frames were cut to fit the longitudinal runs of planking which defined the shape of the hull. The ship was conceived as a shell with frames as reinforcement.

Over time Mediterranean builders came to rely more upon the frames and less upon the tenons to strengthen the hull. A new 'frame-first' method developed which supplanted 'shell-first' construction. In this method the hull was split into three parts; a central section and the two ends. Three frames defined the shape of the hull; a master frame at the widest part of the hull and two tail frames that marked the end of the center section. All of the central-section frames were installed, and then ribbands or wales were

affixed over these to determine the shape of the end sections. Planking came last, after all the frames were added; the ship was conceived as a skeleton of frames covered with a skin of planking.⁷⁸

In the south of Holland shipwrights went even further and used only the three pre-designed timbers and the ribbands to determine the shape of all the remaining frames (instead of merely those beyond the tail frames). First they assembled all the planks in the flat bottom section of the ship, and then installed the central frame and two tail frames. They ran ribbands from stem to stern over these frames, and picked the rest of the frames to fit inside the ribbands (just as earlier shipwrights had picked frames that fit the shell of planking). The rest of the hull planking was added last. In this hybrid ‘bottom-based’ method neither the skeleton of frames nor the skin of planks was created first.⁷⁹

Mediterranean shipbuilders commonly used a variation of this system called ‘whole-molding’ in which a number of the frames were pre-designed (that is to say, these were cut to shape before the ribbands were placed instead of being selected to fit the ribbands’ curve). In long hulls such as galleys a set of noncontiguous frames (for example, every fifth frame) would be assembled, while in round ships a number of contiguous frames would be placed in the central section. In either case the shape of the extremities (the most difficult sections to determine mathematically) was still defined by ribbands laid from stem to stern along the frames. The designers conceived the frames of the hull as

⁷⁸ Castro 2005a, 34.

⁷⁹ Bellabarba 1993, 290.

‘narrowing’ and ‘rising’ in both directions from the master frame. All of the pre-designed frames were traced out and cut using only the mold of the master frame, which was adjusted in position relative to the keel to provide the proper rising and narrowing.

The progressive curve of the hull was determined by use of a geometric tool, such as the *mezza-luna* (called a *besta* or *meia-lua* in Portuguese) or half-moon (Figure 4). For example, Oliveira’s treatise specifies a narrowing fore and aft of one-sixth of the width of the master frame’s flat section, while the frames should rise the distance of one frame and space forward, and the stern 50% more than the bow.⁸⁰ If the forward hull were to rise by 2 *palmas de goa* (51.36cm – the sided dimension of one frame and futtock pair), over 17 frames (and the spaces between them for the futtock timbers), the designer would draw a half circle with a radius of 2 *palmas de goa*. Dividing the circle in half and then subdividing each half into as many equal parts as there are frame pairs and then drawing a line across the *mezza-luna* to connect each side’s corresponding marks produced a progressively decreasing scale for the rising of each timber. As shown in Figure 5, this scale could be marked off onto a ruler or even onto the master frame itself for ease of positioning as the other frames were marked out. Three scales (the rising forward, the rising aft, and the narrowing of the floors) would suffice to determine the relevant placement of the mold to produce all the frames of the central section of the ship (Figure 6).

⁸⁰ Oliveira 1580, 175.

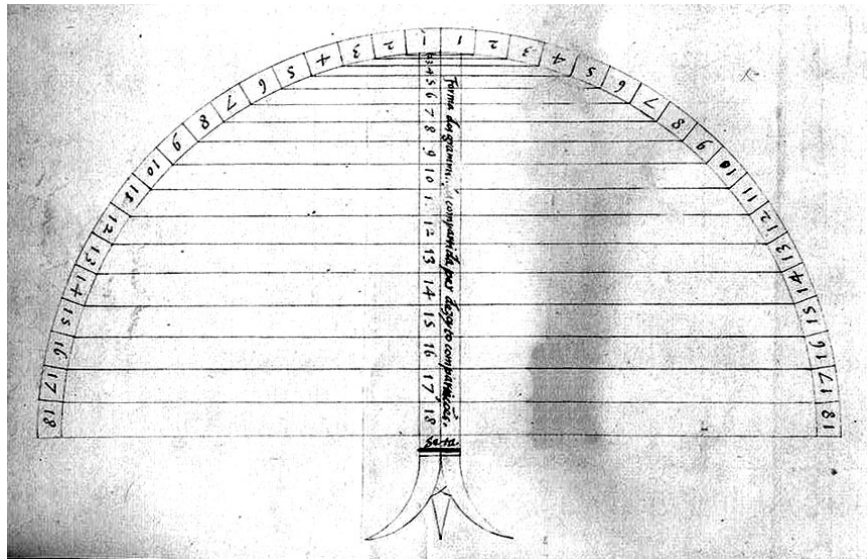


Figure 4. *Mezza-luna* With Ruler⁸¹

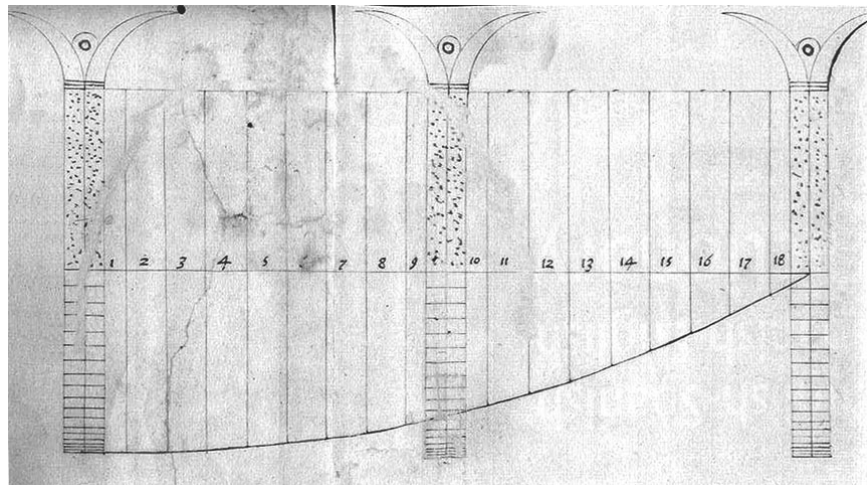


Figure 5. Graduated Ruler in Use⁸²

⁸¹ Oliveira 1580, np.

⁸² Oliveira 1580, np..

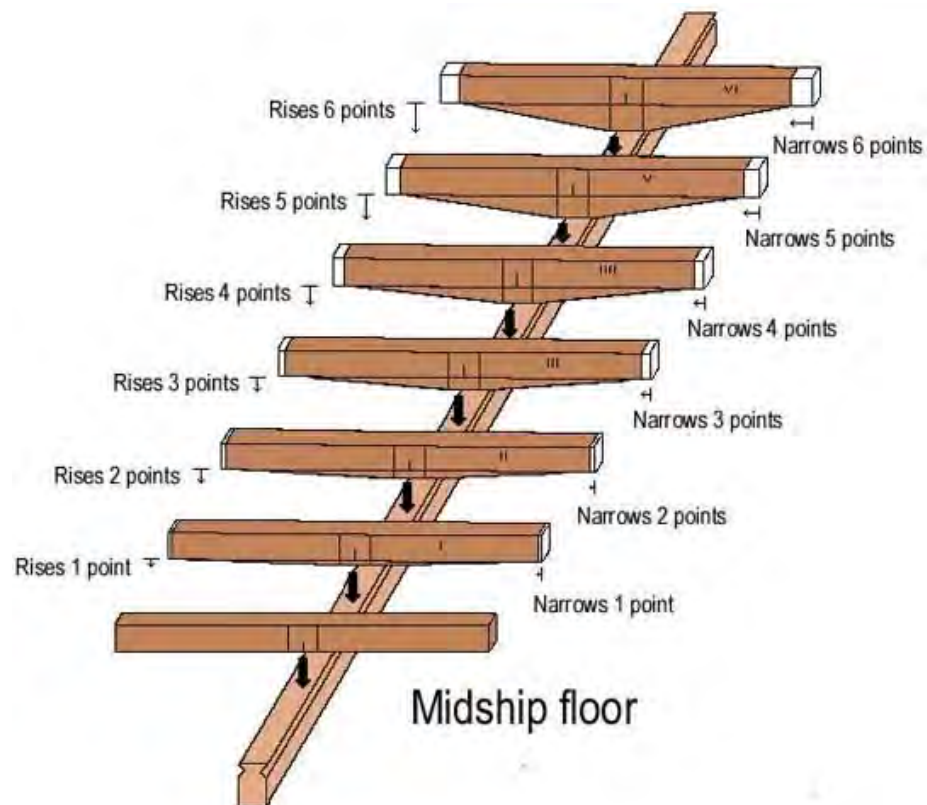


Figure 6. Rising and Narrowing Floor Timbers⁸³

Whole molding allowed the shipwright to define the size and capacity of a ship before it was assembled, it provided consistent and symmetric hulls, and most importantly, it made easy duplication (and even standardization) of ships possible, using simple rules and geometric concepts that could be easily communicated or recorded. The predictability and repeatability also makes modern reconstruction of vessels built by this system possible even with no drawings and little archaeological evidence.

⁸³ Castro 2000, 7.

CHAPTER V

THE *NAU* OF THE *LIVRO NAUTICO*RECONSTRUCTING A *NAU* FROM TEXTS

The primary sources for this reconstruction were a document from the *Livro Nautico* as well as Oliveira's *Livro da Fabrica das Naus* and the Portuguese contracts included with Lavanha's treatise. Data derived from these sources was compared to that found in other treatises, iconography, and the archaeological record.

Part of the reconstruction work presented below was my own English-language translation of one of the documents in the 1590 *Livro Nautico*, "Medidas para fazer hũa Nau de seiscentas Tonelladas, e os paos que hà de leuar de Souro e Pinho" ("Measurements to make a *Nau* of 600 tons, and the timbers it will take of Cork Oak and Pine"). My translation is based upon Mendonça's 1898 transcription of this document into modern Portuguese (he worked from the handwritten original), along with five other documents from the codex and a complete list of its contents. Mendonça arranged his translation just like the original; each entry in this document (except the few that addressed the layout of timbers) included the number of *paos* or 'timbers' the vessel would take. If unspecified, the timbers were *Souro* (Cork Oak), those to be made of *Pinho Manso* (Stone Pine) were so designated in the entry that described them. I translated Mendonça's Portuguese text into English, and checked it against images of the original handwritten document. All of the quotes in this chapter are from my translation.

This is an incredibly useful text for anyone interested in these vessels; it is a combination of scantling list and construction sequence (it lists each timber that went

into a *nau* of this size, in the order of the vessel's construction), with notes on the placement of selected individual timbers. The text also defines the vessel's principal dimensions as well as the geometrical tools for determining the rising and narrowing of the frames, the arc of the frames and bow, the placement of the masts, and a host of other details.

Oliveira's treatise was used to supplement the *Livro Nautico* document, as it also addressed the construction sequence, proportions, and the geometrical methods for defining the hull shape. Lavanha's treatise and the Portuguese contracts cited in Lavanha were checked for information on timber dimensions and hull proportions as well. The consistency between the dimensions and proportions in these texts gave confidence in their accuracy as well as in the *Livro Nautico* construction sequence.

Although drawn 25 years later than the vessel in the *Livro Nautico* and showing a larger vessel, Fernandez' illustrations of a *nau* proved quite useful in determining where certain timbers and structures were placed. Diego Garcia de Palacio's *Instrucion Nautica* on Spanish carrack construction was also considered.

Iconographic sources including images in the *Livro de Lisuarte de Abreu, Memorias das Armadas*, and *Roteiro do Mar Roxo de Dom Joao de Castro* were also consulted, as well as pictures and drawings of the model of the carrack *Madre de Deus* built for the *Museu de Marinha* in Lisbon.⁸⁴ These helped to explain the layout and proportions of the castles, the *varanda* (the 'balcony' at the stern), and hawseholes, as well as details of planking runs and rigging.

⁸⁴ Lisuarte de Abreu 1992, Anonymous 1995, Castro 1991, Simoões and Leitão 2004.

While more weight was given to the one Portuguese example, *Nossa Senhora dos Martires* (dated to 1606), archaeological evidence from Spanish wrecks was considered as well, particularly the well-preserved (although much smaller) Basque vessel *San Juan* (dated to 1564). This evidence was used both in comparison to written texts and illustrations and in explanation of construction techniques (for example, the layout of decks and knees).

To begin the reconstruction, a single construction sequence was hypothesized, based upon the *Livro Nautico* and the treatises of Oliveira and Lavanha. With this sequence and the scantlings lists, supplemented with data on timber dimensions, and using the contemporary geometrical formulas and other data, each timber was modeled, from the keel up, using *Rhinoceros 3* three-dimensional modeling software. The end result of this research and modeling is the annotated and illustrated 3-D model, which is presented below. The construction sequence and scantling list that detail each timber and every step in the construction of a Portuguese Indiaman are also presented.

The reconstruction of the hull was built entirely using the Portuguese increments of *dedos* (fingers, 4.28cm in length), *palmos de goa* (handspans, 25.68cm, made up of six *dedos*), and *rumos* (1.54m, six *palmos de goa*). All of these increments were derived from human dimensions or fractions thereof. One additional increment, the *braço* (2.048m, eight *palmos de goa*, equivalent to the span of both arms from fingertip to fingertip), was used to define the masts and yards.

Each entry below follows the same format: a block quote from the *Livro Nautico*, an image showing the timbers under discussion, and any notes or commentary.

ILLUSTRATED AND ANNOTATED SEQUENCE OF CONSTRUCTION

First of all, the keel (Figure 7) will have a length from end to end of 17 Rumos, and this keel will have the thickness of one palmo de goa, and molded another two fingers [the sided dimension is 1 palmo de goa, and the molded dimension is 1 palmo de goa and two fingers], to make this keel it will take, with the couças [the timbers that make the transition between the stempost and the keel, and the sternpost and the keel], seven timbers.



Figure 7. Keel and Couças (red)

The length of the vessel's keel precluded the use of a single timber (such as was used in the Basque whaler *San Juan*); the dimensions and number of 'timbers' required shows how the shortage of large trees shaped Portuguese ship construction at the time. The keel is the very spine of the ship, with every force resting on it or tied to it, yet it is only 25.68cm wide and 34.24cm deep. The strength of this ship comes from the great number

of small timbers that are used in its construction, rather than from the size of any single piece.

The stem post (Figure 8), which is the second thing one puts in, will be 50 palmos de goa high and will spring 35 palmos, in this way: for each ten palmos that the stem rises in height, we will take three, and the ones that remain are the spring [how much it goes forward]. It will be higher in the timber [meaning its section will be thicker] by two fingers. The stem post will take three timbers to make it and from the inside will be put four coraes, which are inner stem posts, which is called contra Roda, and these are seven timbers.



Figure 8. Roda (red) and Contra Roda (orange)

The ‘spring’ described here produces an arcing stem that finishes with a vertical extension, just as described in Oliveira’s treatise, but without the theoretical explanation given by Oliveira.

The stern post (Figure 9), which is the third timber which one puts over the couce de popa [the stern knee], will have one palmo and a half in thickness square, and will have forty-two palmos de goa in height and seventeen palmos that this *Nau* takes as Ragel [the deadwood aft, which runs to the stern], for good accounts seventeen Rumos of keel takes seventeen palmos of Ragel: from this Ragel above there will be twenty-five palmos in which the three decks will fit, in this way: the first deck will rise six palmos, the second will have eight palmos, and the third will have seven palmos, and three more palmos that the wood fills in between makes the twenty-five: the sternpost rakes abaft in this manner: for each four palmos that it rises, it will rake one abaft, this sternpost takes two timbers.



Figure 9. Codaste (Sternpost)

The simple one in four rule for the rake was a common practice. Although Oliveira preferred a steeper rake of 4.5 to 1, he conceded that the slightly less vertical rake prescribed here relieved the rudder and improved steering.⁸⁵ The rule of thumb for the

⁸⁵ Oliveira 1580, 171.

Ragel (one palmo of deadwood per Rumo of keel) is simple to follow and easy to adjust for vessel size, much simpler than Oliveira's fractionally-based method.⁸⁶

The Gio (Figure 10), which is the timber that crosses over the sternpost, will have twenty-five palmos de goa of breadth, which is half of the maximum breadth the *Nau* will have, and will have a thickness in the middle of one palmo and a half, and in the end one palmo, and it takes three timbers of Cork Oak, and two of Stone Pine in the gridding that it makes.



Figure 10. Gio

This is quite a large timber (6.42 meters long, 25.68cm to 38.43cm thick, and 25.68cm tall) to be set unsupported atop the sternpost. Although the fashion pieces and grid timbers are listed later in this document, Dr. Castro argues that the stern panel (in English it is the transom) would be raised whole after construction on the ground, rather

⁸⁶ Oliveira 1580, 193.

than in the piecemeal manner described in this document.⁸⁷ It would certainly have to be raised early in the construction sequence, because the shape of the frames at the stern would have to match the shape of the stern panel. Figure 10 shows the *Gio* with the stern panel or transom timbers and fashion pieces in place as well.

This *Nau*, to be beautiful, will have as many pre-designed frames as it has of Rumos of the keel, and the master frame will be set over the keel three Rumos before the middle of the keel, because the middle of the keel is the place where we put the foot of the main mast: on this midship frame, three Rumos to the bow, and from there to the forward end of the keel will be five Rumos and a half on which will have to fit the seventeen pre-designed frames that this ship will have forward, and this means seventeen floors and seventeen futtocks, and that will make the thirty-four palmos building the room and space [each frame and each futtock is one palmo wide, so each pair takes two palms of the keel]; and when these frames that are put next to each other will end the last one will be called the *Almogama* [tail frame], which is the last frame one Rumos below the forward end of the keel, and so much that this timber will take over the keel from the master frame to the stern [as in the bow, the 17 pairs of floors and futtocks to the stern from the master frame will take 34 palmos, or five and a half Rumos of keel], and abaft that place, will be six Rumos of keel without any pre-designed frames, this is the *Ragel* that we also call *delgado* [‘thin’, the deadwood abaft]: this stern *Almogama* will have a *garaminho* [the mezza-luna for the amount of rising] three palmos de goa, because three time six is eighteen palmos the *Ragel* will have [the total rise abaft is three palmos from the Master frame to the *Almogama*].

As shown in Figure 11, Oliveira’s treatise prescribed two Master Frames for a vessel of this size, with a futtock between them, so that the proper spacing of floors and futtocks continued in both directions. In order to fit all the pre-designed frames in the space described here, however, it seems that these ‘master’ floors and futtocks were not

⁸⁷ Castro, personal communication 15 August 2006.

additional timbers as prescribed in the treatises; they were in fact the first of the 17 pre-designed floors in each direction.

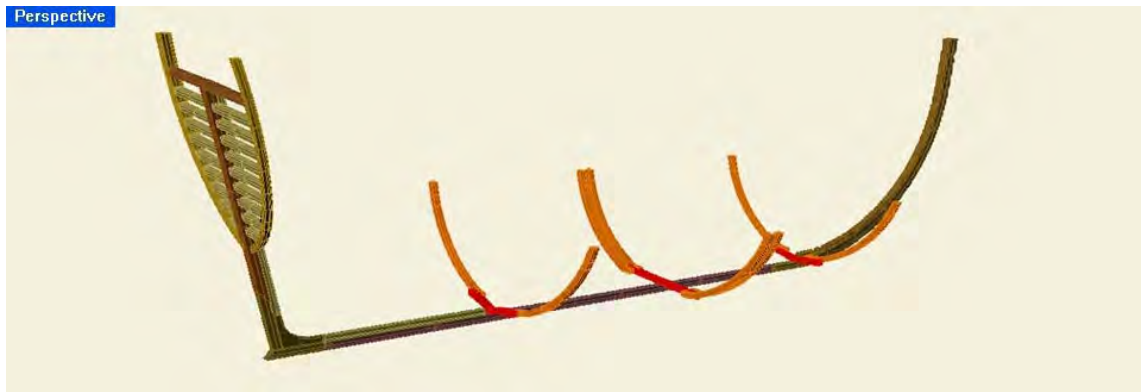


Figure 11. Master Frame and Almogamas

This ship will take seventeen pairs that are thirty-four frames (Figure 12)

It takes in these frames sixty-eight futtocks

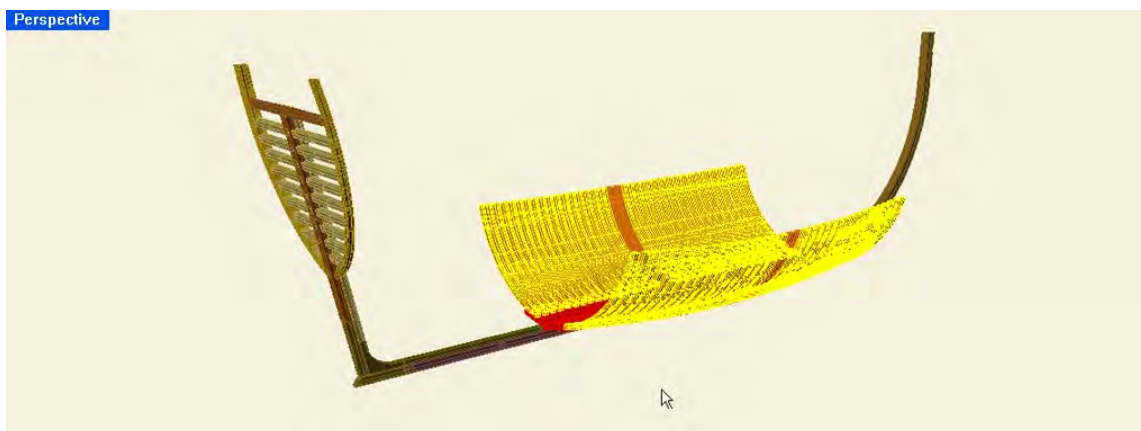


Figure 12. Pre-designed Frames

From the tail frame to the bow it takes thirteen Enchimentos (Figure 12) [the ‘V-frames’ or ‘fillings’; these are the floor timbers ahead of the Almogama that are not pre-designed].

It takes on these fillings twenty-six Astes [the first futtocks for the v-frames, these correspond to the futtocks of the pre-designed frames]

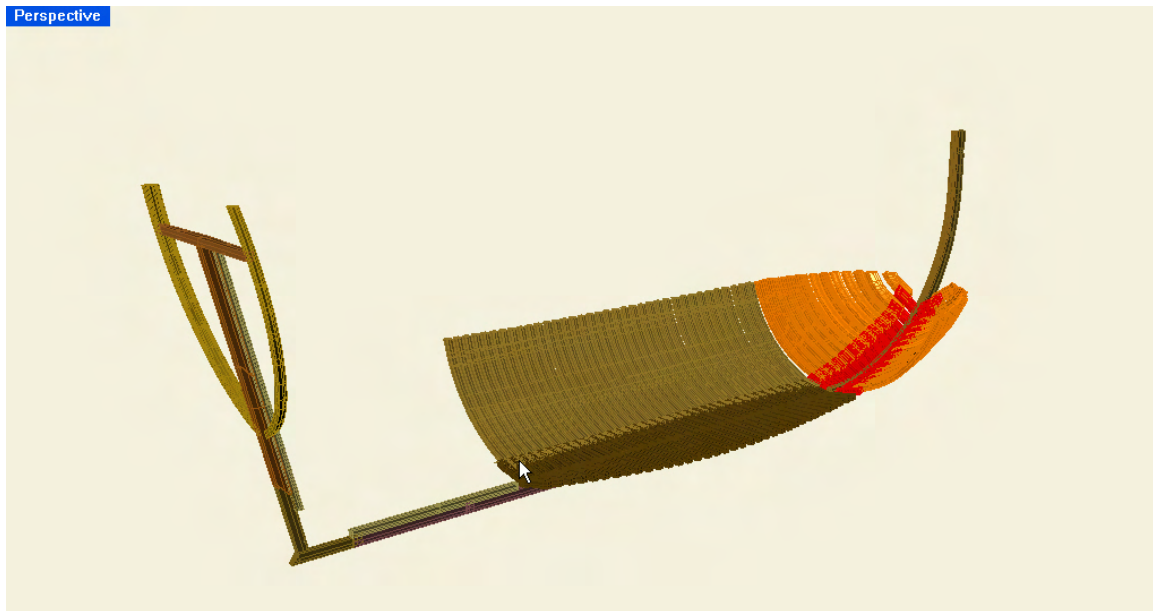


Figure 13. Enchimentos (red) and Astes (orange)

It takes to the stern twenty-one enchimentos (Figure 14) and piquas [v-frames and epsilon frames]

It takes forty-two areuessados (Figure 14) [concave futtocks].

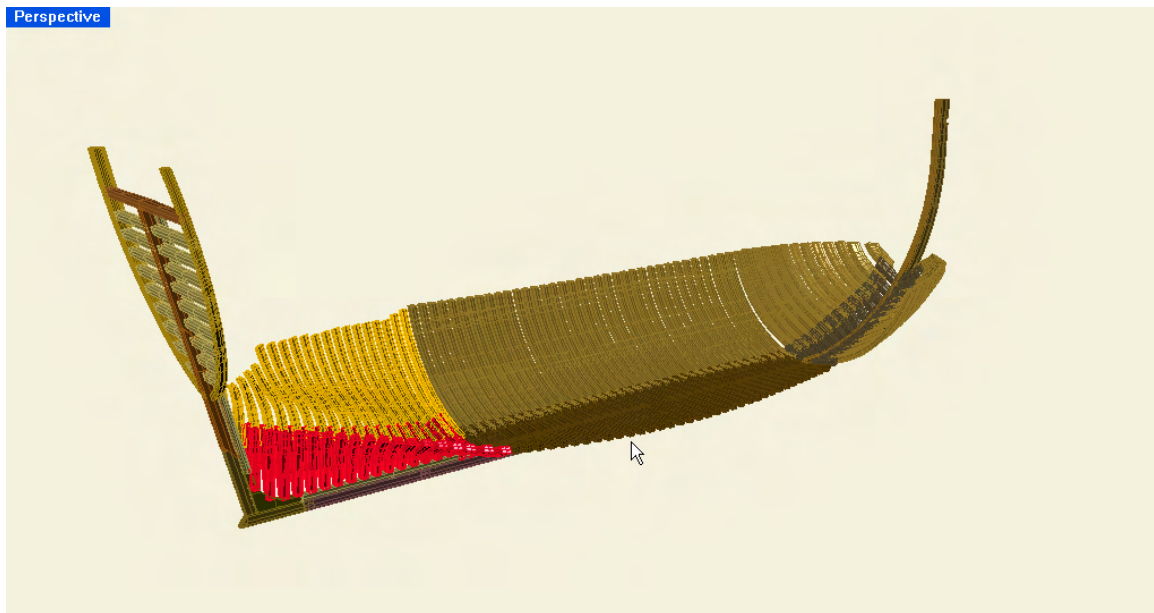


Figure 14. Enchimentos and Piquas (red) and Areuessedos (orange)

These epsilon-and v-frames sit upon the Coraes (the deadwood timbers at the stern that reinforce the keel and sternpost, which have not yet been mentioned). The author should have listed the placement of the deadwood before adding the frames that rest upon the deadwood.

It takes one Carlinga [mast step], with two trinquanis [waterways] bracing it on both sides to make it stronger

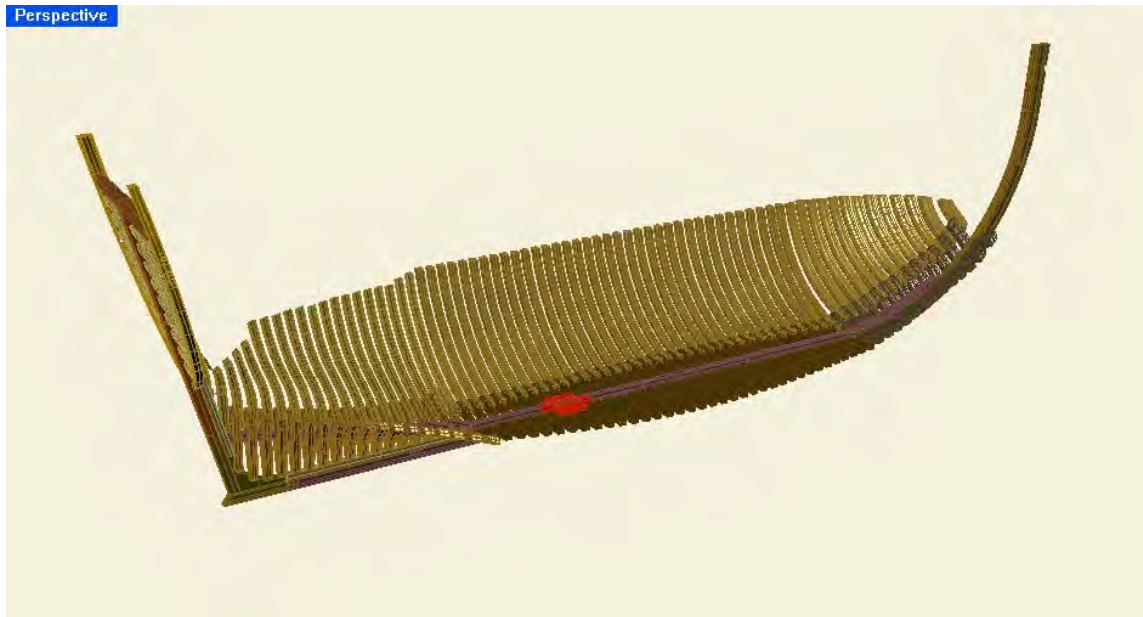


Figure 15. Carlinga and Trinquanis

As seen in Figure 15, the trinquanis support the mast step against lateral movement. The text does not mention the triangular buttresses found on many Iberian shipwrecks that would be placed on either side of the mast step to brace it laterally.

It takes two coraes [deadwood timbers] to the stern

Since the Enchimentos and Piquas at the stern either rest upon or are notched into the side of these deadwood timbers, this entry is out of place, and the Coraes should have been placed prior to the V-frames and Epsilon frames being added.

It takes ten timbers that make the Sobrequilhas [keelson]

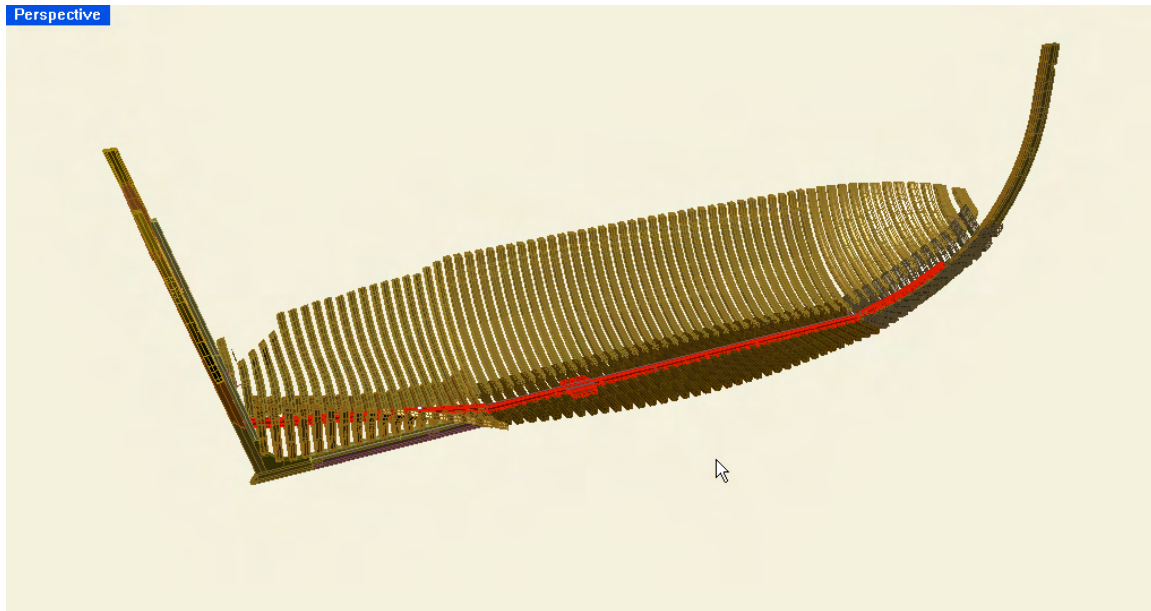


Figure 16. Sobrequilhas (Keelson)

Note that the Carlinga (main mast step) previously described is one of the ten Keelson timbers. These are scarfed together and long bolts are fastened completely through the keel, frames, and keelson to tie the bottom structure together.

It takes on the first aposturagẽ [second futtocks] a hundred and forty timbers

Counting the timbers that I had, and considering the sequence, I was at first inclined to believe this was a repeated entry, a mistake in copying, since I had 140 timbers already, and they reached all the way to the first deck.

I now suspect, however, that I made an incorrect assumption in the shape of my master frame and futtocks. Based upon an illustration in Fernandez' treatise, I had thought the first futtock began (with some overlap) at the turn of the bilge, and extended up to a point slightly above the first deck, and that subsequent futtocks were each long enough to overlap the previous and extend to a similar position at the next deck. In my model, the futtocks, arreuessados, and astes all extend to overlap just above the first deck. Instead of one long futtock for each frame, though, I think that there should have been two futtocks – first the futtock, arreuessado, or asta described with the frame pairs, and then another that would be the first aposturagẽ described above.

It takes 44 timbers for the dromentes [clamps] and contradromentes [lower clamps]

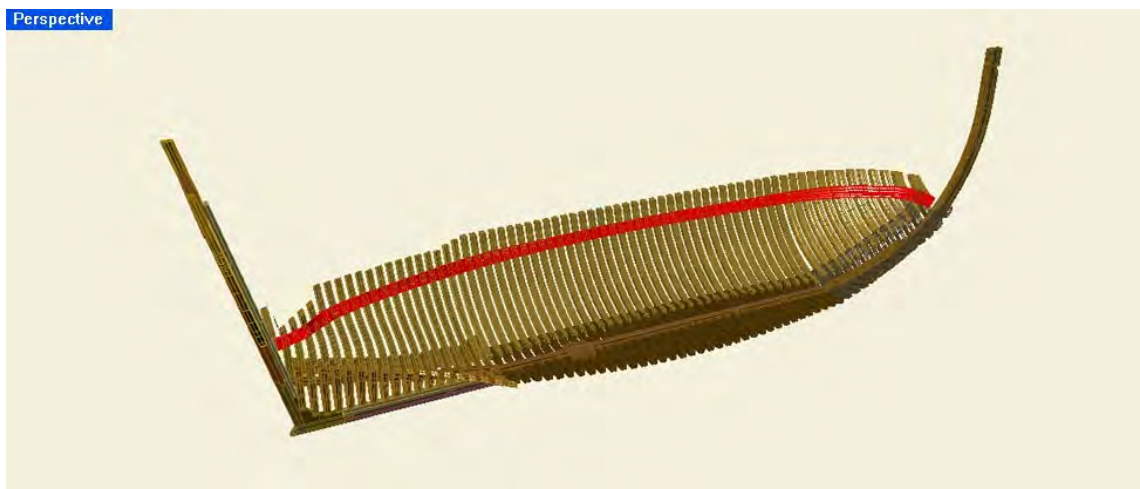


Figure 17. Dromentes and Contradromentes

It takes 70 timbers of Stone Pine for Escoas (Figure 18) [stringers]

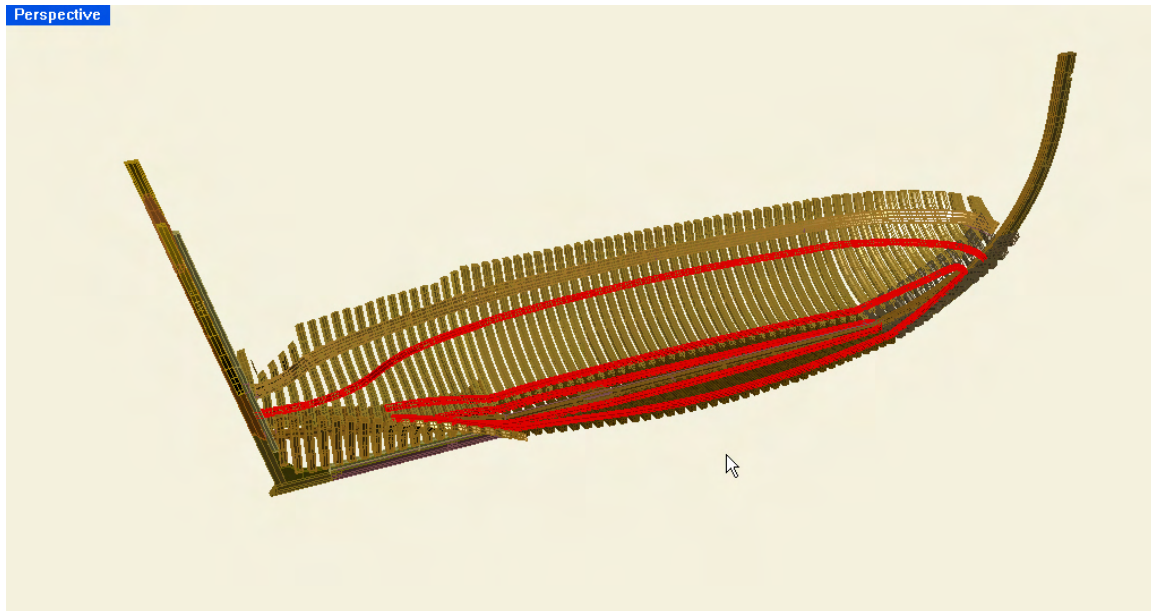


Figure 18. Escoas

To lay the first deck we do the following, we put a cord vertically in the middle of the midship frame, fourteen palmos high which is the depth in hold of our deck, which is called porão [the hold], and from here below we lay the dromente [the clamp, which supports the deck of the hold, is fastened to the frame so that the upper surface is 14 palmos above the center of the floor].

Vertically above the mast step, they will mark a point; from here to the stern they will make one interval of three palmos, and to the bow two palmos, in these five palmos the mast will fit, and then they put two deck beams which will make two palmos, and leave the middle clear for the pumps, [in other words, moving aft from the vertical of the mast mortise, first they place a space of three palmos, then two deck beams, then a space of two palmos for the pumps, and then they continue the deck beams].

And from here the hatch will be seven palmos strong/thick/filled with timber, and a hatch of another seven palmos in square so that barrels can fit; from the hatch

to the stern there will be seven palmos filled, and the [aftermost] hatch will be another seven palmos square so that barrels can fit, and from the mast to the bow, they will put another seven palmos filled with timber, and then, the middle hatch that will have another seven palmos, and from this hatch to the bow, there will be twenty-one palmos filled, and the [forward] hatch will have another seven palmos [the hatch is seven palmos square].

It takes on the first deck eighty beams (Figure 19) both large and small

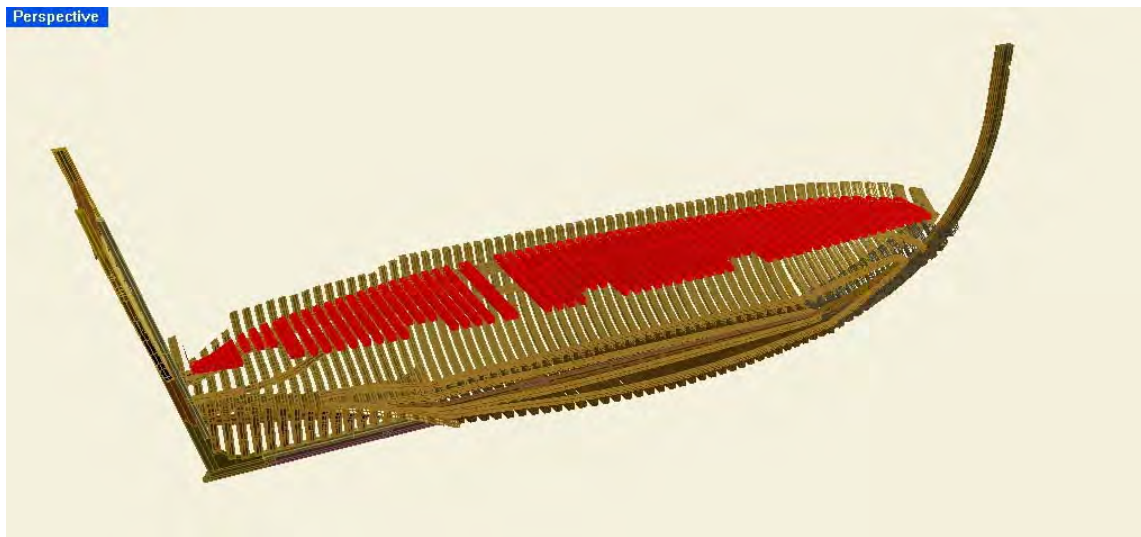


Figure 19. First Deck Beams

The deck beams rest upon the Dromentes described above; the large beams extend completely across the hull while the small beams reach only to the hatches. This is another point where the timbers seem out of sequence – there is nothing placed at this point that will hold up the small beams. I believe the Cordas (fore and aft carlings described below) would have been placed first, so that the shorter beams would be supported.

This passage is quite clear about the spacing and size of the hatches for the first deck, but from the description above, one might think the beams were placed side by side for most of this deck. Unfortunately, the number of beams that was given does not support this, the best fit that I could make was to set the beams at one-palm intervals (as shown in Fernandez' illustrations of deck beam spacing and hatch arrangement). Happily, using this spacing meant that each hatch was bounded by beams fore and aft, as shown in Fernandez' illustrations.

It takes fourteen cordas (Figure 20) [carlings]

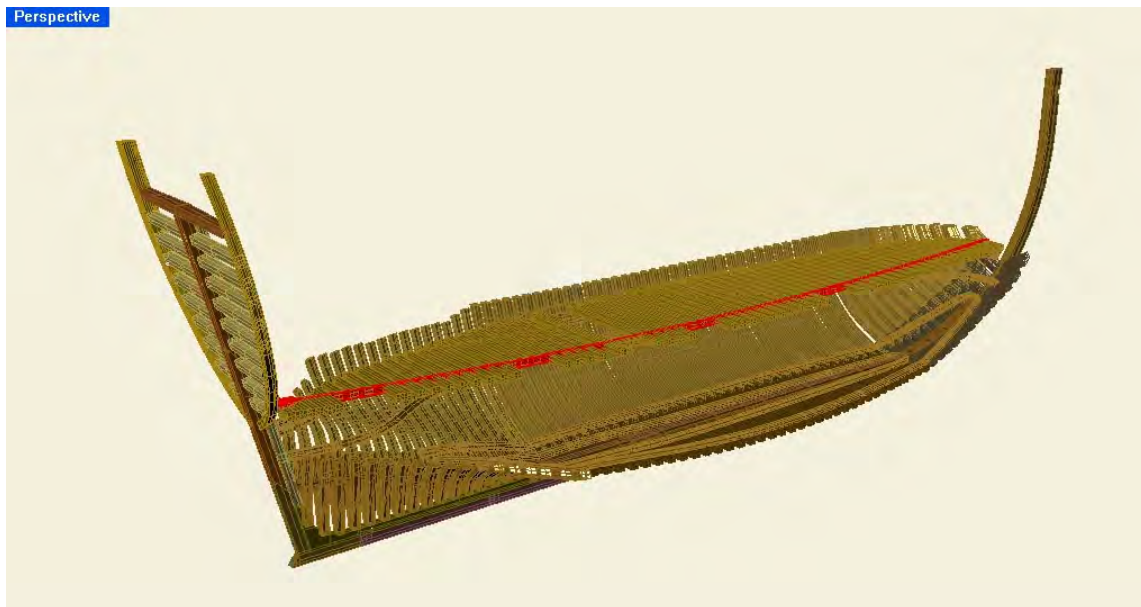


Figure 20. Cordas

The Cordas stiffen the deck structure, and support the short beams. Fernandez' illustrations show these timbers spaced 7 palmos apart (the width of the hatches) and that is how I have modeled them.

