The methods of experimental archaeology apply in the reconstuctions of ship remains, the Ganzeng Warship Case

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Abstract

As one of the most important instruments of production in ancient time, ships are a complicated and systematic carrier. To study their uses one could broach the subjects of naval architecture, art of seamanship, fishing production, social function of trade and navy, and its anthropological meaning as a special settlement[3]. With respect to naval architecture our study divided it into the following: shipform, structure and principle of design.

The method of experimental archaeology ship-reconstructions first in the late half of the last century in Europe. Initial endowment by the Danish National Research Foundation reconstructed a Viking ship. This methodology involves archeology, ancient documentation, and ethno-archaeological investigation of the same culture-tradition of shipbuilding. In this way, ancient ships can be restituted, rebuilt, and understood.

Chinese junks had adopted the bamboo strip sail in the Western Han dynasty (B.C.206—A.D.220). This tool was still in use in the Early Qing Dynasty (1644-1799) as evidenced by the Ganzeng warship. However, archaeologists have not found tangible evidence and are unclear on its structure and manufacturing methods.

Nautical archaeology had never carried out an experiment on replica and reconstruction according to ancient navigation environment perspectives. The reconstruction of Ganzeng warship from the Early Qing Dynasty was based on the study of historic documents, integrated with methods of ship design and building traditions acquired from the ethnographical field work in Fujian province. This was the first full scale experimental anthropology reconstruction project in China. the design principle and method began with the preliminary sorting of the modular system of construction that was largely based on the study of the transverse watertight bulkhead, mast base structure, and the axis helm that can lift and swing bamboo strip sail.

From this project we concluded that experimental reconstruction of ship remains is the only effective means to preserve the Chinese junk heritage. Furthermore, in this paper we introduce the use of modern technology and research tools used in experimental archaeology of ship remains.

Key words: experimental archaeology, reconstruction sailing ship, ship remain, Ganzeng, naval architecture.

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[3] Eric Rieth, 2006. Epaves, Archeologie Sous-Marine Et Histoire De L'architecture Navale. Histoire, Archeologie Et Societe Confererces Academiques Franco-Chinoises, Ecole francaise d'Extreme-Orient Centre, Beijing, Cabier No 13, pp. 1-20.

1. Preface

The encyclopaedia Heavenly Creation [4] (1637) has a chapter on naval architecture. The author Songyingxing divided the vessels into sea-going, river and other craft according to their environment. These classifications have been followed until now. In the book he elaborated parts on usage and navigation environments of ship, shipform and building procedure, design principle and modular proportion, design and manipulation of sail and helm, form and usage of anchor, sealant, rigging, log material and so on. Those have made the book the most systematic work of naval architecture of the Ming Dynasty (1368-1644) and the decoding norms for traditional sailing junks till now.

This study only focuses on sea-going junks. By the 21st century ancient Chinese sailing junks had disappeared, their memory only retained through studies in nautical archaeology, historic documents, the craftsmen traditions of shipbuilding, models and the odd recently-built traditional ships. The surmise of only four kinds of shipforms (ie. Shachuan, Niaochuan, Fuchuan, and Guangchuan) is incomplete and further study is required.

