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Acknowledgments

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The Symposium “Edge of Empire” was made possible through two grants, one from The Fundação Luso-Americana para o Desenvolvimento and another from Dr. Peter Amaral. These funds allowed a group of students to present their research, network, and get acquainted with their peers’ ongoing research. These meetings offer invaluable opportunities for students to gather comments and opinions about their work as well as to make acquaintances, combine summer projects, exchange ideas, discuss practices, and, not less importantly, gossip about their universities’ politics, their teachers and advisors.

The Symposium would not have been as interesting without the collaboration of the two discussants, Dr. Roger Smith and Dr. Brad Lowen, both good friends and old time collaborators with the Institute of Nautical Archaeology and the Nautical Archaeology Program. We want to thank them for their words of encouragement and their input.

Finally, we want to thank the sponsors of this publication, which was only possible through the sponsorship of Texas A&M University’s Center for Maritime Archaeology and Conservation.
A Group for the Study of Iberian Seafaring

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Abstract
Continuing an old tradition of the Nautical Archaeology Program, a group of students has started a coordinated study of issues pertaining to the history of Iberian Seafaring during the Age of Sail. The vessels of the Spanish and the Portuguese were perhaps the best of their time in Europe, and it is difficult to imagine the modern world without them. The student’s first results were presented at the Society for Historical Archaeology 2006 Annual Meeting. This is a compilation of their papers.

Introduction
Texas A&M University and its associated Institute of Nautical Archaeology (INA) have a long tradition in the study of Iberian seafaring. It is almost 30 years ago that Robin Piercy, an INA archaeologist, started the excavation of a Portuguese frigate at Mombasa, Kenya, the Santo António de Tana, lost in 1697 (Figure 01-01).

Figure 01-01 – Robin Piercy during the excavation of the frigate Santo António de Tana (Photo: INA Archives).
Later, in the early 1980s, a group of students of the Nautical Archaeology Program started a number of projects related to the study of Iberian ships (Figure 01-02). In 1986 they formalized their mission under the name EXPLADISC – an acronym for Exploration and Discovery – and developed a series of projects aimed at the study of the technology of the 15th and 16th centuries that led the Europeans into the New World. The entire issue of *INA Newsletter* 13.1, from March 1986, was dedicated to this endeavor.

The Exploration and Discovery group carried out a number of extremely interesting projects during the 1980s (Bass 1988). St. Anne’s Bay in Jamaica and the mouth of Belen River in Panama were surveyed in search of Columbus ships, unfortunately without positive results. However, these groundbreaking experiments, which included the geological study of the evolution of the coastline in the two areas surveyed, set the standards for future work.

Two early 16th century shipwrecks – the Highborn Cay Shipwreck in the Bahamas, and the Molasses Reef Shipwreck in the Turks and Caicos Islands – were archaeologically excavated, and published under the highest

![The Exploration and Discovery group](Photo: KC Smith)

These are still today considered the two earliest European vessels found in the New World. Measuring around 20 m overall, these ships may have been caravels or small naos, and showed scantlings similar to those found in the Playa Damas shipwreck, another early Spanish shipwreck recently visited by the Institute of Nautical Archaeology near Nombre de Dios, in Panama (Castro 2005b and Castro and Fitzgerald 2006).

Some of the students from the Exploration and Discovery group continued their work on Iberian ships through the 1980s and 90s (Keith and Smith 1984; Lamb et al. 1990). Just to give a few examples, Donald Keith founded the Ships of Discovery organization, Roger C. Smith excavated another early Spanish ship, believed to have been lost in 1559, at Emanuel Point, and Thomas Oertling wrote a series of seminal articles on the definition of Iberian ships as a regional subtype (Oertling 1989c, 2001, 2005; Smith 1978, 1993; Smith et al. 1995; Smith et al. 1998).

Iberian Ships

The study of Iberian ships as seafaring technology remains a small field of research in spite of the obvious importance that these vessels had in setting the age of the European expansion overseas. Very few studies about Iberian ships have been carried out, and even less published, in spite of the discovery of more than 70 suspected Iberian shipwrecks worldwide, all built and sailed between 1500 and 1700 (Tables 1 through 5).

There is no doubt that the particular way in which the vessels under analysis were built derives from a older Mediterranean shipbuilding tradition, probably brought to the Iberian Peninsula by Italian – perhaps mainly Genoese – shipwrights. What makes it interesting is the fact that it incorporates construction features that have been observed in North Atlantic craft. The process by which the ships of the Portuguese and the Spanish evolved and adopted structural characteristics from both the northern and Mediterranean worlds is unknown to us, and to make things more complicated, a number of shipwrecks – admittedly still small – have been found with similar characteristics, but clearly originating from outside the Iberian Peninsula (Table 6).
Table 1
New World Routes: 16th Century Shipwrecks

<table>
<thead>
<tr>
<th>Shipwreck</th>
<th>Date</th>
<th>Location</th>
<th>Timber remains</th>
<th>Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Molasses Reef Shipwreck</td>
<td>Early 16th c.</td>
<td>Bahamas</td>
<td>Small portion</td>
<td>Salvaged / Excavated (1)</td>
</tr>
<tr>
<td>Highborn Cay Shipwreck</td>
<td>Early 16th c.</td>
<td>Bahamas</td>
<td>Part of the bottom</td>
<td>Salvaged / Excavated (1)</td>
</tr>
<tr>
<td>Bahia Mujeres Shipwreck</td>
<td>Early 16th c.</td>
<td>Mexico</td>
<td>None</td>
<td>Surveyed (1)</td>
</tr>
<tr>
<td>Playa Damas Shipwreck</td>
<td>Early 16th c.</td>
<td>Panama</td>
<td>Part of the bottom</td>
<td>Surveyed / Salvaged (2)</td>
</tr>
<tr>
<td>San Esteban</td>
<td>1554</td>
<td>Texas</td>
<td>Stern heel</td>
<td>Salvaged / Excavated (1)</td>
</tr>
<tr>
<td>Espiritu Santo</td>
<td>1554</td>
<td>Texas</td>
<td>Unknown</td>
<td>Salvaged (1)</td>
</tr>
<tr>
<td>Santa Maria de Yciar</td>
<td>1554</td>
<td>Texas</td>
<td>Unknown</td>
<td>Destroyed by dredges (1)</td>
</tr>
<tr>
<td>La Condesa</td>
<td>1555</td>
<td>Portugal</td>
<td>Unknown</td>
<td>Looted? (3)</td>
</tr>
<tr>
<td>Emanuel Point Shipwreck</td>
<td>1559</td>
<td>Florida</td>
<td>Extensive</td>
<td>Partially Excavated (1)</td>
</tr>
<tr>
<td>Pensacola Shipwreck</td>
<td>1559?</td>
<td>Florida</td>
<td>Part of the bottom</td>
<td>Currently being excavated (1)</td>
</tr>
<tr>
<td>Saint John’s Bahamas Shipwreck</td>
<td>Mid. 16th c.</td>
<td>Bahamas</td>
<td>Part of upper works</td>
<td>Excavated (1)</td>
</tr>
<tr>
<td>Mystery Wreck of MAREX</td>
<td>Mid. 16th c.</td>
<td>Bahamas</td>
<td>Unknown</td>
<td>Salvaged (1)</td>
</tr>
<tr>
<td>Cayo Nuevo Shipwreck</td>
<td>Mid. 16th c.</td>
<td>Mexico</td>
<td>None</td>
<td>Surveyed (1)</td>
</tr>
<tr>
<td>Francisco Padre</td>
<td>Mid. 16th c.?</td>
<td>Cuba</td>
<td>Unknown</td>
<td>Salvaged? (4)</td>
</tr>
<tr>
<td>La Galera</td>
<td>Mid. 16th c.?</td>
<td>Cuba</td>
<td>Unknown</td>
<td>Surveyed? (5)</td>
</tr>
<tr>
<td>San Juan / Red Bay Shipwreck</td>
<td>1565</td>
<td>Canada</td>
<td>Extensive</td>
<td>Excavated (1)</td>
</tr>
<tr>
<td>San Pedro</td>
<td>1596</td>
<td>Bermuda</td>
<td>Unknown</td>
<td>Salvaged (1)</td>
</tr>
<tr>
<td>Western Ledge Reef Shipwreck</td>
<td>Late 16th c.</td>
<td>Bermuda</td>
<td>Extensive</td>
<td>Excavated (1)</td>
</tr>
<tr>
<td>Spanish Wreck</td>
<td>Late 16th c.</td>
<td>Bermuda</td>
<td>Yes</td>
<td>Salvaged (1)</td>
</tr>
<tr>
<td>Ines de Soto Shipwreck</td>
<td>Late 16th c.</td>
<td>Cuba</td>
<td>None</td>
<td>Excavated (1)</td>
</tr>
<tr>
<td>San Cayetano</td>
<td>Late 16th c.?</td>
<td>Cuba</td>
<td>Unknown</td>
<td>Excavated? (5)</td>
</tr>
<tr>
<td>Basque galleon 1</td>
<td>16th c.</td>
<td>Canada</td>
<td>Yes</td>
<td>Surveyed (6)</td>
</tr>
<tr>
<td>Basque galleon 2</td>
<td>16th c.</td>
<td>Canada</td>
<td>Yes</td>
<td>Surveyed (6)</td>
</tr>
<tr>
<td>Basque galleon 3</td>
<td>16th c.</td>
<td>Canada</td>
<td>Yes</td>
<td>Surveyed (6)</td>
</tr>
<tr>
<td>Saona Site 1</td>
<td>16th c.</td>
<td>Dominican Republic</td>
<td>Unknown</td>
<td>Salvaged / Surveyed (7)</td>
</tr>
<tr>
<td>Saona Site 2</td>
<td>16th c.</td>
<td>Dominican Republic</td>
<td>Unknown</td>
<td>Salvaged / Surveyed (7)</td>
</tr>
</tbody>
</table>
### Table 2

**New World Routes: 17th Century Shipwrecks**

<table>
<thead>
<tr>
<th>Shipwreck</th>
<th>Date</th>
<th>Location</th>
<th>Timber remains</th>
<th>Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fuxa Shipwreck</td>
<td>Early 17th c.</td>
<td>Cuba</td>
<td>Extensive</td>
<td>Excavated (1)</td>
</tr>
<tr>
<td>Green Cabin Shipwreck / San Martin</td>
<td>1618 ?</td>
<td>Florida</td>
<td>Part of the bottom</td>
<td>Surveyed (1)</td>
</tr>
<tr>
<td>San Antonio</td>
<td>1621</td>
<td>Bermuda</td>
<td>Unknown</td>
<td>Salvaged (1)</td>
</tr>
<tr>
<td>Nuestra Señora de Atucha</td>
<td>1622</td>
<td>Florida</td>
<td>Part of the bottom</td>
<td>Salvaged / Partially recorded (1)</td>
</tr>
<tr>
<td>Shot Wreck</td>
<td>1622</td>
<td>Florida</td>
<td>Unknown</td>
<td>Salvaged (1)</td>
</tr>
<tr>
<td>Santa Margarita</td>
<td>1622</td>
<td>Florida</td>
<td>Part of upper works</td>
<td>Salvaged / Partially recorded (1)</td>
</tr>
<tr>
<td>Dry Tortugas Shipwreck</td>
<td>1622 ?</td>
<td>Florida</td>
<td>Extensive</td>
<td>Salvaged (1)</td>
</tr>
<tr>
<td>Nuestra Señora del Rosario</td>
<td>1622</td>
<td>Florida</td>
<td>None</td>
<td>Surveyed (1)</td>
</tr>
<tr>
<td>Urca La Viga</td>
<td>1639</td>
<td>Bermuda</td>
<td>Unknown</td>
<td>Salvaged (1)</td>
</tr>
<tr>
<td>Nuestra Señora de la Concepción</td>
<td>1641</td>
<td>Dominican Republic</td>
<td>Unknown</td>
<td>Salvaged (1)</td>
</tr>
<tr>
<td>Stonewall Shipwreck</td>
<td>Mid. 17th c.</td>
<td>Bermuda</td>
<td>Part of the bottom</td>
<td>Salvaged / Surveyed (1)</td>
</tr>
<tr>
<td>Nuestra Señora de las Maravillas</td>
<td>1656</td>
<td>Bahamas</td>
<td>Unknown</td>
<td>Salvaged (1)</td>
</tr>
<tr>
<td>Jesús M.ª de la Limpia Concepción</td>
<td>1654</td>
<td>Ecuador</td>
<td>Unknown</td>
<td>Salvaged (1)</td>
</tr>
<tr>
<td>Santíssimo Sacramento B</td>
<td>1668</td>
<td>Brazil</td>
<td>Extensive</td>
<td>Excavated (1)</td>
</tr>
<tr>
<td>San Francisco Wreck</td>
<td>1650-1660</td>
<td>Cape Verde</td>
<td>Unknown</td>
<td>Salvaged (9)</td>
</tr>
<tr>
<td>Los Lingotes</td>
<td>Late 17th c.?</td>
<td>Cuba</td>
<td>Unknown</td>
<td>Surveyed? (5)</td>
</tr>
</tbody>
</table>
Table 3  
Manila Galleons: 16th and 17th Century Shipwrecks

<table>
<thead>
<tr>
<th>Shipwreck</th>
<th>Date</th>
<th>Location</th>
<th>Timber remains</th>
<th>Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>San Felipe</td>
<td>1575</td>
<td>Baja California</td>
<td>None</td>
<td>Surveyed (10)</td>
</tr>
<tr>
<td>San Diego</td>
<td>1600</td>
<td>Philippines</td>
<td>Extensive</td>
<td>Partially recorded (1)</td>
</tr>
<tr>
<td>Nuestra Señora de la</td>
<td>1638</td>
<td>Guam</td>
<td>Unknown</td>
<td>Salvaged (1)</td>
</tr>
<tr>
<td>Concepción</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Santa Margarita</td>
<td>17th c.?</td>
<td>Guam</td>
<td>Unknown</td>
<td>Salvaged (1)</td>
</tr>
<tr>
<td>Nuestra Señora del Pilar</td>
<td>1690</td>
<td>Guam</td>
<td>Unknown</td>
<td>Salvaged? (11)</td>
</tr>
</tbody>
</table>

Table 4  
Europe: 16th and 17th Century Shipwrecks

<table>
<thead>
<tr>
<th>Shipwreck</th>
<th>Date</th>
<th>Location</th>
<th>Timber remains</th>
<th>Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corpo Santo</td>
<td>Late 14th c.</td>
<td>Portugal</td>
<td>Stern heel</td>
<td>Excavated (1)</td>
</tr>
<tr>
<td>Ria de Aveiro A</td>
<td>Mid. 15th c.</td>
<td>Portugal</td>
<td>Part of the Stern</td>
<td>Excavated (1)</td>
</tr>
<tr>
<td>Cais do Sodré</td>
<td>Late 15th c.?</td>
<td>Portugal</td>
<td>Extensive</td>
<td>Excavated (1)</td>
</tr>
<tr>
<td>Santo António</td>
<td>1527</td>
<td>England</td>
<td>Unknown</td>
<td>? (26)</td>
</tr>
<tr>
<td>Studland Bay</td>
<td>Early 16th c.</td>
<td>England</td>
<td>Extensive</td>
<td>Excavated (1)</td>
</tr>
<tr>
<td>Baleal 1</td>
<td>16th c.</td>
<td>Portugal</td>
<td>Unknown</td>
<td>Looted (12)</td>
</tr>
<tr>
<td>Arade 1</td>
<td>Late 16th c.</td>
<td>Portugal</td>
<td>Extensive</td>
<td>Excavated (13)</td>
</tr>
<tr>
<td>Santa Maria de la Rosa</td>
<td>1588</td>
<td>Ireland</td>
<td>Part of the bottom</td>
<td>Excavated (1)</td>
</tr>
<tr>
<td>Capitana de Ivelle</td>
<td>1596</td>
<td>Spain</td>
<td>None</td>
<td>Surveyed (1)</td>
</tr>
<tr>
<td>Ponta do Altar B</td>
<td>Early 17th c.</td>
<td>Portugal</td>
<td>None</td>
<td>Surveyed (1)</td>
</tr>
</tbody>
</table>

Table 5  
Portuguese India Route: 16th and 17th Century Shipwrecks

<table>
<thead>
<tr>
<th>Shipwreck</th>
<th>Date</th>
<th>Location</th>
<th>Timber remains</th>
<th>Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Portuguese Shipwreck</td>
<td>Early 16th c.</td>
<td>Mayotte</td>
<td>Unknown</td>
<td>Salvaged (14)</td>
</tr>
<tr>
<td>Name</td>
<td>Date</td>
<td>Location</td>
<td>Florencia</td>
<td>Outcome</td>
</tr>
<tr>
<td>-----------------------------</td>
<td>------------</td>
<td>-----------------</td>
<td>-----------</td>
<td>-----------------------------------</td>
</tr>
<tr>
<td>Etoile Shipwreck</td>
<td>1530 c.</td>
<td>Madagascar</td>
<td>Unknown</td>
<td>Salvaged (24)</td>
</tr>
<tr>
<td><strong>S. João</strong></td>
<td>1552</td>
<td>South Africa</td>
<td>Unknown</td>
<td>Surveyed (1)</td>
</tr>
<tr>
<td><strong>S. Bento</strong></td>
<td>1554</td>
<td>South Africa</td>
<td>Unknown</td>
<td>Surveyed (1)</td>
</tr>
<tr>
<td>Fort San Sebastian Shipwreck</td>
<td>Mid 16th c.</td>
<td>Mozambique</td>
<td>Extensive</td>
<td>Salvaged (15)</td>
</tr>
<tr>
<td><em>Santiago</em></td>
<td>1585</td>
<td>Bassas da India Atoll</td>
<td>Unknown</td>
<td>Salvaged (1)</td>
</tr>
<tr>
<td><em>Sº António</em></td>
<td>1589</td>
<td>Seychelles</td>
<td>Small portion</td>
<td>Looted / Surveyed (1)</td>
</tr>
<tr>
<td><em>Sto. Alberto</em></td>
<td>1593</td>
<td>South Africa</td>
<td>Unknown</td>
<td>Surveyed (1)</td>
</tr>
<tr>
<td>Cochin Shipwreck</td>
<td>Late 17th c.</td>
<td>India</td>
<td>Unknown</td>
<td>Looted? (14)</td>
</tr>
<tr>
<td>Wan-Li Shipwreck</td>
<td>Early 17th c.</td>
<td>Malaysia</td>
<td>Unknown</td>
<td>Salvaged (15)</td>
</tr>
<tr>
<td>IDM-003 Shipwreck</td>
<td>Early 17th c.</td>
<td>Mozambique</td>
<td>Extensive</td>
<td>Salvaged (15)</td>
</tr>
<tr>
<td><em>Nossa Senhora dos Mártires / Pepper Wreck</em></td>
<td>1606</td>
<td>Portugal</td>
<td>Small portion</td>
<td>Looted / Excavated (1)</td>
</tr>
<tr>
<td><em>São Salvador</em></td>
<td>1606</td>
<td>Malaysia</td>
<td>Unknown</td>
<td>Looted?</td>
</tr>
<tr>
<td>Galleon of Duarte Guerra</td>
<td>1606</td>
<td>Malaysia</td>
<td>Unknown</td>
<td>Looted?</td>
</tr>
<tr>
<td><em>Espíritu Santo</em></td>
<td>1608</td>
<td>South Africa</td>
<td>Unknown</td>
<td>Surveyed (1)</td>
</tr>
<tr>
<td><em>Madre de Deus</em></td>
<td>1610</td>
<td>Japan</td>
<td>Unknown</td>
<td>Destroyed by dredge works (16)</td>
</tr>
<tr>
<td><em>Nossa Senhora da Luz</em></td>
<td>1615</td>
<td>Azores</td>
<td>None</td>
<td>Surveyed (1)</td>
</tr>
<tr>
<td><em>S. João Baptista</em></td>
<td>1622</td>
<td>South Africa</td>
<td>Unknown</td>
<td>Surveyed (1)</td>
</tr>
<tr>
<td><em>São José</em></td>
<td>1622</td>
<td>Mozambique</td>
<td>Unknown</td>
<td>Salvaged? (17)</td>
</tr>
<tr>
<td><em>S. ta Catarina</em></td>
<td>1622</td>
<td>Mozambique</td>
<td>Unknown</td>
<td>Salvaged? (17)</td>
</tr>
<tr>
<td><em>S. Bartolomeu (?)</em></td>
<td>1626</td>
<td>France</td>
<td>Unknown</td>
<td>Looted? (18)</td>
</tr>
<tr>
<td><em>S. Gonçalo</em></td>
<td>1630</td>
<td>South Africa</td>
<td>Unknown</td>
<td>Survivor’s camp excavated (1)</td>
</tr>
<tr>
<td><em>Santa Catarina de Rilamar</em></td>
<td>1636</td>
<td>Portugal</td>
<td>Unknown</td>
<td>Surveyed (1)</td>
</tr>
<tr>
<td><em>Santa Maria Madre de Deus</em></td>
<td>1643</td>
<td>South Africa</td>
<td>Unknown</td>
<td>Surveyed (1)</td>
</tr>
<tr>
<td><em>Santíssimo Sacramento</em></td>
<td>1647</td>
<td>South Africa</td>
<td>None</td>
<td>Salvaged (1)</td>
</tr>
<tr>
<td><em>N.ª S.ª da Atalaia do Pinheiro</em></td>
<td>1647</td>
<td>South Africa</td>
<td>Unknown</td>
<td>Survivor’s camp excavated (1)</td>
</tr>
<tr>
<td>Sunchi Shipwreck</td>
<td>Mid 17th c.</td>
<td>India</td>
<td>None</td>
<td>Excavated (17)</td>
</tr>
<tr>
<td><em>Sto. António de Tana</em></td>
<td>1697</td>
<td>South Africa</td>
<td>Extensive</td>
<td>Excavated (19)</td>
</tr>
</tbody>
</table>
### Table 6
**Europe: 16th and 17th Century Shipwrecks**

<table>
<thead>
<tr>
<th>Shipwreck</th>
<th>Date</th>
<th>Location</th>
<th>Timber remains</th>
<th>Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cattewater Shipwreck</td>
<td>Early 16th c.</td>
<td>England</td>
<td>Extensive</td>
<td>Excavated (20)</td>
</tr>
<tr>
<td><em>Lomelina</em></td>
<td>1512</td>
<td>France</td>
<td>Extensive</td>
<td>Excavated (21)</td>
</tr>
<tr>
<td>Rye A Shipwreck</td>
<td>16th c.</td>
<td>England</td>
<td>Part of a mast step</td>
<td>Surveyed (22)</td>
</tr>
<tr>
<td>Calvi 1 Shipwreck</td>
<td>Late 16th c.</td>
<td>France</td>
<td>Extensive</td>
<td>Excavated (23)</td>
</tr>
<tr>
<td>B&amp;W 7 Shipwreck</td>
<td>Late 16th c.</td>
<td>Denmark</td>
<td>Small portion of the bottom</td>
<td>Excavated (24)</td>
</tr>
<tr>
<td><em>Saint Honorat I</em></td>
<td>17th c.</td>
<td>France</td>
<td>Unknown</td>
<td>Surveyed (1)</td>
</tr>
</tbody>
</table>


It is therefore difficult to precisely define what constructional features characterize an Iberian ship from the 16th and early 17th centuries. These ships were the end result of a long process that entailed many decisions regarding the financing, conceptualization, construction and outfitting. They were all different and the standards within which they were built changed constantly in time. State built ships were among the most expensive and sophisticated artifacts constructed during the 15th, 16th, and 17th centuries, and a drive for improvement seems to have been a constant incentive for change.

The history of the three centuries of European expansion is hard to imagine without these complex machines, which carried – as J. Richard Steffy put it – people, merchandises and ideas across the globe, and made possible the contact between populations of all continents, even if often times that contact had dreadful consequences for some of the less technologically
developed players. Unfortunately, ships also carried diseases, wars, and oppression.

What is worth stressing here is that given the importance of the technical characteristics of the vessels of this period, it is almost incomprehensible how little we know about them.

The excavation of one of four 16th-century Basque galleons found in Red Bay, Canada, greatly advanced our understanding of this type of ship. Paradoxically, this excavation brought more questions than answers to the discussion: Can we define a regional type for the entire Iberian Peninsula in the 16th or 17th centuries? How different were these ships from the English, Danish, or French ocean-going ships of their time? How much did Portuguese and Spanish shipwrights change the original Mediterranean model through time? How different were the Spanish and the Portuguese ships?

During my first semester at Texas A&M University’s Nautical Archaeology Program, in the fall of 1998, I had to interrupt my studies to attend a meeting in Lisbon which gathered some of the best scholars on Iberian seafaring (Alves 2001). On the way back I missed an airplane connection, and spent a delightful afternoon with J. Richard Steffy, in an airport somewhere, discussing how little was (and still is) known about this subject.

Victims of the international market of antiquities, most Iberian shipwrecks have been destroyed by treasure hunters who abandoned the remains of the hulls after stripping the wreck of all artifacts with market value. Both the artifacts without high monetary value (but with significant academic value) and the hull remains are destroyed in this process. Sometimes treasure hunters are looking for sunken treasures for their own amusement, sometimes working for savvy anonymous investors, and other times they just use shipwrecks as a pretext to raise money from credulous folks. No matter their rationale, however, treasure hunters have forever destroyed many untouched shipwrecks, and important artifacts are scattered in private collections where they remain off limits to the scholarly world.

These shipwrecks are remembered only through an occasional auction catalog, a story in a glossy paper magazine, or a coffee table book, all of which are generally full of unreferenced pictures and anecdotal stories that cannot be verified. Publications originating in treasure hunting ventures
seldom add any information to our knowledge about the ships, their crews, their voyages, or the period to which they belong. Moreover, we only know of the shipwrecks whose artifacts are actually sold at advertised auctions. How many ships have simply been erased from the archaeological record without publicity?

Because they are believed to house artifacts with market value, Iberian vessels seem to have suffered the largest share of treasure hunters’ destructions, perhaps only matched by the Dutch Indiamen of the 17th and 18th centuries.

Nine years after my delightful afternoon with J. Richard Steffy I am now part of the Nautical Archaeology Program faculty, and I am still studying the ships of the Iberian Peninsula. There is so much to learn about these fascinating vessels. They were almost without decorations or any other particular aesthetic arrangements, but were nevertheless symbols of power that commanded respect around the world. They carried a multitude of sailors, soldiers, merchants, priests, and adventurers around the seven seas; all during an age without sufficient communication systems so that each one of these ships had to be an autonomous floating city for up to eight months at a time. We don’t know much about the way they were conceived, designed, built, sailed, or inhabited. We don’t know much about their performance under sail, as war vessels, living spaces, or conveyors of peoples’ ambitions, dreams, and ideas.

During the 20th century historians have found, studied, and published most of the important documents pertaining to these ships in Portugal and Spain (Domingues 2000, 13-58 and 2004, 21-33; Fernández Duro 1973, 1996; Artiñano y Galdácano 1920; Vicente Maroto 1998; Rahn-Phillips 1987, 1993, 2000). In the 21st century we hope that the advancements in archaeology will allow us to reinterpret the documentary evidence – written and iconographic – and reconstruct not only the ship’s hulls, but also their intact stability, and sailing abilities. Perhaps more importantly, we hope to recreate the life-aboard conditions, the spaces within which such large and diverse crowds interacted, worked, and went about their days for months in a row, away even from the sight of land.

One word of caution must be cast regarding the role of nautical archaeologists in the studies of Iberian craft, mostly in southern European countries. Personal hatreds and power wars have delayed the publication
of many shipwreck excavations. Secrecy is the rule in many countries, and a tribal attitude towards foreign scholars has prevented a healthy circulation of information and barred the creation of conditions for an open and scholarly debate of these issues.

The Society for Historical Archaeology 2006 Annual Meeting

The task of understanding such a diverse number of ships and boats, all solutions for particular problems at particular times, is daunting. Each one of the ship types considered evolved through time, within very loose standards of shape, rigging configuration, and size. To understand such a diverse number of ships and boats is not a task that can be tackled by any one scholar alone, nor in any one lifetime. That is why I decided to organize an informal group dedicated to the study of Iberian seafaring during the 16th and 17th centuries. The student response was great, their enthusiasm contagious, their competence outstanding, and their focus reassuring for any coordinator of such a group.

Two years ago I thought that it was time to make sense of all this work and organize a symposium at the 2006 Society for Historical Archaeology Annual Meeting – which was held in Sacramento, California, between the 11th and the 15th of January – where all these students could present and discuss their research with their peers.

We set up weekly meetings to define strategies and list needs in terms of research (bibliographical reviews of each subject, etc.), and in terms of resources (how much research we must do, where, for how long, and at what cost). My second ongoing effort was to identify professional niches for these students, keeping in mind that they are going to graduate, get jobs, and hopefully continue their research in this and related subjects.

The symposium was approved and, even better, the idea of publishing the proceedings was applauded by the participating students. Generous grants from the The Luso-American Foundation and Texas A&M University alum Dr. Peter Amaral made the event possible.

The Society for Historical Archaeology meeting’ theme for 2006 was “Life on the Edge”, and Dr. Jerome Hall, former INA president and Underwater Program Chair of this SHA’s annual meeting, suggested that our symposium be called “The Edge of Empire: Iberian Ships” (Figure 3).
The papers presented in this volume are a snapshot of a work in progress. Some need to be polished, others need to be developed further, and some open new avenues for research. My hope is that this volume inspires all the students that participated in the SHA 2006 meeting to continue their research with the same enthusiasm and aim at publishing their final academic works, which will undoubtedly be relevant contributions to the knowledge of Iberian seafaring in the age of sail.

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The Iberian Caravel: Tracing the Development of a Ship of Discovery

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Abstract

Caravels are the icons of the Age of Discoveries. This paper summarizes some of the aspects related to their past research and hopeful future contribution of nautical archaeology for the understanding of these elusive and almost unknown vessels. Their origins and development are analyzed and part of the standing sources for their understanding commented upon. Far from an exhaustive compilation of sources, and not pretending to be a critical analysis of the bibliography – which I intend to publish in the near future – this text is just a preliminary reflection on the problem of reconstructing the 15th Century caravel of the discoveries.

Introduction

The caravel of the 15th and 16th centuries was a ship with a distinctive shape and admirable qualities. A gently sloping bow and single stern castle were prominent features of this vessel; it carried a main and a mizzen mast that were generally lateen-rigged – referring to a triangular sail set from a long spar at an angle to a short mast (Figure 02-01). Although the caravel had already been in use for hundreds of years, it developed into an incredibly fast, easily maneuverable vessel at the height of the Age of Discovery, and was noticed by eminent people. Gaining fame with Spanish and Portuguese voyages of discovery, these former fishing craft were sent down around the west coast of Africa and into the New World. Though Santa Maria was a nau, Columbus’s smaller vessels, Niña and Pinta, were caravels. In his log from the first voyage to the New World, the Admiral of the Ocean Sea often expressed admiration for his favorite ship, Niña, commenting on her exceptional speed, handling, and safety. After sailing
this caravel through violent storms on the return voyage, Columbus remarked, “if the caravel had not been very sound and well equipped, I fear we would have been lost” (Columbus 1987: 184). Bartolomeu Dias too sailed in caravels during his famous rounding of the Cape of Good Hope in 1488. It has become evident in the historical record, however, that not all caravels were designed the same way, and many changes were made throughout the history and development of the ship. Thus, it is difficult to define the quintessential caravel (Elbl 1985:543).

The caravel was an integral part of the Iberian expansion during the Age of Discovery. The Portuguese were able to navigate the treacherous coasts of southern Africa and reach India using of this craft, and with the same ship type the Spanish were able to traverse the Atlantic Ocean and discover the Caribbean Islands. Although this vessel is well-known as the vanguard of European expansion, little is understood about its development. In spite of the fact caravels were used almost exclusively as exploratory vessels during the 15th and 16th centuries, there is a paucity of information about this particular type of craft. Although many of these ships were reported to have sunk during the Age of Discovery, there are no confirmed physical remains of caravels in the archaeological record. Due to this lack of material evidence, most of the vessels’ structural elements are unknown. A number of scholars have attempted to reconstruct the lines of a caravel throughout the last hundred or so years, but these reconstructions are conjectural and based on a perceived ideal shape of a caravel. With these ship plans in mind, full scale ‘replicas’
of caravels have been built for occasions such as the 1892 fourth centenary of Columbus’s voyage to the New World. The sailing capability of some of these vessels has been compared by the captains to sailing a barrel (Smith 1992:39). Consequently, scholars of Iberian seafaring and shipbuilding must look to proxy data and secondary sources in order to determine the finer structural characteristics of the caravel, as well as shipbuilding techniques, size range, rigging arrangement, living spaces, sailing capabilities, crew size, cargo space, and other ship-related details.

Obtaining a comprehensive understanding of the caravel cannot be achieved solely through researching old texts, but must also include examining a wide variety of sources, analyzing and synthesizing the data, comparing and contrasting similar works, evaluating the trustworthiness of the sources, and finally reconstructing a view of the vessel that most closely and reliably adheres to the most dependable evidence available.

This approach involves drawing on many lines of evidence, including Iberian history, iconographic representations of caravels, ethnographic analogies to shipbuilding techniques still used in some parts of the world today, archaeological parallels of similarly built Iberian watercraft, and contemporary shipbuilding and nautical treatises. This research embodies a variety of themes, such as how the Portuguese became the leaders and innovators in this age of exploration. They expanded their empire to the north coast of Africa, set up trading ports all along the west coast of Africa, and traded extensively with India. The fact that they were capable of achieving the establishment of trade in these areas through expansion leads to interesting suppositions of events that led up to these accomplishments.

**The Development of the Caravel**

With its shallow draft, lateen-rigged masts, relative lightness, and quick maneuverability, the caravel became an amazingly adaptive vessel for the task of exploration; however, it should not be assumed that the advent of this type of ship allowed easy passage to uncharted waters. Fifteenth and 16th Century mariners, in general, faced many dangers at sea, but the unknown regions to which the Portuguese navigated were laden with additional hazards. The distances they traveled required them to secure a source of water along the way or to carry more water than on shorter journeys. They also had to face the inevitability of death along the way,
which required a larger crew. The early explorers were confronted with unfavorable weather conditions, harsh rocky coasts, unfamiliar currents and adverse winds, and limited geographical knowledge. Undoubtedly, the caravel was a pivotal factor that enabled the exploration of these unknown and potentially dangerous waters that the Portuguese entered. The question remains, however, as to exactly how the Portuguese utilized this diminutive craft to achieve such great accomplishments. The more maritime historians and archaeologists know about caravels, the more scholars will be able to study the lives of Iberian seafarers and explorers during the Age of Discovery.

Researching the development of any ancient ship begins with the investigation of its origins; tracing the vessel historically allows a scholar to analyze the usage and development of the ship as well as its structural attributes. The exact origin of the caravel can be debated indefinitely, since its development was a gradual transition. There are many possibilities and theories, but no conclusive evidence to sustain them. It is clear from historical Portuguese records that the caravel was a fishing vessel in the 13th century; however, it may be possible to trace the vessel’s origin to an earlier time and even another region by examining the etymology of the term ‘caravel’. Elbl reports that in the early 13th century, the term ‘caravel’ was connected to a small ship related to Muslim Algarvian and Maghrebin models of lateen-rigged craft made to suit Atlantic sailing conditions. Called qârib this vessel was well equipped to travel in shallow waters and was used as a fishing boat, coaster, and light warship (Elbl 1985:545). Although little is known about the technical details of this small Arab vessel, it had preferred features that allowed it to transform into progressively larger forms, much like the caravel. Because the caravel presumably had some of the same characteristics of the qârib, some speculate that the word ‘caravel’ is derived from qârib, and, therefore, the vessel is of Arabic origin.

Spanish and Portuguese scholars, during the 19th century, also sought Roman and Greek terms that could have spawned the word ‘caravel’. Jal’s Archéologie navale even suggested an Italian origin for carabela as cara bella, apparently owing to the beauty or grace of the vessel. Although some possible origins of the word ‘caravel’ were proposed, the scholars found no references to the design and construction of the ships they were attempting to trace to the 15th-century vessel, except that they were referred to as
small, light vessels with good sailing capabilities that traded widely inside and outside the Mediterranean (Edwards 1992:420).

Despite the uncertainty concerning the etymology of the word ‘caravel’, the first mention of the Portuguese vessel in an official document was its integration into the English fleet upon its return to Gascony in 1226 (Michel 1876:1, 153; Elbl 1985:546). By examining the sources in which these early caravels appear, as well as other contemporary ships, an indication of the size and capacity of the early caravels can be found. Early sources, such as the *foral* (chart) of Vila Nova de Gaia, refer to the caravel as paying the lowest of the entry tolls (Marques 1944:7-8; Elbl 1985:546). By comparing the caravel with other ships on the list, a relatively small size and capacity can be attributed to this early version of the vessel. Throughout the centuries, this changed as the utilization of the caravel also changed.

Returning to the 13th Century caravel, a variety of forms can be seen. It is known from the *foral* of Vila Nova that these caravels were small and of limited capacity. This is logical, as during this period of their development they were likely used primarily as fishing vessels along the Atlantic and Mediterranean coasts; their shallow draught and low sides were fit for such use. It is also conceivable that these ships were employed for trade and, therefore, could have been fully decked at this time. Since many ships during this period were similar to the caravel in size and rigging, a tentative comparison can be made with other vessels regarding tonnage and keel to beam ratios. The 13th-Century caravel is surmised to have been a lateen one-or two-master under 30 tonéis, with a keel to beam ratio of 5:1. This is rather high compared to the ratio of the ship during its last stages of development in the 17th century, which had a keel to beam ratio of 2.64:1, based on instructions set forth for a caravel of eleven rumos in the 1616 nautical treatise *Livro de traças de carpintaria* by Manoel Fernandez. The ratios and tonnages of the 13th-century vessel are speculative, but as Elbl (1985) notes, the 14th Century record – dated AD 1307 – from the Biscayan area mentions small caravels with crews of nine men each. According to Azevedo, these manning ratios in the 15th century represent vessels of 18-20 tonéis (Azevedo 1934; Elbl 1985:548).

There is little doubt that caravels continued to be utilized as fishing and commercial vessels during the 14th century. There is, however, an odd absence of the ship in records, which cannot be easily explained. Caravels
are not mentioned in historical accounts other than the Biscayan records of 1307, nor are they depicted in the available iconography of the period. Despite this nonappearance, there was definitely a shift in the size of caravels as they seem to have taken over the functions of another light Portuguese vessel, the \textit{barinel}. The \textit{barinel}, which resembled the Atlantic balener, was better suited to sail in the Bay of Biscay than other southern ships of the same size. This shift may be indicative of transitions from a coastal vessel to one capable of faring well in the high seas as is noted in Catalonia in the first half of the 15\textsuperscript{th} century.

The \textit{setee}, a light vessel with a long hull, lateen sails, and a size comparable to a caravel, is mentioned in an ordinance of 1438 issued by Alfonso the Magnanimous: “…we know that the \textit{setee} was in other times a light oared vessel and now it is the heaviest ship, of greater board and capacity for long voyages; the same for the bark…today it is taken in general as a vessel of lateen sail that consists of three masts” (d’Albertis 1892:41; Elbl 1985:549). For these reasons, it is plausible to assume that throughout the 14\textsuperscript{th} century the caravel underwent alterations – such as increases in carrying capacity – that made it somewhat more suitable for ocean voyages.

It is easy to see then why navigators during the Age of Discovery used caravels to voyage along the west coast of Africa in the 1440s. Earlier explorers used barks of about 25 tons, which had a single mast. They also experimented with the longer and larger \textit{barinels}, but neither of these vessels was adequate for the increasing length of the voyages (Unger 1980:212). Being longer, lighter, and of shallower draft, the caravel was chosen to replace the \textit{barinel} in the voyages of exploration down the west coast of Africa. Other key reasons were the caravel’s speed and its ability to sail to windward, which was paramount for return trips into the trade winds. This early 15\textsuperscript{th} Century caravel had more admirable qualities than previous ships used for reconnaissance, but was still far from perfect. The ship’s great lateen sail required a large crew, which was dangerous because the small exploratory vessel could not carry enough fresh water for the sailors.

During the 15\textsuperscript{th} century Iberian shipbuilding underwent a new phase of design, adapting the vessels to meet to the demands placed on ships of discovery. To illustrate the elevated preparation of shipyards and shipping of the 15\textsuperscript{th} century, Dom João II of Portugal (1477-1495) ordered a nau
of 1,000 tonéis burden to be built, in a time when they rarely exceeded 300 tonéis; the keel of this vessel was 31.50 m long and the ship’s length overall was 50 m (Barata 1987:161). There are records of other impressive ships from Portugal, such as São João of 1533/34, which was one and a half times the size of the largest Indian ships (Barker 2001:215). Such ambition also called for changes in the caravel as a ship of discovery. Rather than relying solely on the technical knowledge of naval architects, these demands were taken on by skilled craftsman, who were capable of transforming the geometry of the vessel to suit the requirements of a sea-going explorer (Barata 1987:167).

As mentioned previously, the caravels Niña and Pinta were chosen to accompany the nau Santa María for Columbus’s attempt to discover a route to the East in 1492. By this time in Spain, however, the caravel had largely transformed from the caravela latina to the caravela redonda; the former wielding lateen sails while the latter was rigged with a combination of lateen and square sails. The Portuguese retained the lateen sails for their caravels, because they better suited their purposes along the west coast of Africa. The Spanish caravel was now a three-master with a square sail on the main and fore masts, and a lateen sail on the mizzen mast. As in the case of Columbus’s Pinta, the caravel could be converted from a lateen-rigged vessel to a square-rigged vessel. This new sail arrangement provided the necessary adjustments to make the caravel what was commonly referred to as the best sailing vessel of its time. The caravel continued to increase in size, but was still small enough to be easily maneuvered. As the ship became heavier, it also became beamier in order to increase the carrying capacity for each meter of length. The length to beam ratios were now likely in the range of 4:1 to 3:1 (Unger 1980:214). The caravel’s development over the centuries made it a viable choice for exploration, trading, warfare, and piracy.

It is evident from the historical record that the Portuguese caravel underwent a gradual development since its inception as a fishing vessel in the 13th century. By carefully examining such historical data as presented in the previous paragraphs, scholars can compare similarly built ships from the archaeological record in an effort to understand how the caravel was built throughout its various developmental phases. Moreover, historical research assists archaeologists in further understanding the shipbuilding trends that were affected by numerous circumstances in the medieval
and post-medieval eras. These trends were influenced by socio-political, economic, and environmental conditions of the periods and cultures under study. Additionally, information that is gleaned from the historical record can be compared with other lines of evidence in order to substantiate and assure the reliability of the sources.

Archival Evidence of the Caravel: Treatises and Manuscripts

Contemporary treatises and manuscripts, many of which describe the practice of Iberian shipbuilding, are excellent tools for understanding the construction sequences and capacities of ancient ships. Unfortunately these documents do not become available until the late 16th century, when records of shipbuilding practices were written and kept; before this time information was safeguarded in the minds of skilled masters who passed on the traditions, both orally, from generation to generation, and by shared work experience. Additionally, as Casado Soto points out, the combination of low life expectancy and the rigid secrecy that was practiced regarding this specialized knowledge ensured that these traditions would not survive in writing (Casado Soto 2001:131).

In Spain there was little mention of shipbuilding in Castilian documents before the reign of Christian kings, and when ships do appear it is usually only with regard to their names, types, and occasionally tonnage. With the reign of Charles V (1516-1556) and the expansion of foreign policy, however, there was an increase in management techniques. When Phillip II (king 1556-1598) ascended the throne even more was accomplished; he regulated navigation in convoy, set a standard for mercantile shipbuilding, and introduced technical specifications that led to improvements in safety (Casado Soto 2001:135). Phillip II provided incentives to shipbuilders by exempting sales taxes on the purchasing of shipbuilding materials. Likewise, Phillip II established an efficient system for measuring the hulls and capacities of ships, and he was the first European monarch to use a prototype to build ships for the armadas, choosing the galleon as the model (Casado Soto 2001:135). It is during his reign that documentation of shipbuilding techniques and navigation grew the most including the following published examples:

- 1536, Alonso de Chavez: *Espejo de navegantes*
- ca. 1560, President Visitador: *Papeles*
- 1568, Domingo de Busturria: *Memorial*
ca. 1570, Rodrigo Vargas: *Apuntamiento*

1575, Juan Escalante de Mendoza: *Itinerario de navegación*

1581, Cristóbal de Barros y otros: *Discusión de prototipos de galeón*

1587, Diego García de Palacio: *Instrucción náutica*

1611, Tomé Cano: *Arte para fabricar, fortificar y aparejar naos*

These documents are useful tools for studying the history of shipbuilding and navigation, but caution must be taken when interpreting them. The various authors were influenced by their own professions and the extent of their experience in shipbuilding is largely unknown. Nevertheless, these manuscripts and treatises give information on types and amounts of raw materials needed for shipbuilding, as well as dimension and tonnage of ships. The documents listed above give no indication of how ships were built; they merely list the capacities and tonnages of vessels. The few remaining Iberian nautical treatises are more helpful in understanding how these ships were constructed. Four in particular deal with shipbuilding in detail and deserve brief attention here: *Livro da fábrica das naus, Instrução náutica, Livro primeiro da architectura naval*, and *Livro de traças de carpintaria*.

Father Fernando Oliveira’s book, entitled *Livro da fábrica das naus*, dates to 1580, and is the earliest surviving treatise dealing with the construction of Iberian vessels. Fernando Oliveira was not a shipwright, but he claims to have studied in shipyards throughout Europe including Italy, Spain, France, and England. He had varied interests and pursued many goals during his life, and may be considered a true renaissance man. Some of his professions included sea pilot, sailor, adventurer, priest, and writer, and he had an extensive knowledge of ships. His book is comprised of nine chapters, and although incomplete, it provides a wealth of relevant information. One section details the materials employed in shipbuilding, such as iron nails, oakum and pitch for caulking, and grease used in lubricating the vessel. Additionally, Oliveira briefly describes various kinds of ships, including *naus*, galleys, galleons, and caravels. Furthermore, he goes into detail on the construction and measurement of ships, which is extremely useful. Oliveira illustrates how the frames of ships are predetermined using Mediterranean lofting techniques that still survive in parts of the world today. This was achieved by using algorithms such as the *graminho* to calculate the rising and narrowing of the floor timbers, which gave the shape of the ship’s hull. The *almogamas* were the first and last pre-determined frames of the vessel. The remainder of the frames was probably inserted after ribbands —
wooden bands temporarily attached longitudinally to the pre-determined frames — were used to get the whole curvature of the vessel. Measurements are given in the standards for 16th-Century Portuguese shipbuilding; dedos (1.83 cm), palmos (25.67 cm), and rumos (1.54 m). Other instructions, such as the use of arcs to determine bow and stern rakes, are also included in considerable detail (Oliveira 1991; Domingues 2004).

Doctor Diego Garcia de Palacio’s *Instrución náuthica* is the second surviving treatise on shipbuilding and was published in Mexico City in 1587. The majority of the book was written in dialogue between a Biscayan and a Montañés, a common form of writing during that time. This treatise is a valuable guide on a variety of maritime subjects, including astronomy, navigation, duties of officers and crew members, and ship design. It is an important work as it provides Garcia de Palacio’s notions of ideal ship proportions. In his description of a *nao* of 400 toneladas Garcia de Palacio gives a keel to beam ratio of 2.13:1, a length to beam ratio of 3.21:1, and a depth to beam ratio of 0.72:1. Although these proportions are for a *nao*, Garcia de Palacio asserts that they could be used for any size ship. The treatise also contains sections detailing the design of hulls, masts, spars, sails, rigging, ship’s boats, artillery, and other features (Garcia de Palacio 1988). Garcia de Palacio also includes helpful drawings of his descriptions in his manuscript.

*Livro da arquitectura naval*, composed by João Baptista Lavanha, was published around 1609. Lavanha, born in Lisbon in the middle of the 16th century, worked in the courts of both Spain and Portugal. He taught mathematics at the Academy of Madrid and was appointed Engineer of the Realm of Portugal in 1586 and in 1591 Lavanha was named Chief Cosmographer. His treatise is divided into seven chapters, the last one further separated into five sub-sections. The first three chapters are concerned primarily with general architecture, but the fourth deals with architecture as it pertains to naval construction. The rest of the manuscript describes materials, timbers, and other necessary components for ship construction. Lavanha gives detailed instructions on how to build a four-decked *nau* with a keel length of seven and one-half rumos, or 11.55 m. His specifications include swinging arcs to achieve the proper curvature of frames and rakes, construction of the ship’s transom, scarfing or joining of the keel, narrowing and rising of the bottom of the vessel using a graminho, and positioning of the pre-determined frames of the ship, among a host of other directives (Lavanha 1996; Domingues 2004).
The fourth treatise, *Livro de traças de carpintaria*, is by a shipwright named Manoel Fernandez and dated to 1616. The *Livro de traças de carpintaria* is a valuable book because it was supposedly written by a man with practical experience in the shipyard, although there is some contention among scholars whether he spent much time constructing or just theorizing. There are two parts of this treatise: the first section lists dimensions of various ships and their primary components, such as keel, stem, and sternpost. In this first part, Fernandez sets forth instructions on how to build a variety of Portuguese vessels, including galleons of varying tonnage, carracks, warships, brigantines, and caravels (Fernandez 1995; Domingues 2004). The second part is a collection of drawings of the ships described by the author in the first section of the manuscript. Regardless of his true affiliation with the shipyard, Manoel Fernandez was a man with the presence of mind to record the general rules and procedures for building certain Portuguese – and perhaps Spanish – vessels of the late 16th and early 17th centuries. His drawings and lists of dimensions of various ships are invaluable sources for scholars of Iberian shipbuilding because they give a perspective of the three dimensional aspects of Iberian vessels, many of which cannot yet be examined archaeologically.

**Ethnographic Studies of Iberian Shipbuilding Techniques**

The shipbuilding treatises that have survived provide scholars with at least a rough guide as to how ships were built in the 15th and 16th centuries. These same methods may have been used even earlier, for there are some traditions that never completely fade away. An example of this is the aforementioned ‘Mediterranean method’ of frame molding. This method survives today in certain parts of the world, including Bahia, Brazil. Ethnographic studies involving modern day boat builders can yield some astonishing and extremely useful information. The following study illustrates how this pertains to the study of the caravel.

Situated on the northeastern coast of Brazil, Bahia is immersed in history, especially concerning ships and seafaring. The discoverers first reached these shores using caravels, and also in the smaller version, the *caravelão*, which was perfectly adapted to the reef strewn coast of northeastern Brazil. Gaff sails were soon substituted for lateens in these coastal vessels, which retained the windward ability and required a much smaller crew. Up until 1960, fishing and transportation of cargo was done in wooden
sailing vessels, including *barcos, lanchas, saveiros,* and *canoas* (Sarsfield 1985:85). These vessels were vestiges of the original ships of exploration, although they suffered adaptations to the coastal environment. But in the 1960s, when highway construction and large commercial ferries began to dominate, the traditional way of life changed and boat building began to wane. Nevertheless, According to Sarsfield (1985) the ancient boat building traditions were not completely extinguished. Some of the old boats were being bought and repaired for recreational purposes. Many were re-rigged as schooners and before long became increasingly popular. Soon, all the old boats were sold and there was a growing demand for this new pleasure schooner. Once again the boat building industry began to thrive, and although boats were built for pleasure instead of work, many of the traditional methods of construction were retained and can be seen today.

Sarsfield’s journey to Bahia and observation of boat builders in this region uncovered that boats were constructed by the method of Mediterranean molding. This was the same technique used by Iberian shipbuilders to construct carracks, caravels, and naus during the Age of Discovery (Sarsfield 1985:87). By carefully studying these Bahian boat builders, scholars such as Sarsfield can get an authentic perspective of how boats were built in the 15th and 16th centuries. Certainly there are variations in the methods used by the modern Bahians, but the basic building methods have survived to this day. Sarsfield described the manner of construction of the Bahian boats:

First the keel, usually hewn from a single tree, is set up. Next, sternpost and stem are fixed upon the keel, together with their respective knees. The angle made by the stem with the keel in conjunction with the knee provides a large surface of deadwood that gives these boats, and very possibly their caravel ancestors, a certain amount of windward ability (Sarsfield 1985:87).

Through ethnographic studies researchers are able to get a physical sensation of how ancient vessels were constructed, in addition to the written knowledge that is obtained from studying manuscripts. Such studies also enable scholars to detect the nuances when comparing archaeological evidence to historical documents and other references. Since very few places – perhaps some parts of Portugal and Newfoundland, Canada – still practice this type of boat building today, more ethnographic research needs to be done before these shipbuilding practices become extinct.
The Archaeological Record: identifying the unknown?

Although there are presently no known surviving timbers known to belong to caravels, it is essential to incorporate archaeology into the investigation of this type of ship. It is another line of evidence that ensures, through careful comparison and assessment, a thorough and accurate depiction of the vessel. There are a number Iberian ship remains that have been found in the recent past, some of which were about the size of a caravel of discovery. Since the Molasses Reef and Highborn Cay wrecks may represent the structural limitations of a caravel more than the larger shipwrecks, these two wrecks will be examined briefly to give substance to the concept of the construction of an Atlantic vessel. The Molasses Reef wreck is a 16th Century ship that was discovered off the Turks & Caicos Islands, in the British West Indies in 1980. Excavation began in 1982 to analyze the preserved part of the hull, which was only about 2%. The hull was of oak (*Quercus sp.*) and the floor timbers were joined to the futtocks with a dovetail scarf, in the Iberian way, with two transverse treenails and two nails (Figure 02-02). The timbers were also locked together with dovetail joints (as depicted by the projecting piece and corresponding cavity in Figure 02-01). That the frames were preassembled before they were placed on the keel is evident in the method of joining the floor and futtock (Oertling 1989a:232-3). This ship had at least 11 to 16 frames that
were preassembled. There were also three nearly complete gudgeons found at this site (Figure 02-03), which indicates that the ship had a flat transom and exposed sternpost. Finally, there were heart blocks – wooden blocks with holes for extending rigging lines – at the site, which means it was probably square-rigged rather than lateen-rigged; there were no indications of blocks or toggles to facilitate the rapid movement of the lateen sail from one side of the ship to the other (Oertling 1989a:239).

The second wreck is the Highborn Cay wreck, a 16th Century Iberian vessel discovered in 1965 on the Bahamas Grand Bank. Excavations for this armed vessel began in 1983. Artillery pieces, including bombards and culverins, as well as anchors, were brought up from the site (Oertling 1989b:249). There was 12.64 m of the keel remaining, out of an estimated 12.75 m keel. The ship was approximately 19 m long and 6 m in breadth. This vessel features three pairs of buttresses that laterally reinforced the mast step, which is an extended portion of the keelson (Figure 02-04). The supporting buttresses lie on top of the floor timbers, and fit into the notched stringers on their outboard ends (Oertling 1989b: 249). The keelson was notched over the tops of the floors, and holes were cut to accommodate the bilge pump. The hull was of oak (*Quercus sp*), and also had the characteristic filler planks that were part of the ceiling planking. Finally, the futtocks and frames were attached in the manner of the Molasses Reef wreck, by treenails
and nails driven through the molded surface. Alignment of the futtocks and floor frames was provided by dovetail scarves (Oertling 1988:118).

There are certain characteristics of Iberian shipbuilding methods from this era that are evident in these two wrecks. Oertling put together a list of traits that have been found together in Iberian shipwrecks from the 16th century, such as an expanded keelson to accommodate the mast step. Other traits include rigging chain assemblies, preassembled central frames, ceiling and filler planks, keelson notched over the floor timbers, and a flat transom, among a list of 12. These Iberian traits are to be taken as a whole instead of individually, because other types of vessels may naturally show any of the features listed. Taken collectively, however, they represent a type of vessel with the characteristics necessary to survive and thrive in the Atlantic Ocean. A 15th or 16th century Portuguese or Spanish caravel would be expected to possess most, if not all, of these Atlantic vessel characteristics. Although these traits provide valuable clues as to how a caravel could have been constructed, presently there are no archaeological remains of such a vessel—thus, still others sources must be examined.

**Exploring the Iconographic Evidence**

Another source to consider when investigating a vessel of the past is iconography. The contemporary visual representations of caravels
show the shape of the vessel; its rigging, and other details that can be extracted from an exterior view of the ship are generally above the waterline. Like other sources of the past, caution must be used when interpreting iconography, because it can be deceptive: the nature of the art could be stylized; the object rendered may be simplified due to lack of knowledge; and there is often times no specification of the vessel type. It is also difficult to date images, either because information is missing, or because of artists’ tendency to copy previous models while distorting them in the process (Casado Soto 2001:139). Some of the extant images of 15th and 16th Century caravels, of varying quality, do at least reveal some of the hallmarks of the ship. Figure 02-05 is a picture from the early 16th Century Book of Fortresses of Duarte Damas, depicting three vessels from Valença do Minho (Pires 1988:54). The ship in the center is a caravel bearing a mainmast and mizzen, both lateen-rigged. The characteristically low, gently sweeping bow is portrayed, which distinguishes it from the other two, larger ships. The caravel is depicted as having relatively low sides, with a single castle. This stern castle is not a dramatically rising superstructure, but rather a simple deck to assist sailors with the operation of the mizzen mast, which is stepped at the aft portion of the castle. The mainmast is situated at the center of the vessel, and wields an enormous lateen yard, with the sail furled. Clearly, this vessel appears designed for navigating in shallow waters, and is appropriately closest to the shore.

The traits of the caravel from the Book of Fortresses of Duarte Damas are typical of the attributes exhibited in most of the other available iconography,
such as the caravels from the Mapa de Piri-Reis of 1513 shown in Figure 02-06 (Pires 1988:54 and 55). This two-masted, lateen-rigged vessel has the small stern castle, low sides, and general shape characteristic of a caravel. The most apparent difference is the shape of the bow, which is not as gently slopping as most other depictions of caravels. As mentioned previously, distortions occur and therefore iconographic resources cannot always be trusted as accurate renditions of particular vessels. Nevertheless, comparisons of many images yield notable characteristics that can be tentatively attributed to specific ship types.

Conclusion

It is evident from the information presented in this paper that, although currently archaeologists cannot directly study the physical remains of an Iberian caravel, an enormous amount of knowledge can nevertheless be gained from various lines of available evidence that relate in one or more ways to the caravel. By carefully and critically analyzing the sources that do exist, scholars can develop a distinctive description of this vessel’s attributes, development, and historical significance. Although a certain amount of knowledge obtained from various sources of information is up for scholarly interpretation, a well-organized and systematic approach can produce the most accurate conclusions. When tangible archaeological evidence of a caravel has been discovered and identified, nautical archaeologists and historians will be able to study the ship in a context that will enable comparison of data from historical, ethnographic, iconographic, and
archaeological sources, providing scholars with the affirmations of their research and adding to the information gap regarding these ships of discovery.

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Exploration and Empire: Iconographic Evidence of Iberian Ships of Discovery

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Abstract
This paper stems from my dissertation research project and focuses on maritime exploration during the Age of Discovery and the vessels that were the technological impetus for this dynamic era, which ultimately led Christopher Columbus to the New World and Vasco da Gama to India. Little is known about the caravels, naus, and galleons, three ship types that defined the era of global expansion; the archival documents provide scant information regarding these vessels and there are no proven archaeological remains of Iberian vessels of exploration. These vessels became lasting symbols of the burgeoning Portuguese and Spanish maritime empires. They are embedded within the seafaring cultures of the Iberian Peninsula and featured prominently in contemporaneous iconography. This study is an attempt to bridge the gap between the humanities and sciences through the statistical and representational analysis of the caravels, the naus, and the galleons in the iconographic record. In the scope of this study nearly 500 images will be analyzed using multivariate morphometric statistics in order to explore the following research questions: 1) can the iconography provide information on constructional characteristics of these vessels that will help us better understand typology, evolution, and design changes; and 2) how accurate is contemporary iconography in representing these ships?

Introduction
Nautical archaeology is more than the study of seafaring technology; it also entails an examination of the ambitions and motivations of individuals and nations for purposes of trade, exploration, and colonization. Ships represent an invaluable record of symbolism, national pride, and the human drive to look beyond the known world and discover the unknown. My dissertation research project focuses on maritime exploration during
the Age of Discovery and the vessels that were the technological impetus for this dynamic era, which ultimately led Christopher Columbus to the New World and Vasco da Gama to India. Little is known about the caravels, nau, and galleons, three ship types that defined the era of global expansion and are the focus of my research. The exploratory voyages would not have been possible without the unique blend of constructional design from the Mediterranean and Northern Europe. The ships of discovery here regarded in a broad sense that encompasses the caravel and the nau as vessels of exploration and the galleon as a vessel of expansion became lasting symbols of the bourgeoning Portuguese and Spanish maritime empires. It is likely that galleons were from the beginning specially designed warships that also had a role in this dynamic era of seafaring, but their function as well as their ship design is not yet fully understood. These three vessels of discovery and expansion are embedded within the seafaring cultures of the Iberian Peninsula and are featured prominently in contemporaneous iconography.