It takes sixteen Bonequas [knighthead timbers]

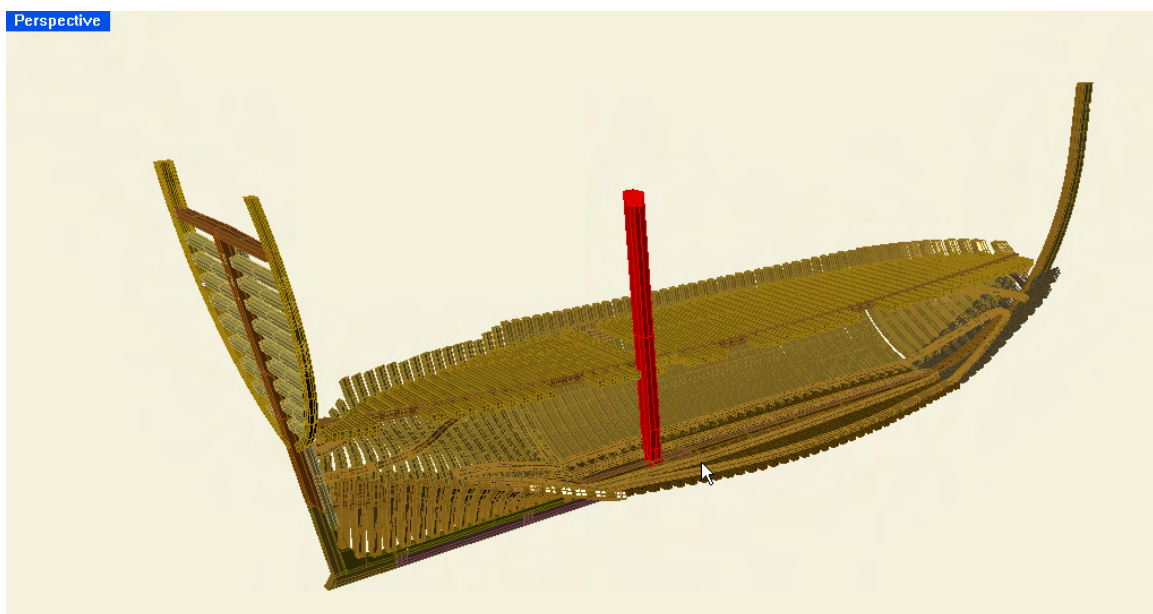


Figure 21. Bonequas

In Figure 21 this large assembly of timbers rests upon the keel but extends all the way to the weather deck, where it serves as the knighthead for the main yard. It passes through the gaps in the deck beams that were left for the pumps.

It takes thirty-two peis de carneiro [stanchions] in the hold

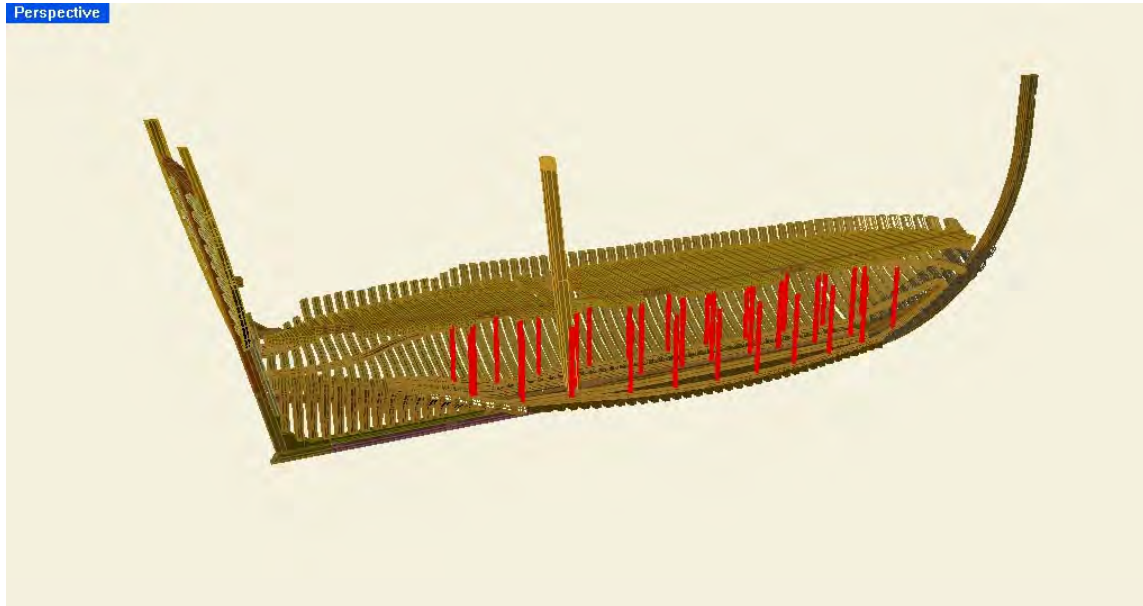


Figure 22. Peis de Carneiro

These sit upon the Keelson and the Escoas (Stringers). Their layout is purely conjectural; in Figure 22 I arranged them in three rows to allow enough space between them for bulky cargo to be moved around the hold. If they had been set in two rows (as suggested in Figuerido Falcao's diagram of an Indiaman's hold, which showed a clear central aisle with the cargo arranged on either side⁸⁸) there would have been less than a rumo of space between stanchions, which would have hampered the loading and distribution of bulky cargo and barrels.

⁸⁸ Castro 2005a, 20.

It takes four paixóes [mast partners] and tamboretas [fore and aft mast partners] that enclose and support the mast

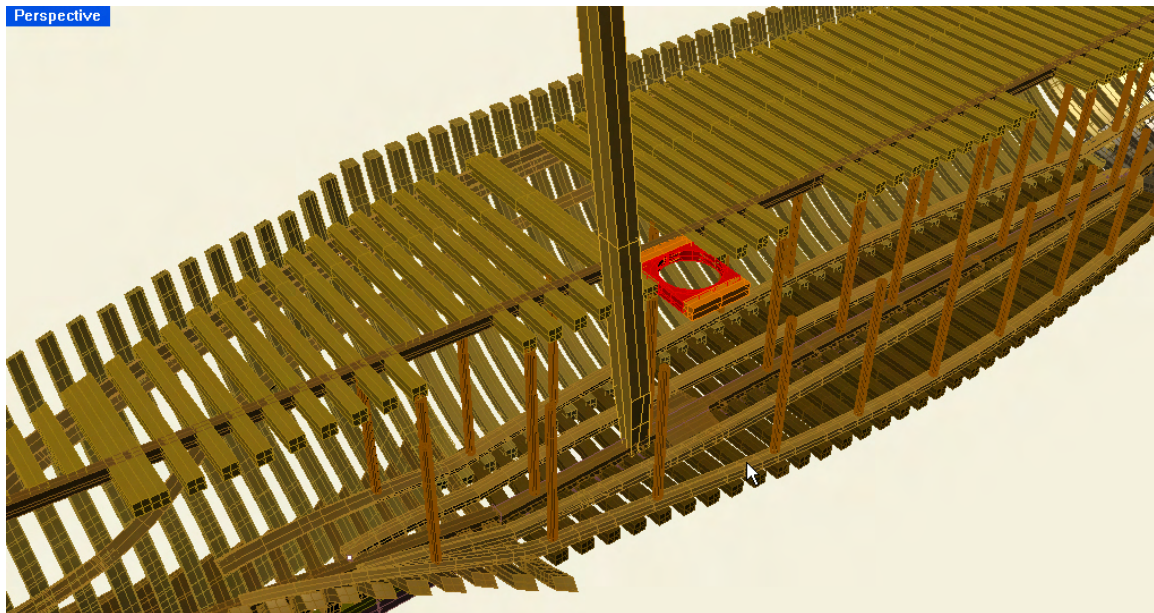


Figure 23. Paixoes (red) and Tamboretas (orange)

The cordas are spaced 7 palmos apart; adding the tamboretas (one-palmo-wide timbers the length of the opening) on each side leaves a 5-palmo square opening for the mast and the four partners that chock it in place here.

It takes twenty-one trinquanis (Figure 24) [waterways] on the first deck

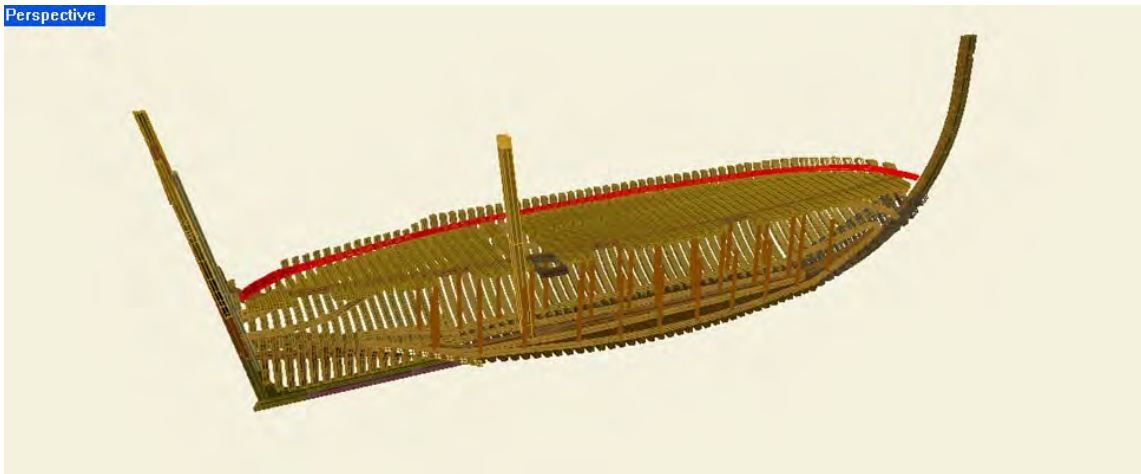


Figure 24. Trinquanis

The Trinquanis (waterways) provide a smooth surface for the deck planks to butt up against and would, with the coceira fit just above them, serve to keep items on deck from rolling into the gaps between futtock timbers (like a wainscoting or a sill at the edge of the deck). They also serve to hold the deck beams down against the beam shelves.

It takes on the stern four areuassados (Figure 25) [vertical timbers in the stern panel]

It takes nine porquas (Figure 25) [the horizontal timbers that make up the grid of the stern panel] in the stern

As noted before, the stern panel (including these timbers) was most likely raised as one piece much earlier in the construction sequence, after being assembled on the ground.

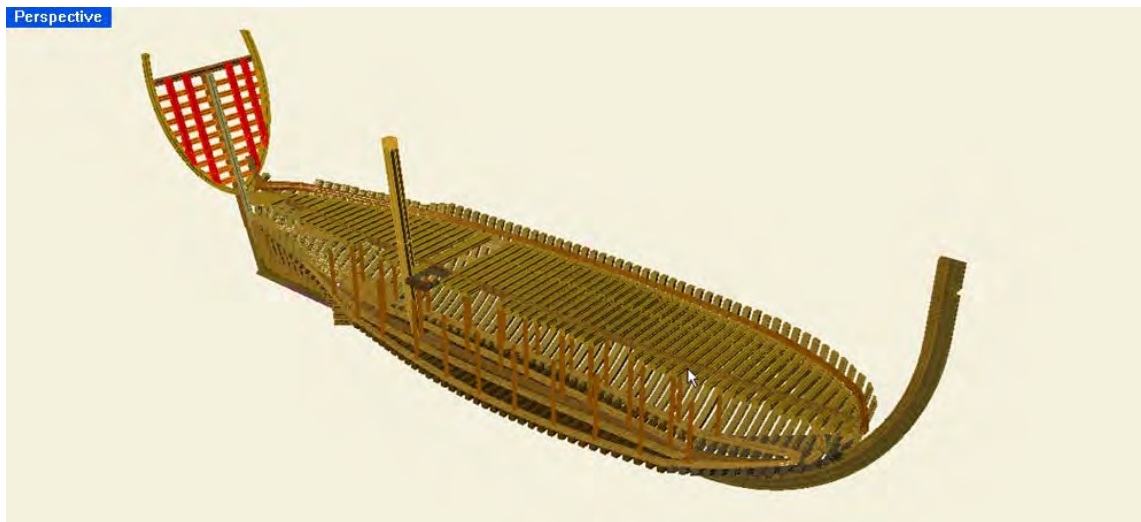


Figure 25. Arreussados (red) and Porquas (orange)

It takes twelve dozen timbers of Pinho Manso [Stone Pine] for the planking (Figure 26) of this hold including the hatches

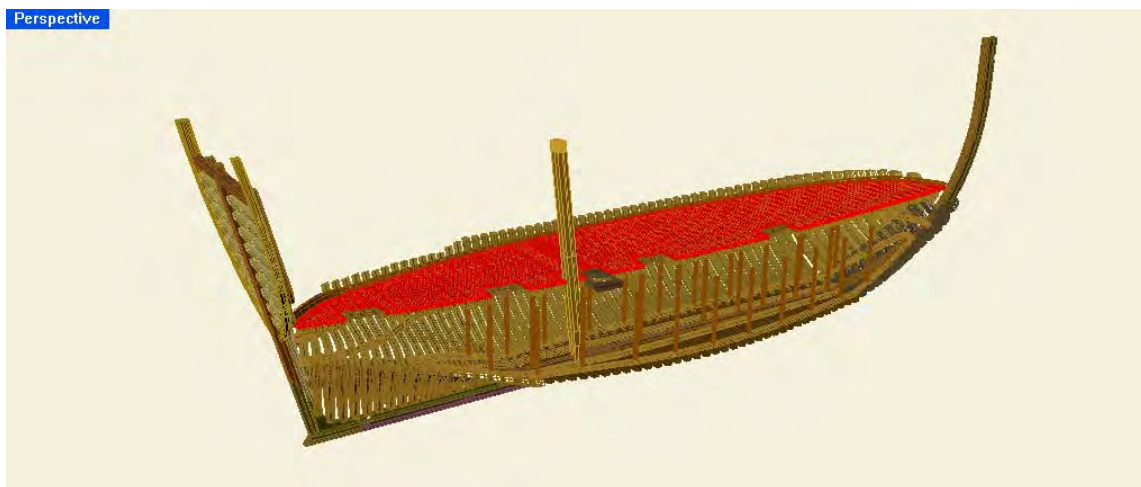


Figure 26. First Deck Planking

Here the author specifies that the hatches will be covered with stone pine. This does not include the timbers for the hatch coamings, which will be specified in another entry. This is the only place in the text where hatch covers are specified.

It takes a Buçarda [breast hook] in the hold

It takes ten dragas [stringers] of Stone Pine

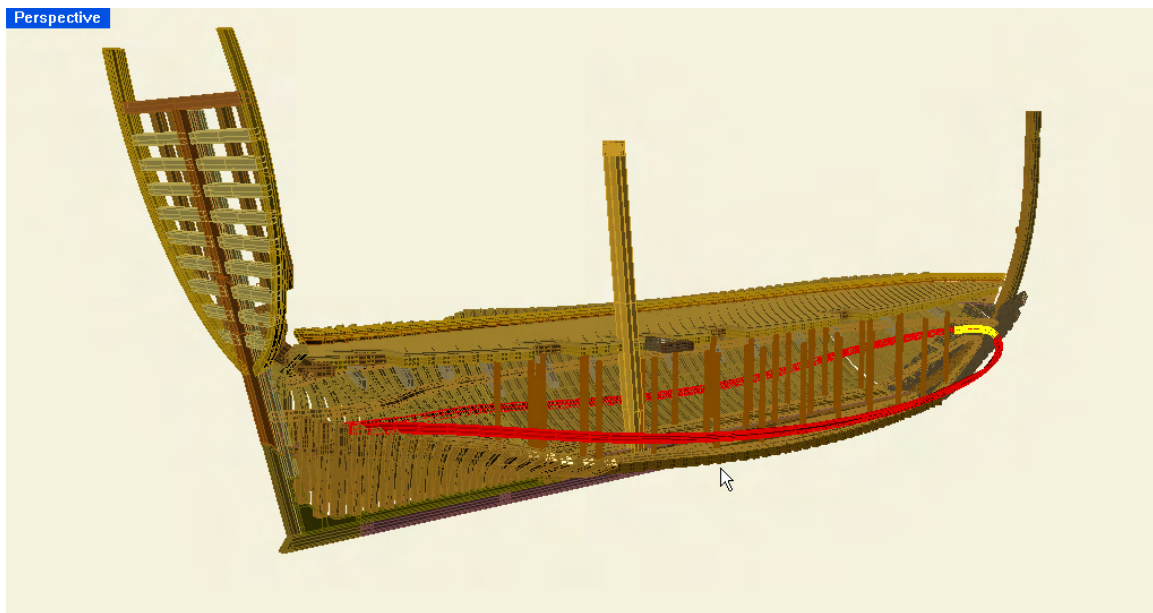


Figure 27. Buçarda (yellow) and Dragas (red)

In Figure 27 the breast hook ties the stringers together and to the stem post, adding longitudinal stiffness to the hull.

It takes fourteen lines of curves (Figure 28), which are twenty-eight curvas de conues [deck or hanging knees]



Figure 28. Curvas de Conves

Literally, these are ‘Curves (Knees) of the Conves (Deck).’ These are notched to fit over the Dromente, Contradromente, and Escoa; they support the deck beams and tie the deck beams to the futtocks. They are spaced along the length of the deck every five deck beams.

It takes twenty antremichas [lodging knees, these are knees with one long arm that extends across the hull beneath the deck to support it, with the long arms of each pair scarfed together]

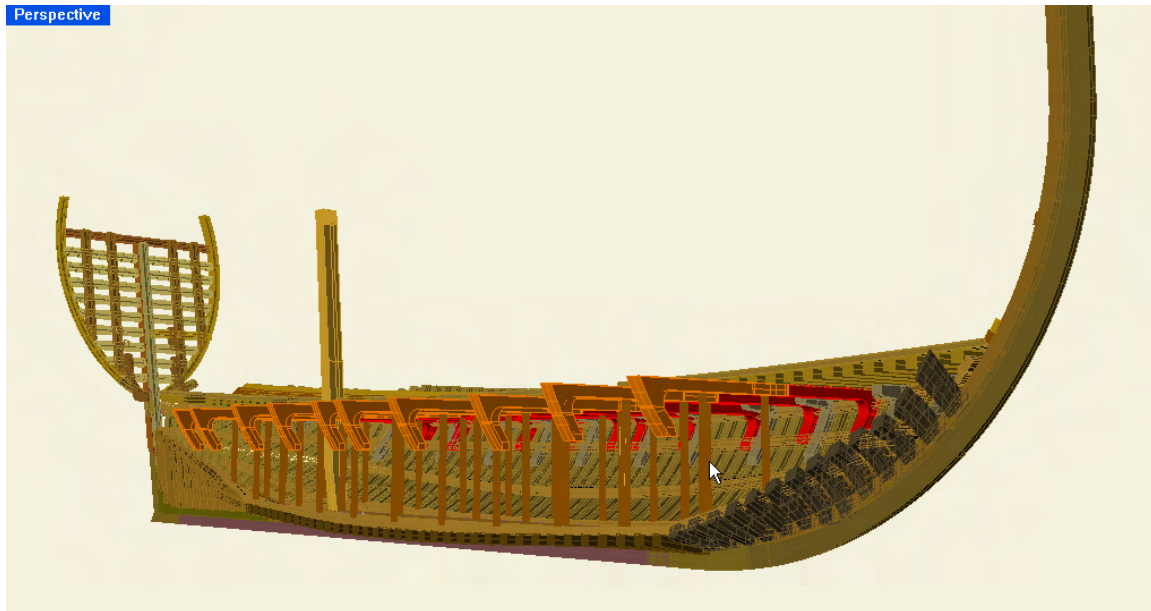


Figure 29. Pairs of Antremichas

The term ‘Antremicha’ [or Entremicha] has several meanings, all related to the concept of a horizontal member that ties other timbers together. In Fernandez’ treatise the Entremicha is described as “...a knee with a long arm that runs across the ship and is scarphed with a similar one coming from the opposite side...”⁸⁹ and that is how I have modeled these timbers in Figure 29. Twenty Entremichas would be 10 pairs; they are spaced five deck beams apart along the length of the deck between the Curvas de Conves.

These tie the deck beams and futtocks together, and tie the sides of the hull together as well.

It takes two curuas [knees] at the stern which connect the cordas [carlings] and the porquas [the timbers which make the grid of the stern panel]

⁸⁹ Fernandez 1616, 254.

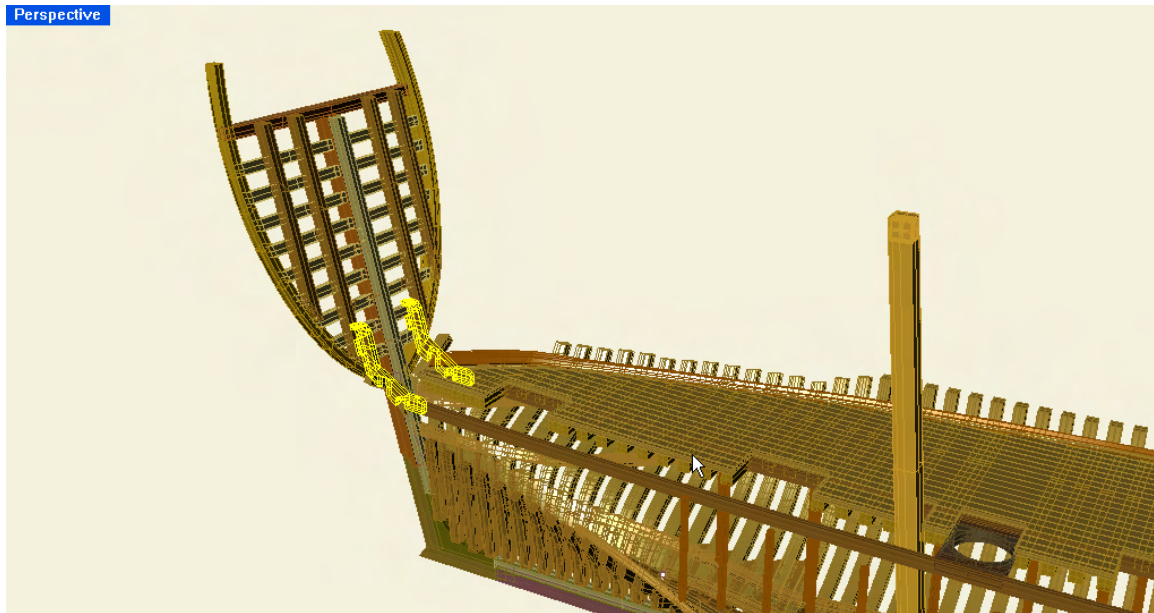


Figure 30. Knees for the Cordas

There is a problem here – the carlings lie so close to the bottom of the stern panel that there is no room beneath the deck for these knees to connect the carlings to the stern panel.

Placing them above the deck (as shown in Figure 30) would mean the builder would have to leave space for the knees when the deck planking was installed earlier in the sequence.

The stern panel is so narrow at the height of the deck that there is little space for horizontal knees here (since the deck beams spacing fits all the way to the stern panel, without more than a 1 palmo gap, which leaves little space for a horizontal knee).

It takes another Buçarda (Figure 31) at the dragas [the stringers]

It takes one dozen of planking of Stone Pine in the dragas (Figure 31)

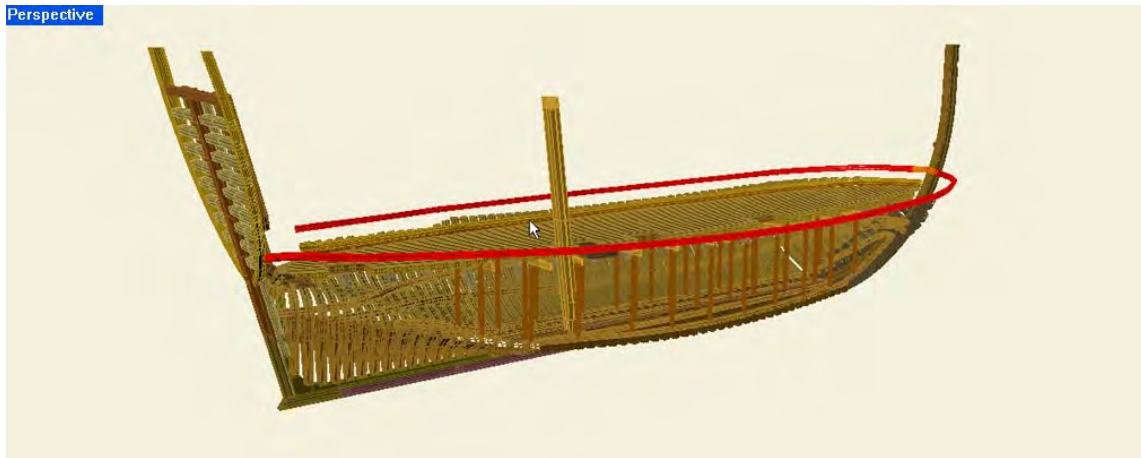


Figure 31. Buçarda (orange) and Dragas (red)

When I modeled the hull, I defined the shape of the hull up to the weather deck, and drew all of the futtocks (the first, second, and third Aposturage) up to that point, to be sure that they flowed smoothly and consistently from bow to stern as they should.

The problem that is shown here is that the dragas were modeled to fit appropriately within those futtocks, without consideration of the order of the construction sequence. It is clear that the first futtocks should extend higher at this level, since the dragas are supposed to be affixed to those futtocks already in place (in my model they float above the futtocks because the dragas were actually drawn to fit midway between the first and second deck, against the second Aposturage, but the futtocks of the second Aposturage haven't been put into place at this point in the construction sequence).

It takes ten planks of Stone Pine in the coçeiras [these planks are fixed to the frames longitudinally, above the waterways]

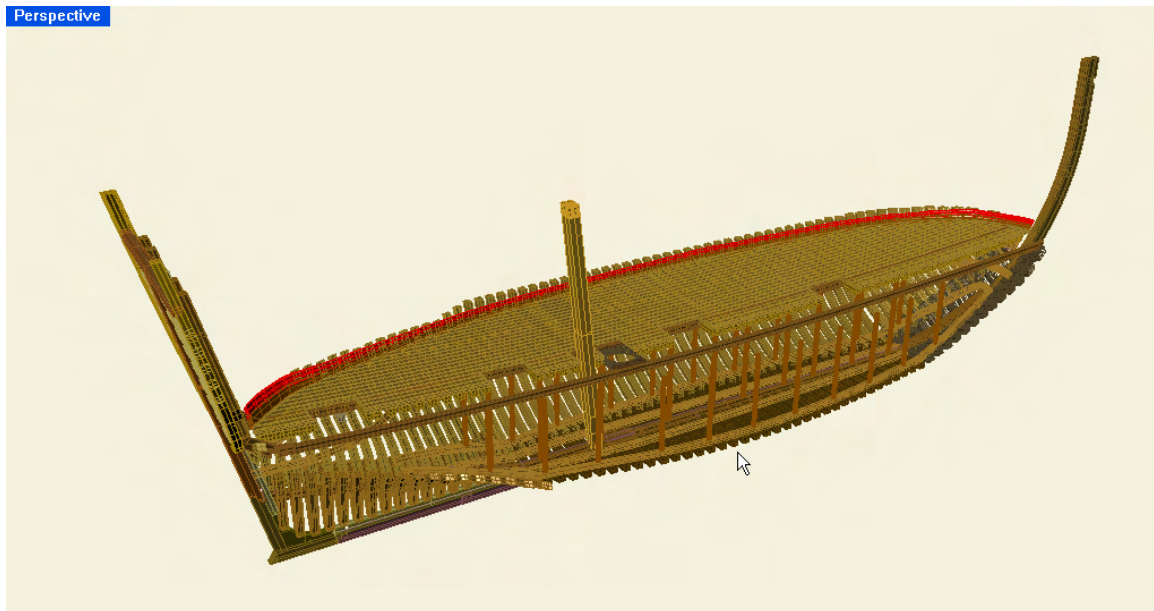


Figure 32. Coçeiras

Since the top edge of the waterway is higher than the deck, and the coçeiras (Figure 32) add another palmo of height, they act (with the trinquantis) as a sill along the sides of the deck to keep any small objects from rolling into the gaps between futtocks or at the ends of the deck beams, in addition to strengthening the frames and beams of the hull.

It takes two timbers of Stone Pine in the madres das Escotilhas (Figure 33) [the frame around the hatches]

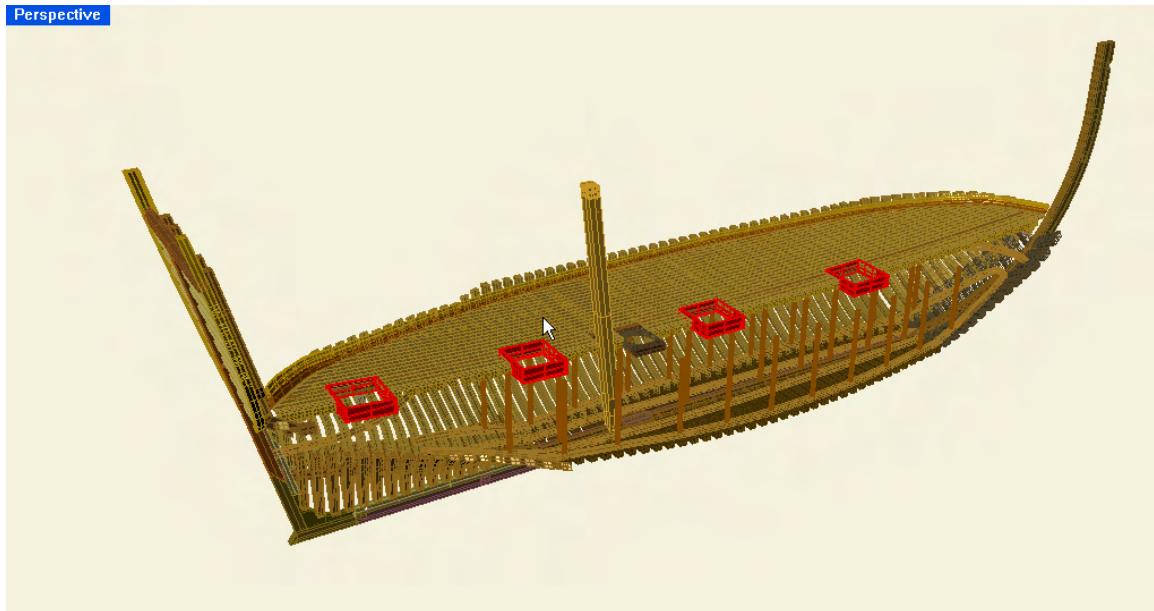


Figure 33. Madres das Escotilhas (Hatch Coamings)

Like the deck planking, these hatch coamings were specified as Stone Pine instead of Cork Oak, perhaps because they were not primary structural components (so there was no need to waste oak on them), or because they were large, flat pieces of timber that could be cut from pine more easily than from oak.

When you put the cordas [carlings] in this first deck, you put the first wale (Figure 34) that at the stempost dies at a height of twenty-one palmos, and at the center of the *Nau* it goes exactly at the level of the beam [the clamp that was set at 14 palmos], and that at the stern it rises one palmo from the deck, which is a good dimension for the third wale to be even with the seis bordo [the stern window or hatch – this is a hatch in the side of the hull, at the stern]

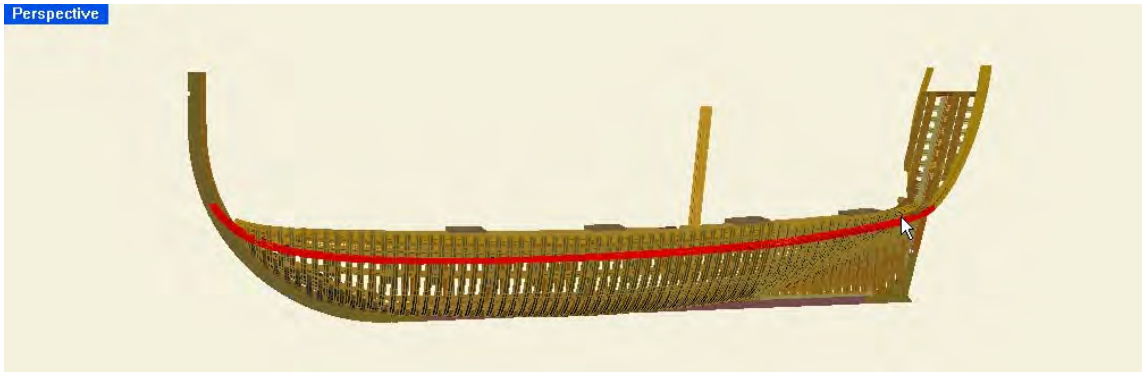


Figure 34. First Wale

In order to run parallel to the seis bordo at the stern (the white arrow in Figure 34) while passing through the three points (bow, center, and stern) listed, the wale had to turn up more sharply at the bow. This affected all subsequent wales and planks above it.

After planking the first deck, we will put reference points for the second aposturagẽ [third futtocks], which is done, and will put the top timbers of the seis bordo [the hatch in the side of the stern] two Rumos before the Porqua de Popa [the grating of the stern panel], and from this timber forward the hatch will be seven palmos, which is the size of the seis bordo in square [that is, the seis bordo is seven palmos square], so that a barrel can fit through: This hatch stays straight exactly on the vertical of the coçe [the knee connecting keel and stern post] because two Rumos is what the sternpost springs abaft. [the after end of the seis bordo is two rumos forward from the stern panel, which puts it vertically in line with the foot of the stern post]

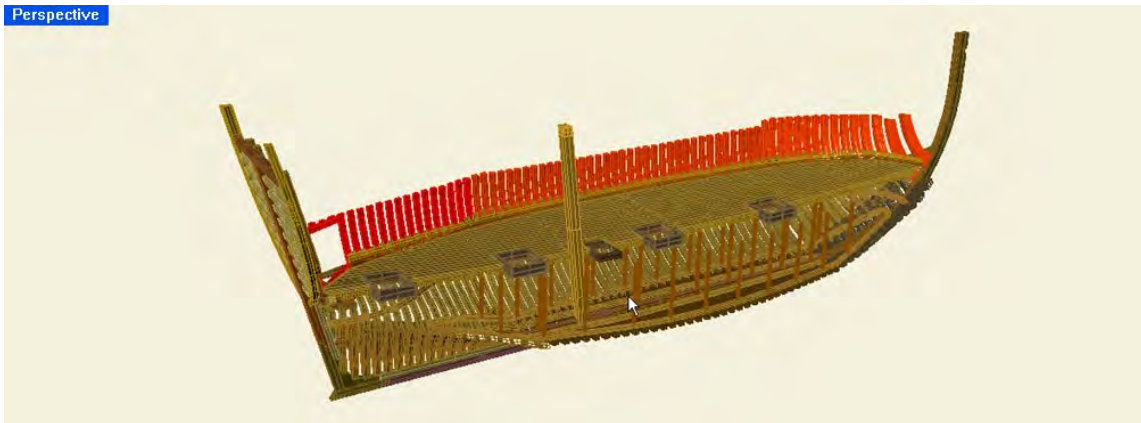


Figure 35. Seis Bordo and Second Aposturagẽ

And having made this second aposturagẽ [complete set of third futtocks] we will lay the clamps/beams of the second deck and this will go eight palmos high, and it will be beamed in this way,

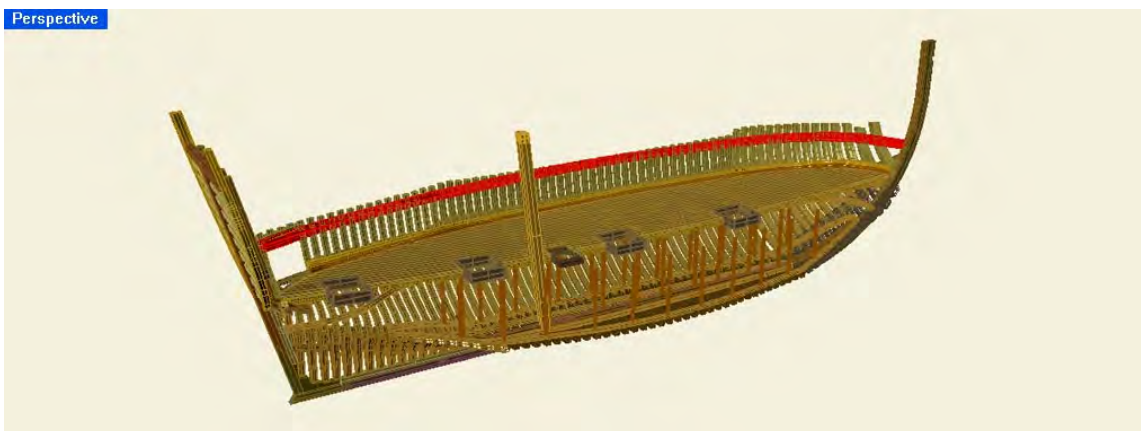


Figure 36. Second deck Dromente and Contradromente

The first deck had ample headroom for cargo handling; with the second-deck clamp set at 8 palmos (2.05m) there was plenty of space below to tip up or stack the standard Portuguese barrel (which was 6 palmos (1.54m) high and 4 palmos (1.03m) at its widest point). Four deck hatches and a wharf-height seis bordo (a loading port, set aft on the port side of the hull) allowed for easy loading and unloading of cargo from this deck and the hold.

Here is another sequence error; the clamp is being affixed to the second aposturage but the text hasn't told us how many of these futtock timbers to install yet.

you will lay one crossbeam one palmo to the stern from the one that is below [on the second deck, the beam at the forward edge of the mast opening is set one palmo aft of the beam on the deck below], which is what the mast will rake abaft, and this will be done in all of the decks, and immediately after will make a place for the pumps, as we have done in the previous deck, and from here to the stern it is full of beams with empties and fulls [one space, one room]: and the middle hatch and the forward hatch will be set exactly vertical over the ones below, it will be layed to the bow in the same manner as the stern [one space, one room].

It will take in this second Aposturagẽ one hundred and forty aposturas [third futtocks]

It takes in the second deck nineteen dormentes [clamps]

It takes eighty-three latas (Figure 37) [beams]

The paragraph above prescribed the rake of the mainmast (and the pumps and knighthead as well) in the simplest of terms, by setting the deck beam at the front of the mast opening one palm aft of the same beam one deck below.

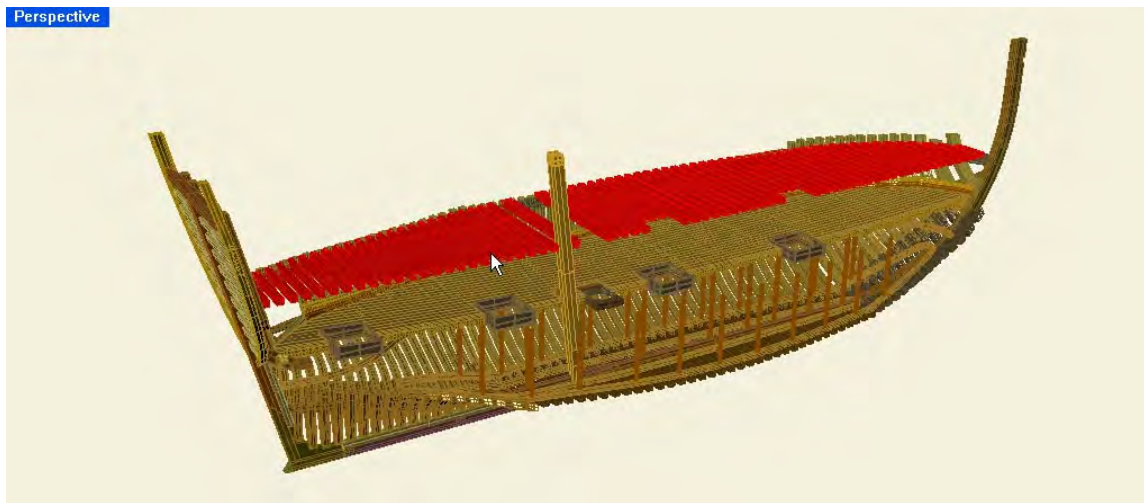


Figure 37. Second Deck Beams

It takes sixteen cordas (Figure 38) [carlings] which are those ones which run along the vessel

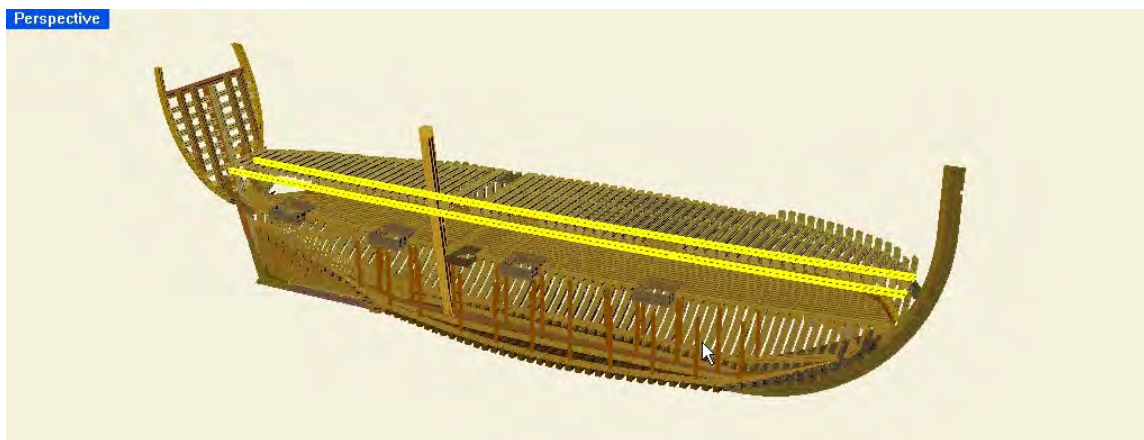


Figure 38. Second Deck Cordas (yellow)

Like the carlings of the first deck, these were notched fore-and-aft timbers fit underneath the deck beams to tie them together, set 7 palmos apart. They define the width of the hatches, and support the mast laterally (with the tamborettes and porquas).

