A proposed model for the reconstruction of shipwrecks. Case study: a late seventeenth century Portuguese frigate

TIAGO FRAGA*

R E S U M O Este artigo tenciona apresentar um modelo teórico dos passos necessários para uma efectiva reconstrução de um navio. Este deriva principalmente da experiência do autor resultante dos seus dois anos no mestrado de arqueologia náutica no qual se encontra a reconstruir uma fragata do século XVII. Demonstra nas páginas seguintes os três mecanismos necessários para a essa reconstrução, os vários passos a efectuar nesses mecanismos e os diferentes graus de correcção necessários ou recorrentes. Este modelo, que não tenciona ser único, apresenta as suas vantagens e desvantagens, mas, em geral, é no parecer do autor um válido acrescento a disciplina da arqueologia náutica.

A B S T R A C T This article presents a model for the reconstruction of vessels in nautical archaeology. This model is intended to explain the steps necessary to reconstruct an individual ship. These steps are divided into three parts and presented in a sequence essential for any scientific model reconstruction. The steps include data collecting, data processing and drafting work. Each step has a specific process and methodology, which are explained in this paper. This model has advantages and disadvantages, which are discussed, but overall it is a sound presentation of a methodology which is accessible to the nautical archaeologist and the general public.

1. Commentary from the author

Thus, our ability to make high-level statements about the past is dependent upon the quality and validity of low-level statements (Young et al., 1994, p. 210).

Nautical archaeology is concerned with the interaction of man with the nautical environment. This interaction can be expressed in material remains, harbors, ships, coastal improvements; or in cultural spheres, trade networks, navies, exclusive economic areas, national waters. Nautical archaeology is a recent discipline and has focused primarily in the study of shipwrecks. This focus is necessary to build our knowledge of shipbuilding, explain change in an economic and social context, and then attempt to answer prehistoric and historic questions with higher range theories.

There has been debate over the validity of this discipline because it does not flag its methodology or parade its models. However, this discipline has repeatedly shown to the archaeological community its contributions to the humanistic and scientific knowledge in numerous ways. The specific of nautical is responsible for the need to develop a new set of guidelines from the standard archaeological methodology and theory, because it could not adequate resolve our issues. This separation as led to critics attacking nautical archaeology for not contributing to theories commonly used in general archaeology; this created the myth of a lack of theory in nautical archaeology. Furthermore, those critics have evolved into the belief that we do not concern ourselves with the field of archaeology and want to become a separate science. The goal of nautical is to improve our knowledge of the past by studding the areas neglected by traditional fields, this does not evolve separation, and this involves integration.

The reasons for this shortcoming or brilliance are not well defined. Some state that the discipline is too young, there are no schools of thought, and there is not enough data yet. Another reason is subjective, for some believe there is no reason for methodology, model building is pointless, and there is no time for theory when field archaeology work is needed.

Adding the binding moral negativity that comes from theory building (Johnson, 1999, p. X), and that the younger the discipline the less it considers a valid pursue for its members, it is understandable this lack of theory appearance.

The main reason for this hostility is that theory building is binding. There is some truth in this. A science begins its life with a group of people dissatisfied with the views, paradigms and schools of thought of the fields to which they originally belong. They break away to present new views in a new discipline. Anthropology as a discipline developed from History, Antiquarianism or Classical Studies. Nautical archeologists usually come from an Archaeological or Oceanography background. The scholars that we young archaeologist are taught to revere are known for rebelling against the norms and theories enforced by their respective original fields.

The denial of accepted theory is one of the main factors in this young discipline. As it matures (speaks the evolutionist in me) it contributes to the general field of archaeology with theoretical models of its own. However, in the time being, the theory and methodology, (and if anyone as doubts about methodology building by this discipline, one only needs to read Steffy's (1994) work created by this discipline are not accepted in its 'true colors'. Accepting theory is one of the steps for maturity in the discipline and some day it can take its place equally in the category of humanistic science.

2 Research question/problem

Ironically, the work presented in this paper represents one of the first steps in writing about nautical theory. The reasons for this? The belief that an adequate model for reconstructing a ship can be achieved by the present state of nautical archaeology.

The model presented in this paper, divided into three parts, is specifically designed to answer three recurrent questions in any nautical reconstruction work (Fig. 1).

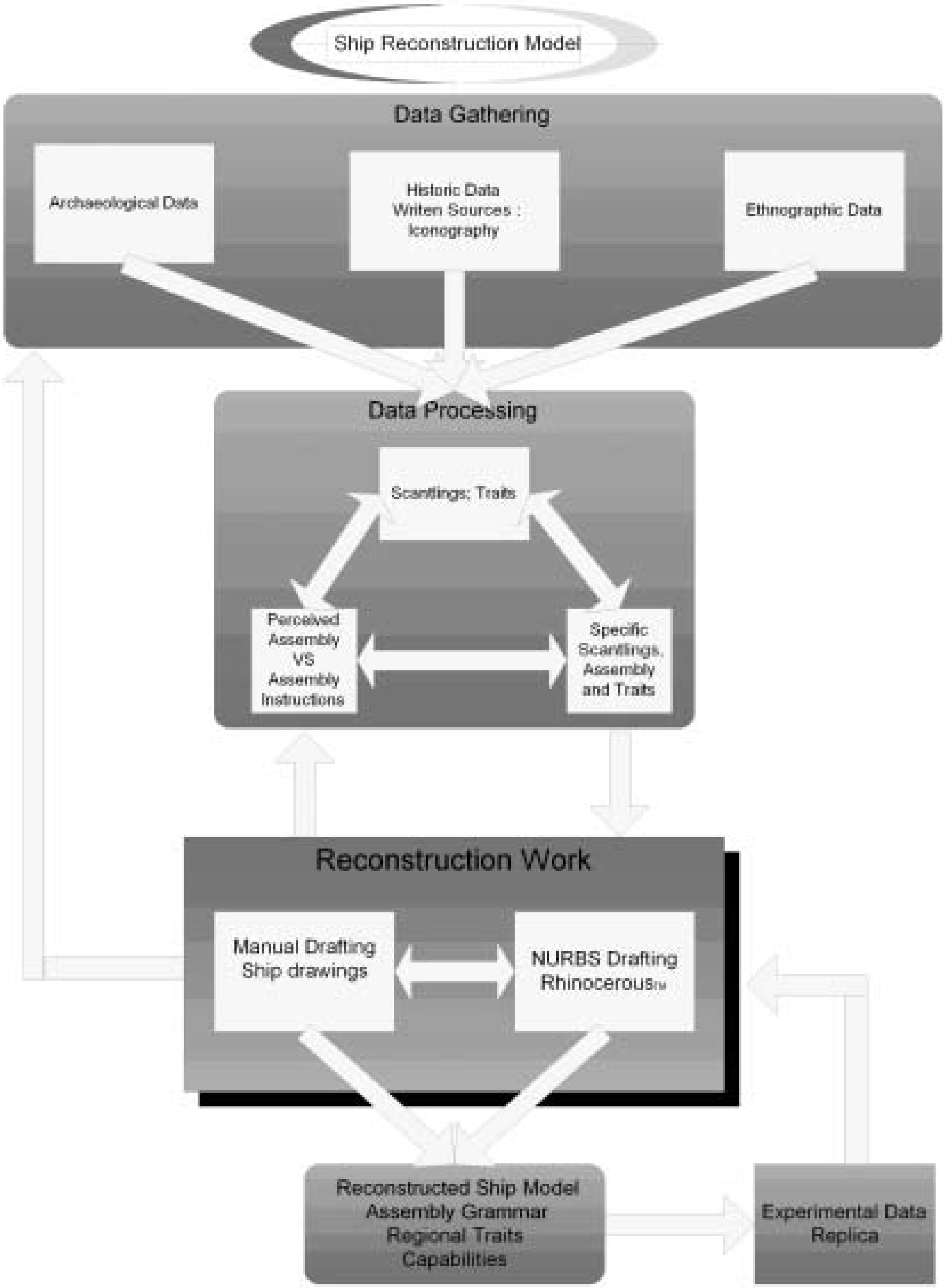

Fig. 1 Graphic representation of the model.