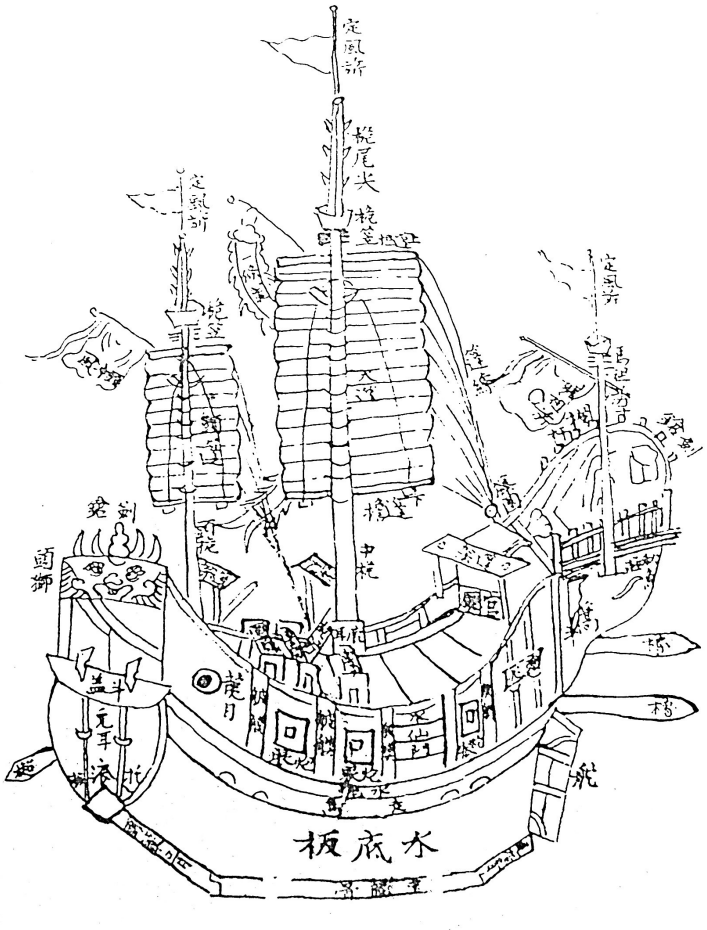

Figure 1. Ganzeng style warship recorded in the middle of 18th century (Anonymous).

[4] Song Yingxing, 2002. Heavenly Creations(Tian-Gong-Kai-Wu) in *Sequel to Si-Ku-Quan-Shu*, Zi radical, 1637, reprint Shanghai Ancient Books Press, Shanghai.

2. Experimental archaeology

2.1 Conception and origins

"Experimental Archaeology: The systematic approach used to test, evaluate and explicate method, technique, assumption, hypothesis and theories at any and all levels of archaeological research" (Ingersoll 1977).

The field of experimental archaeology can generally be divided into four categories: controlled replication of recovered artifacts or known activities; testing the validity of methodological assumptions by applying them to known data or results; "contextual"; and ethnographic data. Experimental archaeology can also be described by using these questions: What was ancient man doing? Why? How? These questions can be answered in many different ways.

"Experimental archaeology employs a number of different methods, techniques, analyses, and approaches in order to generate and test hypotheses, based upon archaeological source material, like ancientstructure or artifacts" (Mathieu 2002).

One of the main forms of experimental archaeology is the creation of copies of historical structures using only historically accurate technologies. This is sometimes known as reconstruction archaeology.

2.2 Reconstruction experiment of ship remains

The reconstruction experiment of ship remains chooses an original prototype from the historical documents, sets proper design and procedure application of the original tools and materials, copies the similar environment, reconstructs the replica, manipulates the replica under the similar navigation circumstances, and finally verifies and explains the set prototype. Followed the technical logic during all the procedures of building and voyage, previous conclusions need to be retested and re-evaluated, and sometimes previous hypothesis could be re-written. Or at least some possibilities of the unsettled questions could be expelled at the same time.

Although experimental methods are not yet fully approved as scientific method in the European archaeology discipline be cause of the absence of common standards and untenable evidence. In nautical archaeology this method could be the most effective way to assemble all the information from shipwrecks, documents, interviews, models and operating ships, while also being the most effective in verification and preservation of the historical prototype.

There are distinct differences between the experiments and other replicas. Firstly, the former are strictly document studies. Secondly, choosing the appropriate historical objects as prototype. The experiment replica could be ships with the ability to sail, proportionate models, specific sections or tools, or the clarify shipwrecks.

3. Reconstruction experiment of Ganzeng warship of early Qing dynasty

Our team chose to conduct the experimental project on the Ganzeng warship of the Early Qing Dynasty based on evidence available in nautical and historical archaeology. The inital

study of historical documents revealed multiple examples of European depictions of Fujian boats, these included:

- The two large-scale trader in Zhujiang River printed by Netherlandish armada commanded by Cornelis Matelief de Jonghes[5]. The illustrations of side plate, gangway, deck castle, bamboo matting sail were particular for studies.
- A middle 17th century, collection of Berlin Etnologisches Museum was the earliest meticulous color image of Fujian style junks[6].
- William Alexander's colour images are the earliest and the best realistic portrayals of Fujian style junks available to us today[7].

We also studied Chinese historical documents and drawings from which we gained examples of shipforms during the reigns of Emperors Kangxi (1662-1722), Yongzheng (1723-1735) and Qilong (1736-1795). They were shrunk into medium(length over all under 30 meters) or small scales (length over all under 20 meters). The drawings largely consisted of double mast forms of warships and traders, with the majority of drawings being of single masted fishing boats. In and after the Jiaqing reign shipforms expanded. Examples include the Tongan Suochuan[8] and Guangting warships of three masts. During the reign of Emperor Daoguang (1821-1850) large numbers of traders emerged with three masts. We believe the Ganzeng warship originated from the fishing junk of the Fujian and Zhejiang coast of the late Ming Dynasty (1600-1644). At the time it may have had a secondary use in trade.

