During the 16th- and 17th-centuries European seafaring underwent an incredible transformation driven mainly by the exploration of newly discovered lands, the contact with previously unknown cultures, and the increase in maritime commerce. The social changes that resulted from this cultural revolution affected the long chain of events entailed by the construction of oceangoing ships and determined a number of technical innovations in the construction of ships. From an original oral tradition, where apprentices learned from masters the intricacies of shipbuilding techniques; this process evolved into a more formal field as masters began to follow guidelines, materials used, and construction sequences in a more systematic way, forming a corpus of information that was soon compiled in manuscripts known as shipbuilding treatises.

The first shipbuilding treatises, understandably, were written by mathematicians, priests and other learned men, reflecting a reality where shipbuilders probably were largely illiterate. Rich in technical descriptions, shipbuilding treatises play a key role in Nautical Archaeology both for scholars and students. Scholars access these manuscripts for several reasons. For example, working on the reconstruction of sunken ships, they can provide vital information for reassembling fragments and damaged timbers of ship remains recovered from underwater excavations. Also, their contents often help our understanding of shipbuilding techniques. In addition, they can be used to compare different construction traditions both from geographical and chronological standpoints. Moreover, they are great sources for understanding the evolution of shipbuilding (Figure 2 shows our treatises browser).

Nautical Archaeology students—although not carrying out the complex tasks of ship reconstruction—are exposed to treatises early in their studies. For them treatises are a good source to understand the basic terminology and concepts they will be using during the rest of their studies. Current teaching practices are constrained to browse physical copies of the original sources; with obvious restrictions such as limited number of copies and access, or unknown language—depending of their provenance, they were written in different languages, and difficult technical terminology. In fact, treatises inherit most of the limitations of printed books.

Providing ways in which shipbuilding treatises can be used digitally by both scholars and students is an attractive interdisciplinary effort for a number of reasons. First, is the opportunity to investigate the variety of ways in which manuscripts’ contents (both texts

1 This material is based upon work supported by the National Science Foundation under Grant No. IIS-0534314.
and illustrations) can be structured and classified. Second, is the opportunity to make original-source material available at the location of an excavation; the treatises description of the construction of the physical objects can provide valuable information about fragments of ship timbers that are recovered from an excavation site. This effort clearly draws techniques from the earlier projects in the digital humanities that examine the characteristics of digital representations of paper-based texts. However the linkage to physical artifacts opens up additional possibilities and considerations.

Digital humanities projects involving manuscripts or printed texts have been related, for the most part, to literature and historical records; some well-known examples include the Canterbury Tales Project¹, the Rossetti Archive², and the Perseus Digital Library³. We have been involved in creating collections of this form as well for Cervantes⁴, Donne⁵, and Picasso⁶. In the context of Nautical Archaeology, the manuscript of Michael of Rhodes captures the knowledge obtained by this 15ᵗʰ century seaman during his 4-decade-long career⁷. The presentation of the manuscript, oriented to a general audience, hints at the value that such materials will have to the professional archaeologist when representations and tools are provided that meet his scholarly needs.

Until relatively recently, ships were the most advanced and complex transportation means designed. Nautical treatises hold the key to understanding their technical complexity. In essence, the collection of treatises represents the technical manuals describing the components, their use, and the steps taken in manufacturing of the ship. Several characteristics of treatises make understanding them a very challenging task. Language is a major problem; in order to better understand their contents, it is necessary to provide translations and explanations of concepts, pieces, and sequences. Beyond the multiple languages in which the treatises were written, they also come from diverse geographical locations and span centuries, making terms, concepts, and descriptions difficult to understand. Different units and standards of measurement—a key aspect in technical descriptions—raise problems about not only comparing treatises with different provenance, but also translating them into modern scales; units of measurement used in the treatises are not necessarily the ones used by archaeologists to measure recovered evidence. To tackle these problems, we have developed a multilingual glossary, in which terms include their corresponding translation and definition into ten languages (which can be expanded as needed). The incorporation of “roles,” enables us to expand characteristics related to the terms, for example spellings and synonyms. Our framework allows multiple values per role as well the addition of more roles as they are required (see figure 1).