1. Look and feel of a vessel (qualitative assessment).
2. Determine the construction techniques (quantative).
3. Comparison of those techniques on a regional level and enacting shipbuilding generalization models.

The main trigger of the reconstruction may come from a recent archaeological discovery, a re-interpretation of an older site, iconographical sources, and class requirement or, my personal favorite, just for the fun of it.

The first part of this model is the gathering of all relevant information concerning the specific research problem.

3. Model

3.1. Part one: data collection

Any reconstruction work starts by assessing the data available to us. Two types of data exist and they can be researched from three input groups. The two types of data are components and Assembly.

3.1.1 Components

Components are groups of characteristics expressed in a physical form. They are the pieces used to build a vessel. Characteristics express dimensions, patterns or any relevant feature in a component. Common characteristics, which either present themselves by a wide range of specific components or appear in the same component in different archaeological sources, can be considered traits (Oertling, 2001). Traits are the cultural signatures of the shipbuilders and represent behavior constricted not as much by the technological restraints but by cultural restraints.

3.1.2 Assembly

Assembly is the manner by which components are placed together. This includes the order and manner of placement. Common assembly order or manners observable in different situations can also be considered a trait.

The three input groups are archaeological, historic and ethnographic data (Table 1). The most relevant to our field is archeological data. The reason of the primacy of archaeological data is that of all three, archaeology is the one that depicts the reality. You cannot state that the ship was made of coca-cola cans if we have a wooden shipwreck of that ship in front of us. For as much absurd the fact is, archaeological facts are still undeniable (we actually have examples of rafts made out of coca-cola cans). The results derived from the archaeological group are either unquestionable if derived from field data, or strongly accurate if derived from reports and reconstructions. The other two fields do talk of the reality perceived, but as they are not the reality itself and that is the reason of my primacy of archaeological data theoretical work is always different from the real object itself.

This is especially true in the case of ship treatises, which are written and illustrated books about ship construction. Rarely all components are not addressed in treatises, nor the shortcuts or mannerisms used by shipwrights. Moreover, although the 'architect' is the main person responsible for the ship design, it is the shipwright that is actually constructing the ship and it is safe to assume that some of his personal preferences will be present in the final product, those will be absent from the majority of written sources. Regarding ethnographic data, although, it is the study of a people doing an actual object, those people are in the present, they are not the original shipbuilder. Any surviving remains belong to the original shipbuilder and as such take preference.

Table 1. Summarized source groups and respective types.

Archaeological	*Historic*	*Ethnographic*
Field data	Written sources	Field data
Excavation reports	Iconography	Ethnographic studies
Reconstruction Work		

3.2. Archaeological data

Buy a puzzle, assemble it, and then destroy the box it came from. Pick up the puzzle and go to your backyard, throw the puzzle high into the air and leave it for a few weeks. Come back and try to reconstruct the puzzle from the remaining pieces. This is what an archaeologist faces every time he goes into the field.

Archaeological data (as the name indicates) is data originated from a field excavation of any know shipwreck. It can be divided into three types: field data, excavation reports and reconstructions all three have Accuracy Measures appended to them (Table 2).

Table 2. Summarized information on accuracy assessment for the subtypes of data existent in the archaeological data group.

Field	*Excavation Reports*	*Reconstruction works*
Assembly	Reputation	Primary sources
Availability	Validity	Scientific community assessment
		Personal assessment

3.2.1. Field data

Field data is the primary data collected in its raw form from a shipwreck site. Components, assembly data and traits can be inferred with ease in this case, and most of the reconstruction work based on this type of data should accurately depict the ship. Shipwreck sites can be categorized in two ways: assembly information and availability of information.

Assembly information can be either coherent or incoherent. Coherent shipwreck sites retain a majority of their components in a well preserved state. They are preferred sites for they provide the most and best information for reconstructing a vessel. Conversely incoherent shipwreck sites have components which have suffered post-depositional movement, degraded and or destroyed. Little to no assembly data can be gleaned from this type of site.

Availability of Information, this is the percentage of the components that survived to be excavated. In simple words, how many of the pieces of the puzzle survived. When more than 10% of the actual ship survives it is already considered high. The more components which survive, the easier it is to determine the ship's characteristics. In some cases, like the *Kamikaze* site at Taitashima, Japan, the enormity of components recovered without any recordable junction data will present a difficult task to the most resilient archaeologist. This site is categorized as an incoherent site with a large amount of information (Delgado, 2003; Sasaki, 2003). Other cases, like the *Corpo Santo* site at Lisbon, Portugal, where a small number of components survived but all of them still assembled, it provides much detail about a very small percentage of the ship. This site is considered a coherent site with a small amount of information (Alves et al., 2001). The presence of both categories, coherent and large amount are usually preferred for reconstruction work as in the case of the *San Juan* shipwreck at Red Bay, Labrador (Grenier, 1985). Even so, any characteristics derived from this type of data are preferable against contradictions presented by the other two groups. The reason is very simple; archaeological record, when properly excavated is the best source of information for reconstructing a vessel.

3.2.2. Excavation reports

Excavation reports are the written records of an excavated shipwreck. They can provide important information for reconstructing similar or equal vessels. It is, however, necessary to measure the accuracy of the published data. This can be achieved in two ways. The first being the reputation of the excavator and the other is the validity of the work. Reputation speaks for itself. For example, a published report from a treasure hunter with no primary field data would be considered unsuitable. Validity of a report is a qualitative measurement of its accuracy based on the amount of archaeological evidence used to support the report.

3.2.3. Reconstruction works

This one also requires some measure of accuracy to prevent error in our own reconstruction work. Accuracy is measured in three ways: the observable use of primary sources, the assessment of the work by the scientific community and finally the personal assessment of the person using this model.

The extent that the reconstruction work was based in primary sources has to be visible for one to test the conclusions of the author. A lack of accurate primary sources in any reconstruction work will be detrimental.

The assessment of the work by the scientific community is seen in articles supporting or criticizing it. This feedback, positive or negative, must be taken into consideration.

The personal assessment can only be described as the subjective 'critical eye' one gains from experience.

3.3. Historic data

Historic data is information gained from a cultural historical approach to written sources and iconography. Written sources include books, treatises, orders, contracts, receipts, accounts, diaries, ships journals, etc. Iconography includes drawings, paintings, tapestries, coins, wax seals, sketches, graffiti and reliefs. Either written sources or iconography have specific measures of accuracy (Table 3).

Table 3. Summarized Information on Accuracy Assessment for the Historic Group.

Written Sources	***Iconography***
Authorship	Painter knowledge
Knowledge	Graphic aptitude

3.3.1. Written sources

Written sources can usually take three forms:

3.3.1.1. The user/professional view

These are the written descriptions by people with first hand experience with a ship's components. This is the most desirable source, but can also be the most misleading because it is a human characteristic to disregard the obvious. For those involved in any kind of recollection of a journey when we write our memoirs, or our voyage journal, how many of us actually depict the car in which we derived so much pleasure of the voyage. Written memory and recollections are inaccurate. If reread, in the journal, the vehicle is often referred as "the car", "the Mustang", "the RV", "the four-wheeler", sometimes it goes further, "the gray car", or "I lament the lack of a trunk". Moreover, does someone take time to state the type of windows, to enumerate all of the components of the car and its dimensions? No. This analogy is very true when dealing with the sailors or captains perspective of a ship; they rarely spend time writing of what is obvious to them and usually only account the ship in generalist terms or only write more information about the ship when something unusual or extraordinary happens. However, with these cautions, first-hand knowledge can be very useful.