It takes twenty-eight curvas de Reves (Figure 39) [standing knees]

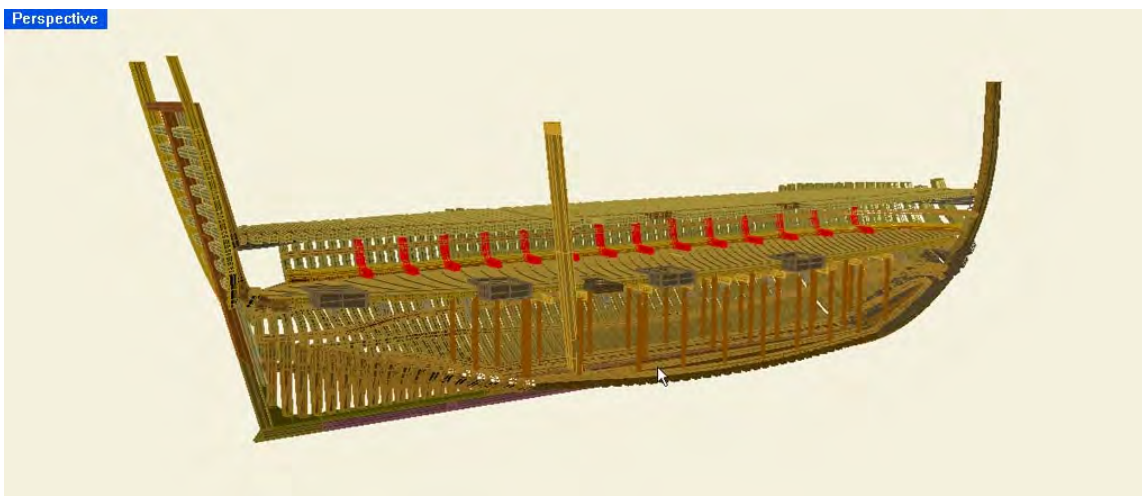


Figure 39. First Deck Curvas de Reves

This arrangement of knees below and above the deck is also seen in Basque vessels. Barkham cites a 1573 contract for a *Nau* that specifies, "...the beams of the first row and those of both decks are to have knees beneath and on top..."⁹⁰ This means the deck knees are each set directly over the Curvas de Conves.

⁹⁰ Barkham 1981, 68.

Although none of these knees are large there are quite a number of them; each side of the hull is strengthened with 28 knees and Entremichas below the deck and another 14 above it. It seems clear that strengthening and stiffening the lower hull was of paramount concern to the Portuguese shipwrights.

It takes one mesa [sill] for the seis bordo [the hatch in the side at the stern]

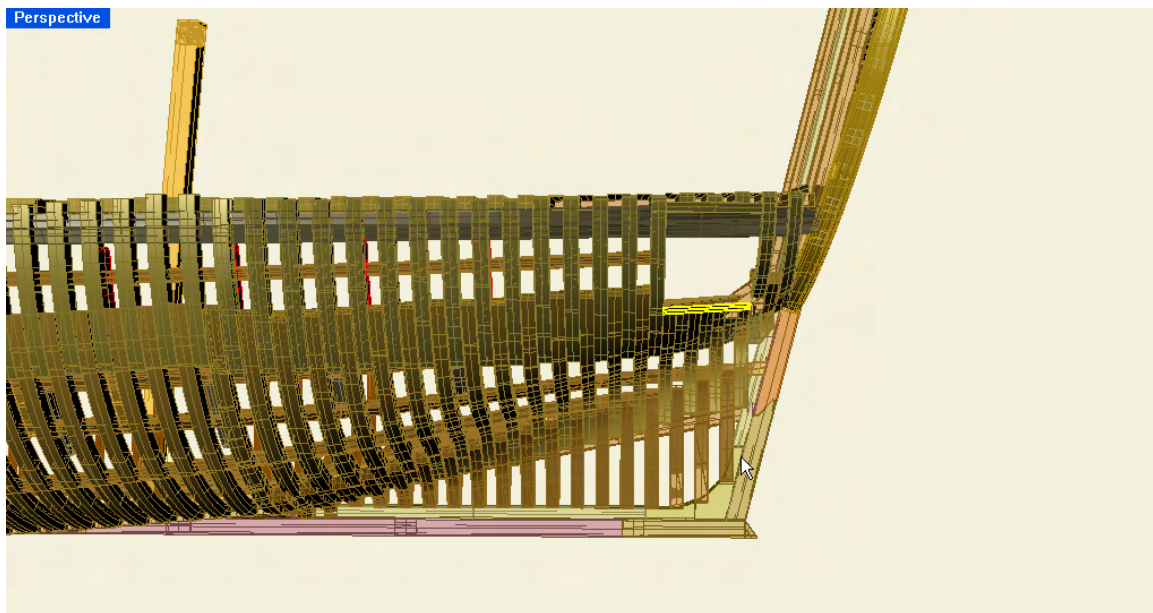


Figure 40. Mesa (sill, in yellow) for the Seis Bordo (loading hatch)

It is possible that in this case the term mesa stands for the panel that would fill this loading hatch, rather than the sill of the loading port as I have chosen to model it in Figure 40. No other mention is made in the text of a hatch for this port.

Unfortunately, the seis bordo is not shown in any of the treatises which I consulted, nor (as far as I know) was it preserved in any of the Iberian wrecks of this period (the well-preserved Basque galleon *San Juan*, which might have provided an example, showed no sign of a side-loading hatch).

It takes four paixoes (Figure 41) [mast partners]

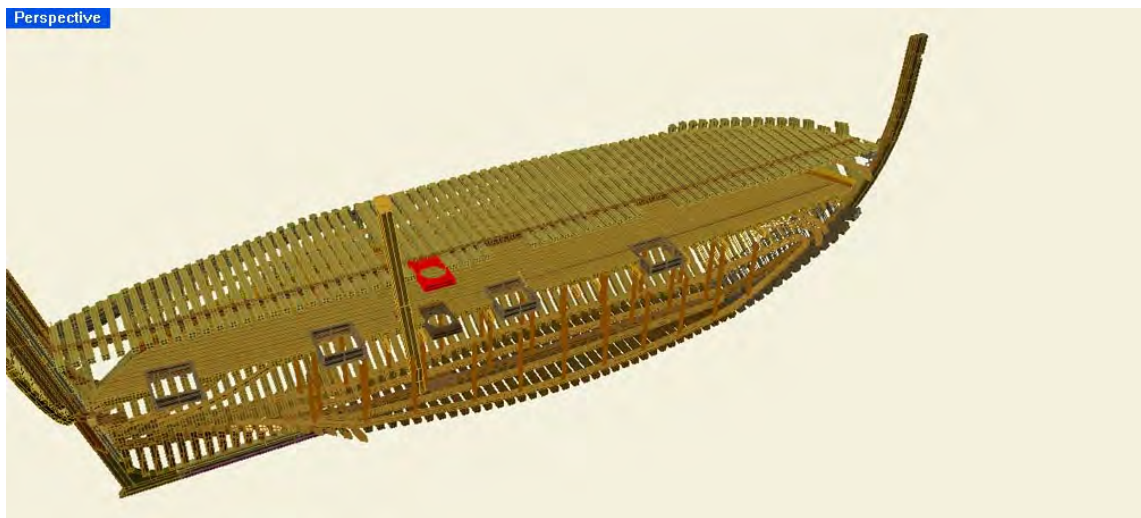


Figure 41. Second Deck Paixoes (orange) and Tamborettes (red)

Although they were not specified in the text, there should have been tamborettes here to hold the mast partners centered in the deck opening just as there were at the first deck. I chose to add them to the model them here at the same time as the mast partners. I made the tamborettes the same size as those on the deck below, and the paixoes were cut to fill the space around the diameter of the mast at this deck.

It takes eighteen trinquanis [waterways]

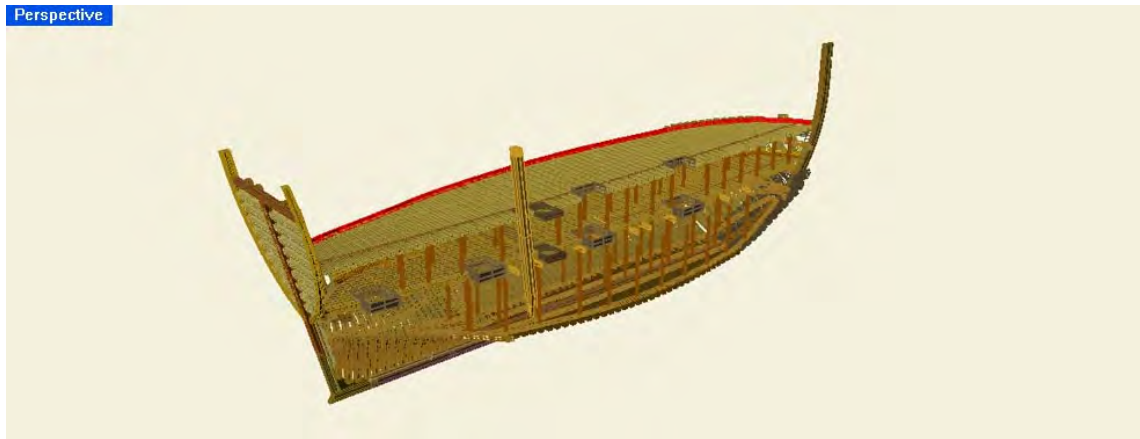


Figure 42. Second Deck Trinquanis

The Trinquanis in Figure 42 provide a smooth surface for the deck planks to butt up against and would, with the coceira fit just above them, serve to keep items on deck from rolling into the gaps between futtock timbers (like a wainscoting or a sill at the edge of the deck). They also hold the deck beams down against the beam shelves.

It takes two curuas (Figure 43) [curves or knees] in the carlings that connect to the stern

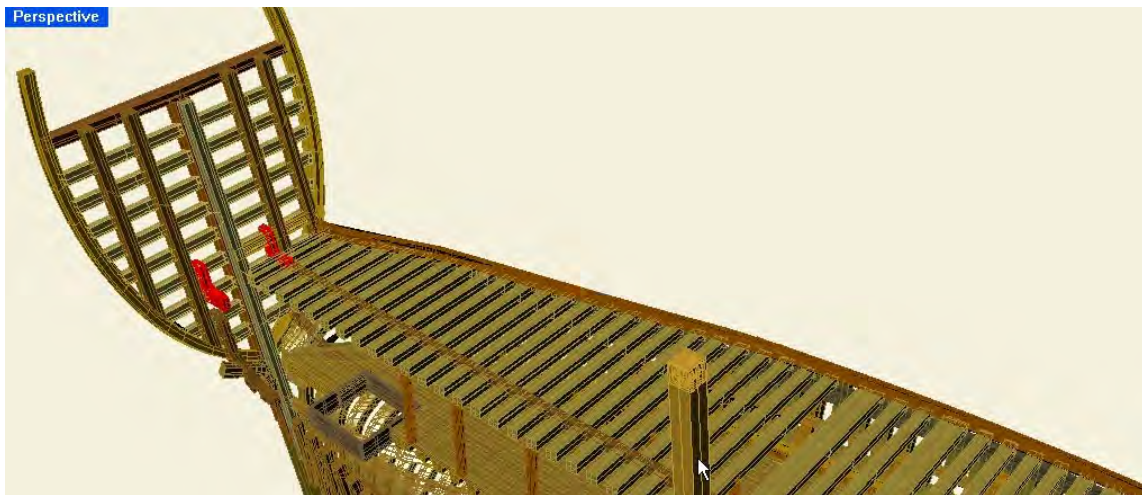


Figure 43. Second Deck Knees for the Cordas

It takes sixteen dozens of Pinho brauo [Wild Pine] for the decking

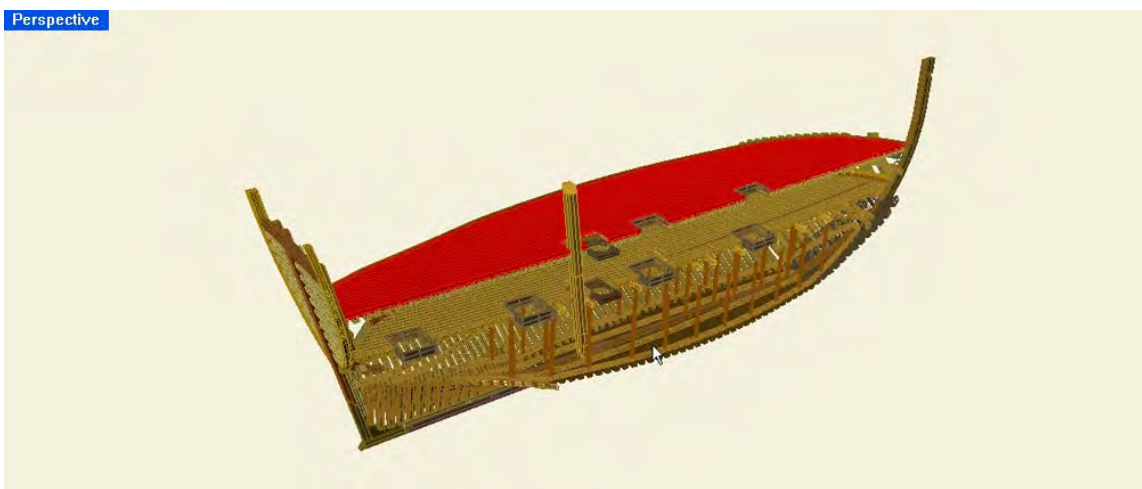


Figure 44. Second Deck Planking

It takes forty-two peis de carneiro [stanchions] underneath

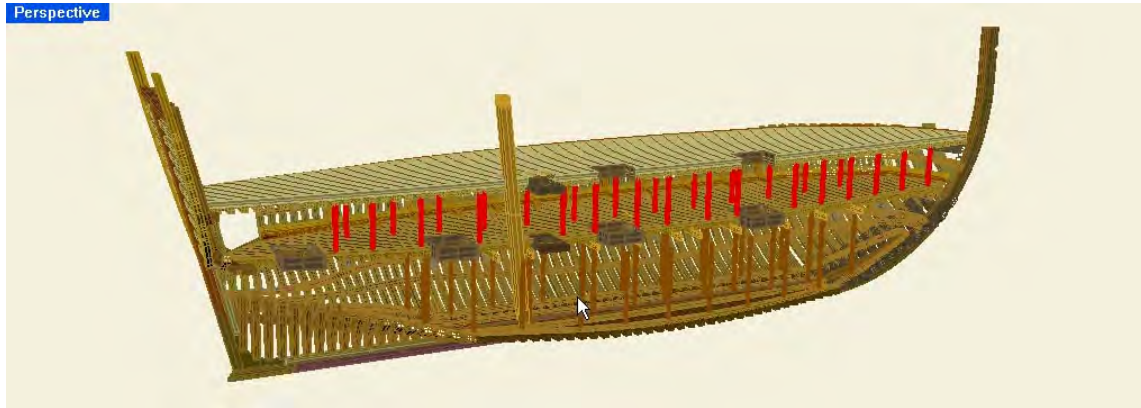


Figure 45. Second Deck Peis de Carneiro

Like the stanchions in the hold, I arranged these first deck stanchions (Figure 45) in three rows, one row down the center, and the outer rows set 7 palmos apart, so that they were positioned over the cordas of the first deck (and under the cordas of the second deck). This meant more room between stanchions fore-and-aft than just two rows would have allowed. Bulky cargo such as barrels could be brought in through the seis bordo and rolled along the outer part of the deck to the hatches, to be passed down to the hold.

It takes fifteen rows of curuas do cõues (Figure 46) which makes thirty hanging knees

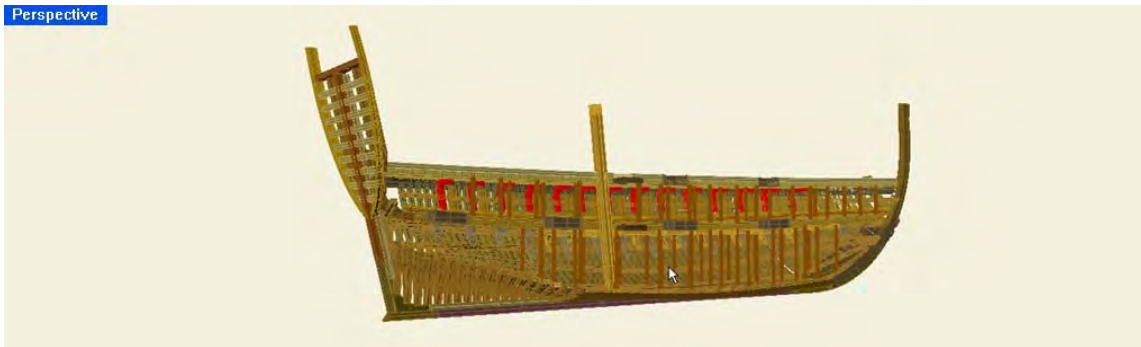


Figure 46. Second Deck Curvas do Conves

Like those of the first deck, these are notched to fit over the Dromente, Contradromente, and Escoa; they support the deck beams and tie the deck beams to the futtocks. They are spaced along the length of the deck every five deck beams.

It takes twenty-five entremichas

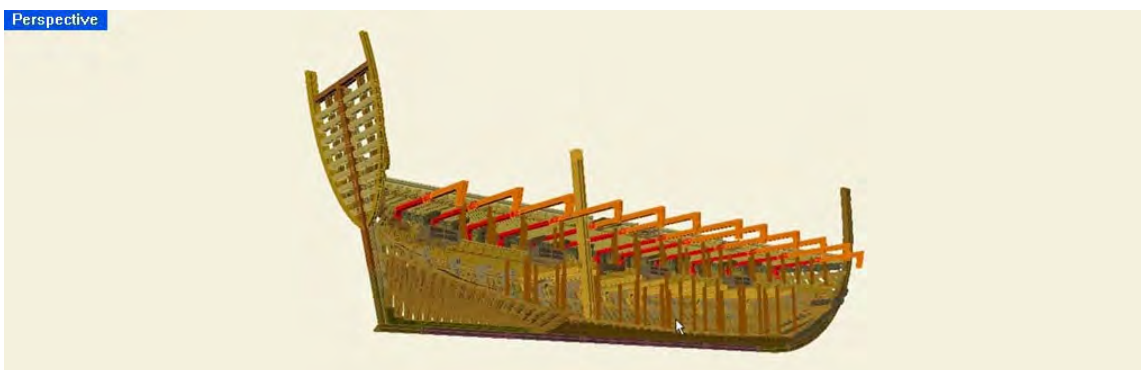


Figure 47. Second Deck Entremichas

Assuming these *entremichas* were paired (as I modeled them for the first deck) there should only be 24 *entremichas*, I have modeled them in Figure 47 as twelve pairs scarfed together. They are spaced every five deck beams, set evenly between the *Curvas de Conves* (hanging knees).

It takes one *carlinga* (Figure 48) [mast step] for the *mastro do traquete* [foremast] with its *cunhos* [buttresses, the heavier beams in which the mast step stands] that are four timbers.

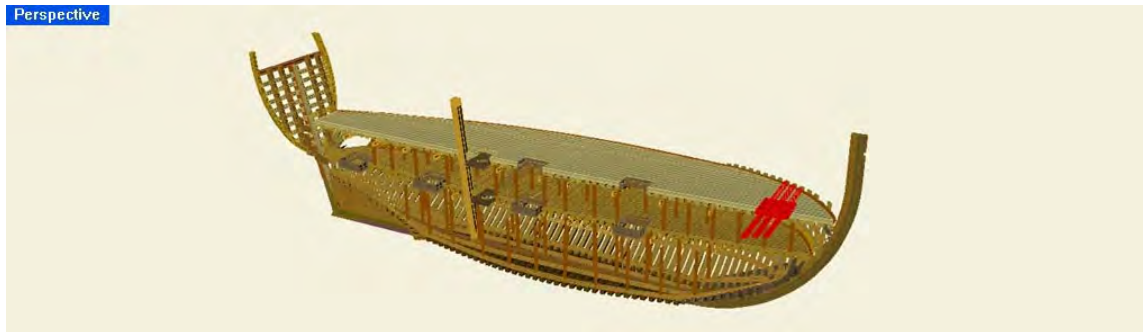


Figure 48. *Carlinga* and *Cunhos* for the *Mastro do Traquete*

The foremast is stepped fairly high, here on the second deck, rather than directly upon the stem post. In smaller vessels, like the two-decked *nau* depicted by Figuerido Falcão, the foremast might be stepped on the keel or stempost instead.⁹¹

The weight of the foremast assembly is spread over the deck planking by the *cunhos* as well as the large mast step.

⁹¹ Castro 2005a, 20.

It takes one aguarda [most likely this is a Buçarda or breasthook, given the context] in the stringers

It takes one dozen Pinho m​ãso [Stone Pine] timbers for the dragas [stringers]

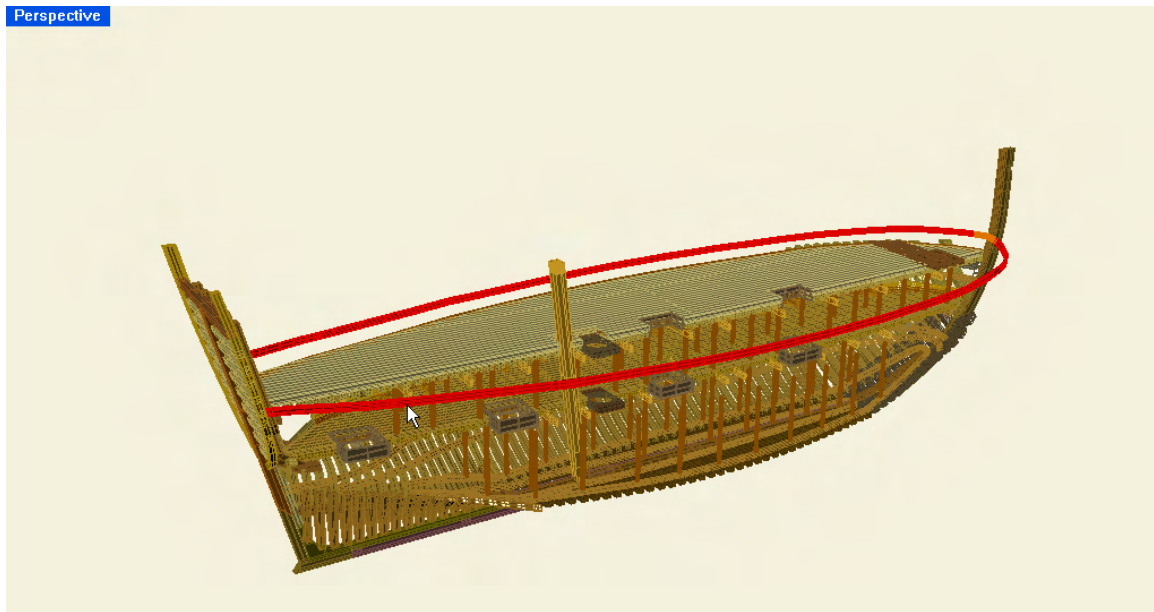


Figure 49. Second Deck Buçarda and Dragas

Once again, the Dragas were modeled to fit inside the next set of aposturage, which have not actually been attached at this point, showing that the futtocks should have been modeled higher.

It takes sixteen coçeirias (Figure 50) [the planks nailed to the frames above the waterways]

It takes three timbers of pine for the madres das Escotilhas (Figure 50) [the frames of the hatches]

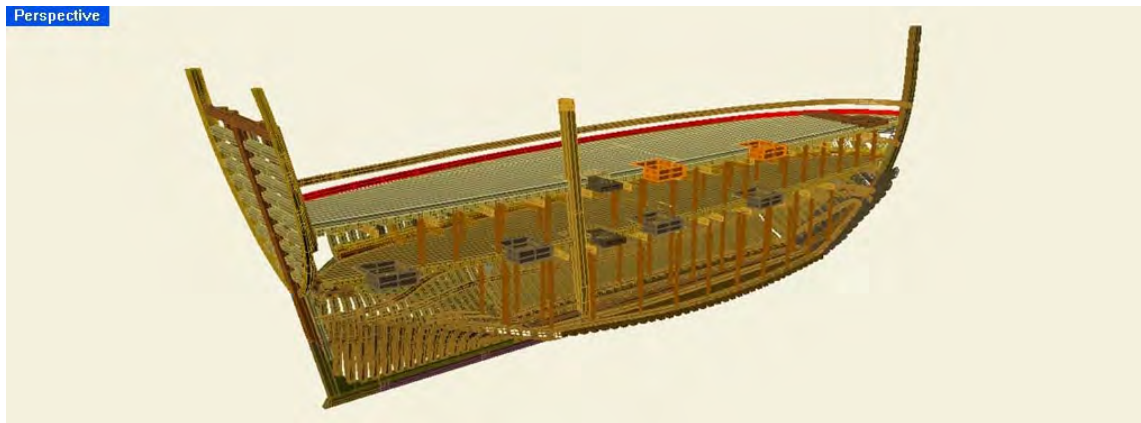


Figure 50. Second Deck Coceiras (red) and Madres das Escotilhas (orange)

Unlike the description of the first deck, there is no mention of a grid or hatch covers for these hatches, and three timbers would not suffice to frame and fill these hatches, so I have modeled them open.

It takes two conchas (Figure 51) [sides] with six curuas (Figure 51) [knees], four on the sides, and two on the edges, for the strinqua [windlass]

And this windlass will be layed in the following way, from the deck beam where the pumps lean against, to the middle of the concha [the cheek, or side of the windlass] will be eight palmos, because the circle of the windlass is nine palmos, and the half, which is four and one half palmos, and three and one half palmos

This places the windlass far enough aft that it is clear of the pumps and knighthhead, yet it is still close to directly underneath the the top of the mainmast.

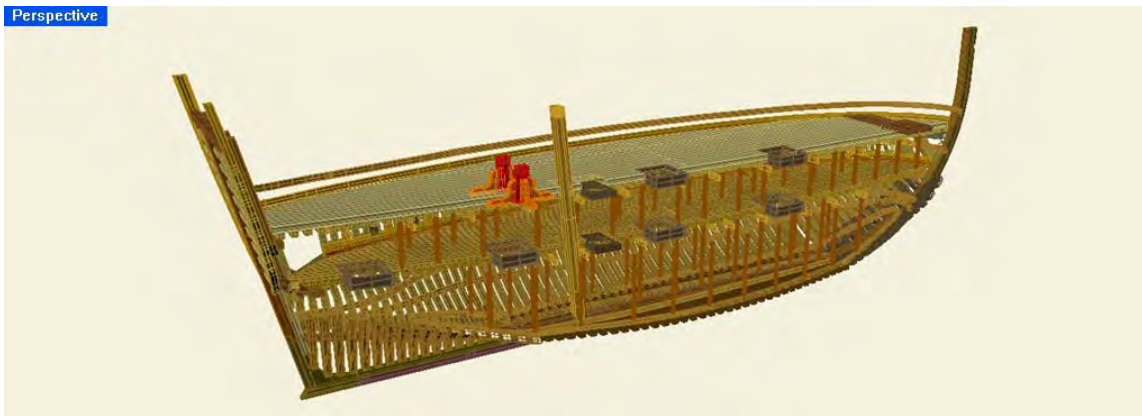


Figure 51. Conchas (red) and Curvas (orange) of the Strinqua

This windlass will take one timber for the eixo (Figure 52) [spindle/axis]

It takes nine timbers on the cruzetta (Figure 52) [the circle of the windlass]

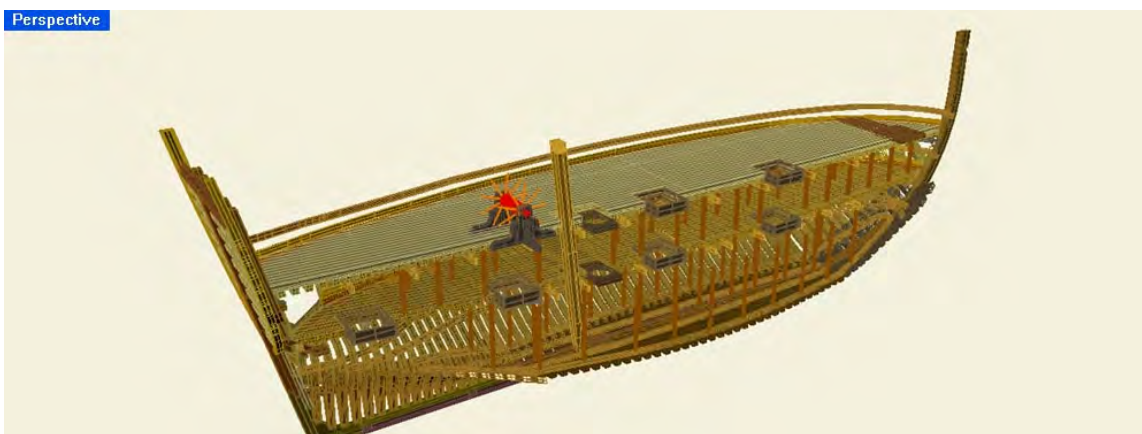


Figure 52. Eixo (red) and Cruzetta (orange) of the Strinqua

It is unclear how the timbers are arranged in the cruzetta - later windlasses use removable bars to turn the spindle rather than a fixed circle of handles. There is no description here of a ratcheting pawl either, as is commonly found in later windlasses.

After the second deck is done, you put up the third aposturagẽ [the fourth set of futtocks], that from the level of the Portinhola [gunport], will start going inwards, five palmos on each side,

and once done, we will lay the dromente [clamp] of the third deck, which is called the bridge or weather deck, and it is seven and one half palmos in height.

This bridge deck will be beamed in this way: the beam where the mast will go will be one palmo to the stern of the one below, and soon after there will be a hole, to make a chimney for the windlass which will have ten palmos in breadth, and from the middle of this hole to the stern, the conchas [partners] of the capstan will be laid so that its bar will be 24 palmos in length, and before the mast will go the tilha [the cuddy, a tiled area where food was cooked] standing on the vertical of the middle hatch, and from here to the bow will make its cuxias [walkways] so that they reach all the way to the Castle, and from these cuxias will go the space of the Batel [ships boat], which has to be 12 goas which are 36 palmos, and they will be in beam, next to the tilha 14 palmos, because this is the length that the Batel will have, and at the bow, it will be 12 palmos, and from there until the stem everything will be beamed and in the center there will be a small hatch that will be four palmos square so they can put one quarto [a small barrel, smaller than a pipa].

The Bita [Bitt] that goes on this deck will lie vertically to the beam of the Castle, and will have 3 palmos above the deck so that underneath we can store a pipa. In the middle of the quarters they will make a small hatch of 3 palmos so that people can reach the ships boat.

The third aposturagẽ (Figure 53) [row of fourth futtocks] takes 145 top timbers

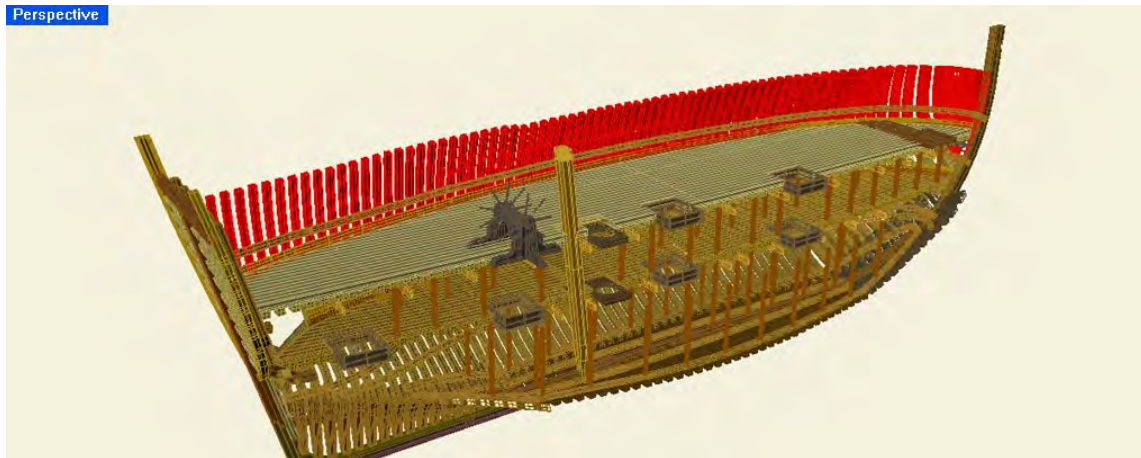


Figure 53. Third Aposturagē

The widest portion of this vessel, following the treatises of Oliveira⁹², Fernandez⁹³, and Palacio⁹⁴ is here at the weatherdeck, two decks above the waterline (assuming the *seis bordo* marks the waterline, since a loading hatch is no use, after all, if it is set below the waterline). Although it might seem counterintuitive to set the widest portion of the ship so far above the waterline (the point of maximum beam is as far above water as the keel is below water), the treatises all agree that the maximum beam is set high in the hull.

It is important to consider that these ships were not built to carry many (if any) heavy cannon, and the bulk of their cargo was loaded at or below the waterline, so the heaviest portion of their load was set low in the ship. The largest mast (with by far the largest yard and sail) was set directly upon the center of the keelson, in the bottom of the hold. Perhaps these craft were not as top-heavy as we might imagine from their looks.

⁹² Oliveira 1580, 166.

⁹³ Fernandez 1616, 118.

⁹⁴ Palacio 1587, 115.

Upon consideration the shape probably did offer some advantages. First of all, it would have put the most deck space for passenger use high in the hull. These ships carried hundreds of passengers, particularly on the voyage out to India, and touched land as little as possible (many times they never touched land between Lisbon and Goa). Accounts of the voyages relate how foul the spaces below decks became during the voyage. With the beamiest part of the hull at the weather deck, the maximum deck space for the passengers and crew was as far from the stinking bilges as possible.

A second benefit would have been evident at sea, where having the beam continue widening above the waterline might help to keep the bow from plunging deep in the huge seas that were common as the vessels made their way around the southern tip of Africa.

It takes another 21 dromentes (Figure 54) [clamps]

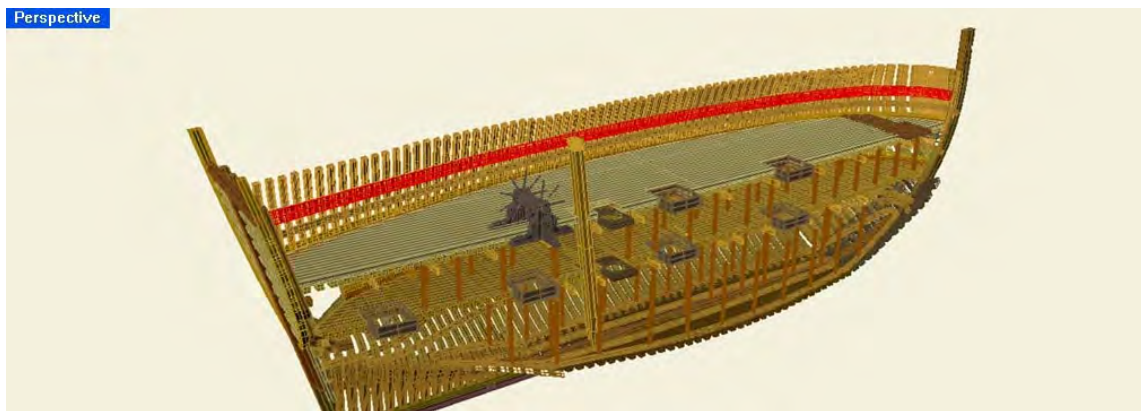


Figure 54. Third Deck Dromente and Contradromente

It is clear from the lower deck height given above (which leaves less space to move or store bulky cargo here than on the lower decks), the placement of the windlass on this deck, and the reduced number of hatches, that this deck was not used as much for cargo as the lower decks. Falcão's chart of cabin arrangements below the weather deck⁹⁵ also supports the notion that this deck served more as passenger and crew space than as a cargo hold.

It takes 52 latas inteiras (Figure 55) [full beams]

It takes 52 meas latas (Figure 55) [half beams]

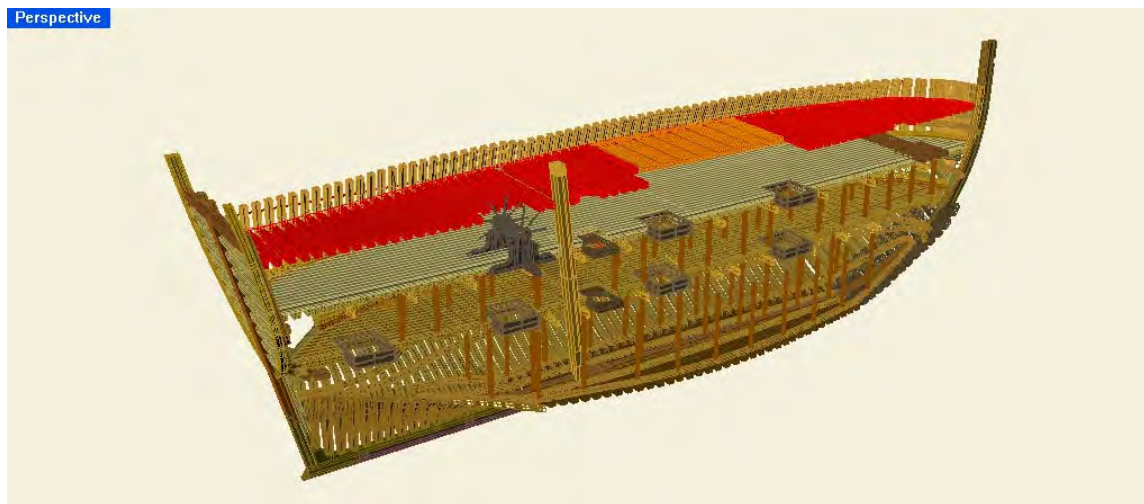


Figure 55. Third Deck Beams (red) and Cuxias (orange)

⁹⁵ Castro 2005a, 20.

The hatch above the windlass is just long enough that the windlass arms can revolve freely – since the cruzetta is nine palmos in diameter, it must protrude through the deck above somehow, and this (ten palmos long by seven palmos wide) hatch provides the appropriate amount of space in the deck above the windlass. The beams framing the main mast and pumps are again offset one palmo aft from the deck below to maintain the rake of the mainmast, pumps, and knighthead.

Interestingly, no mention is made of making an equivalent space between the beams for the foremast, although it is a stout assembly four palmos in diameter, and would have to pass up through the weather deck. Perhaps there should be half-beams there to allow an opening in the deck for the foremast.

It takes 16 cordas (Figure 56) [carlings]

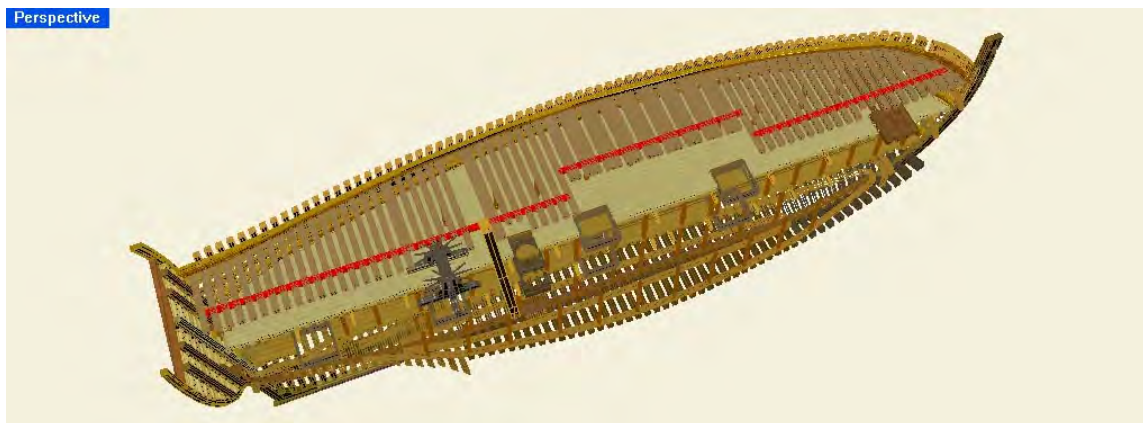


Figure 56. Third Deck Cordas

It is clear the cordas cannot be spaced 7 palmos apart the length of the third deck, since the forward hatch is 14 palmos wide aft tapering to 12 palmos wide at the forward end. There is no mention of the text as to how the cordas are arranged in the vicinity of the hatch, so I chose to model them separately there, in position to brace the half-timbers.