The first record of Ganzeng mentioned in *Conquest Memoir*[9] by an official historian of Zheng Chenggong armed force named Yangyin in 1658, he mentioned that Zheng's Navy dispatched a Ganzeng to salvage an European heavy cannon from a wrecked warship in Jieyang port (South-east of Guangdong Province). The first record found describing it as a warship is the 1664 August entry of *East China Memoir*[10], written by Jiang Liangqi. In 1688 the ship served in the Fujian Navy to quard the coast of China. The final historical record is of an equipment list of the national navy, from the time of Emperor Guangxi's reign (1881).

The first illustration of Ganzeng warship could be found in *The Navy Abstract*[11] written by the east Guangdong regional commander Chen Liangshi during the reign of Emperor Kangxi. In the book, 14 kinds of seaman position, numbers of each kind, and the post requirements were firstly founded. It was the first document that explained the design principle and main modular system based on the length of main beam.

The Taiwan Conversation by Writing[12] was written by Huang Shujing between the years

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[5] This printing was cited by Isaac Commelin,1646. *Beginning and Ending of the Dutch-East Company,* Amsterdam.

[6] Anonymous, middle 17th century. The Island of Formosa, painted on parchment, collection of Berlin Ethnologisches Museum.

[7] William Alexander and George Henry Mason, 1988. Views of 18th Century China Costumes,History, Custom. 1796, reprint Portland House, New York.

[8] Jiang Youxian, 1817. Memorial to the throne with picture, 38cm×35cm, collection of The National Palace Museum, Taibei.

[9] Yangyin, 1958. *Conquest Memoir(Cong-Zheng-Shi-Lu)*, 1658, reprint Economic Academe of Taiwan Business Bank, Taibei.

[10] Jiang Liangqi, 2000. *East China Memoir (Dong-Hua-Lu)*, 1664 reprint Xueyuan Press, Beijing.

[11] Chen Liangshi, 2002. *The Navy Abstract (Shui Shi Ji Yao)*, later 17th century, reprint Shanghai Ancient Books Publishing House, Shanghai.

[12] Huang Shujing, 1957. *The Taiwan Conversation by Writing* (C*hi Kan Bi Tan)*, early 18th century, reprint

of the Emperors Kangxi to Yongzheng. Shujing was the first imperial senior government official in Taiwan during the Qing Dynasty. He used mandarin tongue to record and explain the dialect of about 100 details of the ship construction, recording materials, quantities and specifications needed to build the Ganzeng warship.

In 1731 a Guangdong general named Cai Tianlue stated to the emperor the Ganzeng's details of dimensions and materials. In the statement he included the depth of the hulk, the upper width and the lower width of watertight hulk measured by a Luban ruler[13].

All the evidence from the three documents mentioned above provided us with a practical base to conduct our reconstruction experiment. We had detailed information including principle of design, modulus system, main unit data, material data, and measures.

The five historical documents that recorded units dimensions, two of them with detailed illustrations, are: *The Illustrated Manual Of Instruction In Shipbuilding For The Navy Of Fujian Province* (Figure 1)[14], Cai Tianlue' memorial to the throne, *The Regius Formula of Fujian Sea Going Warships*[15], *The Regius Formula of Jiangsu River and Sea Going Warships* [16], and *The Illustrated of Shandong Dengzhou Naval Ganzeng warjunk*[17]. Among the documents, *The Regius Formula of Fujian Sea Going Warships* had the most complete records of 17 Ganzeng's specifications and a detailed list of the amounts and costs of materials used for the construction (Table 1). In our experiment, we used this document as the main base data, and considered the others as complements.

Table.1 The key dimensions of all sizes of Fujian Ganzeng warships

Number	Qty	Length of deck	Beam	Deep of hold	Cabin
Liminary	3	22.2 m	5.61 m		21
Chap.1	5	13.8 m	3.96 m	1.29 m	15
Chap.2	2	16.2 m	4.71 m	1.60 m	16
Chap.3	4	15.0 m	4.38 m	1.46 m	16
Chap.4	9	16.5 m	4.71 m	1.60 m	16
Chap.5	14	17.1 m	4.86 m	1.60 m	16
Chap.6	8	18.6 m	5.01 m	1.66 m	17
Chap.7	3	19.5 m	5.52 m	1.84 m	18

Economic Academe of Taiwan Business Bank, Taibei.