3.3.1.2. The 'newbie' view

This is the recollections of someone experimenting with nautical related facts for the first time. This is very comprehensive source of information as the newbie goes into great lengths to explain what he saw. What happens if we give a pen to someone that never seen a car, but, is going to travel in it for several months. Today that is very hard to happen, but let us image it. That person would take great lengths to record every aspect of the driving, every component of the car and as much of the mechanics of the thing as he possibly could. This view is the second type of written accounts. The passengers of a ship, would usually depict what they saw and experienced when on a ship because they had never seen one, but by lacking of the expertise of what they were seeing one must be careful with this data because what they depict in their journals could be incorrect due to ignorance.

3.3.1.3. The builder's view

This is the best source of historic evidence available to us. They are written sources from a shipyard about the components and assembly methods of a vessel. Unfortunately, these are rare, but when they survive they are the most comprehensive and knowledgeable of all three sources. Their scarcity is due in part to the fact that much of this information was never written down. It was primarily an oral tradition and the 'secrets of the trade' were well guarded. This protected the builder's livelihood but in the case of warships; it was in the interest of a nation's security. The information was passed down through apprenticeship, often Father to Son and rarely shared outside the group.

Stated the first type of historic data one must present the second.

3.3.2. Iconography

This data can be found in historic and pre-historic cultures. For some of the reconstructing works it is the only data available to us (Doyle, 1998).

Two ways to measure the accuracy of the iconography exist: the knowledge and graphic aptitude of the painter.

The knowledge of a painter about the vessel(s) he is depicting is very important in measuring the accuracy of the depiction.

The graphic aptitude of the painter/painting is another aspect of measuring the accuracy. This can be ascertained by two factors: One: Objective of the painting. Does the painter intend to paint a realistic portrait or a coin insignia? Two: The talent of the individual. Can he accurately depict a vessel or not?

The limitation of this source is the view that the painting addresses. Usually a painting depicts a ship from its perceived aspects. This is very important; a painter usually paints the outer shell and rarely the inner side of the vessel, and usually only paints what is above the water. Although the overall dimensions and rigging can sometimes be inferred, very little of assembly or internal components can be inferred. Exceptions to this rule are shipyard paintings, inner compartments paintings or technical drawings, all of which are very welcomed but very rare.

This brings us to the last of the source data groups.

3.3.3. Ethnographic data

Ethnographic data in this case it defined as modern day analogues to the situations that we intend to study. In the specific case of this model, ethnographic evidence is the one obtained from observing modern-day shipbuilders that are presumed to still build in the ancient way.

Some 'traditional' shipbuilding applied to local fishing boats or small transport vessels is still available today, but the shipbuilding techniques used in the constructing of military, commercial long going, ocean-going vessels is either nonexistent or disappearing. This makes ethnographic data on ships very rare, but available for other types of vessels. Moreover, ethnographic data for wooden shipbuilding not based in regional level is very rare.

Two types of ethnographic data occur in this world (Table 4). One is ethnographic studies and the measurement protocols are the same as for the excavation reports. The other is field data

When someone had the fortune of finding an ethnographic parallel to the specific reconstructing work, he is presented with the same type of variables for accessing accuracy. Those apply to the relativity of the ethnographic subject to the vessel intended for reconstructing work. This relativity is possible to measure in three forms, cultural distance, time distance and geographic distance.

Table 4. Summarized information on accuracy assessment for the ethnographic group.

Ethnographic
Relative distance to subject
Time distance
Culture distance
Geographic distance

Cultural distance is the distance separating the actual living subject from the ancient shipbuilder. This distance can originate 'cultural pollution' as new tools, materials, ideas or new techniques originate cultural transformation.

Time distance is the time separating the living subject from the ancient shipbuilder. An ethnographic analogue of a separated by a decade as increased chances to be more precise than one separated by centuries.

Geographic distance is the geographic distance separating the living subject from the ancient shipbuilder, being both of the same culture. This is very important when addressing new world nautical due to the transportability of cultures at that time. A Portuguese shipbuilder in Goa, India would build slightly or very differently from a Portuguese shipbuilder in Lisbon, Portugal.

After assessing the values of the different source groups relating to each other and the different values of the information collected inside each group, one proceeds to the data processing phase.

4. Part two: data processing

The objective of the data processing phase is to create the clearest picture possible from the data collected. Three interconnecting processes can achieve this.

First is the assembly of a *scantlings* list. This is a list of every component and associated characteristics used to build the vessel and identifiable traits list (Fig. 2).

The second is the comparison of the *assembly instructions* from contemporary sources and previous existing historic or archaeological models, against the *perceived assembly* of the new data (Fig. 3).

The third is a merging of the first two, the identification of specific traits and assembly models that would identify and accurately depict a vessel in its time, culture and geographic boundaries (Fig. 4).

Each of this processes have internal processes as well.

4.1. Scantlings and traits list

The scantling list indicates the number of components present in the ship. It also gives the dimensions and other characteristics each individual component or component type might have.

The components are sorted by usually by the following typology:

Keel elements (I), these are the keel, the stem and stern post, the keelson, the knee and the deadwood.

Planking elements (II), those are deck planking and the hull outer and inner planking. A row of planks are called a strake.

Frame elements(III), those are the floors and futtocks

Ceiling elements(IV) , like beams, posts, knees, caps, and others

Metal works(V), those are every component made of metal like nails, bars, and clamps.

Rigging (VI), those are the components responsible by the handling of the ship, and they included sails and rudders.

An example of a scantlings list is appended as an annex of this paper.