The study of the iconographic record is one of the best means to help archaeologists in the difficult task of identifying the caravel, the nau, and the galleon in the archaeological record as well as better understanding these vessels as ship types. There is only one archaeologically excavated shipwreck of a Portuguese nau, the Nossa Senhora dos Mártires which sank in front of a fortification at the mouth of the Tagus River in Portugal in 1606 (Castro 2005a, 110). This shipwreck, informally known as the Pepper Wreck, contained minimal hull remains, consisting of a few bottom timbers, and was identified as the Nossa Senhora dos Mártires, a historically documented ship that wrecked at this location in 1606. Its identification was further supported by the use of contemporary representations of nau. (Castro 2003, 14). The ship’s lines were drawn from the shipwreck data, and the upper portion of the ship’s hull as drawn by Castro closely matched profiles seen in the iconographic record. Although there are several other located Iberian shipwrecks dated to this period such as the Emanuel Point Shipwreck (Smith et al. 1998), the Molasses Reef Shipwreck (Keith 1987) the Highborn Cay Shipwreck (Oertling 1989), and the Western Ledge Reef Wreck (Watts 1993) at present there is no way to identify them as archaeological remains of any particular type of Iberian vessels of exploration. The archival record broadly describes the favorable sailing qualities of these ships, as well as their general construction and appearance. However, the
information gathered from this line of evidence is not enough to identify a caravel or a nau in the archaeological record; iconography documents the ships above the waterline and the archaeological remains are predominantly parts of the hull below the waterline.

I propose that the comprehensive use of the iconographic record to procure data on constructional and rigging details can subsequently be used to draft new lines for these vessels projecting what is known about the upper hull into the unknown lower hull. This is the reverse of Castro’s reconstruction of the one identified nau; the success of his project in correlating the projected superstructure of the vessel to the iconography lends support for this research. Likewise, the temporal evolution and typological constructional characteristics can be better understood through representational trends in the iconography and multivariate morphometrical statistical analysis of the data. This research project intends to try to bridge the gap between the humanities and sciences through the statistical and representational analysis of the caravel, the nau, and the galleon in the iconographic record. As this is the first intensive use of iconography within nautical archaeology for the purposes of determining ship design and construction, several theoretical considerations must be posed regarding this study’s validity and accuracy of the ships represented due to the fact that artists were not shipwrights.

Symbolic implications are paramount in this work. The significance of this project is closely tied to the historic and cultural importance of the caravel, the nau, and the galleon as symbols of a past Golden Age of their country; these vessels are part of the Portuguese cultural identity and played an important role in shaping modern European history. On a broader level this study will try to demonstrate that, when used correctly, iconography is a viable source of data within nautical archaeology. There is also considerable potential for increasing our knowledge of ship design theory at a time that directly preceded the wide-ranging use of shipbuilding treatises and formally drafted lines. Although there is evidence that by the end of the Age of Discovery the Portuguese shipwrights had begun to draft the lines of their caravels, naus, and galleons all drawings seem to have been destroyed when Lisbon was demolished by an earthquake, several tidal waves, and a long fire, in November of 1755 (Edwards 1992, 421). Additionally, this doctoral research will address the conceptualization of technology as a cultural symbol to understand how and why societies
attach such powerful and important symbolism to technology and adopt it as an identifying feature of their culture.

The Portuguese Seafaring Empire in the Age of Discovery

The Portuguese voyages of discovery began with the military capture of Ceuta in Northern Africa in 1415, initiating a decades-long exploration down the western coast of Africa and concluding with the discovery of Brazil and the sea route to India at the very beginning of the 16th century (Scammel 1981, 226). Likewise, utilizing the same seafaring technology (the caravel and the nau), the Spanish dominated the norther portion of the New World. The Portuguese were ideally suited to initiate the voyages of discovery due to their geographic location, a strong maritime tradition, and national political unity. Portugal’s geographic location on the edge of the Iberian Peninsula was advantageous, as it was located at the center of trade routes between Europe and the Mediterranean for centuries prior to the voyages of exploration (Smith 1993, vi). This position allowed the Portuguese to incorporate ship design technology from both areas and to interact with merchants and sailors from whom they could expand their knowledge of seafaring. This incorporation of regional technology and knowledge expanded an existing maritime subsistence tradition into a seafaring empire. The people and the sea became intertwined and remain so to this day. Fisherman, sailors, and workers in auxiliary maritime activities became the backbone of the country. The coasts were lined with ports and people receptive to the idea of exploration; their own personal motives of harvesting new fishing grounds or finding sources of trade items created a united maritime community.

This pursuit of fishing and trade alone would not have sufficed; it was through the deliberate actions and planning of the Portuguese government that the ships of exploration were designed and the expansion of their commercial interests ensued. The core of the Portuguese national unity was embedded in almost eight centuries of struggles with the resident Moorish population, the so-called reconquista, which ended in the middle 13th century with the conquest of the city of Silves, on the southern coats of the country (Smith 1993, 3). This sense of nationalism reached its height in the beginning of the 15th century; while most of Europe was busy fighting old dynastic rivalries, as well as new international and religious contentions, Portugal was free from strife (Diffie 1960, xiv). This freedom allowed
the nation to concentrate on non-military activities and redistribute its resources for other pursuits, in this case maritime exploration.

Geographic location, a seafaring heritage, and national unity provided the means to explore, but economic and religious motives provided the incentive. The economic conditions were underlined by profit and gain. The Portuguese government was well aware of the monetary potential of a sea route to the Orient that bypassed traditional routes via the Mediterranean and which promised to open new markets and guarantee a monopolistic status. Purchasing luxury items from the East increased as the production of gold and precious metals fell steadily from the mid fourteenth century. This enticed traders and merchants to look outside the continent for gold suppliers. It was known from Arab caravans that gold was available in Africa in the Upper Niger and Senegal rivers (Boxer 1969, 19; Morrison 1978, 353). As the Portuguese made their way down the African coast, the acquisition of slaves together with abundant fisheries and seal banks (harvested for salted meat, blubber, and hides) was added to the economic incentives, as well as the search for gold dust and exotic products (Boxer 1972, 24).

Religious motives were also evident in the Portuguese endeavor and must not be minimized in their importance. A crusade to convert infidels and extend the *reconquista* to the Muslim territories in Africa appeared to the Portuguese as a solemn right and duty, as these lands were thought to have once been Christian possessions (Diffie 1960, 26). Strategy and religion combined in securing an alliance with the mythical medieval priest-king Prester John, who the Portuguese thought could be a Christian ally in the East thereby helping the struggle against the Muslim advance, which at the time did not appear as if it would stop with the conquest of Constantinople in 1453 (Boxer 1969, 20). The Portuguese believed Prester John to be a powerful ruler and because of this a papal bull was released in 1455 granting the king of Portugal exclusive trading rights with the inhabitants of newly discovered lands (Boxer 1969, 7). These motives did not come into existence simultaneously; as time and space were crossed, they were defined and redefined and all are pertinent to our understanding of the nature of the Portuguese maritime expansion. However, this is not the whole story, for it cannot be told without considering the technology of seafaring. The Portuguese could not have successfully completed the voyages of discovery without the advanced ships, sailing technologies, and navigational tools they possessed.
Iberian Ships of Discovery and Empire: Caravels, Naus, and Galleons

The era from the mid-15th to mid-16th centuries is commonly referred to as the century of the caravel and is marked by Portuguese exploration, conquest, and colonization of the coastal regions of Africa and areas in and near the Indian Ocean. Throughout this century the evolution of the caravel was driven by a shift of vessel function from exploratory vessel to cargo carrier to armed man-of-war, resulting in three basic types of caravels; caravela latina, caravela redonda, and the caravela de armada. It was the exploratory period of the caravels that was the most remarkable, however, for they took part in almost every major expedition of discovery. These vessels accompanied Iberian explorers in charting the western coast of Africa. They were part of Christopher Columbus’ fleets to the New World and served as scout ships in the early East India voyages, including the one of the fleet under Pedro Cabral in 1500-1501 (which was blown off course discovering what is now Brazil) and naus were used by Vasco da Gama in 1497-98 (the first to reach India). Caravels were also used to reconnoiter the northern and eastern coasts of South America and in 1519 one caravel, Santiago, accompanied Ferdinand Magellan’s expedition (Elbl 1985:93).

Early caravels had a shallow draft that was useful for riverine and coastal commerce and this feature of the caravel quickly inspired their adaptation as exploratory vessels (Smith 1993:38). The caravel was the product of an innovative combination of constructional and rigging characteristics from the Mediterranean (lateen sails, frame first hull construction, and flush laid planking) and Northern Europe (heavier construction, stern rudder and flat transom) (Gay and Ciano 1996:75). The caravela latina seems to have been a longer, lighter version (on average 50+ tons, 20-30m in length, and 6-8m in breadth) of the Northern European round ship with one to three raked masts, all of which were rigged with lateen sails on long yards, a small, low stern castle that ran nearly to the main mast, no forecastle due to the length of the main yard, and a perhaps a flat transom and stern mounted rudder (Smith 1993:39). The caravela latina was designed for speed and windward performance; the shallow draft allowed the caravel to enter a variety of unknown bays and inlets, the length to beam ratio of the hull produced a faster vessel with reduced leeway drift, and the lateen sails allowed the sailors to sail closer to the wind which proved vital for the return trip to Lisbon (Barker 1992:434-436, Duffy 1955:49). As the voyages increased
in length and duration, design changes were incorporated, producing first the *caravela redonda* and then the *caravela de armada*.

The *caravela latina* was modified to mount square sails on the main and fore masts, to which sometimes was added a small fourth, lateen-rigged mast. Along with these modifications a larger tonnage capacity defined the *caravela redonda*, which had evolved from an exploratory vessel to a heavier ship (Elbl 1994:93). Likewise, with the addition of armament and subsequent constructional adaptations to counter the inherent stability problems, and mounting square sails on the foremast and lateen sails in the main, mizzen and bonaventure masts, the *caravela de armada* seems to have become a light man-of-war designed to be used as a scout vessel for the fleets bringing valuable cargo from the East back to Portugal (Elbl 1994:97, Cipolla 1965:80). These annual routes, however, necessitated a vessel that was stouter with more cargo capacity and crew quarters than was found on either the *caravela redonda* or the *caravela de armada*.

The *nau* was designed to meet these needs while retaining a portion of the favorable sailing characteristics of the caravel. The *nau* became a seaworthy, full-rigged ship suitable for the eighteen-month round-trip voyage to India. *Naus* were large (over 100 tons) cargo carriers rigged with square-rigged fore and main masts, with topsails and crow’s nests, lateen mizzens, and bowsprits fitted with deep spritsails (Smith 1993:46). A special type, the Portuguese India *nau*, was purpose built for the India trade and averaged, during the 16th century, a capacity of 500 to 600 *tonéis*, which is equivalent to 1,100 to 1,200 tons of displacement (Castro 2005b).

As the 16th century gave way to the 17th century the Portuguese Crown moved their intentions away from an economic-based exploration of sea routes towards colonizing their newly gained territories and securing their maritime dominance in the Indian Ocean. Galleons were part of the seafaring ventures that followed the voyages of discovery with the determination to turn exploration into empire. *Naus* and galleons illustrate the changing needs of the Portuguese resulting in a shift of function that parallels the evolution of the caravel itself from exploratory vessel to cargo carrier (*nau*), to armed man-of-war (galleon). The galleon as a ship type was used by many nations and served many different functions. They all seem to have similar features which identify them under one ship type. This research refers solely to the Iberian galleon with dominant focus on that
of the galleon of the Portuguese, which was a specially designed warship with lower superstructure and wider main deck, as well as much thicker scantlings in regards to rigging specifications (Castro pers. comm. 2006).

The galleon was a longer, sleeker version of its contemporary ship-rigged vessels. They probably had length to beam ratios ranging between 3.2:1 and 4:1, square-rigged main and fore masts, and lateen-rigged mizzen and bonaventure mast (Rahn Philipps, 1994:102). This ship type had top sails and eventually top gallants, but the Portuguese galleons had longer yards giving them a more impressive lower sail plan (Barata, 1989:335). Galleons typically had two planked decks which supported artillery; aft of the main mast was a prominent half deck, quarter deck, and poop deck that provided adequate defensive positions when drawing fire (Rahn Philipps, 1994:102). Before the main mast they had a low forecastle that gave the galleon its characteristic crescent profile as well as a bowsprit and projecting beak (Guilmartin, 2002: 158).

**The Iconography of Ships of Discovery**

In the study of seafaring technology and ship design there are three main types of evidence available; archival, pictorial, and archaeological. This research pertains to the pictorial line of evidence. However, there are problems associated with this analysis, mostly due to the fact that there is very limited scholarship on the use of iconography within nautical archaeology. Two maritime scholars, Ian Friel and Christine Villain-Gandossi, have written on the use of iconography in relation to medieval seafaring in Europe and set the foundation for this research into post-medieval iconography. Likewise, in Portugal, João da Gama Pimentel Barata wrote a seminal paper on this subject regarding the accuracy of the images (1989).

The ship is a powerful symbol in European art that has continued to be represented from the 2nd and 3rd centuries BC in the Mediterranean region to the modern world (Villain-Gandossi 1979:169). In order to understand why ships hold symbolic power it is necessary to contextualize them within the artwork. Throughout the Middle Ages and until the very late 16th century the sea provided symbolic imagery used primarily in conjunction with religious subjects that signified a changing and unstable world and a stormy sea further represented the dangers and difficulties experienced in life; the ship implicitly guided by Christ came to represent the Church
itself (Villain-Gandossi 1979:169). Religion dominated art through the Middle Ages and into the Renaissance, and this relationship of religious themes and the symbolic imagery of the sea and its ships is one explanation for their prevalence in the artwork. However, in a political context here associated with the consolidation of the modern, centralized state, the ship came to symbolize the bourgeoning empires and their growing power and strength. Ships themselves were known to be symbols of such and it is a logical and easy extension to their representation in the art. Naval flagships throughout Europe were built to be structurally imposing and heavily armed indicating power and strength, both the armament and the ship itself contained highly ornamental elements intended to convey an image of power and wealth.

As previously mentioned, there are inherent problems associated with using iconographic evidence of technology to try to bridge the gap between art and science all of which stem from the fact that most artists were not shipwrights. Problems of determining technical accuracy are seen from the start; the Roman mosaics at Ostia are remarkable for their precision and advanced artistic skills, but in spite of this early example of technical accuracy in the artistic record, there are many examples of the earliest Christian art in which realism gives way to symbolism (Villain-Gandossi 1979:169). In the Middle Ages, artists generally had little knowledge of perspective and regardless of their artistic medium few worked in traditions that were concerned with realism (Friel 1995:18). However, within the maritime art tradition, ships were often depicted with a growing attention to detail, starting in the 15th and 16th centuries. Moreover, the understanding of perspective became more developed starting in the 15th century, although according to Ian Friel, “these too are not without their contentious aspects” (Friel 1995:18). The natural limitation of the art form on which the ship is depicted also has an affect the accuracy of proportions and perspective (Villain-Gandossi 1979:172-174). This is seen in a study of medieval town seals (round coins); distortion was an inevitable occurrence, but many included credible detail and a majority did not appear ill-proportioned (Friel 1995:21).

Another problem related to the use iconography is that of schematism and stylization of an object, which is a means of simplifying forms by only expressing their most characteristic elements (Villain-Gandossi 1979:174). In nautical art this often affects such elements as the numerous standing and
running rigging lines, which impede the overall visualization of the ship. Unfortunately, rigging is not frequently discussed within the archival record, and rigging elements are rarely found in the archaeological record. Problems of proportion and distortion will be more apparent to a scholar of nautical archaeology than to one of art history. Additionally, some artists used stock images of ships consistently throughout their work while others tended to copy images from other sources (Friel 1995:19, Barker 1992:442).

Friel suggests that the solution to dealing with these associated problems is to not rely on one pictorial source or type, but to examine representational trends or the repeated occurrence of constructional features in the images (1995). Representational trends can determine technical accuracy, which is evidenced by Friel’s unpublished iconographic study of medieval Hulks which incorporated over 200 images. Temporal changes were found in the collection of images, and more importantly the study proved through the use of archival evidence these modifications were a reflection of actual technical change (Friel 1995:21). This research proposes to look at the representational trends of nearly 500 sources a majority of which contain several examples of different ship types.

**Research Questions and Hypotheses**

This project will provide the first intensive utilization of ship iconography based on two main research questions: 1) can iconography provide information on the construction of the caravel, the nau, and the galleon? and 2) are the depicted vessels accurate enough to add to our knowledge of the ships represented? The following research questions and hypotheses, including the conditions under which the hypotheses will be rejected, are concisely stated in Table 1.

**Research Question 1:** Can iconography provide information on constructional characteristics of the caravel, the nau, and the galleon that will determine typology, evolution, and design changes?

As previously discussed, the constructional details of the caravel, the nau, and the galleon are poorly known to us due to the scarcity of documental evidence and an almost complete lack of archaeological evidence; thus, other sources of data are needed. The following hypotheses are based on one such source, the iconographic evidence. A list of constructional characteristics is to be determined through representational trends in the iconography. These characteristics will then be used to draft new tentative lines for these
ships, including the projection of the hull shape to the lower portions of the hull, which is what prevails in the archaeological record. This research project will determine whether or not iconographic sources can provide enough data to identify typological constructional characteristics and temporal evolution for the caravela latina, caravela redonda, caravela de armada, the nau, and the galleon. Additionally, this project will verify if these constructional characteristics, as well as the newly drafted lines, can lead to the identification of suspected shipwrecks of caravels, naus and galleons, or facilitate the identification of archaeological remains of these vessels eventually found in the future.

Hypothesis 1: Iconography indicates different typological constructional characteristics for each of the three caravels, the nau, and the galleon.

Determining the typological constructional details of these vessels will enable archaeologists to understand sets of typical ranges of sizes of the ships under analysis, and the variation between and within each type. This knowledge is important to identify shipwrecks in the archaeological record, as it may help understand the main differences between what could potentially be a caravel, a nau, or a galleon. Iron rigging elements sometimes settle atop archaeological sites, due to their size and relative density. Understanding typical rigging plans along with general hull size and constructional could help in the identification of a caravel, a nau, or a galleon.

If this hypothesis is correct then it is expected that: 1) There will be statistically significant differences in the range of proportions in the hull, defining dimensions for each of the caravela latina, caravela redonda, caravela de armada, the nau, and the galleon; 2) There will be statistically significant differences in the rigging components for each of the caravela latina, caravela redonda, caravela de armada, the nau, and the galleon that distinguish it from the others.

Hypothesis 2: The iconography indicates a temporal evolution for each of the three caravels, the nau, and the galleon.

If this hypothesis is correct then it is expected that: 1) The hull construction of each vessel type will become larger and more complex through time; 2) The rigging of each vessel type will become larger and
more complex through time 3) There is a temporal correlation between the growing size and complexity of the caravels and the evolution of the caravel as a type; 4.a) The constructional design of the stern of each vessel will change from a rounded to a flat transom panel 4.b) All vessels will show stern design changes within discrete time changes.

**Hypothesis 3:** The iconography indicates design changes due to the addition of armament on the caravela de armada and the nau that correlate to the historical documentation.

If this hypothesis is correct then it is expected that: 1) The armed vessels will be proportionally larger and stouter than the unarmed vessels; 2) The armed vessels will have more pronounced tumblehome than unarmed vessels.

**Research Question 2:** Are the ships represented in the iconography accurate enough to be of any use to the researcher?

In order to use representational trends in the iconography it is necessary to first determine which images are accurate portrayals of the caravel, the nau, and the galleon and which are subject to too much artistic license. In the preliminary examination of iconography inaccurate images were easily identified due to limitations in media or overly stylized representation; however, the majority of the images need further scrutiny to determine accuracy. Due to the lack of theoretical and methodological considerations regarding the use of iconography as a source of data, two hypotheses will test whether or not it is possible to determine the accuracy of the depicted caravels, naus, and galleons. While the third hypothesis will test whether or not multiple depicted vessels within one source of iconography are stock images and is important in determining the accuracy of the iconography as it relates to the use of representational trends.

**Hypothesis 1:** The accuracy of some of the depicted caravels or naus can be determined using art-historical background research on the artist.

This hypothesis is based on the expectation that accuracy can be determined for some of the iconography by an art-historical examination of the role of the artist as well as the position of the depicted ship within the artwork. When the artists and their work are historically documented it may be possible to establish whether they were known to conduct research
on the subject and if their work tended to be true to the nature of the subject. An additional consideration addressed in this hypothesis pertains to the placement of the ship within the artistic composition; is it in the background or the foreground, and what is the relation of the ship to the predominant subject?

If this hypothesis is correct then it is expected that: 1) Art historical research of the known artists will indicate if they researched and accurately portrayed subject matter; 2) There is a strong correlation between the level of accuracy of the depicted ship and the predominant subject matter of the artwork; 3) The placement of the ship within the foreground or background of the art will be a predictor of the level of accuracy.

Hypothesis 2: The accuracy of the depicted caravel, *nau*, or galleon can be deduced by determining the technical accuracy of secondary ships in the iconography.

Art-historical research is not available for a majority of the iconography and thus it is necessary to rely on archaeological means to determine accuracy whenever possible. This hypothesis is based on the premise that accuracy can be deduced by determining the precision with which secondary ships were represented in the iconography. Most iconographic sources portray more than one vessel type, and it is common to have a caravel, *nau*, or galleon depicted next to contemporary ship types for which we may have both archaeological and archival evidence. It is assumed that if the artist correctly depicted these secondary ships, then the representation of the caravel, *nau*, or galleon is also accurate. Only secondary ships that have correlated archaeological, archival, and iconographic evidence will be used.

If this hypothesis is correct then it is expected that the accuracy of known secondary ships will determine, at least in part, the accuracy of the depicted caravels and *naus*.

Hypothesis 3: The use of stock images in the representation of the caravel, *nau*, or galleon can be determined statistically by examining proportionality.

This hypothesis is based on the possibility that multiple depicted vessels within one source of iconography were generated from a few stock images. A limitation in the use of iconography within nautical archaeology is the uncertainty of whether artists were depicting a stock image of a particular
type of vessel repeatedly or if each representation of a ship constitutes a
different ship. This consideration affects the validity of the representational
trends of the first research question and needs to be established so that
during analysis stock images do not account for a higher percentage of the
representational trend than they should.

If this hypothesis is correct then it is expected that: 1) Vessels depicted
by the same artist that were original productions will show a statistically
significant range of proportion. 2) The statistical range of proportionality
of suspected stock images of vessel types of one artist will be significantly
smaller than depicted vessel types from several different artists.

**Image Analysis**

Representational trends in the iconography as well as multivariate
morphometrical statistical analysis of the hull and rigging proportions
(cluster analysis and principal components) are expected to provide a set of
constructational characteristics with which to draft new lines for each of the
caravels, the *nau*, and the galleon. Representational trends will be assessed by
the presence or absence of predetermined constructional and rigging features,
along with country of origin and date when possible. The list will primarily
be composed of characteristics from the literature, along with features noticed
in preliminary observations while working with the iconography (i.e.,
number of decks, number of levels on both the fore and stern castles, shape
of the beak structure, general rigging plan, number of shrouds, number of
wales and fenders, position of chain plates, superstructure components, etc.).
It is expected that this checklist of constructional features will provide a list
of characteristics encountered within the iconography, and show a temporal
evolution of when constructional changes came into popular awareness. This
study of representational trends will constitute the preliminary analysis of the
data and the resultant information will then be compared to the statistical
analysis. Cluster analysis and principle components’ statistical tests will be
used on a representative sample of the iconography to distinguish typical
constructional proportions and temporal evolution of the caravels, the *naus*,
and the galleons as well as to determine the use of stock images in the
iconography. In both cases only the iconography established as a credible
source will be used in the data analysis.

I am currently conducting statistical pilot studies. Initial testing is
based upon determining appropriate proportional measures that may help
define the construction of these vessels; these defining features are: the length of the keel, spring of the stem post, rake of the sternpost, length overall, length of the fore and aft castles, height of the masts above deck, maximum beam, height and width of the stern panel, lengths of yards and spars, inclination of the bowsprit, and height of the castles. A limited study on the proportionality of stern panels of caravels and naus in the Memoria das Armadas, a contemporary Portuguese manuscript, resulted in distinctly separated clusters of the caravels and the naus. Likewise, in principle components analysis six logical components explain roughly 92% of the variability within the data set and all components were highly correlated at the 0.01% significance level. These preliminary results indicate that the artists depicted the vessels fairly accurately as shown by the correlation of the components and that it is possible to determine ship types through morphometric multivariate statistics.

To my knowledge there has been only one application of statistical analysis to iconography for the purpose of collecting constructional data; this was the Duyfken project (de Winter and Burmingham 2001), which will serve as the methodological foundation for this research project. According to de Winter and Burmingham, when an iconographic data set of sufficient size exists, typical proportions can be identified through univariate statistical analysis which makes possible the drafting of a ship by a largely non-subjective process (de Winter and Burmingham 2001:58). In the Duyfken project, which reconstructed a 17th Century Dutch ship, univariate statistical analysis was individually done for each character and then correlations between the characters were identified. The sample size of the study conducted by de Winter and Burmingham was a reported 13 sources with 15 ship representations. Morphometrics is the statistical analysis of relative proportions and although most statisticians will argue that only absolute measurements should be used, this is not possible when working with iconography of a variety of media and sizes (de Winter and Burmingham 2001:58). The Duyfken study aimed at identifying individual vessels as jachts within the iconography, and it was found through the use of univariate morphometric analysis that the proportions of some characters were relatively consistent throughout the data set (i.e., position of the main mast) while others showed a range of values or were clusters with value-range specific to a sub-set of jacht types (de Winter and Burmingham 2001:58). Likewise, multivariate analysis of the characters determined that the set
of vessels of which some were previously identified in the iconography as jachts were, in fact, distinguishable within the multivariate data space (de Winter and Burmingham 2001:58).

These conclusions provide solid support for the incorporation of statistical analysis in this study of iconography. I believe that typological characteristics and temporal evolution of the caravel, the nau, and the galleon can be discerned through the use of representational trends and multivariate morphometrical statistical analysis. This information will enable new lines to be drawn for all three types of ships. The logical projection of the lines to the lower portion of the hull, which is not depicted in the iconography, may help identify ship types in archaeological ship remains, which are typically the remains of the lower portion of the hull, sometimes together with concretions containing remains of iron rigging and armament elements.

**Research Significance**

The significance of this project is based on the historic and cultural importance of the caravel, the nau, and the galleon; these vessels played an important role in shaping modern European history and became lasting symbols of the bourgeoning post-medieval Portuguese (and Spanish) maritime empires. The archival record details the favorable sailing qualities of the caravel, the nau, and the galleon, and their general appearance, but tells us little about their design and construction.

Almost eighty Iberian shipwrecks dated to this era (e.g., Emmanuel Point, Highborn Cay, Molasses Reef, and the Western Ledge Reef) have been found, but cannot be conclusively identified as caravels, galleons or naus without a better understanding of these ship types’ design and constructional features.

As mentioned above, an extensive analysis of the iconographic record is expected to generate new and more comprehensive data regarding the superstructure, upper-hull constructional details, and rigging details of these vessels. A list of constructional characteristics will hopefully be determined through the statistical analysis and representational trends in the iconography. Additionally, it is highly probable that the statistical analysis of the iconography will provide enough data to identify typological constructional characteristics and temporal evolution for the caravela latina, caravela redonda, caravela de armada, the nau, and the galleon. There is also
considerable potential for increasing our knowledge of ship design theory in a time directly preceding the wide-ranging use of treatises and formally drafted lines.

On a broader level this study will demonstrate that when used correctly iconography can be a tenable and viable source of data within nautical archaeology. Establishing statistical methods for determining the accuracy of artistic representations of technology and analyzing the trends embedded within will hopefully have broad applications in the fields of anthropology, art history, and the history of science and technology. Additionally, this project addresses the conceptualization of technology as a cultural symbol to help us understand how and why cultures attach such powerful and important symbolism to technology and adopt it as an identifying feature of their culture.

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The Nau of the Livro Nautico: The Textual Excavation of a Portuguese Indiaman

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Abstract

Documents and illustrations show that the premier ship in Portugal’s India trade during the 16th century was the nau, a beamy, three-masted 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 ship’s plans, they include theoretical treatises and scantling lists. From these documents it is possible to reconstruct the construction of a nau timber by timber, using the mathematical relations and formulas used by the Portuguese shipwrights in conjunction with the timber specifications of one of these scantling lists. Iconography and early 17th century documents which do include lines and images were used to check the reconstruction.

Introduction

In the 16th century 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, which may help to explain why so much more is known about Spanish shipwrecks today. The Spanish trade was organized into convoys 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 6,000-mile 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. At the end of the 16th century, annual profits from this trade were 7 to 10 million cruzados (Castro 2005, 12).
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 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 8 months, and the round trip typically 18 months, often touching land only once during the 25,000-mile journey (a journey equivalent to the circumference of the world with one stop). Profits for the *Carreira da India* – as the maritime route was known – averaged 5 million cruzados (Castro 2005, 12), or some 50 to 70% of Spain’s trade.

Although a number of 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 predate the modern systems of developing ships’ hull designs by drawings, but the construction sequence and system of controlling hull shape is clearly explained. This shipbuilding data can be tested by comparison to the archaeological record (for example, Basque and Portuguese contracts specify the dimensions and the size of important timbers for ships, which can be compared to excavated Basque shipwrecks in Labrador).

This research focuses upon the textual excavation of a *nau* of the *Carreira da India*, 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 and using Rhinoceros 3 software to model each step in the ship’s construction. The final model can be compared to existing hull remains, and also to what is know of ships from this period. It can also be tested with modern naval architectural software to investigate the vessel’s handling characteristics in various sea and weather states.

**Development of the Nau**

The Renaissance carrack, which the Portuguese called a *nau*, was developed in the 14th and 15th centuries from the mixing of separate Mediterranean and Atlantic ship technologies. In the Baltic and Atlantic the cog (Figure 04-01) was the typical cargo carrier; a clinker-sided, flat-
bottomed vessel with angled stem and sternposts, rigged with a single square sail and steered by a stern rudder. The Mediterranean nave (Figure 04-02), in contrast, was a much bigger, round-hulled vessel; built skeleton-first with flush-laid planking, high curved posts, and two or more great and unwieldy lateen sails, steered by a pair of large side rudders (Unger 1994, 77-78).

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 rudder of the cog while being built skeleton-first in the Mediterranean tradition. These ships were cheaper to operate and more spacious than their predecessors, and the vessels became increasingly commonplace (Lane 1934, 39-40). In England ships of this sort were called

![Figure 04-01 - Atlantic cogs (after Friel 1994).](image1)

![Figure 04-02 - Mediterranean nave (after Andersen 1945).](image2)
carracks, while in Italy and Spain they were simply called “ships” — naves in Italian, naos in Spanish (and naus in Portuguese).

By the middle of the 14th century cocche had begun to carry two masts, with a square-rigged mainmast and a lateen-rigged mizzenmast (Figure 04-03). The three-masted rig with square sails on a foremast and mainmast along with a lateen mizzen appear early in the 15th century (Figure 04-04), 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 uses, along with a lateen-rigged bonaventure mast located at the stern to assist the mizzen (Unger, 1994, 79-81).

By the 16th century, the design was mature. Naus were large, typically three-masted ships, square-rigged except on the mizzen (and the bonaventure, if a fourth mast was present), with keels only twice as long as the ship’s beam (Figure 04-05). Their masts and yards were massive assemblies of multiple timbers, and their main sails were characteristically large as well, with bonnets added to their lower edges when more sail was needed (Figure 04-06). 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
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 (Boxer 1969, 207). Their primary function was the carriage of large volumes of cargo.

Galleons appeared in the early 16th century, and although typically defined today as purpose-built warships, they differed only slightly from the nau; most notably their castles were lower, their structure sturdier (to support the larger weight and firing stresses of their strong armament) and they mounted four masts, generally lower and thicker than those of the nau. The ships of the Carreira changed incrementally during the 16th century, adopting wider stern panels, lowering their fore castles, increasing in size (17th-Century Indiamen commonly had four decks and a broader relative beam) and gradually increasing in armament (Castro 2005b, 111).

These great ships carried the bulk of Portugal’s 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. Fifteen carracks actually made more than nine voyages per ship. 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 percent on a voyage of close to 16 months round trip (Duncan 1986, 14). Guinote, Frutuoso, and Lopes cite losses of 143 ships out of 1183 sailings for the period from 1497 to 1600, a loss rate of 8.27%, though they estimate losses of around 20% for the Carreira over its entire lifespan (Guinote, Frutuoso, and
Lopes 1998, 106). 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 end of the century (from 1590 to 1620) when losses to piracy increased dramatically and more vessels were lost to late departures as well (Castro 2005, 25-26). These ships truly were the supertankers of the 16th century, hauling a bulky but valuable cargo over great distances of open sea, built for capacity more than maneuverability.

**Lack of Archaeological Evidence**

Unfortunately there is little archaeological evidence for 16th century Portuguese Indiamen. Nearly a dozen Spanish shipwrecks with significant hull remains have been at least partially archaeologically excavated, but only a few Portuguese vessels have received similar treatment. Only one Portuguese *nau*, *Nossa Senhora dos Mártires*, has been archaeologically excavated.
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 two more galleons), Portugal (the Angra D wreck), and England (the Studland Bay wreck). Portuguese vessels include Nossa Senhora dos Martires and the Cais do Sodre ship (Oertling 2004, 129).

The only Portuguese nau that has been archaeologically excavated, Nossa Senhora dos Martires (Figure 04-07), 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 (Castro 2005, 106-107).

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 (Chapman 1998, 60). 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 (Fabrica di galere, the Timbotta manuscript, Raggione antique spettanti all’arte del mare et fabbriche de vasselli, and Drachio’s Visione) described the process of building Mediterranean galleys and round ships in the 15th century (Bellabarba 1993, 291). 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. Sixteenth-century shipwrights, however, 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 were used to first envision and then create a vessel.

These Iberian shipbuilding documents included 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.
The Basque contracts cited by Michael Barkham in his *Report on 16th Century Spanish Basque Shipbuilding c.1500 to c.1600* describe ships built from 1575 to 1625, 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, in Labrador, fit these specifications. Similar contracts for Portuguese ships (dated to 1598) were copied and included with the manuscript of João Baptista Lavanha’s early 17th-century treatise (Lavanha 1996, 237-241). The surviving timbers of *Nossa Senhora dos Martires* appear to fit these contracts; though little of the hull remains. This lends confidence in the rest of the 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. All but three documents in the codex pertain to the arming, maintenance, crewing, or construction of vessels at the end of the 16th century (between 1575 and 1625). 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. In 1892 Henrique Lopes de Mendonça published six selected documents and a list of the codex’s entire contents transcribed into modern Portuguese.

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 the art 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 theory of symmetry that relates 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 nautíca 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 (Palacio, 115-141).

Written only 30 years after Oliveira’s *Livro da fabrica das naus*, João Baptista Lavanha’s (ca. 1608-1615) *Livro Primeiro de Arquitectura Naval* 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 *nao*. 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 (Oliveira 1991, 175). This treatise is most useful for its accurate description of construction techniques and its detailed illustrations (Figure 04-08).
It is clearly more modern than Oliveira’s *Livro da fabrica das naus* in its basing the construction of hulls on paper drawings.

By the 17th century this new technique of illustration (seen also in Matthew Baker’s *Fragments of Ancient English Shipwrightery* and Manoel Fernandez’ *Livro de traças de carpintaria*) had arisen to show ships lines with drawings and how they were used to first envision and then create a vessel (Figure 04-09). In 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 (Figure 04-10). This was a fundamental departure from the simpler (and more conservative) method used by 16th Century shipbuilders.

**Reconstructing a Nau From Texts**

While reconstruction of a 15th Century vessel such as a caravel seems impossible due to the lack of both archaeological and documentary evidence, the same may not be said for the 16th century *Nau da India*. The primary sources for this reconstruction were a document from the *Livro Náutico* as well as Oliveira’s *Livro da Fabrica das Naus* and the Portuguese contracts included in Lavanha’s treatise. They were all consistent with a particular model. 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 an English-language translation of one of the documents in the 1590 *Livro Náutico*,

![Figure 04-09 - Drawing from Fernandez' treatise (after Fernandez 1616).](image)
as it also addressed the construction sequence, proportions, and the geometrical methods for defining the hull shape. 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 construction sequence.

Lavanha’s treatise was also consulted to explain the construction sequence and to help define the shape of some of the timbers. Although drawn 25 years later than the vessel in the Livro Náutico 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 of naus in Fernandez, on Japanese screens, and in the Livro de Lisuarte de Abreu and Roteiro do Mar Roxo de Dom João de Castro were also consulted. 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 (only the Livro Nautico had much to say about the rigging, so iconography was crucial in this regard). While more weight was given to the one Portuguese example (Nossa Senhora dos Mártires) archaeological evidence from Spanish wrecks was considered as well, particularly the well-preserved Basque vessel San Juan. 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 Oliveira and Lavanha’s treatises. With this sequence and the scantling lists, supplemented with data on timber dimensions, and using the contemporary geometrical
formulas and other data, each timber is being modeled, from the keel up, using Rhinoceros 3 three-dimensional modeling software (Figures 04-11 to 16). The end result of this research and modeling will be a 3-D model and an annotated and illustrated construction sequence and scantling list that details each timber and every step in the construction of a Portuguese Indiaman.

The final model can be compared to iconographic and archaeological evidence of 16th century Portuguese (and other) ships. It can also be compared to the Iberian/Atlantic tradition of shipbuilding described by Tom Oertling. Does the Portuguese Indiaman described by the Livro Náutico fit that ‘tradition’ of ship construction? What similarities does it have to Basque ships, for instance, and what differences? How does it compare to the vessels of the Spanish fleets?

The finished model will also be a very useful tool to test the performance characteristics of these vessels using modern computerized naval architectural tools. Portuguese history and literature describe many wrecks of these vessels. Why were so many of these vessels lost at sea? How did they handle high seas and strong winds? How well did they maneuver at all?

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The Spanish Navy and the *Ordenanzas* of 1607, 1613, and 1618

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Abstract

During the late 16th and early 17th centuries the Spanish crown ruled over a global empire, which encompassed the Mediterranean Sea and the Atlantic, Indian and Pacific Oceans. The necessity to standardize procedures and regulate the activity of the many royal fleets that maintained contact between all the Spanish and newly inherited Portuguese strongholds, territories, colonies, and factories, lead to the emission of a number of laws (*ordenanzas*) whose study helps understand their amazing ships, which remain poorly understood.

Introduction

In the last decades of the 16th century Spain was the first European nation to build and maintain a truly international empire. As historian Jose Luis Casado Soto points out, “technically and logistically maintaining the empire would have not been possible unless Spain by this time possessed the necessary organization, seamanship, armament, and quite specifically, shipping industry” (Casado Soto, 1988a: 95). This achievement was made possible by the careful regulation of the Indies trade system, which became known as the *Carrera de Indias*. This regulation of the trade routes included a series of laws and regulations established by the Spanish crown during the 16th and early 17th centuries to properly control New World trade. The research presented in this paper will review the *Ordenanzas para la fabrica de navíos de Guerra y Merchantes*, and their relation to the attempts of the Spanish Crown to establish a navy.
Regulating the **Carrera de Indias**

Trade to the Indies increased continuously from 1493 to 1520; however, during the following three years there was a decline in the voyages due to a drop of the production of gold in the Antilles as well as a newly initiated Hapsburg war with France (McAlister 1984, 234). The recovery of trade with the Indies began in 1524 and extended into the 1530’s and it was this rise in New World trade that attracted the first French pirates thereby triggering the creation of a fleet system. In 1526, in a measure to protect the trade routes, King Charles I prohibited the ships from making the trans-Atlantic return voyage alone (Fernandez Duro 1972, 1: 24). Two years later, in 1528, the crown prohibited isolated voyages for the entire length of the sea-lanes. From this moment on, the crossing of the Atlantic would be arranged into fleet systems, or *Flotas*.
Once the fleet system was created, it was essential for Spain to maintain strict control over the routes across the Atlantic to the New World, which they made effective by dividing the routes into the New Spain and *Tierra Firme* fleets. The New Spain Fleet, bound to the port of Veracruz, Mexico, would depart from Seville during April or May of each year while the *Tierra Firme* Fleet, bound for the port of Nombre de Dios, Panama, was sent out between the months of July and August. Both fleets initiated the voyage with the navigation down the Guadalquivir River. Once the treacherous bars of the Guadalquivir were left behind, the vessels started the voyage towards the Canary Islands. The fleets would then sail south to roughly twenty degrees latitude — past the Golfo de Yeguas — reaching the Isla del Hierro seven to ten days later (Castillo Juarez 1992, 238). Having traveled about two hundred leagues, or about 965 km, a stop at the Canaries was needed to provide the fleets with a chance to replenish their provisions.

From the Canary Islands, the convoys sailed into the Atlantic. Their next landfall was on the Lesser Antilles, typically on the islands of La Deseada, La Dominica, Todos Santos, Marigalante, Guadalupe or any other island in their vicinity; however, the fleets avoided stopping at the Lesser Antilles, unless there was an urgent need to replenish supplies (Castillo Juarez 1992, 239). At this point the New Spain and *Tierra Firme* routes separated. The New Spain Fleet would continue its way from Puerto Rico, to La Hispaniola, and past the north coast of Jamaica and into the Gulf of Mexico in order to reach their final destination of San Juan de Ulua, Veracruz. The *Tierra Firme* Fleet sailed from La Deseada to Cartagena de Indias, after which it headed towards its final stop at Nombre de Dios, Panama.
On the return voyage, both the New Spain and the Tierra Firme fleets would meet in Havana, Cuba and it was from here they embarked to make the return voyage to the Iberian Peninsula. Leaving Havana, the fleets headed for the peninsula of Florida after which they navigated into the Bahamas channel. During summer, the fleets sailed northwest in order to reach 32 degrees of latitude and upon reaching it, they changed direction – one quarter north of northwest – until they reached 39 degrees of latitude north. During winter, the preferred route took them to the Bermuda Islands, and from there favorable winds usually allowed a north and northeast voyage to 37 degrees latitude (Castillo Juarez 1992, 244). No matter the season or the route they sailed, the fleets reached the Azores Islands usually stopping in Angra Bay, on the southern coast of Terceira Island. Once the fleets had reached this part of the journey a *patache*, or messenger ship, was sent from the island to the mainland to obtain information about the current safety conditions along the Iberian coast. From the Azores, the route would continue toward the San Vicente cape, and Sanlúcar de Barrameda, on the mouth of the Guadalquivir River.

Figure 05-04 – Caribbean routes in the late 16th and early 17th centuries (Drawing: Blanca Rodriguez).

As for the protection of the fleets, the Spanish crown had neither a standing navy nor the means to create one. As a result, the first contingent sent to protect the Atlantic routes had to be funded by a tax known as the *Avería* that was placed on imported and exported merchandise. Furthermore, during the 16th century the crown encouraged the production of vessels that could serve as both merchantmen and as warships. Throughout the century, the monarchy established a system for leasing private ships and
incorporating them into the armadas that protected the Indies. Merchants, who in most cases were not paid in full for their leasing services, never favored the embargo policies. Towards the end of the century, private shipbuilding was also rapidly declining, making it harder for the crown to continue hiring private vessels. At the same time, warship design had become more specialized throughout Europe, rendering the Spanish merchant vessels less appropriate for their service in the crown’s fleet.

Figure 05-05 – Vera Cruz, Mexico (after Juarez 1972: Figure 2).

Figure 05-06 – Cartagena de las Indias, in today’s Colombia (after de la Matta Rodriguez 1979: 94-95).

Figure 05-07 – Portobelo, in today’s Panama (after Ward 1993:93).
At the beginning of the 17th Century, King Philip III was confronted with the pressing necessity of establishing a standard system for measuring ships’ tonnage. The main reason was that “the subsidies for naval construction, the payment of fees to embargoed ships, the custom dues on Indian commerce and maintenance of its monopoly, and even the security measures decreed for commerce with the New World, were based on the tonnage of the ship.” The first way in which Philip III addressed this necessity was through the standardization of ship measurements. Under the main advice of Admiral Diego Brochero, eleven experts, including several of the best shipwrights of Biscay (i.e., Juan de Uriarte, Martin de Zautua, and Juan de Axpe), assembled in Madrid to discuss and establish an “optimum set of design specifications.” On December 21, 1607, the King expedited the first ordinances for construction of war and merchant ships (Ordenanzas para la fabrica de navios de guerra y mercantes); from this point on, it was regulated that all ships built in
Spain were to be constructed following the measurements and fortification standards established within these ordinances.

![Figure 05-10 – Nao from García de Palacio’s work (after Bankston 1988).](image)

The 1607 Ordenanzas were rendered obsolete within four years, however, after many complaints by shipwrights who argued the measurements and proportions dictated by the ordinances produced deficient ships; this resulted in the assembly of a new council in order to correct these deficiencies. The members of the new council were mostly mathematicians from Madrid’s royal academy of Mathematics, who through geometry tried to solve the problem of ship design. The final measurements obtained at the assembly were sent to the Duke of Medina Sidonia for the final approval. The new Ordenanzas became official on July 6th, 1613 overruling the previous ones; however, the new specification again proved to be less than perfect. In 1618, after yet another council, the Ordenanzas were amended for a third time.

**Ordenanzas para la fabrica de navíos de Guerra y Merchantes**

The 1607 Ordenanzas are divided into three main sections. A copy of these Ordenanzas is found in the Martín Fernandez de Navarrete Collection in the Naval Museum of Madrid (1971). The first section includes the measurements used for the basic design of three out of a total of thirteen types of ships: Navíos, which measure from 151 to 238 ton; Galeonetes, which are described as 297 or 373 in tonnage; and Galeones, which measure from 487 up to 1351 tons. The following measurements are provided for each vessel type: the beam, the depth in hold, the length, the keel, and the runs (delgados). Of these measurements, the beam was seen as the key element in the design, and all the other measurements were proportional to it.
The second section of the Ordenanzas describes how the ships were to be designed and fortified while the third section is dedicated to the calculation of the tonnage. According to the 1607 regulation, tonnage was to be calculated based on the measurement of the depth in hold, the beam, and the length of the vessel. For this purpose, the depth in hold had to be calculated from the hold and up to the first deck. The beam and the length were also measured at the first deck; the length was measured from the inner stem post to the inner sternpost, while the beam measurement was taken amidships. In this regulation, the measurements to calculate depth of hold are described, but it does not indicate how to combine them to produce the tonnage; however, it does stipulate that 20% of the total tonnage is to be added to the ships that have two decks. Likewise, it also specifies that an additional 5% is added to Spanish ships to account for the runs. The most important change in tonnage calculation following the regulation of 1607 is that all the measurements had to be taken in the actual structure of the ship and not in the air.

The 1613 Ordenanzas are divided into 4 main sections a copy of which can be found in the Indies General Archives, and have also been transcribed as an appendix in Función y Evolución del Galeón en la Carrera de Indias by Fernando Serrano Mangas (1992). The first section, as in the 1607 Ordenanzas, includes the measurements used for the basic design of three types of ships: Pataches, which measure from 55 up to 99 tons; Navios, which range from 148 up to 258 tons; and Galeones, which measure from 316 up to 1037 tons. In total, the measurements for fifteen vessels are presented.

For each vessel, as in the 1607 Ordenanzas, the measurements of the beam, the depth of hold, the length, the keel, and the runs are given. Added to these are the measurements of the flat of the main frame and the transom,
the number of frames the vessel should have and their raising, thus providing further standardization of the ships. Likewise, there is a section on the steps to follow when laying down the basic structures of the ships, like the keel, stem and sternposts, and a section that provides calculations for the proper measurements of the masts and yards based on the beam of the vessel.

The 1613 Ordenanzas do not include a section on the calculation of the tonnage. Instead, a separate Ordenanza was decreed for this function, which was passed three months later, on October 19, 1613. According to this revised Ordenanza, five measurements are to be taken into account for the calculation of tonnage: the beam, the depth in hold, the length, which were the basis for calculating the tonnage according to 1607 Ordenanzas, and added to them, the measurements of the keel and the flat of the main frame. Based on such measurements, three ways of calculating the tonnage are given.

The depth in hold (H) is calculated from the top of the keel to the level of first (lower) deck. The beam (B) is calculated amidships, also at the level of the lower deck. The length overall (L), is again measured at the first deck, from the inner stem post to the inner sternpost. The floor (F) is the flat portion on the base of the master frame.

1. Under the assumption that the depth in hold (H) is half the value of the beam (B), the first way for calculating tonnage is done by multiplying the beam by half the depth in hold. The result is, then, multiplied by $\frac{1}{2}$ of the sum of the length overall (L) and the keel (K), and then divided by 8 (to change the result from cubic codos to toneladas).

$\text{if } H = \frac{B}{2} \rightarrow [BH/2 \times (1/2 \times (L+K))] / 8 \quad [1]$
2. If the depth in hold is more or less than half of the beam, the tonnage is calculated in the following way:
   a) If \( H < \frac{B}{2} \), then the depth in hold is subtracted from half of the beam, the result divided by 2, and added to the beam. This new value of the beam \( B_1 \) is then entered in equation [1] above.
   b) If \( H > \frac{B}{2} \), then half of the beam is subtracted from the depth in hold, the result divided by 2, and added to the beam. This new value of the beam \( B_2 \) is then entered in equation [1] above.

\[(if \ H < \frac{B}{2}) \rightarrow \frac{B_1 H/2 x (1/2 x (L+K))}{8} \quad [2]\]
\[(if \ H > \frac{B}{2}) \rightarrow \frac{B_2 H/2 x (1/2 x (L+K))}{8} \quad [3]\]

3. And the third way was done by adding \( \frac{3}{4} \) of the beam to \( \frac{1}{2} \) floor and then multiplying the result by \( \frac{1}{2} \) of the sum of the length and the keel. Again, the total is divided by 8 to convert cubic codos into toneladas.

\[\left(\frac{3}{4} B + \frac{1}{2} F \right) x \left(\frac{1}{2} (L+K)\right) / 8 \quad [4]\]

The rules to calculate ship’s tonnages were established by the 1613 Ordenanzas; however, the Ordenanzas of 1618 have no section regulating tonnage and the existence of a separate Ordenanza for calculating tonnage is not known. The 1618 Ordenanzas, rather, focused on the change in design measurements and a copy of these Ordenanzas forms part of a compilation of laws regarding the Carrera de Indias made in 1680. Already in the 1618 laws the types of ships are eliminated, and the ships are only described by the all-inclusive name of Navío. Thirteen vessels, ranging from 80 to 1074 tons, are described based on the same measurements provided by the 1613 Ordenanzas and the difference from the 1613 is the actual proportions for the ships.

Figure 05-13 – Measurements for the calculation of tonnage according to the 1618 Ordenanzas (over the gallón de Utrera: replica of 16th century ex-voto lost by fire in the 20th century).
Changes throughout the Ordenanzas

To explain the changes in proportions throughout the Ordenanzas and as an example, I will now compare the depth in hold, the length, and the keel of Navio of 12 codos in beam according to the different regulations of the 1607, 1613, and 1618 Ordenanzas.

Based on the 1607 Ordenanzas, a Navio of 12 codos in Beam should have 6 1/2 codos of depth in Hold, 43 codos of length, and 36 codos of length of keel. Common design before the Ordenanzas followed the as-dos-tres formula, marking the ratio beam to keel to length as 1 to 2 to 3. The Ordenanzas depart from this formula and a beam to keel to length ratio of 1:3:3.58 is obtained from the 1607 measurements. By changing this proportion, the committee favored longer, narrower ships, and thus raised the speed potential of Spanish vessels.

Based on the 1613 Ordenanzas, a Navio of 12 codos in beam should have 6 codos in depth of hold; exactly half of the beam, 45 codos in length, and the length of the keel remained the same at 36 codos. The length to beam ratio is then slightly increased from 3.58 to 1 to 3.75 to 1, while the keel to beam ration remained the same.

Based on the 1618 Ordenanzas, a Navio of 12 codos in beam should have 5.5 codos in depth of hold, 41 ½ in length and 34 codos in length of keel. The proportions obtained from the measurements are of 1 to 2.8 to 3.4, making the ships beamier a requirement that many shipwrights had asked for, considering that the 1613 Ordenanzas were lacking beam. As observed, the ratio is closer to the old ratio of as-dos-tres that in any of the other two Ordenanzas.

Conclusions

In regards to Spanish shipbuilding of the time, the regulations for the standardizations of the ships were important in two ways. First, they allowed the crown to have closer control over the volume of merchandise that was transported through the Spanish sea-lanes. This meant that the crown was able to obtain the proper custom dues on Indian commerce and to control the Avería used in the protection of the trade.

Secondly, it would open a new era in Spanish ship design. Through the assemblies of experts in the matters of shipbuilding in three different occasions, the Spanish crown was trying to perfect the Spanish ship which could function both as a merchant and as a warship. The construction and
use of a dual purpose ship led to the possibility of creating a navy that did not have to be supported fully by the crown.

Appendix 1 – Ordenanzas 1607

Ordenanzas expedidas por el rey en Madrid a 21 de diciembre de 1607 para la Fábrica de los navíos de guerra y mercante, y para la orden que se había de Observar en el arqueamiento de los que se tomassen a particulares para servicio en Las armadas reales.

(Fernández Navarrete 1971: 288-297)
Transcribed by Vera Moya

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Año de 1607.

Ordenanzas expedidas por el rey en Madrid a 21 de diciembre de 1607 para la fábrica de los navíos de guerra y mercante, y para La orden que se había de observar en el arqueamiento de los que Se tomasen a particulares para servicio en las Armadas reales.

El rey por cuanto considerando los inconvenientes, y daños, que han resultado a mi servicio, y vasallos de estos reinos de que los navíos de guerra y mercante, que se han fabricado en ellas, no hayan sido de la traza, y fortaleza que se requiere para navegar, y pelear mandé que viniesen a esta corte las personas, que se hallaron de mas experiencia de fábricas de navíos, y navegación del mar océano, y carrera de las indias occidentales para acatar del remedio de ello, y de los abusos introducidos en su arqueamiento, y cargazón; y habiéndose conferido, y tratado en el mí consejo de guerra; y lo que sobre todo advirtieron las dichas personas, y otras que de mis armadas enviaron su parecer sobre lo mismo, y conmigo consultado deseando enderezar todo lo que a esto toca como más convenga a mi servicio, y al bien universal de estos reinos, he resuelto, que para que los navíos que en ellos se fabriquesen de aquí adelante así de guerra, como de mercante, sean muy capases, y seguros para lo uno, y para lo otro, se fabriquen en las medias, traza, y fortificación que para los de todos partes va declarado en estas ordenanzas en que también se dice como se ha de hacer el arqueamiento de los navíos, que se tomaron a particulares para servicio de mis armadas, y lo que han de ganar por su flete, y la forma en que ha de servir, y ser pagada la maestranza de mis fábricas reales de navíos: por tanto mando, que lo susodicho se entienda, y establezca en la manera siguiente.
Para fabricar galeones, y otros navíos para mis armadas del mar océano, y carrera de las indias del porte, y perfección, que los han menester desde el menor hasta el mayor así para de guerra como de mercante se han de usar estas medidas:

Para navío de ciento y cincuenta, y una Toneladas y media.

De manga diez codos.
De puntal cinco codos y medio, y ahí la cubierta, y lo más ancho.
De eslora de treinta y ocho codos en la propia cubierta.
De quilla veinte y nueve codos.
El alcázar hasta el mástil mayor, y batallera en proa en dos codos y dos tercios sobre la cubierta.
De raser tres codos y un cuarto.

Para navío de ciento y setenta y ocho toneladas y seis octavos.

De manga once codos.
De puntal seis codos, y ahí la cubierta, y lo más ancho.
De eslora cuarenta codos en la propia cubierta.
De quilla treinta y tres codos.
Del alcázar y batallera como el de arriba.
De raser tres codos y medio.

Para navío de doscientas y treinta y ocho toneladas y dos octavos.

De manga doce codos.
De puntal seis codos y medio, y ahí la cubierta, y lo más ancho.
De eslora cuarenta y tres codos en la propia cubierta.
De quilla treinta y seis codos.
De alcázar, y batallera como el de arriba.
De raser tres codos y tres cuartos.

Para galeonzete de doscientas noventa y siete toneladas y cinco octavos.

De manga trece codos.
De puntal siete codos, y ahí la cubierta, y lo más ancho.
De eslora cuarenta y seis codos en la propia cubierta.

1. Todos los subrayados son del original hasta que se indique lo contrario.
De quilla treinta y siete codos.
El alcázar, y batallera como el de arriba.
De raser cinco codos.

**Para galeonzete de trescientas y setenta, y tres toneladas, y tres octavos.**

De manga catorce codos.
De puntal siete codos y medio a la cubierta, y ahí lo mas ancho.
De eslora cincuenta codos en la propia cubierta.
De quilla treinta y nueve codos.
El alcázar, y batallera en tres codos de la puente.
De raser cinco codos y cuarto.

**Para galeón de cuatrocientas y ochenta y siete toneladas, y un octavo.**

De manga quince codos.
De puntal ocho codos, y ahí la cubierta, y lo mas ancho.
De eslora cincuenta y dos codos en la propia cubierta.
De quilla cuarenta y dos codos.
La puente en tres codos de la cubierta principal.
El alcázar, y batallera en otros tres codos.
De raser cinco codos y medio.

**Para galeón de quinientas sesenta y siete toneladas y siete octavos.**

De manga dieciséis codos.
De puntal ocho codos, y tres cuartos, y ahí la cubierta, y lo mas ancho, y
De ahí a la puente tres codos a raíz de la lata, y otro tanto en el alcázar, y batallera.
De eslora cuarenta y dos codos en la propia cubierta.
De quilla cuarenta y dos codos.
De raser cinco codos y tres cuartos.

**Para galeón de seiscientas sesenta, y nueve toneladas y tres octavos.**

De manga diecisiete codos.
De puntal nueve codos, y un cuarto, y ahí la cubierta, y lo mas ancho, y
y de ahí a la puente tres codos a raíz de la lata, y otro tanto de la puente al alcázar.
De eslora sesenta codos en la propia cubierta principal.
De quilla cuarenta y tres codos.
De raser seis codos.

Para galeón de setecientas, y cincuenta y cinco toneladas.

De manga dieciocho codos.
De puntal nueve codos, y medio, y ahí la cubierta, y lo mas ancho, y de ahí a la puente tres codos al canto de la lata, y otro tanto de la puente al alcázar.
De eslora sesenta y dos codos en la cubierta principal.
De quilla cuarenta y cuatro codos.
De raser seis codos y medio.

Para galeón de ochocientas y noventa y siete toneladas, y tres octavos.

De manga diecinueve codos.
De puntal diez codos, y ahí la cubierta, y lo mas ancho, y de ahí a la puente tres codos al canto de la lata, y otro tanto de la puente al alcázar.
De eslora sesenta y cinco codos.
De quilla cuarenta y siete codos.
De raser seis codos, y tres cuartos.

Para galeón de mil, y treinta y tres toneladas.

De manga veinte codos.
De puntal diez y codos y medio, y ahí la cubierta, y lo mas ancho, y de ahí a la puente tres codos al canto de la lata, y otro tanto de la puente al alcázar.
De eslora sesenta y nueve codos.
De quilla cuarenta y ocho codos.
De raser siete codos.

Para galeón de 1351 toneladas y cinco octavos.

De manga 22 codos.
De puntal once codos y medio,
Y ahí la cubierta, y lo mas ancho, y de ahí a la puente tres codos al canto de la lata, y otro tanto de la puente al alcázar.
De eslora 75 codos.
De quilla 53 codos.
De raser siete codos y medio.
Para galeón de mil, y ciento y ochenta y cuatro toneladas, y cinco octavos.

De manga veinte y un codos.
De puntal once codos, y ahí la cubierta, y lo mas ancho, y de ahí a la puente
dos codos al canto de la lata, y otro tanto de la puente al alcázar.
De eslora setenta y dos codos.
De quilla cincuenta y un codos.
De raser siete codos y un cuarto.