[13] Cai Tianlue,1989. *Memorial to the throne about Zhejiang province's Ganzeng warships*, 1731, reprint Jiangsu Ancient Book Press, Nanjing. Luban ruler is a Chinese yardstick to length named with the fonder of capenter in ancient legend and widely used by traditional Fujian shipwright till now, 1 Luban's foot is about 0.3 metres.

[14] Anonymous, middle 18th century. *The Illustrated Manual Of Instruction In Shipbuilding For The Navy of Fujian Province* (*Min Sheng Shui Shi Ge Biao Zhen Xie Ying Zhan Shao Chuan Zhi Tu Ji)* , manuscript.

[15] Anonymous, 2002. *The Regius Formula of Fujian Sea Going Warships (Qin Ding Fu Jian Sheng Wai Hai Zhan Chuan Ze Li)*, 1768, woodblock edition. reprint Shanghai Ancient Books Publishing House, Shanghai.

[16] Anonymous, 1719. *The Regius Formula of Jiangsu River and Sea Going Warships (Qin Ding Jiang Su Sheng Wai Hai Zhan Chuan Ze Li)*, collected by The National Science library, Beijing.

[17] Anonymous, middle Qing Dynasty. The Illustrated of Shandong Dengzhou Naval Ganzeng warjunk, 66cm×55cm, collected by The National Science library, Beijing.

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Chap.16	3	25.8 m	6.39 m	2.37 m	22
Chap.17	9	24 m	6.24 m	2.18 m	22

3.1 Reconstruction design

Stage 1

Based on above studies of historical documents, and considering the difficulty of experiment and financials, we chose Qing 8 of Taiwan Navy recorded in Chapter 1 of *The Regius Formula of Fujian Sea Going Warships,* the length of deck 13.8 metre Ganzeng warjunk as the original ship, and applied the reconstruction design steps as follows:

- Step 1: Listed all the units of 17 sizes according to *The Regius Formula of Fujian Sea Going Warships*, and compared the list of Chapter 1 Ganzeng to other sizes. We got a supplement list of Chapter 1 Ganzeng from the compare (Table 2), which was hold to testify or modify used above mention other historical documents later.

Table.2 The specification of Chapter 1 Fujian Ganzeng warship

Main measurement			
Length of deck	13.80 m	Beam of middle bottom	3.06 m
High sheer forward	1.20 m	Length of tail	3.60 m
High sheer tail	0.9 m	Beam of tail deck	3.78 m
Length of fore ship	5.40 m	Beam of tail bottom	2.82 m
Beam of forship deck	2.64 m	Length of top-side plank	15.78 m
Beam of forship bottom	2.40 m	Height of top-sideplank	1.20m
Length of middle	4.80 m	Cabin	15
Beam of middle deck	3.96 m	Deep of hold	1.29 m

- Step 2: Distinguished and sorted every component of the list according to the illustrations of *The Illustrated Manual Of Instruction In Shipbuilding For The Navy Of Fujian Province* and the explanations of *The Navy Abstract and The Taiwan Conversation.*
- Step 3: The uncertain components and units were questioned in interviews conducted in the field investigation of traditional shipbuilding sites in Fujian, and the explanations were compared. The accordant explanations were accepted and the inconsistent ones were held for further tests.
- Step 4: The main technical parameters like thickness of bottom plates were sent to the master of craftsmen, and confirmed that the parameters were almost the same as the tradition of the master. The traditional Luban ruler was used as the measurement tool, whose 1 Luban's foot (chi) was equal to 0.3 metres.
- Step 5: The complex list was sorted to five systems including configuration system, drive system, directional system, anchor system, decoration system. Then converted

to a new List of The Specifications Of Components & Materials, including 977 wood parts and 27 metal parts, nailed with 17886 nails, and sealed with a mixture of 686 kilograms of shell ash, 276.5 kilograms of tung oil, 223.5 kilograms of net, 223.5 kilograms of bamboo fibers.

- Step 6: The new list was handed to four teams for reconstruction detail design. The four teams were Fangshijian from Fuzhou, Hongzhigang from Hui'an, Chenfangcai and Chenrongliang from Jinjiang, Kongbinghuan and Xuxihui from Dongshan. All the teams are traditional shipbuilding specialists in Fujian.