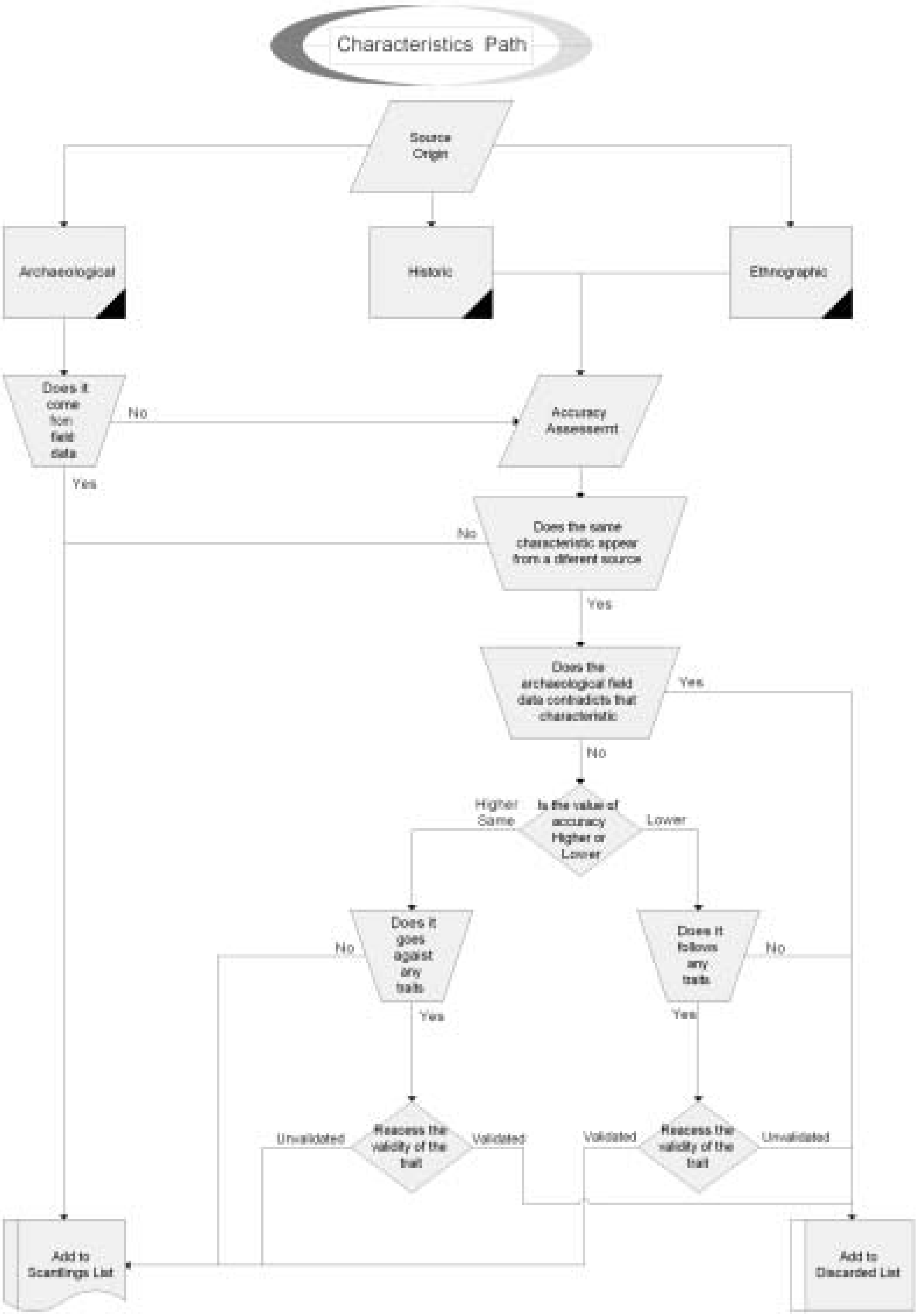

Fig. 2 Characteristics flow chart.

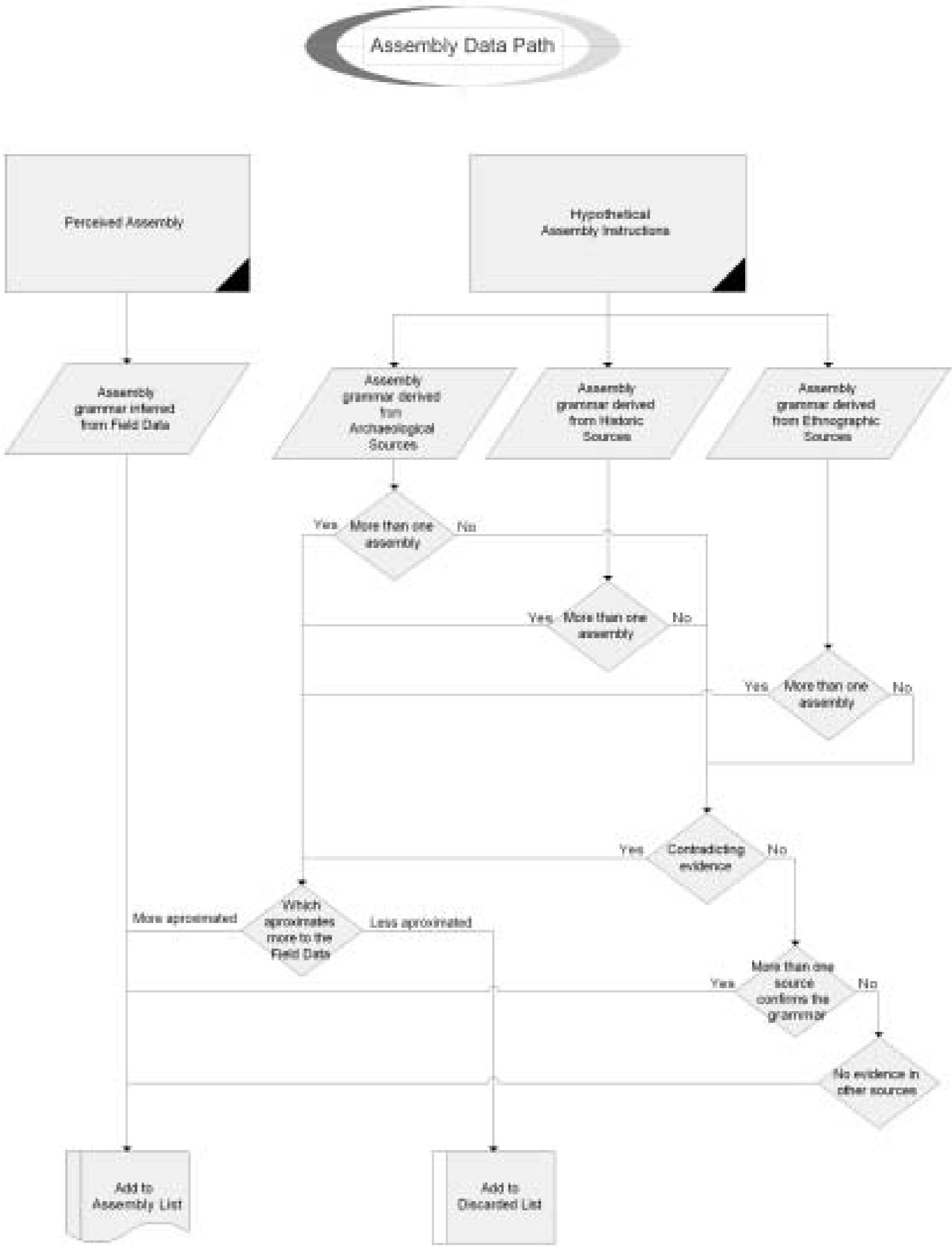

Fig. 3 Assembly grammar flow chart.