However, despite common features shared by physical fragments and their corresponding descriptions in the texts, fragments obtained from individual ships have important differences because of the differing physical conditions that they have been exposed to. Damaged and incomplete ship remains require the adoption of an encoding scheme to describe and quantify uncertainty; textual descriptions do not encompass “uncertainty.”

In the previous paragraphs we have briefly outlined the relationship between physical archaeological evidence and written descriptions in the treatises. However, treatises in
themselves have properties that make them unique. For example, an important question is how similar or different are treatises in terms of the sequences, construction techniques, and materials used. An initial approach would suggest that probably the encoding used in their description could be used to quantify the degree of similarity.

Since treatises are “technical manuals,” illustrations are essential in their understanding; therefore, we adopted a two-step process. First, illustrations have to be segmented, an illustration \( I_j \), can be composed of a set of components \( C = \{c_1, c_2, \ldots, c_k\} \), where a component \( c_i \) has a list of properties \( P = \{p_1, p_2, \ldots, p_k\} \). Second, each component might have a description within the text, thus a linkage between the two is required. To make things more complex, a component \( c_j \) can be formed from a subset of components, a step that resembles a recursive property, where the ship as a whole is formed by small parts, which in turn are composed by smaller ones, and so on. Figure 3 depicts the interface for capturing coordinates in images linking them to terms from the glossary.

Conversely, components can be mapped to other representations; a good example is a model created in 3D rendering software such as Rhino. We have done preliminary tests, exporting geometric data from Rhino models into XML and linking them to both 2D slides of the model and their corresponding occurrences in the treatises.

Although linking text and images has been extensively studied; the context of treatises raises a series of complex issues. For example, the text of a treatise could be segmented in a variety of ways based on different needs; assemblage sequences, materials used, and section of the ship being described. This in turn raises some interesting questions, for example: could the components being included in part of the text give a hint of what that section is about, or what section of the ship it describes? How could components in different treatises be compared?

Our current collection includes digital images and transcriptions of three of the most relevant late 16th and early 17th century Portuguese treatises: 8 Fernando Oliveira’s Livro da Fabrica das Naos (dated to 1580), João Baptista Lavahna’s Livro Primeiro da Architectura Naval 9 (dated between 1608 and 1615), and Manoel Fernandez’s Livro de Tracas de Carpintaria (dated to 1616). We expect to add more manuscripts as permissions from holders are granted.

The treatises’ dual role as historically-significant text and as formal specification of elements of ship design affords an opportunity to investigate the relationship of techniques developed within the context of textual studies to applications with physical objects and virtual 3D models. Further, the treatises provide the foundation for our development of the Nautical Archaeology Digital Library (http://nadl.tamu.edu/), which will center on providing resources in support of archaeologists’ work and on dissemination of expedition artifacts. The combination holds promise of extending the reach of the digital humanities.
Figure 1. The multilingual glossary interface depicting terms, translations, and definitions in various languages.
Figure 2. Treatises browser allows navigation of the treatises.

Figure 3. Treatises markup utility allows to mark certain areas of the image and associate them with terms and categories in the glossary.
Notes and References


8 Special thanks to Academia de Marinha, Lisbon Portugal for providing the facsimiles. http://www.marinha.pt/Marinha/PT/Menu/DescobrirMarinha/Actividade/AreaCultural/academia/ Accessed on November 12, 2006.


10 Dissemination of archaeological artifacts also has been the focus of other significant efforts including ArchaeoML, used in OCHRE (http://ochre.lib.uchicago.edu/), formerly XSTAR, and ETANA (http://www.etana.org/). (Web sites visited on November 12, 2006.)