Todos estos galeones, y navíos se han de fabricar por la traza, y con las fortalezas
siguientes.

Puesta la quilla, arbolado, branque, y codaste, y escorado de proa a popa
se ha de procurar, que lleve muy buen contrazapato por la parte de dentro,
y toda la madera que pudiere.
Poblada la quilla de orengas, y pies de genoles se ha de echar la carlinga
mayor, y coserla con cabillos de fierro echando las 2 bulárcamas que
hubiere de llevar.
Las orongas con los pies de los genoles se han de embrazar con los pernos ribeteados, y
endentados; y lo mismo se ha de hacer en los genoles redondos, espaldones, y revesones,
picas, y buzardas, y en todo el aposturaje de popa a proa.
En el comentario de revés de los piguas de popa no ha de llevar costura,
sino un madero grueso, que hincha el ángulo que hacen los piguas
con la estamenara que viene de arriba empernado con las apetaras
de arriba, y cabezas de las picas.
Estando cabillada la carlinga se le ha de echar su contraquilla por
La parte de abajo, y ha de ir clavada con la quilla con pernos de suerte
Que entren hasta la mitad de la quilla y se advierta, que se ha de clavar
Por los lados y no derecho.
El branque ha de llevar de muy buena madera limpia, y su contrabranque
por la parte de adentro cavilado con cavillas de fierro, y se han de
ectar antes del tajamar.
El codaste ha de llevar su contracodaste por la parte de adentro endentado
en el corbatón del zapato, y las puercas, de popa, y se ha de cavillar con el
codaste antes que se cierre con las picas.
Se le ha de echar su contracodaste por la parte de fuera con sus dientes,
y ha de ir cosido con el codaste, y contracodaste de dentro con buenas cavillas
de chaveta.
Los bao varios han de ir donde se fijen con el durmiente los escarpes
de los pies de genoles, y ligazones endentados con su cola de milano,
y sus cavillas de fierro en cada cabeza, y ha de haber de bao a bao lo que
fuere el rumbo de una pipa.

2. Tachado en el original.
Por cada cabeza de bao ha de llevar tres corbatones con sus entremiches. Endentados con los corbatones, y con el mismo bao por encima.

Desde la primera ornizón arriba se ha de procurar buscar madera que alcance todo lo que pudiere hasta llegar a las varangas, y que ninguna tenga de vació mas de tres cuartos de codo, y pudiéndose hallar, que junto, será mucho mejor, y de ahí arriba lo más que se pudiere.

A plomo de cada bao ha de llevar su hulárca en el granel endentadas en la carlinga, y con sus mechas, que lleguen a la cabeza del bao endentadas, y arriba al costado.

El plan ha de ir entablado como es ordinario con sus escoperadas.

Los durmientes de la cubierta principal han de ser los mas anchos, y fuertes que se hallaren, y se han de coser con las cintas, y corbatones de dentro.

Por la parte de abajo del durmiente ha de llevar su contralierna.

En esta cubierta ha de llevar cuatro baos al través de las bombas, y escotillas principales, y en ellos dos corbatones para cada cabeza uno de alto abajo en el cual ha de ir su entremiche con los corbatones y con el mismo bao, y otro corbatón por debajo del bao con su diente en el mismo bao.

Ha de llevar sus latas en toda la cubierta a cuchillo que vengan por nivel con el bao, y ha de haber de lata a lata un tercio de codo de vació endentadas en el durmiente con cola de milano, y en cada cabeza un perno, que rebite cosido con el durmiente.

Estas latas han de ir asentadas como queda referido, y dejando tres en vació, la cuarta ha de ir corbatonada con un corbatón, en cada cabeza con su entremiche de revés endentado en los corbatones con diente en la misma lata.

Los trancaniles han de ser de muy buena madera, y grosor conforme al porte del navío, de forma que se cosa el costado con él, y las cabezas de los baos, y latas, llevando su cola de milano en cada lara, y cosida.

Con un perno en la cabeza de cada lata, que pase al durmiente, y ha de llevar sus pernos, y cavillas a costado de fuera para dentro, y sobre.

El trancanil no ha de llevar más de una tabla para escoperar.

En esta cubierta principal han de ir cuerdas de popa a proa por bajo, y por encima de babor, y estribor endentadas en los baos, y latas cosidas con ellas, y en los remates sus corbatones de proa, y popa, y en los baos vacíos se han de echar las mismas cuerdas por encima con sus corbatones de proa, y popa.

La puente ha de ir con cuatro baos en la forma que la cubierta de la artillería con sus latas, cuerdas, trancaniles, durmientes, corbatones, y escoperadas como la cubierta principal sin llevar otro aforro más de las medias tablas que han de servir de albolas.

Las columnas que fuesen necesarias conforme al porte del galeón, ó navío han de ir fijadas en la[s] cabezas de los primeros baos vacíos, y han de venir a la puente a fijarse en las cuerdas, y latas con su cola de milano,

y al pie ha de llevar dos corbatones fijados al costado de proa, y popa con sus cavillas, y en las cubiertas corbatonadas, y endentadas. Las victas han de ir a la inglesa fortificándolas con sus corbatones.
endentadas en las latas así por abajo de la cubierta como por arriba, y ha de venir a raíz de la chimenea de proa, de modo que la artillería de proa pueda jugar libremente.
La chimenea de proa ha de llevar sus latas corbatonadas con sus entremiches y cuerdas por abajo, y por arriba endentadas.
El alcázar de popa hasta el pie del árbol de la manera que el de proa, y han de llevar estos alcázares sus pies de carnero con dos esloras de popa a proa, las unas por encima de las latas, y las otras por debajo endentadas con las mismas latas con cavillas chaveteadas.
Ha de llevar los guindastes encima de la puente.
La cámara de popa ha de ir encima de la puente, y su corredor en ella sin que lleve mas vuelo, ni salga mas que la bóveda de la popa y por las bandas cuanto un hombre pueda andar de lado.
Encima de esta cámara ha de llevar su camarote para el piloto, y maestre.
El espolón ha de ir a la portuguesa y a las alas se han de poner de forma que quede ancho para tomar la vela del trinquete, y para pelear, y el tajamar ha de ser el mas cumplido, y ancho que se hallase, y que alcance al escarpe de la contraquilla; y chupando no alcance, se podrá añadir de otra madera, y ha de ir endentado en el branque el tajamar con dos dientes uno por abajo, y otro para arriba bien cavillado.
Los fieles de popa han de ir desde su nacimiento hasta la primera cinta callimados a la portuguesa.
Estos fieles han de abrir desde la lumbre del agua hasta el yugo lo que pudiere para que tenga donde escorar, y han de ser redondos todo lo que se pudiese alzando la lemera cuanto diese lugar la cubierta, de modo que vengan a tener la mitad de la manga, y algo más.
Las tres primeras andanas de cintas dobles a la portuguesa, y las demás sencillas, y se han de coser con las liernas en la cubierta principal, puente, y alcázares y no saliendo del cuerpo del galeón mas de dos dedos, y que sean muy anchas por lo menos un tercio de codo cada una.
Las cintas, y cubiertas han de llevar la menos arrufadura que pueda procurando que vayan en su punto, de manera que se pueda jugar la artillería muy bien, y que queden defendidas del agua.
la caña de timón la ha de llevar en la primera cubierta, como se acostumbra, y el molinete en la puente, y se ha de venir a gobernar el pinzote encima del alcázar cortando el alcázar entre lata, y lata donde ha de andar el pinzote.
La victacola ha de ir azainada a la mesana encima del alcázar.
Las mesas de guarnición han de ser conforme se aseen en Vizcaya.
La tabla del costado ha de ser de cinco en codo hasta la cinta, y de allí arriba de siete y ocho en codo en navíos de trescientas toneladas arriba, y de allí abajo al respeto.
La tabla de la puente ha de ser de seis en codo, y de pino de Flandes.
si fuere posible, y de allí arriba como pareciere muy ligero que será lo mejor.
Las portas del artillería han de tener codo, y cuarto. Los tamboretes del árbol mayor han de ir abiertos en la puente tres dedos, y en la cubierta principal uno, y en los baos vacíos fijos. Los árboles mayores, y trinquetes a la flamenca con sus chapucees debajo de la gavia para las ustagas en ocho codos desde la punta del árbol.
Los tamboretes de los masteleos de gavia han de ser de fierro por ser más fijos.
Cada corbatón de los que llevara ha de ir cavillado con cinco cabillas de chaveta con que se ha de coser, y algunos pernos rebitados. Se ha de empernar a media tabla para que salga la obra fija. La clavazón que ha de llevar ha de ser toda de martillo, y no de metal de Navarra.
Las latas de la puente, alcázar, y batallera han de pasar hasta la mitad de la cinta en forma de cola de milano tanto en el durmiente como en las cintas, y lo mismo se ha de hacer en los castillos de popa, y proa hasta donde alcanzaren las cintas.
La orenga y plan se le ha de dar todo lo mas que sea posible conforme al porte de cada navío procurando que sea la mitad de la manga en plan para que pese menos agua, y se le han de echar las mas orengas que se pudiere conforme a los tercios, y largor de cada navío. No se han de echar llaves en la cubierta, ni en la puente, porque se podrecen con ellas, y hace embarazo para jugar el artillería; pero se han de echar por la parte de abajo endentadas con los corbatones, baos, y latas como queda referido.
Todos los que de estos galeones ó navíos fuesen de ciento y cincuenta y una toneladas hasta doscientas, y noventa, y siete han de llevar un cabestrante cada uno encima del alcázar, y los de este porte arriba dos cabestrantes el uno encima del alcázar con dos campanas, y sus orientes, una debajo y otra encima, y el otro cabestrante en el combés. En la puente se ha de poner una tabla de popa a proa a raíz de la propia cubierta levadiza que sirva para cuando se diere carena calafateando bien los barraganetes, de forma que entre el agua hasta la escotilla, y sirva para la carena sin que sea necesario hacer bordado, y esta prueba se podrá hacer en un galeón de la primera fábrica que por mi cuenta se hiciere, porque este estilo es de la nación ragusea.
Para que toda la obra sea fija convendría, que fuese todo el material seco, y que la madera se corte en las menguantes de noviembre, diciembre, y enero, ó en la de junio, y no en otro ningún tiempo. Advirtiese, que cuando se fabricaren semejantes galeones por mí cuenta se han de hacer cubas que quepan hasta cuatro pipas de agua cada una, y ha de llevar diez arcos de fierro cada cuba de cuatro dedos de ancho cada arco, y de estas cubas llevará cada galeón las que conforme
a su porte hubiere menester de aguada para la navegación con que será menos el gasto, y se conservará la aguada, y el galeón irá estibado.

Todos los navíos que fabricaren para el comercio los naturales de estos reinos conviene, que lo hagan por las susodichas medidas, y traza, y con las mismas fortificaciones sin discrepar en nada, y para los que hubieren de navegar de mercante a las indias advierte lo siguiente. Desde principio del año de mil y seiscientos y diez en adelante todos los navíos que se recibieren para navegar en las flotas de las indias, han de ser fabricados con las dichas medidas, traza, y fortificación, y de hasta quinientos y sesenta y siete toneladas, y de ay abajo, y no mayores, porque de esta manera podrán entrar, y salir por las barras de san Lúcar de Barrameda, y San Juan de Úlua cargados sin alijar nada, y harán la navegación muy breve, y serán los navíos muy duraderos, y toda la carga y navegación de las flotas más igual, y con menos riesgo de la mar, y enemigos, y, más comodidad de los dueños de las mercaderías para la carga, y descarga, y se aprestarían las flotas con mas brevedad y menos costo, y si desde aquí adelante acudieren a Sevilla para las dichas flotas navíos de estas medidas, y traza, prefieran en la carga a todos los otros tanto en España como en las Indias.

Cuando concurrieren algunos navíos, fabricados con las dichas medidas y fortalezas, se entienda que el dueño del navío que le hubiere fabricado, y navegare en él, ha de preferir en la carga a los otros, no siendo tan viejo el navío que corra riesgo en la navegación.

La casa de la contratación de las indias que reside en Sevilla ha de nombrar persona de ciencia, y conciencia que reconozca, mire, y considere lo que podrá cargar cada navío de estas medidas, de manera que pueda salir, y entrar por las dichas barras sin alijar de la carga, que hubiere embarcado, y hacer seguramente su navegación; y porque los dueños de naos; y cargadores de ellas no puedan con su desorsenada codicia usar de engaño, cerca de esto perná la dicha persona dos señales de fierro en el codaste, y branque de cada navío que sirvan de límite para que hasta allí, y no más se cargue el navío, de manera que aquel fierro, ó señal quede sobre el agua, y esta persona tenga un libro en que asiente la parte donde fijase en el navío las dichas señales declarando en cuantos codos de agua está aquella señal, y los que hubiere de ella a la lemera, y quien contraviniere a esta orden, perderá la mitad del valor del navío, y de esta condenación se aplique la tercia parte al juez, y las otras dos partes al denunciador, y esta denunciación se podrá hacer ante cualquier justicia tanto de la mar como de la tierra.

Cuando yo mandare tomar navíos de particulares fabricados por estas medidas, y trazas referidas para servir en mis armadas del mar océano, y mediterráneo, considerando la mucha costa que
se les seguirá fabricándolos con las nuevas medidas, trazas, y fortalezas, y el beneficio que se sigue a mi servicio de que anden en mis armadas navíos de esta perfección y fortaleza, les mandaré pagar a razón de ocho reales, y medio por tonelada cada mes incluso en ellos el socorro que se suele dar en las dichas mis armadas a semejantes navíos para sebo, y mangueras, advirtiendo, que para lo que toca a la carrera de las indias, quede, a arbitrio de los ministros de la casa de la contratación que reside en Sevilla para que conforme al tiempo señalen el precio de cada tonelada.

La orden que se ha de guardar en el arqueamiento de los navíos de arqueo\(^3\) Particulares, que se tomaren para servicio de mis armadas es como se sigue. Se han de arquear, y medir con el codo que se usa, y mandó establecer en estos reinos el rey mi señor; que dios tiene, que es de dos tercios de vara, y un treinta y doceavo de las dichas dos tercias. Supuesto que los galeones nuestros, y navíos de particulares que de aquí adelante se fabricaren, han de tener las cubiertas principales en lo mas ancho, se tomará la medida de la manga de parte de proa del árbol mayor en el bao donde remata la escotilla, ó de allí para popa hasta el árbol de babor a estribor, y de tabla a tabla sobre la misma cubierta, y no en el aire como hasta aquí se ha hecho. El puntal se ha de medir sobre el graner hasta encima de la tabla de la cubierta principal, que es donde ha de tener la manga, y para que sea con más justificación, y no pueda haber engaño, ha de ser con una pica limpiando ante todas cosas el graner, de manera que se vea claro, que no se caiga abajo, por algún agujero como ha sucedido en que se ha de tener muy particular cuidado, y porque en el arca de la bomba podría también haber algún engaño por la dificultad que tiene el verlo, se ha de apartar el lastre, y limpiar el graner a boca de escotilla para que se vea donde se pone la pica porque no haya engaño en esas cosas; advirtiendo, que a las naves levantiscas, y urcas respeto de tener los soleres mas altos de lo que acá se usan, se les ha de quitar una tabla del soler que ellos traen en sus cargazones, y encima de las propias varengas se les ha de poner otra tabla de ocho en codo, y sobre aquella se ha de poner la pica donde se ha de medir el puntal.

No se ha de medir la eslora, ni manga en el aire, sino que por encima de la cubierta del branque al codaste de tabla a tabla, y todas las medidas que se tomasen, las han de poner por memoria los mis oficiales a quien tocaren conforme a sus títulos, é instrucciones, asistir, y estar presentes a hacer la cuenta de las toneladas en que fueren arqueados los tales navíos, y a las toneladas que salieren por [a la]\(^4\) cuenta, si fueren navíos de puente y cubierta, se les ha de añadir la refacción.

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3. Notación con letra distinta.
4. Arriba del renglón.
de veinte por ciento excepto a los navíos de cien toneladas abajo, porque con estos no se ha de hacer esta cuenta sino recibirlos a sueldo al través conforme pareciere a los dichos mis oficiales en la parte donde se hiciere el embargo del navío, ó donde se despidiere. Antes de reducir la cuenta de la toneladas, se ha de sacar de todo lo que procediere de las multiplicaciones a razón de cinco por ciento por los raseres en los navíos españoles, y levantiscos lo cual no se debe entender cuando se arquearen, ó midieren algunas urcas, porque no se les debe quitar ninguna cosa de lo que procediere de las dichas multiplicaciones respecto de ser muy llanas, y que tienen muy pocos raseres, y si hubiere algunas que no lo sean, podrá quedar a elección de los dichos mis oficiales, que las arquearon que ante todas cosas las han de reconocer, y si pudieren verlas en seco en caso que no se satisfagan de su traza.

Si algún navío tuviere la cubierta desproporcionada en el altor por tener la manga alta, no se le ha de dar mas puntal de lo que le tocare por la buena regla; es a saber; que si tuviere diecisésis codos de manga siendo bien proporcionado en los demás tercios, se le han de dar nueve codos, y un tercio de puntal, al que tuviere dieciocho de manga, diez y medio, y a este respeto a los demás navíos de mayor, ó menor porte, y si tuviere la cubierta mas abajo de la mitad de la manga, se ha de tomar la medida en la cubierta, y no mas arriba en el aire, sino en la forma que a los otros navíos, y esta regla se podrá tener conforme al porte de cada uno en mas, ó en menos con lo cual cesaran los arbitrios y abusos pasados, pues si se abriesen la puerta a lo que los dueños de los navíos pretenden por añadir medio codo, ó uno de puntal, dirán, que tienen lo mas ancho entre cubiertas, aunque fuese lo contrario, y estuviese debajo.

Sobre todo se ha de procurar por todas las vías y modos posibles, que no haya medidas en el aire sino fijas en la cubierta por excusar los inconvenientes pasados, y esto se entiende no estando las cubiertas fuera de proporción de altas, que en tal caso no se ha de dar mas puntal, que conforme a la dicha regla.

La forma en que se ha de servir, y ser pagada la maestranza en las Fábricas de mis navíos; y adovios de las mis reales Armadas.

A los maestres, calafates, y carpinteros que tuvieron una legua aderredor de los astilleros donde se fabricaren los galeones no se les ha de pagar ningún socorro el día de fiesta, y a los que tuvieren sus casas mas lejos, les socorrán con real y medio los días de fiesta en consideración, que han de alquilar posada, cama, y servicio, y este mismo salario han de gozar los unos y los otros cuando por falta de materiales, ó por mal tiempo dejaren de trabajar.
Y porque es costumbre entre la maestranza no traer las herramientas necesarias para usar sus oficios, respeto de que yo les mandé proveer de herramientas, las cuales pierden, y la toman unos a otros, y por faltar de ellas usan de la hacha, que es la ordinaria que traen, y con ella desperdician mucha madera, y gastan más tiempo en lo que labran, considerando esto, se tiene por conveniente a mi servicio, beneficio de la real hacienda, utilidad, y provecho de la misma maestranza, que como el jornal ordinario que hasta aquí se le ha dado, ha sido de cuatro reales, sea cuatro y medio cada día en el señorío de Vizcaya, provincia de Guipúzcoa, cuatro villas de la costa de la mar, Asturias, y reino de Galicia con condición que ningún nuestro carpintero, ni calafate pueda llevar más de dos aprendices, y los cabos uno, y a estos no se les ha de pagar más de lo que merecieren conforme a la suficiencia de cada uno de que ha de constar en las fábricas al superintendente de ellas, y en las armadas al capitán de la maestranza, con condición que de aquí adelante no se les ha de dar por mi cuenta ningún genero de herramienta, mas que las muelas de piedra para amolar, y a los oficiales que fueren de casas, no se les ha de dar este jornal por entero sino a cada uno según lo que mereciere.

Estando mi armada del mar océano en el río, y puerto de la ciudad de Lisboa, y haciéndose los adovios, y apuestos de sus navíos allí, ó en cualquiera puerto del dicho reino se ha de pagar a cada oficial así calafate como carpintero a razón de cinco reales cada día así por la corona de Portugal como de castilla.

Las herramientas que han de servir
El carpintero ha de traer hacha, sierra, ó serrón, ariela de dos manos, gurbia, barrenos de tres suertes, martillo de orejas, mandarria, y dos escoplos.
El calafate ha de traer mallo, cinco ferros, gurbia, magujo, mandarria, martillo de orejas, saca estopa, tres barrenas diferentes desde el aviador engrosando.

El cavillador ha de traer barrenos, aviadores, taladros y mandarrias.

El aderezo de lo que de estas herramientas se les rompiere, ha de ser por mí Cuenta; y por la costa que se les seguirá a estos tres géneros de oficiales Se les acrecienta el medio real de jornal que queda dicho.

El alistador que alista esta maestranza, y el maestro mayor, que tuviere a su cargo la fábrica del galeón, y se les probare, que han alistado alguno sin traer las dichas herramientas, sea condenado cada uno en doscientos ducados, la mitad para el denunciador, y la otra mitad para el juez, y el que no tuviere hacienda para pagar esta pena, la cumpla con cinco años de servicio de galera al remo.

cuando se hiciere la paga a la maestranza ha de presentar cada oficial la herramienta de su oficio, y cada uno la ha de tener marcada con marca diferente registrada por el veedor, y puesta en el asiento de la lista de su nombre.

no se ha de permitir por ningún caso, que ningún maestro carpintero, calafate, oficial, ni discípulo saque astillas, cabacos, clavos, estopa, ni otro ningún material de las fábricas de galeones, ni navíos de armadas.
Y porque en Portugal está puesto en costumbre ser parte de jornal las dichas astillas, ó cabacos, se les crece el jornal a los dichos cinco reales de que se han de sustentar, y no se les ha de consentir a los dichos maestros carpinteros calafates, oficiales, ni discípulos que salgan a tierra desde la mañana hasta la noche, sino que han de comer los unos, y los otros en las naos planchadas, ó astilleros donde quiera que trabajaren.

Cualquiera persona de la maestranza, marinero, ó otra suerte de gente que hurtare clavazón, plomo, estopa, grasa, aceite, sebo, ó otro cualquier material tocante a fábrica, y adovio de navíos sea condenado en cien ducados, la mitad para el denunciador, y la mitad para el juez, y en esta misma pena incurra cualquier persona, que se lo comprare, y en falta de no tener con que pagar esta condenación sirvan cinco años en galera al remo tanto el vendedor como el comprador.

Todo lo cual según, y de la manera que queda referido, se ha de guardar; y mando, que se guarde por premática inviolable en estos mis reinos, y en virtud de la presente, ó de su traslado firmado del mi infrascripto secretario, mando a los mis superintendentes de las dichas mis fábricas reales de navíos que ahora son, y adelante fueren: que cada uno en su distrito lo haga publicar, y que se ejecute, y cumpla lo que de estas ordenanzas le tocare, y lo mismo ordeno a los mis presidentes, y jueces, oficiales de la dicha casa de la contratación de las indias, y a los mis veedores, y proveedores generales; y particulares de mis armadas en cuanto a lo que por sus oficios están obligados a hacer, y también encargo la observancia de ello al capitán general de la armada del mar océano, y a todos mando, que no hagan, ni consientan hacer, ni alterar cosa contra ninguna de las aquí referidas sin expresa y particular orden mía, y del conocimiento de los pleitos,
y causas que resultasen de hacerlas ejecutar y castigar los transgresores inhibo, y doy por inhibidos a los presidentes, y oidores de las mis audiencias, y chancillerías de estos reinos, y otras cuales quiera justicia de ellos: por cuanto han de tratar del cumplimiento y ejecución de estas ordenanzas solamente los dichos mi capitán general de la armada presidente, y oficiales de la dicha casa de contratación, veedores,
y proveedores generales, y particulares y los superintendentes de mis fábricas de navíos y las demás personas a quien yo lo cometièrent cada uno en su distrito, y conforme a su oficio le tocare, y que se tome la razón de estas ordenanzas en mi contaduría mayor de cuentas, que así conviene a mi servicio, y es mi voluntad.

Dada en Madrid a veinte y un días de diciembre de mil seis y cientos y siete años=yo el rey= por mandado del rey nuestro Señor Antonio de Aroztegui.

Advertencia
El cuarto del codo de que se hace mención en estas ordenanzas para medir los miembros de los navíos es la señal que va puesta aquí debajo.
=concuerda con el original que queda en mi oficio= 102
Hallase un ejemplar impreso, en el archivo general de indias en Sevilla entre los papeles traídos del de Simancas legajo titulado: cartas y otros papeles tocantes a las pretensiones de los mareantes de Sevilla, causados desde el año mil 600 [?] 1602 a 1640, confrontase en 30 de marzo de 1795.

Martín. Fernández de Navarrete
[rúbrica]

Appendix 2 – Ordenanzas 1613

Ordenanzas de 6 de julio de 1613.
Archivo General de Indias. Indiferente, 2595.
(after Serrano Mangas 1992ª: 211-236)

EL REY

Por cuanto habiendo mandado juntar en esta Corte las personas que se han hallado de más ciencia y experiencia de fábricas de navíos y navegación del Mar Océano y Carrera de las Indias Orientales y cargazón de las flotas de ellas a tratar de remediar algunos defectos que ha descubierto la ejecución de las Ordenanzas firmadas de mi mano a veinte y uno de diciembre del año de mil seisientos y siete sobre la forma de fabricar navíos de guerra y de merchantes en estos reinos y demás cosas contenidas en ellas, y visto y conferido en mi Consejo de Guerra lo que en razón de ello se les ofreció advertir a las dichas Ordenanzas de manera que, juntamente con ajustarlas a lo más conveniente a mi servicio, se le iguale la utilidad universal de mis vasallos, he resuelto que mis navíos de guerra y los de particulares de merchantes que se fabriquen en estos reinos sean por unas mismas medidas diferentes de las pasadas y que todo lo que contienen las dichas Ordenanzas (que por la presente derogo) se entienda y quede establecido por estas de aquí adelante de la manera siguiente:

Para fabricar Galeones y otros navíos de Guerra y merchantes para mis armadas del Mar Océano y Carrera de las Indias desde el menor hasta el porte. Se han de usar estas medidas.

1. Para patache de ocho codos de manga
Porte de 55 toneles machos.
De plan, cuatro codos.
De puntal, tres codos y tres cuartos de lo más ancho y allí ha de tener la cubierta.
De quilla, veinte y ocho codos.
De eslora, treinta y tres codos y tres cuartos, dando a la roda de proa cuatro codos de lanzamiento y de a popa un codo y tres cuartos.
De rase, dos codos y medio a popa y la mitad a proa.
De yugo, cuatro codos.
Ha de llevar veinte y cinco cuadernos de cuenta con la maestra.
De astilla, medio codo repartido en tres partes iguales las dos de muerta en medio y la otra tercera parte repartida en tantas partes iguales cuantos fueren los maderos de cuenta que llevaré empezando desde la segunda cuaderna de en medio a popa y a proa.

De joba, medio codo a proa repartido en tantas panes iguales cuantos fueren los maderos que llevaré de cuenta desde la segunda cuaderna a proa y la mitad repartida en la cuadernas que tiene desde la sexta a popa.

De arrufadura en la cubierta, medio codo a proa y uno a popa.

De arrufadura en las cintas, un codo a proa y uno y medio a popa.

No ha de llevar puente ni castillo, sino, tan solamente, una cámara a popa.

Este patache será de porte de cincuenta y cinco toneles machos, quitados cinco por ciento que no se le dan veinte por ciento porque no tiene más de una cubierta.

2. Para patache de nueve codos de manga
Porte de 70 toneles y medio machos.

De plan, cuatro codos y medio.

De puntal, cuatro codos de lo más ancho y allí la cubierta.

De quilla, treinta codos.

De eslora, treinta y seis codos, dando cuatro codos de lanzamiento a proa y dos a popa. De rasel, tres codos a popa y la mitad a proa.

De yugo, cuatro codos y medio.

Ha de llevar veinte y siete cuadernas de cuenta con la maestra.

De astilla, medio codo repartido en tres partes iguales las dos de muerta en medio y la otra tercera parte repartida en tantas partes iguales cuantos fueren los maderos de cuenta que llevaré desde la segunda cuaderna de en medio a proa y a popa.

De joba, medio codo repartido en partes iguales de las cuadernas que hubiere desde la segunda a proa y la mitad repartida en las cuadernas que llevaré desde la sexta a popa.

De arrufadura en la cubierta, medio codo a proa y uno a popa.

De arrufadura en las cintas, un codo a proa y uno y medio a popa.

Ha de llevar un castillo pequeño a proa y una media tolda a popa sobre la cubierta.

Este patache será de porte de setenta toneles y medio machos, quitándole cinco por ciento y no se le dan veinte por ciento porque no lleva segunda cubierta.

3. Para patache de diez codos de manga
Porte de 94 toneles y medio machos.

De plan, cinco codos.

De puntal, cuatro codos y medio de lo más ancho y allí la cubierta.

De quilla, treinta y dos codos.

De eslora, treinta y ocho codos y tres cuartos, dando cuatro codos y medio de lanzamiento a proa y dos y un cuarto a popa.

De rasel, tres codos y un tercio a popa y la mitad a proa.

De yugo, cinco codos.

Ha de llevar veinte y nueve cuadernas de cuenta con la maestra.

De astilla, cinco octavas repartidas en tres partes iguales las dos de muerta en medio y la otra tercera parte repartida en tantas partes iguales cuantos fueren los maderos de cuenta que llevaré desde la segunda cuaderna de en medio a proa y popa.
De joba, cinco octavas repartidas en partes iguales en las cuadernas que hubiere desde la segunda de en medio a proa y la mitad repartida en las cuadernas que llevare desde la sexta a popa.
De arrufadura en la cubierta, medio codo a proa y uno a popa.
De arrufadura de las cintas, codo y medio a proa y dos a popa.
Ha de llevar encima de la cubierta una tolda a popa y castillo o chimenea a proa.
Este patache será de porte de noventa y cuatro toneles y medio machos, quitado cinco por ciento y no se le dan veinte por ciento porque no tiene más de una cubierta.

4. Para navío de once codos de manga
Porte de 148 toneladas.
De plan, cinco codos y medio.
De puntal, cinco codos de lo más ancho, y allí la cubierta.
De quilla, treinta y cuatro codos.
De eslora, cuarenta y un codos y medio, dando a la roda de cinco codos de lanzamiento y dos y medio a popa.
De rasel, tres todos y dos tercios a popa y la mitad a proa.
De yugo, cinco codos y medio.
Ha de llevar treinta y una cuadernas de cuenta con la maestra.
De astilla, cinco octavas y media repartidas en tres partes iguales, las dos de muerta en medio y la otra tercera parte repartida en tantas partes iguales cuantos fueren los maderos de cuenta que hubiere desde la segunda cuaderna de en medio y a proa.
De joba, cinco octavas y media repartidas en partes iguales en las cuadernas que hubiere desde la segunda de en medio a proa y la mitad repartida en las cuadernas que llevare desde la séptima a popa.
De arrufadura de la cubierta, medio codo a proa y uno a popa.
De arrufadura en las cintas, codo y medio a proa y dos a popa.
Ha de llevar puente corrida si fuere mercante, pero si fuere de Armada no ha de llevar encima de la cubierta más de alcázar y batallera.
Este navío, añadiéndole veinte por ciento, será de porte de ciento y cuarenta y ocho toneladas por llevar dos cubiertas.

5. Para navío de doce codos de manga
Porte de 207 toneladas y tres cuartos.
De plan, seis codos.
De puntal, seis codos a la primera cubierta y si fuere de mercante allí lo más ancho, pero si fuere de Armada, medio codo más abajo de la cubierta lo más ancho.
De quilla, treinta y seis codos.
De eslora, cuarenta y cinco codos, dando seis de lanzamiento de la roda de proa y la mitad a popa.
De rasel, cuatro codos a popa y la mitad a proa.
De yugo, seis codos.
Ha de llevar treinta y una cuadernas de cuenta con la maestra.
De astilla, tres cuartos de codo repartidos en tres partes las dos de muerta en medio y la otra tercera parte repartida en tantas partes iguales cuantos fueren los maderos que llevaren de cuenta desde la segunda cuaderna de en medio a popa y a proa.
De joba, tres cuartos de codo repartidos en partes iguales en las cuadernas que hubiere desde la segunda de en medio a proa y la mitad repartida de las cuadernas que tuviere desde la séptima a popa.

De arrufadura de las cintas, codo y medio a proa y dos a popa.

Si este navío fuere de Armada ha de llevar la segunda cubierta en dos codos y un tercio al canto de arriba de la tabla y esta no ha de pasar sino desde la bita hasta la dala.

Los Castillos de popa y proa en tres codos y medio con un trazado el árbol mayor y otro a la bita, pero si fuere de mercante no ha de llevar más de puente corrida en dos codos y dos tercios con una cámara a popa.

Este navío será de porte de doscientas y siete toneladas y tres cuartos siendo de mercante, pero si fuere de Armada por cuanto lleva lo más ancho medio codo más abajo de la cubierta será de porte de doscientas y catorce toneladas.

6. Para navío de trece codos de manga

Porte de 258 toneladas y 1/8.

De plan, seis codos y medio.

De puntal, seis codos y medio en lo más ancho y allí la cubierta si fuere de mercante, pero si fuere de Armada, medio codo más abajo de la cubierta lo más ancho.

De quilla, treinta y ocho codos.

De eslora, cuarenta y siete codos y tres cuartos dando de lanzamiento a la roda de proa seis y tres cuartos y a la de popa tres.

De rasel, cuatro codos y un tercio a popa y la mitad a proa.

De yugo, seis codos y medio.

Ha de llevar treinta y tres cuadernas de cuenta con la maestra.

De astilla, seis octavas y media repartidas en tres partes iguales lados de muerta en medio y la otra tercera parte repartida en tantas partes iguales cuantos fueren los maderos que llevare de cuenta desde la segunda cuaderna de en medio a popa y a proa.

De joba, seis octavas y media repartidas en partes iguales en las cuadernas que hubiere desde la segunda de en medio a proa y la mitad partida en las cuadernas que tuviere desde la octava a popa.

De arrufadura en la cubierta, medio codo a proa y uno a popa.

De arrufadura en las cintas, dos codos a proa y dos y medio a popa.

Ha de llevar puente corrida en tres codos de altor de la cubierta hasta encima de la lata ora sea de guerra ora de mercante y encima su cámara.

Este navío será de porte de doscientos y cincuenta y ocho toneladas y una octava siendo de mercante, pero si fuere de Armada será de porte de doscientas y sesenta y ocho toneladas porque tiene lo más ancho medio codo debajo de la cubierta y lo mismo se ha de entender en todos los navíos de Armada.

7. Para galeón de catorce codos de manga

Porte de 316 toneladas.

De plan, siete codos.

De puntal, siete codos en lo más ancho y allí la cubierta si fuere de mercante, pero si fuere de Armada medio codo más abajo de la cubierta lo más ancho.

De quilla, cuarenta codos.
De eslora, cincuenta codos y medio dando de lanzamiento a la roda de proa siete codos y un cuarto y a la de popa, tres y un cuarto.
De rasel, cuatro codos y dos tercios a popa y la mitad a proa.
De yugo, siete codos.
Ha de llevar treinta y cinco cuadernas de cuenta con la maestra.
De astilla, siete octavas de codo repartidas en tres partes iguales las dos de muerta en medio y la otra tercera parte repartida en tantas partes iguales cuantos fueren los maderos de cuenta que llevar de la segunda cuaderna de en medio a popa y a proa.
De joba, siete octavas repartidas en partes iguales en las cuadernas que hubiere desde la segunda de en medio a proa y la mitad repartida en las cuadernas que tuviere desde la octava a popa.
De arruñadura, medio codo a proa y uno a popa.
De arruñadura en las cintas, dos codos a proa y dos y medio a popa.
Ha de llevar a puente corrida de popa a proa en tres codos de altor desde la cubierta hasta el canto bajo de la lata con una cámara a popa y un castillo a proa para el fogón encima de la puente.
Este navío será de porte de trescientas y dieciseis toneladas si fuere de mercante, pero si fuere de Armada será de porte de trescientas y veinte y cinco toneladas y tres octavas.

8. Para galeón do quince codos de manga
Porte de 381 toneladas y 314.
De plan, siete codos y medio.
De puntal, siete codos y medio en lo más ancho y allí la cubierta si fuere de mercante y si fuere de Armada medio codo más bajo de la cubierta lo más ancho.
De quilla, cuarenta y dos codos.
De eslora, cincuenta y tres codos y un cuarto dando de lanzamiento a la roda de proa siete codos y tres cuartos y a la de popa tres y medio.
De rasel, cinco codos a popa y a proa la mitad.
De yugo, siete codos y medio.
Ha de llevar treinta y cinco cuadernas de cuenta con la maestra.
De astilla, siete octavas y media repartidas en tres partes las dos de muerta en medio y la otra tercera parte repartida en tantas partes iguales cuantos fueren los maderos de cuenta que llevar desde la segunda cuaderna de en medio a popa y a proa.
De joba, siete octavas y media repartidas en partes iguales en las cuadernas que hubiere desde la segunda de en medio a proa y la mitad repartida en las cuadernas que tuviere desde la octava a popa.
De arruñadura en la cubierta medio codo a proa y uno a popa.
De arruñadura en las cintas, dos codos a proa y a popa dos y medio.
Ha de llevar la puente corrida de popa a proa en tres codos de altor al canto de la lata de abajo con un castillo a proa y una media tolda con dos latas adelante de la mesana donde llevará la cámara de popa con un camarotillo para el piloto si fuere de mercante podrá correr la tolda hasta el pie del árbol.
Este Galeón será de porte de trescientas y ochenta y una toneladas y tres cuantos si fuere de mercante, pero si fuere de Armada será de porte de trescientas y noventa y tres toneladas y una ochava.
9. Para galeón de dieciséis codos de manga
Porte de 456 toneladas.
De plan, ocho codos.
De puntal, ocho codos en lo más ancho y allí la cubierta si fuere de mercante y si fuere de Armada, medio codo más abajo de la cubierta lo más ancho.
De quilla, cuarenta y cuatro codos.
De eslora, cincuenta y seis codos dando de lanzamiento a la roda de proa ocho codos y a la de popa cuatro.
De rase, cinco codos y un tercio a popa y la mitad a proa.
De yugo, ocho codos.
Ha de llevar un codo repartido en tres partes iguales los dos tercios de muerta en medio y el otro tercio repartido en tantas partes iguales cuantos fueren los maderos de cuenta que llevar desde la segunda cuaderna de en medio a popa y a proa.
De joba, un codo repartido en partes iguales en las cuadernas que hubiere desde la segunda de en medio a proa y la mitad repartida en las cuadernas que tuviere desde la novena a popa.
De arrufadura en la cubierta medio codo a proa y uno a popa.
De arrufadura en las cintas dos codos a proa y dos y medio a popa.
Ha de llevar la puente corrida en tres codos de altor desde encima de la cubierta hasta el canto bajo de la lata con su tolda y castillo y un camarote encima de la tolda para el piloto y la cámara encima de la puente. Este navío será de porte de cuatrocientos y cincuenta y seis toneladas si fuere de mercante, pero si fuere de Armada por cuanto lleva la manga medio codo más baja de la cubierta será de porte de cuatrocientos y sesenta y nueve toneladas y tres cuartas.

10. Para galeón de diecisiete codos de manga
Porte de 539 1/4 toneladas.
Plan, ocho codos y medio.
De puntal, ocho codos y medio en lo más ancho y allí la cubierta si fuere de mercante y si fuere de Armada medio codo más abajo de la cubierta lo más ancho.
De quilla, cuarenta y seis codos.
De eslora, cincuenta y ocho codos y tres cuartos dando de lanzamiento a la roda de proa y ocho y medio a la de popa cuatro y un cuarto.
De rase, cinco codos y dos tercios a popa y la mitad a proa.
De yugo, ocho codos y medio.
Ha de llevar treinta y siete cuadernas de cuenta con la maestra.
De astilla, un codo y medio octavo de codo repartido en tres partes iguales las dos de muerta en medio y la otra tercera parte repartida en tantas partes iguales cuantos fueren los maderos que llevar de cuenta desde la segunda cuaderna de en medio a popa y a proa.
De joba, un codo y medio ochavo repartido en partes iguales en las cuadernas que hubiere desde la segunda de en medio a proa y la mitad repartida en las cuadernas que tuviere desde la proa a popa.
De arrufadura en la cubierta, medio codo a proa y uno a popa.
De arrufadura en las cintas, dos codos a proa y dos y medio a popa.
Ha de llevar la puente corrida a tres codos y un octavo de altor desde la cubierta hasta el canto de la lata debajo con su tolda y castillo esto es alcázar y chimenea y debajo la tolda la cámara de popa y encima un camarote para el piloto.
Este galeón será de porte de quinientas y treinta y nueve toneladas y un cuarto si fuere de mercante, pero si fuere de Armada será de quinientas y cincuenta y cinco toneladas y un cuarto.

11. Para galeón de dieciocho codos de manga
Porte de 632 toneladas.
De plan, nueve codos.
De puntal, nueve codos en lo más ancho y allí la cubierta si fuere de mercante y si fuere de Armada, medio codo más abajo de la cubierta lo más ancho.
De quilla, cuarenta y ocho codos.
De eslora, sesenta y un codos y medio dando de lanzamiento nueve codos en la roda de proa y a la de popa cuatro codos y medio.
De rasel, seis codos a popa y la mitad a proa.
De yugo, nueve codos.
Ha de llevar treinta y nueve cuadernas de cuenta con la maestra.
De astilla, un codo y un octavo repartido en tres partes iguales las dos de muerta en medio y la otra tercera parte repartida en tantas partes iguales cuantas fueren los maderos de cuenta que llevaré desde la segunda cuaderna de en medio a popa y a proa.
De joba, un codo y un octavo repartido en partes iguales en las cuadernas que hubiere desde la segunda de en medio a proa y la mitad repartida en las cuadernas que tuviere desde la décima a popa.
De arrufadura en la cubierta medio codo a proa y uno a popa.
De arrufadura en las cintas, dos codos a proa y dos y medio a popa.
Ha de llevar puente corrida a tres codos y un sexto de altor desde la cubierta al canto de abajo de la lata y encima el alcázar hasta el pie del árbol mayor y chimenea a proa debajo del alcázar la cámara de popa y un camarote encima para el piloto.
Este Galeón será de porte de seiscientos y treinta y dos toneladas si fuere de mercante pero si fuere de Armada será de porte de seiscientos y cincuenta y una toneladas.

12. Para galeón de diecinueve codos de manga
Porte de 721 toneladas y tres cuartos.
De plan, nueve codos y medio.
De puntal, nueve codos y medio en lo más ancho y allí la cubierta si fuere de mercante, pero si fuere de Armada medio codo más abajo de la cubierta lo más ancho.
De quilla, cuarenta y nueve codos.
De eslora, sesenta y tres codos y un cuarto dando de lanzamiento en la roda de proa nueve codos y medio y en la de popa cuatro y tres cuartos.
De rasel, seis codos y un tercio a popa y la mitad a proa.
De yugo, nueve codos y medio.
Ha de llevar treinta y nueve cuadernos de cuenta con la maestra.
De astilla, nueve octavas y media repartidas en tres partes iguales las dos de muerta en medio y la otra tercera parte repartida también en tantas partes iguales cuantos fueren...
los maderos de cuenta que llevare desde la segunda cuaderna de en medio a popa y a proa.

De joba, nueve octavas y medio repartidas en partes iguales en las cuadernas que hubiere desde la segunda a proa y la mitad repartida en las cuadernas que hubiere desde la décima a popa.

De arrufadura en la cubierta, medio codo a proa y uno a popa.

De arrufadura en las cintas, dos codos a proa y dos y medio a popa.

Ha de llevar puente corrida a tres codos y cuarto de altor a la cubierta hasta el canto bajo de la lata con su alcázar hasta el pie del árbol y chimenea a proa y debajo del alcázar la cámara de popa y encima el camarote del piloto.

Este Galeón será de porte de setecientas y veinte y una toneladas y tres cuartos si fuere de mercante, pero si fuere de Armada será de porte de setecientas y cuarenta y tres toneladas.

13. Para galeón de veinte codos de manga
Porte de 833 toneladas.

De plan, diez codos.

De puntal, diez codos en lo más ancho y allí la cubierta si fuere de mercante, pero si fuere de Armada, medio codo más abajo de la cubierta lo más ancho.

De quilla, cincuenta y un codos.

De eslora, sesenta y seis codos dando de lanzamiento a la roda de proa diez codos y a la de popa cinco.

De rasel, seis codos y dos tercios a popa y la mitad a proa.

De yugo, diez codos.

Ha de llevar cuarenta y una cuadernas de cuenta con la maestra.

De astilla, un codo y un cuarto repartido en tres partes iguales dando las dos de muerta en medio y la otra tercera parte repartida también en tantas partes iguales cuantos fueren los maderos de cuenta que llevare desde la segunda cuaderna de en medio a popa y a proa.

De joba, un codo y un cuarto repartido en partes iguales en las cuadernas que llevare desde la segunda a proa y la mitad repartida en las cuadernas que llevare desde la undécima a popa.

De arrufadura en la cubierta, medio codo a proa y uno a popa.

De arrufadura en las cintas, dos y medio a proa y tres a popa.

Ha de llevar puente a tres codos y un cuarto de altor desde la cubierta hasta el canto bajo de la lata con su alcázar hasta el pie del árbol mayor y batallera a proa y debajo del alcázar la cámara de popa y encima el camarote del piloto.

Este galeón será de porte de ochocientas y treinta y tres toneladas y cinco octavas si fuere de mercante, pero si fuere de Armada, será de porte de ochocientas y cuarenta y ocho toneladas y cinco octavas.

14. Para galeón de veinte y un codos de manga
Porte de 956 toneladas y 318.

De plan, cinco codos y medio.

De puntal, diez codos y medio en lo más ancho y allí la cubierta si fuere de mercante, pero si fuere de Armada, medio codo más abajo de la cubierta lo más ancho.
De quilla, cincuenta y tres codos.
De eslora, sesenta y ocho codos y tres cuartos dando de lanzamiento a la roda de proa diez y tres cuartos y a la de popa cinco codos.
De rasel, seis codos y dos tercios a popa y la mitad a proa.
De yugo, diez codos y medio.
Ha de llevar cuarenta y una cuadernas de cuenta con la maestra.
De astilla, un codo y un cuarto y más media ochava repartido en tres partes iguales cuantos fueren los maderos que llevar de cuenta desde la segunda cuaderna de en medio a popa y a proa.
De joba, un codo y un cuarto y más media ochava repartido en partes iguales en las cuadernas que llevar desde la segunda a proa y la mitad repartida en las cuadernas que tuviere desde la undécima a popa.
De arrufadura en la cubierta, medio codo a proa y uno a popa.
De arrufadura en las cintas, dos y medio a proa y tres a popa.
Ha de llevar puente a tres codos y un cuarto de altor desde la cubierta hasta el canto bajo de la lata con su alcázar hasta el pie del árbol mayor y castillo a proa y debajo del alcázar la cámara de popa y encima el camarote del piloto.
Este galeón será de porte de novecientas y cincuenta y seis toneladas y tres octavas si fuere de mercante, pero si fuere de Armada será de pone de novecientas y ochenta y cinco toneladas.

15. Para galeón de veinte y dos codos de manga
Porte de 1.073 toneladas y un tercio.
De plan, once codos.
De puntal, once codos en lo más ancho y allí la cubierta si fuere de mercante, pero si fuere de Armada, medio codo más abajo de la cubierta lo más ancho.
De quilla, cincuenta y cuatro codos.
De eslora, setenta codos y medio dando de lanzamiento a la roda de proa once codos y medio y a la de popa cinco.
De rasel, siete codos a popa y la mitad a proa.
De yugo, once codos.
Ha de llevar cuarenta y tres cuadernas de cuenta con la maestra.
De astilla, un codo y tres octavas repartido en tres partes iguales de las cuales se darán dos de muerta en medio y la otra tercera parte repartida en tantas partes iguales cuantos fueren los maderos que llevar de cuenta desde la segunda cuaderna de en medio a popa y a proa.
De joba, un codo y tres octavos repartido en partes iguales en las cuadernas que hubiere desde la segunda a proa y la mitad repartida en las cuadernas que llevar desde la duodécima a popa.
De arrufadura en la cubierta, medio codo a proa y uno a popa.
De arrufadura en las cintas, dos y medio a proa y tres a popa.
Ha de llevar la segunda cubierta a tres codos y un cuarto de altor desde la primera hasta el canto bajo de la lata con su alcázar hasta el pie del árbol mayor y batallera a proa y debajo del alcázar la cámara de popa y encima un camarote para el piloto.
Este galeón será de porte de mil y setenta y tres toneladas y un tercio si fuere de mercante, pero si fuere de Armada, será de porte de mil ciento y cinco toneladas y media.
Regla general para armar todos los navíos

16. Por cuanto a los pataches de menos manga de los ocho codos que tiene el primer capítulo de estas Ordenanzas no se pone limitación, sino que queda al albedrío de como cada uno quisiere fabricar por ser barcos pequeños y en los demás no han de exceder de las dichas medidas.

17. Si acaso fuere que en los navíos de doce codos de manga arriba por el peso de las maderas abrirá más la manga de la medida que le pertenece hasta cantidad de medio codo no por eso se entienda haber excedido ni alterado la buena fábrica sino cumplido con la Ordenanza.

18. Puesta la quilla que ha de llevar las juntas de tope y arbolado branque y codaste y escorado de proa y popa se ha de tomar un cordel del largo de la eslora del navío que se arma y doblarle por medio y luego volverle a doblar también por medio para tomar la cuarta parte de la eslora, la cual se ha de poner en el lanzamiento de la roda de proa y donde llegare encima de la quilla un codo más a proa se ha de poner el redel y de la misma manera se ha de poner la cuarta parte en el lanzamiento del codaste de popa y donde cayere encima de la quilla dos codos más a proa se ha de poner el otro redel y en la distancia que hubiere de redel a redel se han de repartir los maderos de cuenta.

19. Para que los navíos queden llenos en todos sus tercios y con buena proporción respecto de su manga, es necesario que los redeles tengan de ancho la mitad del plan y algo más y además de esto que el redel de proa por la amura tenga un codo menos que en la manga y el redel de popa por la cuadra dos codos menos que en la manga y para saber cuanto ha de ser aquel poco más que los redeles han de ser mayores que la mitad del plan, se ha de tomar la cantidad que tuviere la grúa del plan que es la mitad de todo el plan por la cuaderna maestra desde el punto de la escoa hasta el punto de la quilla y esta distancia se dividirá en cinco partes iguales y la una parte de estas se volverá a dividir en otras cinco partes iguales y lo que montare una quinta parte de estas es lo que han de ser los redeles mayores que la mitad del plan en la grúa lo cual es importante para quedar el navío con más buque y también, por lo que levanta la astilla, conviene que los redeles abran no solamente tanto cuanto fuere la mitad del plan pero que se le añada aquello poquito más porque con esto y con lo que se le da de joba a proa más que a popa, que siempre es doblado, vendrá a salir el redel de proa por la amura (como esta dicho) con un codo de menos manga que en medio y con la joba que se le da al redel de popa que es la mitad que al de proa viene a quedar el mismo redel de popa por la cuadra con dos codos menos de manga que en medio y haciendo todo el costado con una misma grúa vendrá a salir el navío o Galeón con las calidades dichas.

20. Para que salga el navío marinero y boyante y no boquiabierto ni emparedado, ni tenga balance, conviene que cierren la puente tanto cuanto abrió en los baos que estarán a tres codos y medio más abajo de la cubierta y de la puente arriba ha de enderezar un poco el barraganete porque tenga más plaza de armas.

Todos los dichos Galeones, Navíos y Pataches se han de fabricar con las fortalezas siguientes:

21. Armadas las cuadernas o arengas que han de ir endentadas bien clavadas y rebatidas con los pies de Genoles se poblará la quilla de ellas después de haber puesto las maestras o
armaduras y haber nivelado la madera de cuenta y apuntalado por la escoa se hinchará de cabeza con los espaldones, picas y rebesones, los cuales han de ir endentados y clavados con tres pernetos de ribete cada uno que rebiten en los escarpes los cuales hinchamientos se han de ir asentando ordenadamente uno a uno de medio para proa y de medio a popa porque den lugar los unos a los otros a clavarse y endentarse y de allí arriba toda la ligazón y aposturaje ha de ir de la misma manera endentada y clavada una contra otra para que los costados queden fuertes y no haya lugar de jugar las ligazones y de esta manera vendrá a quedar el plan y costados fuertemente unidos y en esto se ha de poner gran cui- dado porque es el fundamento de toda la fábrica.

22. Desde la segunda ornización, que son los pies de Genoles, arriba se ha de pro-curar buscar maderas largas que alcancen a cruzar hasta llegar a las cabezas de las orengas o todo lo más que fuere posible y que asimismo alcancen las mismas maderas arriba a la segunda ornización lo más que pudieren.

23. Los escarpes de los pies de Genoles con las varengas o planes han de ser lo más largos que se pudiere porque crucen más por el plan y hagan buen encolamiento.

24. Han de llevar dos andanas de singlas por las cabezas de las varengas y por las de los pies de Genoles todas endentadas y ajustadas por que no jueguen las cabezas que es la llave de las fábricas.

25. La sobrequilla ha de ir bien endentada con las varengas y cosida a madero en salvo con cavillas de hierro escateada la quilla con la sobrequilla.

26. El plan y piques de popa a proa han de ir llenos de calarena y cascote de güijarro menudo entre cuaderna y cuaderna y encima de ellas se ha de entablado el granel de popa a proa hasta llegar a las singlas de las cabezas de las varengas y por encima de esta singla ha de ir una tabla bien ajustada que servirá de albaola y en ella la escoperada del granel encima del cual han de ir los taquetes de la carlinga endentada y enmalletados en las propias tablas del granel que alcancen hasta la singla que va por las cabezas de los pies de genoles con su diente en la propia singla.

27. Las albaolas han de ir a tabla en salvo desde abajo hasta arriba con su albaola debajo de todas las liernas o durmientes.

28. Las durmientes han de ser de medio cabo de ancho y de grueso un cuarto ajustados y endentados unos con otros con esgarabote.

29. Los navíos de diecinueve codos de manga abajo no han de llevar más de una andana de baos varios en altor de la mitad del puntal y se han de asentar de manera que los durmientes tomen los escarpes de las ligazones si fuere posible y han de llevar dos corbatones en cada cabeza, uno por encima del bao y otro por el lado pero los navíos de veinte codos de manga arriba llevarán dos andanas de baos varios y para ello se ha de repartir el puntal entre partes iguales y por el alto de cada una de ellos se han de asentar de suerte que pueden igualmente distantes los unos del plan y los otros de la cubierta y también ellos entre sí.

30. El contradurmente ha de ser de un cuarto de codo en cuadro ajustado como el durmiente.

31. La cubierta principal ha de llevar cuatro baos a boca de escotilla y al través del árbol de un cuarto de codo de ancho y un tercio de canto por causa de la fogonadura del árbol mayor.
32. Las latas de la cubierta han de ir a cuchillo que estén a nivel con los baos asentadas una de otra un tercio de codo a cola de milán bien clavadas las cuales han de tener de canto un tercio de codo y de ancho han de ser de cinco en codo.

33. Los trancaniles han de ser de muy buena madera y de grueso conforme el porte del navío andados y encajados a cola de milán, como las latas en el durmiente, y clavados en cruz que alcancen de fuera para dentro y de arriba abajo y por encima del trancanil no ha de llevar más de una tabla para la escoperadura.

34. Las cuerdas o esloras de la cubierta principal y puente han de ser de canto que alcancen por debajo de las latas a endentar hasta la mitad y por encima de la cubierta otras que ajusten con las de abajo, y para esto será bien que sean un tercio de codo de canto y un quinto de codo de ancho como las latas y por encima de los baos han de ir otras dos andanas de cuerdas o esloras enmalletadas en los baos por encima del entremiche y estas han de ser cuadradas de un cuarto de codo.

35. Los corbatones han de ir a tres latas en salvo y han de llevar cada uno cinco cabillas de hierro escateadas.

36. Las latas de la puente han de llevar de canto un tercio de codo de ancho de seis en codo asentadas una de otra a tercio de codo como las de la cubierta principal con los corbatones a tres latas en salvo para abajo así mismo como las de la cubierta con sus trancaniles acanalados endentados con su cola de milán y clavados como las demás y con cuatro baos en la forma que la cubierta principal y ni más ni menos las esloras o cuerdas.

37. En los navíos de Armada desde diecisiete codos de manga arriba llevarán las columnas que fueren necesarias desde las cabezas de los baos varios hasta las cuerdas que están debajo de la puente endentadas arriba y abajo y en la cubierta principal y con dos corbatones en cada cabeza en el costado y debajo de la puente otros dos endentados contra ellas y encabilladas con cabillas de hierro y escateadas y en los navíos de dieciséis codos de manga abajo se pondrán de esta manera = Las columnas que tuvieren los pies arrimados a los baos de la banda de estribor han de tener las cabezas arriba arrimadas a la cuerda que está de la banda de babor y de la misma suerte los que tuvieren los pies de la banda de babor tendrán las cabezas arriba de la banda de estribor en la cuerda de la propia banda endentada como queda dicho y este se hace para que vengan cruzadas por que no embaracen los encabalgamientos de la Artillería y donde se cruzaren se han de endentar una con otra y clavarse en la propia cruz fuertemente.

38. El Navío o Galeón grande de diecisiete codos de manga arriba ha de llevar bularcamas por encima del granel de babor a estribor a un bao en salvo que lleguen a endentar en el ramo del corbatón que viene de la cubierta hacia bajo endentadas con las cabezas de los baos vacíos y en el costado por la parte que no llevare corbatón.

39. La popa se ha de calimar hasta el yugo y el Palo cintón para henchir el ángulo del rasel ha de ser bueno y ancho que alcance arriba y abajo las puercas y buzardas de proa como se acostumbran con sus corbatones en las puercas y sus pernadas bien ajustadas y de una puerc a otra ha de haber un tercio de codo de hueco o vacío y en las buzardas otro tercio de vacío como en las puercas.