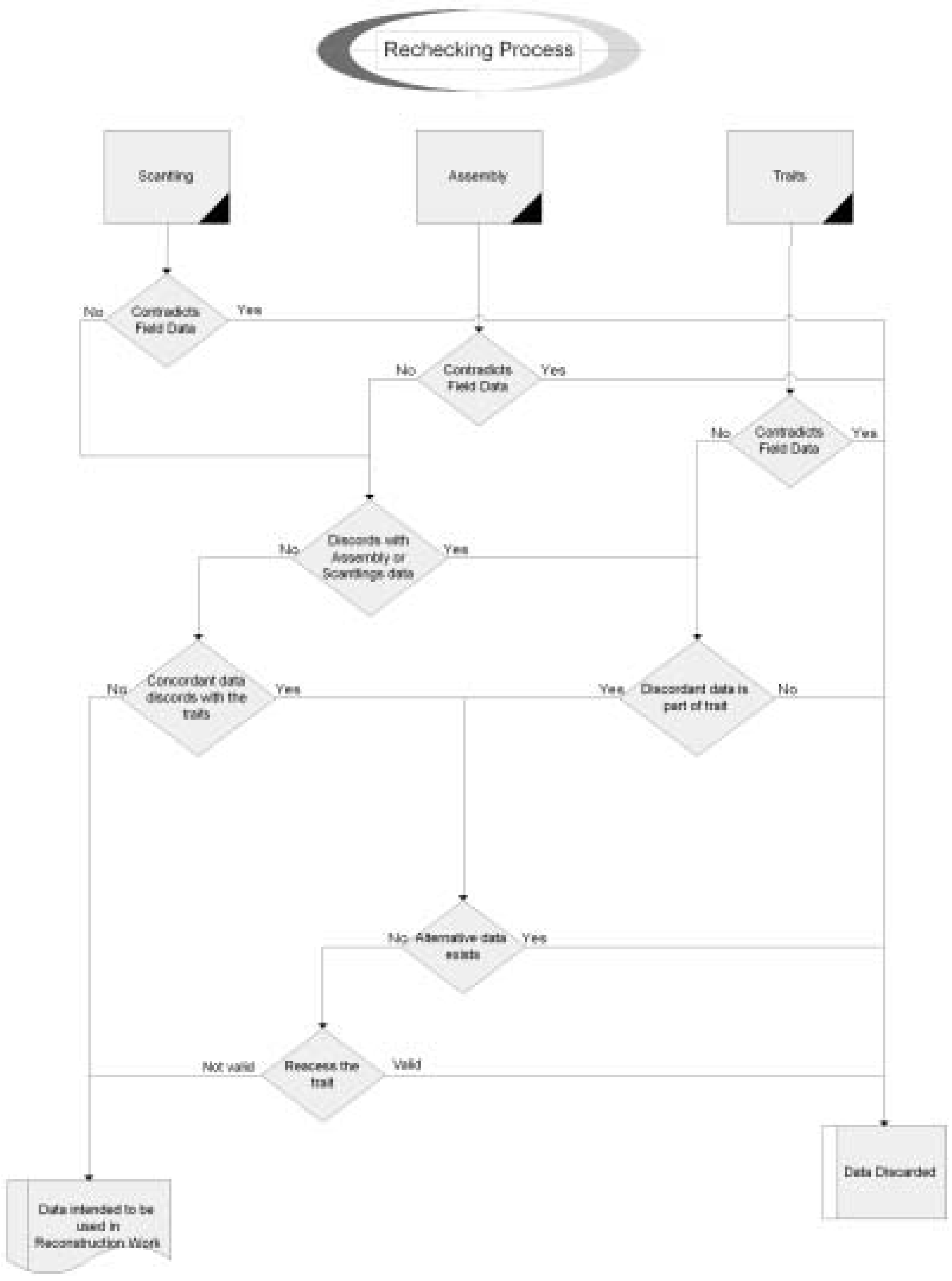

Fig. 4 Specific traits and assembly, rechecking process.

All collected data about components and their associated characteristics are then entered into a database for analyses. This database states the component name, the name of every characteristic found about the component, the value of accuracy of each characteristic and associated data. After this, contradicting components and characteristics are discarded, but not eliminated from the database. To choose between the contradicting facts one resorts to the accuracy value we have appended to the fact, according to the group origin (archaeological, historical or ethnographic), any strengthening or weakening circumstances, and our own experience.

An example: Beam dimensions. A shipbuilder source indicates 11 centimeters for molded dimensions, but a written account of a passenger states eight centimeters for molded dimensions. The value given to the information from the shipbuilder is higher than the one given from a newbie, because one must assume that a shipbuilder is always more knowledgeable of the subject of shipbuilding, so in the scantlings list the following would appear (Table 5).

Table 5. An Example of a Component and Associated Characteristics.

Component Characteristics	***Beam***
Dimensions	Molded 11 cm, Sided 14 cm
Quantity	44 beams
Numeration	Roman numbered
Nailing patterns	Square nails in the extremities, treenails in the middle, 22 cm apart
Beam spacing	100 cm

The non-discarded components are then assembled according to their respective taxonomy and given a grammar number.[1] The remaining characteristics are grouped into any visible traits.

4.2. Perceived assembly versus assembly instructions

Assembly list is the way each component is assembled to each other and the order by which they are assembled, those are represented by a construction grammar.

Perceived assembly list is the one inferred from the combination of all of the source groups, giving special weight to any observable assembly from archaeological field data. Assembly instructions are those reflected in historic or ethnographic sources and previous assembly information derived from excavation reports and reconstruction works.

Construction grammar is the representation of each of the components taxonomy groups by a roman number, each of the components types by a letter, and individual components by a number.

Example: The floor of master frame would be III.A.1 — meaning the group the frame belongs is the *Frame elements* (III), the type is *Floor* (A), and it is the *first* floor timber (1). The first futtock of the master frame would be III,B,1 — meaning that it belongs to the same group *Frame Elements* (III), different type *Futtock* (B), and it is the *first* floor timber (1).

The construction grammar allows several things: present the taxonomy of the vessel type intended for reconstruction work in an easy way; illustrate the order of assembly; and present a grammar signature for the assembly method used.

The Group and Type of each component as shown above represent the taxonomy.

The order of assembly is presented in the sentence constructed (that is why they call it grammar), as the first components to be put will show in the beginning of the sentence and the last on the end.

Example, a frame-first vessel is built by placing the keel and posts first then several of the frames of a ship and only after that the outer hull planking. This would translate in our assembly grammar as: I (keel);I.a (stern post); I.b (stem post); III (frames); II (planking).

However, a shell first vessel is constructed by placing the keel and post as the frame-first, but then the planking is placed first and after the frames. This would translate as I (keel); I.a (stern post); I.b (stem post); II (planking); III (frames).

Finally, it is the belief that each regional ship construction would have a grammar signature, different regions has slightly different assembly methods. Building a database of grammar signatures, one would increase the chances of identification of the cultural and time boundaries of unknown vessels.

Each individual assembly instructions found and transformed into a construction grammar is compared against the perceived assembly grammar. Differences, absences or contradictions are then noted.

This allows the differences stated in the reconstruction work to be specifically addressed to present a scientific paper.

4.3. Specific assembly and traits

The two previous explained processes give a tentative scantlings list, a possible traits list and a theoretical assembly list. The objective of this process is to compare the results and determine if the combined information results in a sound reconstruction model.

To achieve this, first all information derived from the field data is presented. Every chosen component, characteristics and assembly grammar are tested against the field data and all misinterpretations corrected.

Unfortunately, not all necessary data to do reconstruction work will be present in the field data; as such, the results from the assembly are confronted with the results from the scantlings and traits. This will allow for any discordant data to surface. For an example, what happens if the assembly data requires the use of forty strakes, but in our scantling list only it was thirty? The difference will show at this time and can be corrected.

From this process, a specific scantlings, assembly and traits list is then selected. This will be the data used to start the third part.

Even though the processes have been presented in a separated manner, this is an ongoing process as each component and characteristic passes through them. This stage of the work can be self-absorbing but usually one of two thing happens to makes it go forward to the second phase, time constraints by our publisher or professor who want to see the final product, or the remaining doubts about the scantlings, traits and assembly list can not be resolved without the actual reconstructing work or can not be resolved at all. In that last case comes the creative part of the 'calculated guess'.

5. Part three: drafting work

Any data processing work is only good as the graphic result of every component assembled and put together in a coherent model of a ship. Drafting work is the task of placing all of the pieces together and tries to represent a sound model of what the vessel would look like. Three methods, manual drafting, NURBS drafting, and physical three-dimensional reconstruction are used.

For the purpose of this model only two are discussed. This is because only two methods were envised for a general use. The physical three-dimensional reconstruction depends on the first two and it can take two forms, a scaled model replica or a full size replica. Both types are discussed further in this paper.

5.1. Manual drafting

The manual drafting skill is addressed in Dr. Castro's class of 616 Research and Reconstructing of Ships. This consists of two stages, lines drawings and construction plans.