It takes 24 curuas de reues (Figure 57) [standing knees]

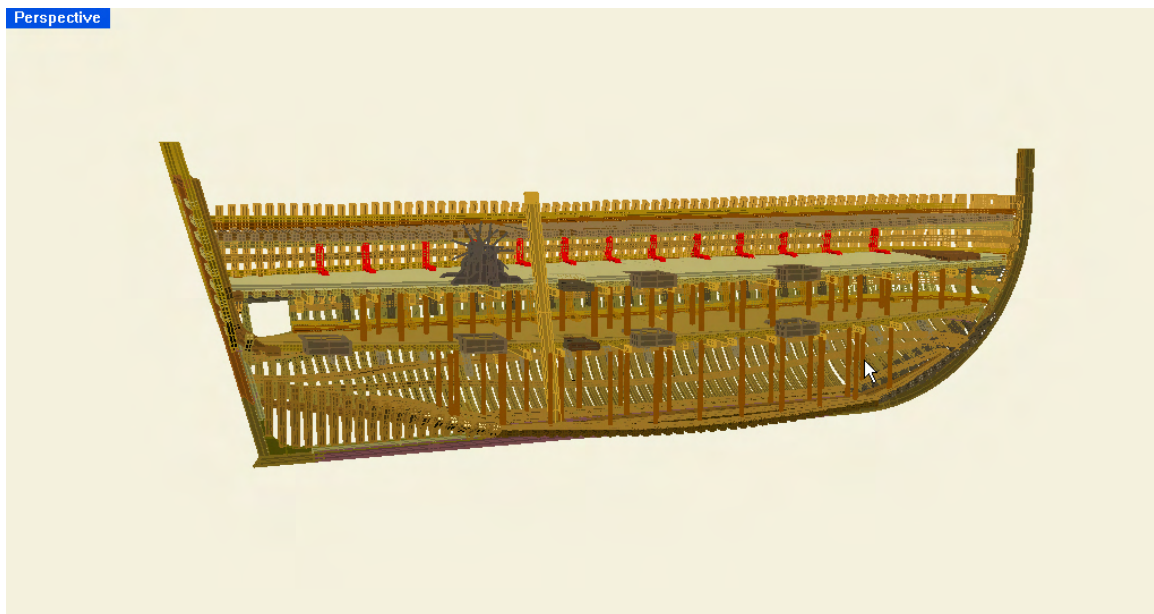


Figure 57. Second Deck Curvas de Reves

It takes 20 dozen timbers of Pinho brauo (Figure 58) [Wild Pine] for the deck planking

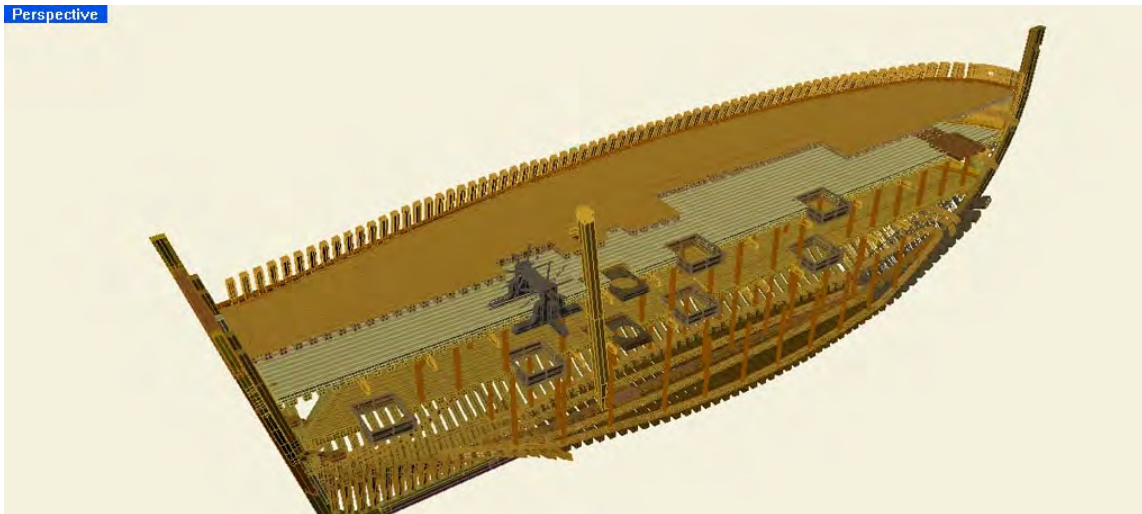


Figure 58. Third Deck Planking

It takes 20 trinquanis (Figure 59) [waterways]

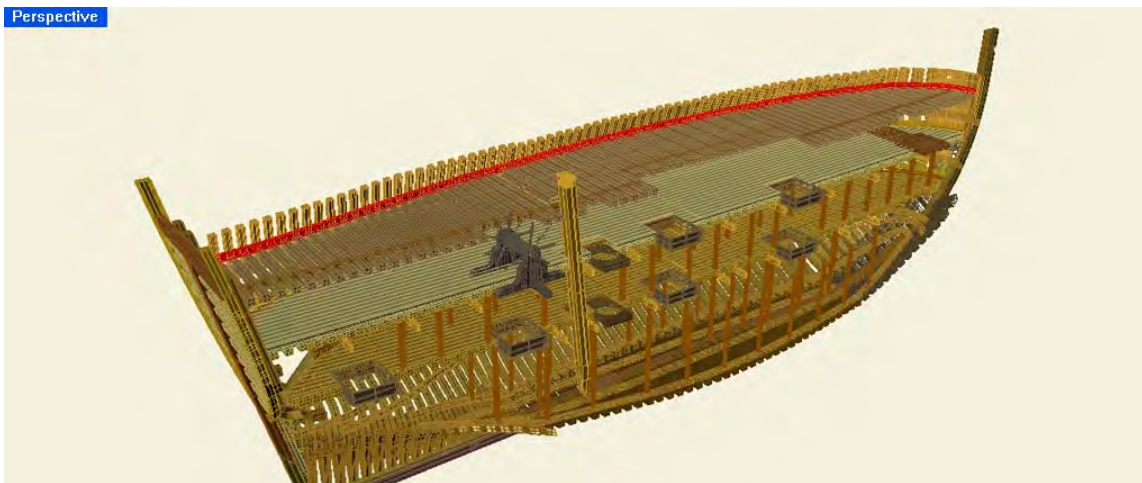


Figure 59. Third Deck Trinquanis

This is most likely a mistake in the sequence, since the waterways should have been affixed before the deck planking.

It takes 4 paixóes (Figure 60) [mast partners/reinforcements]



Figure 60. Third Deck Paixoes

It takes 12 pairs of Curvas do Conves (Figure 61) (hanging knees), which are 24 timbers

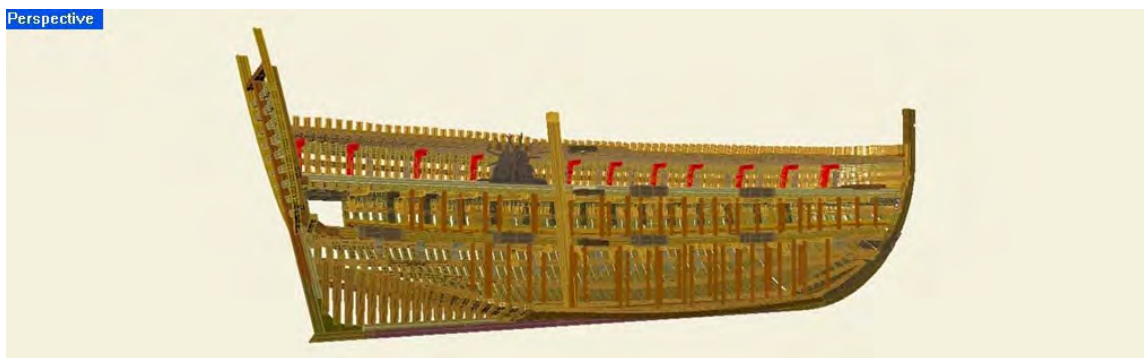


Figure 57. Third Deck Curvas do Conves

It takes 20 entremichas (Figure 62) [deck supports]

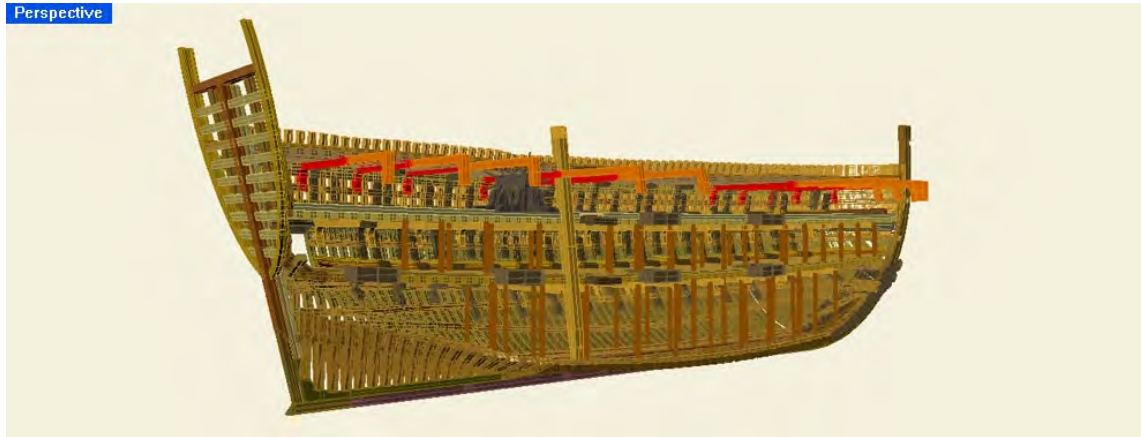


Figure 62. Third Deck Entremichas

It takes two Conchas do Cabestrante (Figure 63) [partners for the capstan]

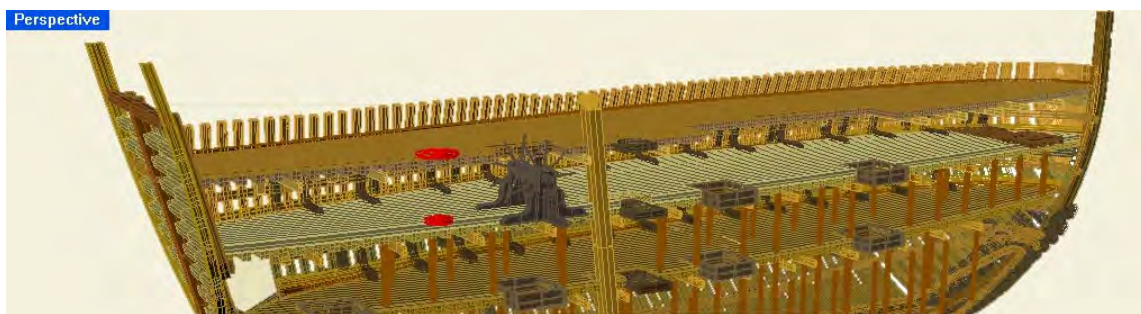


Figure 63. Conchas do Cabestrante

These are the heavy sockets that support the spindle of the capstan. The capstan rests upon the upper concha (on the weather deck) while the spindle passes down through it, between the deck beams, and rests in a socket in the lower concha (on the second deck).

The text specifies two capstans for the vessel (one larger and one smaller), but never describes the placement of the second, it is possible that this entry describes conchas for two capstans instead (the second might have been placed near the bitts in the forecastle).

It takes 2 Abitas [Bitts] to the stern, which are three timbers



Figure 64. Abitas

Since there are no knees listed in this text to support the Abitas (Figure 64), (and given three timbers, the legs of the bitts could be long enough to extend between two decks), I envisioned these bitts getting their support from being braced against two sets of deck timbers. Each leg is one timber, and the crosspiece is the third.

It takes 1 buçarda (Figure 65) [breasthook] for the dragas [stringers]

It takes 12 Escoas (Figure 65) [stringers] of stone pine

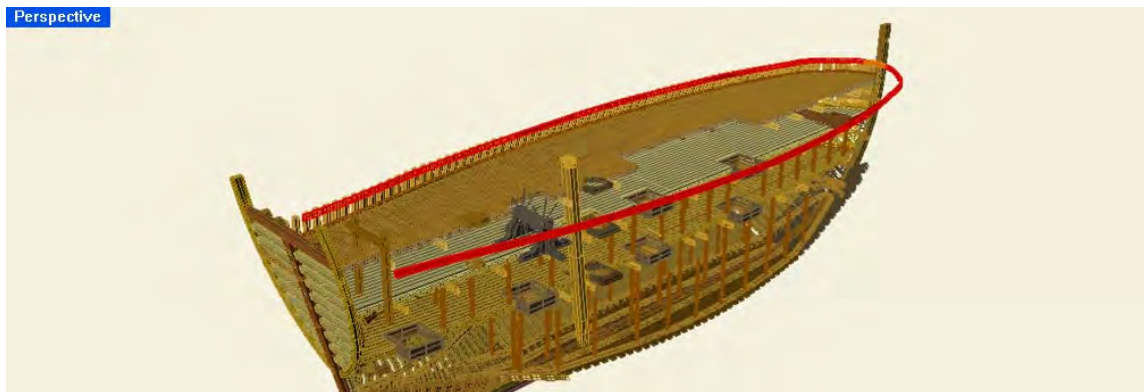


Figure 65. Third Deck Buçarda (orange) and Escoas (red)

It takes 12 coçeiras (Figure 66) of Stone Pine

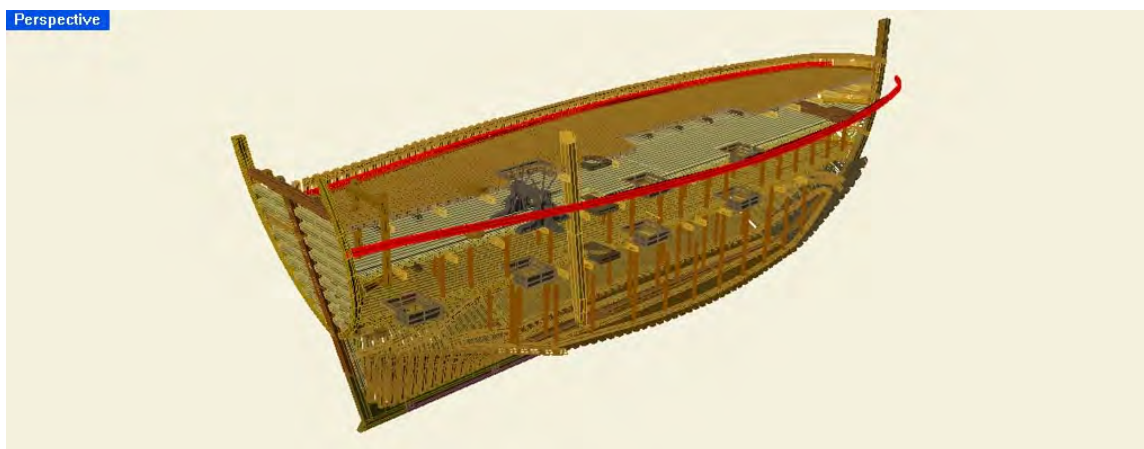


Figure 66. Third Deck Coçeiras

I chose to end the coçeiras short of the bow so they would not interfere with the placement of the Contraescouvems (the inner reinforcements for the hawseholes) against the inner face of the forward frames.

Underneath it takes 26 Peis de Carneiro (Figure 67) [stanchions]

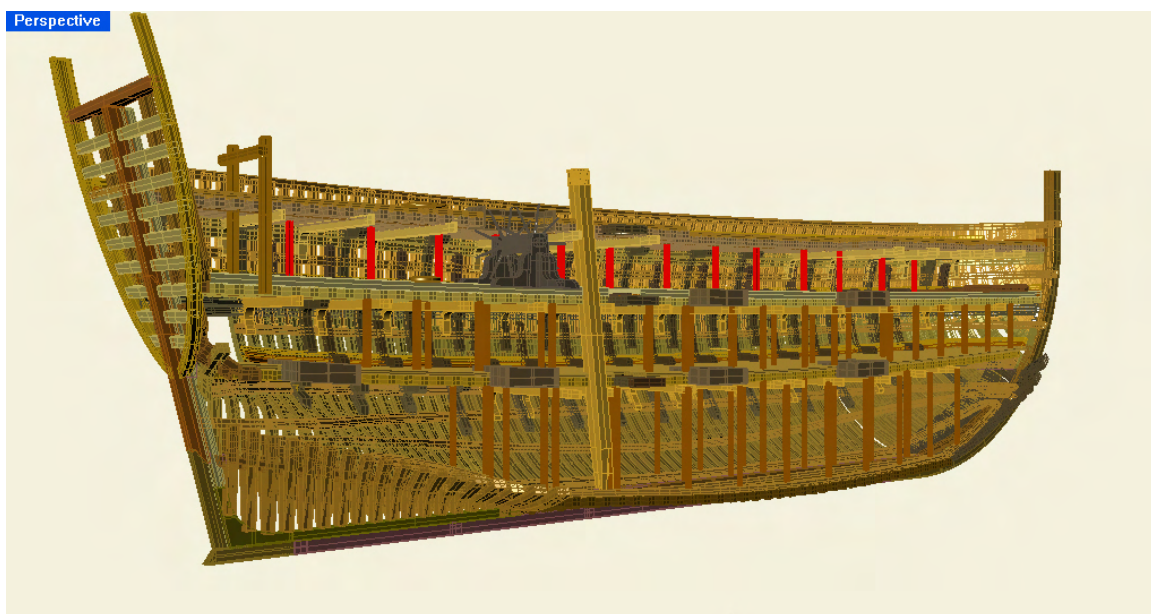


Figure 67. Third Deck Peis de Carneiro

These are arranged in two rows beneath the third deck cordas, spread five frames apart (except under the halfbeams on either side of the hatch, where they are spread six frames apart to fit the arrangement of the half beams).

It takes on the quarters (Figure 68), six madres [the frame of the main hatch], and 21 Barrotes [smaller fashion timbers] which are 15 timbers of white pine

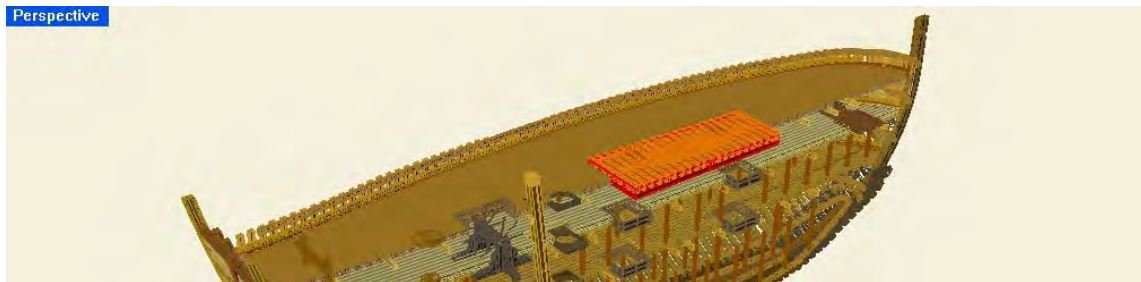


Figure 68. Quarteis (quarters for the ships boat)

The Barrotes (orange) are set into notches in the Madres (red) and serve as the cradle for the ships boat.

It takes two timbers of stone pine for the barçolas (Figure 69) [coamings] of the hatch

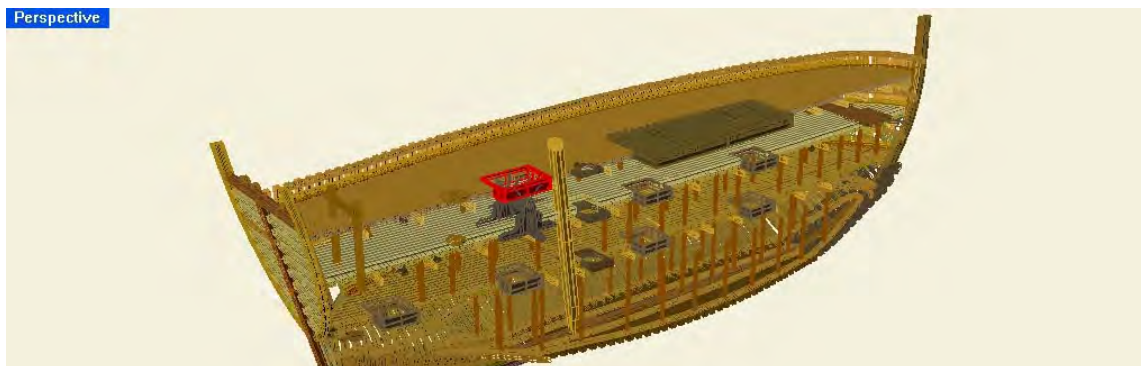


Figure 69. Barçolas

These must be the timbers to frame the hatch above the capstan, since the frame of the main hatch has just been discussed.

And to finish this deck, they will build before the middle hatch two portinholas (Figure 70) [‘little doors’, this term is used to denote gunports⁹⁶], one on each side, and two Rumos before these two portinholas they will make another two that will stay abaft the amura [the round of the bulwarks at the bow].

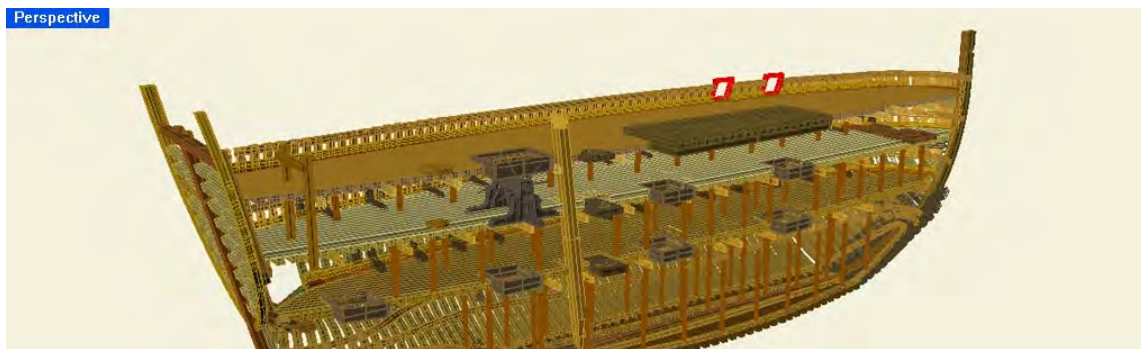


Figure 70. Portinholas

In my model, the forward edge of the first portinhola is aligned with the front of the quarters, and the portinholas are spaced two rumos apart. I discovered later that this position causes problems with the Arpa, the after bulkhead of the forecastle, which should meet the bulwark approximately 2 palmos forward of the quarters.

Moving the portinholas forward would alleviate the conflict between the portinhola and the Arpa, but would interfere with the placement of the forward channels (which fit

⁹⁶ Castro, personal communication, 15 August 2006.

along the outside of the hull, from the Arpa to the foremast, at the level of the weatherdeck).

Dr. Castro suggested that this was one reason the portinholas were sometimes left until later in the construction process, when it was clear what portions of the ship would be affected by their positioning.⁹⁷

The tolda [quarterdeck] will start at the mainmast and run abaft, and from the beam in which the mast leans to the bow will be ten palmos clear, that will make twenty palmos to the gingamoches of the bomba [the levers of the pump], and to the stern everything will be beamed, and above the capstan they will make a small hatch so that they can see, and the tilha [a cuddy] that stands before the mast will stand right above the vertical of the ones underneath, and in the center are the quarteis [the quarters] with its beam running inbetween, and in the deck it will take 30 aposturage (Figure 71) [the fifth futtocks], 15 on each side; and from the mast to the stern it will take 35 uirotas [filler timbers] on each side which will only be put after all the beams of the sterncastle are laid, then the chapiteo [the poop deck] will be laid, which will be 7 and a half palmos high, and it will not be longer than the distance between the small hatch of the Capstan and the stern. And the bulwarks will be 7 palmos.

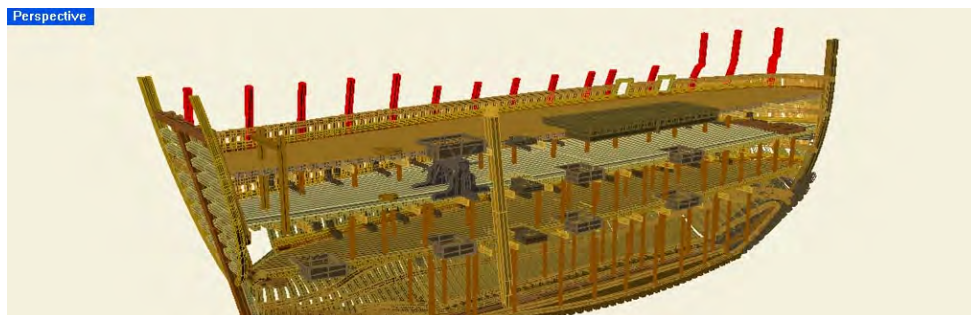


Figure 71. Fourth Aposturage

⁹⁷ Castro, personal communication, 2 October 2006.

Portuguese treatises divide the structure of a ship into two categories; the *Obras Vivos* (live works) and the *Obras Mortas* (dead works).⁹⁸ The live works includes the whole body of the ship up to the weather deck. As Oliveira describes it, the live works are the ship's body, on which its life depends, "...which will not be safe if that be broken, weak, or badly cared for."⁹⁹ The dead works are the castles built upon the weather deck, because, "...should they die, the ship will not die as well, as a consequence. These are usually built in ships for convenience and looks."¹⁰⁰

The decreased number of apostorage at this point indicates the shift from live works to dead. While virotes will be added to reinforce the bow and stern castles there are only a handful of structural timbers erected to support the clamps and beams of the castles, compared to the greater number of futtocks on the lower decks.

This shift in framing above the weather deck is evident in construction photos of the model of the carrack *Madre de Deus* in the *Museu de Marinha* in Lisbon, with a scattering of frames to support the castles and bulwarks, instead of the 'one-frame, one space' pattern up to that deck.¹⁰¹

⁹⁸ Fernandez 1616, 257.

⁹⁹ Oliveira 1580, 200

¹⁰⁰ Oliveira 1580, 201.

¹⁰¹ Simoões and Leitão 2004, 47.

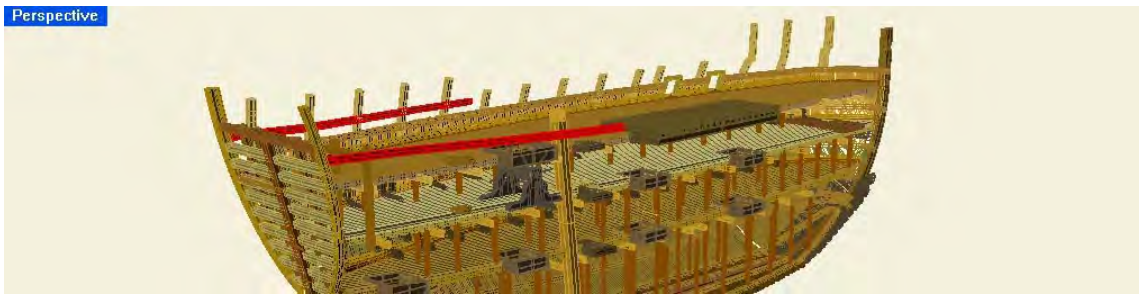


Figure 72. Tolda Dromentes

This is another sequence error; the text fails to indicate a dromente (Figure 72) (clamp) here but there must be one to hold up the tolda (quarterdeck) beams (which are the next timbers listed in the sequence). These clamps may extend beyond the stern panel to support the Varanda, but lacking written or archaeological evidence to support this, I ended them at the stern.

It takes 40 latas inteiras [full beams] in the tolda [sterncastle]

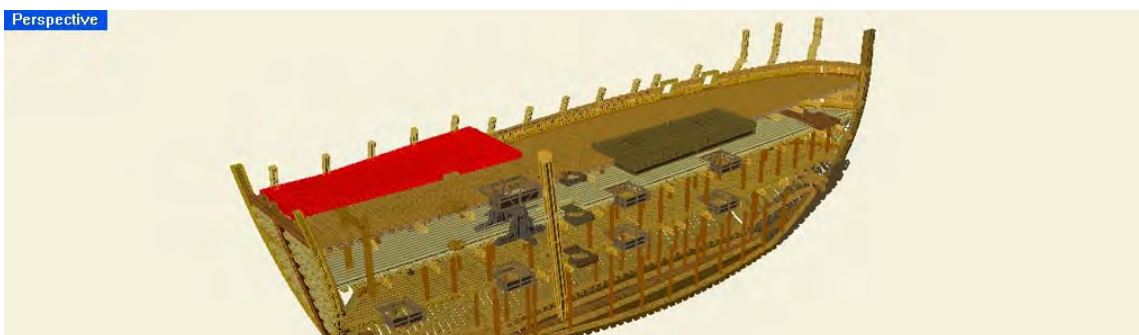


Figure 73. Tolda Beams

If we are to believe that there is no change in scantlings, these 40 beams fit into the quarterdeck's 48 palmos only if they are crowded together (in the model these beams are spaced only one dedo apart, instead of the more typical one-palmo spacing). It is very likely that these beams would have been smaller in section than those of the decks of the lower hull.

If they were spread out as beams for the quarterdeck and the *Varanda* (which springs 12 palmos beyond the stern, however, they could be spaced 3 dedos apart, which seems more reasonable.

Nevertheless, the *Varanda* is not described until much closer to the end of the text, so I chose to model the beams extending aft only as far as the stern panel.

It takes on the deck 8 dromentes (Figure 74) [clamps]

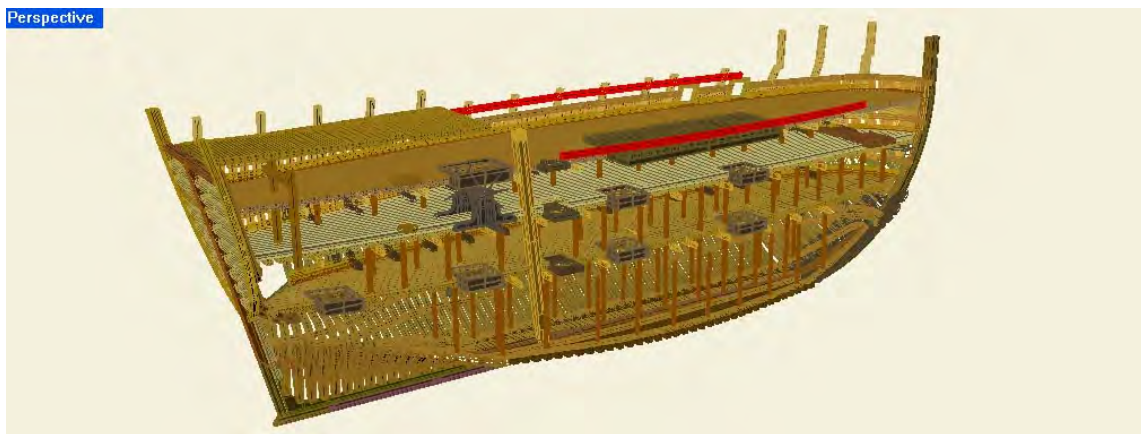


Figure 74. Cuxia Dromentes

Given that it took only 12 timbers for the coceiras that run from stem to stern on this deck, I believe that the 8 dromentes prescribed here might well include clamps for both the quarterdeck (in the tolda, as mentioned previously) and the cuxias (over the waist), although I have modeled them separately, as each set of beams is discussed.

In the cuxias (Figure 75) [gangways] and on the place of the gingamochoes [the pump-levers] it takes 54 half-beams

It takes on the deck 14 cordas (Figure 75) [carlings]

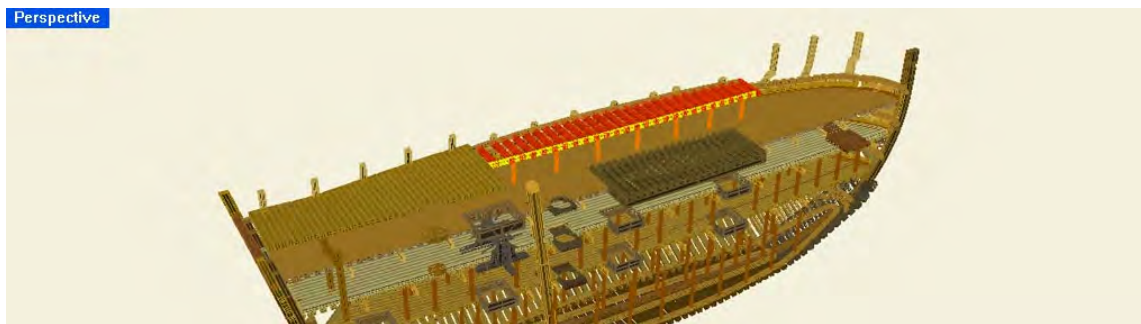


Figure75. Cuxia Beams (red), Carlings (yellow), and Stanchions (orange)

Other than the carlings, the text does not specify how these beams in the waist are to be held up. I chose to model them supported by stanchions and carlings in the same manner as the half beams on the lower decks.

It takes from the castle to the Serpe [the curving timber at the corner of the stern, where the stern meets the side, which takes a serpent-like shape] 40 beams

This seems to be a mistake, as there are already 40 beams in the stern castle, and little room for more (there is certainly not enough room for 40 more beams).

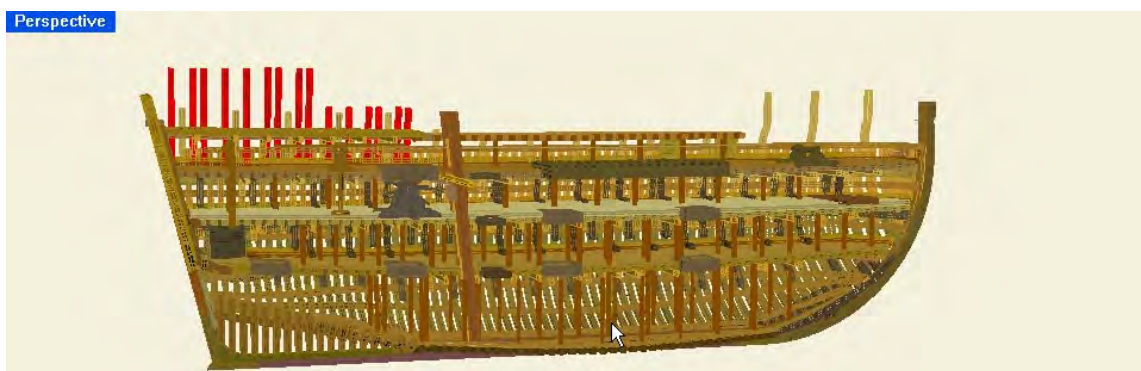


Figure 76. Sterncastle Viotes

Once the beams had been laid for the quarterdeck, the previously described viotes (Figure 76) (filler timbers) were attached. These additional timbers filled in the sides of the quarterdeck, and added support for the sides of the poop deck.

It takes in the decking of the tolda [quarterdeck] and the chapiteu [poop deck] 11 pairs of Curvas (Figure 77) (knees), which are 22 timbers



Figure 77. Tolda and Chapiteu Curvas

Although the text does not specify what sort of knees these Curvas would be, in each previous case the first knees to be installed were curvas do conves, so I modeled these as hanging knees.

It takes 15 entremichas



Figure 78. Tolda Entremichas

Seven pairs of entremichas would fit neatly into the space beneath the quarterdeck. In most other cases, the number of entremichas has been evenly divisible by two and so I modeled them as pairs in Figure 78; in this case I chose to follow the same procedure and modeled seven pairs of entremichas.

It is difficult to see how 15 pairs would have fit under the quarterdeck without conflicting with the placement of the Curvas already emplaced.

It takes 12 curvas de Reues (Figure 79) [standing knees] in the sterncastle

At the poop deck it take 10 curvas de Reves (Figure 79)

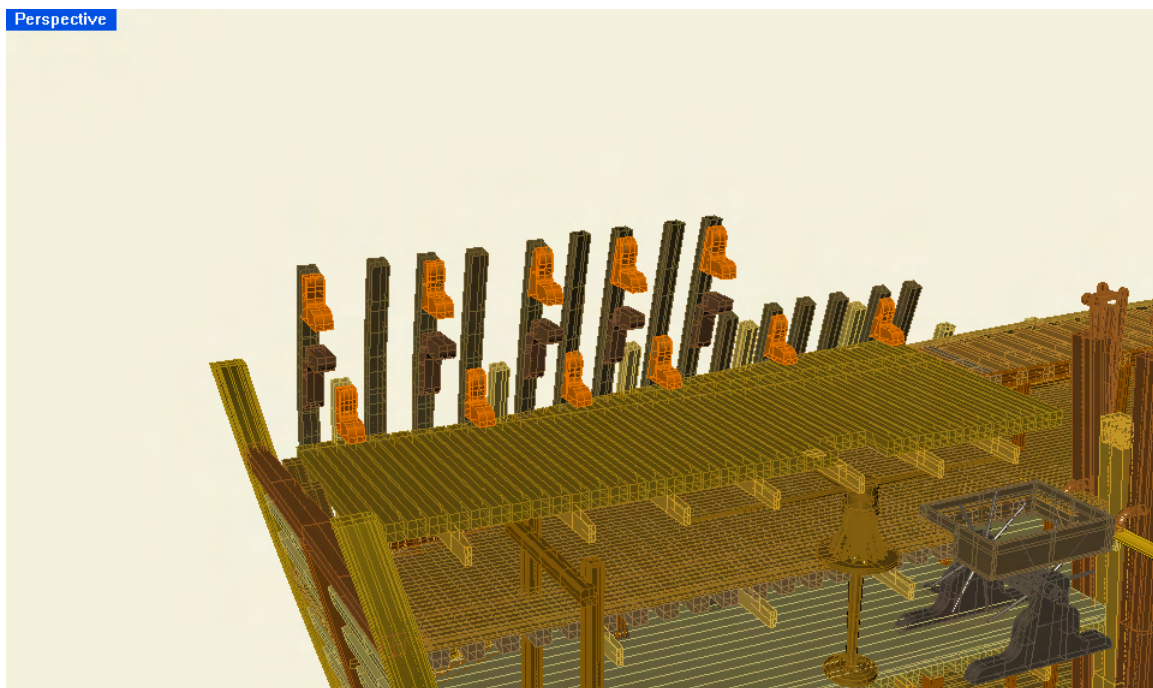


Figure 79. Tolda and Chapiteu Curvas de Reves

It seems odd that these standing knees are added now, particularly on the poop deck, where the knees have nothing below them (on all the lower decks they are placed after the deck is laid, and would be attached to the side and to the deck).

Likewise there is no clamp yet; on the lower decks one of these knees (most likely the curva do revés) would have been notched to fit over the clamp (and no knees would have been placed before the clamp).

Certainly the curvas de revés could be placed on the quarterdeck now, resting on the deck beams, but on the previous decks they've always been placed after the deck planks.

It takes 4 curuas (Figure 80) [knees] for the Abita [Bitt]

2 timbers for the Abita (Figure 80)



Figure 80. Abita at the Bow

Unlike the Abita at the stern (seen in Figure 64), the text specified that four knees (colored red in Figure 80) were present to support this bitt and provided only two timbers; the resulting bitt assembly differs markedly from Figure 64. Here one timber serves as the crosspiece, and the second timber provides the posts that support it (these timbers are colored orange in Figure 80). Standing knees were placed fore and aft to hold the bitts in position.

Although the post timbers as modeled could fit between the beams of the weather deck for added support, I do not believe they would be long enough to extend between two decks (in the way that they did in Figure 64) if they were two halves of a single timber.

It takes 1 Papoya (Figure 81) [a bitt that holds the foot of the mizzen sail]

It takes one curua do falcão (Figure 81) [a deck knee to support the Papoya]

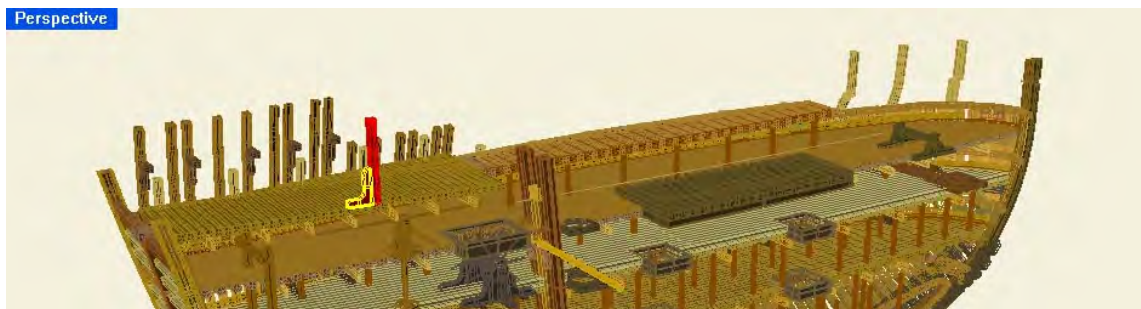


Figure 81. Papoya (red) and Curua do Falcão (yellow)

As modeled, the Papoya is braced between the poop deck and quarterdeck beams as well as by the Curva do Falcão. There is no evidence for where the knee would be placed, nor indeed (other than by its place in the sequence) for what the Curva do Falcão was or how it was used. The treatises and dictionaries I consulted did not discuss this knee at all.

It takes 20 beams (Figure 82) on the Chapiteu [poop deck]

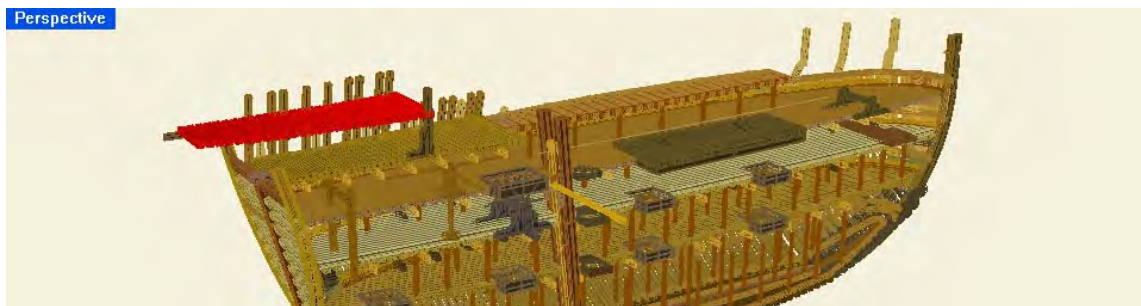


Figure 82. Chapiteu Beams

Again the deck beams are discussed before any clamp that might hold them up. In this case the clamp is not mentioned until another two full pages of entries have been listed (it is described as one of the single wales, during the discussion of the wales and planks that make up the outer covering of the vessel).

The knees that support the deck beams were also listed out of sequence; on previous decks the knees were placed after the clamp (so they could be notched to fit

around the clamp) and the beams. According to this text, the poop knees were placed well before the clamp and beams; I believe this was a mistake by the writer.

The Castle will be laid on the level of the main deck, and will be 50 palmos long which is the same as this *não* has in its breadth, and from the stem you have 16 palmos springing forward of the stempost, and to the inside [abaft the stempost] it will have 34 palmos which makes 50 palmos altogether, and this castle will have, in breadth on the first *lata* [beam] of the Arpa [the harp-shaped aft bulkhead of the forecastle] 40 palmos, and the *gurita* [quarter gallery] will be laid at a height of 7 palmos, and its breadth at the first *lata* [beam] will be 30 palmos, and over the stem post will have these *guritas*, in breadth 16 palmos.

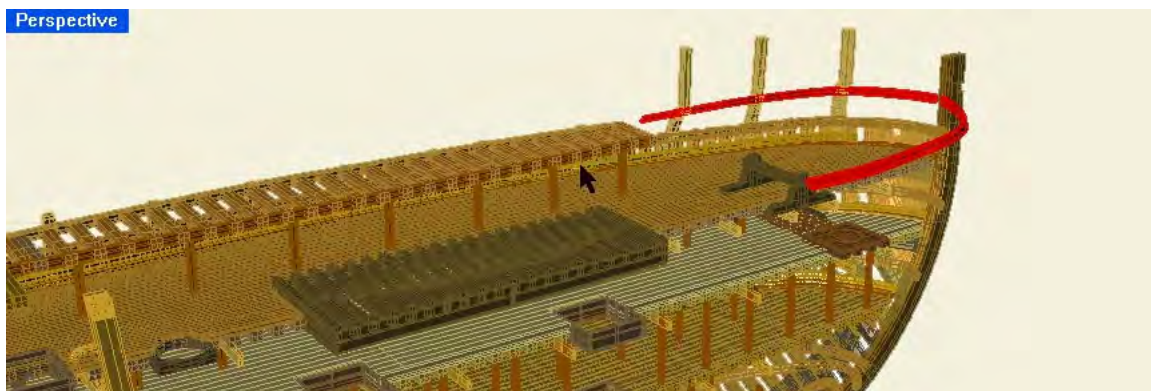


Figure 83. Forecastle Dromente

As in the case of the poop deck, this clamp (Figure 83) is not actually mentioned until another two full pages of entries have been listed (it is described as one of the single wales, during the discussion of the forecastle wales). I modeled it at this point so that I could place the timbers that would rest on the clamp in their proper positions as they were discussed.