40. Las aletas o fieles de popa han de abrir en el yugo la mitad de la manga hay más abajo dos codos o dos y medio han de abrir un cuarto de codo más que en el yugo para que sea la popa más redonda y con más sustento para cuando caiga la nao que tenga donde escorar.
41. El espolón ha de tener de largo tres quintos de su manga del branque para fuera.
42. La lemera ha de ir dos codos y medio de la cubierta principal para que por debajo lleve dos portas para jugar dos piezas de artillería en navío de armada y en los de mercante ha de ir la lemera en el mismo lugar, pero no ha de llevar piezas por ir muy largadas cuando van a las Indias pero volviendo de ellas porque vendrán aliados pueden poner las piezas en las por- tas y ni más ni menos debajo de la puente de popa a proa pueden poner toda la artillería y de esta manera podrán servir de mercante y de guerra.
43. Las portas de la artillería han de tener el batidero un codo encima de la cubierta y ha de tener cada una un codo y un cuarto de cuadro.
44. La caña del timón ha de andar debajo de la puente con el molinete en la propia puente cortando en la tolda entre lata y lata de babor a estribor donde ende el pinzote para que el que gobernare esté encima de la misma tolda.
45. Las mesas de guarnición han de ser a la portuguesa.
46. Los navíos de puentes, tolda y castillo han de llevar la madre del espolón codo y medio encima de la puente y los que no tuvieren más de puente corrida han de llevar la madre del espolón en la propia puente y los que no tuvieren más de una cubierta con tolda y castillo han de llevar la madre del espolón dos codos encima de la cubierta y los que no tuvieren más de una cubierta llevarán la madre del espolón encima de la cubierta un codo, la cual madre se ha de asentar hecho un diente por la una banda de roda y otro a la madre de manera que quede encajada en medio y ha de subir la propia roda o branque encima de la madre codo y medio para que por encima del dragante que se ha de poner por la banda de fuera del branque y arrimado a él y por encima de la madre se fije un corbatón contra la rod que subió encima de la madre.
47. Los escobones han de ir encima dela puente medio codo.
48. El corbatón del tajamar que va por debajo de la madre ha de ser con dos machos encajados en el branque y de allí abajo su tajamar y contrabranque hasta la quilla con sus juntas de entremiches y machos en la roda y el tajamar el más ancho que se hallare.
49. La popa ha de llevar contracodaste por la banda de fuera endentados con sus machos o dientes de manera que arriba en la lemera no sea más grueso que el través de dos en dos endentados e incorporados en el codaste de manera que no salga nada fuera de la parte de arriba y abajo junto a la patilla de dos tercios de codo en navíos de diecisésis codos de manga y siendo de mayor porte será más ancho en proporción del porte como creciere.
50. Ha de llevar otro contracodaste por la banda de dentro por encima de las puercas que ajuste con el codaste.
51. A proa ha de llevar contrabranque por la banda de dentro y han de clavar en él tablas de fuera para que se ajusten todas las cabezas encima del propio branque y para esto se ha de buscar el Palo más fornido que se hallare para que alcance de una banda a otra a clavar las tablas en él.
52. La vita ha de ser a la inglesa fortificada con sur corbatones por la banda de popa en la cubierta principal y en la de arriba por la parte de proa en- dentados en las latas y ha de venir a raíz del castillo de modo que la artillería de proa pueda jugar libremente sin embarazarla.
53. Los durmientes de la tolda y castillo han de ser de cinco en codo de grueso y de un tercio de codo en ancho.
54. Las latas de la tolda y castillo han de tener de canto un cuarto de codo y de ancho seis en codo.
55. La primera cinta ha de ir un codo debajo de la cubierta principal y la segunda en la cabeza de las latas enfrente del durmiente de manera que el agua de los embornales vierta por encima de la cinta y la tercera encima de las portas de la Artillería que viene a ser dos codos y medio encima de la cubierta principal.
56. La primera y segunda cinta han de ser dobles que las dos juntas hagan dos tercios de codo de ancho y un tercio de cantos descanteados de la parte de arriba y abajo de manera que queden ahovadas.
57. Los navíos de trece codos de manga abajo han de ser las fortificaciones en proporción de su porte.
58. Los navíos de dieciséis codos de manga arriba han de llevar la tablazón de la segunda cinta abajo de cinco en codo y de la segunda cinta arriba de seis, siete y ocho adelgazando la madera arriba lo más que se pudiere la tabla de las cubiertas ha de ser de seis en codo.
59. Los navíos de quince y dieciséis codos de manga han de llevar tablas de seis en codo hasta la segunda cinta y de allí arriba se ha de echar de siete, ocho y nueve en codo adelgazando la madera mientras más arriba más la tablazón de la cubierta ha de ser de siete en codo.
60. Los navíos de trece y catorce codos de manga han de llevar la tabla de siete en codo hasta la segunda cinta y de allí para arriba de ocho, nueve y diez adelgazando la madera como se ha dicho mientras más arriba más, proporcionalmente la tabla de la cubierta ha de ser de ocho en codo.
61. Los navíos de once y doce codos de manga han de llevar la tabla de ocho en codo hasta la segunda cinta y de allí para arriba de nueve, diez y once adelgazando la madera proporcionalmente, mientras más arriba más, la tablazón de la cubierta ha de ser de nueve en codo.
62. Los navíos de diez, once y doce codos de manga han de llevar las tablas de nueve en codo hasta la segunda cinta y de allí para arriba de diez, once y doce y de allí para arriba de doce, trece y catorce adelgazando la madera como se ha dicho y la tabla de la cubierta de doce en codo.
63. La tablazón de la puente tolda y castillo ha de ser de pino y si fuese posible sea de Flandes porque es más liviano y de allí para arriba la tablazón también de pino para que no tenga peso arriba que cause balance, la cual tablazón ha de ser conforme al porte de la Nao como arriba está dicho.
64. La tablazón desde la puente arriba ha de ir entablada tinglada a la flamencas por ser de menos costa y más estanco.
65. El grosor de toda la tabla dicha se entiende le ha de tener después de labrada.
66. Para que toda la obra sea fija conviene que todo el material sea seco y que la madera se corte en las menguantes de agosto hasta la de febrero, y no en otro tiempo y, si fuese posible, se corte de medio día para la noche.
67. El timón ha de tener de grueso lo que tuviere de ancho el contracodaste y un dedo más y en la frente de la parte de fuera doblado grueso que el de la parte de dentro y algo más al ancho será proporcionado al porte de la Nao y el largo el que pudiere y en todas las naos se guardará una forma del timón que tuviere para poder hacer otro por ella caso que se rompa o por otra causa le falte.
68. En los navíos de guerra se han de poner los cabrestantes encima de la puente y en los de mercante que tuvieren tolda y castillo se pueden poner encima y las que no como en los de guerra.
69. La carlinga del árbol mayor del trinquete se ha de asentar en el medio del largo de la quilla.
70. La carlinga del árbol del trinquete se ha de asentar en la mitad del lanzamiento de la roda de proa.
71. La carlinga del bauprés se ha de fijar en la cubierta principal.
72. En los navíos de quince codos de manga para arriba si quisiéren poner corredores han de ser en el soler de la cámara de popa que viene encima de la puente con un salto de un tercio de codo más arriba por amor de la cabeza del timón y han de ser pequeños que no salgan más que la bóveda de arriba y por las bandas dos tercios de codo.

Las medidas de los árboles y vergas que han de llevar los dichos pataches, navíos y galeones

73. El árbol mayor ha de tener de largo tanto cuanto llave de quilla desde la coz hasta los baos de gavia o barrotes, que todo es uno.
74. El grosor que ha de tener el árbol mayor de cualquier navío se ha de medir a los tamboretes de la puente y ha de ser de tantos palmos de vara en redondo cuantos tuviere de codos la mitad de la manga.
75. El trinquete, llevando la carlinga en mitad del lanzamiento de la roda, ha de tener cuatro codos menos de altor que el árbol mayor y de grueso sexta parte menos dela circunferencia.
76. El bauprés ha de ser dos codos menos de largo que el trinquete porque ha de calar la coz en la cubierta principal, de grosor ha de ser medio palmo menos que el trinquete ala fogonadura de la puente y ha de ir arbolado la cabeza por la mitad del cuadrante que son cuarenta y cinco grados roman- do por horizonte la cubierta principal donde está la coz o carlinga.
77. El mastelero ha de tener desde la cuña de la coz hasta los baos o barrotes del propio mastelero manga y media de la nao y de grosor ha de tener lo que tuviere la garganta del árbol mayor una pulgada menos.
78. El mastelero de proa ha de ser el quinto menos que el del mayor, y de grosor ha de ser conforme a la garganta del trinquete una pulgada menos.
79. La mesana ha de ser tres codos mayor que el mastelero de gavia mayor porque ha de calar hasta la cubierta principal de grosor como el mastelero.
80. La verga mayor ha de tener dos mangas y un cuarto de la misma manga de largo y de grosor al medio ha de tener tanto cuanto hubiere la garganta del árbol, y de ahí a la punta, ha de ir adelgazando hasta quedar la punta de la verga en dos quintos.
81. La verga del trinquete ha de tener dos mangas de largo y de grosor, como la garganta del trinquete, una pulgada menos hecha por los quintos reducida como la de arriba. mastelero de gavia mayor hecha por el quinto.
82. La verga de la cebadera ha de ser el quinto menos de largo que la del trinquete hecha por el quinto.
83. La verga de la gavia ha de ser tan larga como la manga del navío y de grosor como la garganta del mastelero hecha por el quinto.
84. La verga del borriquete o masteleo de proa ha de ser el quinto menos qu la del masteleo de gavia mayor hecha por el quinto.

85. La verga de la mesana ha de ser tan larga como la del trinquete.

86. Los árboles y vergas han de ser hechos por el quinto, esto es que el grosor que tuvieren por los tamboretes se ha de repartir en cinco partes, de las cuales las tres han de quedar de grueso en la cabeza y las otras dos partes se han de ir multiplicando desde ella hasta los tamboretes repartidos en los tamaños que quisieren por la circunferencia del árbol.

87. Las vergas se han de hacer, asimismo, por el quinto dando los dos quintos de grueso en el penol y los tres se han de ir multiplicando en los tamaños que quisieren por la circunferencia hasta llegar por una y otra parte a la bustagadura que es en medio de la verga donde vendrá a quedar todo el grueso de los cinco quintos que se le han de dar por el medio que es lo más grueso.

88. La gavia del árbol mayor ha de tener de ámbito o circunferencia por el arco de arriba tantos codos como tuviere la nao de manga y en el soler codo y medio menos, o lo que conviniere según su parte.

89. La gavia del trinquete tendrá de boca por el arco de arriba tanto cuanto la mayor por el soler de abajo y en su soler un codo o lo que pareciese convenir.

90. El dragante del bauprés ha de ir arrimado al branque de proa y no más fuera porque no juegue el espolón con el peso del bauprés y la reata ha de ir pegada al propio dragante que tome la bragada del corbatón del tajamar porque no dé trabajo al espolón.

91. Los tamboretes del árbol mayor y trinquete han de ir fijados en los baos vacíos y en la cubierta principal ha de haber un dedo de vacío en redondo en la fogonadura que quepa entre el tamborete y el árbol y en la puente han de caber tres dedos en redondo entre los tamboretes y el árbol en la misma fogonadura.

92. Los árboles mayor y trinquete han de llevar chapuces a la flamenca y no calceses y las ostagas han de ir por encima de la gavia encima de la garganta donde se fija la gavia.

La forma en que ha de servir y ser pagada la Maestranza en la fábrica de mis navíos y los de particulares y abvios de ellos.

93. Porque es costumbre entre la maestranza no tener las herramientas necesarias para usar sus oficios respecto de que se los solían proveer por cuenta de mi Real Hacienda, las cuales perdían y las tomaban unos con otros y por falta de ellas usan de la hacha que es ordinaria que traen y con ella desperdician mucha madera y gastan más tiempo en lo que labran considerando esto se tiene por conveniente a mis servicios y beneficio de la Hacienda, utilidad y provecho de la misma maestranza que como el jornal ordinario que solían ganar era de cuatro reales sea de cuatro y cuartillo cada día en el mi Señorío de Vizcaya, Provincia de Guipúzcoa, Cuatro Villas de la costa del mar, Asturias y Reino de Galicia, con condición que ningún maestro carpintero ni calafate pueda llevar más que un aprendiz y el cabo dos y estos no se les ha de pagar más de lo que merecieren conforme a la sufiiciencia de cada uno como pareciere a mis superintendentes de la fábrica y en las Armadas al Capitán de la Maestranza, pero han de ser examinados y no se les ha de dar por cuenta de mi Real Hacienda ningún género de herramienta más de las muelas de piedra para amolar y los oficiales que fueren de lo blanco no han de ganar este jornal por entero sino según lo que cada uno mereciere
y es declaración que la maestranza de Sevilla, Cádiz y Puerto de Santa María ha de ganar ocho reales cada día, inclusa con ellos la comida y en Las Horcadas, Borrego y Sanlúcar a diez reales, inclusa la comida sin que en las unas partes ni en las otras se exceda de esta cantidad y mando que los mis Presidente y Jueces oficiales de Sevilla tengan particular cuidado de la observancia de esta orden de castigar a quien fuere contra ella peñándole en veinte ducados, así al oficial como al dueño del navío, la cual condenación se ha de aplicar por mitad a mi Cámara y denunciador, y cuando fuere maestranza de Sevilla al Puerto de Santa María, Cádiz, Estero de la Carraca y Puente de Zuazo, ganen diez reales como en Horcadas y Sanlúcar, y el día de fiesta o el que lloviere se les ha de dar dos reales por persona o la comida aquel día cual más quisiere la maestranza estando presentes y no yéndose a sus casas.

94. Estando mi Armada del Mar Océano en el no y puerto de la ciudad de cualquiera puerto del dicho Reino, se ha de pagar a calafates, cavilladores y carpinteros examinados a cada cuatro reales y cuartillo al capataz cinco y ocho al cabo maestro, y este crecimiento de jornal se les da por el gasto que se les seguirá de traer las herramientas que adelante se dice y porque no se les ha de permitir que lleven ningún género de astillas o cabacos y los que resucitaren de mis fábricas tengo por bien y mando que sea para el Hospital donde se curare la gente de mis Armadas.

Las herramientas con que ha de servir mi Maestranza

95. El carpintero ha de traer hacha, sierra o serrón, azuela de dos manos, gurbia, barrenos de tres suertes, martillo de orenga, mandarria y dos escoplos.

96. El calafate ha de traer maillo, cinco fernos, gurbia, magujo, mandarria, martillo de orenga, saca estopas, tres barrenas diferentes desde el aviador engrosando.

97. El cavillador ha de traer barrenos, aviadores, taladros y mandarrias.

98. El aderezo de lo que de estas herramientas se les rompiere ha de ser por cuenta de mi Real Hacienda y por la costa que se les seguirá de traerlas a estos tres géneros de oficiales y que no se habían de aprovechar de nada de las dichas astillas ni cabacos como queda referido, se les acrecienta el cuartillo de jornal que queda dicho.

99. El alistador que alistare esta maestranza y el maestro mayor que tuviere a su cargo la fábrica del galeón o navío y se les probare haber alistado alguno sin traer las dichas herramientas sea condenado cada uno en doscientos ducados, los cuales se han de aplicar por mitad para el denunciador y juez que lo sentenciare, y el que no tuviere hacienda para pagar esta pena ha de estar preso en la cárcel pública hasta que se satisfaga la condenación.

100. Cuando se hiciere la paga a la maestranza ha de presentar cada oficial la herramienta de su oficio y cada uno ha de tener marcada con marca diferente registrada por el vendedor y puesta en el asiento de la lista de su nombre.

101. Cualquiera persona de la maestranza, marinero u otra suerte de gente que hurtare clavazón, plomo, estopa, grasa, aceite, sebo u otro cualquier material tocante a fábrica y adovio de navíos sea condenado en cien ducados, la mitad para el denunciador y la mitad para el juez y en esta misma pena incurrir cualquier persona que se le compraré y en falta de no tener con que pagar esta condenación, sirvan cinco años en galeras al remo, tanto el vendedor como el comprador.

102. Para mis galeones de Armada se harán cubas que quepan en cada una hasta cuatro o cinco pipas de agua con diez arcos de hierro de cuatro de dos de ancho cada arco y de
estas cubas llevará cada galeón las que pudiere, según su porte, las cuales irán llenas de agua de respecto enterradas en el lastre para alguna necesidad que se ofrezca y como se variaren para que sirvan de lastre y se conserven las mismas cubas se hincharán de agua salada y en ellas se podrán guardar las velas de los ratones las invernadas para que no las coman que tan de ordinario lo hacen sin poderse remediar y llevando estas cubas llenas no ha menester tanto lastre el navío porque ellas sirven de lastre y sea de mucho ahorro en las carenas en sacar y meter el lastre.

103. Cuando alguno quisiere fabricar navío no lo pueda armar sin que primero haya acudido al superintendente de su distrito para que de las medidas que ha de tener según el porte de lo que quisiere fabricar será conforme a estas Ordenanzas, y para que ninguno exceda, mando que si excediere el fabricador pierda la cuarta parte del Navío, de la cual la mitad ha de ser para el superintendente y la otra mitad para el denunciador, pero si el superintendente no cumpliere estas Ordenanzas en el dar de las medidas, incurra en pena de mil ducados aplicados para el fabricador para los daños que se le recurren y en privación de oficio y para el cumplimiento de esto mando que el superintendente tenga un libro donde se asienten las medidas que así diere el tal fabricador y ponga su nombre y asimismo el del navío y la parte y lugar donde se fabricase y al pie del asiento u orden del superintendente dé fe de un escribano y el fabricador lleve un traslado autorizado y el superintendente no lleve derechos algunos por esta instrucción o medidas que diere y el fabricador pague la fe que diere el escribano de la razón que queda asentada en el libro según mis aranceles.

Todos los Galeones y otras suerte de navíos referidos, como de particulares se han de fabricar y arbolar por las susodichas medidas y trazas con las mismas fortificaciones sin discrepar en nada y el codo con que se han de dar las medidas ha de ser el mismo que se ha usado en mis fábricas de navíos y armadas que es de dos tercios de vara, medida castellana, y un treinta y dozavo de los dos tercios y para los navíos que hubieren de navegar a las Indias se advierte los siguiente.

104. Los navíos que fuere necesario fabricar por cuenta de mi Real Hacienda para traer la plata de las Indias y los que fabricaren para de mercante los particulares para las flotas de ellas han de ser de diecisiete codos de manga abajo sin exceder de aquí arriba en nada ni faltarles en lo que toca a medidas, traza y fortificaciones referidas y pues los dichos galeones o 'navíos de mercante tendrán conforme al dicho porte bastante bodega para su tráfico no se ha permitir que a ninguno de ellos le corran los alcázares como lo acostumbran desde el árbol mayor hasta el castillo de proa ni que se les echen embonos ni contracostados, ni alzarles la lemera, sino que cada uno se quede de la manera que hubiere salido del Astillero porque no siendo mayores, ni siendo envolumados podrán entrar y salir por las barras de Sanlúcar de Barrameda y San Juan de Ulúa con sus mercaderías y harán la navegación más breve y serán los navíos más durables y toda la carga y navegación más igual y con menos riesgo de la mar y enemigos y más comodidad de los dueños de las mercaderías para la carga y descarga y se aprestarán las flotas con más brevedad y menos costa y será causa para aumentar la marinería natural de estos Reinos y mando que los mis presidente y jueces oficiales de la Casa de la Contratación de las Indias que reside en la ciudad de Sevilla, ni el juez oficial que reside en Cádiz no admitan para la Carrera de Indias ningún Navío
que exceda de diecisiete codos y medio de manga y ocho y medio de puntal, ni a los que tuvieren embonos o contracostados, ni corridas las puentes y los que no fueren mayores ni tuvieren las demás calidades de medidas, trazas y fortificaciones referidas refieran en la carga y visitas a cualquiera otros navíos que no fueren de esta Ordenanza y cuando concurrieren algunos que los sean como queda declarado de la nueva fábrica se entienda que el dueño que le hubiere fabricado y navegare personalmente en el ha de preferir en la carga a los otros y ser primero cargado que otro ninguno y poder quitar la carga que el mercader o cargador enviare a otro cualquier navío de la flota llevándolo por el río abajo o de bordo y sacársele de dentro de él para cargar el suyo, así en España, como en las Indias aunque está la tal carga del propio dueño del navío o de la gente que en él navegare porque en todo tiempo y lugar han de ser preferidos los dueños de navíos de esta Ordenanza y navegándolos personalmente y no en otra manera y si alguno de ellos acudieren a una misma flota se les ha de repartir la carga por iguales partes conforme al porte de sus propios navíos y hasta que ellos tengan bastante carga no se ha de dejar cargar otro navío por ningún caso ni siendo tan viejo y el navío de esta Ordenanza que corra el riesgo en la navegación y lo cumpla y ejecute inviolablemente el juez oficial que ha de ir a Sanlúcar al despacho de la flota, así en los navíos de Cádiz como a los navíos que bajaren de Sevilla y en las Indias los Generales y Almirantes de las flotas con apercibimiento que se les hace de que pagarán de sus bienes todos los daños y menoscabos que se recrecieren a los tales dueños fabricadores de navíos de no les cumplir, guardar y ejecutar lo contenido en este capítulo y que además de esto les pagarán el flete y demás aprovechamientos de todo aquello que podían llevar o dejar de traer como si efectivamente los hubieran llevado o traído por cuenta de cada uno de los dichos jueces o Generales que por su culpa o des- cuido dejare de tener cumplido efecto, y por lo que toca a los navíos que al presente hay fabricados que no fueren conformes a esta Ordenanza serán admitidos los que se conformaren más con las medidas de ellas como no sean los levantados sobre barcos, fragatas, carabelas ni otros fustes ni urcas, filibotes, ni otro género de Navío extranjero, aunque estén en poder de naturales, pues estos tales no deben navegar en ninguna manera ni por ningún caso en la Carrera de las Indias en las flotas ni fuera de ellas ni a Santo Domingo, a La Habana, Puerto Rico, Jamaica, Campeche ni otra parte ni puerto alguno de las Indias ni en ellas de una parte para otra sino a falta de los navíos naturales sin embargo de otra cualquier orden que en contrario de esto haya, la cual derogo y doy por ninguna en virtud de la presente por cuanto conviene y es mi voluntad que tan sola- mente naveguen en la dicha Carrera navíos españoles porque sus dueños tengan sustancia para fabricar o comprar otros so pena de perdimiento del navío y mercadería que en los tales navíos fabricados sobre carabelas, fragatas o barcos se embarcaren y en las urcas, filibores o navíos extranjeros no embargante que estén como queda referido en poder de naturales y mando que de las denunciaciones que de estos se hicieren conozcan los dichos Presidente y Jueces Oficiales de la Casa de la Contratación de las Indias que reside en Sevilla y el que reside en Cádiz o los Generales de mi Armada y flotas de la Carrera de las Indias los cuales han de otorgar las apelaciones en los casos que de derecho hubieren lugar para el mi Consejo Real de las Indias y no otro ningún tribunal y lo que por sentencia de revista se condenare de las dichas denunciaciones se ha de aplicar y re-partir por tercias partes para mi Cámara, juez y denunciador.
105. Los dichos mis Presidente y Jueces Oficiales de la Casa de la Contratación de Sevilla han de cometer a los visitadores u otras personas de ciencia y experiencia que reconozcan, miren y consideren lo que podrá cargar cada navío de las susodichas medidas de manera que sea fácil y seguro el salir y entrar por las dichas barras de Sanlúcar de Barrameda y San Juan de Ulúa sin que sean necesario aliar de la carga que hubiere de llevar en su viaje y navegación a las Indias y porque los dueños de naos y cargadores de ellas no puedan usar de engaño cerca de esto podrán los dichos visitadores o las personas a quien fuere cometido este reconocimiento dos señales o argollas de hierro, una a babor y otra a estribor en medio de la nao donde tiene la cubierta principal que sirvan de límite para que hasta allí y no más se cargue el navío de manera que aquel hierro o señal quede sobre el agua y han de tener un libro que pongan por memoria la parte donde fijaron en el navío las dichas señales declarando en cuantos codos de agua las hubieren puesto y los que hubiere de allí a la puente y quien contraviniere a esta orden pierda la mitad del valor del tal navío y de esta mitad se han de hacer cuatro partes, la una para mi cámara, la otra para el juez, y las otras dos para el denunciador y en los casos que de derecho hubiere lugar, otorgarán las apelaciones para ante mí Consejo Red de las Indias, como se dice en el precedente capítulo y para otro ningún tribunal.

106. Cuando yo mandare tomar navíos de particulares fabricados por estas medidas y trazas referidas para servir en mis Armadas del Mar Océano y Mediterráneo, considerando la costa que se les seguirá fabricándolos con las dichas trazas y fortificaciones y el beneficio que se sigue a mi servicio que anden en mis Armadas navíos de esta perfección y fortaleza les mandaré pagar a razón de nueve reales por tonelada cada mes, incluso en ellos el socorro que se les suele dar en las dichas Armadas a semejantes navíos para sebo y manqueras advirtiendo que para lo que toca a la Carrera de las Indias quede a arbitrio de los dichos Presidente y Jueces Oficiales de la Casa de la Contratación para que conforme al tiempo señalen el precio de cada tonelada.

Todo lo cual según y de la manera que queda referida se ha de guardar y mando que se guarde por pragmática inviolable en estos mis Reinos y en virtud de cualquier traslado de estas Ordenanzas firmado de mi Secretario de la Guerra de Mar, mando a los superintendentes de estas dichas fábricas reales de navíos que ahora son y adelante fueren que cada uno en su distrito haga publicar lo contenido en ellas y que se ejecute y cumpla lo que le rocare quedando como quedan derogadas las de veinte y uno de diciembre del año de seiscientos y siete y lo mismo ordeno a los mis Presidentes y Jueces Oficiales de la dicha Casa de la Contratación de las Indias y a los mis veedores y Proveedores Generales de mis Armadas en cuanto a lo que por sus oficios están obligados a hacer y al mi Capitán General de la Armada del Mar Océano y a los Capitanes Generales de la Armada de la Guarda de la Carrera de las Indias y flotas remito el cuidado de hacer observar en ellas estas Ordenanzas y que no hagan ni consentan alterar cosa contra ninguna de las aquí referidas sin expresa y particular orden mía y del conocimiento de los pleitos y causas que resultaren de hacerlas ejecutar y castigar los transgresores inhibo y doy por inhibidos a los Presidentes y Oidores de las mis Audiencias y Cancillería de estos Reinos y otras cualesquier justicia de ellos por cuanto han de tratar del cumplimiento y ejecución de estas Ordenanzas las personas de que arriba se hace mención y en cuanto a las aplicaciones de los casos que haya lugar de derecho los mis Consejos de Guerra e Indias cada uno en lo que tocare, y de estas Ordenanzas se
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ha de tomar la razón en la Contaduría de mi Consejo de Indias y en la de la Casa de la Contratación de Sevilla y después han de quedar originalmente en la mi Contaduría Mayor de Cuentas que tal es mi voluntad.

Dada en San Lorenzo a seis de julio de mil seiscientos y trece años.
Yo El Rey. Por mandado del Rey, Nuestro Señor, Martín de Aróstegui.

Appendix 3 – Ordenanzas 1613 – Tonelage

*Ordenanzas sobre arqueamiento de navíos del 19 de octubre de 1613*
Archivo General de Simancas – Guerra y Marina – Legajo 3146

**El REY**

Por cuanto habiendo considerado los inconvenientes, y daños que han resultado contra mi hacienda, y en perjuicio de mis vasallos, y los extranjeros, que han servido con sus navíos en mis armadas, flotas, de la forma y reglas con que hasta aquí se ha arqueado, y medido los tales navíos, para pagarles su sueldo, y flete, por no ser fundadas en la verdadera ciencia de esta facultad: respecto de que de las cinco dimensiones, o partes en que estriba lo principal de la fábrica de los Navíos, que es la eslora, manga, puntal, quilla, y plan, solamente metían las tres primeras en la cuenta, no considerando las otras dos, sin lo cual de ninguna manera se puede hacer justificado arqueamiento: mandé que se juntasen, los hombres más prácticos en este ministerio, que se hallasen en estos Reinos, los cuales, habiendo con particular atención, estudio, y cuidado trabajado en ello, se tiene por cierto haber dado el punto más ajustado á la razón; que se puede descubrir para los dichos Navíos, de manera que no haya medida falsa, ni otro género de engaño de los que procedían de la incertidumbre de las reglas de que se ha usado, conque siempre era arbitrario lo que ahora ha de ser fiJo, y se excusará el daño que se siguiera á nuestra Real Hacienda, y á los dueños de los Navíos, naturales, y extranjeros, que se recibieren á sueldo para servicio de las Armadas, y Flotas, y tengan satisfacción de que no se les hace agravio: y de que se les pagarán los pleitos, y dudas que había, y las molestias que se les reclamaban, dilatando la averiguación de las cuentas. Visto en el mi Consejo de Guerra, y conmigo consultado, hemos resuelto derogar (como por la presente derogarnos, y anularnos) las reglas, y ordenanzas, que cerca de esto se han usado. Y mando, que de aquí adelante se midan, y arqueen todos los Navíos naturales, y extranjeros, que se recibieren a sueldo, y fletaren para servicio de las dichas mis armadas, y Flotas, y los que se hicieren por cuenta de mi Real Hacienda, por la orden, y forma siguiente.

1. Y porque estas reglas presuponen las cinco dimensiones, ó partes referidas en cualquier Navío que se haya de arquear de los que se fabricaren en estos Reinos, han de traer los dueños de ellos certificación de los superintendentes de los distritos donde se hubieren hecho los dichos Navíos, y de los veedores, o contadores, que conforme á las órdenes que tengo dadas hubieren de intervenir con ellos á hacer los tales arqueamientos, y donde no hubiere los tales superintendentes, han de traer testimonios firmados de la Justicia mas cerca y del Escribano del Cabildo, o Consejo del tal Lugar, en que declaran
los codos que los tales Navíos tuvieren de Eslora, Manga, Puntal, Quilla, y Plan, y también de los Redeles, y de la cuadra, y Amura, las cuales dichas certificaciones, y testimonios se han de entregar á nuestro Secretario de la Guerra de Mar, para que vistas en el dicho Consejo de Guerra; se provea lo que convenga, cuanto a remitirlas á quien hubiere de hacer la cuenta de las toneladas, para que conforme á ellas se les paguen los sueldos, o fletes que hubieren de haber, y sed admitidos sus Navíos á la visita para navegar en la Carrera, y Flotas de Indias, sin la cual certificación mando que no lo sean, aunque concurran en ellos las calidades que se declara en las últimas ordenanzas de fábricas de Navíos, que han de tener para navegar en la dicha Carrera. Y los dichos Superintendente, y Ministros de enviar a manos del dicho secretario, certificación en la misma conformidad de los navíos que se fabricaren por cuenta de mi real hacienda, para que siempre que convenga, se tenga la cuenta y razón de ello, y se sepan las medidas y porta que tuvieren.

2. Para rectificar la medida de los demás navíos, de cuyas dimensiones no se pudiere hacer testimonios, se medirán conforme a la orden que sigue.

3. El codo con que se ha de hacer esta medida, ha de tener dos tercios de vara castellana, y mas un treinta y doceavo de los mismos dos tercios.

4. La Manga se ha de medir de babor á estribor, por lo más ancho de la cubierta principal: hora este en lo más arriba o más abajo, y se medirá por la superficie superior de la cubierta, pegado a ella, de tabla a tabla, y de dentro a dentro, y los codos que se hallaren será la manga: y si estuviere embarazada con algunos genoles, se tomará el grosor de ellos; y también será manga.

5. El puntal se medirá desde la superficie superior de la cubierta principal, donde se tomó la Manga: de manera que no se exceda de la tal superficie. Y en el tomar el altor del Puntal en las Urcas, o en otras Naves extranjeras, no se ha de consentir que se desentable alguna parte del Soler, para calar la pica hasta el Plan, y tomar desde allí la medida, sino es que para cargar de trigo, ó cosa semejante, tenga hecho algún Granel, y en este caso se ha de abrir por junto a la bomba, hasta descubrir la Orenga, y poner encima un pedazo de tabla de grosor de tres dedos, o contárselos y desde allí se ha de medir el puntal, que será como medirlo desde el soler.

6. La eslora se ha de medir desde el branque al codaste por la referida superficie superior de la cubierta, sin desviarse de ella, y si la parte de proa estuviere embarazada con alguna bulárcama, o Genol, ó la de Popa con algún Yugo, se meterá alguna verguilla, ó cosa sutil, con que se pueda medir el grosor de la bulárcama, ó Yugo, y lo que esto fuere también se contará como eslora, advirtiendo que no se ha de tomar el grosor del branque, ni del codaste, roda, ni contrarroda, sino hasta la tabla que en ello se coge de dentro a dentro.

7. El Plan se medirá por la cuaderna maestra, que corresponde á lo mas ancho de la Cubierta, y se ajustará la medida con las señales, ó puntos, que están en la Escoa, á un lado, y á otro de babor á estribor, y la Escoa se hallará junto al Palmejar, que está en la cabeza de la orengas, o planes, en la parte de abajo.

8. La quilla, si estuviere fuera del agua, como sucede, estando el Navío en astillero, ó carena, se medirá de codillo á codillo, y los codos que se hallaren será la Quilla; pero si estuviere debajo del agua, se medirá por de dentro del Navío, lo cual, aunque se ha tenido por tan dificultoso, se conseguirá, como conviene á la certidumbre de la cuenta, con los siguientes medios.
9. Se pondrá una regla (que este dividida en codos) en el sitio del Puntal, y perpendicular sobre el Soler, y en ella se aplicará otra, de manera que queden á escuadra, y se irá prolongando hacia Proa, hasta topar en el albitana, y midiendo los codos que hubiere desde el Puntal á la Albitaná, en la regla que se prolongó, se pondrán aparte, y se volverá á aplicar la misma regla en la que está en el sitio del Puntal, un poco mis arriba de la primera aplicación, dos, ó tres codos, los que se quisiere, y se prolongará hasta topar otra vez en el Albitana, y se medirán en ella los codos como primero, es á saber, desde el Puntal á la Albitana, y se pondrán tambien aparte, y se hará otra tercera aplicación, dos, ó tres codos más arriba de la segunda, haciéndose lo mismo, y notando los codos que hubiere desde el Puntal á la Albitana: luego en el plano de una tabla, ó en otra cosa que esté bien llana se hará el Patrón siguiente: Tiérese una línea recta, que se llamará la línea de la Quilla, y divídase en sesenta partes iguales, que serán codos, y desde su medio se levantará otra, que quede á escuadra con ella, y será la línea del Puntal: y se dividirá en quince, ó veinte partes iguales entre sí, y los de la primera línea, que también serán codos: y desde el lugar donde se cruzan se pondrán tres puntos en la línea del Puntal, que disten del tal lugar los codos que distaron del Soler, los sitios de las tres aplicaciones de la regla, que se prolongó, y por estos puntos se tirarán tres líneas á escuadra, con la línea del Puntal, y en ellas, hacia la parte en que en el Patrón se considera la Proa, se contarán los codos que hubo en las tres aplicaciones de la regla, que se prolongó desde el Puntal á la Albitana, contando en la línea mas cercana, á la que representa la quilla, los codos que hubo en la primera aplicación: y en la siguiente los que hubo en la segunda aplicación: y en la otra los que hubo en la tercera, y donde acabare la cuenta de estos codos, se señalarán tres puntos en las tres líneas, y por ellos se tirará una porción de círculo, buscándole su centro, como se acostumbra, y se extenderá hasta que corte en la línea de la quilla: y las, partes, ó codos que hubiere en ella, desde donde la cruza la línea del Puntal, hasta donde la corta la porción del círculo, serán los codos que tiene la porción de quilla de puntal a proa.

10. Para hallar la porción de quilla del puntal a popa, se prolongara una regla dos veces, desde otra que este en el sitio del puntal, hasta topar en el codaste, guardándose en todo ello lo mismo que arriba se dice, en el aplicar y prolongar la regla, desde el puntal a la albitana: y en cada aplicación de la regla que se prolonga, se contarán los codos que hubiere desde el puntal al codaste, y se guardaran aparte. Luego en el referido patrón, desde donde se cruzan la línea de la quilla, y la del puntal, se pondrán dos puntos en la del puntal, que disten de la línea de la quilla, los codos que distaron del soler, los sitios de las dos aplicaciones de la regla que se prolonga a popa: y por los tales puntos se tirarán dos líneas á escuadra sobre el puntal, y en ellas desde el mismo puntal, hacia la parte en que se pone la popa en el patrón, se contarán los codos que hubo en la primera aplicación, y en la siguiente los que hubo en la segunda: y donde acabare la cuenta de estos codos, en las dos líneas se pondrán dos puntos, y pasando por ellos una regla, se notara en donde corta a la línea de la quilla; y las partes de la misma línea de la quilla; y las partes de la misma línea de la quilla que hubiere desde el cortamiento hasta la línea del puntal, serán los codos que tendrá de porción de quilla, desde el puntal a popa, los cuales juntándose con los que tuvo la porción de la quilla del puntal a proa quedaran conocida toda la quilla.

11. Se ha de advertir que si por la mucha distancia desde el puntal a hasta la albitana o codaste, no se pudiere poner en el sitio del puntal, la regla en que se ha de aplicar lo
que se prolonga, se podrá poner más cerca de la popa a proa, como sea en lo llano del soler, no pasando de los redeles; y se harán desde allí todas las operaciones que arriba se ordenaron, como si estuviera la regla en el sitio del puntal, así en el apuntar y prolongar la regla hasta topar con la albitanas codaste, como en lo demás. Pero se han de medir los codos que distare del puntal a popa o proa, el sitio en que se pone la regla, para poner en el patrón la misma distancia en la línea de la quilla por sus codos, desde donde la cruza la del puntal, hacia la misma parte en que se pone la proa o popa en el mismo patrón, para tirar donde acabare la tal distancia, una línea a escuadra sobre la de la quilla: y desde ella hacer lo mismo que se hizo desde la línea del puntal, para hallar la porción de quila a popa, y a proa. También se pueden añadir los codos que montare la misma distancia a los que se hallasen en cada aplicación desde el sitio en que se puso la regla, hasta la albitana, o codaste y así se podrá obrar en el patrón como si se hubiera puesto la regla en el sitio del puntal.

12. Así mismo se advierte, que la primera distancia o sitio, donde se aplicará la regla que se ha de prolongar a popa y a proa ha de distar tantos codos del soler, que pueda calarse la regla que se prolonga hasta topar en la albitana o codaste, sin que se embarace en lo que se levantan los delgados, desde los redeles, hacia popa o proa y los demás sitios de las otras aplicaciones, cuanto más pudieren distar del primero: y entre si según la grandeza del puntal, será mejor para conseguirse la medida de la quilla, con la precisión que se pretende. Y de haberse tomado estas medidas de la forma referida, traerá el dueño del navío certificación o testimonio, como se declara en el capítulo primero de estas ordenanzas.

13. Sabidos los codos que tiene la manga, puntal, eslora, quilla, y plan, de cualquier navío que se haya de arquear, así de los que queda dicho que se fabricaren en estos reinos, como los que vinieren de fuera de ellos, y se fletaren o recibieren a sueldo, para servicio de mis armadas, se podrá platicar y hacer la cuenta por uno de los tres modos y regla siguiente.

**Primer Modo**

14. Si el navío que se ha de arquear, tuviere el plan igual a la mitad de la manga, como quiera que tenga la eslora, quilla, y puntal, se multiplicaran los codos que tiene la manga, por lo que tuviere la mitad del puntal, o los de la mitad de la manga por todo el puntal, que es todo uno: y lo que de esto procediere se ha de multiplicar por la mitad de la suma de la eslora, quilla, y saldrá la cabida del buque en codos, que partido por ocho queda reducido a toneles.

15. Pero siendo el plan mayor o menor que la mitad de la manga, se hará primero la cuenta, como si fueran iguales, como se hizo en el capítulo precedente, y luego se sacará la diferencia que tiene el plan de la mitad de la manga, restando los codos que tiene el plan de los que tuviere la mitad de la manga, si el plan fuere menor de ella, o al contrario si fuere mayor. Y la mitad de la tal diferencia se multiplicara por la mitad de los codos del puntal, y lo que de esto resulte se multiplique por la mitad de la eslora, y quilla juntas, y lo que saliere se ha de quitar del valor, o cabida del buque, corregida como si tuviera el plan igual a la mitad de la manga, si la mitad de la manga fuere mayor que el plan, o se le ha de añadir si fuere menor, y quedará el valor del buque.

**Segundo Modo**

16. Al navío que tuviere el plan igual a la mitad de la manga, se le hará la cuenta como arriba se hizo: pero si tuviere el plan mayor o menor, que la mitad de la manga se
sacará su diferencia restando el plan de la mitad de la manga, o al contrario como queda dicho, y la mitad de la tal diferencia, se quitara de los codos que tuviere la manga, si fuere su mitad mayor que el plan, o se le añadirá si fuere menor: y la manga habiéndole quitado o añadido esto, se multiplicará por la mitad del puntal, y lo que se esto saliere, se multiplique por la mitad de la suma de la eslora y quilla, y quedará el valor y cabida del buque que se arquea.

**Tercer Modo**

17. A cualquier navío que tenga el plan igual a la mitad de la manga, hora sea mayor, o menor, se tomaran las tres cuartas partes de la manga, y se juntaran con la mitad del plan, y lo que esto fuere se multiplicará por la mitad del puntal, o la mitad de ello por todo el puntal, y lo que resultare se multipliqué por la mitad de la suma de la eslora y quilla, y saldrá el mismo valor y cabida del buque que en los modos pasados.

18. Se ha de advertir, que el valor que da en el buque, cualquiera de los tres modos de la regla del arqueamiento ajusta con el navío que tuviere la cubierta en lo más ancho: pero el que la tuviere mas arriba de lo más ancho, por cada medio codo que así la tuviere, se quitará tres por ciento al dicho valor, y en los que la tuvieren más abajo, por cada medio codo se ha de añadir otros tres por ciento: y para esto se ha de reconocer lo más ancho de la nao, y del valor que diere la regla del arqueamiento, habiéndose añadido los tres por ciento, o habiéndole quitado, si se hubiere que hacer conforme a lo que contiene este capítulo, se quitarán cinco por ciento, y a lo que quedare se ha de añadir veinte por ciento, por todo lo que hay entre cubiertas, y por los alcázares, y quedará el justo valor en codos que se debe de cabida al navío que se arquea, que partidos por ocho, quedará reducido a toneladas.

19. Adviértase que el fundamento de la regla del arqueamiento, presupone que las superficies del plan y la manga desde sus medios hacia popa, y proa, tengan disminución conocida y cierta, y según ella teniendo la manga dieciséis codos, ha de haber un codo en la disminución en la línea que pasa por la cuarta parte de la eslora, desde el medio de la superficie del plan, hacia proa y popa donde se ponen los redeles, a de haber en cada uno de disminución la mitad del plan, de manera que si fuere el plan ocho, a de haber cuatro en cada redel. Y para que esta disminución de las superficies del plan y mangas, se guardare proporcionalmente en todos los bajeles, o a lo menos en las cuatro líneas que se han señalado, para obviar a los fraudes que se pueden intentar contra la regla del arqueamiento, se tomará en el buque que se arquea la medida de las dos líneas que pasan por la superficie superior o inferior, equidistantes de la manga: y que se aparten de ella hacia popa y proa la cuarta parte de la eslora. Y también se medirán en el soler las líneas que atraviesan de babor a estribor, por tales sitios que disten del plan a popa y proa la misma cuarta parte de la eslora: y en el tomar todas estas medidas, se guardará lo que se ordenó en el tomar las de la manga y plan luego para ver si las dos líneas que se midieron en la cubierta del navío que se arquea colaterales a la manga, tienen debida proporción con ella, se multiplicaran los codos de la misma manga por quince, y lo que de ellos resultare, se partirá por diecisésis, y si salen en el cociente, o cuarto número, los codos que se hallaron en la línea que se midió hacia proa, tendrá con la manga la proporción que requiere la regla del arqueamiento: pero si en el cuarto número salieren más o menos codos, que los que tuvo la tal línea, se guardarán en parte, y también se multiplicará la manga por catorce, y de lo que de ello procediere, se partirá por diecisésis, y si saliere en
el cuarto número los codos que se hallaron en la línea que se midió hacia popa estará bien, y si no salieron se notarán los que fueren más o menos, y luego se dividirá por ocho los codos de la mitad de la manga del mismo navío, y por cada una de estas octavas partes que faltare en cada uno de los cuartos números de las dos reglas de tres, para igualar a los codos que se hallaron en cada una de las dos líneas referidas, se añadirá uno y medio por ciento al valor que diera la regla del arqueamiento en el buque en que se midieron, y por cada octava parte de las mismas en que excedieron los cuartos números a los codos hallados en cada una de las mismas dos líneas, se quitará uno y medio por ciento al valor que da la regla.

20. El reconocer la proporción que tienen con el plan, las dos líneas que se midieron en el soler, será fácil, porque si el navío en que se miden, es cada una la mitad del plan, estará bien, pero si no lo fueren, se dividirán por ocho los codos que tuviere el plan, y por cada octava parte de estas que faltare en cada una de las dos líneas referidas, para ser la mitad del plan, se quitará el valor que da la regla del arqueamiento, uno y un cuarto por ciento, y por cada octava parte de las mismas que tuviere cada una de las dos líneas más de la mitad del plan, se añadirá uno y cuarto por ciento al valor que da la regla.

La cual dicha orden y reglas, mando en virtud de la presente (o de su traslado firmado de mi Secretario de la Guerra del Mar) que observen y ejecuten puntualmente mis superintendentes de las fábricas de navíos de estos reinos, y los proveedores de mis armadas, y las demás personas a cuyo cargo es y fuere el medir ya arquear los navíos que se reciben a sueldo y fletaren, para servicio de las dichas armadas y flotas, sin exceder ni faltar en nada de lo de arriba contenido, y que este original se ponga en los libros de mi Contaduría Mayor de Cuentas, habiéndose tomado la razón de él en los de mi Contaduría del Consejo de Indias, y contadores del sueldo de esta corte, para que en las cuentas que se tomaren se guarde los dispuesto por estas ordenanzas: especialmente lo que se dispone por el primer capítulo de ellas, que así es mi voluntad, y conviene a mi servicio. Dada en Ventosilla a 19 de octubre de mil seiscientos y trece años.

YO EL REY
Por mandado del Rey nuestro Señor
Martín de Aroztegui

Appendix 4 – Ordenanzas 1618

Reglas para fabricar los navíos, que se hiciere por cuenta del rey, y de particulares.
(Recopilación de Leyes 1680:340-362)

El mismo en Madrid a 16 de junio de 1618.
Ordenanza de la casa al fin. d. Carlos II en esta recopilación.

Habiéndose cometido por nos a personas de mucha conciencia, y experiencia en materia de fábricas, y navegación, lo que se debía observar en las reglas, y medidas de los bajeles que regularmente, conforme al arte se deben fabricar, y dado sus pareceres, se
confirió en nuestro consejo de guerra lo que en razón de esto se ofreció advertir, y corregir, y enmendar las ordenanzas antiguas, ajustándolas a lo más conveniente a nuestro real servicio, para utilidad, y bien universal de nuestros vasallos, y hemos servido de resolver, que los navíos, que por cuenta de nuestra real hacienda, y de particulares se fabriquen en estos reinos, se hagan por las medidas, que aquí van declaradas; y todo lo que contienen las ordenanzas pasadas, que por la presente derogamos, se entienda, y quede establecido por estas, y de ahora en adelante, en la forma, y con las limitaciones siguientes.

1. Para navío de nueve codos de manga.

   Plan, cuatro codos y medio.

   De puntal cuatro codos en lo más ancho, y medio codo más arriba la cubierta.
   De quilla, veintiocho codos.
   De eslora, treinta y cuatro codos.
   De lanzamiento a la roda de proa, cuatro codos.
   De lanzamiento de popa, dos codos.
   De rase, tres codos a popa.

   Un codo de rase a proa, que es el tercio de popa.

   De yugo, cinco codos menos un cuarto.

   El contracodaste, un cuarto de codo de ancho de la parte del zapato, y disminuyendo por tercios, a morir en la lemera.

   Ha de llevar veinticinco orengas de cuenta con la maestra.

   De astilla muerta, medio codo, repartido en tres partes iguales: las dos en la orenga de en medio, y la otra tercera parte repartida en tantas partes iguales, cuantas fueran las orengas de cuenta que llevar, empezando desde la segunda orenga, en medio, a popa, y a proa.

   De jova, medio codo a proa, repartido en tantas partes iguales, cuanto fueren las orengas que llevar desde la segunda orenga a proa; y la mitad repartida en las orengas que hubiere desde la sexta a popa.

   De arrufadura en la cubierta, medio codo a proa, y uno a popa.

   De arrufadura en las cintas, un codo a proa, y uno y medio a popa.

   Las aletas han de ser redondas como el pie de genol, y no agudo, como se ha acostumbrado hasta aquí en las fábricas que se han hecho.

2. Para navío de diez codos de manga.

   Plan, cinco codos.

   De puntal cuatro codos y medio en lo más ancho, y en cinco codos la cubierta.
   De quilla, treinta codos.
   De eslora, treinta y seis codos.
   De lanzamiento a proa, cuatro codos.
   De lanzamiento a popa, dos codos.
   De rase, dos codos y un tercio a popa, y el tercio de estos raseles se ha de dar a proa.

   De yugo, cinco codos y un cuarto.

   Ha de llevar veintisiete orengas de cuenta con la maestra.

   De astilla muerta, medio codo, repartido en tres partes iguales: las dos de muerta en medio en la primera orenga, y la otra tercera parte repartida en tantas partes iguales, cuantas
fueran las orengas de cuenta que llevare, desde la segunda orenga, de en medio, a popa, y a proa.

De jova, medio codo, repartido en partes iguales, en las orengas que hubiere desde la segunda a proa: y la mitad de esta jova repartida en las orengas que llevare desde la sexta a popa.

De arrufadura en la cubierta, medio codo a proa, y uno a popa.

De arrufadura en las cintas, un codo a proa, y uno y medio a popa.

Las aletas han de ser redondas como el pie de genol.

Ha de llevar un castillo pequeño a proa, y media tolda baja en popa.

El contracodaste de la parte del zapato, un cuarto de codo de ancho, y disminuyendo, a morir en la lemera.


Plan, cinco codos y medio.

De puntal cinco codos en lo más ancho, y medio codo más arriba la cubierta.

De quilla, treinta y dos codos.

De eslora, treinta y nueve codos.

De lanzamiento a proa, cuatro codos, y tres cuartos.

De lanzamiento a popa, dos codos, y un cuarto.

De rasel a popa, tres codos, y dos tercios, y el tercio de estos raseles a proa.

De yugo, cinco codos, y tres cuartos.

Ha de llevar veintinueve orengas de cuenta con la maestra.

De astilla muerta, cinco octavos de codo, repartidos en tres partes iguales, las dos en la orenga de en medio, y la otra tercera parte repartida en tantas partes iguales, cuantas fueran las orengas de cuenta que llevare, desde la segunda de en medio, a popa, y proa.

De jova, cinco octavos de codo, repartido en partes iguales, en las orengas que hubiere desde la segunda de en medio a proa: y la mitad de esta jova; repartida en las orengas que llevar desde la séptima a popa.

De arrufadura en la cubierta, medio codo a proa, y uno a popa.

De arrufadura en las cintas, un codo a proa, y codo y medio a popa.

Las aletas han de ser redondas como el pie de genol.

El contracodaste un cuarto de codo de ancho de la parte del zapato, y disminuyendo por tercios, a morir en la lemera.


Plan, seis codos.

De puntal cinco codos y medio en lo más ancho, y medio codo más arriba la cubierta.

De quilla, treinta y cuatro codos.

De eslora, cuarenta y un codos.

De lanzamiento a proa, cinco codos.

De lanzamiento a popa, dos codos, y medio.

De rasel a popa, cuatro codos, y el tercio de estos raseles se ha de dar en proa.

De yugo, seis codos, y un cuarto.

Ha de llevar treinta y un orengas de cuenta, con la maestra.
De astilla muerta, cinco octavos y medio repartidos en tres partes iguales: las dos de muerta en la orenga de en medio, y la otra tercera parte repartida en tantas partes iguales, cuantas fueran las orengas que llevare de cuenta desde la segunda orenga, en medio a popa, y proa.

De jova, cinco octavos y medio, repartido en partes iguales, en las orengas de cuenta que hubiere desde la segunda de en medio, a proa; y la mitad de esta jova repartida en las orengas que llevare desde la séptima a popa.

De arrufadura en la cubierta, medio codo a proa, y uno a popa.

De arrufadura en las cintas, codo y medio a proa, y dos a popa.

Ha de llevar castillo, y alcázar.

Las aletas han de ser redondas como el pie de genol.

El contracodaste un tercio de ancho en la parte del zapato, y desde ahí ha de ir, disminuyendo por tercios, a morir en la lemera.

5. Para navío de trece codos de manga. Tendrá 251.

Plan, seis codos y medio.

De puntal seis codos, en lo más ancho, y en seis y medio la cubierta.

De quilla, treinta y seis codos.

De eslora, cuarenta y cinco codos.

De lanzamiento a proa, seis codos.

De lanzamiento a popa, tres codos.

De rasele a popa, cuatro codos y un tercio, y en proa la tercera parte de estos raseles.

De yugo, seis codos, y tres cuartos.

Ha de llevar treinta y un orengas de cuenta, con la maestra.

De astilla muerta, tres cuartos de codo, repartidos en tres partes iguales: las dos de muerta en la orenga de en medio, y la otra tercera parte repartida en tantas partes iguales, cuantas fueran las orengas que llevar de cuenta desde la segunda orenga, en medio a popa, y proa.

De jova, tres cuartos de codo, repartido en partes iguales, en las orengas que hubiere desde la segunda de en medio a proa; y la mitad de esta jova repartida en las que tuviere desde la séptima a popa.

De arrufadura en la cubierta, medio codo a proa, y uno a popa.

De arrufadura en las cintas, codo y medio a proa, y dos a popa.

Ha de llevar puente corrida, a tres codos de altura de la cubierta principal, y dos quebrados en la propia puente, uno en proa, y otro en popa, de codo y medio cada uno, y otro quebrado en el alcázar de popa, y el molinete en el mismo quebrado del alcázar, para que el timonero vea la cabeza de la nao; y el castillo de proa a tres codos de altura, desde el quebrado, y a la misma altura de tres codos el de popa.

La vida ha de ser a la inglesa, de la banda de popa del quebrado, y un codo de hueco hasta el travesaño, que ciñe las dos telas.

Los escobenes han de venir debajo del castillo, lo más alto que pueda.

La caña del timón ha de jugar a raíz de las latas del quebrado del alcázar.

El contracodaste de la parte del zapato ha de ser de un tercio de codo de ancho, y disminuyendo por tercios, a morir en la lemera.

Las aletas han de ser redondas como el pie de genol.

La vita ha de ser a la inglesa, de la banda de popa del quebrado, y un codo de hueco hasta el travesaño, que ciñe las dos telas.

Los escobenes han de venir debajo del castillo, lo más alto que pueda.

La caña del timón ha de jugar a raíz de las latas del quebrado del alcázar.

El contracodaste de la parte del zapato ha de ser de un tercio de codo de ancho, y disminuyendo por tercios, a morir en la lemera.

Las aletas han de ser redondas como el pie de genol.

Plan, siete codos.
De puntal seis codos y medio, en lo más ancho, y siete codos la cubierta.
De quilla, treinta y ocho codos.
De eslora, cuarenta y ocho codos.
De lanzamiento a proa, siete codos.
De lanzamiento a popa, tres codos.
De rasel en popa, cuatro codos y dos tercios, y en proa la tercera parte de estos raseles.
De yugo, siete codos, y un cuarto.
Ha de llevar treinta y tres orengas de cuenta con la maestra.
De astilla muerta, seis octavos de codo, repartidos en tres partes iguales, las dos de muerta, en la orenga de en medio, y la otra tercera parte repartida en tantas partes iguales, cuantas fueran las orengas, que llevar de cuenta desde la segunda orenga, a popa, y proa.
De yova, seis octavos y medio repartido en partes iguales, en las orengas que hubiere desde la segunda de en medio a proa: y la mitad de esta yova, repartida en las orengas que hubiere desde la octava a popa.
De arrufadura en la cubierta, medio codo a proa, y uno a popa.
De arrufadura en las cintas, codo y tres cuartos a proa, y dos codos y un cuarto a popa.
Ha de llevar puente corrida a tres codos de altura, de la cubierta principal, con sus dos quebrados a proa, y popa, de codo y medio cada uno, y otro en el alcázar de popa, y el molinete en este quebrado.
La vita, fuera del quebrado para popa, ha de tener un codo de hueco, de la cubierta al travesaño.
Los escobenes, debajo del castillo, lo más alto que se pueda.
La caña del timón ha de jugar a raíz de las latas del quebrado del alcázar.
El castillo, y alcázar han de ser de tres codos de altura, desde los mismos quebrados, y la caña del timón ha de jugar a raíz de las latas, en el quebrado de alcázar.
El contracodaste de la parte del zapato, ha de tener de ancho medio codo, y disminuyendo por tercios, a morir a la lemera.
Las aletas han de ser redondas, como el pie de genol.


Plan, siete codos y medio.
De puntal siete codos en lo más ancho, y en siete y medio la cubierta.
De quilla, cuarenta codos.
De eslora, cincuenta codos y medio.
De lanzamiento a proa, siete codos, y un cuarto en la roda.
De lanzamiento a popa, tres codos, y un cuarto.
De rasel en popa, cinco codos, y el tercio de estos raseles se ha de dar en proa.
De yugo, siete codos, y tres cuartos.
Ha de llevar treinta y cinco orengas de cuenta, con la maestra.
De astilla muerta, seis octavos de codo, repartidos en tres partes iguales, las dos de muerta en la orenga de en medio, y la otra tercera parte repartida en tantas partes iguales, cuantas fueran las orengas de cuenta, que llevar desde la segunda orenga de en medio, a popa, y proa.
De jova, siete octavos de codo, repartidos en partes iguales, en las orengas que hubiere desde la segunda de en medio a proa; y la mitad de esta jova repartida en las orengas que hubiere desde la octava a popa.
De arrufadura en la cubierta, medio codo a proa, y uno a popa.
De arrufadura en las cintas, codo y tres cuartos a proa, y dos codos y cuarto a popa.
Ha de llevar el puente a tres codos de altura, con sus quebrados a proa, y popa, de codo y medio cada uno, y en el alcázar también la ha de llevar, y en este quebrado del alcázar, el molinete, y los corredores.
La vita ha de ser a la inglesa, fuera del quebrado para popa, con un codo de hueco desde la cubierta al travesaño.
Los escobenes han de estar debajo del castillo, lo más alto que se pueda, a raíz de las latas, debajo del quebrado.
Las aletas han de ser redondas, como el pie de genol.
El contracodaste de la parte del zapato ha de tener más de medio codo de ancho, y disminuyendo por tercios, ha de venir a morir en la lemera.

Plan, ocho codos.
De puntal siete codos y medio en lo más ancho, y en ocho codos la cubierta.
De quilla, cuarenta y dos codos.
De eslora, cincuenta y tres codos.
De lanzamiento en la roda de proa, seis codos y tres cuartos.
De lanzamiento en la de popa, tres codos y cuarto.
De raseles, cinco codos, y un tercio a popa, y el tercio de estos raseles se ha de dar a proa.
De yugo, ocho codos y cuarto.
Ha de llevar treinta y cinco orengas de cuenta, con la maestra.
De astilla muerta, siete octavos y medio de codo, repartidos en tres partes, las dos de muerta en la orenga de en medio, y la otra tercera parte repartida en tantas partes iguales, cuantas fueran las orengas de cuenta, que llevare desde la segunda de en medio, a popa, y proa.
De jova, siete octavos y medio de codo, repartidos en partes iguales, en las orengas que hubiere desde la segunda de en medio a proa, y la mitad de esta jova repartida en las orengas que hubiere desde la octava a popa.
De arrufadura en la cubierta, medio codo a proa, y uno a popa.
De arrufadura en las cintas, codo y tres cuartos a proa, y dos codos y cuarto a popa.
Ha de llevar el puente a tres codos de altura de la cubierta principal, con sus quebrados a proa, y popa, de uno codo cada uno, y en el alcázar, otro quebrado.
El castillo de proa ha de llevar tres codos de altura del quebrado, el de popa lo propio.
La vita ha de estar fuera del quebrado para popa, con un codo de hueco, desde la cubierta al travesaño.
Los escobenes han de laborar lo más alto que se pueda.
Las aletas han de ser redondas, como el pie de genol.
El contracodaste, de la parte del zapato, ha de tener más de medio codo de ancho, y por sus tercios venir a morir en la lemera.
Plan, ocho codos y medio.
De puntal, ocho codos en lo más ancho, y en ocho y medio la cubierta.
De quilla, cuarenta y cuatro codos.
De eslora, cincuenta y seis codos.
De lanzamiento de la roda, ocho codos.
De lanzamiento a popa, cuatro codos.
De rase, cinco codos y dos tercios, y el tercio de esos raseles se ha de dar a proa.
De yugo, ocho codos y tres cuartos.
Ha de llevar treinta y siete orengas de cuenta, con la maestra.
De astilla muerta, un codo, repartidos en tres partes iguales, los dos tercios de muerta en la orenga de en medio, y el otro tercio repartido en dieciocho partes iguales, las dieciocho para proa, y dieciocho para popa, y en todos los demás navíos se ha de repartir el tercio, como aquí se dice, a popa, y a proa, en las orengas de cuenta, que llevar desde la segunda orenga de en medio para popa, y para proa, hasta la posterior.

De yoya, un codo, repartido en dieciocho partes iguales, y en las orengas que hubiere desde la segunda de en medio a proa, que son dieciocho, la mitad de esta yoya repartida en las orengas que tuviere desde la novena a popa, inclusa la misma novena.
De arrufadura en la cubierta, medio codo a proa, y uno a popa.
De arrufadura en las cintas, codo y tres cuartos a proa, y dos codos y cuarto a popa.
Ha de llevar la puente corrida a tres codos de altura, con sus quebrados a proa, y popa, de uno codo cada uno.
El castillo ha tener tres codos de altura.
El alcázar, tres codos de altura, con su quebrado de un codo.
La vita ha de estar a la inglesa del quebrado para popa, con un codo de hueco, desde la cubierta al travesaño.
Los escobenes debajo del castillo, a raíz de las latas.
Las aletas redondas, como pie de genol.
El molinete en el quebrado del alcázar, para que juzgue el timonero la cabeza de la nao.
El contracodaste de la parte del zapato ha de tener de ancho más de medio codo, o lo más ancho que se pueda, y por sus tercios ha de ir a morir en la lemera.