Both stages consist of three plans representing a three-dimensional view. Those are the body plan, sheer plan and the breadth plan. The body plan represent the hull shape viewed from the front of the ship in the lines drawings, and in the reconstruction plans the body plan depicts a section cut of the ship (Fig. 5). The sheer plan is the lines drawings representing the ship as viewed sideways, in the reconstruction plans the sheer plan depicts a longitudinal section cut of the ship

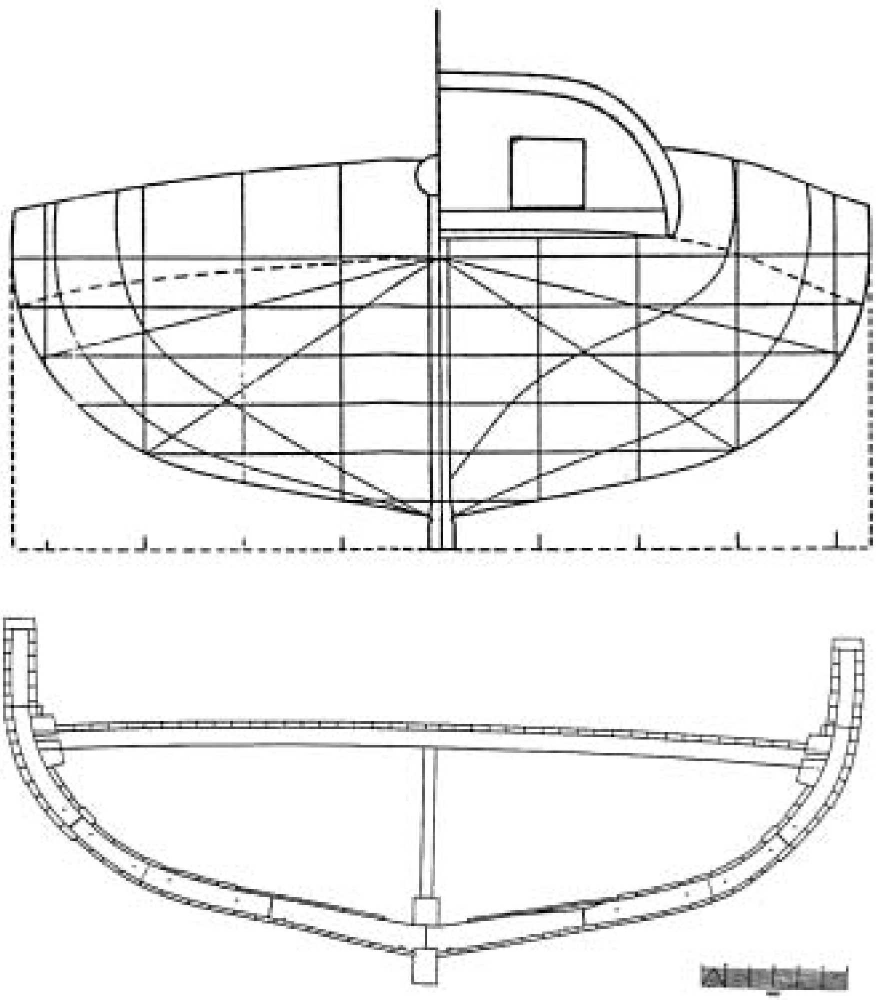

Fig. 5 Body plan from Lines drawings (top) and from Construction plans (bottom) [After Crisman, 1984, Fig. 49, 56].

(Fig. 6). The breadth plan represents the hull shape viewed from above; in the reconstruction plan the breadth plan depicts section cuts of the decks existing on the vessel (Fig. 7).

Lines drawings consist in the rendering of technical lines to present the basic hull shape. The objective is to depict graphically the main characteristics of a vessel in terms of dimensions and hydrodynamics[2]. For this, section lines, rabbet lines, buttock lines, waterlines, sheer lines and diagonals are used (Fig. 8). For a better understanding, it is recommended to read Professor Richard Steffy work (Steffy, 1994).

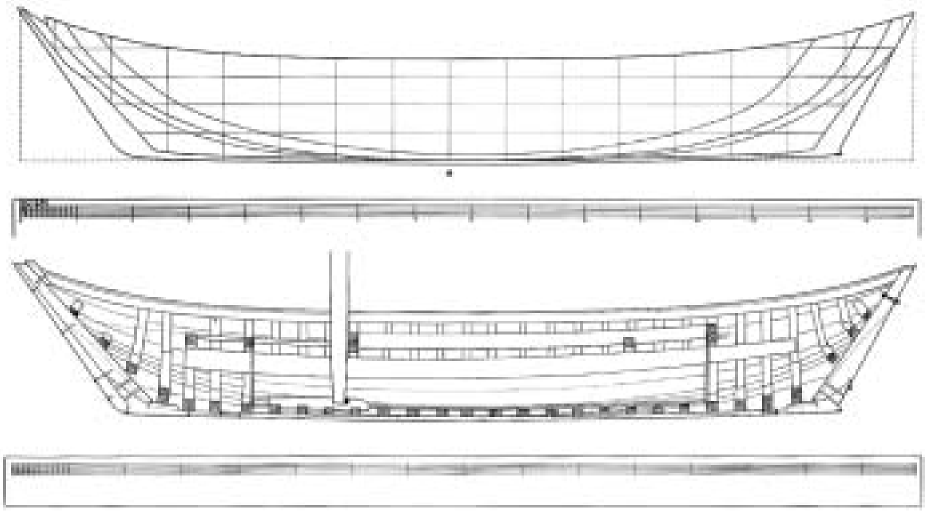

Fig. 6 Sheer plan from Lines drawings (top) and from Construction plans (bottom) [After Steffy, 1994, Fig. 4-46, 4-47].

Ship drawings are the graphic depiction of every component of the ship in its ordained position. These intend to show the vessel in its completed stage. One of the main goals of the construction plan is to show all gaps of knowledge that were not addressed in the components phase. Any incongruence originating from the scantling, traits and assembly list resulting from the data processing will manifest in this view and this usually generates a two-way process of rechecking characteristics and researching new components or characteristics to fill visible gaps in the drawing. Those can manifest by the absence of a component that has to be there but is not mentioned in sources, the incapability of placing the components according to the characteristics chosen or simply the inability to place the components according to the order they are stated.

The construction plans are the test place for all the components. Some characteristics that gain a greater accuracy value might appear incorrect in the construction plan and have to be revised. That revision is expressed in the rechecking and researching arrows of the model, and demonstrates that the two first parts of the reconstruction model are to be addressed first, but they cannot be disassociated from the third part.

The only disadvantage of the manual drafting is that some incongruence will not manifest in any of the three views, because even though that they intend to represent a three-dimensional object they are separate entities. That incongruence would remain unchecked until the physical three-dimensional reconstruction, but with the advent of computers another way presented itself, NURBS drafting.