This Castle takes 15 virotes (Figure 84) [filler timbers] on the side which are 30 timbers and the mareagẽ [bulwarks] is 7 palmos

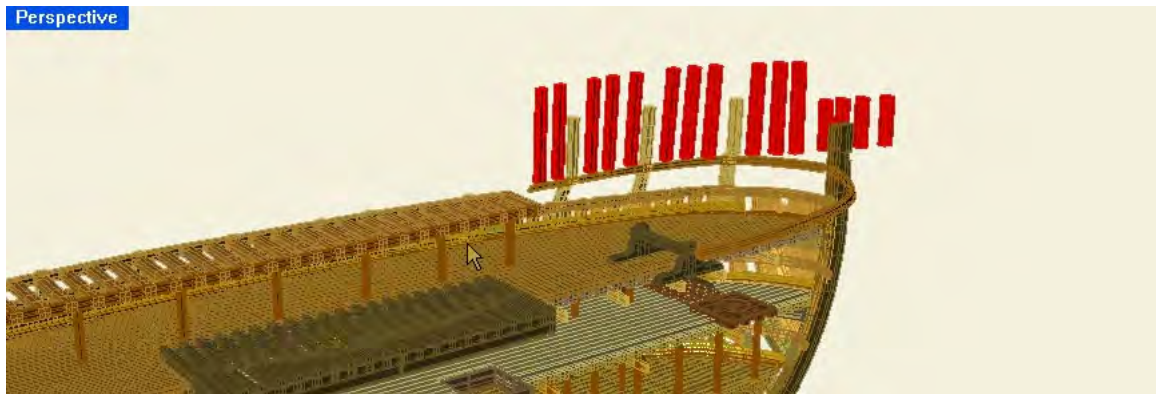


Figure 84. Forecastle Virotes

This must be an error in the construction sequence, since there is no forecastle structure to attach these virotes to at this point. No clamp or other horizontal timbers have been placed, and close to half of these timbers will be placed either ahead of the stempost or outside the hull, where there are no timbers to attach the virotes to at all.

In the image above, the clamp has been added (out of sequence) to indicate the shape of the hull at the level of the forecastle deck where these virotes will be added. While the aftermost eight or nine virote timbers might be extended further than I have modeled them, (making them long enough to attach them at their lower ends to the futtocks below them) the forward six or seven are clearly unsupported by anything (they would be attached to the sides of the forecastle where it juts out ahead of the hull).

At the very least, following the example of the quarterdeck and poop deck, these virotes should be added once the forecastle deck beams (and their clamp) have been fitted.

It takes one falcão [beakhead timber]

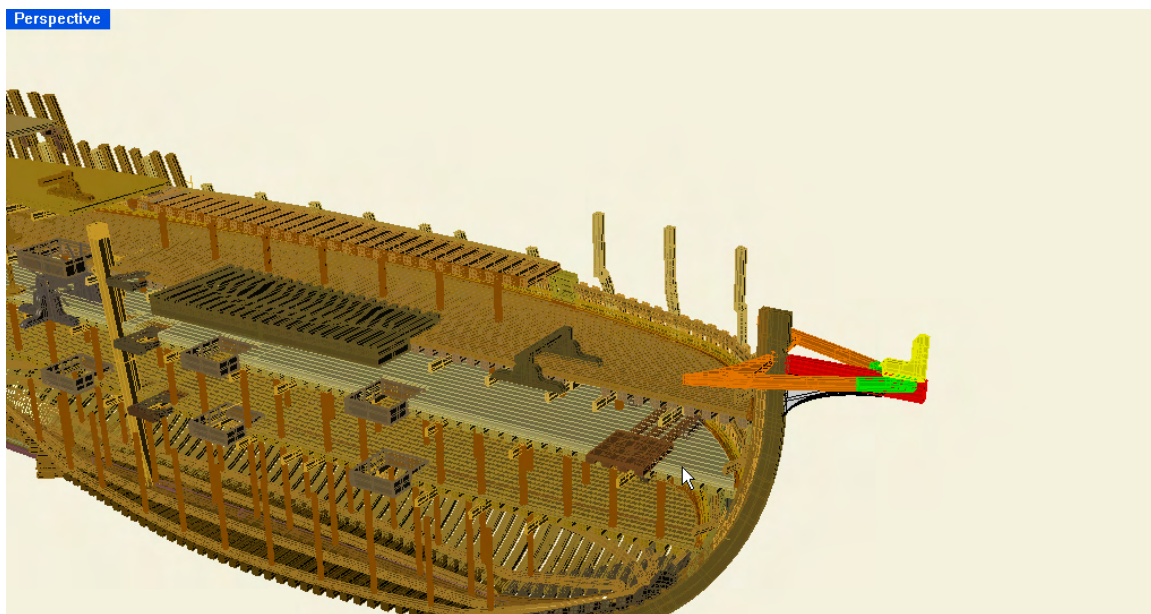


Figure 85. Falcao and Contrafalcao (red)

The falção and contrafalção (marked in red in figure 85) are sturdy beams projecting forward from the stempost that support the rest of the bow structure. The contra falcao rests upon the falcao, with a notch between them for the guçarda, which is difficult to see in this image. Figure 86 shows the arrangement of these and the other bow timbers more clearly.

It takes 5 timbers; the mão [a triangular fairing piece between the side and the stem, to which the wale is fastened, there are two of these], the papa mosqua, the contra falcão [beakhead reinforcement], and the guçarda [probably the buçarda, or breathook]

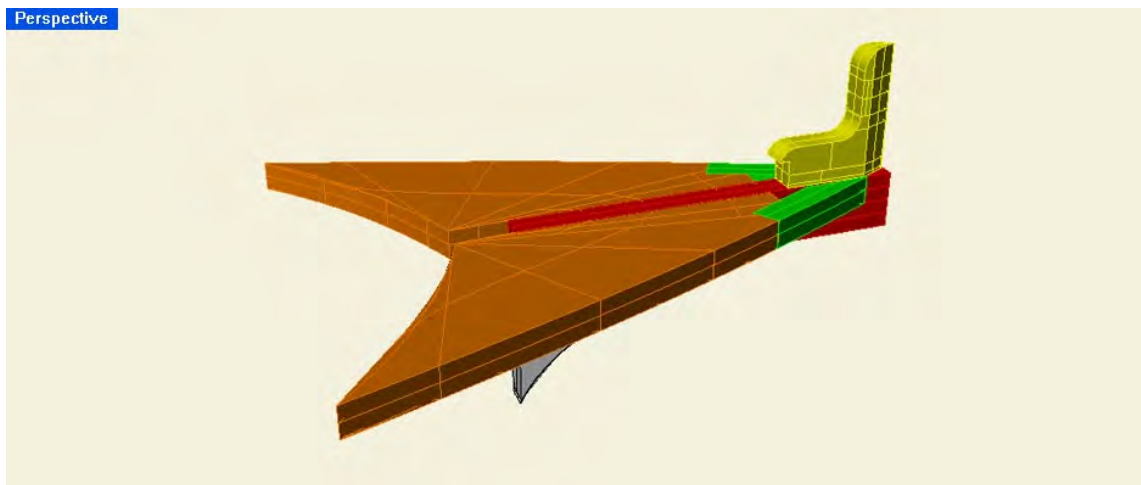


Figure 86. Bow Structure Details

Figure 86 shows both mão timbers (orange), the falçao (red) and contra falçao (red, atop the falçao), the papa mosqua (yellow), and the guçarda (green, inset into the contrafalçao). Supporting the structure from below is the Curva do Beque (Beak Knee, grey) which will be added later in the sequence.

All of these timbers together to form the bow structure forward of the vessel's hull. They are set at the same height (seven palmos above the weather deck) as the forecastle clamp. The deck beams in the gurita will be supported by the clamp inside and the bow structure outside of the hull.

It takes on the gurita, 20 beams

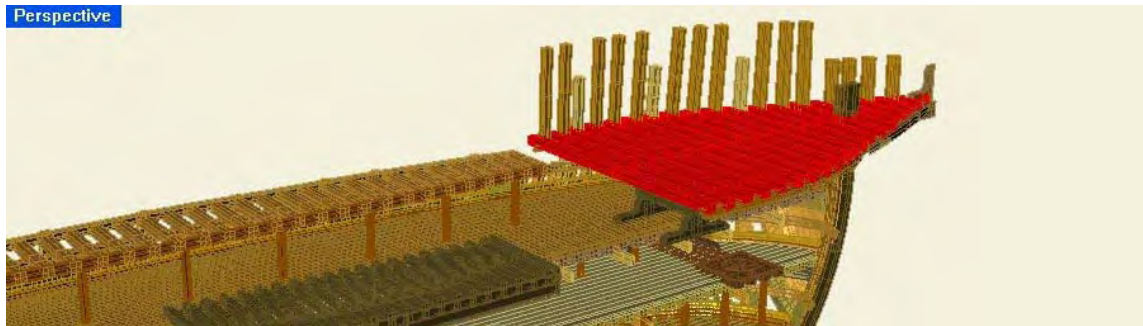


Figure 87. Gurita Beams

Here are the deck beams for the forecastle, although there has been no clamp listed in the sequence yet (nor is there any other support inside the hull for these beams).

It takes 4 curuas de Reues (Figure 88) [standing knees]



Figure 88. Forecastle Curuas de Reves

These are placed over the forward pair of hanging knees on each side, they tie the weather deck to the frames and also support two of the virotes.

It takes 2 Escouvems (Figure 89) [hawseholes], and 2 contraescouvems (Figure 90) [the reinforcements for the hawseholes, inside the hull]

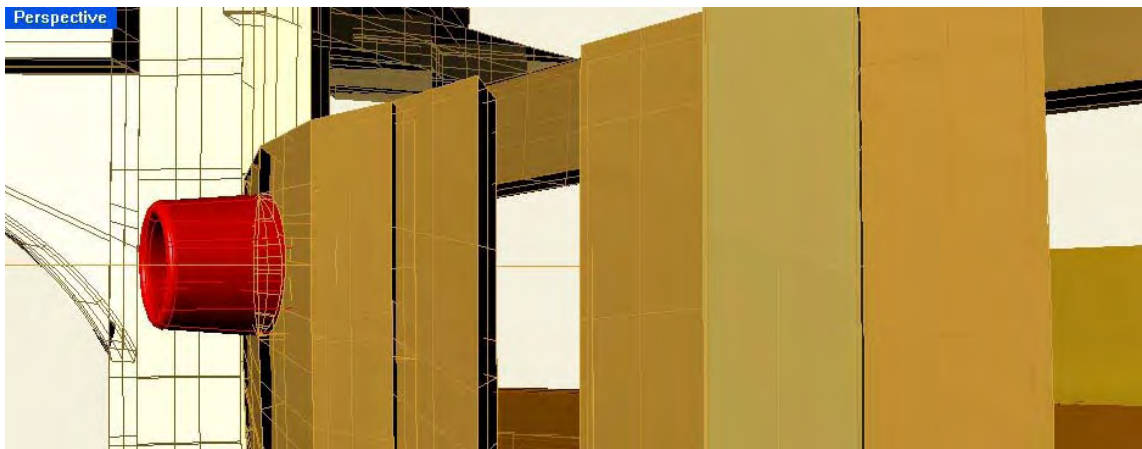


Figure 89. Escouvem

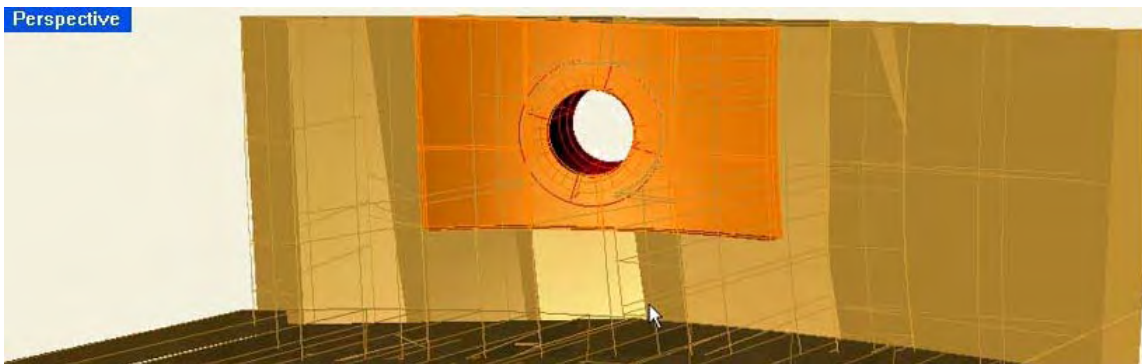


Figure 90. Contraescouvem

The escouvems must be long enough to protrude through the frames and outer planks, they are held in place and reinforced by the contraescouvems inside the frames.

It takes one curve for the Beque (Figure 91) [the Beak]

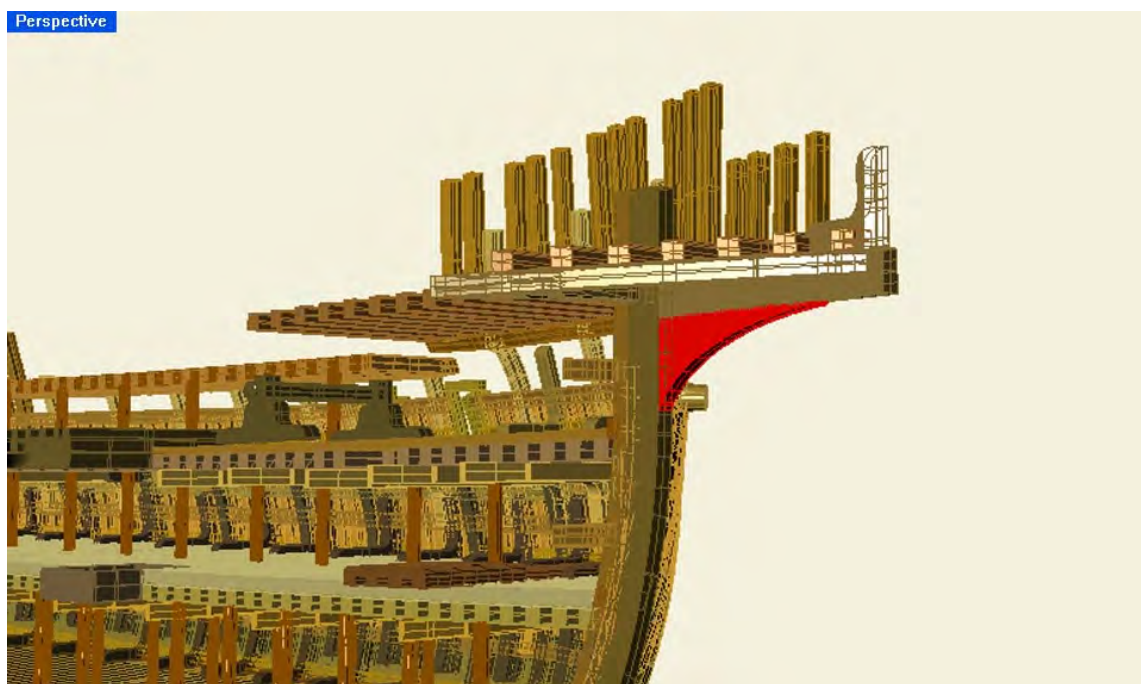


Figure 91. Curva do Beque

This is the knee that supports the beak, in simpler vessels it is the knee that supports the bowsprit, and it can also be the whole beak arrangement.

It takes two curves (Figure 92) for the cordas [carlings]

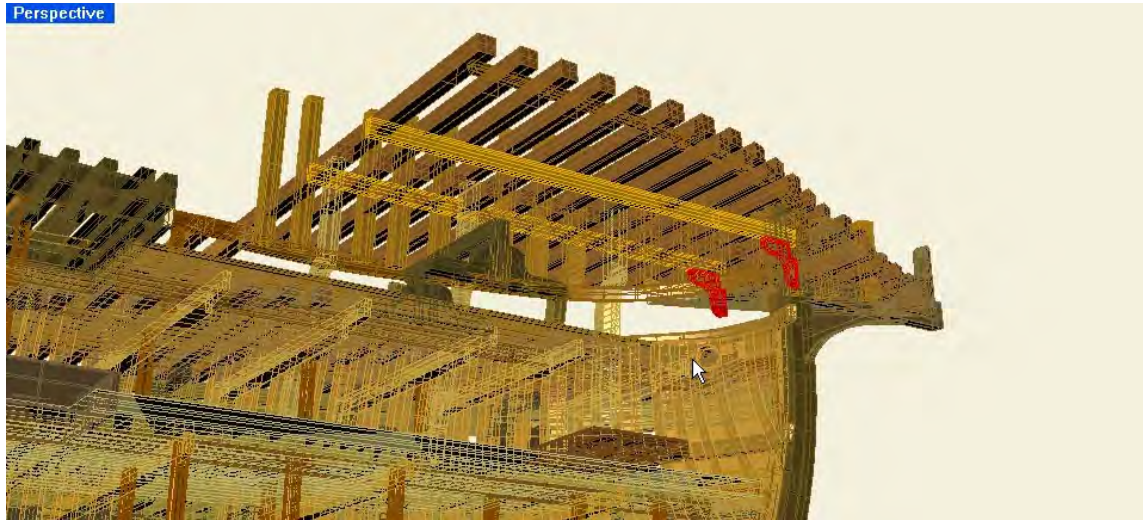


Figure 92. Forecastle Cordas and Curvas

Although the text never specifies cordas for this deck, it does call for knees for the cordas, so I modeled both.

One might think that cordas are not needed for this relatively small deck area, but it is possible they are here to enclose the mast partners where the foremast passes through the deck, and to help center the bowsprit, where it passes through the deck. Unfortunately the text makes no mention of how the foremast, mizzen mast, and bowsprit are accommodated. This stands in sharp contrast to the way the text specified where the main mast would fit through each deck and how many timbers would be used as tamborettes and paixoes to enclose and brace the main mast.

It takes two curves for the bandas [sides, the horizontal supports of the beak]



Figure 93. Curvas pellas Bandas

In Figure 93 I chose to model these with space for the wales and planks to fit ‘behind’ them, because otherwise there is not much hull structure here to brace a knee against. I had thought these curves would help to tie the gunwale to the bow structure (in the same way the breasthooks work inside the hull) but the ‘lay’ of the wales does not line up well with horizontal timbers such as these knees. Instead the wales and planks turn up and inward as they round the hull toward the stempost, dying underneath the forecastle. Having these knees in place provides an extra measure of support to hold the ends of the wales and planks up against the forecastle.

As in the case of the poop deck knees, these beak-supporting knees seem to be out of sequence, I would have thought they should be placed after the wales and planks were added.

It takes four curvas na Arpa (Figure 94) [knees for the aft bulkhead of the forecastle]

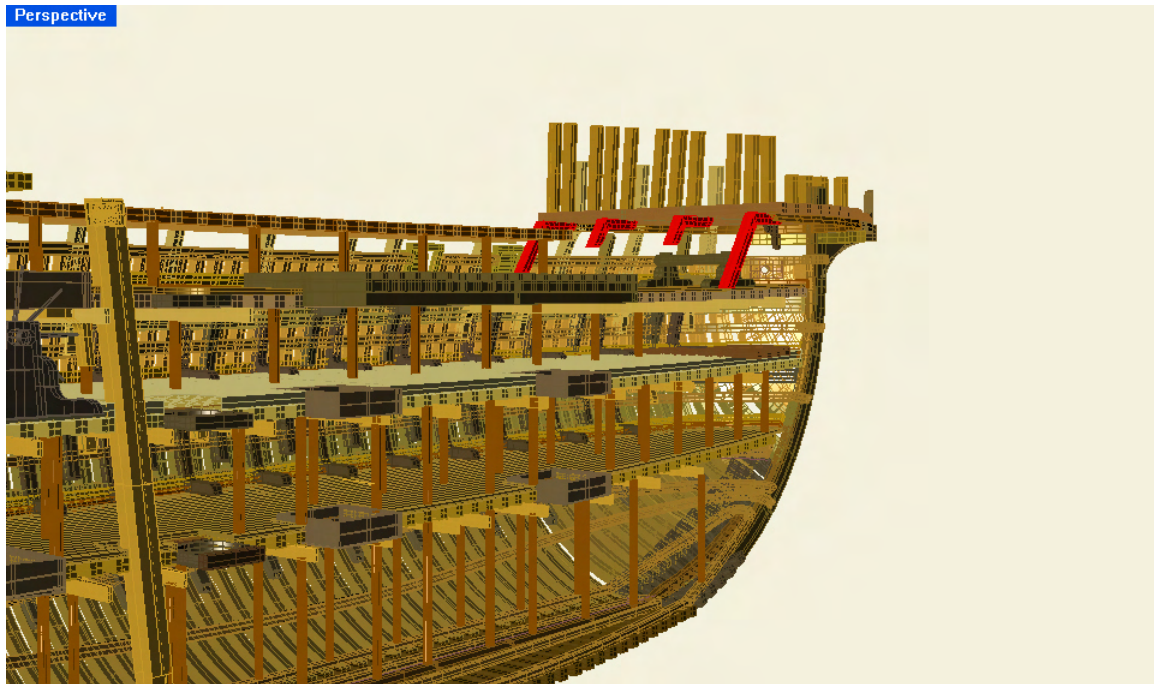


Figure 94. Curvas na Arpa

The aft bulkhead of the forecastle is called the Arpa because the curved opening at the weatherdeck gives it the look of a harp or lyre. The cross-planks that make up the Arpa are fastened to these four knees. These knees also hold up the Perpao, a sturdy crossbeam that ties the sides of the forecastle together and supports the nets that extend across the weather deck from the forecastle to the quarterdeck.

It takes two curvas na Alçaçua (Figure 95) [knees of the castle] that will work as peis do Carneiro [stanchions]

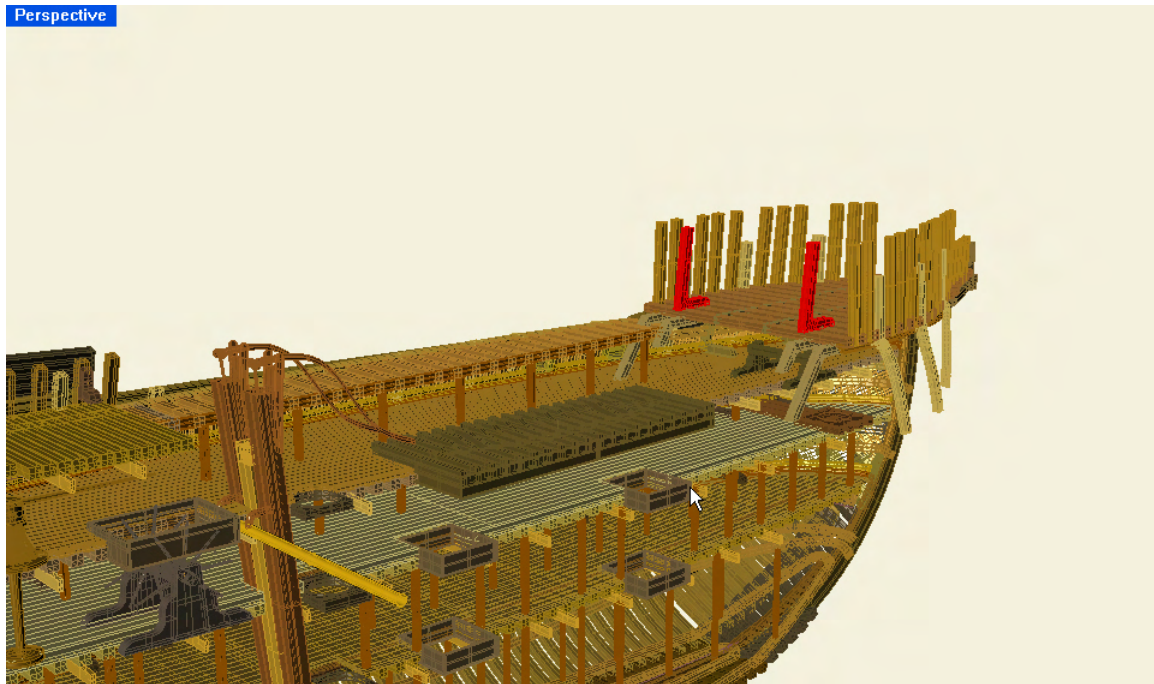


Figure 95. Curvas na Alçaçua

I modeled these as additional supports for the forecastle, because that is the section of the vessel being discussed at this point in the sequence. Further reading suggests the term Alçaçua may refer to the stern castle, but lacking more information on how these knees might fit there (and lacking any supports for this portion of the Arpa) I chose to keep this placement.

It takes one Carlinga da mezena (Figure 96) [mizzen mast step] with two curvas (Figure 96) [knees that support the mast step]

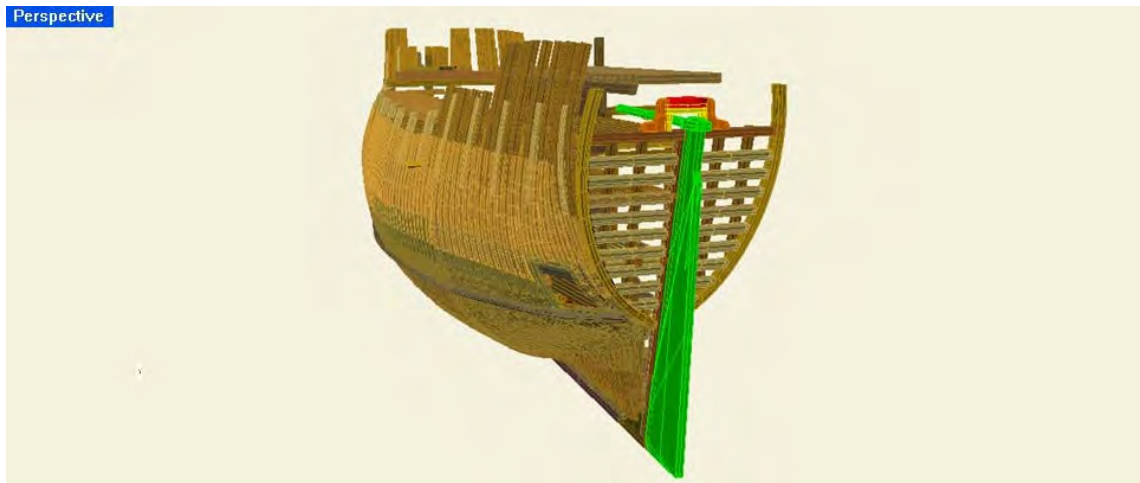


Figure 96. Carlinga da Mezena (red) and Curvas (orange)

While neither Oliveira or Lavanha’s treatises discuss the placement of the mizzen mast, Fernandez states that “The step of the mizzen shall be set upon the tiller port.”¹⁰² There’s no mention in the text of a tiller port, but the first place the tiller could be placed is here where it can protrude forward above the gio. There is also no mention in this document of a rudder. I chose to model both here; the tiller sits at the top of the rudder (green) and protrudes forward onto the quarterdeck through the tiller box (yellow). The mizzen step (red) is notched to fit securely atop the tiller box, and is braced on each side by the mizzen step knees (orange)

¹⁰² Fernandez 1616, 119.

While it seems odd to see the tiller set so high (it is on the quarterdeck) the builders would have had to cut the stern post if they wanted the tiller any lower.

It takes two *curvas na Dala* (Figure 97) [knees to support the pump-dale, the scupper or drain for the pump]

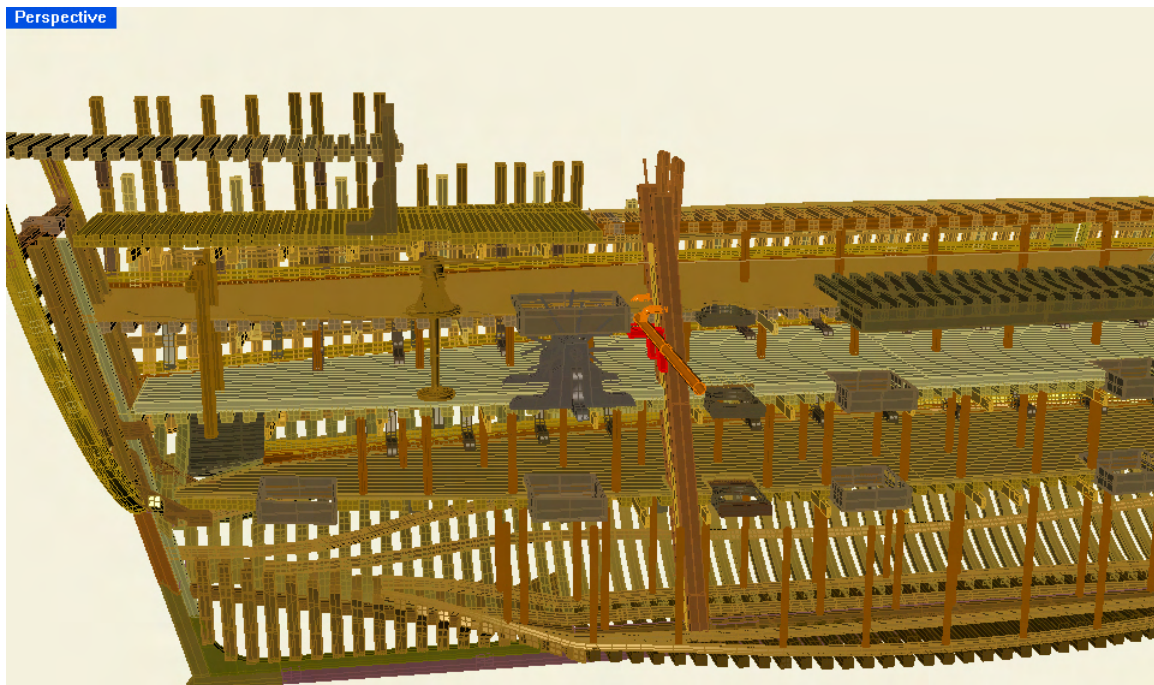


Figure 97. Dala (orange) and Curvas na Dala (red)

The spouts of the pumps empty into the pump dale, a lead pipe (lead pipes have been used for ships plumbing since Roman times) that drains out of both sides of the hull. The dale runs laterally beneath the weather deck planking between two of the beams, it rests upon the two knees and upon the *dromente*.

It takes two curves no Perpao (Figure 98) [two knees for the Perpao, a major cross beam of the castle, which also serves in the rigging of the nets]



Figure 98. Curvas no Perpao

The Perpaos here at the quarterdeck and at the Arpa are essential to the rigging of the nets in the waist of the vessel, period illustrations show netting extending from the quarterdeck to the forecastle.

It takes two gingamochoes da bomba (Figure 99) [levers for the pump]

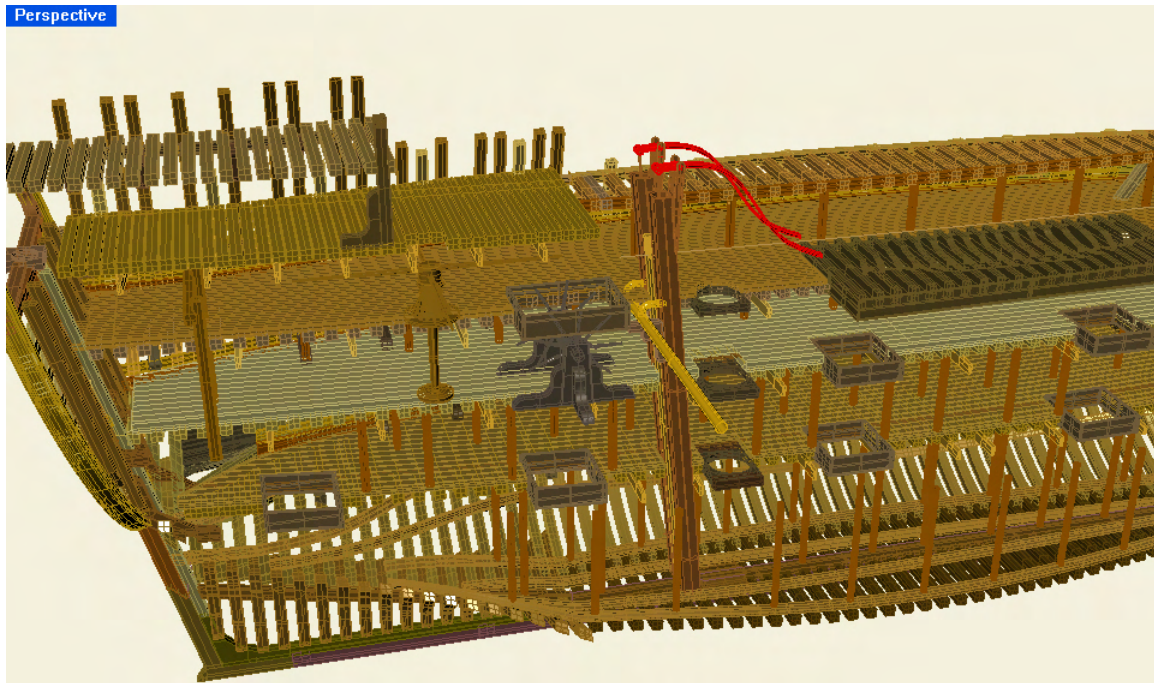


Figure 99. Gingamochoes na Bomba

Given the height of the pumps (the text says they are 45 palmos in length) they would have required long handles to be worked from the weather deck. The pumps are angled outward on each side of the keel and braced against the weather deck cordas, which leaves adequate space at the weather deck for the handles to extend forward on either side of the main mast (and also places them conveniently out of the way of the knighthead and each other's swing arc).

It takes three timbers for the trilhões

I was unable to determine what these timbers were; in modern Portuguese a Trilho is a track or a rail (a railroad track, for example), but I was unable to find a period definition or reference to its use, so I did not model them.

It takes one carregadeira (Figure 100) [downhaul]

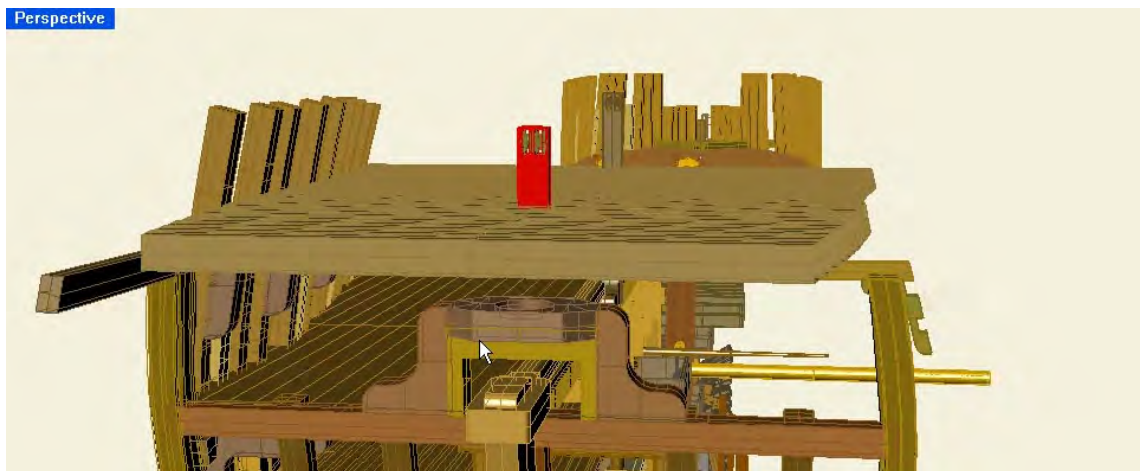


Figure 100. Carregadeira

This timber serves the same purpose for the mizzen mast as the knighthead does for the main mast – it is the downhaul for the mizzen yard. The lines that raise and lower the yard pass through blocks at the masthead and sheaves in the carregadeira, providing mechanical advantage to raise and lower the yard.

It takes 18 cambotas (Figure 101) [counter timbers] for the abobadas [the counter, the curving rake of the stern below the quarterdeck]

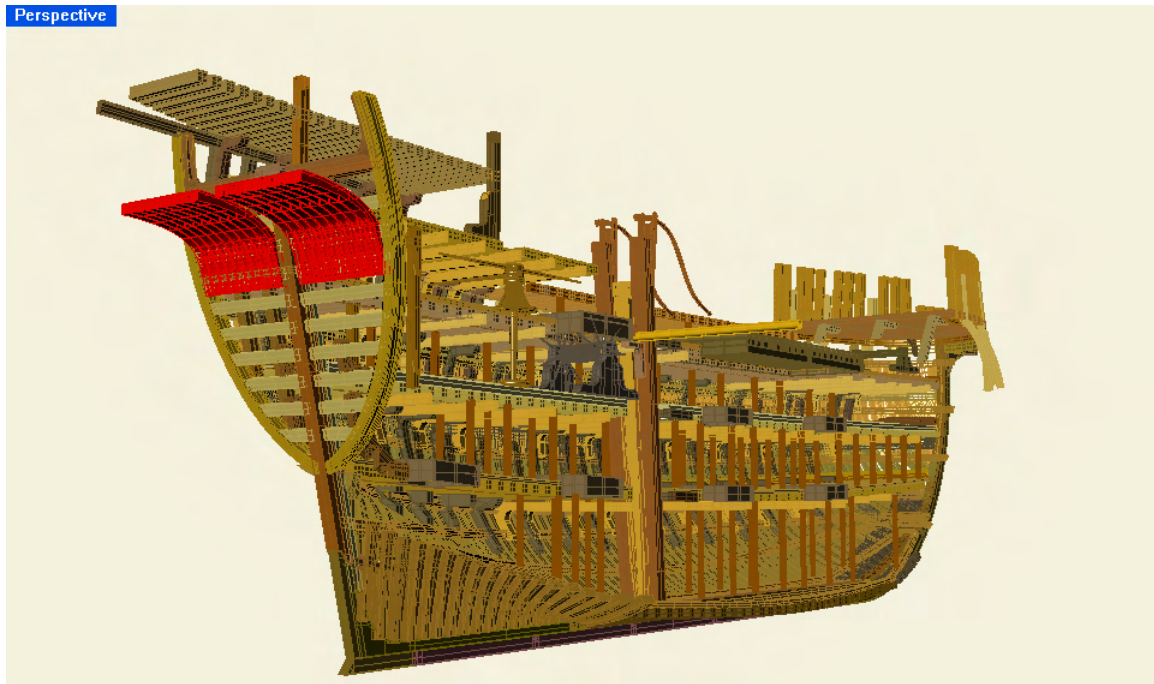


Figure 101. Cambotas

Eighteen Cambotas fit neatly on either side of the sternpost and just inside the fashion pieces. They fill the stern with just enough room between them for the top of the rudder. These timbers provide a strong foundation for the Varanda that will be layed at the level of the quarterdeck.

It takes four cambotas (Figure 102) [counter timbers] for the chapiteu [poop deck]

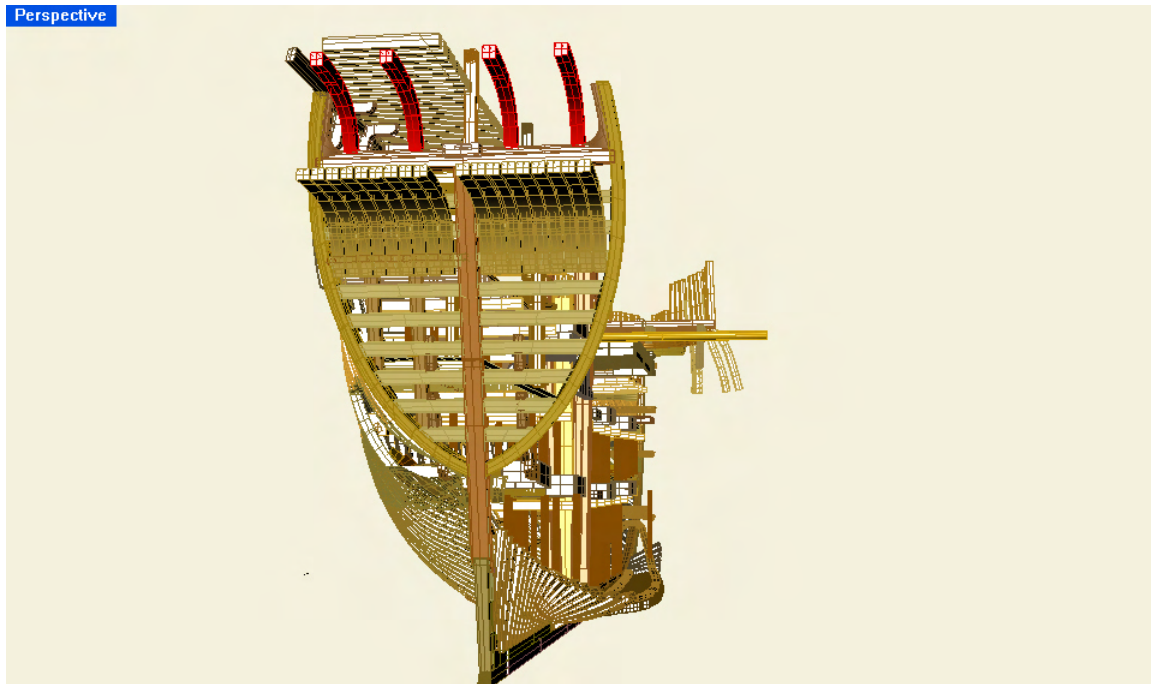


Figure 102. Chapiteu Cambotas

These support the short section of poop deck that protrudes aft of the fashion pieces, and the roof of the Varanda. As there are only four of these timbers there is plenty of space to pass between them to walk on and off the Varanda.

It takes two mulinetes [hand-cranked winches]

It takes one mulinete in the Castle

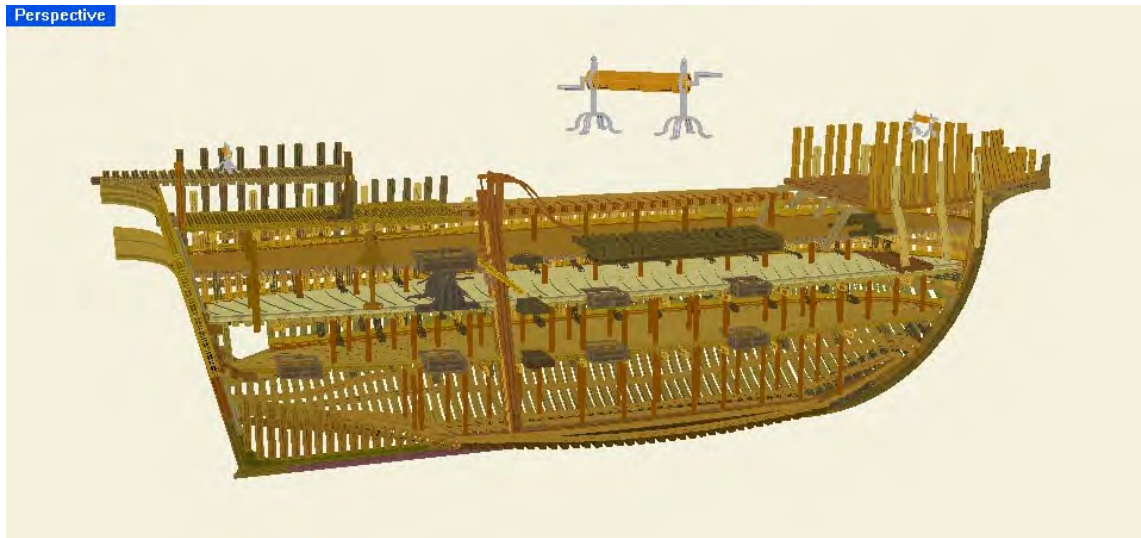


Figure 103. Mulinetes

The definition of a mulinete was a small hand-cranked winch or mill. I based my models upon illustrations in the *Album of the Marques de la Victoria*¹⁰³. Because they are quite small in Figure 103 (they are barely visible on the poop deck and forecastle), I have included a larger example as well to illustrate their construction. They are little more than a hand-cranked wooden drum that is held up by a metal frame, suitable only for light tasks.