Plan, nueve codos.
De puntal, ocho codos y medio, en lo más ancho, y en nueve codos la cubierta.
De quilla, cuarenta y seis codos.
De eslora, cincuenta y nueve codos.
De lanzamiento a la roda, ocho codos y tres cuartos.
De lanzamiento a popa, cuatro codos y un cuarto.
De rasel, seis codos a popa, y dos codos a proa, que es el tercio.
De yugo, nueve codos y cuarto.
Ha de llevar treinta y siete orengas de cuenta, con la maestra.
De astilla muerta, un codo, y un dieciseisavo, repartido en tres partes iguales: las dos de muerta en la orenga de en medio, y la otra tercera parte repartida en tantas partes.
iguales, cuantas fueren las orengas que lleve de cuenta, desde la segunda orenga de en medio, a popa, y a proa.
De jova, un codo, y dieciseisavo, repartido en partes iguales, en las orengas que hubiere, desde la segunda de en medio a proa, y la mitad de esta jova, repartida en las orengas que tuviere desde la novena a popa.
De arrufadura en la cubierta, medio codo a proa, y uno a popa.
De arrufadura en las cintas, codo y tres cuartos a popa, y dos cuartos a proa.
La puente ha de llevar tres codos de alto, con dos quebrados a proa, y popa, de uno codo cada uno.
El castillo, ha tres codos de altura del quebrado, y el alcázar de la misma manera con su quebrado de un codo.
La vida ha de estar fuera del quebrado para popa, y un codo de hueco desde la cubierta al travesaño.
Los escobenes han de laborar lo más alto que se pueda.
Las aletas han de ser redondas como el pie de genol.
El contracodaste de ancho en la parte del zapato, dos tercios, si se hallase madera para ello, y si no, lo más ancho que se pueda, y por sus tercios ha de ir a morir en la lemera.

Plan, nueve codos y medio.
De puntal, nueve codos en lo más ancho, y en nueve codos y medio en la cubierta.
De quilla, cuarenta y ocho codos.
De eslora, sesenta y un codos y medio.
De lanzamiento en la roda de proa, nueve codos.
De lanzamiento en popa, cuatro codos y un medio.
De rasel en popa, seis codos y un tercio, y la tercera parte de estos raseles se han de dar a proa.
De yugo, nueve codos y tres cuartos.
Ha de llevar treinta y nueve orengas de cuenta, con la maestra.
De astilla muerta, un codo y un octavo, repartido en tres partes iguales: las dos de muerta en la orenga de en medio, y en la otra tercera parte, repartida en tantas partes iguales, cuantas fueren las orengas que de cuenta que lleve desde la segunda orenga de en medio, a popa, y a proa.
De jova, un codo, y un octavo, repartido en partes iguales, en las orengas que hubiere desde la segunda de en medio, a proa: y la mitad de esta jova, repartida en las orengas que tuviere desde la décima a popa.
De arrufadura en la cubierta, medio codo a proa, y uno a popa.
De arrufadura en las cintas, codo y tres cuartos en proa, y dos cuartos a popa.
Ha de llevar la puente corrida a tres codos de altura de la cubierta principal, con sus quebrados de uno codo cada uno.
El castillo de proa ha de tener tres codos de altura, y el alcázar lo mismo, con el quebrado de un codo, y debajo de este quebrado ha de jugar la caña de timón.
La vita ha de estar a la inglesa en la puente fuera del quebrado para popa, con un codo de hueco desde la cubierta al travesaño.
Los escobenes han de estar lo más alto que se pueda, debajo del castillo.
Las aletas han de ser redondas como el pie de genol.
El contracodaste ha de ser de la parte del zapato, dos tercios de ancho, y venir a morir en la lemera.

Plan, diez codos.
De puntal, nueve codos y medio, en lo más ancho, y en diez codos la cubierta.
De quilla, cuarenta y nueve codos.
De eslora, sesenta y tres codos.
De lanzamiento en la roda de proa, nueve codos y medio.
De lanzamiento en popa, cuatro codos y medio.
De raseł en popa, seis codos y dos tercios, y el tercio de estos rasełes se han de dar a proa.
De yugo, diez codos.
Ha de llevar treinta y nueve orengas de cuenta, con la maestra.
De astilla muerta, un codo y un octavo y medio, repartido en tres partes iguales: las dos partes de muerta en la orenga de en medio, y en la otra tercera parte repartida en tantas partes iguales, cuantas fueren las orengas, desde la segunda de en medio, a popa, y a proa.
De jova, un codo, y un octavo y medio, repartido en partes iguales, en las orengas que hubiere desde la segunda, a proa: y la mitad de esta jova repartida en las orengas que hubiese desde la décima a popa.
De arrufadura en la cubierta, medio codo a proa, y uno a popa.
De arrufadura en las cintas, codo y tres cuartos a proa, y dos codos y cuarto a popa.
Ha de llevar la puente a tres codos, con dos quebrados a popa, y otro a proa, de un codo cada uno.
El castillo ha de estar a tres codos de altura del quebrado, y el alcázar de la misma manera, con su quebrado de un codo, y la caña ha de jugar debajo de la raíz de las latas.
La vita ha de estar fuera del quebrado para popa, con un codo de hueco, desde la cubierta al travesaño.
Los escobenes han de estar a raíz de las latas del castillo, lo más alto que se pueda.
Las latas han de ser redondas, como el pie de genol.
El contracodaste ha de tener dos tercios de ancho en de la parte del zapato, si hallare madera para él, y si no, lo más ancho que se pueda.

De plan, diez codos y medio.
De puntal, diez codos, en lo más ancho, y en diez codos y medio la cubierta.
De quilla, cincuenta y un codos.
De eslora, sesenta y seis codos.
De lanzamiento en la roda de proa, diez codos.
De lanzamiento en popa, cinco codos.
De raseł en popa, siete codos, y el tercio de estos rasełes se han de dar a proa.
De yugo, diez codos y medio.
Ha de llevar cuarenta y un orengas de cuenta, con la maestra.
De astilla muerta, un codo y cuarto, repartido en tres partes iguales: dando las dos de muerta en la orenga de en medio, y la otra tercera parte repartida en tantas partes iguales, cuantas fueren las orengas de cuenta que llevara desde la segunda de en medio, a popa, y a proa.
De jova, un codo, y cuarto, repartido en partes iguales, en las orengas que llevare desde la segunda a proa, y la mitad de esta jova repartida en las orengas que llevare desde la undécima a popa.

De arrufadura en la cubierta, medio codo a proa, y uno a popa.

De arrufadura en las cintas, dos codos a proa, y dos codos y medio a popa.

Ha de llevar a tres codos la puente, con dos quebrados, uno a proa, y otro a popa, de un codo cada uno.

El castillo ha de estar a tres codos de altura del quebrado, y el alcázar lo mismo, con su quebrado a popa.

La vida ha de estar fuera del quebrado para popa, con un codo de hueco desde la cubierta al travesaño.

Los escobenes han de estar lo más alto que se pueda, debajo del castillo.

Las aletas han de ser redondas, como el pie de genol.

El contracodaste ha de ser de dos tercios de ancho en de la parte del zapato, y por sus tercios ha de ir a morir en la lemera.


De plan, once codos.

De puntal, diez codos y medio en lo más ancho, y once codos en la cubierta.

De quilla, cincuenta y tres codos.

De eslora, sesenta y ocho codos.

De lanzamiento en la roda de proa, diez codos.

De lanzamiento en popa, cinco codos.

De rasele en popa, siete codos, y un tercio, y el tercio de estos raseles se dará a proa.

De yugo, once codos.

Ha de llevar cuarenta y un orengas de cuenta, con la maestra.

De astilla muerta, codo y cuarto y medio octavo, repartido en tres partes iguales: las dos de muerta en la orenga de en medio, y la otra tercera parte repartida en tantas partes iguales, cuantas fueren las orengas de cuenta que llevara desde la segunda de en medio, a popa, y a proa.

De jova, un codo, y cuarto, y medio octavo, repartido en partes iguales, en las orengas que llevara desde la segunda a proa: y la mitad de esta jova repartida en las orengas que llevara desde la undécima a popa.

De arrufadura en la cubierta, medio codo a proa, y uno a popa.

De arrufadura en las cintas, dos codos a proa, y dos codos y medio a popa.

Ha de llevar la puente a tres codos, con dos quebrados a proa, y a popa, de un codo cada uno.

El castillo ha de estar del quebrado, a tres codos de alto.

El alcázar ha de estar a tres codos de la puente, con su quebrado de un codo, y debajo de él ha de jugar la caña del timón.

La vida ha de estar a la inglesa, fuera del quebrado para popa, con un codo de hueco desde la cubierta de la puente al travesaño.

Los escobenes han de estar debajo del castillo, lo más alto que se pueda.

Las aletas han de ser redondas, como el pie de genol.

El contracodaste ha de tener de ancho en de la parte del zapato dos tercios, y de ahí ha de ir disminuyendo a morir en la lemera.
15. Y mandamos que todos los navíos que se fabricaren de aquí en adelante en todos nuestros reinos, y señoríos, sean conforme a estas ordenanzas, sin exceder un punto: y se advierte que se ha de servir con la misma grúa del pie de genol, que sirviera en la primera orenga de en medio, en toda la primera ornización para popa, y proa, y lo propia ha de servir para las aletas de popa, sin mudar otra grúa, de ninguna manera, excepto que en la roda de proa habrá menester seis, u ocho espaldones, que esta grúa no sirve para ellos, y para todas las demás ligazón, si en la primera ornización le sirve; y de esta manera saldrán los navíos redondones, con mucha bodega, y perfeccionados conforme a la cuanta de las ordenanzas.

16. Y no han de llevar ninguna arrufadura en los quebrados a popa, ni a proa, babor, ni estribor, ni arqueadas las cubiertas, sino todo en escuadra, nivelada, para que jüege mejor la artillería, y ha de ir aforrado en los quebrados, hasta las portas de la artillería, con su hinchamiento de tacos, en lugar de escopetadas, ajustados, clavados, y calafateados, abriéndoles embornales en los quebrados, para que despida el agua.

17. Y se advierte, que en todo caso se ha de buscar madera tuerta, que sirva la mitad del branque, y la mitad de quilla, por ser más fuerte y excusar no haya escarpe en el rasel de proa, que habiéndolo, no son estancos los navíos, como en tantos la experiencia ha mostrado.

18. Si se ofrece en todo género de navíos, que por el peso de las maderas, y los terrenos de los astilleros sean blandos, abre el manga de las medidas que les pertenece hasta cantidad de medio codo, no por eso se entienda haber excedido, ni alterado la buena fábrica, sino cumplido con las ordenanzas, como no sea en ninguna de las medidas anteriormente referidas, excepto en la manga, que esto suele suceder por el peso de las maderas, y porque los terrenos de los astilleros son blandos, donde es fuerza consentir las escoras, aunque más cuidado se ponga en ellas.

19. Considerado el gran daño que recibe la gente de nuestras armadas, enfermando por falta de agua, y los gastos que se hacen, y dilación del apresto, con la pipería ordinaria, es necesario que haya pipotes, que cada uno sea capaz de seis pipas de agua, y las duelas, y fondos han de tener de grueso dos pulgadas, y en cada cabeza de pipote cinco arcos de hierro del grueso del dedo meñique, y tres dedos de ancho cada arco, llevando los que pudieren en el plan del galeón, enterrados en el lastre. Y en cima la demás pipería de vino, y agua, que con estos pipotes la bodega queda más desembarazada para poder tomar por dentro un balazo cuando se peleare, y no tendrán riesgo con los balances del galeón, a desarrumarse, y romperse como tan ordinario sucede con la pipería, con que no vendrá a faltarles agua en ningún tiempo, y con esto no será menester hacer cada año pipería nueva: y en los tiempos de la invernada, quitándoles el fondo por una cabeza, dándoles fuego, y enjugándolos bien, se metan las velas dentro, sin relingas, y estarán guardadas de que no se las coman ratones. Estos pipotes han de ser de tres codos de largo cada uno, que es conforme al repartimiento de los baos vacíos, y en bebiéndose el agua de un pipote, se vuelva a hinchar de la salada, y con esto estará el navío en su andana, y no andará desestibado como ahora, que como en la pipería ordinaria es delgada la duela, la pipería se pone encima, abra la de abajo, con que viene a faltar el agua, y el navío queda desestibado, que son dos daños de gran consideración.

Regla general para armar todos los navíos.
20. Puesta la quilla, que ha de llevar las juntas de tope, y arbolado, branque y codaste, y escorado de proa, t popa, se ha de tomar un cordel del largo de la eslora del navío, que se arma, y doblarle por medio: y luego volverle a doblar también por medio para tomar también la cuarta parte de la eslora, la cual se ha de poner en el lanzamiento de la roda de proa, y donde llegare, encima de la quilla, un codo más a proa, se ha de poner la postera orenga, y de la misma manera se ha de poner la cuarta parte en el lanzamiento del codaste de popa: donde cayere encima de la quilla, dos codos más a proa, se ha de poner la otra orenga postera; en la distancia, que hubiere de orenga a orenga, se han de repartir las orengas de cuanta,

21. Para que los navíos queden llenos en todos sus tercios, y con buena proporción respecto de su manga, es necesario que las orengas posteras tengan de ancho la mitad del plan, y algo más, y además de esto, que la orenga de proa por la mura tenga un codo menos, que en la manga, y la orenga postera de popa por la cuadra, dos codos menos, que en la manga; y para saber cuanto ha de ser el poco más que las orengas posteras han de ser mayores que la mitad del plan, se ha de tomar la cantidad que tuviere la grúa del plan, que es la mitad de todo el plan, por la cuaderna maestra, desde el punto de la escoa, hasta el punto de la quilla, y esta distancia se dividirá en cinco partes iguales, y la una parte de estas se ha de dividir en otras cinco partes iguales, y lo que montare una quinta parte de estas, es lo que han de ser las orengas mayores que la mitad del plan en la grúa, lo cual es importante para quedar el navío con más buque: y por lo que levanta la astilla, conviene que las orengas abran, no solamente tanto como la mitad del plan, pero que se les añada aquello poquito más, porque con esto, y con lo que le da de jova a proa, más que a popa (que siempre es doblada) vendrá a salir la orenga de proa por la mura, como está dicho, con un codo menos de manga, que en medio, y con la jova que se le da a la orenga de popa (que es la mitad que al de proa) viene a quedar la misma orenga de popa por la cuadra con dos codos menos de manga, que en medio, y haciendo todo el costado, con una misma grúa, vendrá a salir el navío, o galeón con las calidades dichas.

22. Para que salga el navío marinero, y boyante, y no boquiabierto, ni emparedado, ni tenga balance, conviene que cierre en el puente tanto, cuanto abrió en los baos, que estarán a tres codos y medio de la cubierta, y de la puente arriba ha de enderezar un poco el barraganete, porque tenga más plaza que armas.

23. Las aletas de popa han de abrir el yugo la mitad de la manga, y un cuarto de codo más, y más abajo dos codos, o dos codos y medio, han de abrir un cuarto de codos más que en el yugo, para que sea la popa mas redonda, y con más sostén, para que cuando caiga la nao, que tenga donde escorar.

Todos los dichos galeones, navíos, y pataches se han de fabricar con las fortalezas siguientes.

24. Armadas las cuadernas, u orengas, que han de ir endentadas, bien clavadas, y rebitadas con los pies de genoles, se poblará la quilla de ellas después de haber puesto las maestras, o armaderas, y haber nivelado la madera de cuenta, y apuntándola por la escoa, se henchirá de cabezas con los pies de genoles, y piques, los cuales han de ir endentados, y clavados con tres pernetes de ribete cada uno, y ribeteen con los escarpes, los cuales henchimientos se han de ir asentando ordenadamente uno a uno,
de en medio para proa, y de en medio para popa, porque den lugar los unos a los otros a clavarse, y endentarse, y de allí arriba toda la ligazón, y aposturaje que ha de ir de la misma manera endentada, y clavada una con otra, para que los costados queden fuertes, y no haya lugar de jugar las ligazones, y de esta manera vendrán a quedar el plan, y costados fuertemente unidos, y en esto se ha de poner gran cuidado, porque es el fundamento de toda la fábrica.

25. Desde la segunda ornizón (que son los pies de genoles) arriba, se ha de procurar buscar maderas largas, que alcancen a cruzar hasta llegar a las cabezas de las orengas, todo lo más que fuere posible: y que así mismo alcancen las mismas maderas arriba a la segunda ornizón lo más que pudieren.

26. Los escarpes de los pies de genoles, con las varengas, o planes, han de ser los más largos que se pudiere, porque crucen más por el plan, y hagan buen encolamiento.

27. Han de llevar dos andanas de singlas por las cabezas de las varengas, y por las de los pies de genoles, todas endentadas, y ajustadas, porque no jueguen las cabezas, que es la llave de las fábricas.

28. La sobrequilla ha de ir bien endentada con las varengas, y cosida a madero en salvo, con cavillas de hierro, es cateada la quilla con la sobrequilla.

29. El plan, y piques de popa y proa han de ir llenos de cal, arena, y cascotes de guijarro menudo, entre cuaderna y cuaderna, y encima de ellas se ha de entablar el granel de popa a proa, hasta llegar a las singlas de las cabezas de varengas, y por encima de esta sigla ha de ir una tabla bien ajustada, que servirá de alboala, y en ella la escoperada del granel, encima del cual han de ir los taquetes de la carlinga endentados, y enmalletados en las propias tablas del granel, que alcancen hasta la singla, que va por las cabezas de los pies de genoles, con su diente en la propia singla.

30. Las alboalas han de ir a tabla en salvo desde abajo hasta arriba, con su alboala, debajo de todas liernas, o durmientes.

31. Los durmientes han de ser de medio codo de ancho, y se grueso, un cuarto, ajustados, y endentados unos con otros, con esgaravote.

32. Los navíos de diecinueve codos de manga abajo no han de llevar más de un anadna de baos vacíos, en altura de la mitad del puntal, y se han de asentar de manera, que los durmientes tomen los escarpes de las ligazones, si fuere posible, y han de llevar tres corbatones en cada cabeza, uno por encima del bao, y los dos por los lados de popa, y proa; pero los navíos de veinte codos de manga arriba, llevarán dos andanas de baos vacíos, y para ello se ha de repartir el puntal en tres partes iguales, y por la altura de cada uno de ellas se han de asentar, de suerte que queden igualmente distantes los unos del plan, y los otros de la cubierta, y también ellos entre sí.

33. El contradurmiente ha de ser un cuarto de codo en cuadro, ajustando como el durmiente.

34. La cubierta principal ha de llevar cuatro baos a boca de escotilla, y a través del árbol, de un tercio de codo de ancho, y un tercio de canto, por causa de la faggonadura del árbol mayor.

35. Las latas de las cubiertas han de ir a cuchillo, que esten a nivel con los baos, asentadas una de otra un tercio de codo, a cola de Milano, bien clavadas, las cuales han de tener de canto un tercio de codo, y de ancho han de ser de cinco en codo.

36. Los trancaniles han de ser de muy buena madera, y de grueso, confomne al porte del navío, acanalados y encajados a cola de Milano, como las latas, en el durmiente, y
clavados en cruz, que alcancen de fuera para dentro, y de arriba a abajo, y por encima del tranqui no ha de llevar más de una tablapara la escoperadura.

37. Las cuerdas, o esloras de la cubierta principal, y puente han de ser de canto, que alcancen por debajo de las latas a endentar hasta la mitad, y por encima de la cubierta otras, que ajusten con las de abajo, y para esto será bien que sean un tercio de codo de canto, y un quito de codo de ancho, como las latas, y encima de los baos han de ir otras dos andanas de cuerdas, o esloras, enmalletadas en los baos por encima del entremiche, y estas han de ser cuadradas, de un cuarto de codo.

38. Los corbatones han de ir a tres latas en salvo, y han de llevar cada una cinco cavillas de fierro escateadas.

39. Las latas del puente han de llevar de canto un tercio de codo, y de nacho de seis en codo, asentando una de otra a tercio de codo, como las de la cubierta principal, con sus corbatones, y entremiches endentados, con las latas, y corbatones, a tres latas en salvo para abajo, así mismo como las de la cubierta, con sus trancaniles acanalados, endentados, con su cola de Milano, y clavados como los demás, y con cuatro baos, en la forma como la cubierta principal, y ni más, ni menos las esloras o cuardas.

40. En los navíos de quince codos de manga arriba, llevarán seis columnas por banda, cuatro del árbol a proa, y dos a popa, desde la cabeza de los baos vacíos, hasta las cuerads, que están debajo de la puente, endentadas arriba, y abajo, en la cubierta principal, y con dos corbatones en cada cabeza, en el costado, y debajo de la puente otras dos, endentados contra ellas, y encavillados con cavallas de fierro, y escateadas.

41. La popa se ha de colimar hasta el yugo, y el palo del cintón, para hinchir al ángulo del rasel, y ha de ser bueno, y ancho, que alcance arriba, y abajo las puerca, y buzardas de proa, como se acostumbran, con sus corbatones en las puercas, y sus pernadas bien ajustadas, y de una puerca a otra ha de haber un tercio de codo vacío, o vacío, y en las buzardas otro tercio vacío, como en las puerca.

42. Las portas de la artillería han de tener el batidero un codo encima de la cubierta, y han de tener cada una codo y cuarto de cuadro.

43. Las mesas de guarnición han de ser a la Portuguesa.

44. El corbatón del tajamar, que va por debajo de la madre del espolón, ha de ser con dos codos machos encajados en el branque, y de ahí abajo su tajamar, y contrabranque, hasta la quilla, con sus juntas de entremiches, y machos en la roda, y el tajamar lo más ancho que se hallare.

45. El espolón ha de tener de largo tres quintos de su manga, del branque para afuera.

46. La lemera ha de ir debajo del quebrado del alcázar, y en el mismo quebrado el molinete, y los correderes encima del quebrado del alcázar, y por debajo jugará toda su artillería.

47. Ha de llevar otro contracodaste por la banda de dentro, por encima de las puerca, que ajuste con el codaste.

48. A proa ha de llevar contrabranque por la banda de dentro, y han de clavar en él las tablas de fuera, para que se ajusten todas las cabezas encima del propio branque, y para esto se ha de buscar el palo más forrado que se hallare, para que alcance de una banda a otra a clavar las tablas en él.

49. La vita ha de ser a la Inglesa, fortificada con sus corbatones para la banda de popa, en la cubierta principal, y en la de arriba por la parte de proa, endentados por las latas.

50. Los durmientes de tolda, y castillo han de ser de cinco en codos de grueso, y de un tercio de codo en ancho.
51. Las latas de tolda, y castillo han de ser de canto un cuarto de codo, y de ancho seis en codo.
52. La próxima cinta ha de ir un codo debajo de la cubierta principal, y la segunda en la cabezas de las latas, enfrente del durmiente, de manera que el agua de los embornales vierta por encima de la cinta, y la tercera encima de las portas de la artillería, que viene a ser dos codos y medio encima de la cubierta principal.
53. Los navíos de dieciséis codos de manga arriba han de llevar la tablazón de la segunda cinta abajo, de cinco en codo; y de la segunda cinta arriba, de seis, siete y ocho, adelgazando la madera arriba lo más que se pudiere: la tabla de las cubiertas ha de ser de seis en codo.
54. Los navíos de quince, y dieciséis codos de manga han de llevar tabla de seis en codo, hasta la segunda cinta, y de ahí arriba se ha de dechar de siete, ocho y nueve en codo, adelgazando la madera mientras más arriba, más: y la tablazón de la cubierta ha de ser de siete en codo.
55. Los navíos de trece, y catorce codos de manga han de llevar la tabla de siete en codo, hasta la segunda cinta, y de ahí para arriba de ocho, nueve y diez, adelgazando la madera, como se ha dicho, mientras más arriba más proporcionalmente: la tabla de la cubierta ha de ser de ocho en codo.
56. Los navíos de once, y doce codos de manga han de llevar tabla de siete en codo, hasta la segunda cinta, y de ahí para arriba de nueve, y diez, adelgazando la madera proporcionablemente, mientras más arriba, más: y lo mismo se ha de entender en las frotificaciones: la tabla de la cubierta de a nueve en codo.
57. Los navíos de ocho, nueve, y diez codos de manga han de llevar tabla de nueve en codo, hasta la segunda cinta, y de ahí para arriba de diez, en codo, adelgazando la madera, mientras más arriba, más: y la tablazón de la cubierta ha de ser de diez en codo.
58. La tablazón de la puente, tolda, y castillo ha de ser de pino, y si fuese posible, sea de Flandes, porque es más liviano, y de ahí para arriba la tablazón también de pino, porque no tenga peso más arriba que cause balance: la cual tablazón ha de ser conforme al porte de la nao, como arriba está dicho.
59. La tablazón desde la puente arriba ha de ir entablada, tinglada a la Flamenca, por ser de menos costa, y más estanco.
60. El grosor de toda la tabla dicha se entiende le ha de tener después labrada.
61. La primera, y segunda cinta han de ser dobles, que las dos juntas hagan dos tercios de codo de ancho, y un tercio de codos de canto, descantadas de la parte de arriba, y abajo, de manera que queden ahogadas, y que sea cinta, y tabla todo uno, que quede en la propia cinta, dos dedos de cada parte, de arriba, y abajo, para que sea más estanco en el batidero del agua.
62. Los navíos de trece codos de manga abajo han de ser las fortificaciones en proporción a su porte.
63. Para que toda obra sea fija conviene que el material sea seco, y la madera se corte en las menguantes de agosto, diciembre, enero y febrero, y no en otro tiempo, y si fuese posible, se corte de medio día para la noche.
64. El timón ha de tener de grueso lo que estuviera de ancho el contracodaste, y dos codos más, y en la frente de la parte de fuera dos veces y medio de grueso, que el de la parte de dentro: el ancho será proporcionado al porte de la nao, y el largo el que pidiere: y
en todas las naos se guardará una forma del timón que tuviera para poder hacer otro para ella, caso que se rompa, o por otra causa le falte.

65. Los cabestrantes se han de poner en la puente.

66. La carlinga del árbol mayor se ha de asentar en el medio del largo del aquilla.

67. La carlinga del árbol del trinquete se ha de asentar en la mitad del lanzamiento de la roda de proa.

68. La carlinga del bauprés se ha de fijar en la cubierta principal.

69. En los navíos de quince codos de manga para arriba, si quisieren poner correderos, ha de ser en el quebrado del alcázar, y han de ser pequeños, que no salgan más de la bóveda de arriba, y por las bandas, dos tercios de codo.

70. La ligazón se ha de repartie de la manera que las latas; a donde puedan pasar a endentar, con su cola de Milano, en las cintasse haga; y donde no, han de pasar por entre los genoles, supuesto son dos cintas, que por la parte de fuera han de juntar, y hacer tabla que se pueda calafatear, y las latas endentadas, como se dice, llegando hasta la tabla del costado: y no solo ha de haber la cola de Milano en las cintas, sino también en el durmiente, que de esta manera vendrá a quedar con la fortaleza que se puede imaginar: y en los castillos han de pasar las cabezas de las latas fuera de las cintas, en el costado, para la fortaleza que se pretende, endentadas a cola de Milano, si pudiere, en las cintas, y si no, en el durmiente.

71. Las vagaras del rasel de popa, por debajo de los brazales, no han de juntar con el diente del codaste, sino con todo el gordor del codaste, para que la popa salga más redonda por respecto de los calímas.

Las medidas de los árboles, y vergas, que han de llevar los dichos pataches, navíos, y galeones.

72. El árbol mayor ha de tener de largo tanto, cuanto llevare de quilla de punta a punta, y dos codos más.

73. El grosor que ha de tener el árbol mayor de cualquier navío, se ha de medir a los tamboretes de la puente, y ha de ser de tantos palmos de vara en redondo, cuantos tuviere codos la mitad de la manga.

74. El trinquete, llevando la carlinga en mitad del lanzamiento de la roda, ha de tener cuatro codos menos de altura que el árbol mayor, y de grueso la sexta parte menos de la circunferencia.

75. El bauprés ha de ser dos codos menos de largo, que el trinquete, porque ha de calar la coz en la cubierta principal: de grosor ha de ser medio palmo menos que el trinquete a la fogonadura de la puente, y ha de ir arbolada la cabeza por la mitad del cuadrante, que son cuarenta y cinco grados, tomando por horizonte la cubierta principal, donde está la coz, o carlinga.

76. El masteleo ha de tener desde la cuña de la coz, hasta los baos, o barrotes del propio masteleo, manga, y dos tercios de ella, de largo, de punta a punta, y de grosor ha de tener lo que tuviere la garganta del árbol mayor, una pulgada menos.

77. El masteleo de proa ha de tener el quinto menos, que el del mayor, y del grosor ha de ser, conforme la graganta del trinquete, una pulgada menos.

78. La mesana ha de ser de tres codos mayor, que el masteleo de gavia mayor, poruqe ha de calar hasta la cubierta principal del grosor como el masteleo.
79. La verga mayor ha de tener dos mangas, y un cuarto de la misma manga de largo, y de grosor al medio ha de tener tanto, cuanto tuviere la graganta del árbol, y de ahí a la punta ha de ir adelgazando, hasta quedar la punta de la averga en dos quintos.
80. La verga del trinquete ha de tener dos codos de largo, y de grosor como la graganta del trinquete, una pulgada menos, hecha por los quintos, reducida como la de arriba.
81. La verga de la cebadera ha de ser el quinto menos de largo, que la de trinquete, hecha por el quinto.
82. La verga de la gavia ha de ser tan larga como la manga del navío, y del grosor como la graganta del masteleo, hecha por el quinto.
83. La verga del borriquete, o masteleo de proa ha de ser el quinto menos, que la de masteleo de gavia mayor, hecha por el quinto.
84. La verga de la mesana ha de ser tan larga, como la del trinquete.
85. Los árboles y vergas han de ser hechos por el quinto, esto es, que el grosor que tuvieren por los tamboretes, se ha de repartir en cinco partes, de las cuales las tres han de quedar de grueso en la cabeza, y las otras dos partes se han de ir multiplicando desde ella hasta los tamboretes, repartidos en los tamaños que quisieren, por la circunferencia de árbol.
86. Vergas se han de hacer así mismo por el quinto, dando los dos quintos de grueso en el penol, y los tres se han de ir multiplicando en los tamaños que quisieren, por la circunferencia, hasta llegar por una y otra parte a la ustagadura, que es en medio de la verga, donde se vendrá a quedar todo el grueso de los cinco quintos, que se le han de dar por el medio, que es lo más grueso.
87. La gavia del árbol mayor ha de tener de ámbito, o circunferencia, por el arco de arriba, tantos codos como tuviere la nao de manga, y en el soler codo y medio menos, o lo que conviniere, según su porte.
88. La gavia del trinquete tendrá de boca por el arco de arriba, tanto, cuanto la mayor por el soler de abajo, y en su soler un codo, o lo que pareciere convenir.
89. El dragante de bauprés ha de ir arrimado al branque de proa, y no más fuera, porque no juegue el espolón con el peso del bauprés; y la reata ha de ir pegada al propio dragante, que tome la bragada del corbatón del tajamar, porque no dé trabajo a1 espolón.
90. Los tamboretes del árbol mayor, y Trinquete, han de ir fijados en los baos vacíos, y en la cubierta principal ha de haber un dedo de vacío en redondo en la fogonadura, que quepa entre el tamborete, y el árbol, y en la puente han de caber tres dedos en redondo entre los tamboretes, y el árbol en la misma fogonadura.
91. Los árboles mayor y trinquete no han de llevar calceses, sino chapuces la Flamenca, y como se usan en la armada del océano, y no han de ser de tablones, sino de vigas de robles de a carro cada una, caobana, o nogal, y las toldanas para las ustagas han de ir en el mismo chapuz, y no entre el chapuz, y el árbol: que aunque no le quede al chapuz por la parte de adentro, donde han de ir las toldanas, que han de ser de bronce, más de un dedo de grueso, le basta, acompañándola el árbol, y en el ojo del perno su chapa de hierro, o cola de Milano, embebida en el chapuz.

Forma en que ha de servir, y ser pagada la Maestranza en la fábrica, y aderezos de Navíos del Rey, y en los de particulares, y adovío de ellos.
92. Porque es costumbre entre la Maestranza no traer las herramientas necesarias para usar sus oficios, respecto de que se las solían proveer por cuenta de nuestra Real Hacienda, las cuales perdían, y las tomaban unos de otros, y por falta de ellas usan de la hacha, que es lo ordinario que traen, y con ella desperdician mucha madera, y gastan más tiempo en la que labran: Considerando esto, se tiene por conveniente á nuestro servicio, y beneficio de la hacienda, utilidad, y provecho de la misma maestranza, que como el jornal ordinario, que solian ganar, era de cuatro reales, sea de cuatro y cuartillo cada día en nuestro Señorío de Vizcaya, Provincia de Guipuzcoa, cuatro Villas de la Costa de la Mar, Asturias, y Reino de Galicia, con condición, que ningún maestro, carpintero, ni calafate, pueda llevar más de un aprendiz, y el cabo dos, y esto no se les ha de pagar más de lo que merecieren, conforme a la suficiencia de cada uno, como pareciere a nuestros superintendentes de la fábrica, y en las armadas al capitán de la maestranza; pero han de ser examinados, y no se les ha de dar por cuenta de nuestra Real Hacienda ningún género de herramienta más de las muelas de piedra para amolar, y los oficiales que lo fuere de lo blanco no han de ganar este jornal por entero, sino según lo que cada uno mereciere. Y es declaración, que la maestranza de Sevilla, Cádiz, y Puerto de Santa María, ha de ganar ocho reales cada día, inclusa en ellos la comida; y en las Horcadas, Borrego, y Sanlúcar, a diez reales, inclusa la comida, sin que en las unas partes, ni las otras se exceda de esta cantidad. Y mandamos que los nuestros presidentes, y jueces oficiales de la Casa de Sevilla, tengan particular cuidado de la observación de esta orden, y de castigar a quien fuere contra ella, penándole en veinte ducados, así al Oficial, como al dueño del navío, la cual condenación se ha de aplicar por mitad a nuestra cámara, y denuncia; Y cuando fuere maestranza de Sevilla al Puerto de Santa María, Cádiz, Estero de la Carraca, y Puente de Zuazo, ganen diez reales, como en Horcadas, y Sanlúcar; y el día de fiesta, o el que lloviere, se les han de dar dos reales por persona, o la comida aquel día, cual más quisiere la maestranza, estando presentes, y no y no hiendose a sus casas.

93. Estando nuestra Armada del Mar Océano en el Río, y puerto de la ciudad de Lisboa, y haciéndose los adovíos, y arreglos de sus navíos ahí, do en cualquier puerto de dicho Reino, se ha de pagar a calafates, cavilladores, y carpinteros examinados, a cada cuatro reales y cuartillo, al capataz cinco, y ocho al cabo maestro, y este crecimiento de jornal se le da por el gasto que se les seguirá de traer las herramientas, que adelante se dice, porque no se les ha de permitir que lleven ningún género de astillas, o cabacos; y los que resultaren de nuestras fábricas, tenemos por bien, y mandamos que sean para el hospital donde se curare la gente de nuestras armadas.

Las herramientas con que se ha de servir la maestranza.

94. El carpintero ha de traer hacha, sierra, o serrón, azuela de dos manos, gubia, barrenos de tres suertes, martillo de orejas, mandarria, y dos escoplos.
95. El Calafate ha de traer mallo, cinco ferros, gubia, magujo, mandarria, martillo de orejas, sacaestopa, tres barrenas diferentes, desde el aviador engrosando.
96. El Cavillador ha de traer barrenos, aviadores, taladros, y mandarrias.
97. El aderezo de lo que de estas herramientas se les rompiera, ha de ser por cuenta de nuestra Real Hacienda, y por la costa que se les siguiere de traerlas a estos tres géneros
de oficiales, y que no se han de aprovechar de nada de las astillas, y cabacos, como queda referido, se les acrecienta el cuartillo de jornal que queda dicho.

98. El Alistador, que alistare esta maestranza, y el maestro mayor, que tuviere a su cargo la fábrica de galeón, o navío, y se les probare haber alistado alguno sin traer las dichas herramientas, sea condenado cada uno en doscientos ducados, los cuales se han de aplicar por mitad para el denunciador, y Juez que lo sentenciare; y el que no tuviere haciendo para pagar esta pena, ha de estar preso en la cárcel pública, hasta que satisfaga la condena.

99. Cuando se hiciere la paga a la maestranza, ha de presentar cada oficial la herramienta de su oficio, y cada uno la ha de tener marcada, con marca diferente, registrada por el veedor, y puesta en el asiento de la lista de su nombre.

100. Cualquier persona de la maestranza, marinero, u otra suerte de gente, que hurtare clavación, plomo, estopa, grasa, aceite, sebo, u otro cualquier material, tocante a fábrica, y adovíos de navíos, sea condenado a cien ducados, la mitad para el denunciador, y la mitad para el juez; y en esta misma pena incurra cualquier persona que se lo compare, y en falta de no tener con que pagar esta condenación, sirvan cinco años en galera al remo, tanto el vendedor, como el comprador.

101. Cuando alguno quisiere fabricar navío, no le pueda armar sin que primero haya acudido al superintendente de su distrito, para que le de las medidas que ha de tener, según el porte que lo quisiere fabricar, que serán conforme a estas ordenanzas. Y para que ninguno exceda de ellas, mandamos que si excediere el fabricador, incurrá una pena de quinientos ducados, y el maestro fabricador que le hiciere, en cien ducados, por mitad, para juez, y denunciador; pero sí el superintendente no cumplierse esas ordenanzas en el dar las medidas, incurrá en pena de mil ducados aplicados así mismo poar mitad para juez, y denunciador, y en privación de oficio. Y para el cumplimiento de esto, mandamos que el superintendente tenga un libro, donde se asienten las medidas que así diere al tal fabricador, y ponga su nombre y así mismo el del navío, y la parte, y lugar donde se fabricare, y al pie del asiento, u orden del superintendente, de fe un escribano, y el fabricador lleve un traslado autorizado, y el superintendente no lleve derechos algunos por esta instrucción, u medidas que diere, y el fabricador pague la fe que diere el escribano de la razón que queda asentada en el libro, según nuestros aranceles.

102. Todos los galeones, y otra suerte de navíos referidos, así nuestros como de particulares se han de fabricar, y arbolar por las susodichas medidas, y trazas, con las mismas fortificaciones, sin discrepar en nada, y el codo con que se han de dar las medidas, han de ser el mismo que se ha usado en nuestras fábricas de navíos, y armadas, que es de dos tercios de vara, medida Castellana, y un treinta y doceavo de las dos tercias.

103. Los nuestros Presidente, y jueces oficiales de la Casa de Contratación de Sevilla, han de cometer a los visitadores, o a otras personas de ciencia, y experiencia, que reconozcan, miren, y consideren lo que podrá cargar cada navío de las susodichas medidas, de manera que sea fácil, y seguro el salir, y entrar por las barras de Sanlúcar, y San Juan de Ulúa, sin que sea necesario aliar de la carga que hubiere de llevar en su viaje, y navegación a las Indias. Y por que los dueños de naos, y cargadores de ellas no puedan de engaño acerca de esto, pondrán los dichos visitadores, o las persona a quien fuere cometido este reconocimiento, dos señales, o argillas de fierro, una a babor, y
otra a estribor en medio de la Nao, donde tiene la manga, que sirvan de límite, y para que hasta aquí, y no más, se cargue el navío, de manera que aquel fierro, o señal quede sobre el agua, y han de tener un libro, en que pongan por memoria la parte donde fijaren en el navío las dichas señales, declarando en cuantos codos de agua las hubieren puesto, y los que hubiere de ahí a la puente, y quien contraviniera esta orden, pierda la mitad del valor de el tal navío, y de esta mitad se han de hacer dos partes; la una para el denunciador, y la otra para el juez; y en los casos que de derecho hubiere lugar, otorgaran las apelaciones para ante nuestra Junta de Guerra de Indias, como se dice en estas ordenanzas, y no para otro ningún tribunal.

104. Los navíos, que fuere necesario fabricar por cuenta de nuestra Real hacienda, y los que fabricaren para de mercante los particulares para las flotas, han de ser de dieciocho codos de manga abajo, sin exceder de aquí arriba en nada, ni faltarles en lo que toca a las medidas, traza, y fortificaciones referidas, y no mayores, por los grandes daños que resultan de que sean grandes, por que siéndolo, se desparejan con más facilidad, y pierden con los temporales, faltándoles los árboles, vergas, o timones, y no hallándose otros iguales, los abandonan, y en las entradas, y las salidas de la barras corren más peligro, pescando mucha agua, y como navegan las flotas en verano, y han de menester mucho viento que los pequeños, y medianos, es ocasion de que estos por fuerza los aguarden, con que se retarda la llegada de las flotas, y en ocasión de encontrarse con enemigos, los menores mas fácilmente ganan el barlovento, y se disponen mejor a lo que mas les conviene; y pues los dichos galeones, o navíos de merante, que serán de porte de seiscentas y veinticuatro toneladas tendrán bastante bodega para su tráfico, no se ha de permitir, que a ninguno de ellos le corran los alcázares, como se acostumbra, desde el árbol mayor hasta el castillo de proa, ni que se les echen contracostados, ni alzarles la lemera, pues con los quebrados ira alta bastantemente; sino que quede de la manera que hubiere salido del astillero, por que no siendo mayores, ni yendo embalumados, podrán entrar, y salir por la barras de Sanlúcar de Barrameda, y San Juan de Ulúa, con sus mercancías, y harán la navegación mas breve, y serán los navíos más durables, y toda la carga, y navegación más igual, y con menos riego del mar, y enemigos, y más comodidad de los dueños de las mercancías para la carga, y descarga, y se aprestaran las flotas con más brevedad, y menos costo, y será causa para aumentar la marinería natural de estos reinos. Y mandamos que los nuestros presidente, y jueces oficiales de la Casa de Contratación de Indias, que reside en la ciudad de Sevilla, ni el juez oficial, que reside en la de Cádiz, no admitan para la Carrera de Indias ningún navío, que exceda de dieciocho codos de manga, y ocho y medio de puntal, y ahí lo más ancho como esta dicho, y medio codo más arriba de la cubierta, ni a los que tuvieren contracostados, ni corridas las puentes; y que los que no fueren mayores, y tuvieren las demás calidades de medidas, traza, y fortificación referidas, prefieran en la carga, y visitas a cualquier otro navío, que no fueren de esta ordenanza, y cuando concurrieren algunos que los sean (como queda declarado) de la nueva fabrica se entienda que el dueño, que le hubiere fabricado, y navegue personalmente en él, ha de preferir en la carga a los otros, y ser primero cargado, que otro ninguno, y poder quitar la carga que el mercader, o cargador, enviare a otro cualquier navío de la flota, llevando por el río abajo, o de bordo, y sacársela de dentro de él para cargar el suyo: tanto en las flotas de la navegación de Andalucía, e Indias, como en los demás puertos de nuestros reinos, y señoríos (quedando en su fuerza, y vigor la cédula de siete de marzo de [mil]seiscientos y ocho, para que la preferencia
de la carga no se entienda con navíos de cien toneladas abajo) aunque se la tal carga del propio dueño del navío o de la gente que en él navegare, por que en todo tiempo, y lugar han de ser preferidos los dueños de los navíos de esta ordenanza, navegándolos personalmente, y no en otra manera: y si alguno de ellos acudiere a una misma flota, se les ha de repartir la carga por iguales partes, conforme al porte de sus propios navíos, y hasta que ellos tengan bastante carga, no se ha de dejar cargar otro navío por ningún caso, no siendo tan viejo el navío de esta ordenanza, que corra el riesgo en la navegación: y esto lo cumpla, y ejecute inviolablemente el juez oficial, que le tocare ir a Sanlúcar al despacho de las flotas, y así en los navíos de Cádiz, como en los que bajaren de Sevilla: y en las Indias a los generales, y almirantes de flotas; y las justicias ordinarias en los demás puertos de estos nuestros reinos, con apercibimiento que se les hace de que pagaran de sus bienes todos los daños, y menoscabos, que se recrecieren a los tales dueños fabricadores de navíos, y de no les cumplir, guardar, y ejecutar lo contenido en este capítulo, y que demás de esto les pagaran el flete, y demás aprovechamientos de todo aquello que podrían llevar, o dejar de traer, como si efectivamente los hubieran llevado, o traído por cuenta de cada uno de los dichos jueces, generales, o justicias ordinarias, que por su culpa, o descuido lo dejare de tener cumplido efecto. Y por lo que toca a los navíos que al presente hay fabricados, que no fueren conforme a estas ordenanzas, serán admitidos los que se conformaren más con sus medidas, como no sean los fabricados fuera de estos reinos de España (aunque sean de los de la Indias), por que estos tales y los levantados sobre barcos, fragatas, carabelas, ni otras fustas, ni urcas, filibotes, ni otro genero de navíos extranjeros, aunque estén en poder de naturales no han de navegar en ninguna manera, ni por ningún caso en la Carrera de Indias, en las flotas, ni fuera de ellas, ni a Santo Domingo, a la Habana, Puerto Rico, Jamaica, Campeche, ni otra parte, ni puerto alguno de las Indias, ni en ellas, de una parte para otra, sino a falta de navíos naturales, sin embargo de otra cualquier orden, que en contrario de esto haya, la cual derogamos, y demos por ninguna de la virtud de la presente, por cuanto conviene, y es nuestra voluntad que en tan solamente naveguen en la dicha Carrera navíos españoles, porque sus dueños tengan sustancia para fabricar, o comprar otros, so pena de perdimiento del navío, y mercancías, que en los tales navíos fabricados sobre carabelas, fragatas, o barcos, se embarquen, y en las urcas, filibotes, o navíos extranjeros, no embargante que estén, como queda referido en el poder de naturales. Y mandamos que las denunciaciones, que de estos se hiciere, conozcan los dichos presidente, y jueces oficiales de la Casa de Contratación de las Indias, que reside en la ciudad de Sevilla, y el que reside en la de Cádiz, los generales de nuestra armada, y flotas de la Carrera de Indias, el nuestro regente, y oidores de la Audiencia de Sevilla, los alcaldes de Grados, el nuestro asistente de la dicha ciudad, y sus tenientes, y todas las demás justicias de nuestros reinos, cualquiera de ellos, a prevención, y han de otorgar las apelaciones en los casos, que quede derecho hubiere lugar para nuestro consejo de guerra, o la Junta de Guerra de Indias, cada uno lo que le tocare, y no a otro ningún tribunal: y lo que por revistase condenare de las dichas denuncias, se ha de aplicar, y repartir en dos partes, por mitad, para juez, y denunciador, para cuyo efecto derogamos las pragmáticas, y leyes de estos reinos, en que se declara, que la tercera parte de cualquier denuncia, se aplique a nuestra cámara, por que queremos, y es nuestra voluntad, que se repartan por mitad, por lo mucho que conviene a nuestro servicio, que se proceda por todo rigor, y se observe esta orden con puntualidad.
105. Cuando nos mandaremos tomar navíos de particulares, fabricados por estas medidas y trazas referidas para servir en nuestras armadas del Mar Océano, y Mediterráneo, considerando la costa que se le seguirá, fabricándolos con las dichas trazas, y fortificaciones, y el beneficio que se sigue a nuestro servicio, que anden en nuestras armadas navíos de esta perfección, y fortaleza, les mandamos pagar a razón de nueve reales por tonelada cada mes incluso en ellas el socorro que se suele dar en dichas armadas a semejantes navíos para sebo y mangueras, advirtiendo, que para lo que toca a la Carrera de Indias, quede arbitrio de los dichos presidente, y jueces oficiales de la Casa de Contratación, para que conforme al tiempo, señalen el precio de cada tonelada.

106. Advirtiese, que para más comodidad de los fabricadores en las medidas de uso referidas en todo género de navíos que se dice, lo más ancho ha de ir medio codo debajo de la cubierta principal (que es donde derechamente había de entender ser el puntal), las hacemos merced de que cuando se tomare algún navío, o navíos para nuestro servicio, que estuviere fabricado por estas ordenanzas que ha de ser el puntal el medio codo que hay de lo más ancho a la cubierta, y en la propia cubierta se ha de tomar la medida del puntal para su arqueamiento, respecto que la manga viene a quedar más debajo de la cubierta. Todo lo cual, según, y de la manera que queda referido, se ha de guardar por pragmática inviolable en nuestros reinos, y en virtud de cualquier traslado de estas ordenanzas, firmado de nuestro secretario de la Guerra de Mar: mandamos a nuestros superintendentes de las dichas fábricas reales de navíos, que ahora son, y adelante fuere, que cada uno en su distrito haga publicar lo contenido en ellas, y que se execute, y cumpla lo que le tocare y quedando como quedan derogada la de veintiuno de diciembre de [mil] seiscientos y siete, y la de [mil] dieciséis de julio de seiscientos y trece: lo mismo ordenamos a nuestros presidente, y jueces oficiales de la dicha Casa de Contratación de las Indias, y a los nuestros veedores, y proveedores generales de nuestras armadas, en cuanto a lo que por sus oficios están obligados a hacer: y a nuestro capitán general de la Armada del Mar Océano, y a los capitanes generales de la Armada de la Guardia de la Carrera de las Indias, y flotas, remitimos el cuidado de hacer observar en ellas estas ordenanzas, y que no hagan, ni consientan alterar cosa contra ninguna de las aquí referidas, sin expresa, y particular orden nuestra: y del conocimiento de los pleitos, y causas, que resultaren de hacerlas ejecutar, y castigar los transgresores, inhibimos, y damos por inhibidos a los presidentes, y oidores de nuestras chancillerías, y demás tribunales, por cuanto han de tratar del cumplimiento, y ejecución de estas ordenanzas las personas que arriba se hace mención: y en cuanto a las apelaciones de las cosas que haya lugar de derecho, los nuestros Consejo de Guerra, y Junta de Guerra de Indias, cada uno en lo que le tocare: y de estas ordenanzas se ha de tomar la razón en la contaduría de nuestro Consejo de Indias, y en la Casa de la Contratación de Sevilla, y después han de quedar originalmente en la nuestra Contaduría Mayor de Cuentas que así conviene a nuestro real servicio.

La señal que aquí se pone es el cuarto de codo, de que se hace mención en estas Ordenanzas.
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Diego García de Palacio and the *Instrucción náutica* of 1587

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Abstract

Often cited as the earliest printed treatise on ship construction, *Instrucción nautica* was published by Diego García de Palacio in Mexico in 1587, reflecting the importance of seafaring for Spain’s colonies. The didactic style and an early nautical glossary suggest the document was intended for non-specialists. The text describes navigational techniques, ship proportions, rigging, stores, crew, and naval tactics. Woodcuts depict the dimensions of two ships in an early attempt to illustrate a complex empirical system of hull design. This paper presents reconstructions of the vessels using comparative archaeological, documentary, and pictorial data, and analyzes the document’s significance.

Introduction

Diego García de Palacio published the *Instrucción nautica para el buen uso y regimiento de las naos, su traza y gobierno* in Mexico City in 1587. As the first printed book providing detailed descriptions of ship construction and rigging, the publication of this treatise represents a significant event in the development of early modern shipbuilding practices.

It is significant that the first published work on shipbuilding was printed in the New World and that its author was a colonial administrator rather than a shipwright. The maritime trails of the *Carrera de Indias*, or Indies Route, were the arteries of the Spanish empire, linking Spain with its American colonies, and later extending across the Pacific to the Philippines. An extensive local trade also quickly developed in the New World. By the late 16th century, Spain had established shipyards in Cuba, Mexico, Nicaragua, Panama, and Peru.
Although manuals of ship design and construction are now common, ship construction methods were transmitted almost exclusively through oral communication and repeated bodily practice before the Renaissance. Like architectural treatises, shipbuilding manuscripts first developed in 15th-century Italy and then emerged in other parts of Europe in the 16th century.

The most astonishing aspect of the *Instrucción náutica* is not how early it is, but rather how late it is. Shipbuilding treatises were remarkably slow to appear in print. By 1486, the first edition of Vitruvius’s treatise on architecture had been published, but the first published treatise on naval architecture did not appear until more 125 years after the invention of the printing press, reflecting the esoteric and guarded nature of shipbuilding knowledge.

**The Life and Times of Diego García de Palacio**

The story of Diego García de Palacio is interwoven through a historical tapestry that encompasses many remarkable events in the colonial empire of 16th-Century Spain. The abundant records concerning his career and personal life provide a window into the social and political circumstances of his times. Much of what is known of his life is based on a biographical study completed by Othón Arróniz in 1980 and reprinted posthumously in 1994 by the University of Veracruz. Arróniz’s exceptional work includes an engaging and perceptive commentary as well as transcriptions of 20 key documents pertaining to García de Palacio discovered in the Archivo General de Indias (AGI) in Seville and in the Archivo General de la Nación (AGN) and other archives in Mexico City. The noted historian Edmundo O’Gorman also published several important records from the AGN. The newly launched Archivos Españoles en Red (<http://www.aer.es>) provides online access to facsimiles of dozens of other original documents in the AGI that were written by, about, or to Diego García de Palacio. The following review provides only a brief discussion of these accounts, and a more detailed study is forthcoming.

According to a statement made to the Inquisition, García de Palacio was born in 1524 (Arróniz 1994:142). His family was from Ambrucero, near the port city of Santander in the province of Cantabria. The inhabitants of this region of northern Spain have long been noted for their proficiency in shipbuilding and navigation. García de Palacio’s published works are both written as dialogues between a *vizcaíno* (a native of Biscay in the Basque
Country) and a montañés (a native of Santander), with the latter clearly being the voice of García de Palacio himself. Predictably, the montañés acts as the authority, obligingly sharing his extensive knowledge and wisdom with his captivated companion.

Diego’s father, Pedro García de Palacio, studied at the University of Salamanca (Arróniz 1994:141-142). Having benefited from various family connections, he was eventually ordained into the clergy. He returned home to marry María Sanz de Arce, despite the violent opposition of her family. The marriage so enraged her uncle that Pedro was forced to retreat to a fortified tower owned by his family to escape from death threats (Arróniz 1994:141).

All five sons of the Palacio y Arce family were active in naval and military affairs. In a letter written 8 March 1578, Diego explained that he was the oldest of five brothers who had all served the king (Arróniz 1994:151). Three brothers were killed in battle: Felipe de Palacio died in the Italian Wars as a lieutenant in the defense of Naples; Juan de Palacio was killed during the Siege of Malta in 1565; and Pedro de Palacio met his end while serving in John of Austria’s forces against the Ottoman fleet at Lepanto in 1571. The youngest brother, Lope de Palacio, survived the vagaries of war, attaining the rank of capitán and emigrating to the colonies in 1582 (AGI 1582), where he profited from a close relationship with his eldest brother.

It has been suggested by some authors (e.g., Fernández de Navarrete 1851:334) that Diego was also initially educated for a naval career, but there is no evidence to support this. Whatever the case, he studied at the University of Salamanca and received a licenciado, or law degree. Although literacy was a luxury in the 16th century, the demand for colonial bureaucrats in the Spanish empire augmented the economic yield of a university education. In Spain, economic priority was given to the eldest son, as reflected in the strong tradition of primogeniture. As such, Diego carried the ambitions and aspirations of his entire family, and his career would have been carefully planned to enhance the family’s fortunes. A licenciado was virtually guaranteed a secure and prestigious position in the colonial bureaucracy: “law was the road to wealth, influence, and social prestige” (Kagan 1974:xxii). The civil servants, or letrados, who served in the Spanish bureaucracy were typically impoverished hidalgos, or members of the lower nobility (Poole 1981:149), and the bureaucracy offered an
attractive opportunity for social mobility. A post in the civil service was literally referred to as a *premio*, or reward (Kagan 1974:77).

The investment was worthwhile. By 1567, García de Palacio was appointed to the position of *juez* (judge) in Spain (Cuesta Domingo 1994:80). In 1572, he was assigned to fill the post of *fiscal*, or crown attorney, in the *Audiencia* of Guatemala (AGI 1572), and he received a promotion to *oidor* (high court judge) within a few months, despite the fact that he did not arrive in the New World until early in 1574 (Arróniz 1994:67-69). An *audiencia* was the highest court of appeals in a colonial jurisdiction, hearing both civil and criminal cases. García de Palacio’s responsibilities would have included reporting on circumstances in the colony, issuing decrees, and making recommendations to improve the administration of the colonies. His ability to access these *plazas de asiento*, or high level posts, was undoubtedly enhanced by his advantageous marriage to Isabel de Hoyo. Isabel was the niece of the secretary to Charles V (Arróniz 1994:147), and royal secretaries were influential in determining who was hired for important positions (Kagan 1974:90).

In 1573, the *Consejo de Indias*, or Council of the Indies, sent letters to royal officials in the colonies outlining 135 questions about the geography, resources, population, and native cultures of each *audiencia* (Fowler 1985:49). In response, García de Palacio submitted a detailed letter to Philip II, dated 8 March 1576, reporting on the native inhabitants of various provinces of the Audiencia of Guatemala (García de Palacio 1576). García de Palacio’s ethnographic writings are as valuable to scholars of the native cultures of Central America during the early colonial period as his descriptions of shipbuilding are to maritime researchers. This letter has served as a primary source for ethnohistorical analysis of the Pipil Indians of present-day El Salvador (e.g., Fowler 1985). He was the first European to describe the Mayan ruins at Copán, and his letter provided the most comprehensive account of the site until Juan Galindo initiated formal investigations 250 years later.

García de Palacio was interested in indigenous cultures and gathered information from a range of sources including personal observation, consulting reliable informants such as indigenous elders and local priests, studying and collecting native manuscripts, and soliciting reports from colonial officials (Fowler 1985:50). Ethnographers and historians consider his descriptions of native cultures to be exceptionally reliable. García de
Palacio was so engaged by these ethnographic endeavors that he produced a set of guidelines, preserved in the AGI, to advise other royal officials charged with writing ethnographic accounts (Fowler 1985:50,55).

Acting under the authority of a cédula real, or royal decree, issued in Madrid on 10 February 1576, García de Palacio contracted with Diego López, a vecino (citizen) of Trujillo in Honduras, for the responsibility for the colonization of the province of Tegucigalpa between Cape Camarón and the San Juan River, the area known today as the Mosquito Coast (Fernández de Navarrete 1851:331–332).

In another letter to Philip II dated 8 March 1578, García de Palacio offered to conquer the Philippines at personal expense in exchange for the governorship of the islands (Fernández de Navarrete 1851:332), a proposal that suggests he had some financial resources at his disposal. Spain had assumed control of the Philippines seven years earlier, but the colony was administered until 1584 by the government of New Spain. In the same letter, García de Palacio petitioned for the trade route across Central America to be moved from Panama to Honduras, where it would run from Puerto Caballos to the Bay of Fonseca. The suggestion was evidently self-serving since he was posted in that region at the time. The same scheme had been proposed earlier in a number of memoriales (petitions) written to the king by various pilots since at least the 1550s (Lamb 1995:58). There is no indication that the Consejo de Indias pursued any interest in either of García de Palacio’s initiatives.

On 11 April 1578, García de Palacio was appointed to serve as an alcalde de crimen, or criminal court judge, in Mexico City (AGI 1578), but he did not assume the post until sometime in 1580. In the interim, he remained in the port of El Realejo on the Pacific coast of Nicaragua; a letter written on 6 December 1578 indicated that he had begun construction on two ships at the request of the king (AGI 1578b). García de Palacio also ordered the planting of cotton for canvas and the harvesting of agave, or maguey, to produce pita fiber for rigging.

On 30 April 1579, García de Palacio wrote to the king from El Realejo describing a series of attacks along the coast of Peru by ten men led by the English privateer Sir Francis Drake (Arróniz 1994:78-82). Drake had captured a pilot who was familiar with the route to China, an incident of considerable concern to the Spanish colonial administration. García de Palacio was appointed by the viceroy as capitán general (commander) of an
expedition to pursue Drake, which failed due to the inability to rapidly assemble a fleet. However, Arróniz (1994:82-88) describes how the half-hearted naval expedition provided an ample opportunity for a meticulously executed pillaging of the royal coffers by García de Palacio and those in his favor.

On 24 January 1581, he received a doctorate of law conferred by the Real y Pontificia Universidad de México, now the Universidad Nacional Autónoma de México (Arróniz 1994:161). The conferral of this degree does not indicate that he studied in Mexico City, but rather likely recognized studies undertaken in Spain (Rodríguez-Sala 1994:184). He was appointed rector of the university for a period of one year, beginning 10 November 1581 (Arróniz 1994:163). He served concurrently as an oidor for the Audiencia of Mexico and as consultor (judge) for the Tribunal of the Holy Inquisition.