The design principle was to match all the units of the new list neatly to the traditional way and without any pieces remaining. The construction was based on the functions of main units and systems and was in the accordance with the documents and field investigations.

stage 2

Compared four of the above mentioned ancient documents with three newly found documents: *the Cai Tianlue' memorial to the throne, The Regius Formula of Jiangsu River and Sea Going Warships*, and *The Illustrated of Shandong Dengzhou Naval Ganzeng warjunk*. For prototypes we chose the length of deck at 22.2 m, based on the primary chapter of *The Regius Formula of Fujian Sea Going Warships*, and 21.9 m deck length, from chapter 11. Then organized List of The Specifications of Components & Materials and designed models.

3.2 Full scale reconstruction

In 2007 the building of a full scale reconstruction began. The team from Jinjiang reconstructed the ship based on chapter 1 Ganzeng warship, length of deck 13.8 m, which followed the traditional shipbuilding. The teams of Fuzhou, Hui'an and Dongshan were technical support, the Longhai team painted, and the Zhaoan team finailized adjustments after the trial voyage.

The reason of this prototype chosen was that it was the smallest one in the 17 sizes. Thus the expense was relatively small, and the dangerous factor of the voyage was relatively small too. The reconstruction ship was named *Princess Taiping*.

The procedure of building ancient sea-going sailing junks is rarely found in the historical documents. And there have been many discussions between shell-first and frame-first design. The transverse watertight bulkhead, the most characteristic structure of Chinese sailing junk , is a frame-first system. The reconstruction's procedure was carried out as illustrated (Figure 2):

Figure 2. The sequence of construction.

3.3 Testing and improvement

The trial voyage from Shenhu to Xiamen was carried out during January to April of 2008 (Figure 3). The results of the voyage showed the Princess Taiping sailed at an average speed of 6 knots without wind with good stability but it had visible transverse drift, an issue in most Chinese sailing junks.

The *Princess Taiping* entailed bamboo matting sails. The fabrication of bamboo matting was still mastered by several craftsmen along the Fujian coast[18]. We had no study of the manipulation technique of bamboo mattging sail so we used the cloth sail dyed by Dioscorea cirrhosa Lour. This was not in accordance with the historical prototype.

Figure 3. Princess Taiping (Photo by Qiao Yang).

4. Modeling technology

4.1 Classification and cognition

A three-dimensional reference frame could be set to classify the complex Chinese sailing

[18] Xu Lu, 2006. *The investigation on the traditions of naval architecture along Fujian coast.*

junks, which set time as the first coordinate axis, use space as the second one, and apply usage as the third axis. In this reference frame, every one of the warships, traders, fishers and ambassador ships from different time and space will find their own place. For certain ship forms the classification system of the Ming Dynasty's encyclopedia of *Heavenly Creations* may be feasible. Every ship part and components in the classification should be tested in the field investigations and compared with the study of antique ships. The shapes, the positions, the functions and the behaviors of these parts should be observed on the spot, and recorded on the voyage.

4.2 Suppositional three-dimensional model

Photoshop software and Illustration software are applied to produce the joint picture and vectorgraph of the shipmodel. Then 3dmax software was applied to create models of the ship units and whole ship. We first used this method of a three-dimensional model on the last traditional sailing junk built in Jinhuaxing in 2004, followed by the Ganzeng warship build in 2006 (Figure 4).