¹⁰³ Navarro 1995, fol.41 and fol.47.

It takes one Perpao (Figure 104) [a lateral beam which ties the structure together] at the chapiteu [poop deck] with its gratings (Figure 104), which makes 5 timbers of stone pine



Figure 104. Chapiteu Perpao (red) and Grating (orange)

This Perpao serves to tie the stern structure together laterally, it rests upon the ends of the cambotas. The planking at the after end of the poop deck will be attached to the outside of this grating.

It takes two Perpaos no Castello (Figure 105)



Figure 105. Perpaos no Castello

One perpao rests upon the arpa knees, the other rests upon the perpao knees at the forward edge of the quarterdeck. The nets that stretch above the waist from forecastle to sterncastle will be attached to these thick timbers.

It takes two çeravioles (Figure 106) [catheads]

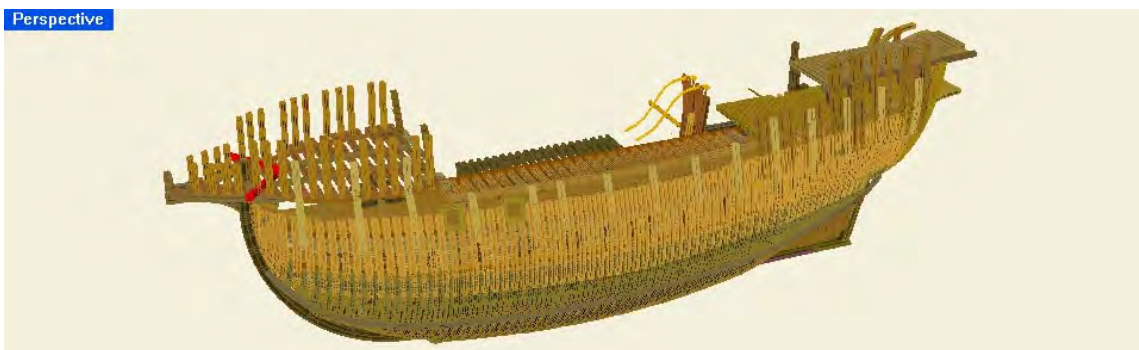


Figure 105. Çeravioles

These are used to 'fish' the anchors (blocks and tackles from the ends of the ceraioules are used to grab and hoist the anchors into their stowed position, once the anchors have been raised above sea level). They stick out of the sides of the forecastle above and in line with the escouvems.

It takes this vessel, on the side, five layers of doubled wales (Figure 107) [a wale with another wale attached on the outside] made up of 145 timbers of stone pine

On the first layer, 29 timbers

On the second layer, 29 timbers

On the third layer, another 29 timbers

On the fourth layer, another 29 timbers

On the fifth layer, another 29 timbers

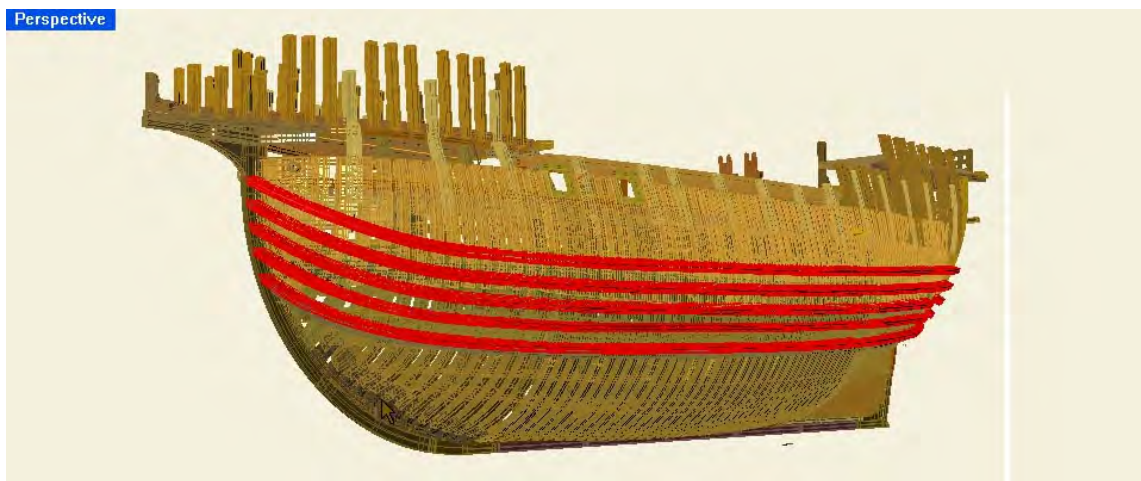


Figure 107. Doubled Wales

According to Oliveira, the wales are one palmo square in section, and spaced approximately every three palmos along the side of the vessel. This pattern fit the model very well. The wales extend across the face of the seis bordo (the loading hatch on the first deck, set far aft on the port side).

It takes another four layers of single wales (Figure 108), one that comes from the side below the hawseholes, on which we lay the poop sill, and on which wale are used 15 timbers of stone pine

The other layer goes/runs above the hawseholes and extends all the way to the stern, and on this layer we lay the bow sill, it takes 15 timbers of stone pine

The other one goes from the tabiquas [partitions] of the Castle all the way to the stern to make it strong, this takes 14 timbers

The other one is the top wale which goes from the alquatrata [the gunwale] of the Castle to the stern, and it takes 14 timbers



Figure 108. Single Wales

I would have expected (based upon the drawings in Fernandez's treatise) to see a wale that ran from the tip of the bow along the top of the bulwarks to the stern. This was not plausible in the model, because all of the wales follow the line of the first wale, which runs fairly flat from the stern to the round curve of the vessel's fore quarter before turning up sharply. Instead, my wales run upwards to the stempost or die under the forecastle overhang.

It takes yet another wale (Figure 109) that works as a dromente [clamp] at the chapiteu [poop deck], that comes all the way to the poussa verga [the 'yard rest', the rest upon which the yard sits when it is lowered], it takes 4 timbers

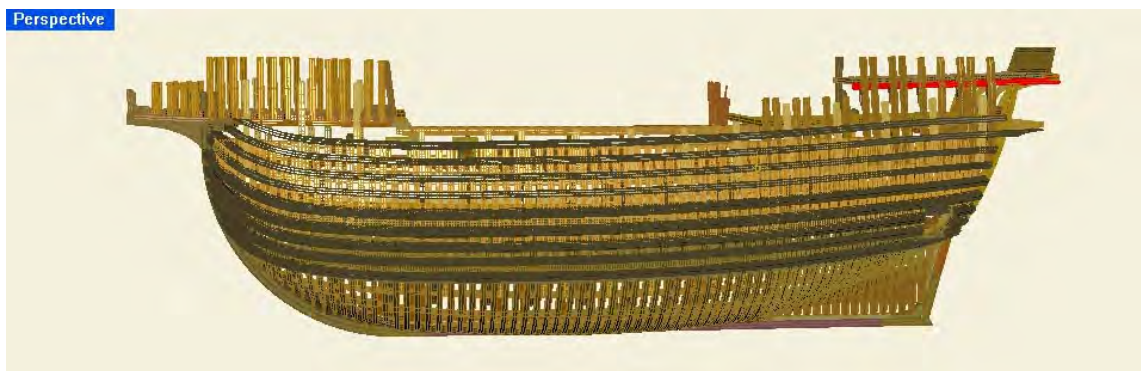


Figure 109. Chapiteu Dromente

Here, finally, is the clamp that was needed to support the beams of the poop deck.

On the bulwarks of the chapiteu [poop deck], it takes 4 wales (Figure 110) on each side, which makes 8 timbers

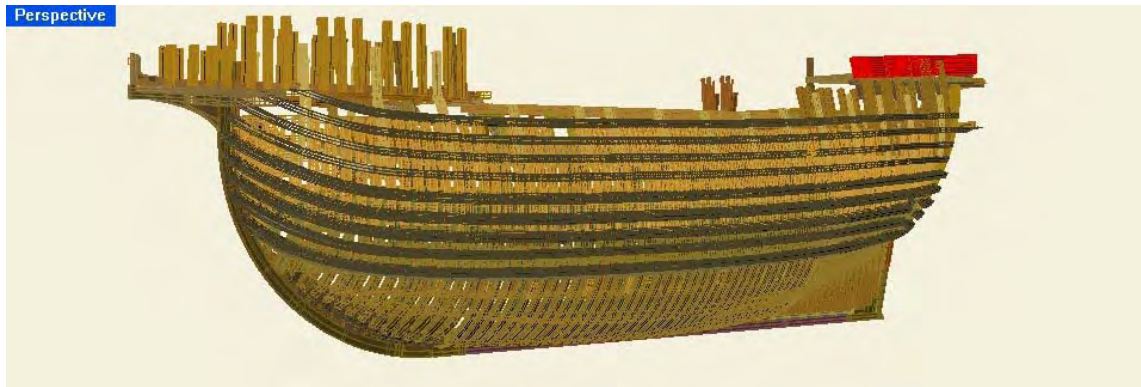


Figure 110. Chapiteu Wales

I find it intriguing that the poop deck and the quarterdeck, which have less framing structure than the lower decks, are almost entirely sided with thick wales, while the lower decks are sided with two planks between each wale. Perhaps the thickness of the wales on the side is to make up for the relative scarcity of futtocks?

It takes one layer of wales on each side of the Castle, which comes over/on top the deck beams in which are used 4 timbers

It takes another layer where where the windows go, and from the mão [triangular fairing piece between side and stem, to which the wale is fastened] towards the Arpa [the aft forecastle bulkhead], it takes 4 timbers

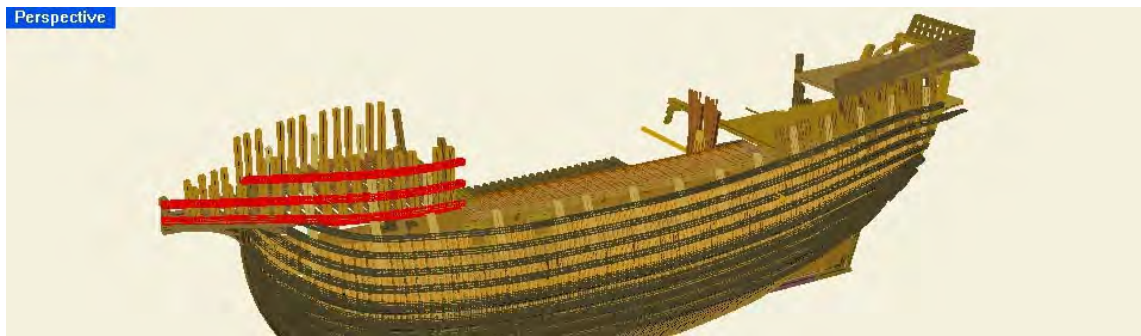


Figure 111. Forecastle Wales

In the text, only two of the wales shown above in Figure 110 are added at this point in the construction sequence, the third will be mentioned slightly later in the sequence.

It takes another wale (Figure 112) that comes from the angle of the papa mosqua [gammoning knee], which serves as the clamp of the gurita [quarter gallery], which takes 4 timbers

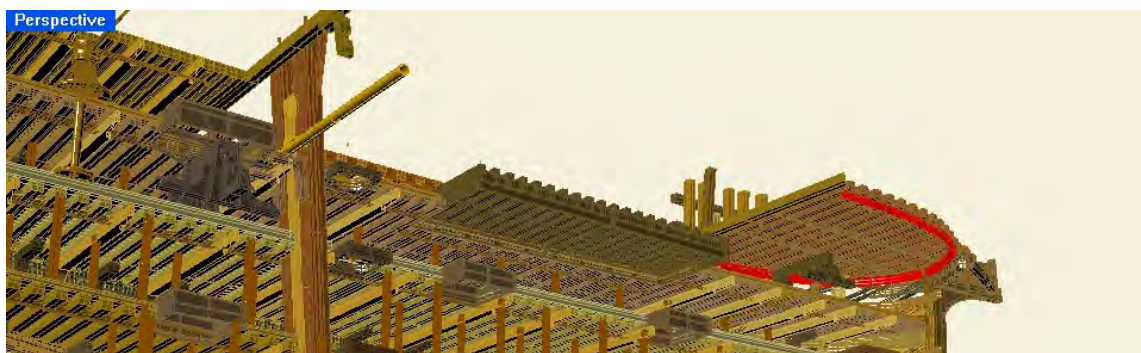


Figure 112. Forecastle Dromente

Here, finally, is the clamp that supports the forecastle beams, far out of the sequence. This clamp should have been emplaced before the forecastle deck beams that rest upon it.

It takes another wale, that goes from the point of the papa mosqua [gammoning knee] to the Arpa [aft forecastle bulkhead], that raises three palmos of the gurita [quarter gallery] and is called the bulwarks, and which uses 4 timbers

And now the third forecastle wale (modeled in Figure 111) is added. I see no reason why this wale is listed here, and not two steps back with the others forecastle wales. Did the writer simply forget one, and add it later?

This Castle takes four wales on each side, in the mareagem [bulwarks], which is eight timbers



Figure 113. Tolda Wales

Like the poop deck, the quarterdeck is sided with four thick wales instead of the wale and two planks pattern seen lower on the side.

The chapiteo [poop deck] takes ten dozen pine planks (Figure 114) in the flooring

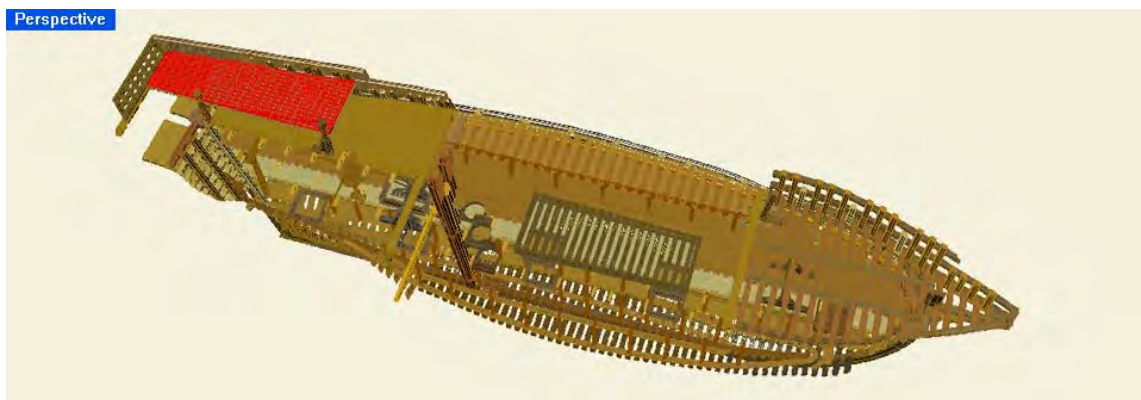


Figure 114. Chapiteu Deck Planking

As noted before, this seems to be out of sequence, perhaps the deck should have been put down before the standing knees were placed. In addition, as mentioned previously, there is no discussion in the text of how the mizzen mast will pass through this deck.

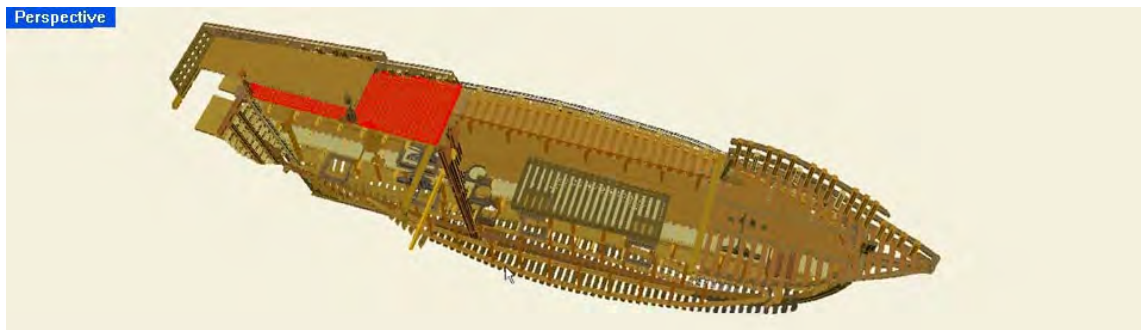


Figure 115. Tolda Deck Planking

The deck planking for the Tolda (the quarterdeck planking, seen in Figure 115) is simply never mentioned at all in the text. I chose to add it at the same time that the poop deck and forecastle planking was installed, although (as with the poop deck) I believe the planks should have been installed earlier in the sequence.

The gurita [quarter gallery] takes 3 dozen planks (Figure 116) in the flooring

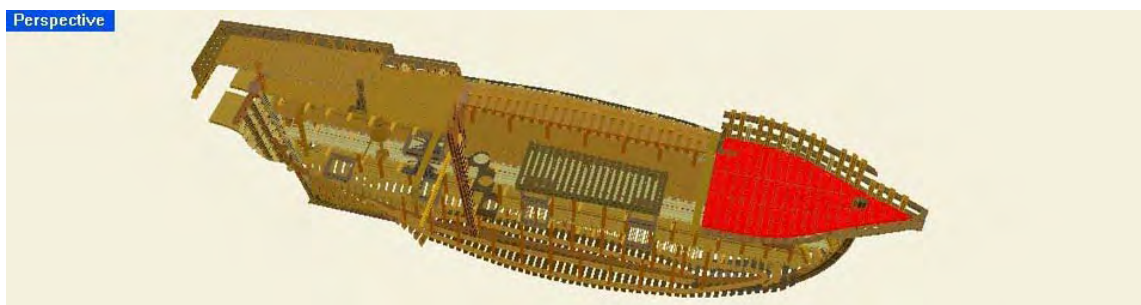


Figure 116. Forecastle Deck planking

As in the case of the weatherdeck, quarterdeck, and poop deck, there is no discussion in the text of how the foremast and bowsprit will pass through this deck either.

The Varanda (Figure 117) [the balcony at the stern of the ship] will be laid on the level of the tolda [quarterdeck] and extends beyond the stern 12 palmos, and is the width of the counter

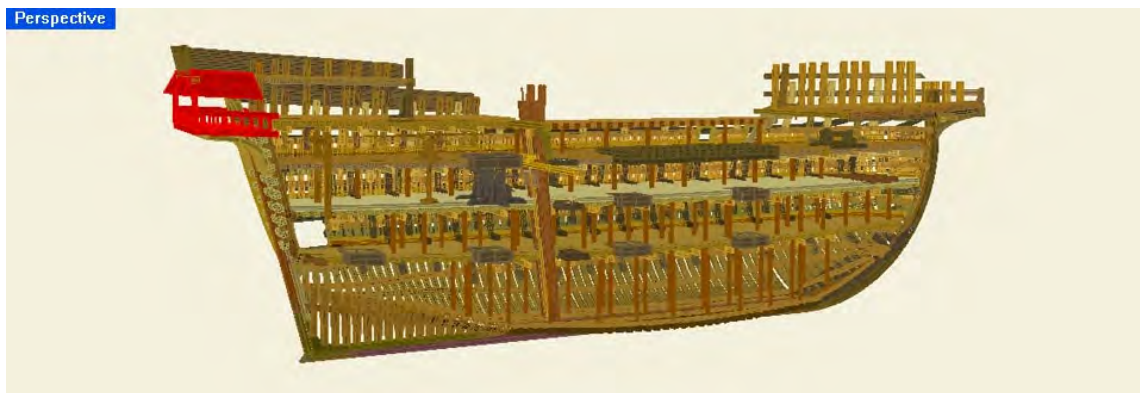


Figure 117. Varanda

I modeled the Varanda based upon the image in Fernandez' treatise, it extends behind the stern panel but does not extend forward along the stern quartered on either side to form quarter galleries as seen in later vessels.¹⁰⁴

¹⁰⁴ Fernandez 1616, fol. 71.

This Varanda [balcony] takes 9 viotes (Figure 118) of stone pine

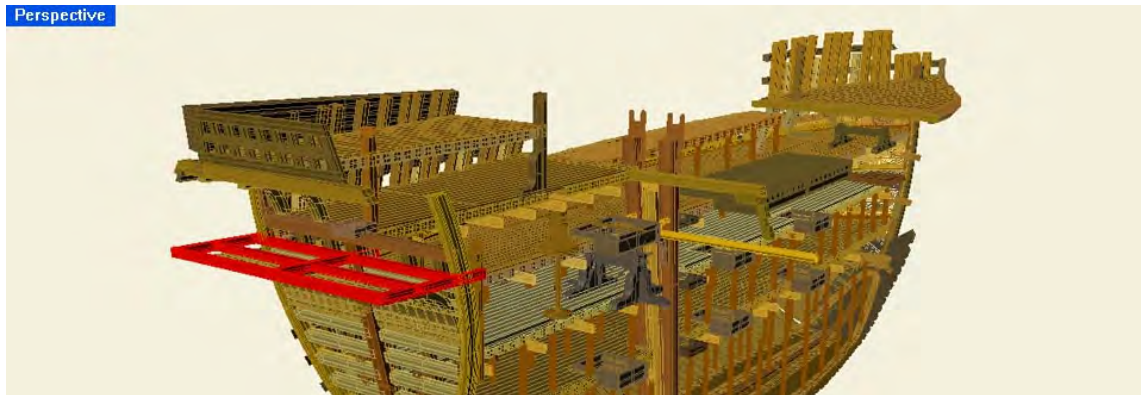


Figure 118. Varanda Viotes

These viotes rest upon the cambotas and provide the base for the Varanda. The arrangement of these timbers in the model is purely conjectural, I was unable to find clear period references that showed or explained the Varanda's construction in detail.

It takes 6 peitoris [railings], and 2 peis de carneiro [corner posts], and 3 mesas de telhado [roof sills], and 30 barrotes [balusters]

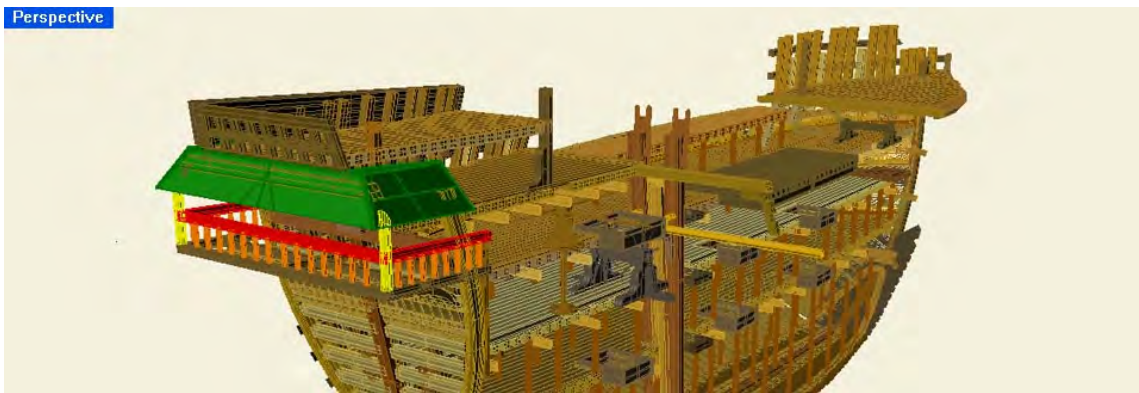


Figure 119. Veranda Timbers

In Figure 119 the barrotes (orange, the balusters) hold up the peitoris (red, the rail), and the peas de carneiro (yellow, the corner posts) support the outer corners of the mesas de telhado (green, the three broad planks that make up the roof).

It takes 6 planks (Figure 120) in the flooring [of the varanda]



Figure 120. Varanda Deck Planking

Although the text does not specify it here, these planks would most likely have been Stone Pine, since they serve merely to cover the floor of the Varanda.

From the keel up to the first wale this *Nau* takes 50 dozen planks (Figure 121) of stone pine, one palmo wide



Figure 121. Lower Hull Planking

The treatises all agree that the planks that hold out the sea (the planks of the lower hull) are to be four fingers thick, while the *Livro nautico* text specifies these are one palmo wide.

From the first wale to the Portaló [gangway] in all alcaixas [the spaces between wales] it takes 50 more dozen of the said planks (Figure 122) which are 1 dedo thinner

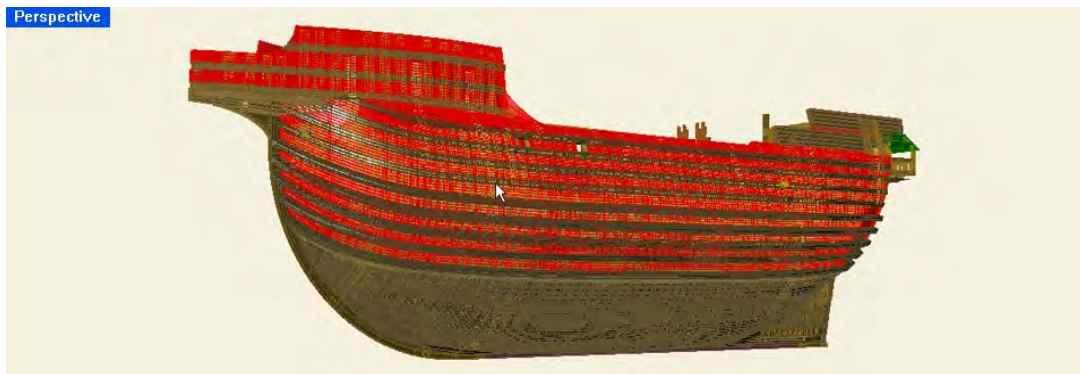


Figure 122. Upper Hull Planking

In contrast, all of the planks that are above the waterline are three fingers thick and one palmo wide.

It takes 60 calimetes (Figure 123) [these are the planks which cover the counter, the rounded portion of the stern panel] for the stern

The emendas (Figure 123) [these are the planks that cover the flat portion of the stern panel] of the said calimes take 25 planks

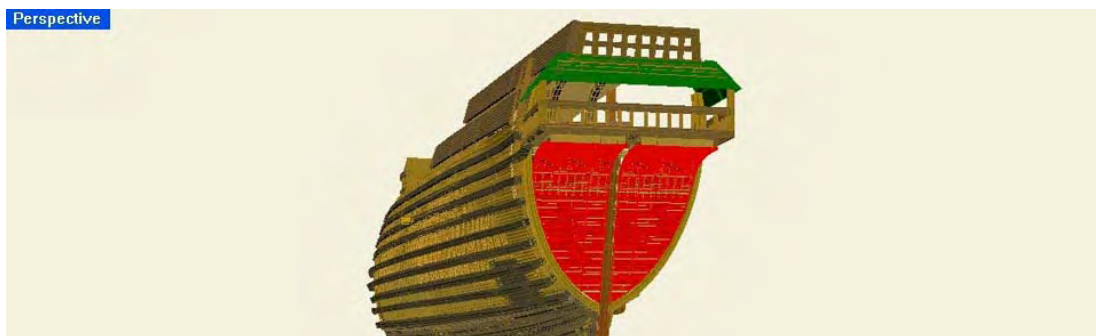


Figure 123. Calimetes and Emendas

Assuming the calimetes and emendas were of equal width, and planking the stern in the most straightforward manner (with all the planks laid horizontally) it appears that the numbers of these two types of planks might have been reversed. Far fewer planks could be fit onto the rounded section of the stern than onto the flat lower portion. Perhaps the builders used planks of narrower width on the counter, increasing the total number given. Because I am not at all certain how they were divided or sized, I chose to model them all the same size, and not to differentiate between the calimetes and emendas in the image above.

It takes 4 wales (Figure 124) in the stern



Figure 124. Stern Wales

Since the planking of the poop deck was four single wales, I modeled these four wales as their equivalent timbers on the stern, fastened to the grating at the aft end of the poop deck, above the roof of the Varanda.

This *Nau* has *mesas grandes* (Figure 125) [channels] that go from the *pousaverga* [yard rest] to the *face de Re do seis bordo* [aft face of the loading hatch], and take twenty *Apostareos* (Figure 125) [futtock riders]

The *castanhas* and *cunhos* [These are elements that hold the shrouds, the eighteen timbers specified suggests there were nine shrouds on either side of the ship] take 18 timbers

It takes 2 planks of the width of 3 *palmas* and the thickness of a *palmo de goa* [the two channel timbers are three *palmas* wide and one *palmo* thick]



Figure 125. *Mesas Grandes* (red) and *Apostareus* (orange)

The term ‘*apostareu*’ or ‘*futtock rider*’ implies a longer timber than I have modeled, and images of Spanish vessels do show the use of long futtock riders to support the channel timbers, but the images of Portuguese ships I consulted showed smaller timbers (more like knees) for this purpose, so I chose to model these to resemble pairs of knees.

The nine shrouds (counting the number of shrouds in images of ships suggests this is typical for a vessel of this size) that are implied by the number of *castanhas* and *cunhos* would fit neatly between the ten *apostareus*. Although the forwardmost

shroud is well behind behind the main mast, the rake of the mast brings the masthead aft into near-vertical alignment with the forward shroud. If the mast was not inclined, the channels and shrouds would have to have been extended farther forward to maintain the proper alignment.

The mesas de proa (Figure 126) [fore channels] run from the Arpa to the hawsehole, and each one takes 7 apostareus (Figure 126) [futtock riders], which is 14 timbers

It takes 10 timbers in the castanhas and cunhos

It takes 2 planks for the as de popa [the two channel timbers]

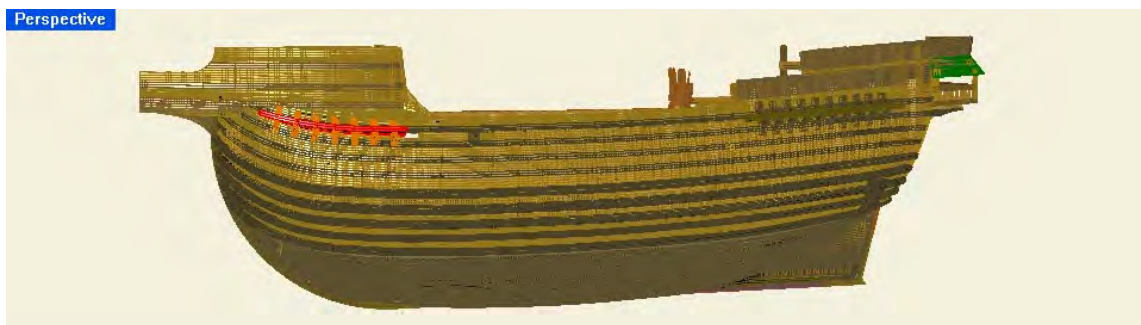


Figure 126. Mesas de Proa (red) and Apostareus (orange)

In the model the fore channels sweep up a bit at the front, because they follow the line of the wales at that point. Although the length of the forward channels is not specified the channels cannot extend farther aft than the portinholas, or much

forward of the foremast (since the forward shroud aligns vertically with the foremast).

The number of castanhas and cleats suggest five shrouds, though the number of apostareus specified leaves room for six shrouds if they followed the same practice as in the main channels, of shrouds separated by apostareus.

If five shrouds were spaced between apostareus, starting at the aft end, this would leave the forward end of the channel open, which would allow room for crew members to stand on when fishing up the anchor, or for stowing the anchor (hooked over the channel and lashed into place).

This *Nau* takes 2 Amures [tack timbers] and each one takes 3 Apostureos [futtock riders], which is 6 timbers

It takes 2 chumaçeirias [fairleads], 11 palmos de goa in length

It takes 6 timbers in the castanhas [cleats]

It takes in these Amuras [halyard/tack timbers], and the mesas de Popa [fore channels] 3 passaros [v-shaped belaying cleats or kevels] which are 6 timbers

In modern Portuguese dictionaries the term ‘Amura’ refers to “...the curved part of the dead works at the back on either side of the prow.”¹⁰⁵ The equivalent term in English is the ‘Tack.’ They are a rounded part of the upper works on either side of the bow, where the tack of a sail is belayed.

¹⁰⁵ Esparteiro 1962, 38-9.

In both cases the term relates to the concepts of sailing upwind and of turning the bow of the ship across the wind while sailing upwind. When the ship sails upwind, the direction the ship is sailing relative to the wind is called its ‘tack’ (a ship with the wind blowing on its starboard bow is on a port tack, since its nose is to port of the wind). To sail upwind the sails have to be braced (by pulling one side forward and one side back) so they catch the wind behind the sail. Likewise, to make the ship ‘tack’ across the wind the foresails are braced to catch the wind on the forward side to help push the nose of the ship around and across the wind. The ‘tack’ is a line attached to the foot of the sail that is used to pull the sail forward; it runs around a fairlead and back to the side of the bow where it is tied off.

The concepts and the objects had already become associated by the 15th century; to the Spanish of that period ‘Amurar’ meant “...to tie the sheet” (in order to tack the ship).¹⁰⁶

Period illustrations of carracks under sail (such as those in the *Memorias das Armadas*) often show the sheets leading back from the foot of the foresail, but not the corresponding tacks nor any sign of how the sail might be braced forward.

The problem modeling this is that from the beginning of the seventeenth century on the practice was to run the lines from both feet forward to a single fairlead attached below the bow and back to the opposite side of the bow (for example, the port tack line would run forward to pass through the fairlead and then back to tie off

¹⁰⁶ Pontillo 1975, 106.

on the starboard side)¹⁰⁷. There was no need for *Apostareus*, and only one *Chumaçeira*. There is no evidence of an arrangement of timbers such as the *Livro Nautico* describes. Lacking any information on the way these timbers would have been placed, I chose not to model them at all rather than to make something up.

I did, however, model (in Figure 127) an upper deck for the forecastle even though the *Livro Nautico* text does not call for it. An Indiaman of this time and size would have had at least one deck atop the *gurita*; its omission must have been a mistake of the original author.



Figure 127. Hypothetical Upper Forecastle Deck

¹⁰⁷ Anderson 1955, 82.

I modeled the minimum of timbers for such a deck; dromentes(red), deck beams (orange), and planks (yellow).

It takes 2 Bombas [pumps] of 45 palmos height for the dalla [the pump-dale]

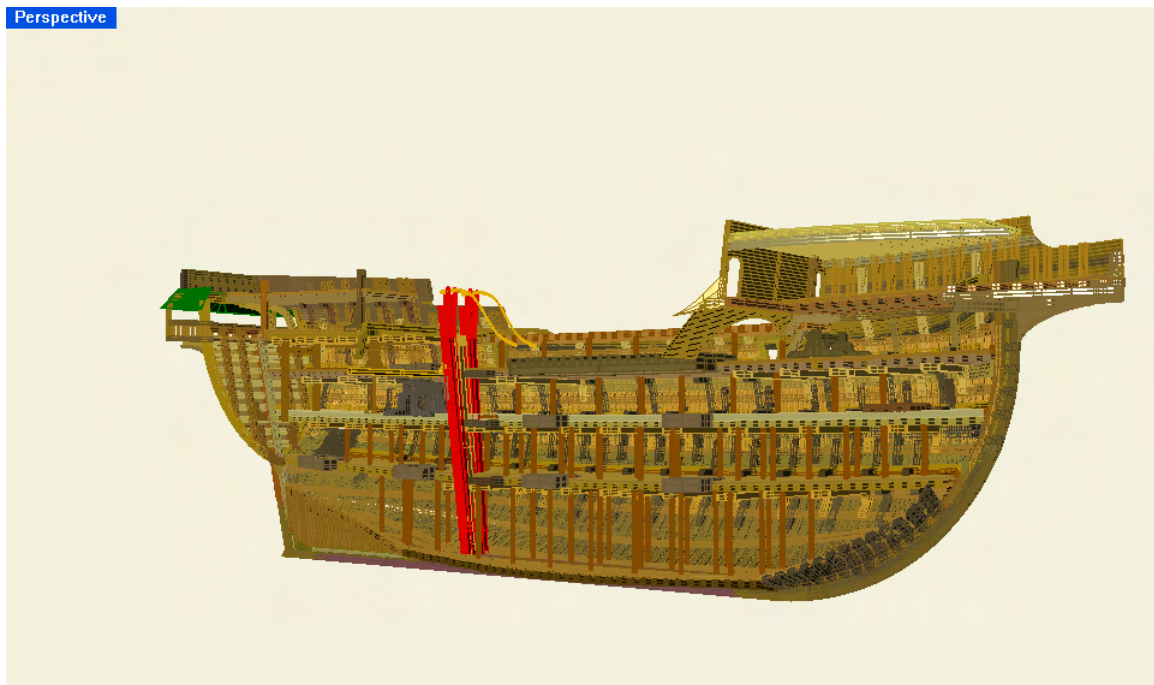


Figure 128. Bombas

Here, finally, the size of the pumps is discussed. At this length, even assuming they were allowed to lean outward to either side against the cordas of the weather deck; they still stand very tall, towering high above the deck. I modeled long handles to allow these pumps to be worked from the weather deck.

This *Nau* takes 2 cabestantes [capstans], one large, and the other smaller on deck

The large one takes 4 timbers for the cunhos [the sturdy timbers it sits upon]

The smaller takes 3 timbers for the cunhos

These 2 cabestantes [capstans] take 6 barras [capstan bars]

I modeled only one of the Capstans (the larger) because I was not sure where the second would have been placed, and because the text fails to list the parts for the body and axis of a second capstan. The second capstan would probably have been placed forward on the weather deck, for hoisting the anchors and raising the foreyard.

THE ESCOTEIRAS THAT THIS *NAU* TAKES

This was a list of the rigging elements for the 600-ton *Nau* included in the *Livro Nautico* document. I include it here for completeness, but lacking information on the size, shape, and arrangement of the vessel's rigging, I chose to leave them out of the model.

It takes 2 escoteiras [sheet bitts] for the escotas grandes [main sheets]

It takes 2 for the Amantilhos grandes [main lifts]

It takes 6 for the troças grandes [main truss]

It takes 2 for the arms of the uerga grande [main yard]

It takes 2 for the ostingues [yard ties]

It takes 2 for the escotas [sheet bitts] of the traquete [foresail]

It takes 2 for the Amontilhos of the traquete [foresail]

It takes 4 for the troças [truss] of the traquete [foresail]

It takes 2 for the escotas [sheet bits] of the çeuadeira [spritsail]

It takes 4 for the bulinas [bow lines]

It takes one for the driça [halyard] of the gauea grande [main top]

It takes one for the driça [halyard] of the gauea de proa [fore top]

It takes 2 for the escotas [sheet bits] of the gauea de proa [fore top]

THE MASTS OF THIS *NAU*

This list of masts and spars was also included in the *Livro Nautico* text on the 600-ton *nau*. Unlike the list of rigging elements this list gave useful dimensions and was useful for modeling.

The masto grande [main mast] is 18 braças in length, not including the calças [mast head], it is 4 ½ palmos thick at the tamboretas [mast partners], and 2 ½ palmos at the garganta [throat]

The masto do traquete [fore mast] is 15 braças in length, without the calças, it is 4 palmos thick, and half that thick [2 palmos] at the garganta

The goroupez [bowsprit] is 15 braças

The Verga grande [main yard] is 17 braças in length, and 2 palmos at its thickest point

The uerga do traquete [fore yard] is 13 braças in length, and 2 palmos in thickness

The mastareo grande [main top mast] is 7 ½ braças in length, and 1 ½ palmo in thickness

The mastareo de proa [fore top mast] is 6 braças in length, and 1 ½ palmo in thickness

The uerga da gauea grande [main top yard] is 6 braças in length, and 1 palmo in thickness

The gauea de proa is 5 braças in length, and 1 palmo pequeno [a ‘small palm’ only 4 dedos in width] in thickness

The uerga da çeuadeira is 9 braças in length, and 1 ½ palmo in thickness

The masto da mezena is 10 braças in length, and 2 palmos in thickness

The uerga de mezena is 13 braças in length, and 1 palmo thick at the ostaguadora [tyes]

In Figures 129 and 130 I modeled the masts and spars in order to show their placement in the ship and relation to the channels, and added fore- and main-top structures (based upon those in Fernandez’ treatise), although they are not mentioned in the *Livro Nautico* text. Each mast is stepped where the document prescribed and the bowsprit is placed and raked in accordance with iconography. The rake of the mainmast is due to the placement of the deck beams at each level.

These are only rough models of the mast and spars, in reality they would have been assemblies of multiple timbers rather than the single pieces that I created, and the gradual taper at their ends would have been controlled by a mezza-luna in much the same manner as the rising and narrowing of the hull, rather than the simple taper that I modeled.