The vessels begun in 1578, named the Santa Ana and the San Martín, were not finished until 1582 and construction costs were considerably higher than originally estimated. The two galleons built using local cedar, had a combined capacity of 1000 toneladas (Spanish tons). Ships used in the Pacific coastal trade generally did not exceed 400 tons, with much smaller vessels being typical, and the size of Manila galleons was officially limited to 300 tons by 1593 (Borah 1954:67). The ships cost 46,000 pesos each to build, at a time when similar ships could be built in Manila for about 6,000 pesos (Arróniz 1994:77). Although construction costs may have been legitimately higher in Nicaragua, this extreme discrepancy soon brought García de Palacio to the attention of archbishop Pedro Moya de Contreras as he began his investigations into bureaucratic corruption in New Spain (AGI 1584). To exacerbate matters, in 1586 García de Palacio entered into a disingenuous scheme, with the complicity of Álvaro Manrique de Zúñiga, marqués de Villamanrique and seventh viceroy of New Spain, to buy the San Martín from the crown for a tiny fraction of its original construction costs (about 16,000 pesos), using the rationale that it would be more economical for private merchants to administer the costs (and presumably the profits) of commerce with the Philippines (Arróniz 1994:127). The viceroy effectively granted Diego and his brother Lope a monopoly over the Manila-Acapulco route. Less than a year later, in late 1587, English privateer Thomas Cavendish captured the Santa Ana off
Baja California, as it returned from the Philippines reprehensibly unarmed (Arróniz 1994:120), while the San Martín sank off Macao in 1591.

In the role of juez visitador (royal inspector), García de Palacio produced a detailed census of the Mayan populations of the provinces of Yucatán, Cozumel, and Tabasco in November 1583 that is preserved in the AGN (O’Gorman 1940). These accurate records have proven invaluable to scholars attempting to reconstruct the early post-contact residential pattern of the Maya (e.g., Roys et al. 1959). This visit was also later recorded in a Chontal Maya account from Acalan-Tixchel written in 1612: “In the year 1586 [sic] Dr. Palacios came to visit the land, and we, the people of Tixchel, gave him canoes and paddles. We opened the roads so that the minister might go to visit these cabob [villages]…” (Restall 1998:74).

The Diálogos militares were published in the same year, evidently with the objective of instructing other colonists in military strategy so they could assist in García de Palacio’s ambition of conquering the Philippines. Like the Instrucción náutica published four years later, this volume comprises four books presenting a dialogue between a vizcaíno and a montañés. In the introduction, García de Palacio recognizes that some readers might question why a lawyer would write about military affairs; his justification is that all aspects of law were already adequately explained, so he had decided to share his thoughts on military matters. Book One describes the qualities and responsibilities of a captain and of a soldier, and provides a discussion of the ethics of warfare. Book Two is a practical treatise on the construction of artillery and the use of gunpowder and shot, while Book Three discusses military tactics and the formation of squadrons for marches and battles. Finally, Book Four outlines the preparations required for a battle, the roles of the troops, and specific techniques for fighting under different circumstances. Eugenio de Salazar, a noted poet of 16th century New Spain and a friend of García de Palacio, provided a prologue for the book. Based on the distinctive styles of different parts of the volume, with some sections written in stanzas and others providing a straightforward discussion of military strategy, Arróniz (1994:46-48) has speculated that Salazar may in fact have written substantial parts of the work without receiving full credit.

On 7 February 1587, viceroy Manrique de Zúñiga conferred the licence to publish the Instrucción náutica. In a letter preserved in the AGI, García de Palacio wrote to the king from Mexico City on 20 April 1587 to give
notice that he had completed a volume on nautical instruction written for the latitude of Mexico (Fernández de Navarrete 1851:333). The content and significance of the *Instrucción náutica* are discussed below.

A commission of 10 September 1587 records that García de Palacio was appointed by the viceroy to serve once again as the *capitán general* of a fleet dispatched from Acapulco to pursue English privateers in the Pacific following a series of raids in Peru by Thomas Cavendish (AGI 1587). The commission granted him considerable discretion in executing the assignment based on his perceived knowledge of naval affairs. Once again, García de Palacio’s mission was unsuccessful. Moreover, after capturing the unarmed *Santa Ana* in November, Cavendish sailed west to the Philippines, guided by captured Spanish pilots.

Two years later, García de Palacio was sentenced by the Council of the Indies on 72 separate charges of corruption and abuse of office (O’Gorman 1946:7). The charges included nepotism, acceptance of bribes, use of threats, using his office for financial gain, displacement of native settlements, and forcing Indians to work without pay. On 19 April 1589, García de Palacio was read the penalty imposed by the Council of the Indies: he was suspended for nine years from his post as *oidor* and ordered to pay fines and restitution.

The fortunes of family members were interconnected, and Diego had evidently used his post to enhance the wealth and social standing of his relatives. Indeed, in 1589, both his brother Lope and his uncle Felipe were cited as beneficiaries of Diego’s questionable business transactions, having received land, slaves, cattle, and water rights for a sugar mill (O’Gorman 1946:25-28). Some of this activity reflected land speculation, with properties acquired illegally by Diego being consolidated in his brother’s and uncles names, a typical practice among *letrados* at the time (Poole 1981:156).

Such corruption was an institutionalized aspect of the colonial bureaucracy in which officials routinely combined public service with financial and social self-interest, leading to conflicts of interest involving judicial favoritism, influence peddling, land speculation, and bribery (Poole 1981:150). Bureaucrats in the colonies complained frequently that their salaries did not compensate for the high prices of goods in the New World. In the first book of the *Diálogos militares*, García de Palacio complained candidly that “matters in the Indies... are so meager that if one is not among those holding offices in the service of His Majesty
or who trade in merchandise, one now cannot possess the comforts that seem reasonable for an honorable person” (García de Palacio 1583:7v). An interesting counterpoint to these charges is provided in a native petition of 1605 protesting colonial exploitation of indigenous labor, which specified that *oidor* “Doctor Palacio” had in earlier years abolished the forced labor rotations imposed on some Maya communities (Restall 1998:174).

García de Palacio did not live long enough to reclaim his post. He died sometime before 15 November 1595, the date his funeral oration was read in the church of the Santísima Trinidad in Mexico City (Bankston 1986: v). The following year, his widow and children petitioned Philip II for a pension to offset the financial suffering caused by the fines (AGI 1596). The family seems to have retained substantial assets despite their asserted hardships: according to a document in the AGN dated 1599, Isabel de Hoyo, widow of Dr. Palacio, sought permission to remove four or five thousand head of cattle from her estate in the region of Coatzacoalcos in the jurisdiction of Villa del Espíritu Santo near Vera Cruz (Arnold 2005).

**Instrucción náutica**

Like the *Diálogos militares*, the *Instrucción náutica* was printed by Pedro Ocharte, a native of Rouen in Normandy, who relocated to Mexico City in 1548 (Rodriguez-Buckingham 1984:67). Ocharte married the daughter of Juan Pablos, an Italian printer who had established the first commercial printing press in the New World in Mexico City in 1539. In 1563, Ocharte assumed Pablos’s business, which he operated until 1592. While early publications of the Spanish colonies were primarily religious texts or grammars of native languages, the range of books published in Mexico City was more diverse and included a some works on technical matters such as medicine, law, and music.

The *Instrucción náutica* was published as a small quarto, made by folding each printed sheet twice to form four leaves with eight pages. Only the recto, or front side, of each leaf is numbered. The 156 sheets, or 312 pages, of the *Instrucción náutica* are divided into standard sections that are recognizable to any modern reader. These include: a title page; a licence for publication; a dedication; a table of contents; an introduction; four books comprising many shorter chapters; and a glossary.

The introduction clearly exhibits García de Palacio’s humanist education, with numerous references to the Bible and to various classical
writers. The discussion begins with a description of the four elements of the classical world (earth, air, fire, water), then proceeds to explain the role of water and of ships in the cosmic order. Using a popular convention of its time, the text of the four books forms a lengthy conversation comprising a dialogue of questions and answers. Many Renaissance humanists imitated the dialogue form used by classical writers such as Plato in their writings (Kristeller 1983:6), and the form was apparently in favor at the University of Salamanca (Rodríguez-Sala 1994:194). The vizcaíno, serves as a foil, asking questions to set up the explanations made by the expert, and requesting examples, clarifications, and figures to ensure his understanding. The vizcaíno then heartily agrees with each explanation, emphasizing the authority of the montañés to the reader.

The publication is set in roman typeface, a style preferred by many Renaissance humanists for its efficient spacing. Like other books of the period, aside from the title page, the Instrucción náutica is relatively plain, with little decoration or rubrication. It was typical of 16th Century Spanish books to include an elaborate display at the beginning, with few pictures in the text (Bliss 1964:89). In this case, Viceroy Manrique de Zúñiga's coat of arms is reproduced on the title page of the book. Some of the chapters begin with decorative initials, but even these are extremely simple.

The Instrucción náutica is an extremely rare book, with perhaps a dozen surviving copies. Original copies exist in the Library of Congress, the New York Public Library, the John Carter Brown Library, and the Huntington Library (Tate 1941:194).

**Navigation**

The first three books of the Instrucción náutica discuss typical navigational techniques of the 16th century. Generally speaking, the navigational information included in the Instrucción náutica reflects information that was previously published elsewhere, and much of the content appears to have been adapted from existing sources. Navigational treatises were relatively common in the 16th century due to Spain’s increasing need to ensure safe navigation as the empire expanded across the Atlantic and Pacific oceans. Only medicine superseded navigation in terms of the number of treatises written in Spanish in the 16th century (Carriazo Ruiz 2003:11). Significant innovations made by García de Palacio include the calculation of dates using the Gregorian calendar introduced in 1582.
and the computation of navigational figures specifically for the latitude of Mexico.

Book One (pages 1 to 49) consists of nine chapters. It is devoted to nautical astronomy and describes the division of the globe by latitude and longitude; the positions of the poles and the equator; the use of navigational instruments, including the astrolabe, cross-staff, quadrant, and compass; and instructions for calculating the time of day. Tables of astronomical declinations are published on pages 15v to 23. Book Two occupies pages 49v to 65 and comprises nine chapters that include a discussion of astronomy, complete with tables of the Zodiac, as well as descriptions of the movement of the sun, the moon, the planets, and the tides. The three chapters of Book Three span pages 65v to 87v, and contain information on navigation, including the use of sea charts and a set of lunar tables computed for the years 1586 to 1604.

Flor Trejo Rivera (2006, elec. comm.) of the Instituto Nacional de Antropología e Historia (INAH) in Mexico is currently undertaking a detailed study of the navigational information presented in the Instrucción náutica. Trejo Rivera’s work will compare the navigational information presented by García de Palacio with other contemporary treatises and will assess its significance in the development of navigational science.

**Ships**

Book Four is the most historically significant section, and has attracted considerable scholarly attention. As García de Palacio (1587:87v) himself emphasized, the fourth book discusses subjects that to a large extent no one had previously written down. The 35 chapters, running from pages 88 to 128v, include information about the dimensions and proportions of ships, masts and rigging; boats; equipment such as pumps, anchors, cables; supplies and stores; the duties and qualities of officers and crew, including the captain, master, pilot, caulker, carpenter, surgeon, seamen, and pages; the modification of vessels for use in warfare; and naval tactics for attack and defense.

García de Palacio describes various vessel types used by the Spanish in the New World, including frigates, brigantines, and naos, while explaining how the size and proportions of ship were modified to accommodate the environment and function in which they would be used. For example, small frigates of 50 toneladas used in the Windward Islands of the Lesser Antilles
needed to be able to sail close to the wind and had minimal upperworks, while those used in the Gulf Coast of Mexico needed to be shallow to enter the ports in that region.

García de Palacio centers his discussion around a *nao* of 400 toneladas, the size that he considered to be ideal for both warfare and trade (1587:90). As García de Palacio contends, *naos* were multipurpose vessels that could be used in a wide range of activities including trade, fishing, exploration, and warfare. The text provides a number of proportional rules used to derive the breadth, depth, and overall length based on the length of the keel, roughly following the traditional proportions for Iberian ships of *as, dos, tres* (1, 2, 3) for the ratios of the breadth, keel length, and overall length. Interestingly, García de Palacio’s use of proportional methods to control the size of the ship are paralleled by a shift in Renaissance architecture away from geometric principles toward rules of proportion (Hart 1998:5).

Woodcuts depict the shape and dimensions of the 400-tonelada ship and of another 150-tonelada vessel that is briefly mentioned, but not discussed, in the text. Notably, the two ships García de Palacio describes both have the same length of keel. However, the larger ship has more than twice the capacity of the other. The difference in capacity results from variations in the breadth, the overall length and, especially, the depth of hold.

These drawings represent an early attempt to graphically illustrate the complex empirical system of hull design in use at the time. While only a sheer view and sections are given for the larger vessel, the drawings of the 150-tonelada ship provide a plan view, a sheer view, and three sections (the master frame and two tailframes), presaging the sheer, body, and half-breadth plans of modern lines drawings. However, the information that they convey regarding hull form is much less comprehensive.

There is a noticeable lack of symmetry in the sections, and Burlet and Rieth (1988:473) calculated distortion of up to 6 percent in the dimensions in the drawings. Because woodcut plates were made of softwood such as pear or apple, the plates wore quickly, reducing the quality of later impressions (Lindley 1970:13). In addition, some methods of woodblock printing involve placing the block face down on the paper and then hammering the back, causing the block to shift slightly and distorting the image.

Careful comparison of the text and plates leads to the conclusion that the illustrations may be only tangentially related to the text. While it is clear that García de Palacio understood the importance of proportions for
determining the tonnage and handling qualities of ships, certain technical aspects of ship design that are embedded in the drawings are not discussed in the text and seem to have escaped his comprehension. While the text discussed methods used to establish the basic proportions of a ship, unlike the contemporary notebooks of shipwrights and naval architects such as Mathew Baker (ca. 1580) and Manoel Fernandes (1616), García de Palacio fails to address the means of determining the curvature of the bow, the frame shapes, or the rising and narrowing of the frames. For example, the drawings reflect a design method in which the shipwright thought of the hull in three parts: a wide central section and the two ends of the vessel where the shape narrowed dramatically toward the stem and sternpost. The tailframes illustrated for the 150-tonelada vessel marked the transition between these three sections, and with the midship frame comprised the basic reference points that determined the form of the hull. To create a fair hull, the shipwright had to be able to create gradually increasing curves between these points, but García de Palacio is silent regarding such matters.

The drawings in the García de Palacio publication clearly suggest the use of a *graminho* – a geometrical algorithm – to calculate fair narrowing and rising lines, but this technique is not discussed in the text. From as early as the 15th century, at least two different methods were commonly available for calculating the rising and the narrowing: one was based on the *mezzaluna*, a pattern shaped like a half moon, and the other uses a simple geometric progression projected onto a triangle. Although the drawings in García de Palacio are crude, the curvatures appear to have been calculated with a *mezzaluna*.

Given the level of detail with which García de Palacio addresses other subjects, it seems unlikely that the lack of discussion regarding these problems is an oversight. As we know, shipbuilders closely guarded such knowledge and, without some explanation, methods such as the *mezzaluna* would be inscrutable to even the most patient observer. A plausible explanation is that the woodcuts are not based on drawings made by García de Palacio himself, but are adapted from another source. Reusing pictures from older manuscripts by inserting them into new books was customary in early printing (McKitterick 2003:60). Illustrations and text were almost always produced by different people and were often entirely unrelated. Many printers maintained a stock of woodblocks that were used somewhat
arbitrarily to decorate the pages of books, and only cursory attempts were made to match the illustrations to the text (Lindley 1970:15).

As a scholar, it is possible that García de Palacio had in his collection a notebook or other documents prepared by a shipwright or naval architect who was intimately familiar with details of ship design. Typical contemporary shipbuilding manuscripts contain numerous illustrations of frame shapes, rising lines, and other principles of ship design similar to those embodied in the woodcuts of the *Instrucción náutica*. García de Palacio may have had an artisan produce woodcuts based on drawings in such a notebook. There were undoubtedly many hand-written treatises and notebooks describing ship construction that have not survived to the present day. Although no exact matches have been identified for the source of the illustrations, the images exhibit general similarities with contemporary treatises. For example the shapes of the master frames echo those depicted Mathew Baker (1580) and Antonio de Gaztañeta Yturribalzaga (1688), suggesting some common lineage.

**Rigging**

Perhaps the greatest contribution of García de Palacio’s treatise has been in improving understanding of late 16th Century Spanish rigging. García de Palacio provides proportional rules for calculating masts and yards, and illustrates the dimensions and shapes of the sails for the mainmast (including mainsail, bonnet, and topsail) and mizzen. The treatise also describes in considerable detail the proper rigging of the stays and shrouds that formed the standing rigging, and the ties, lifts, braces, sheets, tacks, and bowlines used to manipulate the yards and sails.

The discussion of the spars and rigging refers specifically to the larger 400-*tonelada* ship. Initial attempts at reconstruction have produced masts and spars that appear extreme by modern standards, but the proportions indicated by García de Palacio are supported contemporary images suggest that some of 16th Century vessels carried masts that would be considered overly long today. García de Palacio himself comments that the main mast may be dangerously long, and suggests that it could be shortened, with the extra length added to the topmast. All of the lengths of the masts and spars are based on the keel length, which is the same for both the 150 *toneladas* and 400 *toneledas* ships, but García de Palacio does not indicate how the spars should be reduced for the smaller vessel.
These written descriptions of 16th Century rigging are confirmed by archaeological evidence from contemporary shipwrecks, with the largest collections of surviving 16th Century rigging belonging to the Mary Rose and the Red Bay wreck (presumably the San Juan, 1565). For example, García de Palacio describes pendant tackles rigged inside the shrouds that were used for hauling boats and cargo and that also reinforced the shrouds and backstays. Tackles similar to those described by García de Palacio are visible in many 16th Century ship depictions and were found lashed to the chainwales of the Mary Rose (Rule 1982:142). Other interesting features described by García de Palacio include bowsprit shrouds, which are commonly considered to be an innovation of the 18th century (e.g., Lees 1979:159). He also clearly describes the use of a preventer stay, which other sources suggest should not appear until 1650 (Anderson 1982:96).

**Glossary**

The final section of the Instrucción náutica, running from pages 129 to 156v, is titled “Vocabulary of the terms used by seafarers, in all that concerns their art, in alphabetical order.” It comprises one of the earliest nautical glossaries, and lists over 500 terms related to navigation, shipbuilding, rigging, and equipment. The inclusion of the glossary reinforces the inference that the Instrucción náutica was intended for a non-specialist audience. The glossary appear to have been a primary source for the anonymous Vocabulario marítimo published in 1722 in Seville, as well as Timoteo O'Scanlan’s Diccionario marítimo español, published in 1831.

**Discussion**

The general form and content of the Instrucción náutica share similarities to a number of contemporary documents, in particular the works of Juan de Escalante de Mendoza (1575), Thomé Cano (1611), and an anonymous treatise of ca. 1631–1632 tentatively attributed to Pedro López de Soto (Vicente Maroto 1998:23-26). Each of these documents discusses the shipbuilding traditions of northern Spain and all are written as dialogues. Unlike the shipbuilding notebooks of Mathew Baker and other incipient naval architects, these texts were written by captains, navigators, pilots and administrators who, although familiar with ships and seafaring, did not necessarily have direct experience building or designing ships. They include few illustrations and are concerned with the overall proportions of
ships rather than the specifics of design or construction. Either the beam or the length of the keel is used as the basic measurement from which all of the other measurements are calculated.

Until the Renaissance, the skills and techniques of ship construction were passed empirically between masters and apprentices through oral tradition and repeated practice, and were carefully guarded. In the words of Elizabeth Eisenstein (1983:138), “doctrines cultivated by cloistered monks and veiled nuns were less hedged in by secrecy than trades and mysteries known to lay clerks and craftsmen.” During the 16th century, the printed word took on increasing influence and importance. The fact that the manuscript was published in Mexico City reflects the importance of seafaring for Spain’s colonies. However, it may also indicate that the ability of the guild system to control specialized knowledge relating to shipbuilding was less effective in the New World.

It is also likely that there were relatively fewer shipwrights in the Americas with the knowledge and experience to build ships of consistent dimensions. For Renaissance ship builders and designers, the shipyard was a place of negotiation. Within general limits, ship design and construction were adapted to specific circumstances. New World shipbuilders may have been more likely to disregard prescribed formulas than their counterparts in Europe. An 18th Century description of the colonial shipyard at Guayaquil illustrates the lack of standardization in at least some isolated parts of the Americas:

The builder in this shipyard is a negro: he is the only one who directs the construction of ships, according to the best idea his experience permits, because even the principal measurements received from Europe, which are fundamental to ship, are not followed: the keel, length, breadth, and depth of the ship is left to his judgment or to that of the owner who is paying for the vessel; once these dimensions are determined, he continues the construction until the end, eyeballing it all the way. (Clayton 1980:65)

Juan de Escalante de Mendoza referred to this uncontrolled method of ship design as troche moche (haphazard) and complained that, as a result, ships that were intended to be small turned out large, and ships that were intended to be large turned out small (Escalante de Mendoza 1985:38).

Further Research

Despite frequent references to García de Palacio in discussions of 16th Century Spanish ships and seafaring, little substantive analysis of
the *Instrucción náutica* has been undertaken. A number of short articles describe the work and its potential significance (e.g., Tate 1941; Cuesta Domingo 1994), while other brief studies focus on specific aspects of the document, particularly García de Palacio’s method of calculating tonnage (e.g., Phillips 1987; Mawer 2006). The present research will evaluate the *Instrucción náutica* in terms of its historical context, accuracy, and contributions to understanding 16th Century Iberian seafaring and shipbuilding. Hypothetical reconstructions of the lines and rigging of the 150- and 400-toneladas vessels are being prepared. A previous reconstruction of the 400-tonelada ship using a half model of the hull (Burlet and Rieth 1988), although generally valid, requires some refinement, particularly concerning the placement of the tailframes. No reconstructions of the smaller 150-tonelada ship or of the masts, rigging, and sails have been developed. Tonnage calculations based on preliminary reconstruction of the 150-tonelada vessel have produced a value near that intended by García de Palacio, suggesting a high level of accuracy. In addition, the contemporary design principles embedded in the illustrations, but not discussed in the text, are being analyzed. Relevant documentary, pictorial, ethnographic, and archaeological data will be incorporated into the interpretation.

Although this research is focused on technical aspects of ship construction and rigging, the description of the ships constitutes one very small section of a single chapter of Book Four, which comprises a total of 35 chapters. Therefore, this research will include discussions of García de Palacio’s writings on navigation, crew and officers, equipment and provisions, and naval tactics.

J. Bankston (1986) prepared a very useful English translation of the *Instrucción náutica*. Nevertheless, detailed study has confirmed the value of returning to the original Spanish text. In conjunction with the current research project, a transcription and new translation of the document is also in preparation.

**Conclusions**

Without a doubt, García de Palacio’s careful observations of many remarkable aspects of life in 16th Century New Spain were motivated in part by his natural intelligence and inquisitiveness. But what was the intention of this colonial bureaucrat in publishing a manual containing
shipbuilding information that was already understood by most of the illiterate workers in the shipyards? Who was the intended audience for the *Instrucción náutica*?

Based on its instructive style and the inclusion of an early nautical glossary, the document was clearly intended for non-specialists. Once published, information that had been guarded as the domain of specialists was made available to anyone who could read. Carriazo Ruiz (2003:11) points out that navigation, along with medicine, and was one of the first disciplines to apply technical knowledge, grounded in complex scientific principles, to a practical problem. However, García de Palacio may have been as concerned about the political interests as the pragmatic technical demands of his time. Arróniz (1994:37) aptly compares the notion that the *Instrucción náutica* contains all of the practical knowledge required to build a ship in 16th century Mexico to the expectation that a treatise on the theory of musical composition might provide a reader with sufficient understanding to write a symphony.

The information provided by García de Palacio would have been of value and interest to a colonial elite that required only a general understanding of nautical matters. Similarly, 16th Century architectural books were read primarily by the nobility rather than by actual practitioners, and their publication did not lead to any substantive changes in the practice of architecture or construction (Morresi 1998:265). Shipbuilding orders issued by a viceroy usually specified only the general measurements and tonnage of the ship, along with authority to procure materials and labor (Clayton 1980:23). Although their control over the shipbuilding process was more administrative than technical, additional information may have been of interest to bureaucrats. Given his known business ambitions regarding the construction of ships on behalf of the king and control over the trade to the Philippines, García de Palacio motivation in publishing the document may have largely been to establish that he was competent to undertake such activities.

The ability to construct dependable ships for trade and defense was essential to the operation of the trade routes linking Spain’s empire, not only along the *Carrera de Indias*, but also across the Pacific and along the local coastal routes of the New World. One of García de Palacio’s objectives in publishing the *Instrucción náutica* was not only to reach and influence a larger audience, but also to regulate shipbuilding in the New World by
establishing standards for construction. This reflects an increasing concern with regularizing ship types to create better naval and merchant fleets, presaging the shipbuilding standards that were legally prescribed by the Spanish crown in the ordenanzas of the early 17th century.

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Rigging an Early 17th – Century Portuguese Indiaman

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Abstract

The Pepper Wreck is an early 17th Century nau da India, the first Portuguese Indiaman ever to be excavated by archaeologists, and it is believed to be the remains of the Nossa Senhora dos Mártires, lost on the Tagus River sandbar, Portugal, in 1606. The archaeological remains yielded enough information to allow a tentative reconstruction of the hull and rigging. A series of tests was performed on the reconstructed ship, which allowed a better understanding of these ship type and are the basis of an ongoing in-depth study of its sailing characteristics, intern space and life aboard.

Introduction

The Pepper Wreck was found in 1992 and archaeologically excavated between 1996 and 2000 (Figures 07-01 and 02). It has been identified as the Portuguese nau Nossa Senhora dos Mártires, lost at São Julião da Barra on the 14th of September 1606, on its returning voyage from Cochin, India, where it had been laden with a rich cargo of peppercorns, cotton bails, spices, drugs and a number of exotic products from the rich markets of the Indian and Pacific oceans (Alves et al. 1998).
The hull remains were preserved in a layer of peppercorns and the excavation of a small area around the shipwreck yielded more than 2000 artifacts, all consistent with the time frame of the voyage of the nau Nossa Senhora dos Mártires (Afonso 1998). For instance, astrolabe SJB III is dated to 1605, the date of departure of the nau Nossa Senhora dos Mártires, and bears the “G” of the Portuguese Góis workshop where it is thought to have been made (Figure 07-03).

Shattered against the rocky bottom off the fortress of São Julião da Barra in a matter of a few hours, the hull of the Nossa Senhora dos Mártires was salvaged soon after the shipwreck and during the following years. Only a small portion of the forward bottom of the hull survived, protected between two rocky outcrops, at a dept of around 9 m. After analysis, the artifacts distribution was consistent with the reconstructed site formation process. The positions of the astrolabes SJB II and SJB III, together with a pair of dividers found nearby and a small iron gun, are close to where the starboard stern castle is though to have been broken, and an anchor and bronze culverin were found on the starboard bow, to leeward of the strong
southern winds that are described in the contemporary accounts of the shipwreck (Figure 07-04).

Astrolabe SJB I was 20 m away from the center of the shipwreck site and, although it may have belonged to another shipwreck that occurred at São Julião da Barra – there are historical references pertaining to many shipwrecks in this area – may also attest the violence of the storm and the rapid drift of the ship, once it lost headway and started heeling in the swell, and hitting the bottom.

The study of the hull, the most important artifact, yielded precious and unexpected information, of which the carpenter’s marks found at the turn of the bilge are undoubtedly the most relevant (Castro 2003a and 2005a).

Identification

The amount of peppercorns found over and around the hull remains pointed clearly to a returning India nau, a hypothesis that was reinforced by the nature of the artifact collection. The date of this shipwreck was objectively determined after 1605, the date inscribed on the astrolabe SJB III (Figure 07-03), but very soon after, because Wan-Li porcelain (Figure 07-05) was dated to the last decade of the 16th century (Shingraw and Porten 1996).
Curiously, the bronze culverin was dated to the mid-16th century, based on the signature of its maker, Remigy de Halut, who had been a founder at Malines, Belgium, between 1536 and 1568 (Figure 07-06). It was not uncommon for ships to carry old guns – certainly in service – as attested, for instance, by the elusive “CFRO” guns, found in shipwrecks such as the one of the great galleon São Bento, lost in 1554, at the mouth of the Msikaba River, South Africa, and the shipwreck of Ponta do Altar B, Portugal, dated to the early 17th Century (Auret and Maggs 1984, 4-7; Alves 1992).

A quick search in the archival database immediately yielded a shipwreck exactly on that spot: the India nau Nossa Senhora dos Mártires, lost right in front of the São Julião da Barra fortress in September of 1606, on its return trip from Cochin, the Portuguese port in the Indian subcontinent.

The ship’s hull
The ship’s hull remains were recorded in plan and sections were taken at every preserved frame station. The planking was mapped at a 1/1 scale and all spike holes’ positions were double-checked. Samples were taken from the
The first clue to the study of the ship remains was the nature of the scantlings: a certain number of very important features measured either exactly or very close (within a 3 or 4% error) to the units in the Portuguese shipyards. The second clue was the timber utilized to build this ship. The two species identified, cork oak (*Quercus suber*) for the keel, frames and apron, and umbrella pine (*Pinus pinea*) for the hull planking, were indicated in Portuguese shipbuilding treatises of this time, the first preferred for the structure and the later for the hull planking, as found on the site. The third clue was the shape of the bottom, expressed by the values of the rising of the floor timbers over the keel, and the values of the narrowing of the turn of the bilge marks found. It was possible to measure the narrowing values only in four frames, where the turn of the bilge marks, inscribed by the shipwright, were still visible. These later values were obtained after “closing” a fracture with highly eroded edges and are not all equally reliable. The values obtained after subtracting the width of the fracture nevertheless fit very well the shape obtained with theoretical values. The forth clue pertained to the construction details, which looked very familiar when compared with the drawings and descriptions of contemporary shipbuilding treatises.

Carpenter’s marks were paramount for the interpretation of this ship’s construction, and consisted of three types of marks with obvious archaeological significance: turn of the bilge marks, centre and sides of the keel marks, and frame numbers (Castro 2005a).

The caulking arrangement was another detail adding to the already strong conviction that this was a Portuguese ship (Castro 2005a). It consists of one or two layers of oakum pressed from the outside against a twisted string of lead and has been reported in only another two shipwrecks: the Portuguese wreck of the Seychelles, probably the nau *Sto. António*, lost in 1589; and the Molasses Reef shipwreck, lost in the Turks and Caicos Islands during the first decade of the 16th century and though to have been at least related to a Portuguese venture, because the ballast is known to have been loaded in the Tagus estuary.

The archaeological data retrieved from this ship’s hull remains was therefore analyzed in light of the contemporary Portuguese treatises. These were primarily:

a) Fernando Oliveira’s *Livro da Fabrica das Naus*, dating to the 1580s (Oliveira 1991);
b) João Baptista Lavanha’s *Livro Primeiro de Arquitectura Naval*, from around 1610 (Lavanha 1996);
c) Manoel Fernandez’ *Livro de Traças de Carpintaria*, dated to 1616 (Fernandez 1989);
d) Two contracts from the late 1590s, by Valentim Themudo and Gonçalo Roiz (Lavanha 1996);
e) Figueiredo Falcão’s *O Livro de toda a Fazenda* (Falcão 1859);

However, a list of prices pertaining to the construction of two India naus in the 1620s from the Harvard University library was also consulted, as well as the recipes contained in the *regimentos* of the manuscript *Livro náutico*, dated to c. 1590 and therefore closely related to period in which this ship was built and sailed (Domingues 2004).

Based on the values of the narrowing and the rising of the bottom at each station preserved in the ship remains it was concluded that this portion of the hull was located more or less before the three master frames, which were not preserved, but clearly visible from the fastening marks on the surviving hull planking (Figure 07-02).

The ship treatises and *regimentos* give a solid number of simple fractional relations between the ship’s main dimensions that make a strong case for the definition of a standard India nau within relatively small ranges of values. India naus remain nevertheless largely unknown to us and we must keep in mind that whatever standard may have existed or not, it was one that evolved continually, as time went by.

A set of lines was developed based on the portion of the hull remains preserved at São Julião da Barra and on the proportions indicated in the contemporary ship treatises and texts (Figure 07-07) and indicated below, on Table 01.

![Figure 07-07 – Set of lines drawings from 2001.](image-url)
All measurements in the contemporary documents are given in *rumos* (1.54 m), *braças* (1.76 m), *goas* (77 cm), *palmos de goa* (25.67 cm), *palmos de vara* (22 cm), and *dedos* (1.83 cm). Cargo capacities are indicated in *tonéis*, a unit that corresponds to the space necessary to house a barrel 1.54 m in height and 1.03 m in diameter, or 6 by 4 *palmos de goa*.

Table 1- Basic measures for the construction of Oliveira’s India nau

<table>
<thead>
<tr>
<th>Element</th>
<th>Rule of Proportion</th>
<th>Value (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Keel</td>
<td>18 <em>rumos</em> for 600 <em>tonéis</em></td>
<td>27.72</td>
</tr>
<tr>
<td>B. Spring of the stem post</td>
<td>1/3 of A</td>
<td>9.24</td>
</tr>
<tr>
<td>C. Height of the stem post</td>
<td>1/3 of A</td>
<td>9.24</td>
</tr>
<tr>
<td>D. Rake of the stern post</td>
<td>1/4 of A/3</td>
<td>2.31</td>
</tr>
<tr>
<td>E. Height of the transom</td>
<td>1/3 of A</td>
<td>9.24</td>
</tr>
<tr>
<td>F. Maximum breadth</td>
<td>1/3 to 1/2 of A</td>
<td>12.32</td>
</tr>
<tr>
<td>G. Flat amidships</td>
<td>1/3 to 1/2 of F</td>
<td>4.10</td>
</tr>
<tr>
<td>H. Room and space</td>
<td>1 <em>palo de goa</em> + 1 <em>palo de vara</em></td>
<td>0.48</td>
</tr>
<tr>
<td>I. Rising of the bottom</td>
<td>Forward: H; Aft: 1.5 H</td>
<td>0.48/0.72</td>
</tr>
<tr>
<td>J. Narrowing of the bottom</td>
<td>1/6 of G</td>
<td>0.68</td>
</tr>
<tr>
<td>K. Height of the fashion pieces</td>
<td>Start at 1/3 of E</td>
<td>3.08</td>
</tr>
<tr>
<td>L. Breadth of the transom</td>
<td>1/2 of F</td>
<td>6.16</td>
</tr>
<tr>
<td>M. Maximum breath on main deck</td>
<td>F - (∼ 1 + 1 <em>palo de goa</em>)</td>
<td>11.81</td>
</tr>
<tr>
<td>N. Depth of the hold</td>
<td>14 <em>palmos de goa</em></td>
<td>3.59</td>
</tr>
<tr>
<td>O. Depth of the second deck</td>
<td>9 <em>palmos de goa</em></td>
<td>2.31</td>
</tr>
<tr>
<td>P. Depth of the gun deck</td>
<td>9 <em>palmos de goa</em></td>
<td>2.31</td>
</tr>
<tr>
<td>Q. Length of the quarter deck</td>
<td>1/2 of length of deck (D + A + B)</td>
<td>20.46</td>
</tr>
<tr>
<td>R. Height of the quarter deck</td>
<td>8 <em>palmos de goa</em></td>
<td>2.05</td>
</tr>
<tr>
<td>S. Length of the poop deck</td>
<td>1/2 of Q</td>
<td>13.86</td>
</tr>
<tr>
<td>T. Height of the poop deck</td>
<td>7 <em>palmos de goa</em></td>
<td>1.80</td>
</tr>
<tr>
<td>U. Length of the forecastle</td>
<td>1/2 of M</td>
<td>5.90</td>
</tr>
<tr>
<td>W. Height of the forecastle</td>
<td>1/3 of M</td>
<td>3.94</td>
</tr>
<tr>
<td>V. Height of bulwarks on the deck</td>
<td>1 <em>rumo</em></td>
<td>1.54</td>
</tr>
<tr>
<td>X. Height of bulwarks on the castles</td>
<td>3 <em>palmos de goa</em></td>
<td>0.77</td>
</tr>
<tr>
<td>Y. Length overall</td>
<td>A + B + D</td>
<td>39.27</td>
</tr>
<tr>
<td>Z. Depth in hold</td>
<td>N + O + P</td>
<td>8.21</td>
</tr>
</tbody>
</table>
After this analysis the *Nossa Senhora dos Mártires* was reconstructed as a ship with a keel of around 27.72 m (18 *rumos*) and an overall length of close to 40 m.

The lines drawing developed in 2001 from the analysis of the ship’s hull remains and published in 2003 and 2005 (Castro 2003a and 2005a) was later used in a tentative reconstruction of the ship’s structure, and completed with information contained in the treatises mentioned above, as well as a number of ship representations dating to the 16th and 17th centuries (Castro 2003b).

As a result, the position of the ship’s decks and the basic defining dimensions of the hull were reviewed and corrected in order to get a better, a perhaps more accurate, representation of this ship type (Figure 08). However, because ship treatises, *regimentos*, and other texts on shipbuilding, were not intended for the average twenty-first century nautical archaeologist, they are always incomplete, often times unclear, and sometimes contradictory. This makes it almost impossible to state whether a reconstruction based on such small hull remains as the Pepper Wreck is accurate or not.

Only careful analysis, based on scientific premises, may make it possible to evaluate a given reconstruction, and to state whether it is a plausible solution or not.

![Figure 07-08 – Reviewed model, 2005.](image)

**The ship’s rigging**

The next logical step for the understanding of our India nau was the reconstruction of the ship’s masts and spars, sail plan, and then standing and running rigging.

Reconstructing the ship’s rigging is again a purely conjectural endeavor, but again the contemporary written sources have provided enough data to produce an educated guess. A comprehensive list of the documents of
potential interest was published in the meantime, providing an easy access to most of the documents consulted (Domingues 2004; Castro 2005b). Four of these documents were especially important:

a) “Medidas para fazer hũa Nao de Seicentas Tonelladas” regimento from the Livro náutico, a manuscript dating to the late 15th century (c. 1590) in the Códice 2257 of Biblioteca Nacional de Lisboa, Reservados;

b) “Medidas para fazer hũ galião de quinhentos toneis” also from the Livro náutico;

c) “Conta e Medida de hũa Nao de quarto cubertas como adiante se vera…” from the Livro de traças de carpintaria, Manoel Fernandez, 1616 (Fernandez, 1989);

d) “Conta das medidas de uma nau da India” from the manuscript Coriosidades de Gonçallo de Sousa, dated to c. 1620, in the Biblioteca da Universidade de Coimbra – Reservados, ms. 3074.

The first three sources contain both values and rules for the calculation of the lengths and diameters of masts and spars of several types of vessels (Table 2). The fourth is believed to be a copy of a source common to the Livro de traças de carpintaria (Xavier 1992) and was only used because it contained information that helped determine the rake of the main mast.

All texts pertain to similar vessels and were written over the period of time spanning from 1580 to 1620. It is a pity that Fernando Oliveira’s Liuro da fabrica das naus, the written source that best described the hull of the Pepper Wreck, does not include a section on rigging. Moreover, given the date of its construction, it is possible that the Nossa Senhora dos Mártires was a four-decker.

In fact, the main difference between the ships described in the documents mentioned above and the nau of Fernando Oliveira – and therefore the reconstruction under analysis – is that the later has three decks, as was the norm throughout the sixteenth century, and the naus described in the documents indicated in a) and c) had four decks, as it was the trend in the first decades of the seventeenth century (Barcelos 1899).

As it has been noted elsewhere (Castro 2005b), it is interesting to mention the fact that 17th century four-deckers had slightly shorter keels and slightly higher rakes of the sternposts, which seem to compensate the values of their lengths overall. Furthermore, the values of the maximum beam of these India naus grew continuously during the period under analysis, and so did the area of the main deck, both forward, through a
slight lengthening of the spring of the stem posts, and abaft, through a widening of the transom.

Table 2. Basic dimensions of the vessels under study

<table>
<thead>
<tr>
<th></th>
<th>Oliveira c. 1580</th>
<th>a) LN - Nau c. 1590</th>
<th>b) LN - Galleon c. 1590</th>
<th>c) Fernandez 1616</th>
<th>d) Sousa c. 1620</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tonnage</td>
<td>500 tonéis</td>
<td>600 tonéis</td>
<td>500 tonéis</td>
<td>no mention</td>
<td>no mention</td>
</tr>
<tr>
<td>No. of Decks</td>
<td>3</td>
<td>4</td>
<td>3</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Keel Length</td>
<td>27.72 m</td>
<td>26.18 m</td>
<td>27.72 m</td>
<td>26.95 m</td>
<td>26.95 m</td>
</tr>
<tr>
<td>Spring of Stem</td>
<td>9.24 m</td>
<td>8.98 m</td>
<td>7.70 m</td>
<td>9.50 m</td>
<td>9.50 m</td>
</tr>
<tr>
<td>Length Overall</td>
<td>39.27 m</td>
<td>37.86 m</td>
<td>37.73 m</td>
<td>39.78 m</td>
<td>40.04 m</td>
</tr>
<tr>
<td>Max. Beam</td>
<td>12.32 m</td>
<td>12.38 m</td>
<td>13.35 m</td>
<td>14.37 m</td>
<td>14.50 m</td>
</tr>
<tr>
<td>Transom</td>
<td>6.16 m</td>
<td>6.42 m</td>
<td>6.67 m</td>
<td>7.57 m</td>
<td>10.01 m*</td>
</tr>
</tbody>
</table>

* Almost certainly a mistake: in the original 39 palmos de goa, instead of the more plausible 29 palmos de goa.

The sizes of masts and spars were determined based on the lists of dimensions given in the documents in Table 2. When they were redundant, the documents did not yield very different values, and it was therefore fairly easy to build a table with the values proposed for the Pepper Wreck reconstruction (Tables 3, 4 and 5, from Castro 2005b). The symbol 'Ø' indicates a diameter.

Table 3. Masts: proposed basic dimensions

<table>
<thead>
<tr>
<th>Mast</th>
<th>Length</th>
<th>Ø max.</th>
<th>Ø min.</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Main</td>
<td>31.68 m</td>
<td>116 cm</td>
<td>83 cm</td>
<td>12.81 t</td>
</tr>
<tr>
<td>Main top</td>
<td>18.48 m</td>
<td>44 cm</td>
<td>22 cm</td>
<td>0.82 t</td>
</tr>
<tr>
<td>Fore</td>
<td>27.28 m</td>
<td>77 cm</td>
<td>51 cm</td>
<td>4.56 t</td>
</tr>
<tr>
<td>Fore top</td>
<td>14.08 m</td>
<td>39 cm</td>
<td>13 cm</td>
<td>0.39 t</td>
</tr>
<tr>
<td>Mizzen</td>
<td>17.60 m</td>
<td>44 cm</td>
<td>29 cm</td>
<td>0.96 t</td>
</tr>
<tr>
<td>Bowsprit</td>
<td>28.16 m</td>
<td>51 cm</td>
<td>26 cm</td>
<td>1.70 t</td>
</tr>
</tbody>
</table>

Table 4. Mast tops: proposed basic dimensions

<table>
<thead>
<tr>
<th>Top</th>
<th>Ø rail</th>
<th>Ø basis</th>
<th>Height</th>
<th>Weight*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Main</td>
<td>4.10 m</td>
<td>3.59 m</td>
<td>0.77 m</td>
<td>1.28 t</td>
</tr>
<tr>
<td>Fore</td>
<td>3.59 m</td>
<td>3.08 m</td>
<td>0.64 m</td>
<td>1.07 t</td>
</tr>
</tbody>
</table>

* estimated based on a simple structure with two trestletrees and four crosstrees; the upper rail should be 1 palmo de goa square to support the artillery.
Table 5. Yards: proposed basic dimensions

<table>
<thead>
<tr>
<th>Yard</th>
<th>Length</th>
<th>Ø max.</th>
<th>Ø min.</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Main</td>
<td>31.68 m</td>
<td>52 cm</td>
<td>26 cm</td>
<td>1.97 t</td>
</tr>
<tr>
<td>Main top</td>
<td>10.56 m</td>
<td>29 cm</td>
<td>15 cm</td>
<td>0.21 t</td>
</tr>
<tr>
<td>Fore</td>
<td>24.64 m</td>
<td>44 cm</td>
<td>22 cm</td>
<td>1.10 t</td>
</tr>
<tr>
<td>Fore top</td>
<td>8.80 m</td>
<td>26 cm</td>
<td>13 cm</td>
<td>0.14 t</td>
</tr>
<tr>
<td>Mizzen</td>
<td>28.16 m*</td>
<td>29 cm</td>
<td>15 cm</td>
<td>0.56 t</td>
</tr>
<tr>
<td>Bowsprit</td>
<td>15.84 m</td>
<td>33 cm</td>
<td>17 cm</td>
<td>0.40 t</td>
</tr>
</tbody>
</table>

* With two pennons of 15.84 and 12.32 m respectively.

Given the sizes of the masts and spars, defining the sizes of the sails became quite easy (Figure 09).

Whether this configuration is plausible is another matter, and that can only be accessed through further study, which is being developed at the Secção Autónoma de Engenharia Naval (Instituto Superior Técnico), Lisbon, Portugal.

Testing the plausibility of the reconstruction

Once completed, this tentative reconstruction was ready to be analyzed with hard scientific methods, in order to test its plausibility and build a model that could be easily modified when new data about these ships becomes available.

The answers to the many research questions facing the investigator today are not simple: we are aiming at a moving target. Ships evolved
constantly, and what we are trying to understand are the principles that presided over their conception, rather than a set of fixed values for their dimensions and proportions.

The best strategy is to try to understand which ranges of values are actually plausible, when we compound the archaeological data with documentary evidence – both descriptions and representations – and then test our theoretical model again and again, humbly and patiently, against all the information we will be able to gather.

A methodology was devised for testing and evaluating the sailing characteristics of the ship reconstructed from archaeological and documentary evidence (Castro and Fonseca, 2006). The research plan is extensive since it covers a large number of topics related to the assessment of nautical qualities of the ship and it is expected that within the step by step research process, a number of hypothesis related to the tentative reconstruction will be either validated or adjusted/modified. The planned work includes the use of computer programs based on mathematical models, and also experimental testing with scaled models of the ship and sailing rig.

The main objectives of the research plan are: (a) to understand the complexities of the construction sequence and structural details, (b) to determine the fundamental characteristics of these ships in terms of total weight, weight distribution, displacement and trim, (c) to assess the sailing abilities under different weather conditions, in terms of stability, propulsion force, resistance to the advance, performance regarding the waves, and maneuverability, and (d) to assess the ship’s structural strength to extreme loads and fatigue loads.

The first steps of the work plan have been taken and the following paragraphs present the main results and conclusions drawn until now. Very briefly, the main results include an assessment of the ship tonnage and comparison with contemporary documented values, and an analysis of the ship stability and comparison with modern stability criteria.

**Cargo Capacities According with XVI Century Empirical Methods**

One of the ways of checking the plausibility of the lines plan given in Figure 07-08 is to calculate the capacity of the interior spaces of the ship and estimate if the ballast, cargo and provisions that these ships were known to transport (from written sources), could be carried inside
the reconstructed hull. This can be made using a combination of the old Portuguese tonnage measurement techniques and modern cargo capacity calculations. This section also presents an analysis of the distribution of ballast and cargo inside the hull form and cargo spaces. Besides being an interesting exercise on its own, this analysis is necessary to estimate the position of the centre of gravity of the ballast and cargo, both needed for the ship stability calculations.

Costa (1997) cites several XVI century documents, which describe in variable depth the empirical tonnage measurement techniques used at the time. These consisted in measuring each of the fixed decks of the ship using arcs of *tonel*, *pipa* and *quarto*. The *tonel* was a barrel with a height of one *rumo* (1.5 m) and a maximum diameter of 1m, but the dimensions of the other two types of barrel are not known with certainty, although it is known that 2 *pipas* are equivalent in capacity to one *tonel*.

![Figure 07-10 - Model of the ship's hull and cargo spaces.](image)

For the purpose of applying these measurement techniques, a numerical model of the ship’s hull and decks was created (Figure 10), allowing a “virtual” measurement of the capacity of the ship’s inner spaces. Within each deck, the space was divided in transverse sections of 1.5 m in length, and the net breadth of each section was measured using the arcs. The values obtained for each transverse section were then added to attain the total tonnage capacity of each deck. This procedure was then repeated for all decks and the values summed to yield a total tonnage for the ship. The capacities of the three decks were found to be those shown in Table 6 and the total tonnage is slightly higher than 600 *toneis*. If the allowance for unusable spaces is made, then the result is a value slightly below 600.
Table 6. Tonnage capacity of the decks of the Pepper Wreck Nau.

<table>
<thead>
<tr>
<th>Space</th>
<th>Capacity (toneis)</th>
<th>Area (m²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Third deck</td>
<td>250</td>
<td>378</td>
</tr>
<tr>
<td>Second deck</td>
<td>212</td>
<td>319</td>
</tr>
<tr>
<td>First deck (hold)</td>
<td>142</td>
<td>216</td>
</tr>
<tr>
<td>Total</td>
<td>604</td>
<td>913</td>
</tr>
</tbody>
</table>

The numerical model used for this estimation takes into account the floors, frames and beams, which reduce the useful space aboard the ship. These structural elements are described in some detail in Oliveira (1580) and in the Livro Náutico (1590). However, the book ignores pieces of the structure, masts, hatches and other un-useful areas, which are known to have been deducted from the useful cargo spaces by XVII century calculations of the tonnage capacity, at least when this tonnage measurement was carried out according with the rules used at the Lisbon shipyards, where the Nossa Senhora dos Mártires most probably was built. Unfortunately, these rules are only known in an indirect manner by means of texts, reproduced in Costa (1997), containing short accounts of the procedures used in Lisbon when evaluating the tonnage of specific ships. For this reason it is expected that the results presented in table 2 slightly overestimate the tonnage numbers that can found in some old documents.

Regarding the actual tonnage capacity of the XVI and XVII centuries Portuguese ships, authors such as Barata (1989) give tables which relate the length of the keel of different vessels with its capacity expressed in toneis. For this type of ship, with a keel length of 18 rumos, the indicated tonnage capacity is 600 toneis, a value corroborated both by Oliveira (1580) and by the shipbuilding instructions contained in the Livro Nautico (1590). One concludes that there is a close agreement between the tonnage estimation based on the hull reconstruction presented here and the tonnage referred in several historical documents for an 18 rumos of keel Nau. This result enhances the confidence in the bodylines reconstruction (Figure 10) and general arrangement derived earlier.

Cargo Capacities Obtained by Modern Naval Architecture Methods

Table 7 shows the cargo capacities of the three decks, modeled as above, and calculated using modern mathematical techniques, current in naval
architecture. Information of this type, relative to the lower deck (hold), can be used to verify if the ballast could be easily accommodated inside the hold and to estimate the location of its centre of gravity. The same applies to the pepper cargo and to the substantial amount of water, wine and provisions carried onboard.

<table>
<thead>
<tr>
<th>Space</th>
<th>Volume(m$^3$)</th>
<th>LCG(m)</th>
<th>TCG(m)</th>
<th>VCG(m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lower deck</td>
<td>719.2</td>
<td>19.88f</td>
<td>0.00</td>
<td>2.55</td>
</tr>
<tr>
<td>Middle deck</td>
<td>735.9</td>
<td>19.54f</td>
<td>0.00</td>
<td>5.23</td>
</tr>
<tr>
<td>Gun deck</td>
<td>881.7</td>
<td>19.47f</td>
<td>0.00</td>
<td>7.71</td>
</tr>
</tbody>
</table>

The exact amounts of ballast carried in these ships are not known, but Blot (1994) indicates that a 18$^{th}$ century ship with 64 guns carried 270 t of ballast. Taking into account the dimensions of that ship and the dimensions of the *Nossa Senhora dos Martíres*, the ballast could be estimated, with a considerable uncertainty, to amount to 154t. Castro (2001) indicates that taking into account the ballast found in the Molasses Reef and Highborn Cay wrecks (Oertling 1989a, 1989b), the ballast for this ship could be in the region of 200 t. In this study, a value of 175 t has been considered.

The ballast consisted generally of broken limestone (1.55 t/m$^3$) and was carried directly above the keel, inside the lower hold. The 175 t of ballast then occupy 113m$^3$ and would fill the lower hold up to a height of 1.46 m. The centre of gravity would be 21.2 m forward of the aft perpendicular and 1.03 m above the baseline. This height of the ballast allows the conclusion that a substantial portion of the lower deck was still available for cargo, with a usable free height of around 2 m, after taking into account that generally a layer of wood was added on top of the rocks to smooth the surface where the cargo was to be laid.

The cargo aboard this *Nau* consisted mainly of pepper, weighting between 3000 and 5000 quintais (1 quintal equals to 58.75 kg), as indicated by Castro (2005a). Costa (1997) indicates some cargo weights for ships returning from India and 4500 quintais (265 t) is a usual cargo weight for ships of this size. The available volume in the hold above the ballast can be found to be 606 m$^3$ and, taking into account that the pepper density can be estimated to be 0.5 kg/dm$^3$, the volume required for the 4500 quintais is 530 m$^3$. This indicates that the estimated cargo of pepper could
be carried entirely in the lower hold, which is according to the loading scheme described by Falcão (1607). The centre of gravity of the pepper can be estimated to be located 19.6 m forward of the aft perpendicular and 2.83 m above the baseline.

These results indicate that the lines plan derived from the archeological remains and contemporary shipbuilding treatises is plausible, given that the estimated ballast and cargo can indeed be accommodated inside the hold, as prescribed in Falcão (1607).

**Ship floatability and stability**

This section presents an analysis of the ship floatability and transversal stability. The transversal stability represents the ship’s ability to recover its mean static position, or upright position, after being subjected to an inclining moment. This ability is directly related to the ship safety against capsizing.

The analysis of the floatability and stability characteristics of a ship requires knowledge of the ship mass and centre of gravity. The estimation of these properties for an early 17th century ship, whose constructive details are not known accurately, represents a major task and one bound to yield a result with some uncertainty. Furthermore, as usual, a considerable number of loading conditions are possible. Some results are presented for two loading conditions, being the first the condition at the departure from India for the return voyage. This condition is selected because the ships tended to be severely overloaded and this appears to have caused a considerable number of losses around the turn of the 16th to the 17th centuries, especially in the area of the Cape of Good Hope. The arrival condition is also considered since it is of interest to evaluate the ship’s stability at the moment of the accident.

To obtain the mass and centre of gravity, the weight of the ship has been subdivided into a number of components, namely: hull, masts and yards, sails, rigging (shrouds, etc), anchors and ship’s boats, artillery, ballast, cargo, crew, soldiers, passengers and supplies. The hull was further decomposed into an extensive list of components, comprising the hull planking, decks and structure, and were identified together with their individual weights and positions of the centre of gravity. The various types of wood employed in the different structural elements were also considered.

Fonseca et al. (2005) describes the sources of information, assumptions and details used to derive the distribution of masses of the whole ship
and of the cargo. Figure 07-11 presents the weight distribution for the loading condition at the departure from India. For the arrival at Lisbon condition, it is assumed that weight of the water and wine, biscuit and other supplies is 10% of the corresponding weights when departing from India.

![Weight distribution for the loading condition at the departure from India](image)

For the hydrostatic and stability calculations, the planking thickness (11 cm) was taken into consideration when defining the hull sections and the forecastle and aft superstructure were not considered watertight. Table 8 shows the drafts aft and forward, the trim of the ship, freeboard and metacentric height in the different conditions. The freeboard is defined as the distance from the waterline to the main deck, or weather deck, and it is a measure of the flotation reserve of the ship. The metacentric height is a measure of the ability of the ship to return to the upright position when subjected to a small inclination angle. The related restoring moment is given by the $W^*GM^*\theta$, where $W$ is the ship weight, $GM$ is the metacentric height and $\theta$ is the heeling angle.
Figure 07-12 presents the righting arm and righting energy curves, as functions of the heel angle, for the ship loading conditions when departing from India and when arriving at Lisbon. The righting arm multiplied by the ship weight results on the restoring moment, or stability moment, when the ship is heeled. While the stability lever is related to the static stability and represents how the ship reacts to a static inclining moment, the dynamic stability is related to how much the ship heels in response to a sudden and dynamic inclining moment, like for example a wind gust or a wave impact.

The graph shows that, for the departing condition, the maximum static stability moment occurs for a heel angle around 50 degrees, while the ship stability vanishes for an angle of 104 degrees. These values are slightly increased for the arrival condition, basically because the centre of gravity is slightly lower thus the stability levers are higher.

The Portuguese shipbuilders of the late 16th century knew very little about ship stability, except that, for example, locating large weights high in the ship would degrade the ship’s stability and that increasing the beam had good effects in the behavior and cargo carrying capacity of the ship, as mentioned by Oliveira (1580). Therefore, it is interesting to investigate if a Portuguese nau would comply with modern intact ship stability criteria. For this purpose we adopted the US Coast Guard (1983) criterion for large sailing vessels.

**Table 8. Drafts of the ship in different loading conditions**

<table>
<thead>
<tr>
<th></th>
<th>Draft Aft (m)</th>
<th>Draft Forw (m)</th>
<th>Trim (m)</th>
<th>Free-Board (m)</th>
<th>GM (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Departure from India</td>
<td>5.25</td>
<td>4.75</td>
<td>0.50</td>
<td>3.21</td>
<td>1.00</td>
</tr>
<tr>
<td>Arrival at Lisbon</td>
<td>4.68</td>
<td>3.74</td>
<td>0.94</td>
<td>4.0</td>
<td>1.13</td>
</tr>
</tbody>
</table>
Table 9. Stability criteria and numerals calculated for the reconstructed nau

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Minimum value (criterion)</th>
<th>Departure</th>
<th>Arrival</th>
</tr>
</thead>
<tbody>
<tr>
<td>X</td>
<td>16.4</td>
<td>19.4</td>
<td>31.1</td>
</tr>
<tr>
<td>Y</td>
<td>18.6</td>
<td>21.5</td>
<td>18.9</td>
</tr>
<tr>
<td>Z</td>
<td>20.8</td>
<td>31.9</td>
<td>31.7</td>
</tr>
<tr>
<td>Angle of extinction</td>
<td>90º</td>
<td>104º</td>
<td>112º</td>
</tr>
</tbody>
</table>

According with this criterion, the ship shall have numerals X, Y and Z larger than given values. The X numeral expresses a measure of protection against water on deck. Numeral Y expresses the resistance against down flooding the interior of the ship and numeral Z indicates the capacity of the ship to resist a knockdown (leading to capsize). The procedure to calculate the numerals are presented in Fonseca et al. (2005), while Table 9 presents the minimum criterion requirements and the results for the reconstructed ship for the departing and arrival loading conditions.

It is observed that the ship complies with the stability criterion for both loading conditions. The general conclusion is that this ship had stability characteristics appropriate for open sea operation, at least when well maintained and correctly operated. This conclusion is valid under the assumptions of watertightness up to the main deck and of the gun holes. In practice, watertightness was often far from satisfactory and the
overloading and overcrowding common practice. In fact, for instance, D’Intino (1998) indicates that the real distribution of cargo, supplies and people onboard seldom followed the theoretical scheme of Falcão (1607).

Life aboard

One of the most interesting approaches to the study of this type of ships is the simulation of life aboard conditions in particular situations, such as under storms of various magnitudes, becalmed at sea, taking water through different parts of the hull, or maneuvering.

How did the enormous crowd that populated these ships sleep, cook, eat, work, spent their idle moments, or handle their children, their women and their sick companions? How did they discipline the crews? Where? How did they move heavy weights around, such as the ship’s boats or the provisions?

This avenue of research is still pending the elaboration of a more refined computer model, one with a tentative separation of spaces and a detailed distribution of cargoes, provisions, weapons, personal items, or livestock. Not to mention the ship’s fittings, such as the capstan, windlass, or bitts, as well as the ship’s operational areas, such as cable lockers, spare spars’ room, or even the carpenter’s shop.

An Iberian ship type?

Another interesting avenue of research is the definition of an Iberian Atlantic type (Alves 2001). Such a study will entail a comprehensive comparative study of all deep sea cargo ships of the broad period under analysis, compounding historical, iconographic and archaeological information. Some characteristics consistently found in Iberian shipwrecks seem to indicate that there was a well-defined type, typical from Portugal and Spain (Figure 13). There are (many) reasons to believe that the long sea traders built in the Iberian Peninsula during the 16th century are therefore a particular blend of both Mediterranean and North Atlantic shipbuilding traditions. Nevertheless, only further studies will be able to assert how much of the shape and size of the Portuguese India naus resulted from imported models, and how much was developed and perfected in Portugal, and if so how, when, and by whom.
Figure 07-13 – Schematic representation of the most common structural characteristics found in Iberian shipwrecks: knees connecting the keel to the stem and sternpost, pre-designed central frames rising and narrowing the turn of the bilge points according to old Mediterranean algorithms, floors and first futtocks connected with dovetail scarves, and deep flat stern panels.