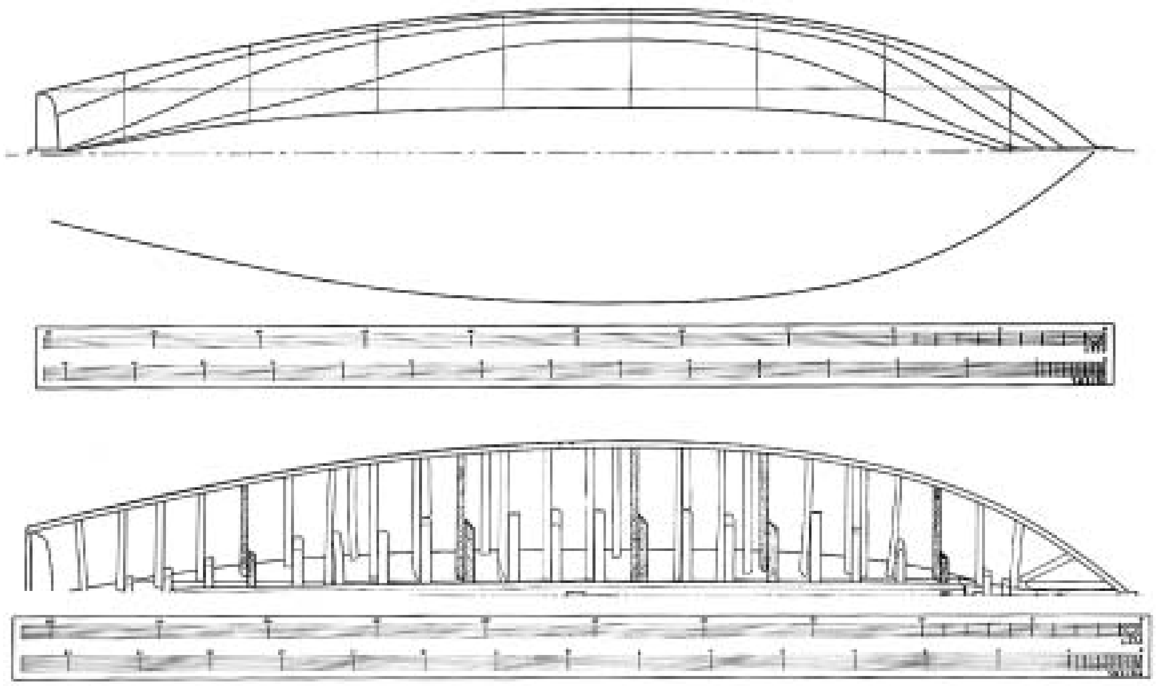

Fig. 7 Breadth plan Lines drawings (top) and from Construction plans (bottom) [After Steffy 1994, Fig. 5-42, 5-43].

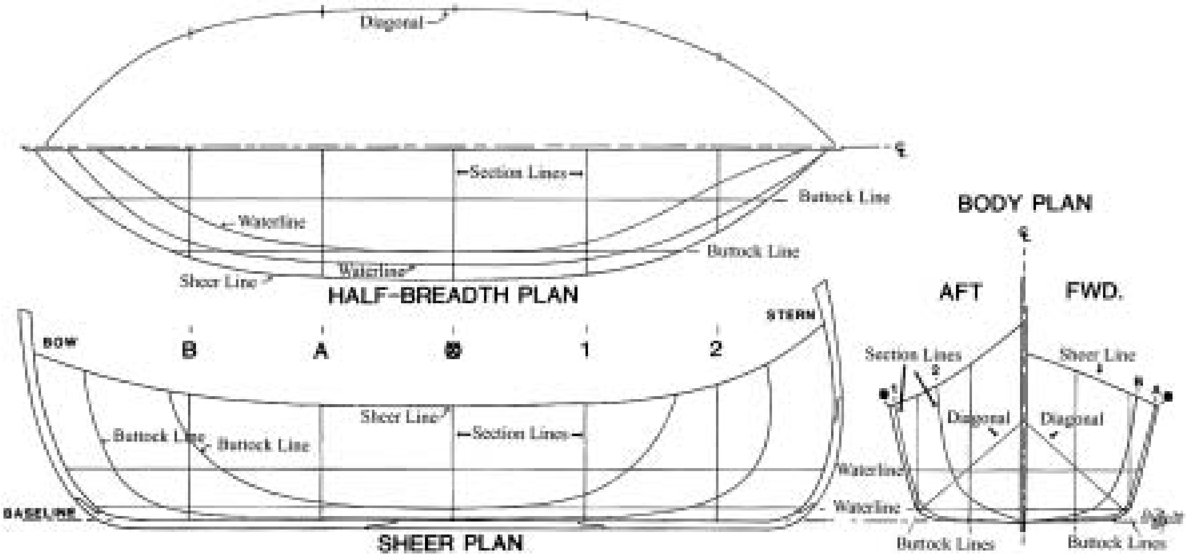

Fig. 8 Lines nomenclature after Steffy (1994, Fig. 2-10).

5.2. NURBS drafting

NURBS drafting is the computerized version of manual drafting to represent a workable model derived from the three views. Any discrepancies that would not show on the separate views will be self-evident on the combined model resulting from the three views. This is a great advance in the art of model reconstructing as the only way to see those discrepancies would to actually build a model replica of the reconstructing work and that requires a very talented and skilled individual with experience in wood handling.

NURBS also allows for an easier trial and error. In a replica any error is costly both in material-wise and time-wise. Finally, NURBS allows for the recording of every phase of the reconstruction work. However, it has to be pointed out that NURBS do not replaces three-dimensional physical reconstruction for either a scale or full size replica. Some things cannot be computerized, as the feel and properties of wood when bent into the shape, and the ship's feel and handling on water.

In the case of Texas A&M Nautical Archaeology Program, NURBS drafting is taught by the use of Rhinoceros™ in Professor Wayne Smith's class, Computer Archaeology. Rhinoceros™ is a NURBS program considered adequate to the needs of nautical reconstruction.

6. Conclusions

When one completes the third part of this model, there are four outcomes: a graphic depiction of the ship itself, an assembly grammar of scantlings and their order in the ship, the traits identifiable with this type of vessel, which is very useful to identify future remains and the predicted capabilities of the vessel in question.

The testability of this model is greatly based on previous reconstruction work made for the 616 class; however, it is believed that it can effectible be used for the reconstruction of any vessel regardless of its period, nationality or characteristics.

However, the outcomes can only be fully tested with the construction of a full size replica of the reconstruction work. This would allow ascertaining some experimental data on the constructing and sea handling of the ship. That data might show a need to improve on the reconstruction work. The cycle starts again

Following this model is the actual progress on a reconstructing work in which the author intends to use the model and at the same time reconstruct an end of the seventeenth Portuguese frigate.

Case study: the Mombassa wreck

In this case, the research problem is one of regionalism, the national shipbuilding techniques and characteristics of Portugal. Not much is know about Portuguese or general Iberian shipbuilding. The studies of Portuguese shipbuilding have addressed some traditional vessels (Filgueiras, 1980), some shipbuilding terms (Leitão and Lopes, 1990[3]), and very few archaeological studies have been conducted (Vieira de Castro, 2001; Alves, 2001).

Several of the excavations were addressed in the spirit of treasure hunting and those contribute little to scientific knowledge. The few in-depth archaeological studies have presented a very fractal image of Iberian and Portuguese shipbuilding along the centuries. For the seventeenth century, there is not a single study of Portuguese shipbuilding. Many questions arise, especially in view of the new military organization of ships, the specialization of merchant and military craft, the new understanding of winds, hydrodynamics, geometry, just to name a few. Portugal in the seventeenth century is the crown of a dying empire, one that encompassed half of the world, an empire that was very dependent on ships; it was a nautical empire.

One of those ships types that arose in the seventeenth century was the ship of the line, one of its smallest types were the frigate. Those ships were responsible for patrolling the seas, for intercepting fast vessels, for resupplying military installations, for protecting trade routes, are in the Portuguese case an historic fact, but not an archaeological certainty. It is a necessary study of data that can in effect shed some light on the actual construction characteristics and capabilities of this vessel.

7. Data sources

7.1. Archaeological

Our main trigger for this reconstruction work is the existence of a shipwreck of a Portuguese frigate. The field data of its excavation is available for this work. Also reports derived from that field data are available (Piercy, 1977, 1978, 1979, 1980). This is the first attempt of a reconstruction work, so no previous or similar reconstruction work can be used.

7.2. Historic

In the case of historic data, our main corpus of data comes from ship treatises, secondly from shipyard's records and finally from personal journals or official journals.[3]

In the cases of Spain, England, and France there is at least one treatise that can be used for reconstruction (Fraga, 2003, p. 16-18).

In Portugal, unfortunately there is no known surviving treatise, and this one of the reasons that Portuguese frigates were never studied in detail. The only know source is five plans sent to India with dimensions of frigates (Jordan, 2001, p. 313).

Historic sources such as treatises are our second level of data. Although those might have deviations from the real object, they at least represent the known way of building ships or the accepted norm of shipbuilding.