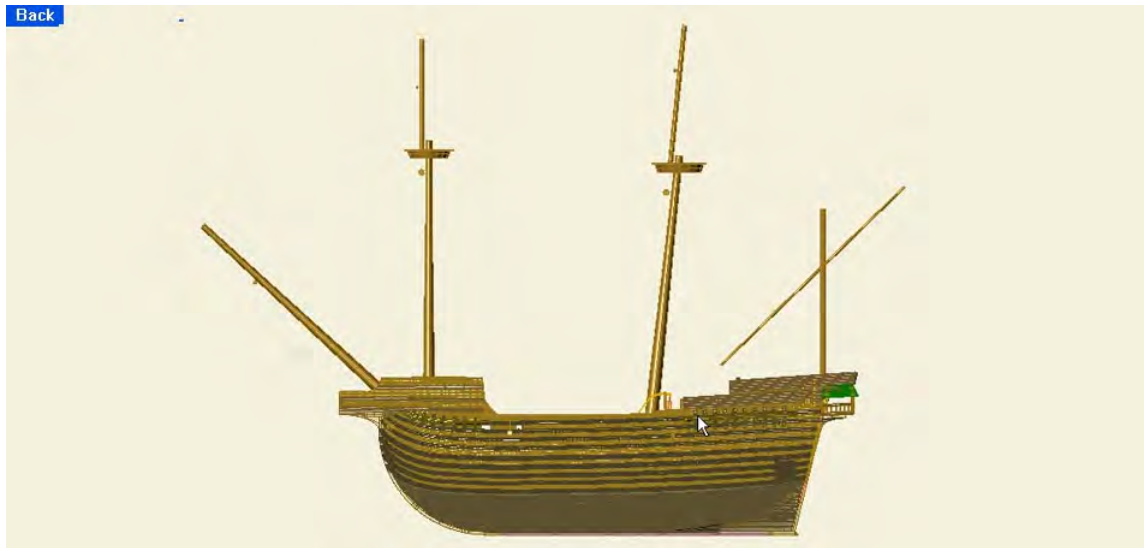


Figure 129. Masts and Yards of the *Nau*

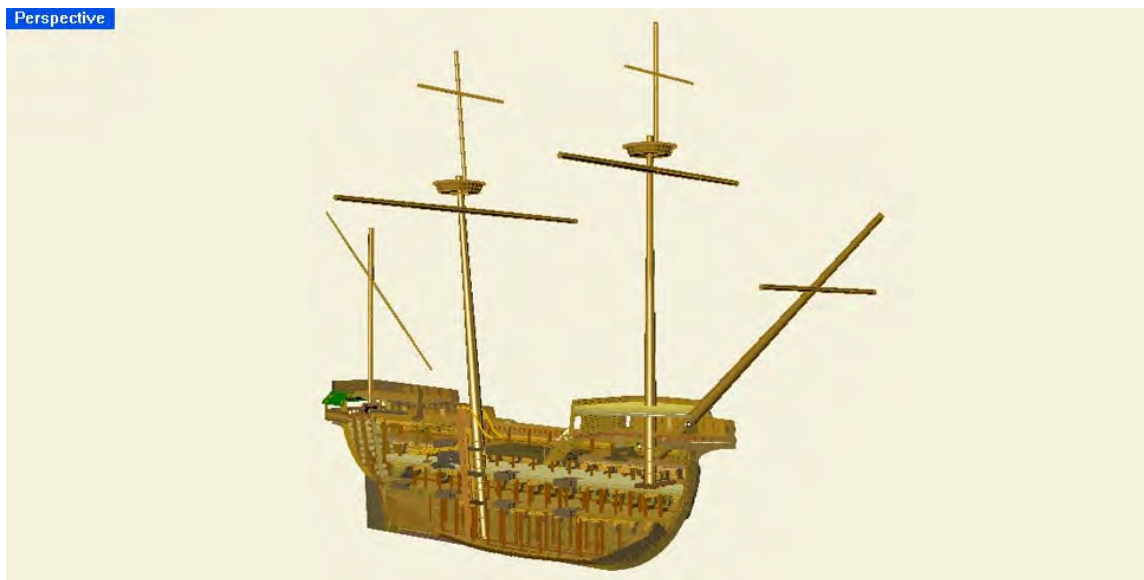


Figure 130. Mast Placement in the Hull

CHAPTER VI

CONCLUSIONS

Beyond the production of a timber-for-timber model of a ship (useful though it will be), the exploration and analysis of its construction sequence has brought me to the following conclusions about the text, its author, Portuguese shipbuilding practices, and about the value of computer modeling for this project.

THE TEXT AND THE AUTHOR

First of all, the *Livro Nautico* document is essentially devoid of the shipbuilding theory that permeated the treatises of the period. There are few formulas, there is no discussion of timber types or the tools of the shipyard and the rules of thumb that are described are simple and straightforward. Although the text gives us the *graminhos* for the rising and narrowing of the hull, their use is not explained. That is to say, unlike the treatises, this text specifies how much the hull will narrow and rise from the master frames to the *almogames* or tail frames but doesn't spell out how to make a *mezza-luna* using these dimensions. There is nothing in this document about 'building by eye' (allowing the shipwright to vary the dimensions or the shape of the timbers as it suited him) which Oliveira and Lavanha suggested was common practice (although it is true that there is also nothing in the text that rules out the process being done by eye). In the *Livro Nautico*, the underlying methods of conceiving and controlling the shape of the ship are implied in the description of the timbers and the method and order of their assembly.

Nevertheless the *Livro Nautico* scantling list is tremendously useful for the reconstruction of a Portuguese Indiaman because it supports and amplifies the construction sequence described in the treatises. Neither the treatises nor the text alone provide all the information needed to reconstruct the ship. Where the treatise authors listed the theoretical concepts that guided the shipbuilder and described a ship's assembly in broad terms, this text complements the treatises with real numbers and the description of how the timbers were arranged.

The construction sequence is generally clear and consistent; the same steps are taken as each deck is finished. Frames are raised, a clamp is placed, the beams rested upon the clamps, knees and antremichas are added to support the beams, and so on. Interestingly, the construction sequence order so regularly described begins to break down at the level of the weather-deck, the point at which the treatise authors state that carpenters take over construction from the shipwrights (the castles and upper works are called the 'obras mortas' or 'dead works' because they are not essential to the life of the ship¹⁰⁸). Given the systematic and complete sequence up to the weather deck, the inconsistencies above were unexpected confirmation of the assertion made by the treatise authors.

It seems possible, from the type of omissions and out-of-place steps, that the author of the *Livro Nautico* document was neither a shipwright himself nor well-versed in ship construction. In particular, the omission or misplacement (several pages out of sequence) of the dromentes in the castles and the raising of the forecastle virotes when

¹⁰⁸ Oliveira 1580, 201.

there were no timbers in place to affix them to make little or no sense, if you know how these ships are constructed. On the other hand, it is equally possible these were simply forgotten and then added later in the sequence as the author recalled them, since there was not enough space between lines to add the forgotten steps where they belonged.

In the end, even though there were errors in the construction sequence, I found that whenever the *Livro Nautico* disagreed with the treatises or with my understanding of ship construction, the best result was achieved following the prescriptions of the *Livro Nautico*.

PORTUGUESE SHIPBUILDING

One of the great divisions in European shipbuilding is the way the builder conceives of the vessel before and during the construction process; separate European shipbuilding traditions conceived and built their vessels ‘shell-first,’ ‘skeleton-first,’ or ‘bottom-based.’ Both Classical Era and Scandinavian shipwrights assembled a shell of hull planks first and only later added internal frames for extra support. In the Middle Ages this ‘shell-first’ practice was gradually supplanted by a new ‘skeleton-first’ method in which the frames of the ship were assembled, the decks were installed, and the planking added only late in the process as a skin over the hull. Dutch shipbuilders developed a ‘bottom-based’ method that blended the two, in which the bottom planks were fitted first, and then the frames, the decks, and finally the skin of upper planks. Unlike any of these methods, the *Livro Nautico* ship is built completely, deck by deck, before the frames for the next deck are added.

Assembling the model timber-by-timber showed clearly how sturdily these ships were built, with overlapping frames the length of the ship as high as the weather deck, braced below the decks by knees, *entremichas*, and stanchions, and above each deck with more knees. The castles, which were framed with far fewer timbers, were planked with stout wales (thicker than the planking below) and tied together with additional sturdy crossbeams (the *perpaos*). All of this massive structure was necessary for vessels built to make the long voyage to India and back.

On the other hand, we know from the treatises that large timbers for shipbuilding had become scarce in Portugal by the end of the 15th century. The *Livro Nautico* supports this, as it enumerates how many *paos* (timbers) are needed for each set of ships structures. Where the Basque *San Juan* had a single long timber for its keel, this text calls for ten *paos* scarved together.¹⁰⁹ Furthermore, these ‘timbers’ are not that big; the keel of the *Livro Nautico* vessel is only one palmo de goa (25.68 cm) sided by one palmo de goa and two dedos (34.19 cm) molded, and the keelson is only one palmo de goa square. In contrast, American clipper ships in the 19th century had keels two and three times as deep, and keelsons made up of multiple baulks of timbers stacked three and four high. The model shows just how 16th-century Portuguese shipwrights made a virtue of necessity by building with many smaller timbers.

The reconstruction can be compared to two 16th century wrecks of comparable size, the English warship *Mary Rose* (which sank in 1645) and the Genoese *nave La*

¹⁰⁹ Granted, the *San Juan*'s keel was only 14 Rumos (21.56 meters) long, while the *Livro Nautico* ship's keel is 27 Rumos (41.58 meters).

Lomellina (which sank in 1516). Unlike many, in both of these wrecks the sides and internal structure were preserved. This allows us to compare the arrangement of their deck beams, knees, and other structural components.

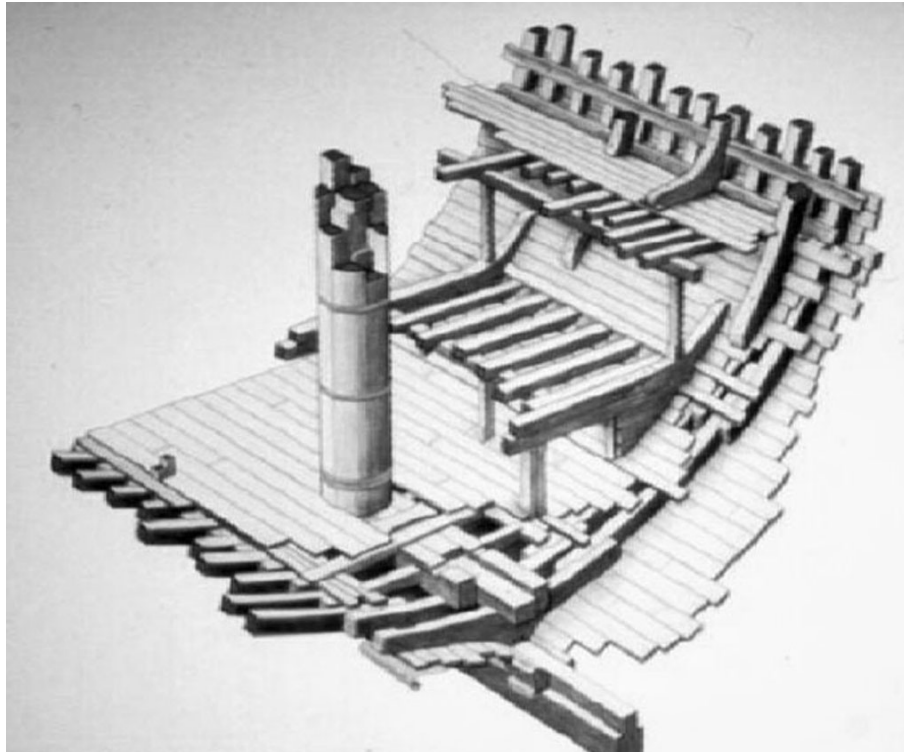


Figure 131. Midship Structure of *La Lomellina* After Blotti¹¹⁰

For example; unlike *Mary Rose* and the *nau* of the *Livro Nautico*, the frames of *La Lomellina* (Figure 131) were covered with ceiling planking, which supported the ends of

¹¹⁰ Blotti's untitled illustration on the French Ministry of Culture and Communication website for *La Lomellina* (2002, 18 September. <http://www.culture.gouv.fr/culture/archeosm/archeosom/en/lomel-s.htm>) depicts the midship structure of the vessel in detail.

the deck beams. Vertical riders were fastened over the ceiling planking to stiffen the side as well as to hold down the ceiling planking. On the orlop deck, standing knees were affixed atop the deck beams; the knees were scarfed into the beams and into cross-members (in Spanish and Portuguese, these would be called *entremichas*) which sat upon the beams. Like the riders, the knees were fastened to the frames, sandwiching the ceiling planking between the knees and frames. Smaller standing knees were used on the second deck, which was planked (unlike the orlop); the knees for the second deck were installed after the deck planking. The stanchions for the orlop deck were seated atop stringers, and those of the second deck were seated upon the orlop knees.

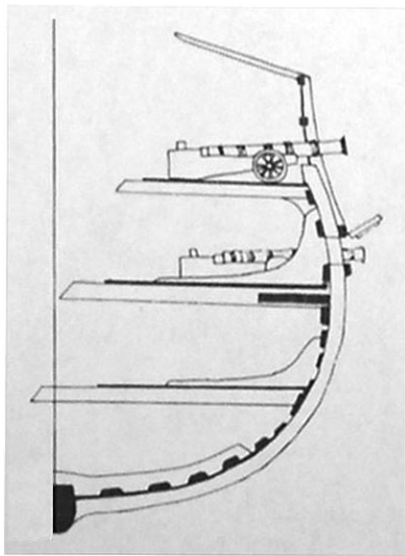


Figure 132. Midship Section of the *Mary Rose* After Fielding¹¹¹

¹¹¹ Fielding 1982, 120.

The beams of the *Mary Rose* (Figure 132) rested on sturdy beam shelves nailed to her frames. Stout stringers were fastened to the frames as well for lateral stiffness but not so many as to cover the inside face of the frames. Deck planks were laid down before the very large standing knees were fastened to the frames. These knees were notched to fit over the stringers. Hanging knees were fitted beneath the weather deck (perhaps because the side did not protrude high enough above the deck to fit standing knees there). Unlike the other two examples, in *Mary Rose*, lodging knees were fitted to brace the deck beams of the lower gun deck laterally (this was possible because the deck beams were spaced much farther apart in this ship than in either *La Lomellina* or the *nau*). The gunports were positioned in line with these beams and lodging knees, so the heaviest guns in the ship were given the maximum supporting structure. There were no *entremichas* such as those found on *La Lomellina's* orlop deck, and no stanchions.

The beams of the *nau* (Figure 133) rested on the dromente (the clamp or beam shelf, which was nailed to the frames) and contradromente (which was nailed below the dromente to support it). Hanging knees and stanchions supported the beams from below. Standing knees were nailed to the beams from above after the deck planking had been laid down. The knees were notched to fit over the dromentes below and the waterway and sill planks above the beams. Stringers in the hold and the dromentes, trinquantis (waterways), and coçeiras at each deck served to stiffen the hull lengthwise.

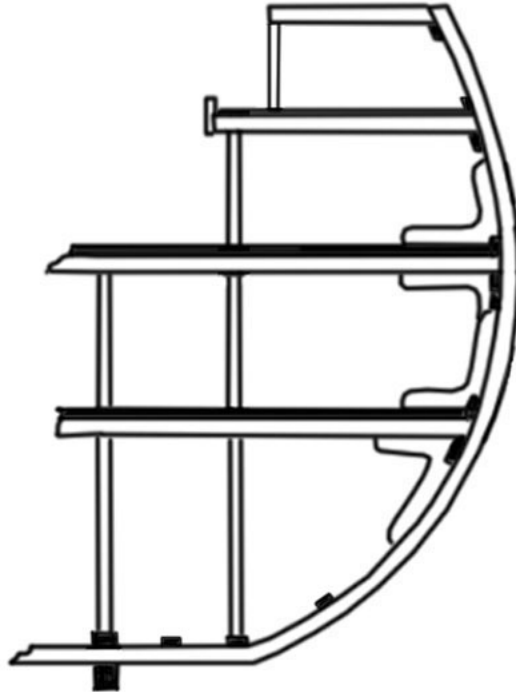


Figure 133. Midship Section of the *Nau* of the *Livro Nautico*

The beams of the *nau* (Figure 133) rested on the *dromente* (the clamp or beam shelf, which was nailed to the frames) and *contradromente* (which was nailed below the *dromente* to support it). Hanging knees and stanchions supported the beams from below. Standing knees were nailed to the beams from above after the deck planking had been laid down. The knees were notched to fit over the *dromentes* below and the waterway and sill planks above the beams. Stringers in the hold and the *dromentes*, *trinquantis* (waterways), and *coçeiras* at each deck served to stiffen the hull lengthwise.

Although all three wrecks exhibit common construction features, it is clear even from this limited comparison that these vessels were built for very different

environments and purposes. *La Lomellina*'s sides are stiffened by the layer of ceiling planking held in place by the widely-spaced knees and rider timbers, but the sides are connected only by scattered beams and *entremichas*. *La Lomellina* was a Mediterranean shipwreck; perhaps the vessel was built with this relative lack of lateral bracing since she operated in the relatively calm Mediterranean Sea. *Mary Rose* has stout stringers and knees (she was built for the much rougher waters of the Atlantic), but fewer deck beams to tie the sides together (although the lower gun deck received the extra support of lodging knees under each gunport). With the beams and knees lined up under her gunports, the English warship is clearly purpose-built to carry her cargo of guns in specific positions (rather than a general cargo spread more evenly across her decks). The Portuguese *nau* had many deck beams spaced close together (like *La Lomellina*) but fewer stringers than either of the others. Unlike the others, the *nau* had knees above and below the deck beams and *entremichas* as well. This vessel was built very sturdily, to survive the harshest storms and waves of the long passage to India and back with cargo and passengers packed into her hull.

COMPUTER MODELING

An entirely unexpected problem in this reconstruction was the straightjacket of modern methods of drafting. The modern graphically-based system emphasizes certain viewing angles (profile, plan, and section views are the norm for ship plans) where the 16th-century shipwright would have seen the vessel much more in terms of the run of battens and the placement of timbers. Trying to visualize the arrangement and shape of

timbers as they would be seen in the modern viewing system was sometimes baffling, and occasionally it was necessary to put all reference drawings aside and reread the text, keeping in mind only how the timbers would fit together or how a plank would lie against the frames, before returning to the modeling process.

A related problem came when I consulted modern drawings, which are typically drawn in these same viewing aspects. Relying on standard viewing angles limited the information that could be gleaned from modern images. Features of construction I hoped to find were omitted or difficult to see because they were just not shown in a profile or plan view.

Modeling in 3D on the computer, in contrast, allows the viewer to consider the ship from a myriad of angles; a rat's-eye-view of the deck is as easy to achieve as a profile or plan view, and the image can be enlarged to examine details or reduced to view the arrangement of the masts and spars. The model can be rotated, and selected portions of the model can be hidden or made translucent, so that features that were obscured may be clearly seen.

Computer modeling also allows modification or outright replacement of portions of the ship during and after the modeling process. Early in the process, I replaced the forward 20 futtocks, the stringers, clamp, and all the first deck planking in order to make the shape of the lower bow smoother and the narrowing of the gripe more visible. Later, I replaced approximately 20 percent of the the forward end of the model (frames, beams, knees, clamps, stringers and all the other timbers above the keel) after I had modeled the ship up to the weather deck, in order to rebuild the bow with a rounder, more appropriate

shape. Multiple variations of hull shape, frame patterns, hatches and castle shapes were modeled as different layers of the model, to ‘try out’ different configurations of timbers. Two stern sections (one without a tiller port or rudder, and one that incorporated both) were constructed. This sort of wholesale modification, particularly so late in the building process, would have been much harder with traditional pen-and-ink drafting.

Finally, the model was built entirely with the Portuguese increments of *dedos*, *palmos de goa*, *rumos*, and *braços*. Computer modeling allowed me to set my scale once, when the model was started, and then to think and model only in period increments, without having to make any calculations for scale or adjustments for different measuring systems. This is not unique to computer modeling, but it is certainly convenient.

SHORTCOMINGS

Problems with this reconstruction are due to three main factors; mathematical error, choice of program, and designer limitations.

By far the largest shortcoming with this model relates to the dimensions mentioned above. While the measurements I used for *palmos* (25.68cm), *rumos* (1.54m), and *bracos* (2.048m) were correct, when I first started to model a *nau* using Rhinoceros, I used the wrong figure for *dedos* (I used 4.28cm but the correct length is 1.83cm) and I continued to use this figure throughout this reconstruction. Although I cannot find the original source for this error; Dr. Castro and I believe it was based upon my misinterpretation of a Spanish document. The result is most obvious in the thickness of

the planking (which was specified in *dedos*); my 4-*dedo* (17.12cm) planks should have only been 7.32cm thick.

Although this model was created with Rhinoceros 3.0 software, I would not choose to do another model of this sort with the same modeling software. I started modeling in Rhinoceros because I had used it in course work, not because it was the best tool for the job. The program excels at creating images of 3D artifacts, but is not the best choice for building a ship model that can be tested for strength and stability afloat. Rhinoceros is a surface modeler, not a solid modeling program; to create a solid object with this software, the modeler creates each of the surfaces that enclose it. In Rhinoceros, for example, a beam would be created by making the six surfaces that define it – its two ends and four sides. Every part of the model is really a hollow shape enclosed by surfaces. In a solid modeling program, such as SolidWorks or Autodesk Inventor, each object is created from the start as a solid, multi-sided part. Many of the tools in such a solid-modeling program act the same as their real-world counterparts; for example, objects can be milled, punched, and extruded in the modeling process. The solid parts can be assigned mass properties (weight, tensile strength, and so on) and can be tested with engineering software.

A related problem with Rhinoceros is the question of fasteners. My *nau* model shows the location of every part of the ship, but none of the individual parts is actually fastened together. Because solid modeling software has been developed to make parts for production, those programs include tools for creating and inserting fasteners. A ship

modeled in SolidWorks could be nailed and pegged together, in the same manner as the original, and the strength of the construction tested in virtual seas.

Finally, some of the shortcomings in the model are the result of designer limitations rather than drafting or software problems. Some structural elements were just not well defined, and I was forced to make a “best-guess” as to their shape and dimensions without much archaeological or iconographic data to back up my design (the knees, for example, are modeled with the same width as the beams and frames they are fastened to, but their actual dimensions were never specified. I cannot compare them to those in other vessels, since I know so little about their actual size). While I am confident that the planking above the first wale is arranged plausibly, I was not able to work out how to lay the plank runs below the first wale. In the real world, the shipwright had much more control of the plank runs than I was able to achieve. After several failures to come up with a plausible arrangement of timbers, I simply modeled a shell of planks to fill in the lower planking.

Modeling line by line from a 16th-century document has been at times painstaking, exciting, challenging, and frustrating in equal measure. The task was painstaking in the placement (and subsequent replacement or modification, in some cases more than once) of each frame and plank. It was exciting when the sequence explained something heretofore unconsidered (for example, the placement of the *cordas* to frame the hatches on each deck also gave me the maximum angle the pumps could take from the vertical as well and defined the maximum size of the *tamboretas* and *paixoes*). It was challenging when not only the *Livro Nautico* entry, but the treatises, iconography, and archaeological

evidence all failed to explain just how the timbers could be fit together in accordance with the terse description given (the worst case being the tack timbers at the end of the document), and frustrating when the dictates of the *Livro Nautico* disagreed with the treatise authors or with my understanding of Iberian shipbuilding practice or terminology. I believe that the resulting model and annotated construction sequence has shed new light on the *nau* of the *Livro Nautico*.

REFERENCES

- Anderson, J. A. 2000. *The History of Portugal*. Westport, CT: Greenwood Press.
- Anderson, R. C. 1955. *Seventeenth Century Rigging: A Handbook for Model Makers*. Hertfordshire, England: Model and Allied Publications.
- Anonymous. 1995. *Memória das armadas que de Portugal passaram à Índia*. Facsimile printed in 1995. Macau: Comissão Territorial de Macau para as Comemorações dos Descobrimentos Portugueses.
- Barkham, M. 1981. Report on 16th Century Spanish Basque Shipbuilding c. 1550 to 1600. Parks Canada Manuscript Report. Ottawa, Canada: Parks Canada.
- Bellabarba, S. 1993. "The Ancient Methods of Designing Hulls." *The Mariner's Mirror*, volume 79(3): 274-292.
- Birmingham, D. 1993. *A Concise History of Portugal, Second Edition*. Cambridge, England: Cambridge University Press.
- Bondioli, Mauro. Personal communication. Via Strada Vecchia, 68/1, 42011 Bagnolo in Piano, Reggio Emilia, Italy.
- Boyajian, J. C. 1993. *Portuguese Trade in Asia under the Hapsburgs, 1580-1640*. Baltimore, MD: Johns Hopkins University Press.
- Boxer, C. R. 1969. *The Portuguese Seaborne Empire, 1415-1825*. New York: A. A. Knopf.
- Castro, F. Viera de. 2000. "The Last Field Season on the Pepper Wreck: A Preliminary Analysis of the Hull." *INA Quarterly*, 27(4): 3-9.
- Castro, F. Viera de. 2005a. *The Pepper Wreck: A Portuguese Indiaman at the Mouth of the Tagus River*. College Station, TX: Texas A&M University Press.
- Castro, F. Viera de. 2005b. "Rigging the Pepper Wreck. Part 1—Masts and Yards." *International Journal of Nautical Archaeology*, 34(1): 110-122.
- Castro, F. Viera de. Personal communication. Nautical Archaeology Program, Texas A&M University, Anthropology Bld. 105, College Station TX 77843-4352
- Castro, J. de. 1991. *Roteiro do Mar Roxo de dom João de Castro : Ms. Cott. Tib. DIX da British Library*. Facsimile and transcription printed in 1991. Lisbon, Portugal: Edições INAPA.

- Chapman, C. J. 1998. "The Construction of European Sea-Going Vessels in the Sixteenth Century: A Comparison Based on the Archaeological Evidence". M.A. thesis, Texas A&M University.
- Duffy, J. 1955. *Shipwreck and Empire: Being an Account of Portuguese Maritime Disasters in a Century of Decline*. Cambridge, MA: Harvard University Press.
- Duncan, T. 1986. "Navigation Between Portugal and Asia in the Sixteenth and Seventeenth Centuries". In *ASIA AND THE WEST: Encounters and Exchanges From the Age of Explorations*, edited by C. K. Pullapilly, 3-25. Notre Dame, IN: Cross Cultural Publications.
- Esparteiro, A. M. 1962. *Dicionário Ilustrado de Marinha*. Lisbon, Portugal: A. M. Texeira and C.^a (Filhos) Lda.
- Fielding, A. 1982. "Section through the waist of the ship." Illustration in *The Mary Rose: The Excavation and Raising of Henry VIII's Flagship*, Margaret Rule, author, 120. London, England: Conway Maritime Press.
- Fernandez, M. 1616. *Livro de Traças de Carpintaria*. Facsimile, transcription and translation into English printed in 1989. Lisbon, Portugal: Academia de Marinha.
- French Ministry of Culture and Communication. 2002, 18 September. "La Lomellina." <http://www.culture.gouv.fr/culture/archeosm/archeosom/en/lomel-s.htm> (22 December 2006)
- Friel, L. 1994. "Two early representations of the Mediterranean *cocha*". Illustration in *Cogs, Caravels, and Galleons: The Sailing Ship 1000-1650*, edited by R. W. Unger, 78. London, England: Conway Maritime Press.
- Guinote, P., E. Frutuoso and A. Lopes. 1998. *NAUFRÁGIOS E OUTRAS PERDAS DA "CARREIRA DA ÍNDIA": SECULOS XVI E XVII*. Lisbon, Portugal: Grupo de Trabalho do Ministério da Educação para as Comemorações dos Descobrimentos Portugueses.
- Kirsch, P. 1990. *Galleon: The Great Ships of the Armada Era*. London, England: Conway Maritime Press.
- Lane, F. C. 1934. *Venetian Ships and Shipbuilders of the Renaissance*. Baltimore, MD: Johns Hopkins Press.
- Lavanha J. B. 1610. *Livro Primeiro de Arquitectura Naval*. Facsimile, transcription, and translation into English printed in 1996. Lisbon, Portugal: Academia de Marinha.

Lisuarte de Abreu. 1992. *Livro de Lisuarte de Abreu*. Facsimile printed in 1992. Lisbon, Portugal: Comissão Nacional para as Comemorações dos Descobrimentos Portugueses.

Livermore, H. V. 1966. *A New History of Portugal, Second edition*. Cambridge, England: Cambridge University Press.

Marques, A. H. de Oliveira. 1972. *History of Portugal, vol.1: From Lusitania to Empire*. New York: Columbia University Press.

McManamon, J. 2001. "The 'Archaeology' of Fifteenth-Century Manuscripts on Shipbuilding." *The INA Quarterly*, 28(4): 17-25.

Navarro, Juan Jose. *Album del Marqués de la Victoria*. Facsimile reprinted in 1995. Barcelona, Spain: Museu Naval and Lunwerg Editores, S.A.

Newitt, M. 2005. *A History of Portuguese Overseas Expansion, 1400–1668*. London, England: Routledge.

Oertling, T. 2004. "Characteristics of Fifteenth- and Sixteenth-Century Iberian Ships." In *The Philosophy of Shipbuilding: Conceptual Approaches to the Study of Wooden Ships*, edited by F. M. Hocker and C. A. Ward, 129-136. College Station, TX: Texas A&M University Press.

Oliveira, F. 1580. *Livro da Fabrica das Naus*, Facsimile, transcription, and translation into English printed in 1991. Lisbon, Portugal: Academia de Marinha.

Palacio, D. Garcia de. 1587. *Instrucción nauthica para el buen uso y regimiento de las naus, su traza y gobierno*. Pedro Ocharte, Mexico City. Reprinted and translated into English by J. Bankston. Bisbee, AZ: Terranate Associates.

Payne, S. G. 1973. *A History of Spain and Portugal in Two Volumes*. Vol 1. Madison, WI: University of Wisconsin Press.

Perez-Mallaina, P. E. 1998. *Spain's Men of the Sea: Daily Life on the Indies Fleets in the Sixteenth Century*. Translated by Carla Rahn Phillips. Baltimore, MD: Johns Hopkins University Press.

Phillips, C. R. 1994. "The Caravel and the Galleon." In *Cogs, Caravels, and Galleons: The Sailing Ship 1000-1650*, edited by R. Gardiner, 91-114. London, England: Conway Maritime Press.

Pontillo, J. J. 1975. "Nautical Terms in Sixteenth Century American Spanish". Ph.D. diss., Texas A&M University.

Subrahmanyam, S. 1993. *The Portuguese Empire in Asia, 1500–1700: A Political and Economic History*. London: Longman Group UK, Ltd.

Subrahmanyam, S., and L. F. F. R. Thomaz. 1991. “Evolution of Empire: The Portuguese in the Indian Ocean During the Sixteenth Century.” In *The Political Economy of Merchant Empires*, edited by J. C. Tracy, 298-331. New York: Cambridge University Press.

Unger, R. 1994. “The Carrack: The Advent of the Full Rigged Ship.” In *Cogs, Caravels, and Galleons: The Sailing Ship 1000-1650*, edited by R. Gardiner, 77-90. London, England: Conway Maritime Press.

SUPPLEMENTAL RESOURCES CONSULTED

Afonso, S., ed. 1998. *Nossa Senhora dos Mártires: The Last Voyage*. Verbo / Expo’98, Lisbon, Portugal.

Anonymous. 1575-1625. *Livro Náutico*. Anonymous manuscript in Codex 2257 in the Secção de Reservados of the Biblioteca Nacional de Lisboa. Selected documents transcribed and contents listed in *Estudos sobre navios portugueses nos séculos XV e XVI* by Henrique Lopes de Mendonça in 1892. Lisbon, Portugal: Academia Real das Ciências.

Simoões, F. O., and M. Leitão. 2004. *Modelo da Nau “Madre de Deus.”* Lisbon, Portugal: Museu de Marinha.

Tracy, J. D. 1991. *The Political Economy of Merchant Empires*. New York: Cambridge University Press.

APPENDIX A

AN INDIA *NAU* RECONSTRUCTED

The reconstruction of an India *nau* that was made for this dissertation was done with Rhinoceros 3.0 software. Because of the large file size of the model (112,637 Kbytes) it is hosted separately on the Theses and dissertations section of the Texas A&M University Digital Archive, at <http://txspace.tamu.edu/handle/1969/2>

A fully functional evaluation version of the Rhinoceros 3.0 software that will let the viewer view and manipulate the model without restriction but will not save any changes is available as a free download at <http://download.mcneel.com/rhino/3.0/eval/default.asp>

This software is only available for the Windows operating system.

APPENDIX B

GLOSSARY OF PORTUGUESE SHIPBUILDING TERMS

	English1	notes
Abatimento da madeira	Bevelling	
Abita	Forecastle	
Abita	Forecastle	
Abobada	Counter	
Adriça	Halyard	
Alçaçava	(Stern) Castle	
Alçaçeva	(Stern) Castle	
Alçaçova	(Stern) Castle	
Alefriz	Rabbet	
Almogamas	Tail Frames	Last of the pre-designed frames
Amantilhos Grandes	Main Lifts	
Amure	Halyard or Tack Timber	Rounded bow timber where these are belayed
Antrecostas	Intercostal (side to side) beams	
Antremichas	Deck Supports	Cross beams fit between the knees
Apostareus	Futtock Timbers	
Apostura	Top Timber	
Aposturage	Top Timber	
Aposturagem	Top Timbers	
Arevesado	Fashion Piece	
Armamentos	Ship's Gear	Masts, sails, yards, oars, rudder
Arpa	Aft Forecastle Bulkhead	
Arrevesado	Fashion Piece	
As de Popa		
Astes	Futtocks	
Astilha	Foot of the floor	The part of the floor that sits on the keel
Astilha	Rising	
Bandas	Beakhead Side Timbers	Also "sides"
Barçolas	(Hatch) Coamings	
Barra	Horizontal timber	Part of the stern grid
Barra	Capstan Bar	
Barrote	Vertical timber	Part of the stern grid
Barrotes	Joists	
Boca	The ship's Beam at the main deck	Set at 1/3 of keel length
Bolinas	Bowlines	

Bomba	Pump	
Boneca	Knighthead	
Bonequa	Knighthead	
Braço	First Futtock	From Lavanha
Bracolas	(Hatch) Coamings	
Buçarda	Breasthook	
Bulinas	Bowlines	
Cabestrante	Capstan	
Cabrestante	Capstan	
Calafete	Caulking	
Calçês	Mast Doubling	i.e., where the mast and topmast overlap
Calimas	Stern Planks	From Lavanha
Calimetes	Stern Planks	
Cambota	Counter Timber	
Cana	Tiller Arm	Attached to the rudder
Canto	Interior/Exterior Faces of Frames	
Capelo	Top of the Stern	
Carafate	Caulking	
Carlinga	Mast Step	
Carregadeira	Downhaul	
Castanhas	Cleats	
Castellos da Proa	Forecastles	
Caverna	Frame	
Caverna Mestra	Master Frame	
Ceraviolas	Catheads	
Cevadeira	Spritsail	
Chapiteo	Poop Deck	
Chapuzes	Mast Reinforcing Knees	
Chumaceira	Block or Bearing	
Chumaçeira	Block or Bearing	
Cintas	Wales	
Cintas	Wales	
Cintas Dobradas	Doubled Wales	
Coçeira	Longitudinal Timber	These are placed right above the trinquanis
Codaste	Stern Post	
Conchas	Windlass/Capstan Side Frames	
Contra Dromente	Lower Clamp	This reinforces the dromente
Contra Escovem	Hawsehole Reinforcement	Ring-shaped reinforcement for the hawsehole
Contra Falcao	Beakhead Reinforcement	
Contra Roda	Inner Stem Post Timber	

Conves	Weatherdeck	
Conves	The uncovered deck amidships	
Coraes de Popa	Stern Timbers	Deadwood, Inner Stern Knees
Coral	Stemson or Sternson	
Coral de popa	Inner Stern Knee or Hook	
Corde	Carling	
Costado	Side	The planking of the hull, the side of the ship
Cotamento	Bevelling	
Couce de Popa	Stern Heel	Keel/Sternpost transition piece
Cuberta	Deck	
Cunhos	Belaying Cleats	
Curva do Beque	Beak knee	Knee supports the beak or bowsprit
Curva do falcão	Beakhead Deck Knee	Knee that supports the Beakhead deck
Curvas	Knees	
Dala	Dale (Drainpipe/Scupper)	The Pump Dale
Distegas	Two-decked vessels	
Dormente	Clamp or Beam Shelf	
Dragas	Inwales or Stringers	
Dragas	Stringers	
Driça	Halyard	
Dromente	Clamp or Beam Shelf	Beam ends rest on this
Emendas	Stealer Planks	
Enchimento	V-Frame	
Entremicha	Deck Support Knees	The long arm of these knees are scarfed together transversely to support the deck
Escoa	Bilge Stringer	
Escoas	Bilge Stringers	
Escotas Grandes	Main Sheets	
Escoteiras	Sheet Bitts	
Escovem	Hawse Timber	The Hawsehole is cut through this heavy timber
Estrinqua	Windlass	
Estroncados	Vessels with no decks at all	
Face	Fore/Aft Faces of Frames	
Falcão	Beakhead Timber	
Forma	Template for Frames	
Garganta	Mast Throat	Just below the Cheeks at the top of the mast
Gavea da Proa	Fore Top	
Gavea Grande	Main Top	
Gingamoche	Handle or lever	For example, a pump handle
Gingamoche da Bomba	Pump Handles or Levers	

Gingamocho	Handle or Lever	
Gio	Transom	
Goroupez	Bowsprit	
Governalho	Rudder	
Grade	Stern Grid	Formed of Gio, Barrotes, and Barras
Gurupes	Bowsprit	
Habita	Lodging (in the forecastle)	By extension, this is another name for the forecastle
Habita	Lodging (forecastle)	Oliveira says this is because the boys live here.
Lancamento	Rake or Spring	
Lata	Beam	
Lata	Deck Beam	
Leme	Rudder	
Madres das Escotilhas	Hatch Frames	
Manço	Fashion Piece	
Mão	Shorter branch of a Knee	
Mareage	Waist Rail or Bulwarks	
Mareagem	Waist Rails or Bulwarks	
Mastareo	Top Mast	
Mastareo de Proa	Fore Top Mast	
Mastareo Grande	Main Top Mast	
Masto	Mast	
Masto da Mezzena	Mizzen Mast	
Masto do Traquete	Fore Mast	
Masto Grande	Main Mast	
Mastro	Mast	
Mesa	Sill or Lower Beam	Literally 'table', can be any horizontal surface
Mesa de Telhado	Roof Sill	
Mesa do Seis Bordo	Loading Hatch Sill	
Mesas de Proa	Fore Channels	
Mesas Grandes	Channels	
Monostegas	Single-decked vessels	
Mulinete	Small winch	A 'mill', a small, hand-cranked winch
Obras Mortas	Dead Works	Upper works; Castles and the like
Ostagas	Yard Tyes	
Ostingues	Yard Tyes	
Paa	Blade Rudder or Side Rudder	As opposed to a rudder mounted on the sternpost
Paixoes	Mast Partners	
Papamosqua	Gammoning Knee	

Passaro	Kevel	
Patilha	Skeg	Also called Unha or Polegar do Leme
Peis de carneiro	Stanchion	
Peitoris	Parapets	Part of the Varanda
Perpao	Transverse Beam	A strong cross beam in the Castle
Pes de Carneiro	Stanchion	
Pica	Epsilon Frame	
Pincao	Whipstaff	
Piqua	Epsilon Frame	
Polystegas	Many-decked vessels	
Porquas	Stern Panel Timbers	These make the grid of the stern panel
Porquetes	Mast Wedges	
Portalo	Gangway	
Pousa Verga	Yard Rest	
Pregadura	Fastenings	
Primera Cuberta	Lowest or Orlop Deck	
Quilha	Keel	
Ragel	Stern Deadwood	The deadwood below the fashion pieces at the stern
Rede	Netting	Raised on poles above the deck
Reversado	Fashion Piece	
Reversado	Fashion Piece	
Roda	Stem Post	
Seis Bordo	Loading Hatch	On the port quarter aft at 1st Deck level
Sisbordo	Loading Hatch	
Sobrecostado	Double planking	
Sobrequilha	Keelson	
Sotamento	Bevelling	
Sovina	Treenail	
Tabuado	Planking	
Tamboretetes	Fore and Aft Mast Partners	
Telhado	Roof	
Tojinos de Cabestrante	Capstan Whelps	
Tolda	Quarterdeck	
Torno	Treenail	
Traquete	Foresail	
Trilhoes	Rails	
Trinquanis	Waterways	
Tristegas	Decked Vessels	Particularly 3-deckers but also a general term
Troças	Trusses	This holds the yard to the mast
Trocas Grandes	Main Truss	

Varanda	Stern Gallery or Balcony	
Verga da Cevadeira	Spritsail Yard	
Verga da Gavea da Proa	Fore Top Yard	
Verga da Gavea Grande	Main Top Yard	
Verga da Mezzena	Mizzen Yard	
Verga do Traquete	Fore Yard	
Verga Grande	Main Yard	
Virotes	Filler Timbers	

APPENDIX C

TRANSLATED *LIVRO NAUTICO* TEXT**Medidas pera fazer hũa Nau de seiscentas Tonelladas, e os paos q̄ hà de leuar de Souoro e Pinho****Measurements to make one Nau of Six Hundred Tons, and the timbers that it will take in both Cork Oak and Pine**

|| Primeiramente a Quilha terá de comprido de esquadria a Esquadria, dezasete Rumos, e terá esta Quilha de grossura hú palmo de Goa, e de altura terá mais dous dedos; leura esta Quilha cõ os couçes sete paos. bij. p.

Primarily the keel will have of length and from end to end 17 Rumos, and will this keel have the thickness of one palmo de goa, and molded another two fingers [total molded is 1 palmo de goa and two fingers], it will take, to make this keel, with the couçes [the timbers that make the transition between the stempost and the keel, and the sternpost and the keel], seven timbers.

|| A Roda que he a Segunda cousa que se arma, terá de Altura çincoenta palmos de Goa, e terá de lançamento, trinta e cinco palmos, por esta conta: de cada dez palmos que ests Roda tiner d'altura lhe tirarão tres, e os que fiquarem he o lançamento: será mais alta na madeira que a quilha dous dedos: leuará esta Roda tres paos, e por dentro quatro coraes, que he contra Roda, e são sete paos. ij. p.

The stempost, which is the second thing one puts in, will be 50 palmos de goa high and will spring 35 palmos, in this way: for each ten palmos that the stem rises in height, we will take three, and the ones that remain are the spring, how much it goes forward. It will be higher, in the timber, meaning its section will be thicker, two fingers. The stempost will take three timbers to make it and from the inside will be put four coraes, which are inner sternposts, which is called contra Roda, and these are seven timbers.

|| O Codaste, que he o terceiro que se arma sobre o couce de popa, terá de grossura palmo, e meo em quadrado, e tera d'altura corêta, e dous palmos de Goas .s. dezasete palmos que leua esta Nau de Ragel, que pera boa conta dezasete Rumos de Quilha dezasete palmos de Ragel: deste Ragel pa çima hà uinteçinco palmos, em que hão de caber tres Cubertas, desta maneira; a primr.^a cuberta leuanta do Ragel seis palmos, e a Segunda faz de uão oito palmos, e a terceira faz de uão sete palmos, e mais tres palmos que a madeira leuanta fazê os uinteçinco: o lançamento d'este Codaste sera deste maneira: de cada quatro palmos que tiner d'altura lançará hũ; leua este Codaste dous paos. ij. p.

The sternpost, which is the third timber which one puts over the couce de popa [the outer stern knee, the 'hook' one sees in cogs, which is the transition between keel and posts], will have one palmo and a half in thickness square, and will have forty-two palmos de goa in height and seventeen palmos that this Nau takes as Ragel [the deadwood aft, which runs to the stern] that for good accounts seventeen Rumos of keel seventeen palmos of Ragel: from this Ragel above there will be twenty-five palmos in which the three decks will fit, in this way: the first deck will rise six palmos, the second will have eight palmos, and the third will have seven palmos, and three more palmos that the wood fills in between makes the twenty-five: the sternpost rakes abaft in this manner: for each four palmos that it rises, it will rake one abaft, this sternpost takes two timbers.

|| O Gio, que he o que alrauesa sobre esta Codaste há de ter uinteçinco palmos de Goa de largura, que ha a metade de largura, que a Nau ha de ter, e terá de grossura no meo palmo e meo, e na ponta hũ palmo, leua tres paos de souoro, e dous de Pinho manso na grade q̄ faz. iiij. p.