Conclusion
This project is just starting and its possible outcomes are diverse and exciting (Castro and Fonseca 2006). The ultimate goal is to understand these ships in a number of ways:

a) as inhabited places, wandering around the world with a microcosm of Portugal’s 16th and 17th century society in their bellies;
b) as sailing machines, a solution to achieve a number of tasks;
c) as an artifact, complex, large, expensive, and mobile, conceived by an almost certainly illiterate community, based on experience and rules of thumb imported from the Mediterranean world, whose meaning was perhaps forgotten;
d) as a synthesis of several cultures at play in the nexus between the Atlantic and the Mediterranean seafaring worlds;
e) as an expression of power, a symbol of the will of the Portuguese monarchy, expressed perhaps in much more things than the crosses painted on the sails (at least in the first half of the 16th century); and
f) as an engineering project, built from an idea, almost certainly without plans, tuned as they were built, their measurements derived from a small number of fundamental dimensions.
We are sure that there will be many more ideas as the project develops. It will ultimately depend on the amount of resources that the authors will be capable of gathering.

One last word for the use of virtual reality, which is perhaps one of the most exciting avenues of research when we consider the outcomes of such a project, mostly when it comes to the diffusion of the results to the scholarly community as well as to the general public.

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**Santo António de Tanná: Story, Excavation and Reconstruction**

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**Abstract**

The excavation of *Santo Antonio de Tanná*, a 17th century Portuguese frigate, is the perfect example of how collaboration between land archaeology, history and nautical archaeology can answer several questions regarding the history of Portuguese Seafaring. The story of *Santo Antonio de Tanná* wreck began in Mombassa, modern day Kenya, where the frigate was lost on 20 October 1697. It has continued through the reconstruction of lines, general structure, and framing patterns using computer reconstruction techniques. This innovative use of reconstruction techniques was done as part of a thesis presented to Texas A&M University Nautical Archaeology Program and supported by a co-grant of the Gulbenkian Foundation and the Luso-American Foundation for the development.

**The Story of Santo Antonio de Tanná**

The Portuguese Crown ordered the construction of *Santo Antonio de Tanná* in February 1678 by Dom Antonio Sottomayor, the Portuguese captain of Bassai. Bassai, located about 50 kilometers from modern day Bombay, was an important shipyard for the Portuguese maritime presence in the area. This new ship was to be a 42-gun frigate, to be ready in the end of 1678. Funding difficulties delayed the construction of the frigate and the hull was finally launched in December 1680 (Blot and Blot 1984, 5). By that time Dom Vasco Luis Coutinho was the new captain of Bassai and with him came the master shipbuilder, Manuel da Costa, who is historically credited for building the frigate. Construction of the ship commenced prior to his arrival to the shipyards, which means that Manuel da Costa is probably “only responsible for part of the works.” (Blot and Blot 1984, 5).
The upper works, the masts and rigging were added later in the Goa shipyards where the vessel was towed.

By 1681 the ship was part of the viceroyalty fleet, and baptized *Santo Antonio de Tanná* (Blot and Blot 1984, 6). The frigate was a welcome addition to a fleet composed of 11 high profile ships, and several smaller ships and very little mention is made of its career (Blot and Blot 1984, 42; Esparteiro 1987, 56). *Santo Antonio de Tanná* successfully completed at least one round trip voyage from Goa to Lisbon (Boxer 1984, 41) staying in the Spanish port of Vigo for several months (Blot and Blot 1984, 43-4). *Santo Antonio de Tanná* left for India on the 6 April 1696 under the command of Captain Henrique de Figueiredo de Alarcão (Esparteiro 1987, 56). After arriving in India, it latter proceeded to Mombasa having spent six months in Mozambique (Sassoon 1986, 129).

In November 1696, *Santo Antonio de Tanná* sailed under the command of Captain Domingos Pereira de Gusman, as a fleet flagship. It arrived at Mombasa on Christmas day 1696 and proceed to disembark troops and supplies to the fort which was ‘about to fall’ (Kirkman 1981, 4). On 14 January 1697 the ship lost some anchors and was forced to cruise back and forth, while the remaining supplies were transported to the fort by small boats. On 25 January 1697 *Santo Antonio de Tanná*, departed for Mozambique (Piercy 1979, 308) and later that year, in April its rudder was lost during a hurricane that struck Mozambique (Piercy 1979, 308).

On 28 August 1697, General Sampaio de Melo, appointed governor of Mozambique, received distressing news that Fort *São Jesus*, the main Portuguese fortress in Mombassa, had been attacked by Omani forces. The General immediately armed and lead a small fleet to relieve the beleaguered fortress; *Santo Antonio de Tanná* was his flagship. After stopping at Zanzibar to take on more troops, the fleet reached the Mombassa coast on 15 September 1697. During the time it was moored in Mombassa, the ship was subject to gunfire from the Omani forces and lost several cables. Nevertheless, it continued to unload its cargo until 20 October, when, *Santo Antonio de Tanná* lost its last mooring lines during a firefight with Omani forces. It is unknown if the ship lost its lines, due to gunfire, sabotage, or simply because of rotting, but it is certain that the ship ran aground near the Muslim position. Intense fighting continued as Omani forces tried to take the ship, but a relief force from the fortress captured the small palisade overlooking the ship thereby forcing the Omani to retreat.
With the next tide the vessel was towed closer to the fort and at this time the Portuguese decided to strip and scuttle the ship believing the damage to be too severe.

*Santo Antonio de Tanná*, by that period, was part of a diminished overall Indian fleet of 5 frigates and 17 smaller vessels. The loss of this frigate deeply hurt the Portuguese presence in the Indian Ocean as the fleet had already been depleted of too many seaworthy vessels.

**Fort São Jesus**

By 1589 there was no doubt that a fortification in or near Mombassa was needed in order to supervise two of the most important cities of the region, Pate and Lamu (Chitick 1969, 390). Plans for the building of a fort in the “best harbor of the coast” (Kirkman 1975, 1), were commissioned to a renowned Italian architect João Baptista Cairato who had previously supervised the construction of all Spanish fortifications in the Portuguese East Indies. King Filipe II of Portugal appointed Cairato as chief architect of the Portuguese East Indies and it was under this auspice that he designed and supervised the construction of Fort São Jesus; the fort itself was built by a Portuguese master mason named Gaspar Rodrigues.

Fort São Jesus was planned according to the Renaissance humanistic school of thought on architecture which maintained that since the body of man was the most perfect of all God’s designs, the Italian military fortifications should imitate the proportions of a human. Fort São Jesus was a perfect example of these humanistic ideals; its sea bastions represented the arms and head of a human and the land bastions were its legs (Boxer and Azevedo 1960, 110). This almost square design of four bastions was very simple, but highly effective for repelling invaders and was a mainstay in Italian fortification architecture of the 16th century.

Fort São Jesus surrendered on 13 December 1698, the loss of which threatened the security of the Portuguese “India Seafaring Route” and effectively crippling an already decaying Portuguese presence in the Indian Ocean and Northern Africa.

**Excavation of Santo Antonio de Tanná**

The ship was discovered in the 1960s by two skin divers, Conway Plough and Peter Philips at a depth of 15 meters (50 feet) in the old Mombassa harbor (Piercy 1977, 331). It was surveyed in 1976 and excavated from
1977 to 1980 by a joint team of the Institute of Nautical Archaeology and the Fort Jesus Museum, under the direction of Robin Piercy. The workload was intense and in the first year alone, 987 diving hours occurred in only 67 days (Piercy 1978, 307). In 1977, work concentrated in the center part of ship and the stern removing ballast stones and the numerous artifacts that appeared after which the maststep was discovered and mapped (Piercy 1977). The 1978 excavation lasted from January through March and even with the enormous artifact yield, the team was able to excavate six meters forward and abaft of the maststep ending with the discovery and mapping of the stern (Piercy 1978). Photogrammetry was used to map the hull remains, as was done in the first season; however, during that second year Jeremy Green devised a method to profile and trilaterate the hull (1978, 311-314). The 1979 excavation finished clearing the hull structure and dedicated the remainder of the available time to excavating trenches parallel to the ship’s port side. The artifact yield of those trenches was far greater than expected and quickly swamped the conservation personnel. Work continued on those trenches in 1980 with the goal to ‘excavate a 6 m wide band immediately below the entire vessel’s length’ (Piercy 1980, 109). The artifact yield of 1980 unexpectedly exceeded those of the previous years and more than 3,500 artifacts were recorded. In 1981, the last year of the project, work was limited to land-based laboratory work focused on decreasing the amount of artifacts that still needed to be cleaned, drawn and conserved. Although INA planned on continuing the excavation and mapping of the hull remains, the team was unable to return to Kenya due to several external factors.

The shipwreck was positively identified as Santo Antonio de Tanná by the discovery of the figurehead known to belong to the Portuguese Frigate in 1977 and a Portuguese coat of arms found in the 1978 excavation. Although the ship was never raised, full photographic coverage resulted in a site plan and cross-section profiles (Green 1978, 312). Unfortunately, the site plan only reflects the immediately accessible parts of the ship, leaving many questions unanswered. A completed excavation would have resulted in the disassembly of the hull remains and subsequent conservation and recording which would have provided a more in-depth analysis of the constructional characteristics of 17th century Portuguese vessels. However, the abundance of recovered and recorded material culture has allowed researchers to reconstruct many aspects of the career of and life aboard
Santo Antonio de Tanná, 17th-century life in general, and the mechanisms of defense and trade utilized by the Portuguese.

The richness of the site was unexpected because the ship was extensively salvaged not only by the Portuguese crew before it’s scuttling, but also later by the Omani forces. However, during the four years of excavation, more than 15,000 artifacts were recovered.

The armament constitutes the largest group of artifacts containing 600 cannon balls ranging from 2.5 pounds to as large as 38.5 pounds. Only five of Santo Antonio de Tanná’s guns were found (Darroch 1878), which is unsurprising given the extent of salvaging. For instance, it is known that the Omani were able to recover 20 guns from the shipwreck during their salvage operations (Blot and Blot 1984, 53). The excavators discovered a musketun or blunderbuss, which is a weapon well-known to be a favorite of the Portuguese soldiers. The musketun along with a musket barrel, 400 pistol balls, 120 gunflints, several powder flasks, 30 cast iron grenades and 6 glass grenades represent some of the personal weaponry on board of the ship and contribute to the understanding of the weaponry intended for shipboard use (Darroch 1991).

One of the most exciting discoveries was elements of four or five compasses (Richardson 1991). At the time of the excavation, these were the only Portuguese compasses of that era available to study. This important find allowed the researchers to determine the manner in which the Portuguese devised a land-based navigational compass for nautical use. Also worthy of notice is the dovetail assembly of the compass parts, the most indicative signature of Portuguese construction from the 15th to the 17th century.

One of the more pleasant puzzles was a large concretion located in the bow of the ship; after weeks of air scribing it yielded a large amount of carpenter’s tools. Believed to be the contents of the boatswain locker, it helped ascertain what tools and supplies would be required of the carpenter for maintaining a wooden structure as complex as a frigate.

Representing the personal belongings, a large amount of porcelain, glassware, stoneware and Portuguese faience were among Santo Antonio de Tanná remains (Sassoon 1991). As well, twelve items related to smoking helped to identify the personnel aboard the ship (Hall 1991). Portuguese or Europeans would have smoked from the seven English pipes found on the wreck, while, the discovery of five African pipes indicates the existence
of colonial soldiers and African crew on board. Two water pipes were also found which would have been used by the Indian reinforcements troops sent to the fort, who often smoked the water pipes gun deck.

Several martaban jars were found, which are rare on land excavations of the region. According to Hammo Sassoon (1981, 129), one of the project directors, the precise date of the Santo Antonio serves as an temporal anchor for several discussions of pottery and artifacts, and this a excellent example where 'marine archaeology and land archaeology can complement one another.'

Another archaeological confirmation of a known trade item was the discovery of more than 200 hardwood logs identified as Dalbergia Melanoxylon commonly known as ebony. Several of the logs had carvings, marking their possession to Luis de Melo de Sampaio, commander of the relief expedition, and to his cousin Diogo de Melo Sampaio, who was one of the officers on board.

Liberdades – a certain amount of personal trade allowed per person – were a custom used by the Portuguese crown to supplement the salary paid to the personal involved in the Indian Route. The discovery of ebony logs among the artifacts is a perfect example of the use of the liberdades among the crew and officers. Even when a ship was going to relieve a besieged fort it seems that the officers on board took the time to make the voyage profitable.

The Ship

The most important artifact is the ship itself. Composed of more than 200 pieces of timber and thousands of iron fittings, it represents a considerable portion of the ship's hull, and it was instrumental for the understanding of Portuguese shipbuilding practices and allowed the opportunity for the reconstruction work.

Current reconstruction work is based primarily on the introductory site plan (Figure 08-01), which resulted from the photogrammetry data and field notes, but this project also incorporates the cross section profiles (Figure 08-02) done by Jeremy Green (1980) and the resulting preliminary lines drawing (Figure 08-03) by Robin Piercy soon after the last excavation season.

The main objective of this research is to understand the manner of and reasons for the construction of a particular type of Portuguese ship, the late 17th Century frigate. One of the ship types that appeared in the
17th century was the ship of the line the smaller version of which was the frigate. Frigates were responsible for patrolling the seas, intercepting fast vessels, re-supplying military installations and protecting trade routes. The existence of Portuguese frigates are known from historic records, but *Santo Antonio de Tanná* is the only frigate identified in the archaeological record. As such, its reconstruction will enable scholars to better understand the actual construction and sailing capabilities of 17th Century frigates, as well as establishing a list of constructional features that can be used to identify other similar shipwrecks.

A particular challenge of this reconstruction work is ascertaining whether the manner in which *Santo Antonio de Tanná* was built reflects the contemporary state of affairs of the Portuguese trade network. Through the reconstruction process two primary questions were posited:

1. Were the Portuguese still equipped with the superior technological skills that allowed them to prosper in earlier centuries?
2. If not, what were the changes reflected in *Santo Antonio de Tanná*?
These questions are just a beginning but they shed light on what can be learned from the reconstruction of a 17th Century frigate.

**Lines drawings**

The first step in reconstructing *Santo Antonio de Tanná* was to complete and interpret the preliminary lines drawings done by Piercy and present an initial characterization of the ship. To date no 17th century Portuguese lines drawings have been found. This made it necessary to utilize other sources in this study, including: lines drawings of 17th century English and French ship architects, lines produced by shipyards, and lines from known treatises all of which will be used to complement the information from the field notes and the Piercy’s initial lines drawings (Figure 08-03). The English lines done by William Keltridge, an English shipwrights between 1680 and 1685, heavily influenced this work as they are considered the earliest scientific drawings produced in England (National Maritime Museum 2004). A large number of bottom stringers were recorded which was instrumental in determining a portion of what is believed to be the diagonal of the turn of the bilge. The information gathered from the physical remains was supplemented by a letter from Lisbon to the Goa shipyards.
which specified several dimensions and the second diagonal (representing the max breadth of the ship) and the extrapolation of the two diagonals from Piercy’s original lines.

The resulting lines drawings (Figure 08-04), provide a glimpse of the general characteristics of the Santo Antonio de Tanná. Much of the work above the water line is conjectural; however, it is believed to be an accurate representation of a Portuguese ship of this time period. One of the goals of this reconstruction project was to gain an understanding of the ship’s cargo capacity versus speed requirements. The lines clearly demonstrate that cargo capacity was taken more in account than speed and maneuverability. This evidenced by the almost flat bottom of the ship and a hold that is far beamier hold than would be expected, possibly illustrating the ongoing necessity of the Portuguese to conduct trade even on pure military vessels.

The Three Dimensional Reconstruction Project

The author believes that the best manner to answer the main research question is to not only present the reconstruction work in its more ‘classical’ form, but to bring a three-dimensional object such as a ship into a three-dimensional environment, creating a more adequate model of the ship. When the lines drawings were transformed into a three-dimensional environment some of the discrepancies not visible on the classical three views plan were discovered and corrected. The resulting wire-frame model (Figure 08-05) and attached surfaces permit research to extend beyond the
limits of the individual plans drawings with the added benefit of having a model that can be used to calculate hydrodynamics, sailing characteristics and other research questions arising from the morphology of this ship.

The next stage was the reconstruction of the master frame as a center cut-out of the ship and more importantly, a graphic representation of the shape, size and type of pieces required to create such a magnificent tool as a ship. In Figure 08-06 is displayed the information resulting from the excavation and the information derived from the available sources in a three-dimensional result.

At this time the keel and all of the framing have been added to the three-dimensional reconstruction. The ultimate goal of this project is the placement of all constructional elements from the excavation (the ceiling planking, the keelson, and the stringers) in relation to the unknown elements (keel, the frames, the stem, and the transom) in order to verify the accuracy of the part derived from historical and iconographical sources (Figure 08-07). This work has been able to reconstruct some of the more important components of this ship that even that they were present on the site, they have never been seen or recorded and by using the recorded information from the archaeological site it was ascertained that in a ship of 39m in length the reconstruction work missed by 70cm.

Conclusions

The partial reconstruction of Santo Antonio de Tanná which is part of a thesis in the Nautical Archaeology Program of the Texas A&M University

Figure 08-06 – Master frame cut-out in three-dimensions. (Drawing: Tiago Fraga, 2004).
Anthropology department is completed. The shape of the hull has been reconstructed, the scantlings inferred and the framing versus the site plan checked and verified. However, the overall reconstruction is not completed; the author’s goals are to continue the reconstruction until an entire 17th century Portuguese vessel exists in the virtual world of computers up to the point of sail information. This continuing work is done not because it is required, or because it exceeded the scope of a master’s thesis. It is done because the Question is out there.

**Acknowledgments**

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Due credit must also go to Dr. Filipe Castro for arranging this conference and giving the chance to participate, but also for finding the funding to support this endeavor.
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Spanish Shipbuilding in the Eighteenth Century: the Album of the Marques De La Victoria

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Abstract
This paper presents a preliminary analysis of the Album of the Marques de La Victoria, written in Spain between 1719 and 1756, during a period of remarkable reorganization of the Spanish Navy, under the rule of the new Bourbon dynasty. Step by step, following the natural progression from the planned and specialized growing of the trees for vessel construction, to the seasoning of the wood, the incorporation of both English and Dutch methods and machines into the Spanish shipyards, down to the most impressive detail of the nailing patterns on the outer hull, or the launching of the ship, the Album is an incredible creation and opens the door for all historians to know and understand in minute detail the shipbuilding practices of the 18th century Spanish shipyards.

18th Century Spanish Naval Architecture: The Importance of the Album
The reign of the Bourbon kings in Spain during the Age of Enlightenment, beginning with the succession of Felipe V at the turn of the 18th century, is an era that has been given noticeably less academic attention then the 15th and 16th century Age of Discovery and Exploration.
It is commonly perceived that the undeniable vigor, intelligence, and courage that spurred the earlier expansion of the Spanish into one of the largest maritime empire during the previous two centuries had dwindled into a stagnate state under the rule of the Habsburgs, especially the last Habsburg ruler, Carlos II, commonly known as El Hechizado (The Bewitched). The prevailing idea that Spain never again approximated the zenith of military or naval might that was enjoyed during the reign of Fernando and Isabel (1474-
-1516) is reflected in the dearth of publications concerning the reigns of the Bourbon kings, especially Felipe V, and is a situation much commented upon by modern scholars. Lynch (1989) declares:

Bourbon Spain, unlike the Spain of the Habsburgs, has been forgotten by British historians. Yet a century in which Spaniards increased their numbers, their output, and in some cases their wealth, a power which lost Gibraltar and colonized California, a monarchy which tolerated the Inquisition and patronized Goya, and a king who fled from a mob one year and expelled the Jesuits the next, cannot be without interest.

Contrary to the popular opinion, the Bourbons initiated an age of rejuvenation, reformation and military and naval growth that once again made Spain into an international power with a strong presence in European and international politics.

Continuing with the premise that the entire history of Bourbon Spain has suffered from a lack of analysis and neglect, it then stands to reason that the lesser components that make up the whole of 18th-century Spanish society under the Bourbon kings has also been overlooked. In particular the knowledge concerning the Spanish Navy, which became the Armada Real or Royal Navy in 1714, has not been received due attention by historians who are typically more concerned with the burgeoning power and dominance of the British Royal Navy during the same period. The ensuing void created by this lack of investigative scrutiny needs to be filled in order to continue to enhance and expand the modern scholar’s knowledge base concerning this particular subject. One way to accomplish this goal is to locate and analyze primary source documents from the Spanish Royal Navy of the 18th century.

One of the documentary sources that scholars have from this period, directly from a leading member of the Spanish Royal Navy, is entitled the Album Del Marques De La Victoria: Diccionario demostrativo con la configuracion o anatomia de todo la arquitectura naval moderna, (“The Album of the Marques of the Victory: The demonstrative Dictionary with the configuration or anatomy of all the modern naval architecture”), which will be referred to in this text as the Album. The Album is a compilation of thirty-seven years of knowledge (1719-1756) concerning every aspect of the navy accumulated by the author, Juan Jose Navarro de Viana y Bufalo. Navarro’s career paralleled the rebuilding of the navy and climaxed with his being given the noble title of El Marques de La Victoria after he commanded the
Spanish constituent of a joint French and Spanish fleet in the breaking of the British blockade at the Battle of Toulon in 1744.

**The Physical Composition and Content of the Album**

The Marques’ *Album* consists of 133 copper engraved leaves or *fojas*. The engraved plates or leaves average 70cm long and 50cm wide, although there are a number that are over a meter in length. The data engraved upon the copper leaves encompass an astoundingly wide assortment of topics. The scope of this article does not allow the full range of information included in the *Album* to be presented here but listed below are some of the included topics:

1. The developing of designed forests to create the necessary shaped compass timbers utilized in shipbuilding construction;
2. The ordnance carried in different rated vessels;
3. The uniforms of ships’ officers and sailors;
4. The instruments used by the ship’s surgeon, carpenters and chaplain;
5. The size and shape of the different anchors used on specific vessels;
6. The instruments of the pilot or navigator of a Spanish ship;
7. The rigging of various rates of ships, both Spanish and English;
8. A cataloguing of ancient vessels;
9. The design and content of the different warehouses of the Spanish arsenals.

**Spain at the Turn of the 18th Century**

In the year 1700 the last of the Spanish Habsburg rulers Carlos II was dying. *El Hechizado* (The Bewitched) had ruled ignominiously and so poorly that it was almost a relief that he had left no heirs to assume the throne. The Bewitched, whom many viewed as a product of Habsburg familial licentiousness due to his notoriously slow wit and lack of will had done nothing to help prepare Spain for the future. Bergamini (1974) is more direct with his criticism of Carlos II, “The family ugliness compounded with each generation, and so it came to be that Carlos looked ‘like a caricature’ of the dynastic portraits – pale, wild-eyed, and with his chin taking up fully one-third of his long, narrow head.” With such a monarch it is not surprising that, although Spain controlled the largest land empire of the time due to its many colonies in the Americas and the established trade routes to the Indies, the
country was woefully unprepared on almost every level for the new century. The military was in the hands of titled aristocrats from the many city-states of Catalonia, Aragon, Barcelona, Toledo and Castile, and could not be relied upon to support the successor to the throne, whoever it may have been. The navy was practically non-existent and had only a token force with which to defend its enormous trade routes in the Americas and Indies.

Carlos II’s death exacerbated these problems and created a power void that was felt throughout Europe, with many nations scrambling to claim the vacant throne. France and Austria represented legitimate heirs to the monarchy through the Habsburg line and were eager to take over the reins of the Spanish government. Spain’s global empire, the vast territories of Nueva España (New Spain) and the Carrera de las Indias (The Indies Run) and the incredible wealth they represented were prizes any empire would desire.

One of the few positive accomplishments of Carlos II concerning Spain and the Spanish Navy actually came to fruition after his death; the reading of his last will and testament naming Phillip the French duke of Anjou, the grandson of Louis XIV monarch of France, the heir to the Spanish throne.

The remaining Western European powers were uneasy with the proclamation of Phillip as King. They feared the Bourbons would unite France and Spain into one vast empire ruled through a dynasty that controlled the sprawling and incredibly wealthy Spanish colonies and trade routes, under the protection of the prodigious military might of France. William III of England, the Dutch Republic, and the Austrian Habsburgs had foreseen this possibility and had demanded, before Carlos II perished, that Louis XIV partition Spain between England, Austria and France; the agreement for the partitioning of Spain and its holdings was secretly made between them.

The reading of Carlos II’s will made the succession of Louis XIV’s grandson a reality and broke the clandestine partitioning pact. Somewhat reluctantly, knowing that war was on the horizon, but feeling that it was worth the risk, Louis XIV supported his grandson in the acceptance of the Spanish throne. One scholar, R. Trevor Davies (1965) makes the claim that the generous terms of Louis XIV in the Treaty of Ryswick in 1697 were a precursor to his true intention to unite France and Spain, “Louis XIV’s moderation was doubtless due to his designs for claiming the whole Spanish monarchy on the death of Carlos II.”

Reacting against the Bourbon heir, William III, the Dutch Republic, and the Austrian Habsburgs formed the Great Alliance, proclaiming Archduke
Charles of Austria their candidate for the throne, and the War of Spanish Succession was formally declared in 1702. Sentiments in Spain were mixed, mirroring the country’s internal political struggles of the times; however, few Spaniards saw this as a dynastic war between the Habsburg Archduke Charles, and the Bourbon lineage of Louis XIV and Phillip. As Lynch (1989) writes, “For them (Spaniards) it was a defense against dismemberment, against loss of territory, resources, revenues, employment and opportunities.”

**State of the Spanish Military and Navy**

The War of Spanish Succession glaringly illustrated the problems within the Spanish military. The land armies were split internally by the fact that Catalonia, Aragon, Barcelona, and Castile, all wished to retain their aristocratic rights of property and taxation granted to them by the Spanish Habsburgs. The Spanish Navy was in even worse condition; after 1700, there quite literally was no formally acknowledged Navy, only small and ineffectual regional fleets that could not possibly defend the enormous Spanish Empire.

In the western Mediterranean, Spain had only twenty-eight galleys and these were scattered among the empire’s various possessions, and in differing states of readiness. The Atlantic naval fleet, *Armada de Barlovento* (The Windward Squadron), comprised twenty warships but these vessels had been built for purposes other then strictly war, including maintaining communication, and opening trade routes with the Americas and the Philippines, while protecting the two main commercial fleets: *La Flota a Nueva Espana* (Fleet to New Spain) and *Los Galeones de Tierra Firme y Peru* (Galleons to the Continent and Peru). The twenty warships were not the large ships of the line that England and the Dutch possessed; they could not stand in naval combat against the English and the Dutch. The trade routes to the Americas and the Indies further compromised the Spaniards by stretching their resources to the breaking limit.

In the War of Succession the Spanish relied solely on the French *Marine Royale*, and the Alliance saw this as a weakness. Lynch (1989) cuts to the heart of the matter, “In the War of Succession Spain depended on French naval power for the protection of her imperial life-lines. Weakness invited aggression.”

In 1702, in a battle that occurred in the Bay of Vigo, the Alliance almost destroyed an entire Spanish treasure fleet, and the damages on the
seventeen French warships that escorted the Spanish merchant vessels into the bay made it painfully obvious that something would have to be done concerning the state of the Spanish Navy. Bibiano Torres (1992) explains Spain’s situation, “La perdida de la flota de la Nueva Espana en la bahia de Vigo en 1702 vino acompañada de la ocupación de Gibraltar y Menorca por los Ingleses.” (The loss of the New Spain fleet in the bay of Vigo in 1702 was accompanied by the occupation of Gibraltar and Menorca by the English.” The Spanish navy was weak beyond compare and their allies, the French, were not much better off. Jenkins (1973) in his History of the French Navy emphasizes the circumstances facing Spain and France, “England had employed the few years of uneasy peace in strengthening her already strong navy. France had not…. In addition to her frigates, France had more than ninety ships of war; but some were elderly, most were ill-maintained, and only a few were in commission.” France’s rich lands and extensive land frontiers always made investing on the army a priority over the navy.

It was in this time of obvious need that Spain found many of its future leaders. Tinajero de la Escalera would become Spain’s first highly qualified and able naval administrator. Admiral Antonio Gaztañeta y de Iturribalzaga, a seagoing naval officer, administrator and naval architect would vastly shape Spain’s new navy in the next fifty years. It was fortunate for Spain that Gaztañeta’s multi-faceted career, grounded in practical and dangerous application of the theories and principles of shipbuilding being tested in war, was not unique among the Navy.

Building the Foundation for the Rejuvenation of the Spanish Navy

In Spain, the alliance with France had a very powerful and beneficial impact on the empire’s Navy. Several years before the Treaty of Utrecht the dynamic French Minister Jean Baptiste Colbert had advanced the practice of mercantilism to an art form in 17th Century France. The basic theory consisted of creating a strong self-sufficient base of agriculture and the manufacturing of raw goods produced from agriculture to create a surplus of exportable items. This allowed France to stop buying finished products from other countries, while selling French products to these same countries. The state supported and financed anyone that wanted to grow, produce or manufacture goods, and financially and publicly promoted the idea of private research in relatively new fields of scientific investigation.
The motivation behind the promotion of science started with the theories outlined above and then exploded into a veritable cornucopia of new techniques; a broader understanding of the physical world and new technology derived from this understanding. These innovations would then be utilized to increase production, decrease labor, and promote a growing and thriving middle-class. Herr (1958) explains, “In the eighteenth century France did not have a king who could rank with the best enlightened despots, but it did have a powerful middle class, and it was the center for the radiation of Enlightenment. Immediately to the south was Spain.”

The other great improvement over the old feudal system was that Colbert created a vast administrative network of men who had earned their positions by actual experience in their fields rather then the older patrimonial system of being born into them. Thus France had created a powerful agricultural, scientific and manufacturing foundation that could be adroitly administered by the men in the newly created Ministries, of which there were many, to govern virtually every aspect of the burgeoning economy. This “Mercantilism” strongly reflected the inspiration behind the Enlightenment and allowed France to build one of the largest navies the world had ever seen. Harbron (1988) writes, “In 1700, the French Marine Royale was still basking in the twilight of its largest expansion ever under the direction of Jean Colbert, Louis XIV’s great administer.”

Phillip V would take a page out of Colbert’s administrative book and create a series of ministries in Spain that would greatly fuel the expansion of the Royal Navy and the careers of men such as Navarro, Tinajero, Patino and the Marques de Ensenada. France sent Jean Orry to Madrid to help create the administrative framework necessary to revive Spain. Orry was a disciple of Colbert’s and as Hargreaves-Mawdsley (1979) points out, he was sent at the bequest of a powerful member of the clergy in the court of Felipe V, “Cardinal Portocarrero asked Louis XIV for an economist capable of putting in order the precarious Spanish finances. In answer Louis sent Jean Orry to Spain.” Orry created many new ministries. Chief among them was the Ministry of the Navy and Indies founded in 1721.

The administrative network was now in place; reformation, innovation and manufacturing could begin in earnest. Hull (1981) writes, “The first move was to create a number of government supported factories, each with a monopoly in its field that would produce the luxury goods then being imported from other European countries. The influence of Colbert is clear.”
The results of French mercantilism had definitely influenced Phillip V; Spain was producing more and more of its own goods, had a strong administrative framework in government with seasoned statesmen that earned their offices and were opening their borders to foreign ideas about the sciences instead of foreign trade. Again Hargreaves-Mawdsley (1979) emphasizes, “A new and noteworthy feature of government under the Bourbons was the rise of a rank of professional statesman, unknown under the Habsburgs. Under the Habsburgs there had been favorites who had exercised a personal power over the king and who, being untrained in government, had usually wielded that influence with disastrous results.”

**Revival of the Spanish Navy**

The Spanish Navy’s revival took root during the reign of Felipe V. After the Treaty of Utrecht in 1713 the lessons learned in the War of Succession bore fruit when Felipe V created a royal commission headed by Tinajero de la Escalara to define naval needs and address them. Orry, recognizing Tinajero’s abilities, appointed him to Secretary of the Navy in 1714, a post separate from the Council of the Indies. Both men recognized that they would have to bolster both their fleets in the Mediterranean and the Atlantic and Caribbean regions.

To put this into perspective, in the year 1700 there was no national navy and only the small regional fleets already mentioned. By the year 1740 Spain had 46 Ships of the Line in service and ready. In the second year of Carlos III reign, 1760, 18% percent of the entire expenditures of the crown went into the navy budget. The reasons behind the explosion of growth in the Spanish Navy have been outlined in the ideological concepts of the Enlightenment and the practical application of French administration with Spanish naval practitioners.

In the first two decades of the 18th century, Spain had made headway in repairing its woeful military and establishing a salient framework for economic growth; however, for Spain to expand its naval resources, it was intrinsically necessary for them to have seasoned naval officers, who understood the rigorous demands of fighting a naval war to run their shipyards and command the ships they designed. In this respect Spain had exactly what was needed.

Harbron (1988) put it succinctly, “This revival owes much to the newly-introduced French administrative method in government as well as efficient
Spanish practitioners in the navy.” Although Spain lost some major sea battles in the 18th century, the empire managed to accomplish the unprecedented feat of rebuilding a modern Navy in the 18th century from almost nothing; in large part due to the American colonies and especially Havana. This happened largely because of the enlightened views and mercantilist approaches favored by the Bourbon monarchs Felipe V, Fernando VI and Carlos III.

From 1710-1740 early naval planners had to function out of small, inadequate shipyards along the Basque coast and during this time period only 24 new vessels were constructed there. On the Mediterranean there were a few shipyards as well: Orio, La Grana, El Puntal and San Feliu de Guixols, all in Catalonia. New and larger shipyards/arsenals needed to be built and they eventually were; Cartagena, Guarzino and El Ferrol in the mid 1740’s were later expanded in the 1780’s and accounted for 88 new ships by the end of the century.

Havana, which at the start of the century had placed a strain on Spanish resources due to the need of a defensive fleet, created a total of 198 ships within 80 years. It was in Havana that the 140-gun four-decked Santisima Trinidad was built. It was the wood, mahogany and cedar, and the vast forests of the Spanish colonies that allowed the Armada Real (Royal Navy) to construct ships that were resistant to the most damaging elements of the times; the insatiably hungry teredo worms, the humidity that created dry and wet rot in all seasons, and the natural wear and tear of a ship, all of which were effectively combated by these harder, denser woods.

Incredibly knowledgeable captains and shipwrights such as Admiral Antonio Gaztañeta y de Iturribalzaga became the leading administrators in the new hierarchy and were the strength of the new navy. Gaztañeta is considered the father of scientific naval construction in Spain. He created the first full deck on a Spanish ship, usually the lowest gun deck and Harbron (1988) writes, “Gaztañeta drew plans for slimmer more streamlined hulls, plans whose influence was evident in Spanish warship construction until the advent of the screw for propulsion.” Gaztañeta eventually lost his entire fleet of twenty two ships, which he personally designed, to the British in 1718, off of Cape Pasaro; however, the loss at Cape Pasaro didn’t send the Spanish Navy into a decline, largely due to the advanced bureaucratic system that had been built. Intendant of the navy, Jorge Patino promoted growth in the navy and showed remarkable insight by founding the Spanish Marine Guards in 1717 as well as the mariners’ schools at Cadiz.
and engineering and artillery schools in Barcelona one year before the
disaster at Cape Pasaro. Lynch (1989) explains that it was through Patino’s
practicality and diligence that the fledgling navy gathered strength, “He
was able to appropriate a vastly increased defense budget and create almost
from nothing a new Spanish navy and an army which astonished Europe.”

Juan José Navarro: El Marques De La Victoria

Juan Jose Navarro de Viana y Bufalo (1687-1772) was born into these
turbulent times and was considered a man at the age of 15, when the War
of Succession was declared. By the age of 17 he had seen his first military
action at the Battle of the Adda River (1704). In the Company of the Duke of
Vendome he fought at the Battle of Mirandula and at the defense of the San
Osteo pass, where he was taken as a prisoner of war until he was exchanged
for Alliance prisoners at Portofolio castle. Vowing revenge for his capture
he fought in many actions, at the Battle of Ceba castle, in the Campaign
of 1706, the blockade of Turin and the defense of Milan. After Milan he
traveled to Valencia in 1707 returning to the land of his grandfather.

In 1708 he journeyed to North Africa with his father and his brother
Ramon, to inspect the fortifications and recommend ways to improve them.
His father and brother were part of the company protecting Spain’s borders and
it was in North Africa that his father was captured and his brother was slain.
The personal impact of his families’ and his own sense of duty were forging
Navarro into a naval officer that would remain an integral part of the Navy
until the age of seventy-six. Navarro returned to Spain, rejoined his father’s
company, and was part of the force that conquered Alicante and Valencia.
Later he stormed the castle at Miravete, fought at Penalba and in losing
causes at the Battles of Almenara and Zaragoza, where the enemy captured
him once again. Exchanged once more in 1710 he immediately returned to
the fray and was part of the assault at Barhuega and the Battle of Villaviciosa.
In Catalonia he distinguished himself in several actions including Argentera
y de Porreras, Arbio Castle, the burning of Montblanch, and the destruction
of Monroig, all while commanding a company of grenadiers. Finally peace
was declared in 1713 with the Treaty of Utrecht and it was during this
brief interlude of peace that the warrior Navarro noticed a growing feeling of
change in his homeland and in the European world.

Juan Jose Navarro de Viana y Bufalo was a favorite of Patino’s and was
promoted to ensign in the guard and became a willing student of Patino’s
tactics and naval knowledge. He also began instructing the other guards in mathematics and naval ship formations, showing a natural leadership that gained the respect of his countrymen. His prowess in battle was already well known. In 1718 he would get a chance to prove himself again in the War of the Quadruple Alliance. In the guards Navarro’s career progressed and he took part in the Cerdena campaign under Cardinal Alberoni, chief Minister of Phillip V, and was placed second in command on the 64-gun ship Real. In 1719 he was promoted to Lieutenant Colonel and began his naval masterpiece the Album.

Patino and the Royal Navy continued to advance as well; it was Patino that shifted the shipyards out of the smaller yards due to inadequacy and vulnerability to attack and created the large arsenal at Guarnizo. Patino also recalled Gaztañeta from sea duty and put him in charge of the yard at Guarnizo with the acknowledgement that Gaztañeta could design the ships with no interference from Patino. In 1726 Patino was made Minister of the Navy and the Indies and continued to expand facilities at El Ferrol, Cadiz, Cartagena and Havana. Then, in 1720, the War of the Quadruple Alliance ended and a needed peacetime settled over Spain.

Juan Jose Navarro took to work. In 1724 he wrote his first piece, “The Theory and Practice of Working Ships and their Evolution,” followed by “The Captain of a Warship instructed in the Sciences and the Obligations of his position.” In 1728 Navarro was promoted again to “Captain of the frigate.” After visiting the king at Cadiz, in 1729, Navarro became commander of the 64-gun ship San Fernando, already during the Spanish declared Anglo-Spanish-French War.

Patino died before the War of Jenkin’s Ear, or the Austrian Succession, in 1736, but the Royal Navy was much stronger then before his tenure. During the 20 years of his administration Patino was in charge of the construction of 58 vessels, most of which built in Guarnizo and Havana.

Navarro became an admiral in the fleet of galleons in 1730 and in 1732 he commanded the vessel Castilla. He continued to command and write simultaneously. In 1737, one year after the death of his friend and mentor Patino, he finished another treatise entitled, “Working Practices.” In 1739 the year war was declared in the War of Austrian Succession, he finished “Theory and Practice of the Navy and Plan of Military Laws of the Navy” and was given command of a squadron fleet by royal order from Cadiz. From 1741 to 1744 Navarro commanded his squadron fleet in a combined
Spanish-French fleet that contained the first Spanish three-decker of the new Navy, *Real Felipe*, a 114-gun vessel that ushered in a new era for the Spanish Navy. In 1744, after two years of being blockaded by the English at Toulon, the combined 52 vessel Spanish-French fleet won a questionable victory over the English. Questionable due to the loss of several Spanish ships, but victory nevertheless because the combined fleet broke the blockade and permitted supplies to reenter the area. It was this action that gained Navarro the title of Marques de la Victoria from Phillip V.

Patino’s and Navarro’s impacts on the Navy were felt in separate ways. Navarro, or now Marques de la Victoria, led his men into active battle, utilizing the skills about which he wrote, and won concrete victories for Spain. Patino’s accomplishments loom just as large in the naval shipyard arena. Harbron (1988) states, “The results of Patino’s many labors to advance Spanish sea power can be seen in the course of events in the two decades following his death, especially during the War of the Austrian Succession (1740-1748).” The Marques de La Victoria also left a lasting impression with his leadership skills in battle, his treatises, and especially his masterwork *Album*, which was completed in 1756.

**Spanish Shipbuilding in the 18th Century**

The following engravings have been chosen due to the fact that their content is strictly related to the naval architecture being practiced in Spain for at least the first half of the 18th century. These copper leaves contain all of the information necessary to build a Spanish warship beginning with the choosing of the timber from the royal forests and the seasoning of the wood for construction to the actual building, launching and rigging of the ship.

![Figure 09-01 – Plate 22 – Topographical plan of all the places, etc. (Courtesy of Museo Naval de Madrid, Navarro (1687-1772)).](image-url)
The Spanish empire had several forests set aside in order to grow the type of hard and soft wood trees that would enable the building of a large fleet of ships. This was a common practice of the major maritime powers of this period and created a reservoir of the main resource necessary to create the largest most complicated machine of the era, the wooden sailing vessel. The trees could be grown and their shape manipulated during that growth in order to create the specialized timbers necessary to form frames, floor timbers, parts of the transom, and the straight, single-piece wood used for the spars, masts and yards. Spain also enjoyed the added resource of the Nueva España colonies in the Americas that supplied the navy’s shipwrights with the mahogany and cedar mentioned earlier that proved to be more resistant to the common problems encountered by a wooden navy.

The timbers were then taken to the arsenals or shipyards where the wood would be cut into planks to form the outer hull, deck and floors. The image above also highlights the dissemination of naval architectural knowledge that was taking place and had been taking place for at least two centuries before the 18th century. The layout of this sawmill and the sawing methods depicted in the image are denominated as being English. It was either by the hiring of shipwrights knowledgeable in the English manner, information sharing between shifting alliances, the
capturing of ships and their crews as prizes or espionage, which was and is a very common military practice, that this data became available to the Spanish.

This image depicts several different aspects of timber preparation. The top canal or trough is filled with water and then the specially grown compass timbers are placed in the water to ready them for construction. The open air shed is where the straight long pieces of wood used for masts, spars and yards are placed for seasoning. The bottom engravings show a shipwright choosing one of the compass timbers or the v-shaped union formed by the limb’s connection to the tree trunk that were commonly used as ship’s frames and breast hooks. The lattice work timber platform to the right allows the wood to season in the open air without forming rot between the respective pieces. The shipwright on the far right is hitting the trunk with a large maul or wooden hammer and listening for any knots or weakened areas within the wood. The preparation treatment of the varying pieces of timber had become a specialized methodology that allowed for the Spanish shipwrights a plentiful supply of quality wood with which to construct naval and merchant vessels.
The seasoned compass timbers are joined together and placed upon the keel. This engraving shows the ten principle frames and all of the pieces used to create them necessary to construct a large ship. The keel, stern and stem post as well as three completed decks with cannon are also shown.

The skeleton of the vessel is in place as well as part of the hull planking. The views shown illustrate all of the various frames, the ceiling and hull planking as well as the keel, decks, deck beams and knees complete with the tumblehome above the top deck.
The construction and placement of all of the timbers, including deck beams, knees, mast-steps and hatch openings that form the necessary foundation before the deck planking is put into place. The amazing amount of detail encapsulated in the engravings leaves very little to the imagination and gives modern scholars all of the information needed to understand every aspect of 18th-Century Spanish naval architecture.

The acquisition of naval architectural practices from Spain’s European rivals is evident again in this depiction. The image is that of the construction
of a frigate in a shipyard. The crane being used to move the larger timbers above the first deck is described as being of Dutch manufacture, illustrating that the naval administration of Spain was actively pursuing their rival’s best ideas and incorporating those ideas to further their own purposes.

The engraving above demonstrates the main timbers needed to construct the transom and the small frames placed inside the stern progressing towards the stern post as the area decreases. The piece of the tree shown in the upper left corner with the bark still attached is one of the three pieces that will be utilized to form the keel.
The launching of ships was a continuous problem for all of the major maritime powers of this time period. The accepted practice is emphasized here with the ship on the base at the edge of the water in the arsenal or shipyard, pointed bow first. Several different techniques were tried through the years and the bow first method was largely accepted with the French, English and Dutch also utilizing this system. Again, the argument that this sharing of information and methods was acquired by espionage cannot be overlooked. David Roberts (1992), the editor translator of Blaise Ollivier’s Remarks on the Navies of the English and the Dutch (1737) points out in his discussion of Ollivier’s missions of data gathering, “Searches of the French archives reveal however that Blaise Ollivier’s mission was far from being an isolated case: we have identified what amounts to a regular and consistent pattern, one of the earliest being the mission of no less a personage than Colbert’s own son….”

The Album is so detailed and full of vital information that it has to be seen to be believed. There is quite literally no aspect of the entirety of the Spanish Navy that is not presented which is evident in the following image.

Figure 09-10 – Plate 10 – Representation of the nailing pattern of the outer hull planking. (Courtesy of Museo Naval de Madrid, Navarro (1687-1772)).

In this engraving the nailing pattern of the outer hull planking is depicted with wonderful clarity. It would be possible with the information shown in this image to recreate exactly the method and manner in which Spanish shipwrights fastened the outer hull planks to the internal skeleton
of the vessel. It can be safely stated that no other primary documentary source exists from the Spanish Navy, and perhaps from any other navies in the Europe of the 18th century, that can hope to match the Album in the scope of depth and detail. The engravings have to be recognized as the premier repository of information for any scholar looking for data concerning the Spanish Royal Navy of the Marques’ era.

Conclusion

The reformation and rejuvenation of the Spanish Royal Navy during the 18th century can only be viewed as a remarkable response to a dire situation. The problems and challenges facing Phillip V during and after the War of Spanish Succession, especially concerning the state of his maritime administration and the lack of a true navy have been discussed and made poignantly clear. The Bourbon ruler’s decisions coupled with his grandfather Louis XIV’s powerful presence in the Spanish court allowed Phillip to adopt and nurture a more modern and efficient system of ministerial administration. The implementation of new ideas and scientific study born out of the Age of Enlightenment allowed the Spaniards to reconstruct a naval force that enabled them to wage war against Spain’s enemies and protect their rich trade routes from the Americas and the Indies. The Spanish became again a naval power during the 18th century thereby reentering the arena of international politics until succumbing to the British at the Battle of Trafalgar. Historians and maritime archaeologists have for the most part neglected the study of Spain during this time period choosing to concentrate on the prior two centuries in which Spain discovered, colonized, and plundered their newly acquired territories in the Americas and Indies. For scholars of the Spanish during the Age of Enlightenment and especially those who have an interest in the naval forces of 18th Century Spain, the Album is a first-rate primary source collection of engravings that depicts contemporary naval practices with exacting details. The fact that the Album was never published during the 18th century and consists of a very different form of manufacture - being engraved on copper plates versus traditional book binding – had an impact as to the availability of the information ensconced in the precious leaves.

The Album of the Marques de La Victoria, only briefly analyzed in this study in the one specific area of ship construction is an invaluable resource. Step by step, following the natural progression from the specialized
growing of the trees for vessel construction to the seasoning of the wood, the incorporation of both English and Dutch methods and machines into the Spanish shipyard down to the incredible detail of the nailing patterns on the outer hull and the launching of the ship the Marques’ creation opens the door for all historians to know and understand in minute detail the shipbuilding practices of the 18th century Spanish shipyards.

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Abstract

The 15th and 16th centuries were crucial to the economic, political, and social development of the Western world, in large part due to exploration and expansion from the Iberian Peninsula. The primary vessels of this expansion were ocean going ships. Without the resources to build and maintain the naus, caravels, and other large ocean going ships the world would certainly have developed differently, perhaps drastically. The study of Iberian ship timber during this period provides an excellent first glimpse into the subject of my dissertation as this period has seen comparatively more recent scholarship than other eras.

This paper is primarily an introduction to my doctoral dissertation, Ship Timber, in light of its cardinal case-study investigating how the Spanish, Portuguese, Basque, and other Iberian cultures managed, exploited, and processed perhaps the most valuable resource of the Age of Discovery: wood.

Introduction

The role that seafaring played in the discovery, expansion, and conquest of the world should not be underestimated. Whether it was the trade and exploration on the Nile in ancient Egypt that first opened the interior of Africa to the Mediterranean world or the exploits of Spain across the Atlantic to “discover” and explore the New World, there is one common thread: ships.

Until the Industrial Revolution, the primary means of spreading culture were trade and war, both typically facilitated by ships and boats. Watercraft were, and in many cases still are, the culmination of the most
advanced technologies a society possessed and thus clear indicators of power, wealth and organization. In ancient Egypt ships were so important to civilization that pharaohs were frequently buried with several full-sized boats, constructed of only the rarest and largest timbers from neighboring lands. The degree of bureaucracy ultimately required in the age of Christopher Columbus and Ferdinand Magellan to build even a single large ship for trade or exploration was second only to the money required to procure the materials and manpower. Later, England’s ships of the line were perhaps the ultimate case-study of the interaction between public policy, management, and technical ability.

Any study of the vessels that shaped the world in which we live is incomplete without an understanding of the resources required to construct them, specifically, timber resources. Frequently, the restrictions of timber reserves dictated politics, military tactics, and technological changes in the construction of the vessels themselves. When Napoleon’s navy lost access to the Baltic timber reserves it crippled his momentum and forced him to explore other timber resources thousands of nautical miles away around the Black Sea. Such stresses on resources often contributed to or caused modifications in construction. Occasionally, the modified methods were extremely successful, became trends and eventually tradition or rule of thumb.

A complete understanding of the changes in European and Mediterranean shipbuilding over time should include an investigation and discussion of the basic building material, its properties, and how it was acquired and maintained as a sustainable resource. Prior to the end of the great wooden ship battles, generally considered the Battle of Hampton Roads in 1862, there were over 6,000 years of wooden shipbuilding in the Western world, which preceded the conversion to iron as the primary construction material.

Any study of archaeological or historical wood, forests, or timber should begin with two references: R.G. Albion’s *Forests and Sea Power* (1929) and R. Meiggs’ *Trees and Timber in the Ancient Mediterranean World* (1982). Albion was the author first to explore naval history intensively through the filter of the forests. Later, Meiggs took this concept and produced a brilliant addendum to the study of the ancient Mediterranean. Meiggs states that “…the most spectacular addition to the corpus of ancient timbers has come from the development of underwater archaeology” (1982:14). Yet,
Meiggs himself mentions just one archaeologically excavated shipwreck in his entire masterpiece, and this only in passing. He cannot be faulted, however, as his chosen task was epic and, at the time he was writing, the discipline of nautical archaeology was still in its first generation. Both Albion's and Meiggs' works are classics but with the growth of nautical archaeology and the plethora of shipwrecks that was excavated since they wrote, their studies are in need of update and expansion. By the turn of the recent millennium, the field of nautical archaeology was still viewed by prominent botanists and historians as having great potential to add to the knowledge of history through the analysis of hull timbers (Rackham 2001:14). That the discipline was viewed as “potentially” beneficial only a few years ago confirms that no seminal author or series of authors has yet to make a comprehensive addition.

This study is rooted in one general question: what can the wood from ships and boats reveal in terms of construction methods, trade patterns, societal strengths and weaknesses? This dissertation intends to develop a framework for an efficient and practical analysis of the timbers from ships and boats. This framework will consist of a list of analytical questions and quantitative tests that can be explored or performed on any collection of ship timbers with a clear understanding of what can, or cannot, be gained from such analysis. Several resources exist to aid in a study of ship timber, such as the material record, chemical analyses, the written record, iconography, and in some cases ethnographic studies. A study of the timbers alone would be too limiting if carried out outside the social, economic, and political frames from their respective periods. It is important to include varied resources. For example, the analysis of treatises on shipbuilding, of which examples survive dating to the early 15th century (such as the Timbotta Manuscript [ca.1445] and seem to cluster around the late 16th and early 17th century, such as F. Oliveira's O livro da fábrica das naus [ca.1580] and J. Lavanha's Livro primeiro da architectura naval [ca.1610]), shows that they neglect many of the practical aspects of the art that the material record can help reveal. Many of the day-to-day methods used by Italian or Iberian shipbuilders in the 15th and 16th centuries would have been considered common knowledge and may have gone unrecorded for a variety of reasons, but evidence of such methods remains in the shape, placement, and character of the timbers themselves (Loewen 2000).
The specific questions that will be addressed in my dissertation include:

1. What is “ship timber?”
2. How did populations obtain their ship timber?
3. What technological knowledge regarding ship construction can be extracted from a study of ship timber?
4. Can the origin of watercraft be determined based on the timber utilized; can wood typologies reveal the general purpose of the vessel?
5. Did societies recognize a need to manage their timber resources and if they recognized a need to manage their resources did they take action?
6. When does “management of the forests” transition to “forest management?”
7. Can the environment of a given period be reconstructed from geo-archaeological evidence and does ship timber support such reconstruction?
8. Were dominant societies self-sufficient or dependent on foreign resources?
9. Did the availability of adequate ship timber contribute to the growth, dominance, and decline of a society?

Although study in nautical archaeology encompasses many millennia of seafaring history, since man first ventured out onto the water, my work will employ four case-studies of selected time periods and geographic regions to test the effectiveness of the proposed framework. The following periods have been chosen because each one presents a unique combination of challenges and opportunities regarding the study of ship timbers:

1. Ancient Egypt during the Middle Kingdom
2. Athens during the Classical period
3. The Iberian Peninsula during the Age of Discoveries
4. The New World pre-American Revolution.

Some of these four periods have ample written records and limited material evidence, in the form of watercraft (Classical Greece and the Iberian Peninsula), while others have limited written records and ample archaeological evidence (ancient Egypt’s Middle Kingdom). Still others may be prolific in both (the New World). The contributions and limitations of each period will be outlined in a dedicated section and are briefly outlined below. I chose these particular places and times because each case-study
represents a critical period in the history of Western shipbuilding and has benefited from decades of nautical study and excavation.

Ancient Egypt has been chosen because it is the traditional beginning for a discussion on the history of shipbuilding (Creasman 2005, 4). Likewise, it is a great example of a seafaring culture with scarce local timber resources. Within ancient Egypt the focus is on the Middle Kingdom (2055-1650 B.C.) for its corpus of information including: four nearly complete Twelfth Dynasty vessels collectively known as the Dahshur Boats, a series of robust timbers that appear to be ship frames in the Lisht timbers, numerous boat models including the most heralded set from ancient Egypt buried with the Eleventh Dynasty nobleman Meket-Rē (including a model of a carpentry shop), boatbuilding and boat use iconography, as well as some written accounts of trade and war. It should also be noted that this period was chosen as it was the topic of my master’s thesis, *The Cairo Dahshur Boats* (Creasman 2005), and I am already quite familiar with the available resources.

Athens was the pinnacle of Classical Greece (500-350 B.C.) and has been chosen both for its comparative abundance of written records, and because it was home to a seafaring culture whose authority was dependent upon ships. Extensive terrestrial excavations over much of the mainland and the Aegean islands may prove to be useful in acquiring contemporary data and pollen analyses to reconstruct distribution maps for local timber resources. One important resource for this endeavor is the excavation of the Tektaş Burnu shipwreck, by Texas A&M and the Institute of Nautical Archaeology, which was directed by a notable scholar of the period, Dr. Deborah Carlson, a member of my doctoral committee.

The Iberian Peninsula during the Age of Discoveries (A.D. 1400-1600) provides perhaps the most comprehensive series of data from which to make a study of ship timber. The ships from the Iberian Peninsula during this time opened the world to Europe, defining the way history developed thereafter. Several treatises on shipbuilding, historical documents, as well as nearly ten shipwrecks with published hull remains, terrestrial excavations, contemporary histories, tax records, some ethnographic works, and extensive recent scholarship are all available for the period. Another notable scholar of the period is certain to be helpful in this research, Dr. Filipe Vieira de Castro, and is the chair of my doctoral committee.
The New World pre-American Revolution (A.D. 1500-1776) provides evidence in excess, much like the timber resources were at the time. The abundance of obtainable timber in this period may resemble what other societies experienced early in their development. This is perhaps the only case-study in which the early stages are recorded in proportion to the later stages of resource management and technological advancement.

Several other periods were considered at first, but eliminated from this study for the sake of feasibility. Although already at least partially studied, Imperial Rome, Renaissance Italy, the Dutch during the time of the Dutch East India Company (V.O.C.), French Enlightenment, or the British Empire in the 18th century would have each been relevant case-studies worth developing and studying further. However, in the early stages of this research more can be learned by investing effort in almost virgin arenas such as those presented here. Rival’s work with Roman navies (La Charpenterie Navale Romaine, 1991), Lane’s with the Italian city-states (Venice, A Maritime Republic, 1973), Hoving’s work in the Netherlands (Nicolaes Witsen’s Scheeps-Bouw-Konst Open Gestelt, 1996), Bamford’s with the French (Forests and French Sea Power 1660-1789, 1956), and Albion’s work with the English (Forest and Sea Power: the Timber Problem of the Royal Navy 1652-1862, 1929) have each addressed the subject of timber resources in varying depths. Yet, none has made a comprehensive addition to the study of ship timber.

Present Status of the Question

The extant body of work regarding a defined framework for the study and analysis of ship timber is negligible. While several works include chapters regarding ship timbers (particularly in the Baltic region) there are only a few extensive works on this topic, of which three stand as particularly relevant for this study: F.C. Lane’s Venice a Maritime Republic (1973), Rival’s La Charpenterie Navale Romaine (1991), and Meiggs’ Trees and Timber. While Lane, a historian, framed parts of his work within the context of ship construction neither his nor Meiggs’ work are written recently enough to take advantage of the contributions of the field of nautical archaeology. Only Rival’s work presents a study of ships, their construction, and timber in depth. Few nautical scholars have dedicated the entirety of an article or chapter to the varied questions that my dissertation will hopefully address. Among others, F. Ciciliot (2002) and C. Pulak (2001, 2002) are notable
exceptions, although not mentioned elsewhere in this paper, from the nautical community that have devoted entire works to the subject. The majority of the academic references to ship timber are strictly historical or strictly archaeological. By restricting analysis to only one field of evidence, too many details about the most important material of every pre-Industrial wooden vessel have been overlooked.

My dissertation intends to present a more comprehensive approach to the study of ship timbers and try to establish a corpus of information, as reliable as possible, from the real treasures of underwater excavations: timbers. As I have mentioned above, while several authors have made progress towards this goal, none has addressed it in full. By combining the written record, the archaeological record, iconography, and ethnography, with the social, economic, and political factors that went into developing and maintaining the materials used to build the vessels that shaped the world, a more complete analysis of ships and boats can be made. Though few may recognize it, wood was the most valuable resource for many of the world’s greatest civilizations.

Methodology

In order to develop a framework for an efficient and practical analysis of ship timbers, pertinent terminology such as “ship timber” and “forest management” must be clearly defined. Precise definition and applications are critical to the transferability of the proposed analytical framework across regions and time periods. A thorough literature review will primarily focus on the methodological and technical studies of ship timber.

Socio-economic and socio-political events that shape each period will be summarized and documented. Their effects on shipbuilding of the times will be included in the analytical framework to be developed.

After the literature review, a section on quantitative scientific analysis will outline the uses of the following and their specific application to the study of ship timber: 1) dendrochronology, 2) dendro-analysis, 3) radiocarbon, 4) palynological analysis (specifically, pollen analysis), and 5) deoxyribonucleic acid (DNA).