7.3. Iconographic

Iconographic data present us with two very important data. First is the upper levels of a ship, details and decoration which rarely survive from shipwrecks.

Second what is addressed as the dead works, those are the upper deck carpentry made by carpenters and not shipbuilders. Those are rarely discussed in historic sources, usually when a ship designer reaches those areas in his book, he states that "this is the matter of the carpenter and not necessary to discuss".

To be able to accurately depict some detailing in our model of the Portuguese Frigate, the contemporaneous iconography has as to be taken in account. At this time the author's research has not any sound information on the available iconography.

7.4. Ethnographic

At this time the author's research has not any sound information on the available ethnographic data.

8. Research question

In effect that is the main question of this work. How did a Portuguese frigate look like? How was it constructed? What are the similarities with ships built by other 'superpowers' of the time? Moreover, what are the differences from the other 'superpowers' of the time? Can we ascertain a Portuguese way of building a ship from an English way? What were the regional imprints left by its constructors?

To attempt an answer to these questions, it is necessary to proceed with the reconstruction of the *Santo Antonio de Tanna* and compare it against theoretical and archaeological driven models of other nationalities' frigates.

Santo Antonio de Tanna was a Portuguese frigate that sunk off the coast of Quenia in the Mombasa harbor; it is the only surviving example of a seventeenth century Portuguese frigate. The archaeological remains were in a good degree of conservation and were the subject of several excavations and studies (Piercy, 1977, 1978, 1979, 1980). The reconstruction of it will contribute to the understanding of nautical archaeology.

9. Methodology

To achieve those research goals is necessary to build models of known frigates of the five European powers of the time, from contemporary sources, iconography and, when possible, previous studied archaeological sources.

For the case of frigates models from other nationalities it is necessary to bear in mind that limiting the data from only theoretical/historic data, brings some error into the models. Except in the cases that ship models have been built from archaeologists using comprehensive archaeological remains, to propose frigate models reconstructions from all three available sources for each nationality, not only would be a gigantic task, but also the subject for several dissertations and not one thesis.

After concluding those historic models, they are confronted to the model derived from historical and actual shipwreck data recovered from the Mombassa wreck, also know as the *Santo Antonio de Tanna*.

For the comparison, all models are drafted in paper first, followed by three-dimensional reconstruction on rhinoceros™. This will allow not only several blueprints for the comparison, but with the use of rhinoceros™, workable models to help with the conclusions. Those models, thanks to the advance in printing technologies, can also be printed into three-dimensional models for better study.

10. Acknowledgments

I would like to show my appreciation to John Swanson and Laurie Lind for the patient demonstrated in reading and correcting my term paper.

NOTES

* Nautical Archaeology Program
Department of Anthropology
Texas A&M University

1 The discussion of the taxonomy associated with a vessel would be in such amount that it justifies another article. Suffice to say that the major groups of taxonomy are hull components and rigging components. Hull components can be divided into structural and decorative, structural can be divided into major, hold, first deck and more.

2 Although those characteristics do not belong to a specific component; nevertheless they follow the exact same procedures as the ones explained for components characteristics.

3 There is an exception as the French actively requested their ship captains to record into a journal modifications and improvements made to their models (Boudriot, 1993, p. 36-37).

BIBLIOGRAFIA

ALVES, F., ed. (2001) - *Proceedings International Symposium on Archaeology of Medieval and Modern Ships of Iberian-Atlantic Tradition*. Lisboa: Instituto Português de Arqueologia.

ALVES, F.; RIETH E.; RODRIGUES, P. (2001) - The Remains of a 14th Century Shipwreck at Corpo Santo and of a Shipyard at Praça do Município, Lisbon, Portugal. In ALVES, F., ed. - *Proceedings International Symposium on Archaeological of Medieval and Modern Ships of Iberian-Atlantic Tradition*. Lisboa: Instituto Português de Arqueologia, p. 405-426.

BOUDRIOT, J. (1993) - *The History of the French Frigate, 1650-1850*. Translated by, D. H. Roberts. Sussex: Rotherfield.

CRISMAN, K. (1984) - *The Eagle: An American Brig on Lake Champlain During the War of 1812*. Department of Anthropology, Texas A&M University, College Station : Office of Graduate Studies Collection Unpublished Master's thesis.

DELGADO, J. (2003) - Relics of the Kamikaze. *Archaeology*. New York. 56:1, p. 36-41.

DOYLE, N. (1998) - *Iconography and the Interpretation of Ancient Egyptian Watercraft*. Department of Anthropology, Texas A&M University, College Station: Office of Graduate Studies Collection Unpublished Master's thesis.

FRAGA, T. (2003) - The historical sources for frigates of the XVII Century. Texas A&M University, College Station: Manuscript on File, Anthropology Department, Nautical Archaeology Program.

FILGUEIRAS, O. L., ed. (1988) - *Local Boats: Fourth International Symposium on Boat and Ship Archaeology, Porto 1985*. Oxford: BAR International Series.

GRENIER, R. (1985) - Excavating a 400 Year-Old Basque Galleon. *National Geography*. Washington. 168:1, p. 58-68.

JOHNSON, M. (1999) - *Archaeological theory: an introduction*. Cornwall: Blackwell.

JORDAN, B. (2001) - Wrecked ships and ruined empires: an interpretation of the Santo Antonio de Tanna's hull remains using archaeological and historical data. In ALVES, F., ed. - *Proceedings International Symposium on Archaeological of Medieval and Modern Ships of Iberian-Atlantic Tradition*. Lisboa: Instituto Português de Arqueologia, p.310-16.

LEITÃO, H.; LOPES, V. (1990) - *Dicionário da Linguagem de Marinha Antiga e Actual*, Lisbon: Edições Culturais da Marinha.

OERTLING, T. (2001) - The concept of the atlantic vessel. In ALVES, F., ed. - *Proceedings of the International Symposium on Archaeological of Medieval and Modern Ships of Iberian-Atlantic Tradition*. Lisboa: Instituto Português de Arqueologia, p. 232- 240.

PIERCY, R. (1977) - Mombassa Wreck Excavation: Preliminary Report, 1977. *International Journal of Nautical Archaeology*. Portsmouth. 6:4, p. 331-347.

PIERCY, R. (1978) - Mombassa Wreck Excavation: Second Preliminary Report, 1978. *International Journal of Nautical Archaeology*. Portsmouth. 7:4, p. 301-319.

PIERCY, R. (1979) - Mombassa Wreck Excavation: Third Preliminary Report, 1979. *International Journal of Nautical Archaeology*. Portsmouth. 8:4, p. 303-309.

PIERCY, R. (1980) - Mombassa Wreck Excavation: Fourth Preliminary Report, 1980. *International Journal of Nautical Archaeology*. Portsmouth. 10:2, p. 109-118.

SASAKI, R. (2003) - *Making Sense of Piles of Junks: The Search for Kamikase*. Texas A&M University, College Station: Manuscript on File, Anthropology Department, Nautical Archaeology Program.

STEFFY, R. (1994) - *Wooden ship building and the interpretation of shipwrecks*. London: Chatham Publishing.

VIEIRA DE CASTRO, F. (2001) - *The Pepper Wreck: A Portuguese Indiamen at the Mouth of the Tagus River*. Department of Anthropology, Texas A&M University, College Station: Office of Graduate Studies Collection Unpublished Ph.D. dissertation.

YOUNG, D. E.; BONNICHSEN, R.; DOUGLAS, D.; MCMAHON, J.; SWARTZ, L. (1994) - Low-range theory ad lithic technology exploring the cognitive approach. In BONNICHSEN, R.; STEELE D. G., eds. - *Method and theory for investigating the people of the Americas*. Corvallis: Center for the Study of the First Americans, p. 209- 237.