The Gio, which is the timber that crosses over the sternpost will have twenty-five palmos de goa of breadth, which is half of the maximum breadth the Nau will have, and will have thickness in the middle one palmo and a half, and in the end one palmo, and it takes three timber of Cork Oak, and two of Stone Pine in the gridding that it makes.

|| Esta Nau pera boa conta terá tantos pares, como tem de Rumos na Quilha, de modo q̄ dezasete Rumos, dezasete pares, e a Cauerna mestra se há de assentar tres Rumos auãte do meo da Quilha, porq̄ o meo da Quilha he o lugar onde assenta o pe do masto grãde: irá esta Cauerna tres Rumos pa proa, e da qui a esquadria ficão çinco Rumos, e meo, nos quais hão de caberos dezasetes pares, q̄ tanto de uão, como de cheo fazẽ os trinta e quatro palmos; e quando a madeira ajunta fica a Almogama, que he a derradeira cauerna hũ Rumos a tras da Esquadria, e outro tão, que occupa a madeira, da mestra pa a Popa ficão de Quilha uazia, seis Rumos, da Almogama a Esquadria de Popa, e da qui começa a fazer o Ragel, que chamão delgado: Esta Almogama de Popa, terá de gaminho tres palmos de goa, porq̄ tres uezes seis são dezoito palmos que ha de ter o Ragel.

This Nau, to be beautiful, will have as many pre-designed frames, as it has of Rumos of the keel, this means that for seventeen Rumos of keel the ship will have seventeen frames, and the master frame will be set over the keel three Rumos before the middle of the keel, because the middle of the keel is the place where we put the foot of the main mast: on this midship frame, three Rumos to the bow, and from there to the forward end of the keel will be five Rumos and a half on which will have to fit the seventeen pre-designed frames that this ship will have forward, and this means seventeen floors and seventeen futtocks, and that will make the thirty-four palmos building the room and space; and when these frames that are put next to each other will end the last one will be called Almogama which is the last frame one Rumos below the forward end of the keel, and so much that this timber will take over the keel from the master frame to the stern,

and abaft that place, will be six Rumos of keel without any frames, this is the Ragel that we also call delgado[which means just ‘thin’]: this stern Almogama [tail frame] will have of gaminho three palmos de goa, because three time six is eighteen palmos the Ragel will have [the total rise abaft is three palmos].

|| Leua esta Nau dezasete pares que são trinta e quatro cauernas xxxiiij.

p.

This ship will take seventeen pairs which are thirty-four frames

|| Leua nestas cauernas sessenta, e oito braços Lxbiiij. p.

It takes in these frames sixty-eight futtocks

|| Leua dalmogama pa proa treze ênchimêtos xii. p.

From the tail frame to the bow it takes thirteen ênchimêtos [V-frames or fillings -- floor frames that are not pre-designed]

|| Leua nestes enchimentos uinteseis Astes xxbj. p.

It takes on these fillings twenty-six Astes [the futtocks for the fillings]

|| Leua a Popa uinte hũ enchimentos, e piquas xxj. p.

It takes to the stern twenty-one enchimentos [v-frames] and piquas [epsilon frames]

|| Leua corenta, e dous areuessados Rij. p.

It takes forty-two areuessados [fashion pieces or concave futtocks]

|| Leua por dentro hũa Carlinga pao masto, e dous trinquanis das bandas pa fazer forte iij. p.

It takes inside one Carlinga [mast step], and two trinquanis [waterways] on both sides to make it stronger [these support the mast step against lateral movement, one on either side]

|| Leua dous Coraes de Popa ij. p.

It takes two coraes [deadwood timbers] to the stern

|| Leua dez Palmejares q~ são sobrequihas x. p.

It takes ten timbers that make the keelson

|| Leua na primeira aposturagẽ cento, e corenta paos c.^{to}R. p.

It takes on the first aposturagẽ [top timbers] a hundred and forty timbers

|| Leua nos dromentes, e contradromentes da primeira cuberta corẽta e quatro paos Riiij. p.

It takes in dromentes [clamps] and contradromentes [lower clamps] of the lower deck forty-four timbers

Pinho Lxx. p. || Leua settenta Paos de çintas de Pinho mãso nas Escoas

It takes seventy timbers of Stone Pine for Escoas [stringers]

|| A primeira cuberta se assenta nesta manr.^a atrauesarão hũ Cordel a Prumo do meo da mestra em altura de quatorze palmos que ha de ter de pontal, que he porão, e da qui pa baixo uai o dromente, e A prumo da Carlinga, porão hũ ponto, e da hi pa a Popa farão hũ uão de tres palmos, e pera a proa de dous palmos, que são cinco que o uão onde uay o Masto, e logo meterão duas latas juntas, e farão outro uão de dous palmos, e meo pera as Bombas,

To lay the first deck we do the following, we put a cord vertically in the middle of the midship frame, fourteen palmos high which is the depth in hold of our deck, which is called porão [the hold], and from here below we lay the dromente [the clamp, which supports the deck of the hold, is fastened to the frame so that the upper surface is 14 palmos above the center of the floor].

And vertically above the mast step, they will mark another point and from here to the stern they will make one interval of three palmos, and to the bow two palmos, on these five palmos the mast will follow, and then they put two deck beams which will make two palmos, and leave the middle clear for the pumps, [moving aft from the mast, first two deck beams, then space of two palmos, then continue the deck beams]

e da qui a escotilha de Popa hauerá sete palmos moçoço, e a Escotilha terá outros sete palmos ã quadrado porque caiba pipa; e do masto pa Proa farão outros sete palmos de moçoço, e logo a Escotilha do meo que terá outros sete palmos, e desta Escotilha aa de Proa hauerá uinte a hũ palmos de moçoço, e a escotilha terá outros sete palmos.

And from here the hatch will be seven palmos strong/thick/filled with timber, and a hatch of another seven palmos in square so that barrels can fit; from the hatch to the stern there will be seven palmos filled, and the hatch will be another seven palmos

square so that barrels can fit, and from the mast to the bow, they will put another seven palmos filled with timber, and then, the middle hatch that will have another seven palmos, and from this hatch to the bow, there will be twenty-one palmos filled, and the hatch will have another seven palmos [the hatch is seven palmos square]

Pinho Lxxx. p. || Leua nesta primeira cuberta oitenta latas antre grandes, e pequenas

It takes on the first deck eighty beams between big and small

Pinho xiiij. p. || Leua quatorze cordas que são as latas que lião as outras de longo

It takes fourteen cordas [carlings] which are the beams that connect the others in length [the carlings are fit fore and aft between the crossbeams]

|| Leua dezaseis Bonequas que são oito paos biiij. p.

It takes sixteen Bonequas [knighthead timbers] which are eight timbers

|| Leua trinta e dous peis de carn.^o no porão xxxij. p.

It takes thirty-two peis de carn.^o [stanchions] in the hold

|| Leua quatro paixóes no lugar do masto q~ são paos aonde fechão os tamboretas iiij. p.

It takes four paixóes [mast partners] that enclose [and reinforce] the tamboretas [fore and aft mast partners]

|| Leua uinte e hũ trincanis nesta primr.^a cuberta xxj. p.

It takes twenty-one waterways on the first deck

|| Leua na Popa quatro areuessados iiij. p.

It takes on the stern four areuessados [cant frames]

|| Leua noue porquas nesta Popa ix. p.

It takes nine porquas [the vertical and horizontal timbers that close the grid of the stern panel] in the stern

|| Leua doze duzias de taboado de pinho brauo nos soalhados desta
Pin. xij. duz.^{as} cuberta cõ as escotilhas

It takes twelve dozen of Pinho Brauo for the planking/decking of this hold including the hatches

|| Leua no porão hũa Buçarda j. p.

It takes a breast hook in the hold

Pin. x. p. || Leua dez Dragas de pinho manso

It takes ten stringers of Stone Pine

|| Leua esta primeira cuberta quatorze carreiras de curuas que são uinte oito curuas de conues xxbij. p.

It takes fourteen lines of curves which are twenty-eight curuas de conues [hanging knees]

|| Leua uinte antremichas porq~ as do meo não chegãõ xx. p.

It takes twenty antremichas [these are knees with one long arm, which extend across the hull beneath the deck to support it, with the two long arms of each pair scarfed together]

|| Leua duas curuas a popa que liãõ pellas cordas, e pellas porquas ij. p.

it takes two curuas [horizontal knees/lodging knees] at the stern which connect the cordas [stringers] and the porquas [the timbers which make the grid of the stern panel]

|| Leua hũa Buçarda nas dragas j. p.

It takes another Buçarda [breasthook] at the dragas [the stringers]

Pin. xij. p. || Leua hũa duzia de tauoado de pinho mãso nas dragas

It takes one dozen of planking of Stone Pine in the dragas [stringers]

Pin. x. p. || Leua dez taboas de pinho manso nas coçeiras
It takes ten planks of Stone Pine in the coçeiras

Pin. ij. p. || Leua dous paos de pinho manso nas madres das Escotilhas

It takes two timbers of Stone Pine in the madres das Escotilhas [the frame around the hatches]

|| Quando se cordea esta primeira cuberta, se cordea tambem a primeira çinta

q~ a proa na Roda uay em altura de uinte hũ palmos de goa a Esquadria, e no meo da Nau uay por onde o dromente da cuberta, e a Popa de todo leuanta hũ palmo da cuberta, que boa conta **pa** a terceira çinta ficar sãa aos seis bordo.

When you put the cordas [carlings] in this first deck, you put the first wale that at the stempost dies at a height of twenty-one palmos, and at the center of the Nau it goes exactly at the level of the beam [the clamp that was set at 14 palmos], and that at the stern it rises one palmo from the deck, which is a good dimension for the third wale to be even with the seis bordo [the stern window or hatch – this is a hatch in the side of the hull, at the stern]

|| Acabada de soalhar a primeira cuberta, balisarão a segunda Aposturagẽ, a qual feita, porão a apostura de Popa do seis bordo dous Rumos auante da Porqua de Popa, e desta apostura a outra dauante hauerá sete palmos, **q~** tantos hà de ter o seis bordo em quadrado, pera que caiba Pipa por elle: este seis bordo fica direito da Esquadria do coçe que tanto lança o Codaste.

After planking the first deck, we will put reference points for the second aposturagẽ [top timbers], which is done, and will put the top timbers of the seis bordo [the hatch in the side of the stern] two Rumos before the Porqua de Popa [the grating of the stern panel], and from this timber forward the hatch will be seven palmos, which is the size of the seis bordo in square [that is, the seis bordo is seven palmos square], so that a barrel can fit through: This hatch stays straight exactly on the vertical of the coçe [the knee connecting keel and stern post] because two Rumos is what the sternpost springs abaft. [the after end of the seis bordo is two rumos forward from the stern panel, which puts it vertically inline with the foot of the sternpost]

A aposturada esta segunda aposturagẽ assêtarão o dromente da segunda cuberta que irá em altura de oito palmos, e latarão logo desta maneira,

And having made this second aposturagẽ [set of top timbers] we will lay the clamps/beams of the second deck and this will go eight palmos high, and it will be beamed in this way,

atrauessarão hũa lata hũ palmo **pa** a Popa da que uai em baixo, que tanto ha de encostar o masto a Re, e isto farão em todas as cubertas, e logo farão o lugar das bombas como na outra cuberta, e da hi **pa** a Popa será todo latado tanto de uão como de cheo: a Escotilha do meo, e a de Proa serão a prumo das de baixo, e **pa** a Proa será latado da mesma maneira que a Popa.

you will lay one crossbeam one palmo to the stern from the one that is below [on the second deck, the beam at the forward edge of the mast opening is set one palmo aft of the beam on the deck below], which is what the mast will rake abaft, and this will be done in all of the decks, and immediately after will make a place for the pumps, as we have done in the previous deck, and from here to the stern it is full of beams with empties and fulls [one space, one room]: and the middle hatch and the forward hatch will be set exactly vertical over the ones below, it will be layed to the bow in the same manner as the stern [one space, one room].

|| Leuará nesta segunda Aposturagẽ cento, e corenta aposturas c. R. p.

It will take in this second Aposturagẽ one hundred and forty aposturas [top timbers]

|| Leua nesta segunda cuberta dezanoue dormentos xjx. p.

It takes in the second deck nineteen dormentos [clamps]

Pin. Lxxxiiij. p. || Leua oitenta e tres latas

It takes eighty-three latas [beams]

Pin. xbj. p. || Leua dezaseis cordas **q**~ são as que uão de longo

It takes sixteen cordas [carlings] which are those ones which run along the vessel

|| Leua uinte oito curuas de Reves xxbiiij. p.

It takes twenty-eight curuas de Reves [standing knees]

|| Leua hũa mesa do seis bordo j. p.

It takes one mesa [the sill or lower beam] for the seis bordo [the hatch in the side at the stern]

|| Leua quatro paixoes iiij. p.

It takes four paixoes [mast partners]

|| Leua dezoito trinquanis xbiij. p.

It takes eighteen trinquanis [waterways]

|| Leua duas curuas nas cordas que lião a Popa ij. p.

It takes two curuas [curves] in the carlings that connect to the stern [in other words, two lodging knees that connect the carlings to the stern]

Pi. xbj. duz.^{as} || Leua dezaseis duzias de taboãdo de Pinho brauo no soalhado

It takes sixteen dozens of Pinho brauo [Wild Pine] for the decking

Pi. Rij. || Leua corenta e dous peas de carneiro por baixo

It takes forty-two peas de carneiro [stanchions] underneath

|| Leua quinze carreiras de curuas de cõues que são trinta curuas xxx. p.
It takes fifteen rows of curuas de cõues [hanging knees] which makes thirty standing knees

|| Leua uinteçinco antremichas xxv. p.

It takes twenty-five antremichas [knees with one long arm, which extend across the hull beneath the deck beams for support, with the two long arms of each pair scarfed together]

|| Leua hũa Carlinga pera o mastro do traquete e são quatro paos iiij. p.

It takes one carlinga [mast step] for the mastro do traquete [foremast] with its cunhos [buttresses, the heavier beams in which the mast step stands] which are four timbers

|| Leua hũa agucarda das Dragas j. p.

It takes one agucarda [breasthook] in the stringers

Pi. xij. p. || Leua hũa duzia de taboado de Pinho mãso nas dragas

It takes one dozen Pinho mãso [Stone Pine] timbers for the dragas [stringers]

Pi. xbj. p. || Leua dezaseis coçeiras

It takes sixteen coçeiras [the planks nailed to the frames above the waterways]

Pi. iij. p. || Leua tres paos de pinho nas madres das Escotilhas

It takes three timbers of pine for the madres das Escotilhas [the frames of the hatches]

|| Leua duas conchas de strinqua cõ seis curuas .s. quatro das bandas,
e duas de bordo biiij. p.

It takes two conchas [sides] with six curuas [knees], four on the sides, and two on the edges, for the strinqua [windlass]

|| Esta Estrinqua se assentará nesta maneira, da lata em que emcostão as Bombas ate o meo da concha hauerá oito palmos, porq~ a Roda da Estrinqua tem noue palmos e a metade, são quatro palmos, e meo, e tres e meo q~ ficão pera o escotilhão das bombas, fazẽ os noue.

And this windlass will be layed in the following way, from the deck beam where the pumps lean against, to the middle of the concha [the cheek, or side of the windlass] will be eight palmos, because the circle of the windlass is nine palmos, and the half, which is four and one half palmos, and three and one half palmos

|| Leua esta estrinqua hũ eixo j. p.

This windlass will have an axis

|| Leua a Roda cõ a cruzetta noue paos jx. p.

It takes nine timbers on the circle [of the windlass]

|| Feita a segunda cuberta, farão a terceira aposturagem, que do andar da Portinhola pera cima, começará a cubrir, cinco palmos de cada banda, e aposturado, se assentara o dromente da terceira cuberta, que he a ponte, em altura de sete palmos e meo. esta cuberta ponte latará deste maneira: a lata em que demcostar o masto, ira **pa** a popa hũ palmo da debaixo, e logo farão hũ uão **pa** a chaminea da estrinqua que tera de comprido dez palmos, e do meo deste uão **pa** popa,

After the second deck is done, you put up the third set of top timbers, that from the level of the Portinhola [small door], will start going inwards, five palmos on each side, and once done, we will lay the dromente [clamp] of the third deck, which is called the bridge or weather deck, and its seven and one half palmos in height. This bridge deck will be beamed in this way: the beam where the mast will go will be one palmo to the stern of the one below, and soon after there will be a hole, to make a chimney for the windlass which will have ten palmos in breadth, and from the middle of this hole to the stern,

se assentarão as conchas do Cabestrãle porq~ a barra delle hã de ter uinte quatro palmos de comprido, e auante do masto, irá a tilha a prumo da Escotilha do meo, e da qui pa a proa farão suas cuxias que cheguem ao Castello, e no uão destas cuxias yrão os quarteis do Batel que terão de comprido doze goas que são trinta e seis palmos, e terão de largo, junto da tilha quatorze palmos, porq~ desta largura há de ser o Batel, e a proa, terão de largo doze palmos, e da qui ate a Roda sera tudo latado, e no meo hauerã hũ Escutilhão que tenha quatro palmos em quadrado pa caber hũ quarto.

the conchas [partners] of the capstan will be laid so that its bar will be 24 palmos in length, and before the mast will go the tilha [the tiled cooking area] standing on the vertical of the middle hatch, and from here to the bow will make its cuxias [walkways] so that they reach all the way to the Castle, and from these cuxias will go the space of the Batel [ships boat], which has to be 12 goas which are 36 palmos, and they will be in beam, next to the tilha 14 palmos, because this is the length that the Batel will have, and at the bow, it will be 12 palmos, and from there until the stem everything will be beamed and in the center there will be a small hatch that will be four palmos square so they can put one quarto [a small barrel, smaller than a pipa].

|| A Bitã que uay nesta cuberta se assentara a prumo da lata do Castello, irá tres palmos alta da cuberta pa por baixo caber pipa. No meo dos quarteis farão ha escutilhão de tres palmos pera seruintia do Batel.

The Bitã [Bitt] that goes on this deck will lay vertically to the beam of the Castle, and will have 3 palmos above the deck so that underneath we can store a pipa. In the middle of the quarters they will make a small hatch of 3 palmos so that people can access the ships boat.

|| Leua a terceira aposturagẽ cento, e corêta e çinco aposturas c.^{to} Rb.p.

The third aposturagẽ [row of top timbers] takes 145 top timbers

|| Leua mais uinte e hũ dormentes xxj. p.

It takes another 21 dormentes [clamps]

Pi. Lij. p. || Leua cincoenta e duas latas inteiras

it takes 52 latas inteiras [full beams]

Pi. Lij. p. || Leua cincoenta e duas meas latas

It takes 52 meas latas [half beams]

Pi xbj. p. || Leua dezaseis cordas

It takes 16 cordas [carlings]

|| Leua uinte quatro curuas de reues xxiiij.

It takes 24 curuas de reues [hanging knees]

Pi. xx. duz.^{as} || Leua uinte duzias de taboado de pinho brauo no soalhado

It takes 20 dozen timbers of white pine for the deck planking

|| Leua uinte trinquanis xx. p.

It takes 20 trinquanis [waterways]

|| Leua quatro paixóes iiij. p.

It takes 4 paixóes [mast partners/reinforcements]

|| Leua doze carreiras de Curuas de Conues q~ são uinte quatro paos xxiiij.p.

It takes 12 pairs of standing knees which are 24 timbers

|| Leua uinte entremichas xx. p.

It takes 20 entremichas [deck supports]

|| Leua duas Conchas do Cabestrante ij. p.

It takes 2 Conchas do Cabestrante [partners for the capstan]

|| Leua duas Abitas a popa q~ são tres paos iiij. p.

It takes 2 Abitas [Bits] to the stern which are three timbers

|| Leua hũa buçarda das Dragas j. p.

It takes 1 buçarda [breasthook] for the dragas [stringers]

Pi. xij. p. || Leua doze dragas de pinho manso

It takes 12 stringers of stone pine

Pi. xij. p. || Leua doze coçeiras de pinho manso

It takes 12 coçeiras [the planks nailed to the frames above the waterways] of Stone Pine

Pi. xxbj. p. || Leua por baixo uinte seis peas de Carneiro

Underneath it takes 26 stanchions

Pi. xb. p. || Leua nos quarteis, seis madres, e uinte e hũ Barrotes q~ são quinze paos de pinho manso

It takes on the quarters, six madres [the frame of the hatches], and 21 Barrotes [smaller fashion timbers] which are 15 timbers of white pine

Pi. ij. p. || Leua dous paos de pinho manso nas barçolas das escotilhas

It takes 2 timbers of stone pine for the barçolas [coamings] of the hatches

|| Feita esta ponte, farão de frente da escotilha do meo duas portinholas, hũa de hũa bãda, e outra da outra, e dous Rumos auante destas farão outras duas que fiquem a Re da amura.

And to finish this deck, they will build before the middle hatch 2 little doors, one on each side, and two Rumos before these two little doors they will make another two little doors that will stay abaft the amura [the round bulwarks at the bow].

|| A tolda yra lugar do masto pa Popa, e da lata em que emcosta o pasto pa a proa hauerá dez palmos de uão que fazẽ uinte palmos por amor dos gingamocho da bomba, e pera a Popa será tudo latado, e sobre o Cabestrante farão hũ escotilhão pera da uista, e a tilha dauante o masto sera a prumo das de baixo, e no

The tolda [quarterdeck] will start at the mainmast and run abaft, and from the beam in which the mast leans to the bow will be ten palmos clear, that will make twenty palmos to the gingamochoes of the bomba [the levers of the pump], and to the stern everything will be beamed, and above the capstan they will make a small hatch so that they can see, and the tilha [a cuddy] that stands before the mast will stand right above the vertical of the ones underneath, and in

Pi. xxx. p. meo sons quarteis cõ sua madre pello meo, e no Connes leuara trinta aposturas, quinze por banda; e do masto pa a Re leuará trinta e cinco uirotes por

Pi. Lxx. p. cada banda que se metem depois de latada a tolda, e uirotada, assentarão o chapiteo, quo terá d'altura sete palmos, e meo, e não será mais comprido que do Escotilhão do Cabestrante pera a Popa, e de mareagê, 7 pal:

the center are the quarteis [the quarters] with its beam running inbetween, and in the deck it will take 30 top timbers, 15 on each side; and from the mast to the stern it will take 35 uirotas [filler timbers] on each side which will only be put after all the beams of the sterncastle are laid, then the chapiteo [the poop deck] will be laid, which will be 7 and a half palmos high, and it will not be longer than the distance between the small hatch of the Capstan and the stern. And the bulwarks [above the poop deck], 7 palmos.

Pi. R.t. p. || Leua esta tolda corenta latas inteiras

It takes 40 latas inteiras [full beams] in the tolda [sterncastle]

Pi. biiij. p.j. || Leua no Conues oito dromentes

It takes on the deck 8 dromentes [clamps]

Pi. Liiij. p. || Leua nas cuxias, e nos lugares dos gingamochos cincoenta e quatro meas latas

In the cuxias [walkways] and on the place of the gingamoches [the pump-levers] it takes 54 half-beams

Pi. xiiij. p. || Leua no Conues quatorze cordas

It takes on the deck 14 cordas [carlings]

Pi. R^{ta} p. || Leua do Castello ate a Serpe corêta latas

It takes from the castle to the Serpe [the curving timber at the corner of the stern, where the stern meets the side, which takes a serpent-like shape] 40 beams

|| Leua na tolda e castello, e conues onze carreiras de curuas que são vinte dous paos xxij. p.

It takes in the decking of the quarterdeck, on the sterncastle 11 lines of hanging knees, which are 22 timbers

|| Leua quinze antremichas xb. p.

It takes 15 antremichas [deck supports]

|| Leua doze curuas de Reues na tolda xij. p.

It takes 12 curuas de Reues [standing knees] in the sterncastle

|| Leua no Chapiteo dez curuas de Reues x. p.

At the poop deck it take 10 top timbers

|| Leua a Abita quatro curuas iiij. p.

It takes 4 curuas [knees] for the Abita [Bitt]

|| Dous paos pa esta Abita ij. p.

2 timbers for the Abita [Bitt]

|| Leua hũa Papoya j. p.

It takes 1 Papoya [a bitt with built-in sheave which holds the foot of the mizzen sail]

|| Leua hũa curua do falcão j. p.

It takes one curua do falcão [knee for the deck of the beak head]

Pi. xx. p.

|| Leua no chapiteo vinte latas

It takes 20 beams on the poop deck

|| O Castello se assenta no andar do Conues, e terá do comprimento cincoenta palmos q~ he tanto como a Nau tem de largura e da Roda pa for a, tera dezaseis palmos, e pa dentro, terá trinta e quatro que são cincoenta, e terá de largura este Castello na primeira lata da Arpa, corenta palmos, e a gurita se assentará em altura de sete palmos, e tera de largo na primeira lata trinta palmos, e sobre a Roda tera esta gurita do largo, dezaseis palmos.

The Castle will be laid on the level of the main deck, and will be 50 palmos long which is the same as as this não has in its breadth, and from the stem you have 16 palmos springing outwards/forwards/ahead of the stempost [this is the triangular castle at the bow], to the inside [abaft the stempost] it will have 34 palmos which makes 50 palmos altogether, and this castle will have, in breadth, on the first lata [beam] of the Arpa [the harp-shaped aft bulkhead of the forecastle] 40 palmos, and the gurita [quarter gallery] will be laid at a height of 7 palmos, and its breadth at the first lata [beam] will be 30 palmos, and over the stem post will have these guritas, in breadth 16 palmos.

|| Leua este Castello quinze uirotes p bãda q~ são trinta paos e mareagẽ

Pi. xxx. p. tera 7 pal:

This Castle takes 15 uirotes [filler timbers] on the side which are 30 timbers and the mareagê [bulwarks] is 7 palmos

Pi. j. p. || Leua hũ falcão

It takes one falcão [beakhead timber]

|| Leua çinco paos na mão e papa mosqua e contra falcão, e guçarda b. p.

It takes 5 timbers in the mão [a triangular fairing piece between the side and the stem, to which the wale is fastened], the papa mosqua [gammoning knee], the contra falcão [inner beakhead reinforcement], and the guçarda [probably the buçarda, or breathook]

Pi. xx. p. || Leua na gurita vinte latas

It takes on the gurita, 20 beams

|| Leua quatro curuas de Reues iiij. p.

It takes 4 curuas de Reues [standing knees]

|| Leua dous Escouems, e dous contraescouens iiij. p.

It takes 2 Escouems [hawseholes], and 2 contraescouens [circular reinforcements to the hawseholes]

|| Leua hũa curua do Beque j. p.

It takes one curve for the Beque [the Beak] [this is the knee that supports the beak, in simpler vessels it is the knee that supports the bowsprit, it can also be the whole beak arrangement]

|| Leua duas curuas pellas cordas ij. p.

It takes 2 curves for the cordas [carlings]

|| Leua duas curuas pellas bandas ij. p.

It takes 2 curves for the bandas [sides, the horizontal supports of the beak]

|| Leua quatro curuas na Arpa iiij. p.

It takes 4 curves on the Arpa [the aft bulkhead of the forecastle]

|| Leua duas curuas na Alçaueua que seruem de peis de Carneiro ij. p.

It takes 2 curves on the Alçaueua [castle] that will work as peis do Carneiro [stanchions]

|| Leua hũa Carlinga da mezena cõ duas curuas iiij. p.

It takes one mast step for the mizzen with 2 curves [knees which support the mast step]

|| Leua duas curuas na Dala ij. p.

It takes 2 curves for the Dala [the pump-dale, the scupper or drain for the pump]

|| Leua duas curuas no Perpao ij. p.

It takes 2 curves for the Perpao [a major cross beam of the castle, which also serves in the rigging of the nets]

|| Leua dous gingamochos da bomba ij. p.

It takes 2 gingamoches da bomba [levers for the pump]

|| Leua dous paos nos trilhões ij. p.

It takes 3 timbers for the trilhões [rail]

|| Leua hũa carregadeira j. p.

It takes one carregadeira [downhaul]

|| Leua dezoito cambotas nas abobadas xbiiij. p.

It takes 18 cambotas [counter timbers] for the abobadas [the counter, the rake of the stern below the half deck and poop]

|| Leua quatro cambotas no chapiteo, e castello iiiij. p.

It takes 4 cambotas [counter timbers] for the poop deck, and the quarterdeck

|| Leua dous mulinetes ij. p.

It takes 2 mulinetes [hand-cranked winches]

|| Leua hũ mulinete no Castello j. p.

It takes one mulinete [hand-cranked winch] in the Castle

Pi. b. p. || Leua hũ Perpao no chapiteo cõ sua grade q~ são çinco paos de pinho mãso

It takes one Perpao [a lateral beam which ties the structure together and also supports the nets] at the poop deck with its gratings which makes 5 timbers of stone pine

Pi. ij. p. || Leua dous Perpaos no Castello

It takes 2 Perpaos [lateral beams] in the Castle

|| Leua duas çerauiolas ij. p.

It takes 2 çerauioles [catheads]

Pi. c.¹⁰ Rb. p. || Leua esta no costado çinco carreiras de çintas dobradas, nas quais entrão çento corenta e çinco paos de pinho manso .ss.

It takes this vessel, on the side, five layers of doubled wales [another wale attached on the outside] on which [come in/are used] 145 timbers of stone pine

|| Na primeira carreira uinte noue paos

On the first layer, 29 timbers

|| Na segunda carreira uinte noue paos.

On the second layer, 29 timbers

|| Na terceira outros uinte noue paos

On the third layer, another 29 timbers

|| Na quarta outros uinte noue paos

On the fourth layer, another 29 timbers

|| Na quinta outros uinte noue paos

On the fifth layer, another 29 timbers

Pi. xb. p. || Leua mais quatro carreiras de çintas singellas .s. hũa que uem da banda de baixo dos Escouens, pella qual se assêta a mesa de popa, e na dita cinta entrão quinze paos de pinho manso

It takes another four layers of single wales, one that comes from the side below the hawseholes, on which we lay the poop sill, and on which wale are used 15 timbers of stone pine

Pi. xb. p. || A outra carreira uai por cima dos escouens e uai a te a popa, e por esta se assenta a mesa de Proa, leua quinze paos de Pinho manso

The other layer goes/runs above the hawseholes and extends all the way to the stern, and on this layer we lay the bow sill, it takes 15 timbers of stone pine

Pi. xiiij. p. || A outra uai das tabiquas do Castello ate popa pera fazer forte a madeira leua quatorze paos

The other one goes from the tabiquas [partitions] of the Castle all the way to the stern to make it strong, this takes 14 timbers

Pi. xiiij. p. || A outra he a çinta da mareagẽ que uai do alqustrate do Castello ate popa leua quatorze paos

The other one is the top wale which goes from the alqustrate [the gunwale] of the Castle to the stern, and it takes 14 timbers

Pi. iiij. p. || Leua outra çinta que serue de dromente do chapiteo, que uem a te o poua uerga, leua quatro paos

It takes yet another wale that works as a clamp at the poop deck, that comes all the way to the poua verga [the ‘yard rest’, the rest upon which the yard sits when it is lowered], it takes 4 timbers

Pi. biij. p. || Leua na mareagem do chapiteo quatro cintas de cada banda, que são oito paos

On the bulwarks of the poop deck, it takes 4 wales on each side, which makes 8 timbers

Pi. iiij. p. || Leua no Castello hũa carreira de cintas por cada banda, que uem pollas latas em que entrão quatro paos

It takes one layer of wales on each side of the Castle, which comes over/on top the deck beams in which are used 4 timbers

Pi. iiij. p. || Leua outra carreira que uai pellas Jeneladas, e uem da mão ate Arpa leua quatro paos

It takes another layer where where the windows go, and from the mão [triangular fairing piece between side and stem, to which the wale is fastened] towards the Arpa [the aft forecandle bulkhead], it takes 4 timbers

Pi. iiij. p. || Leua outra cinta que uem do cote do papa mosqua, que serue do dromente da gurita. Leua quatro paos

It takes another wale that comes from the angle of the papa mosqua [gammoning knee], that serves the clamp of the gurita [quarter gallery], which takes 4 timbers

Pi. iiij. p. || Leua outra çinta, que uem da ponta do papa mosqua a te Arpa que leuanta tres palmos da gurita e esta se chama da mareagem, em q~ entrão quatro paos

It takes another wale, that goes from the point of the papa mosqua [gammoning knee] to the Arpa [aft forecandle bulkhead], that raises three palmos of the gurita [quarter gallery] and is called the bulwarks, and which uses 4 timbers

Pi. biiij. p. || Leua este Castello quatro çintas de cada banda na mareagem, que são oito paos

This Castle takes 4 wales on each side, in the mareagem [bulwarks], which is 8 timbers

Pi. b. duz.^{as} || Leua no chapiteo çinco duzias de taboade no soalhado

The chapiteo [poop deck] takes 10 dozen planks in the flooring

Pi. iij. duz.^{as} || Leua na gurita tres duzias de taboado no soalhado

The gurita [quarter gallery] takes 3 dozen planks in the flooring

|| A Varanda se assentará no andar da tolda e lançará fora da Popa doze palmos, e será da largura da abobada

The Varanda [the balcony at the stern of the ship] will be layed on the level of the tolda [quarterdeck] and extends beyond the stern 12 palmos, and is the width of the counter

Pi. ix. p. || Leua esta uaranda noue uirotes de pinho manso

This Varanda [balcony] takes 9 timbers of stone pine

Pi. xij. tab. || Leua seis peitoris, e dous peis de carneiro, e tres mesas de telhado, e trinta barrotes

It takes 6 peitoris [railings], and 2 peis de carneiro [posts], and 3 mesas de telhado [roof sills], and 30 barrotes [balusters]

Pi. bj. tab. || Leua no soalhado seis taboas

It takes 6 planks in the flooring

Pi. L. duz.^{as} || Leua esta Nau da primeira çinta a te a quilha cincoenta duzias de taboado de pinho manso de costado de meo palmo de goa de grossura

From the keel up to the first wale this Nau takes 50 dozen planks of stone pine, one palmo wide

Pi. L. duz.^{as} || Leua da primeira çinta ate o Portaló em todas as alcaixas outras cincoêta duzias do dito taboado mais delgado meo dedo que o do fundo

From the first wale to the Portaló [gangway] in all alcaixas [the spaces between wales] it takes 50 more dozen of the said planks which are 1 dedo thinner

Pi. Lx. p. || Leua na popa sessenta calimes

It takes 60 calimetes [these are the planks which cover the stern panel] for the stern

Pi. xxb. tab. || Leuanas emendas dos ditos calimes uinte cinco Taboas

The emendas [stealer planks] of the said calimes [the stern planks] take 25 planks

Pi. iiij. p. || Leua quatro çintas nesta popa

It takes 4 wales in the stern

|| Leua esta Nau has mesas grandes que uão do pousauega a te a face de Re do seis bordo, e leuão uinte Apostareos xx. p.

This Nau has mesas grandes [channels] that go from the pousauega [yard rest] to the face de Re do seis bordo [aft face of the loading hatch], and take twenty Apostareos [futtock riders]

|| Leuão nas castanhas, e cunhos dezoito paos xbiiij. p.

The castanhas and cunhos (the rigging elements for the shrouds) take 18 timbers

Pi. ij. p. || Leuão duas taboas de largura de tres palmos, e de grossura de meo palmo de goa

It takes 2 planks of the width of 3 palmos and the thickness of a palmo de goa [the channels are 3 palmos wide and 1 palmo thick]

|| As mesas de proa yrão do direito d'Arpa até o Escouem, e leuará cada hũa sete apostareos que são quatorze paos xiiiij. P

The mesas de proa [fore channels] go straight from the Arpa to the hawsehole, and each one takes 7 apostareus [futtock riders] which is 14 timbers

|| Leuão dez paos nas castanhas, e cunhos x. p.

It takes 10 timbers in the castanhas and cunhos

Pi. ij. p. || Leuão duas taboas como as de popa

It takes 2 planks for the as de popa [this is the continuation of the upper frame of the beakhead]

|| Leua esta Nau duas Amures e cada hũa leua tres Apostureos q~ são seis paos bj. p.

This Nau takes 2 Amures [halyard or tack timbers, these are a rounded part of the upper works on either side of the bow, where the tack of a sail is belayed] and each one takes 3 Apostureos [futtock riders] which is 6 timbers

Pi. ij. p. || Leua duas chumaçeirias de uinte e hũ palmos de goa de comprido

It takes 2 chumaçeirias [blocks or bearings], 11 palmos de goa in length

|| Leua seis paos nas castanhas bj. p.

It takes 6 timbers in the castanhas [cleats]

|| Leua antre estas Amuras, e as mesas de Popa tres passaros q~ são seis paos

It takes in these Amuras [halyard/tack timbers], and the mesas de Popa [fore channels] 3 passaros [v-shaped belaying cleats or kevels] which are 6 timbers

|| Leua duas bombas de 45 palmos dalto cõ sua dalla

It takes 2 pumps of 45 palmos height for the dalla [the pump-dale]

Pi. ij. p. || Leua esta Nau dous cabrestantes .s. hũ grande, e outro pequeno do Conues

This Nau takes 2 cabestrantes [capstans] , one large, and the other smaller on deck

|| O grande leua quatro paos nos cunhos b. p.

The large one takes 4 timbers for the cunhos [the strong base the capstan sits on]

|| O pequeno leua tres paos nos cunhos iiij. p.

The smaller takes 3 timbers for the cunhos

Pi. bj. p. || Leuão seis barras estes dous cabestrantes

These 2 cabestrantes [capstans] take 6 barras [capstan bars]

Escoteiras q- leua esta Nau
Escoteiras [Sheet bitts or cleats] that this Nau takes

|| Leua duas escotieras das escotas grandes ij. p.

It takes 2 escoteiras [sheet bitts] for the escotas grandes [main sheets]

Pi. ij. p. || Leua duas dos Amantilhos grandes

It takes 2 for the Amantilhos grandes [main lifts]

Pi. bj. p. || Leua seis escoteiras das troças grandes

It takes 6 for the troças grandes [main truss]

Pi. ij. p. || Leua duas dos braços da uerga grande

It takes 2 for the arms of the uerga grande [main yard]

- Pi. ij. p. || Leua duas dos ostingues
It takes 2 for the ostingues [yard tyes]
- Pi. ij. p. || Leua duas das escotas do traquete
It takes 2 for the escotas [sheet bitts] of the traquete [foresail]
- Pi. ij. p. || Leua duas dos Amontilhos do traquete
It takes 2 for the Amontilhos of the traquete [foresail]
- Pi. iij. p. || Leua quatro das troças do traquete
It takes 4 for the troças [truss] of the traquete [foresail]
- Pi. ij. p. || Leua duas das escotas da çeuadeira
It takes 2 for the escotas [sheet bitts] of the çeuadeira [spritsail]
- Pi. iij. p. || Leua quatro das bulinas
It takes 4 for the bulinas [bow lines]
- Pi. j. p. || Leua hũa da driça da gauea grande
It takes one for the driça [halyard] of the gauea grande [main top]
- Pi. j. p. || Leua hũa da driça da gauea de proa
It takes one for the driça [halyard] of the gauea de proa [fore top]
- Pi. ij. p. || Leua duas das escotas da gauea de proa
It takes 2 for the escotas [sheet bitts] of the gauea de proa [fore top]

Mastos desta Nau
Masts of this Nau

|| Leua de masto grande dezoito braças de comprido a fora calças, e terá este masto de grossura no tamborete quatro palmos e meo redondos esforçados, e na garganta terá a metade, e mais dous dedos

The masto grande [main mast] is 18 braças in length, not including the calças [mast head], it is 4 ½ palmos thick at the tamborettes [mast partners], and 2 ½ palmos at the garganta [throat]

|| Leua de masto de traquete quinze braças de comprido sem calces, e de grossura quatro palmos, e a metade na garganta

The masto do traquete [fore mast] is 15 braças in length, without the calças [mast head], it is 4 palmos thick, and half that thick [2 palmos] at the garganta [throat]

|| Leua de goroupez quinze braças

The goroupez [bowsprit] is 15 braças

|| Leua de Verga grande dezasete braças, e de grossura dous palmos de goa cada hũ penão

The Verga grande [main yard] is 17 braças in length, and 2 palmos at its thickest point

|| Leua de uerga do traquete treze braças e de grossura dous palmos de goa

The uerga do traquete [fore yard] is 13 braças in length, and 2 palmos in thickness

|| Leua do mastareo grande sete braças e mea, e de grossura palmo e meo de goa

The mastareo grande [main top mast] is 7 ½ braças in length, and 1½ palmo in thickness

|| Leua de mastareo de proa seis braças, e mea, e de grossura palmo, e meo Redondo

The mastareo de proa [fore top mast] is 6 braças in length, and 1 ½ palmo in thickness

|| Leua de uerga da gauea grande seis braças de comprido, e de grossura hũ palmo de goa

The uerga da gauea grande [main top yard] is 6 braças in length, and 1 palmo in thickness

|| Leua de uerga da gauea de proa çinco braças, e de grossura hũ palmo Pequeno

The uerga da gauea de proa [fore top yard] is 5 braças in length, and 1 palmo pequeno [a 'small palm' only 4 dedos in width] in thickness

|| Leua de uerga da çeuadeira noue braças e de grossura palmo e meo redondo

The uerga da çeuadeira [spritsail yard] is 9 braças in length, and 1 ½ palmo in thickness

|| Leua de masto da mezena dez braças e de grossura dous palmos de goa

The masto da mezena [mizzen mast] is 10 braças in length, and 2 palmos in thickness

|| Leua de uerga da mezena treze braças e de grossura hũ palmo na Ostaguadora

The uerga de mezena [mizzen yard] is 13 braças in length, and 1 palmo thick at the ostaguadora [tyes]

VITA

Alexander Dean Hazlett
 c/o Dr. Viera de Castro
 Department of Anthropology
 Texas A&M University
 College Station, TX 77843-4352

EDUCATION

Ph.D. in Anthropology, Texas A&M University	May 2007
Certificate in Historic Preservation, Texas A&M University	May 2007
Graduate Certificate in Maritime Archaeology and History, University of Hawaii, Manoa	December 2000
M.A., History, University of Hawaii, Manoa,	May 1999
B.A., Asian Studies, University of California, Santa Barbara	June 1994
NAUI Master Diver, AAUS Scientific Diver, University of Hawaii	2000

ARCHAEOLOGY

Team Member, Cairo Dashur Boats Project, Cairo, Egypt	May 2004
Intern, RPM Nautical Foundation, Key West, Florida	June-August 2003
Intern, RPM Nautical Foundation, Key West, Florida	August 2002
Team Leader, TAMU/INA <i>Denbigh</i> Project, Galveston Bay, Texas	May-July 2002
Student, Maritime Archaeological Survey Techniques (UH Marine Option field school), Kaneohe Bay, Hawaii	June-August 2000