The benefits and limits of dendrochronology in an archaeological context are largely well defined (Kuniholm 2002; Brothwell and Pollard 2001), as is the case for radiocarbon or $^{14}$C dating (Taylor 1987; Bass et al. 1982). Pollen analysis, while certainly familiar in an archaeological
context (Bakker 1951; Faegri 1989) has had very little application in the study of waterlogged ship timbers, probably due to disturbed sediments and loss of pollen spores underwater (Giachi et al. 2003). Yet, by using the pollen analysis of terrestrial archaeological sites it may be possible to reconstruct timber distribution maps of the selected region for a given period. Extracting and analyzing DNA from waterlogged wood is extremely difficult, firstly supposing any survives; nonetheless, this resource has been under utilized in studies of ship timber. Yet, by using the pollen analysis of terrestrial archaeological sites it may be possible to reconstruct timber distribution maps of the selected region for a given period. In combination with associated artifacts, timber distribution maps should prove beneficial in helping locate the origin of a vessel or at least the origin of the raw timber source. Further study will investigate how far certain types of ship timber were known to travel (e.g. Levantine cedar in the ancient Mediterranean saw few boundaries, while Egyptian sidder is not known to have left the banks of the Nile as a ship construction material). Comparison of reconstructed distribution maps with modern distribution maps may also help to fill in the gaps where pollen analysis is unavailable or unreliable.

Physical inspection of ship timber can be extremely revealing regarding forestry practices as Loewen (2000) has demonstrated. On many occasions, when a person modifies a raw material, there remains distinctive evidence of the process and this is certainly the case for ship timber. In ancient Egypt tool marks are so well preserved that the different sizes of chisels, saws, and adzes used to shape the timbers can be identified and a shipbuilding tool kit effectively reconstructed (Ward 2000). Similarly, the management of ship timber stores can sometimes be reconstructed by looking at the arc of futtocks, relative age of common timber pieces, percentage of wood wasted, and the identification of “waney edges” (Loewen 2000). Size and shape of timbers can also be revealing about resource availability and construction method (e.g. Nossa Senhora dos Martires, Castro 2005). From these and other empirical observations a general concept of timber management can be inferred. Combined inference with written records, iconography, and other lines of evidence and a detailed understanding of the information the timbers have to offer should be possible.

Applying the methods above to each case-study will validate and caveat the final framework produced in this dissertation. The conclusion
will contain the final framework and notes on how ship timber can best be studied in an archaeological context, particularly nautical archaeology.

The Iberian Case-Study

The Iberian Peninsula during the 15th and 16th centuries is the cardinal case-study of my dissertation as it provides, comparatively, much more information from which conclusions regarding ship timber can be drawn. Recent scholarship from this period has produced several translated and analyzed contemporary treatises, at least seven reliably excavated and published shipwrecks with timber (however limited), and extensive contemporary histories. Recent scholarship by Richard Barker, Michael Barkham, Filipe Castro, Furio Ciciliot, Frederic Guibal, Brad Loewen, Carla Rahn Phillips, Patrice Pomey, Eric Rieth, and others has developed an increasingly comprehensive view of the Iberian Peninsula and will be indispensable throughout this study. Loewen’s work regarding Basque shipbuilding traditions (1998, 2000) provided much of the impetus and structure for this study. He has demonstrated how timber studies from individual wrecks can reveal information regarding forestry practices, but can such continued studies be used to place other wreck fragments into specific cultural contexts (Loewen 1998).

Preliminary results from this period indicate that there was a consistent practice of localized resource management in shipbuilding regions. The term “forest management” implies an inherent altruistic goal in preserving the environment and this was probably not the case during the 15th and 16th centuries. It is more likely that a “management of the forest” mentality pervaded; overseeing the timber and restricting its uses because the primary concern was having enough quality wood for construction purposes. Further study should yield a comprehensive analysis of the state of shipbuilding resources in the Iberian Peninsula during the Age of Discoveries which, in turn, will help develop the framework proposed above.

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Abstract

During the fifteenth century, Portuguese seafarers began to depart from the traditional navigation technique known as ‘dead reckoning’ to develop new systems more suited for their increasingly far-reaching explorations along the coast of West Africa. For decades, the genius of the Portuguese court was devoted to finding solutions to the problems confronted by the ships’ pilots. The most valuable achievement resulting from this effort was a new method of navigation that consisted of measuring the angle of certain heavenly bodies above the horizon in order to determine the latitude of the observer. For this purpose, some instruments that traditionally belonged to the field of astronomy were adapted for the use of seamen. Among them was the astrolabe, which became the most popular by the turn of the sixteenth century.

This paper presents a catalog of sixteen nautical astrolabes, all of which were found after 1988, when the last comprehensive work on this instrument was published. Some of these astrolabes have already been presented in earlier publications. However, this represents the first effort to gather them in a single source and language, making the information more readily available to the researcher. At least seven unpublished samples are presented.

Introduction

Given the vital role the mariner’s astrolabe played in the process of European maritime expansion during the fifteenth and sixteenth centuries, it comes as a surprise that systematic studies on this instrument were not undertaken until the early twentieth century (Estácio dos Reis 2002:7-9). This may be due to the fact that most nautical astrolabes vanished after the early eighteenth century, when the instrument’s popularity declined. During the late fifteenth and early sixteenth centuries sea astrolabes were
sometimes made of wood. Wood is a perishable material and no wooden astrolabe from that period has been preserved. Astrolabes were also made of brass or bronze, which are both valuable metals. It is likely that, when more practical devices began to be used in navigation, most sea astrolabes were melted so their material could be reused.

The first comprehensive work on the mariner’s astrolabe was published by the Junta de Investigações do Ultramar of the Universidade de Coimbra, Portugal, in 1966. The author was David Waters, then Head of the Department of Navigation and Astronomy at the National Maritime Museum in Greenwich, England. In the paper, Waters presented the history of the instrument and its development through the sixteenth and seventeenth centuries, mainly based on contemporaneous literature and iconography. The work concludes with notes on the twenty-one astrolabes known at the time, including measurements, features and scaled illustrations. In his work, Waters proposed a typology for sea astrolabes that has remained the standard:

- Type I (a) – Wheel type with base ballast
- Type I (b) – Wheel type with crown ballast
- Type II (a) – Semi-sphere with base ballast
- Type II (b) – Semi-sphere with crown ballast
- Type III – Wheel type without ballast

Waters’ work remained unparalleled until 1988, when Professor Alan Stimson, then Curator of Astronomy and Navigation at the National Maritime Museum, published the book The Mariner’s Astrolabe: a Survey of Known, Surviving Sea Astrolabes. Stimson’s work is similar to Waters’, but more extensive. The typology proposed by Waters is extended by Stimson to include two new types:

- Type IV – Planisphere for marine use
- Type V – Concentric ring type

Stimson’s book presents the sixty-five nautical astrolabes known in 1988, including the twenty-one discussed in Waters’ paper. There is an illustration or picture of each instrument, as well as their number and name, as Stimson and the National Maritime Museum registered them. Stimson’s work remains to this day the most authoritative source on nautical astrolabes. However, after almost two decades, his survey can now be upgraded to include the instruments found during the last nineteen years. The catalogue presented in the following section is not exhaustive.
and two artifacts did not yield much information. They are the Zacharchak (NMM 66), dated 1593 and found in the late 1980s near the coast of Cuba (Estácio dos Reis 2002:34), and the Ile de Brehat (NMM 85), recovered near the coast of that island off northern Brittany. It is likely that numerous nautical astrolabes have been found around the world that have yet to be registered.

The Astrolabes

Inés de Soto

Two nautical astrolabes (PE-1 and PE-2) were recovered between 1992 and 1995 north of cay Inés de Soto, off Cuba’s northwestern coast, by personnel from Carisub, S.A., the Cuban state institution for underwater archaeology (Cañizares 1998). Of the two instruments, PE-1 is the best preserved, despite that the entire upper right and some of the lower right quadrants are missing (Figure 11-01). Around 36% of the instrument eroded during the centuries it spent on the seabed. The portion that remains weighs 1,380 g, so it is estimated that the artifact’s original weight was 2,156 g. It is 202 mm in diameter and 14 mm thick. On the front side of its bottom ballast is the inscription ‘1555,’ year in which the astrolabe was manufactured (Figure 11-02). This instrument is undoubtedly Spanish and very similar to the Palermo (1540, NMM 1) and the Arts et Métiers I (1563, NMM 24). The former is thought to be Portuguese, while the latter is Spanish. The three specimens are within 4 mm in diameter and 1 mm in thickness.

The PE-1 astrolabe is graded to measure altitude, a typical Spanish feature. A stamp of the Pillars of Hercules is partially discernable on the lower right corner of the date inscription. This mark confirms that the instrument was examined and approved by the Piloto Mayor of the Casa de Contratación, the Spanish institution that oversaw all aspects of the Crown’s overseas affairs. The bottom ballast is triangularly shaped, a typical feature of mid-sixteenth century astrolabes. The alidade, partially eroded, preserves its two sighting vanes. They are 101.5 mm apart and are pierced by holes that are larger on their outer side. This suggests that the alidade was used to make solar observations. The instrument’s suspension ring is absent.
The most remarkable feature of this astrolabe is its marks, which are unique in the archaeological record. At the point where the left spoke joins the rim, five ‘x’s were stamped forming a cross. This pattern also appears below the ‘1555’ inscription. To the left and right sides of the ‘1555,’ three ‘x’s and two ‘x’s were stamped respectively. Additionally, two circles of ‘x’s are inscribed around the astrolabe’s perimeter. The one on the inner rim marks the ten-degree divisions along the circumference. The other, which lies halfway between the inner and outer edges, marks the five-degree divisions (Figure 11-03). As of 1998, the PE-1 astrolabe was kept in the facilities of Carisub, S.A. in Havana.
PE-2 is a type Ia astrolabe, although its poor state of preservation makes it difficult to perform a useful analysis (Figure 11-04). It is likely that this artifact was also manufactured around the mid-sixteenth century. It is 170 mm in diameter. Currently, it weighs 339 g and is 10 mm thick. However, these statistics are relatively useless given the instrument’s condition. Both the suspension ring and the alidade are missing and neither marks nor a scale may be discerned. A loose alidade was found at the site, but its dimensions suggest that it did not belong to PE-2. It is thus likely that another astrolabe was carried in the wrecked ship. After its recovery, PE-2 was stored with its counterpart in Havana.
Aveiro

This astrolabe, which is in an excellent state of preservation, was found in an unidentified wreck in Ria de Aveiro, Portugal, in 1994 (Figure 11-05). It is a typical example of Iberian manufacture from the second half of the sixteenth century, similar in shape and features to four others: the Tenri (ante 1609, NMM 10), Girona II (ante 1588, NMM 27), Atocha I (c. 1600, NMM 34), and Mounts Bay (1550-1600, NMM 46) astrolabes.

As with its four counterparts, the Aveiro astrolabe has a wedge-shaped section, although much less pronounced. The bottom ballast resembles a bell rather than a semicircle, a characteristic shared by these five instruments. The five circles forming a cross on the front side of the ballast attest to its Portuguese origin, as does the scale, which is graded for zenith distance. The figure ‘90’ was not stamped on the rim. The manufacture date, 1575, can be clearly seen below the five-circle mark. Both the alidade and the suspension ring are in good condition. The alidade is secured to the hub by an axis pin with a wedge driven through a slot, a feature replaced in the late sixteenth century by the threaded bolt with a wing nut. The lateral and upper spokes are of constant width. The projection on which the suspension ring rests serves as an ornament and is found, with identical shape, on various astrolabes dated within this period.

Figure 11-05 – The Aveiro astrolabe with all of its components. (Photo courtesy of the Centro Nacional de Arqueología Náutica e Subacuática, Lisbon).

Museo Naval

The Museo Naval in Madrid acquired this astrolabe from Sotheby’s auction house in 2001. Nothing else is known about its origin. However,
metallurgical analyses suggest the instrument was manufactured in Spain during the sixteenth century (Carmen López Calderón 2005, pers. comm.). It is made of bronze and is excellently preserved (Figure 11-06).

Arguably, the most remarkable features are its four spokes, which are elaborately shaped at the points where they join the rim. The bottom ballast of the *Museo Naval* astrolabe is similar to that of the Red Bay (NMM 55). Remarkably, both instruments share identical dimensions. The Red Bay astrolabe was recovered from a Spanish shipwreck in Labrador, Canada, in 1984. During the sixteenth century, Red Bay was an important outpost of the Basque whaling industry. It is, therefore, reasonable to ascribe a Spanish origin to both instruments. The Red Bay astrolabe has been dated to between 1525 and 1575, and the artifact from the *Museo Naval* may also be placed within this timeframe.

The scale of the *Museo Naval* astrolabe is graded for measuring altitude, another indication that the instrument is likely Spanish. There are no numbers stamped at the zero-degree position. The five-degree marks, located between the multiples of ten degrees, show eight-pointed stars instead of digits. Three such stars also appear at the top of the rim, on the projection supporting the suspension ring, arranged as the vertices of an
inverted triangle (Figure 11-07). Two other eight-pointed stars are stamped on the ornamental lobes on each side of the suspension ring.

The alidade of the Museo Naval astrolabe is missing, although its suspension ring is intact. The instrument’s remarkable condition makes it likely that the alidade was removed rather than worn away. This is, however, impossible to ascertain, given the artifact’s obscure origin.

Figure 11-07 – Eight-pointed stars on the Museo Naval astrolabe. (Photo courtesy of the Museo Naval, Madrid).

**Francisco Padre**

This astrolabe was presented as a gift to a member of Spain’s royal family by the French underwater explorer Franck Goddio. It was supposedly found on a wreck site near Cape San Antonio, off Cuba’s northwestern coast, in an area known as Francisco Padre. Given its obscure origin, it is difficult to ascertain the instrument’s authenticity (Figure 11-08).

This artifact is fairly well preserved. It is similar in shape to five other instruments: the Tenri (NMM 10), Girona II (NMM 27), Atocha I (NMM 34), Mounts Bay (NMM 46), and Aveiro astrolabes. Among these, four have been positively identified as Portuguese and all have been dated to the second half of the sixteenth century. The scale, graded for zenith distance, indicates that, if authentic, this instrument was also manufactured in Portugal. The diameter is the same as that of the Atocha I and only 1 mm less than the Tenri astrolabe. As with all its counterparts, the Francisco Padre has a wedge-shaped section.
Figure 11-08 – The Francisco Padre astrolabe. (Photo courtesy of the Museo Naval, Madrid).

The alidade is held in place by what seems to be a modern bolt (Figure 11-09). The suspension ring is absent. Strangely, given the state of preservation, no trace of ornament remains on the crown. At the time this work was written, the Francisco Padre astrolabe was stored at the Museo Naval in Madrid, Spain.

Figure 11-09 – Bolt holding the alidade of the Francisco Padre astrolabe. (Photo courtesy of the Museo Naval, Madrid).

San Diego

The Manila galleon San Diego sank on 14 December 1600 twenty miles south of Manila Bay, Manila, Philippines. It was located in 1991 by a team led by French underwater explorer Franck Goddio. Two field seasons were held in 1992 and 1993, during which the site was excavated and the hull remains partially recorded. Among the finds were an astronomical circle and a mariner’s astrolabe.
The San Diego astrolabe is made of bronze and is in a fair state of preservation. It is 183 mm in diameter, 17 mm thick at the top and 18 mm at the bottom. This could suggest a wedge-shaped section. However, such a small difference could also be explained as an imprecision in manufacture. The lateral and top spokes maintain a constant width as they join the instrument’s rim, while the bottom spoke turns into a semicircle that serves as ballast. The two upper quadrants are graded at five-degree intervals with tick marks. However, there are no digits stamped on the scale. This curious feature repeats itself on the Greenwich (Valencia) astrolabe (NMM 4). In 1988, Stimson theorized that this could be an exception by the manufacturer, given a possible rush in the instrument’s fabrication. Nevertheless, the recurrence of this characteristic in the San Diego astrolabe suggests this may have been the practice of a particular maker (Figure 11-10).

The alidade of the San Diego was cast as a single metal piece. The sighting vanes were pierced for solar observations, with holes that are larger on the outer face. The axis pin is secured by a wedge rather than a wing nut, a practice abandoned by the end of the sixteenth century (Stimson 1988:24).

The suspension ring of the San Diego astrolabe is mounted on a mechanism that allows it to swing both laterally and perpendicular to its main plane. It has two peculiar protrusions, one on each side, which allow the instrument to be suspended by three fingers. This feature is also found in the Kronborg (1600, NMM 5), Barlow (1602, NMM 7), Caudebec (1632, NMM 17), and Banda I (1568, NMM 43) astrolabes. Although no date or marks are present, based on its provenience and the characteristics it shares with the aforementioned artifacts, this astrolabe is most likely Iberian and was manufactured around the last quarter of the sixteenth century.
São Julião da Barra

Three astrolabes were recovered between 1996 and 1997 at the mouth of the Tagus River, Lisbon, from what is believed to be the wreck of Nossa Senhora dos Mártires, a Portuguese Indiaman that ran aground in front of Fort São Julião da Barra on the night of 14 September 1606. They were designated SJB I, SJB II and SJB III by the archaeologists who excavated the site.

Four centuries of abrasion took their toll on the SJB I astrolabe (NMM 78), which is in a poor state of preservation. This instrument is made of brass, but the metal also contains high concentrations of lead and tin. Although the suspension ring is missing, its holding shaft is still in place. Only a portion of the alidade survives. Both sighting vanes are absent. The bottom ballast is shaped in a semicircle (Figure 11-11).

Three rivets were placed on the front face of this astrolabe by its manufacturer, at seemingly random locations. It has been theorized that these were meant to fill voids left on the instrument’s surface during the casting process. The scale is completely obliterated and there are no discernable marks. Little more can be said about this artifact besides the fact that, at least aesthetically, its date of manufacture can be placed somewhere between c. 1575 and c. 1625.

![Figure 11-11 – The SJB I astrolabe. (Photo courtesy of Filipe Castro).](image)

As its counterpart, SJB II (NMM 79) was severely eroded during the centuries spent on the bottom of the Tagus River. The suspension ring is missing. A small portion of the alidade survives, in the area where it joins the wheel’s hub. Conservation work revealed a small section of the scale.
Since the instrument was graded for zenith distance, it can be confirmed to be Portuguese.

Somewhat peculiar to this astrolabe are the five-degree marks, which are at the same radial distance from the hub as the ten-degree marks, rather than further outside, as is usually the case in similar instruments. This can only be found in the Dundee (1555, NMM 2), Aveiro (1575), and Atocha I (c. 1600, NMM 34) astrolabes, all of which are Portuguese (Picas do Vale 1998:101).

The bottom ballast of this artifact is shaped in a semicircle. The upper and longitudinal spokes widen as they join the rim in a shape resembling a bell. This design is identical to that of nineteen other astrolabes manufactured between 1540 and 1650, of which sixteen are Portuguese (Picas do Vale 1998:102).

A curious detail about this instrument is that its rim is fractured at the right lower quadrant. It has been suggested that, as the casting mold was being filled with molten brass, the metal reached the point of the fissure at different temperatures. Even though at that spot the metal would have partially fused, this created a structurally weak section. Although it is unlikely that the instrument was broken in use, the abrasion it endured during the centuries may have exposed this construction flaw. Albeit a precise manufacture date cannot be determined, it is likely that this instrument was built during the last quarter of the sixteenth century, or in the early seventeenth century (Figure 11-12).

![Figure 11-12 – The SJB II astrolabe. (After A. Estácio dos Reis’ Astrolábios náuticos em Portugal).]
SJB III’s (NMM 83) pristine condition makes it the best preserved astrolabe in the São Julião da Barra collection (Figure 11-13). It was recovered from beneath a rock, which prevented the abrasive action of the surrounding elements. The fact that it rested under a heavy load makes it the least likely to be intrusive. Therefore, we may relate this instrument to the Nossa Senhora dos Mártires most confidently. This artifact, which is made of brass, was found in close association with an iron cannon. Through the centuries, the cannon released a flow of electrons that helped to create a protective layer that prevented chemical decomposition.

![Figure 11-13 – The SJB III astrolabe. (Photo courtesy of Filipe Castro).](image)

The origin of this astrolabe is clearly Portuguese, given its scale, graded on the two upper quadrants for zenith distance. A ‘I’ is incised in the zero-degree position, a characteristic shared by ten other astrolabes, both Spanish and Portuguese. At the wheel’s bottom, beneath the ballast, a letter ‘G’ can be clearly distinguished. This mark is also found, in the same location, on the Atocha III astrolabe (NMM 59), with which the SJBIII shares other similarities. These are the date of manufacture, a constant width in the lateral and upper spokes as they join the rim, scale format and alidade shape. The Atocha III is, nonetheless, 18 mm smaller and substantially lighter. Still, this does not preclude the possibility that both instruments were made by the same craftsman. Although it has been suggested that the letter ‘G’ is the maker’s mark of Francisco de Goes, Stimson clearly states in his work that said symbol “might or might not indicate” a connection to the Goes, a Portuguese family of
instrument makers active from around 1587 until the late seventeenth century (Stimson 1988:32-3).

The bottom ballast of SJB III is shaped in a semicircle. On it, the instrument’s date of manufacture (1605) is clearly visible between four six-pointed stars (Figure 11-14). The alidade is in perfect condition, with its sighting vanes spaced at 65 mm and pierced for solar observations. It is attached to the wheel by a threaded pin and a wing nut. The suspension ring is mounted on a mechanism that allows the astrolabe to swing about both its lateral and perpendicular axes. Two lobes, one on each side of the suspension ring, serve as decoration.

Figure 11-14 – Bottom ballast of the SJB III astrolabe, with the date of manufacture. (Photo courtesy of Filipe Castro).

Dry Tortugas Deep Water Shipwreck

Shrimp fishermen discovered this shipwreck in the late 1960s off the coast of Florida, near the Dry Tortugas islets. While dragging their deep-water nets, the men brought up artifacts from the bottom, including a Spanish olive jar from colonial times. Robert Marx was informed of the find and its approximate location, but a site depth of approximately 400 meters made its excavation improbable at the time.

In 1988, a group of investors known as Seahawk Deep Ocean Technology joined Marx in an effort to relocate the wreck. With the advances made in deep water exploration technology during the previous twenty years, it was not hard to find the site. Between 1990 and 1991, a team from Seahawk began excavations, and by the late 1990s, thousands of artifacts had been recovered. This became the first underwater salvage operation in history that was entirely performed with the use of a Remotely Operated Vehicle (ROV).
It has been theorized that this vessel was sailing with the 1622 Spanish *Tierra Firme* fleet, of which the famous *Atocha* and *Santa Margarita* were part. However, no conclusive evidence of this has been presented. The vessel’s cargo consisted mostly of earthenware, gold bullion and personal and religious effects. Three sea astrolabes were also found at the site, according to an interim archaeological report released by Seahawk in the summer of 1999. The three instruments are currently stored in a conservation facility in Sarasota, Florida. They belong to Odyssey Marine Exploration, an underwater exploration and recovery company founded in 1994 by the staff of the former Seahawk Deep Ocean Technology. The astrolabes were recorded as *Seahawk* I, II, and III, presumably after the ROV with which they were recovered. A fourth specimen, purchased by Odyssey at auction, is also kept with the assemblage. These four comprise one of the largest collections of nautical astrolabes in the world, second only to that of the *Museu de Marinha* in Lisbon, Portugal.

*Seahawk* I is a type Ia Iberian astrolabe manufactured most likely during the first half of the seventeenth century (Figure 11-15). A substantial portion of the alidade, 148 mm in length, is still held in place by what remains of the axis pin. Portions of the sighting vanes are also there, although they broke beneath the observation pinholes. The suspension ring is missing. Neither a scale nor marks may be distinguished, since most of the original surface has eroded. Similar examples are the *Sacramento* A (NMM 38), *Sacramento* B (NMM 39), *Isle aux Morts* (NMM 44), *Santa Escolástica* (NMM 49), *Banda* II (NMM 56), *Rincón* (NMM 63), and *Cádiz* I (NMM 65) astrolabes. Nevertheless, *Seahawk* I is larger (from 11 to 19 mm in diameter and 3 to 7 mm in thickness) than its counterparts. The fact that the *Seahawk* I has no discernible marks makes it impossible to draw any further parallels.

Figure 11-15 – The *Seahawk* I astrolabe. (Photo by the author).
The *Seahawk* II (NMM 68) is the most remarkable astrolabe of the collection. The author was unable to inspect this artifact, as it was not at the conservation facility where it is usually stored in the spring of 2005. Consequently, data presented in this document comes from a preliminary report dated July 1999 and prepared by archaeologist Jenette Flow. One unusual feature of this instrument is the image of an armillary sphere stamped on the front side of the ballast (Figure 11-16). Only one other astrolabe in the archaeological record shares this trait: the Zacharchak (NMM 66), dated 1593 and recovered during the late 1980s off the Cuban coast.

![Image of an armillary sphere stamped on the *Seahawk* II astrolabe.](After A. Estácio dos Reis' *Astrolábios náuticos em Portugal*).

The suspension ring of the *Seahawk* II is absent, but a portion of the alidade survives. The instrument is 171 mm in diameter, being more in accord with the typical Iberian astrolabe from this period. It is 26 mm thick and weighs 3,126 g.

The cast wheel of *Seahawk* III is fairly well preserved, but no part of the alidade survived. A portion of the axis pin remains. The suspension ring is also absent, but again, the pin is still there. Like its two counterparts, this astrolabe is a typical example of Iberian manufacture from the first half of the seventeenth century. As with *Seahawk* II, its diameter is close to that of most instruments within this typology. Although most of the original surface is eroded, the upper spoke shows the pairs of thin lines typically present on similar specimens (Figure 11-17).
A fourth astrolabe is kept with this assembly, although it was not found at the Dry Tortugas site. Odyssey Marine Exploration acquired this instrument at auction, but the author knows nothing else about its origin. The difference between this and the other three specimens is evident, as this is a typical Iberian astrolabe from the second half of the sixteenth century. In its shape and characteristics, it is similar to the Tenri (ante 1609, NMM 10), Girona II (ante 1588, NMM 27), Atocha I (c. 1600, NMM 34), Mounts Bay (1550-1600, NMM 46), and Aveiro (1575) astrolabes.

As with its counterparts, this artifact has a conspicuous wedge-shaped section. Although the wheel is fairly well preserved, all features on its surface are abraded, rendering it impossible to ascertain a specific nationality of manufacture, even though it is most likely Iberian. The suspension ring is absent, but its support remains. Pictures from the auction show that a small portion of the alidade survived. This, however, is no longer present. A portion of the axis pin remains. The lateral and upper spokes widen slightly as they join the rim, while the bottom spoke acquires a bell-like shape to form the ballast.

The dimensions, shape and certain features of this instrument are surprisingly similar to the Mounts Bay astrolabe, found in Cornwall, England, in 1982. Especially remarkable is a slight curvature to the left noticeable on the upper spoke of both instruments (Figure 11-18). When describing the Mounts Bay astrolabe, Stimson asserts that a portion of the scale is vaguely discernable. This is not the case with this artifact.
However, such resemblances suggest that we could be dealing with either the same instrument or one that was cast in the same mold.

![Image of astrolabe]

**Figure 11-18** – The fourth astrolabe in the *Seahawk* collection. (Photo by the author).

**Mushrow II**

Wayne Mushrow, a local milkman and amateur diver, discovered this astrolabe in the summer of 1991 near the coast of Isle aux Morts, Newfoundland, Canada. The suffix II is due to the fact that Mushrow recovered another astrolabe from that same location on November 1981. The first instrument, originally called the Isle aux Morts astrolabe (NMM 44), was later renamed Mushrow I after its finder. It was dated 1628 and the inscription ‘Y DYAS’ indicated that it was Portuguese.

Various attempts to acquire information on the Mushrow II from Canadian cultural authorities proved fruitless. Therefore, all the information presented here comes from either a Canadian government website (Government of Newfoundland and Labrador 2001), or is deduced from a picture provided by Kevin Crisman, of the Nautical Archaeology Program at Texas A&M University (Figure 11-19). An inscription on the front side of the instrument’s ballast reading ‘1617’ indicates the year of manufacture. A second inscription, ‘Adrian Holland,’ could point to either the maker’s name or that of the instrument’s owner. Until now, no other astrolabe in the archaeological record bears such a mark. A set of four six-pointed stars may also be seen on each lateral spoke, close to the point where it joins the instrument’s rim.
Similarities with the Caudebec astrolabe (1632, NMM 17), destroyed in a bombing during World War II, suggest that the Mushrow II is French (Stimson 1988:88-9). The most remarkable parallel between both instruments is their alidades, which are virtually identical. The astrolabe is graded for zenith distance all around its rim, with the Roman numeral ‘V’ indicating the multiples of this number in a fashion matching that of the Champlain (Hoffman) astrolabe (1603, NMM 8) (Stimson 1988:72-3). The latter was recovered in Canada in 1867 and is also thought to be French.

The Mushrow II is wedge-shaped, being the latest astrolabe known to have this characteristic. A portion of the suspension ring remains. The instrument seems to be broken in its lower left quadrant. Both Mushrow I and II are likely to have come from the same shipwreck. It has been theorized that it was a French merchantman or fishing vessel that foundered near the coast of Isle aux Morts sometime after 1638. Both instruments are currently stored in the Newfoundland Museum, Newfoundland, Canada.

**Passa Pau**

This astrolabe was found on 5 November 1999, near the Passa Pau stretch on the eastern coast of São Tiago, the largest island in the Cape Verde archipelago (Smith 2002). It was assigned number NMM 84 in
the record kept by Stimson. It was later sold at auction by the salvage company Arqueonautas, S.A. and acquired by the Mariner’s Museum of Newport News, Virginia. It is a typical type Ia astrolabe from the first half of the seventeenth century. The instrument weighs 2,820 g, is 171.5 mm in diameter and 22 mm thick. It was manufactured in 1645, as shown on the inscription on the front side of the ballast.

The Passa Pau astrolabe was cast from copper alloy and, when finished, was coated with silver. Approximately sixty-five percent of the coating survives (Figure 11-20). This is unique in the archaeological record thus far. The maker’s name, ‘NICOLAO RVFFO,’ is inscribed below the ballast and is flanked by two six-pointed stars. This instrument shares similarities with the Cádiz I astrolabe (NMM 64), found in 1981 near the coast of Cádiz, Spain, by the crew of a Dutch dredger working in the area (Stimson 1988:176-7).

The Cádiz I was made in 1648, as the inscription on the ballast indicates. Stimson erroneously states that the scale is graded for measuring altitude and concludes that the astrolabe is Spanish. A close look, however, clearly shows that the scale is graded for zenith distance. It may thus be asserted that the Cádiz I is Portuguese, as is the Passa Pau. In the Passa Pau, the zero-degree position is marked with a ‘I,’ while on the Cádiz I there appear to be no marks.

As with the Passa Pau, the Cádiz I astrolabe has its maker’s name inscribed on the rim below the ballast. The inscription reads ‘ANDRE RVFFO’ and is also contained between two six-pointed stars. A third six-pointed star separates the first from the last name in the Cádiz I, a feature not present in the Passa Pau artifact. Since both makers had the same last name (Ruffo) and worked in Portugal during the 1640s, it is possible that they were related. Furthermore, both instruments share an uncommon feature: three vertical six-pointed stars divide the first two digits of the date of manufacture from the remaining two digits. Another suggestion of relationship between the makers may be found in Stimson’s description of the Cádiz I astrolabe: “… the instrument is complete although it has a strangely rough finish to the casting which slight salt water erosion has not completely disguised.” Did the Cádiz I astrolabe have a silver coating? Both instruments are similar in size, with the Cádiz I having a diameter of 167 mm and a thickness of 20 mm.
The alidade of the Passa Pau astrolabe is made of brass and measures 142.2 mm in length. It is nevertheless eroded, and originally would have been approximately 168 mm long. A clear mark at the 34.5-degree position indicates where the extremity of the alidade was positioned when the ship foundered. The two sighting vanes are 54.6 mm apart and have a single perforation of approximately 0.8 mm. On the outer face of each sighting vane, the area around the holes is countersunk approximately 6.7 mm in diameter. A threaded bolt and a wing nut attach the alidade to the hub. It is likely that the alidade was also silver plated. The Passa Pau astrolabe is currently stored at the Mariner's Museum, Newport News, Virginia, USA.

**Nassau**

The origin of this astrolabe is far from certain. Jeremy Green, of Australia’s National Maritime Museum, suggested that it could have been found during underwater operations conducted by Mensun Bound near Malacca, Malaysia, at the wreck site of VOC ship *Nassau*. This vessel burned and sank in battle against the Portuguese in the Strait of Malacca in 1606 (Jeremy Green 1996, elec. comm.). The astrolabe never appeared on the excavation records and it was apparently taken to Australia, where it was sold to a private collector.
The diameter was estimated from a scaled picture and it is the largest thus far for any astrolabe from the sixteenth century. Because this instrument was never catalogued, its thickness and weight are unknown. Pictures provided by Green suggest it is rather thin. The manufacture date, 1568, is inscribed in the bottom ballast between three six-pointed stars located on the sides and top of the inscription. It is likely that a fourth star was present at the bottom, where a void in the metal now exists (Figure 11-21).

The astrolabe is fairly well preserved, but a calcareous concretion covers almost three quarters of the rim, three of the four spokes, the hub, the alidade with its sighting vanes and the suspension ring. A round formation close to the hub suggests that a coin is also part of this concretion. The portion exposed shows that the metal was considerably degraded by the action of seawater electrolytes (Figure 11-22). No scale is discernable in the pictures available. Because of this scant information, it is hard to propose a nationality for this instrument. Its typology, date of manufacture and the place it was found point to an Iberian origin, but its diameter suggests otherwise.

Figure 11-21 – Date inscription on the Nassau astrolabe. (Photo courtesy of Jeremy Green of Australia’s National Maritime Museum).

Figure 11-22 – The Nassau astrolabe. (Photo courtesy of Jeremy Green of Australia’s National Maritime Museum).
Conclusions

Even though the mariner’s astrolabe played a vital role in the process of European maritime expansion, it virtually disappeared from written records after the eighteenth century. With the advent of more practical devices and increasingly advanced methods, the instrument was virtually forgotten. However, this was reversed in the early twentieth century, when Portuguese scholars began to publish a series of works on the history of Portuguese navigation in the Age of Discovery. Among them were various articles on sea astrolabes. This initiative served as a catalyst for a newborn interest in the study of Portuguese nautical astronomy, with special emphasis on both instruments and methods. If systematic studies on the nautical astrolabe did not materialize immediately, these early writings paved the way for the appearance of sporadic articles and papers, which culminated in the work by David Waters, *The Sea- or Mariner’s Astrolabe*. Based on the foundation laid by Waters and his predecessors, Stimson was able in 1988 to publish what is hitherto the most comprehensive work on the instrument.

The last section of this document presents a catalogue of sixteen nautical astrolabes. When the study began in 2001, it was the author’s intention to include every instrument that had been discovered after 1988. Soon afterwards, it became evident that this would not be possible. Astrolabes are an item fiercely sought by private collectors and instruments recovered in operations undertaken with financial purposes usually end up in auction houses. Once the artifacts are sold, it is hard to obtain any useful information. On occasions, astrolabes are kept in small, remote museums, and contacting the staff is nearly impossible. Lastly, the challenges of motivating people to send information of which they are custodians are never ending.

Data on sixteen astrolabes were added to the sixty-five in Stimson’s book, for a total of eighty-one. If we add the Zacharchak (NMM 66) and the Ile de Brehat (NMM 85), not included in this work, the total rises to eighty-three. Given that the register number of the Ile de Brehat is NMM 85, we know that there are at least two other recorded astrolabes. However, no information on these artifacts was available to the author.

The history of the mariner’s astrolabe is a clear example of how people, in their eternal pursuit of potential glory, adopt existing technologies and improve them. Later, when new challenges require further advances, these technologies are abandoned or taken to more advanced stages. The nautical
astrolabe was a practical instrument during the Renaissance. Afterwards, it was virtually forgotten. No person in the twenty-first century would find practical use for a mariner’s astrolabe. However, without its existence from the fifteenth to the eighteenth centuries, the maps of our world would be drawn quite differently.

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Abstract

In recent years archaeologists have been using a variety of computing technology to speed up research and make information much easier to access, manipulate, and analyze. I propose a Digital Library framework that will assist nautical archaeologists in their research work, enhancing the dissemination of archaeological findings and seafaring related information to the general public. In this essay I will attempt to outline the main characteristics and goals of my approach, which is based on a National Science Foundation grant for the creation of the Nautical Archaeology Digital Library.

Introduction

For millennia seafaring has been an important activity that not only enabled traveling and trading, but also generated the exchange of ideas, ways of life, and knowledge among people from a variety of races, cultures, religions, traditions, and geographies. This exchange in turn, influenced people’s lives and facilitated advancements in science and technology that had otherwise not been possible.

Several aspects played key roles in the development of seafaring; an obvious one is shipbuilding technology. Enhancements in design and construction of ships made it possible to build bigger, safer, and faster vessels.
Bigger ships, for instance, enabled more cargo space, thus improving the owner’s profits. Similarly, design improvements made vessels more stable, reducing the probability of capsizing and above all, reducing voyages’ duration.

Evidence of the evolution of ships through history can be found in different sources. Paintings, frescoes, and drawings, for example, provide a graphic depiction, but one that is typically not very accurate of the real ships they depict. Historical narratives, although not rich in illustrations, also provide descriptions of the characteristics of the vessels. Ship remains from shipwrecks are without doubt the best evidence of this evolution. However, time, nature, and looters damage and quite often destroy this precious evidence, making ship reconstruction a difficult task.

Shipbuilding treatises on the other hand, are a major source of information about ships. Researchers use them as aids in the reconstruction of ships; they can also be used to compare shipbuilding techniques from different traditions, or their evolution in a span of time. Treatises, however, are a complex source of information. For instance, a researcher analyzing futtocks will be interested in finding relevant images in the illustrations contained in the collection of treatises, as well as their corresponding descriptions within the text. One illustration, however, can – and most of the time do include – several components; thus, the need to segment the treatises’ contents to allow access to individual elements.

Digital Library in the Humanities

In recent years archaeologists have been using a variety of computing technology to speed up research and make information much easier to access, manipulate, and analyze. The Perseus Project (Crane 1988 and 1996) is an example of a digital library in the context of cultural and historical heritage material, focused originally on ancient Greek culture, and currently including Roman and Renaissance collections provides a variety of visualization tools for its contents, as well as several access mechanisms to its collection of texts and images. The Digital Atheneum (Brown 2000 and 2001) hosted at the University of Kentucky has developed new techniques for restoring, searching, and editing humanities collections with special emphasis on technical approaches to restoring severely damaged manuscripts. The Digital Imprint1 at the Institute of Archaeology, University of California at Los Angeles proposes a project to design
standards for the electronic publication of archaeological site reports. *The Petra Great Temple excavations* (Joukowsky 1993; Egan and Bikai 1999) located in Jordan, is a joint archeological excavation conducted by Brown University and the Jordanian Department of Antiquities, which illustrates the development of new technologies based on the archaeologists needs. *The Brown University SHAPE Laboratory* (Shape, Archaeology, Photogrammetry, Entropy)² (Hadingham 2000; Acevedo et al. 2000 and 2001) has developed several techniques and tools that can be applied to Archaeology; their multidisciplinary team designed software that enables archeologists to model and reconstruct columns, buildings, statues, and other complex shapes from photos and video. The *Theban Mapping Project*³ (Reeves 1992; Reeves and Wilkinson 1996) based at the American University in Cairo, Egypt provides a comprehensive archaeological detailed map and database of every archaeological, geological, and ethnographic feature in Thebes.

With the use of computer-based tools, The *Canterbury Tales Project*⁴ has collated several of the manuscripts written by Geoffrey Chaucer with the idea of reconstructing the history of the text. Using some techniques from evolutionary biology, it is possible to find relationships among the manuscripts.

The *Rossetti Archive*⁵ is a hypertextual-based collection of the painter and writer Dante Gabriel Rossetti. The project includes access to Rossetti’s original works both pictorial and textual, along materials from critical studies about his life and work. These materials are encoded, enabling structured search and analysis. The archive includes digital images, manuscripts, drawings, paintings, and designs. It also provides an advanced search option.

Dedicated to the life and work of Pablo Ruiz Picasso, The *On-line Picasso Project*⁶ is a digital catalogue reasonee of paintings, sketches, drawings, and sculptures created by this renowned Spanish artist, along an extensive historical narrative documenting his life and time. It also provides a collection of critical commentary about his work by scholars and art critics. Some of the features in this project enable the synchronization of the art gallery and the textual narrative. The use of visualization tools and interactive maps allow users to find patterns, relationships or facts in the collection.

Despite the use of computers and software tools by archeologists, I believe—based on my experience with nautical archaeologists and other
scholars in the humanities – that the full potential which information technology can offer is still being underused. This is a common phenomenon present in other disciplines in the humanities too. Some reasons include – but are not limited to: a) humanists see problems differently from computer scientists, b) needs, goals, and priorities of scholars in different disciplines do not necessarily match, and c) lack of funding for particular research areas. Thus, I propose a Digital Library framework that will assist nautical archaeologists in their research work, enhancing the dissemination of archaeological findings and seafaring related information to the general public. This is, however, a major enterprise. In this essay I will attempt to outline the main characteristics and goals of my approach, which is based on a National Science Foundation grant for the creation of the Nautical Archaeology Digital Library. I will start with a general description of the digital library and its components; followed by a commentary on shipbuilding treatises and ship timbers recovered from the excavation site, will elaborate on managing the collection of artifacts, and conclude with some ideas about this approach.

General Description of the Proposed Digital Library

Information about underwater archaeological sites and the study of shipwrecks can be classified in seven large groups of data, pertaining to: a) the characterization of the site where the ship sank, b) the characterization of the historical period under analysis, c) the specific shipwreck under study, d) the site formation process, e) the excavation, f) the reconstruction of the site, and g) history of the ship, its voyages and crew.

The complexity of the relationships among these sources is not limited to the ability of relating objects in the collection, it also requires establishing a robust protocol that enables scholars to properly identify, catalog, and describe artifacts. Furthermore, it must address the problems involved in mapping the excavation site, building models of the site and ship, as well as identifying and classifying the components of the vessels under study.

Studying and analyzing the components of a ship requires a model that enables researchers to correlate timbers such as keel, frames, planking, rigging elements and any component of the ship with a large collection of shipbuilding treatises, known shipwreck remains, and historical descriptions of shipbuilding techniques. Treatise contents vary depending of the time they were written, the author, the intended audience, provenance, and
the kind of vessels they describe. Typically they include text describing the shipbuilding process, proportions a ship should have, illustrations of timbers and components, and instructions about how to assemble them. In some instances they describe cultural, social, and historical environments related to shipyards and shipbuilding.

As with many areas of scholarly activity, a comprehensive digital library providing immediate and interlinked access to the artifacts digitally generated will provide a critical resource to Nautical Archaeology with the potential of transforming the activities of the domain’s researchers. Primarily changing the way in which research is carried out as well as how educational information is conveyed.

Digital artifacts from an underwater excavation include texts, photographs, drawings, videos, and 3D models (drawn from the excavation site, and acquired from historic sources). Another characteristic of the collection is that it is a dynamically growing one, as new artifacts and timbers are recovered. In this context, this approach will serve as a repository where information stored in the library will be used as the basis for research analyses. Thus, the infrastructure should also support rich interlinking of heterogeneous elements and the easy addition of new ones. Strongly related to the archeological evidence is the ability to handle, quantify, and represent uncertainty.

The proposed framework should support digital library replication and synchronization, since the nature of archaeology fieldwork requires that domain specialists travel to a variety of geographical locations. Therefore, data and information gathered at the excavation site should be properly transferred to a centralized or distributed repository, to be later integrated into the digital library. Conversely, archaeologists should be able to bring stored and processed information to the site. This replication raises obvious questions of maintaining data consistency and integrity.

**Shipbuilding Treatises**

Shipbuilding treatises are documents, either printed or manuscripts – especially the old ones – describing the components of a vessel, its dimensions, proportions, and in some instances the assembling sequence, and properties of the materials to be used in the construction of ships. Two major difficulties associated with treatises are language and time. Provenance of treatises ranges from a variety of countries, kingdoms,
and empires, in a span of several centuries, mainly between the 15th and 19th centuries. When searching for descriptions and illustrations of components of a ship, researchers have to find that component in the treatises’ collection, which often leads to descriptions on the way to assemble them. However, given the fact that ship components have different names in different languages, and in some instances even in the same language in different periods of time, this task is extremely time consuming, often leading researchers to miss important facts or draw inaccurate conclusions. Additionally, since illustrations in treatises are not included in the standard indexes, archeologists have to spend much time searching for them. Thus, a multilingual glossary is required, which should not only include definitions of terms and concepts but also spellings and synonyms.

However, two major distinctions need to be made regarding the use of treatises, on the one hand, readers interested in browsing and navigating through the collection, or looking for specific components. And on the other, researchers working on the reconstruction of a ship, or looking for patterns in construction techniques. In the following paragraphs I will provide a brief commentary about some of the most important shipbuilding treatises from various provenances and ages to give an idea of their characteristics, similarities, and differences, which in turn will dictate the features the proposed architecture should include in order to make them available in a digital library framework.

Although ships have been built for millennia – the Uluburun shipwreck for example, involves the excavation of a circa the 13th B.C. century ship – I will focus on treatises from the Renaissance until the 19th century. In this span of time, the development of shipbuilding techniques had a tremendous advancement. From an early oral tradition, where the techniques were passed from masters to apprentices, the evolution eventually led to sophisticated documents that included illustrations, detailed descriptions, glossaries, proportions, curves, designs, and finally, geometric algorithms and physics.

The 17th century witnessed major changes in naval architecture. England, France, and Holland were forced to improve their fleets due to the new requirements in transatlantic navigation. This time is also known as the Golden Century of the Spanish Galeon. A very important vessel, the Spanish Galeon, played an important role in the transportation of people
and merchandises between Spain and America, which in turn, made the Galeon survive until the first quarter of the 18th century.

José Antonio de Gaztañeta, a Basque sailor with great knowledge of vessels wrote circa 1688 *Arte de Fabricar Reales* (Gaztañeta 1992) which can be considered the first attempt to compose a formal shipbuilding treatise in Spain. Gaztañeta was very familiar with five, seven, and eight-hundred tons galleons, which he sailed. A brilliant learner, observer, and self taught person, he wrote a manuscript describing the shipyard and construction of *La Capitana Real del Mar Océano “Nuestra Señora de la Concepción y las Animas”* – the Spanish flag ship.

In shipbuilding, Gaztañeta’s manuscript marks the transition from an oral tradition to a more formal one. Although dated in 1688, it includes earlier events, and does not follow a consistent style. Certain sections are carefully written, while others are not. Also, several pages were left blank, which might suggest it was not written in a chronological order based on the stages during the construction of the ship. The meaning of certain segments is still unknown and codes are used extensively within the manuscript. However, it contains a rich collection of illustrations, and a comprehensive list describing all the pieces in the galleon, as well as calculations. For the first time also, he comments on difficulties at work, tricks from the master builder, and weakest points in building techniques.

It also describes how to measure and bend timbers, and once the ship is completed, how to measure and compare it with the original specifications to identify structural deformations. Gaztañeta introduced improvements to make ships more stable and allow the artillery to be placed at higher levels while maintaining stability – a key design concept in the defense of the vessels.

In Portugal, *O Livro da Fabrica das Naus* composed by Father Fernando Oliveira in 1580 (Oliveira 1991), illustrates the need to create formal guidelines in the construction of ships, in this case, driven by the extension of the Portuguese domains and interests (America, Africa, and India). The treatise begins by describing the characteristics of the wood used in the construction of a ship. Hard wood has to be used in the framing, since frames support the weight of the ship and are exposed to extreme forces, e.g., water and wind. Soft wood, on the other hand, is recommended for the planking; this allows bending and facilitates joining the planks to the frames. Another section provides information about the materials used in
shipbuilding. Iron nails, for example, are preferable, due to strength and cost. For sealing purposes, oakum is recommended over wool and cotton.

*Livro de Tracas de Carpinteria*, a manuscript written by Manoel Fernandes and dated 1616 (Fernandez 1989), provides in the first section, a comprehensive list of dimensions for different vessels and the most important components to be used in different ship sections, e.g. keel, stem, and sternpost. For ships of different tonnage, it includes calculations, dimensions, and general guidelines. The second section of the manuscript contains illustrations depicting the construction of the ships.

A great source that depicts French galleys in the 17th century is the *Traité de la Construction de Galères* (Fennis 1983). The manuscript was written in 1691, and provides invaluable information about French naval architecture and technical terminology of galleys. This manuscript is divided into two sections. The first section describes timbers used in the hull, elaborates on the theory of the design of galleys, and the steps in the design of the galere senzille (simple galley).

The second section provides practical guidelines about the construction of galleys, including detailed descriptions of the timbers, wood, and their function in the ship. It also contains a sail plan and instructions to build the masts, the outfitting and lading of the galley. It is believed that the handwriting and illustrations were made by different authors. The manuscript is rich in illustrations, containing drawing curves, proportions, plan views, and individual components, such as keel, frames, futtocks, planking, blocks, tackles, and sails, as well as tools used in the construction of ships.

The Netherlands is also a country with a long naval tradition. In 1697 Cornelius van IJk published *Nederlandsche scheeps-bouw-konst open gestalt* (van IJk 1697). In his book, van IJk describes step by step – from a practical rather than theoretical perspective – the design and construction of a complete vessel. Although not very detailed, the descriptions show the required steps in the assembling process. Cornelius’ approach is known as skeleton-based, a technique extensively used in Holland during the 17th century.

*Fragments of Ancient English Shipwrighty* (Baker c. 1570) provides a glimpse to the English ship building industry in the late 16th and early 17th centuries. It is believed to have been started by Matthew Baker around 1586 and completed around 1630 by other authors. Its contents, although mostly unorganized, includes texts and diagrams on different topics, encompassing drawings, descriptions, and scales. Among other things,
Baker established the methods for measuring the “tonnage” of ships, as well as the methods to fix the shape of the “midship bend,” and extensively used arcs in the design of the curves of the ship. Circles and parts of the circles were used as basis for different shapes in the ship.

_Dean’s Doctrine of Naval Architecture_ circa 1670 (Lavery 1981) appears in a period of time that marks the transition of shipbuilding into a more scientific field. Switching from a learning method based on observation, Dean uses a drafting board. His work includes drawings, sketches, and other optical aids, providing detailed calculations, enabling to test the theory with real ships. Deane is also considered the founder of the scientific shipbuilding, as he introduces mathematical formulations in the manuscript.

Other examples in English shipbuilding writings are the _Scott’s Manuscript_ and _A Treatise on Shipbuilding_ (Barker 1994). The _Scott’s Manuscript_ an anonymous and undated work – believed of having been written between 1600 and 1625 – contains mathematical, technical, and practical information. _A Treatise on Shipbuilding_ circa 1600, copied by Sir Isaac Newton, includes drawings, sketches, and steps to conceptualize and build a ship based on the length of the keel. It describes the relationships between tonnage and stability and their effects on performance. In the case of rigging, it includes tables for masts and yards.

**Treatises in the Context of the Proposed Architecture**

To enable browsing and navigation in a digital collection of ancient shipbuilding treatises, the architecture I proposed will have the following features: a) browsing and navigation, b) transcription, translation, and illustrations, c) image segmentation, d) cross-language dictionaries, e) full text retrieval, f) visualization tools, and g) user interfaces. Using Lavahna’s manuscript as test bed, the steps for processing the facsimile in order to be added into the digital library are depicted in Figure 12-01. In cases where modern transcriptions and translations are available, they can be easily converted into text files using OCR (optical character recognition). For other cases, manual transcriptions will be required, something that has been done in other projects in which I have been involved, such as the Cervantes Project and the Digital Donne, the former for Spanish literary works and the latter for XVII century English poetry.
Figure 12-01 - The proposed architecture's workflow in the creation of a digital library of shipbuilding treatises. From the facsimile sources to integrated and interlinked information.

Semantic indexing and retrieval for images and texts will require texts and image metadata to be tagged. Tags within the texts not only provide semantic meaning to their contents, but also facilitates structuring documents.

Textual transcriptions will then be encoded into XML, which enables them to be transformed in multiple ways suiting a variety of requirements from different readers performing various tasks. Relevant terms and concepts within the texts will be identified, tagged, and linked to the multilingual glossary previously described. Thus, it will be possible to find definitions, multiple spellings, and synonyms of nautical terms, concepts, and scales in different languages. Compus (Fekete and Dufournaud 2000) illustrates the use of XML/TEI-encoded texts to graphically visualize the structure of documents; as such, it has been used to analyze French manuscript letters of the 16th century. Some of the features implemented in Compus can also be used to browse through the collection of shipbuilding treatises. Furthermore, the adoption of XML/
TEI as standard for structuring the documents allows the documents to be used in other applications.

Once the data sources have been processed, they can be used in different visualization tools. Figure 12-02 depicts the main browsing interface. Selection controls enable to choose treatises from the collection and sections within individual treatises. On the left, a display area presents transcriptions both in the original language and its translation into English. Using tab panes and scrolling area displays allows users to switch between the two transcriptions. On the right, the corresponding image from the treatise is presented. Since transcriptions and images are synchronized, users can click on the image to find the corresponding segment in the transcription. Conversely, selecting any text segment highlights the corresponding spatial coordinates in the image.

Researchers studying individual components of a ship are presented with two visualization options. The first option is a montage-based interface (Figure 12-03) which presents a slide show of images. Users can control the speed, orientation, and mode of the slide show. For example, a user interested in keels, is presented with images from the collection depicting keels along its associated metadata. From the image it is possible to locate descriptions in the text related to that illustration. Images can be added...
to or removed from the slide show individually or based on a particular condition.

Figure 12-03 - Montage-based interface. Images are presented in a slideshow. Users can change the settings of the slideshow.

The second option is a collage-based interface (Figure 12-04) which presents users with thumbnails of images related to a given component of the ship. Thumbnails can be rearranged by the user in the display area, clustering them based on characteristics the user is interested in. Items can also be added to and removed from the display. Mousing over a thumbnail pops up a window containing related information from the treatise. Visual aids, such as colors, shapes, and patterns can be used to depict additional information. For example, colors can be used to indicate provenance of the image, whereas a horizontal line can provide temporal context of the treatise.
Combining collage and montage interfaces enables to search for patterns in the evolution of shipbuilding techniques; for instance, narrowing and rising of the ship in a span of time, or how keels and frames were assembled in different countries. A more advanced analysis is the identification of techniques and methods adopted from other shipbuilding traditions; for example, what Baltic techniques were introduced in Iberian shipyards. Advanced searching options allow looking for images of ship components based on different criteria in their associated metadata. In the case of the transcriptions, full text capabilities enable searching for terms in context within the transcriptions.

**Text-Image Segmentation**

The creation of a hypertextual-based Digital Library of shipbuilding treatises requires the documents to be segmented. Document segmentation is the process in which document components are identified and classified; for example, the separation of illustrations and text segments in a page.
Textual sections have to be transcribed; this is however, a very difficult task to accomplish in an automatic way, considering that it requires optical character recognition (OCR) processing and most of the treatises are old manuscripts.

OCR is a technique that works quite well for modern business documents, but produces low quality results when applied to old manuscripts or even ancient books. In my experience with the Cervantes Project\textsuperscript{10}, for example, some attempts were made to automatically transcribe the texts of Don Quixote using OCR. After some attempts, the results were so low that manual transcription was used instead. This illustrates the complexity of OCR applied to a printed book published in 1605; manuscripts are even more difficult since they are handwritten documents.

In the case where several components are depicted in one illustration, those components need to be individually identified and classified. To better understand this, let us take for example the case of searching for futtocks. Futtocks are usually depicted in conjunction with other components in the same illustration, thus the need to extract them individually. Also, images and descriptions complement each other. For example, reading a description in the text can be augmented by observing the corresponding image. Conversely, exploring an image while reading the description associated to it; can help to better understand the contents and context of that image. To accomplish this, text-image synchronization is required, which in combination with indexed texts will enable to search for terms in the texts and browse the associated images.

**Managing Artifacts**

Information about artifacts recovered from a shipwreck is subject to multiple representations, spatial and temporal will be two obvious ones. This ranges from the location where the artifacts were found at the excavation site, to the locations where they are stored during the different stages in the conservation process, to the place where they are exhibited or stored. Generally, artifacts are found in a location where they were not originally stored, thus recreating cargo distribution is a complex task given the combinations in which cargo could have been stored.

Artifacts are exposed to multiple changes from the moment the ship sank until its discovery; currents, tides, and time modify the site. Therefore, bathymetry maps, tides and currents, environmental information, and
geological data, is information that helps researchers to understand how these elements have affected the site, and ultimately the ship and artifacts under study. Historical information about the site is also important; this includes ancient maps, historical texts about the site, and large collections of images.

In terms of temporal representations, once the excavation process begins, the site will be completely transformed. During the surveying phase, divers take extensive video footage, photographs of the ship and its surroundings; sketches and drawings of the ship and artifacts are made, along with notes describing the conditions in which they were found. A grid is then created that helps to map the location where pieces of the ship and artifacts were found. Further, divers have to record all the activities during their diving shifts, thus they have to keep a diving log, which can be used to recreate the excavation process.

The digital artifacts associated with underwater excavations include texts, photographs, drawings, videos, and 3D models from the excavation site, and also acquired from historic sources, as well as from other excavations. The proposed framework will serve as a repository of record; information stored into the digital repository will be used as the basis for research analyses. Therefore, it will have to provide fixed, stable reference points for content, even if materials are later updated.

Since the nature of Nautical Archaeology requires researchers to work at the excavation site, the framework has to provide the option of adding – on-the-field – information gathered during field work (as was previously discussed for timbers and ship fragments). Also, researchers should be able to download and consult information obtained from other excavation projects that have been stored in the digital library. I argue that access to stored and processed material at the excavation site can expand the ideas about the artifacts being recovered. At any stage the framework should allow linkage of representations of digital objects in different media to their corresponding physical counterparts in different contexts.

**The Pepper Wreck as Test Bed**

The creation of a digital library framework for Nautical Archaeology is a long-term enterprise given the complexity of the materials under study, the variety of media, the relationships among them, and the size of the collection. Thus, my approach will start by taking the Pepper Wreck
excavation as test bed, and will place it within the context of the broader, extensive collection available to us at Texas A&M University through the Center for Maritime Archaeology and Conservation. I believe that this approach will provide a standard framework that can be extended to other scientific and engineering endeavors.

Located in São Julião da Barra (Portugal), at the mouth of the Tagus river, The Pepper Wreck (Afonso 1998; Castro 2001, 2003, 2005a, 2005b) site is only a few miles away from Lisbon. Its excavation yielded a large collection of artifacts dated from the late 16th and early 17th centuries, and led to the identification of this shipwreck as the nau Nossa Senhora dos Mártires wrecked on September 15 1606 on its way back from India. The study of its hull remains – which include a portion of the keel, eleven frames, and some of the planking – yielded interesting results and a first glance at these largely unknown ships: the Portuguese naus da India.

Given our availability of Portuguese shipbuilding treatises, it will be possible to compare the timbers and fragments recovered from the excavation site with the descriptions and properties present in the manuscripts. As new timbers from other excavations are added to the collection, scholars will be able to compare ship remains from any excavation and treatises, providing an interesting scenario of missing physical damaged archaeological evidence with technical descriptions from the treatises.

**Conclusion**

On-going digital libraries projects show how advancements in information technology— especially computer-aided and hypertextual-based tools—have changed the way scholars work in the humanities. I believe that some tools, techniques, and methods in digital libraries fit the needs of users and researchers in Nautical Archeology, especially in the context of using shipbuilding treatises in the reconstruction of sunken ships from incomplete and damaged components recovered from the excavation site; as well as manipulating a large collection of artifacts.

I believe that this rich interdisciplinary effort between Computer Science and Nautical Archaeology will benefit both fields. Archaeologists’ on-field work and off-field research and analysis can be accelerated; multiple representation and rich interlinking of digital objects will be possible. On the computational side, the unique properties of the materials, ship fragments, and artifacts, and the way archaeologists use and manipulate them, will
require the development of new algorithms, and the implementation of
interfaces and tools; which can in turn be applied to other areas within
Computer Science.

Notes
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thebanmappingproject.com/about/ Accessed on December 10, 2005.
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7 The Nautical Archaeology Digital Library http://nadl.tamu.edu, accessed on November 25,
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8 Center for Maritime Archaeology and Conservation, Texas A&M University. The Uluburun
9 The Text Encoding Initiative (TEI) is an international and interdisciplinary standard for
encoding textual documents for interchange among scholars in the humanities. Extensible
Markup Language (XML) is a flexible text format derived from SGML, extensively used in the
exchange of a wide variety of data.
10 The Cervantes Project (Texas A&M University) http://www.csdl.tamu.edu/cervantes Accessed
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