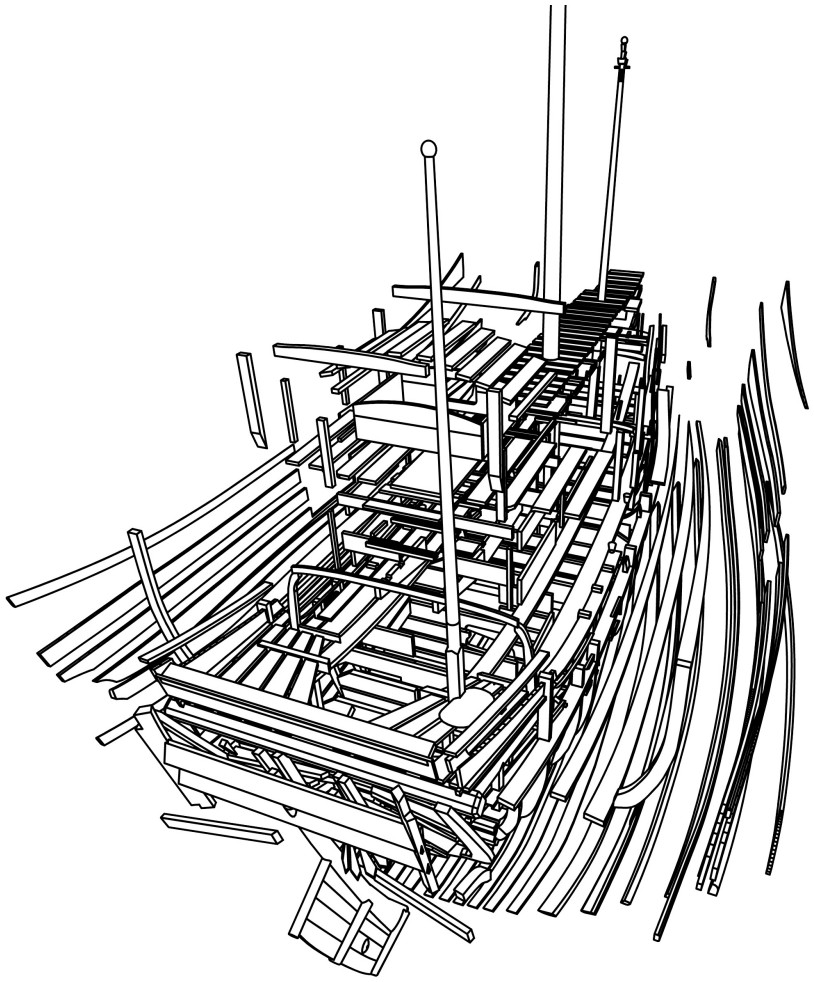

Figure 4. 3D Components of Fujian Ganzeng warship.

5. Conclusions and discussions

5.1 Conclusions

Although shipwreck archaeology has very few cases of Chinese sea-going junks, many clues can be found in historical documents. Furthermore, the majority of sailing junks still voyaged in the middle of 20th century so the last traditional shipbuilding craftsmen are still alive. When we applied experimental archaeology methods to ship remains study, a distinctive prototype could be selected and craftsmen found to build the traditional design. The Ganzeng reconstruction therefore applied traditional technology with steps that trace back to the old building procedures.

The structure of transverse watertight bulkhead was the most important character of all Chinese sailing junks, and watertight bulkhead was the soul structure in this project. The mixture sealant of tung oil and ashes, Chinese rugging sails, the axis ruddle that can swing and lift, the leeboard, and scull were inventions of ancient Chinese sailing junks[19].

As far as the choice of wood is concerned, a kind of natural fir tree Cunninghamia lanceolata (Lamb.)Hook from Fujian a mountainous area was normally used for the parts of a ship's shell that have direct contact with the sea, such as the keel (longgu), bottom, shuishe (literally water snake), and zouma (literally running horse), the deck and transverses (gecangban, literally cabin-separating boards), and natural small-leaf camphor for other parts of the body such as cangliang zhuo (base of cabin beams) liangtou (beam-end) and gecang fuqiang (cabin-separating strengtheners). For the rudder and anchor which required harder material, kundian wood, which was grown in Guangdong and Southeast Asia was used. Wood for the mast was the most carefully selected, natural fir trees from Fujian aged 80 or more were generally used. The craftsmen constructed the ships with the traditional techniques and tools. The aim of the reconstruction experiment is to reveal the technical logic of historical prototypes with similar techniques and environments.

Reconstruction experimental archaeology is an effective method to study history. The replica will be on the trial voyage in same circumstance as it would have historically. Any baseless conjecture must be expelled, quantitative investigations and tangible evidences must be applied, as ship form essentially was the reflection of its wooden structure. This kind of historical study should be based on concrete practice rather than soely on documentation studies, and should avoid in interfusion by knowledge of modern naval architecture as a result like previous Zhenghe treasure ship study[20].

Modular systems are an important and traditional method in naval architecture. Modular system use the length of the keel or deck beam as the base structure. The Ganzeng reconstruction applied this system. This kind of traditional design uses lengths instead of angles as the measurement, which embodies the character of Chinese old math. The principle and method of design can not be understood until all the modulus are grasped. This is the essence of the technical logic in Chinese shipbuilding.

The only way to preserve traditional technique is to conduct it. Reconstruction of ship remains is the rescue solution of heritage preservation. The rise of tourism at the sea may

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[19] Xu Lu, 2006. *The Naval Architecture of Ancient Fujian Style Sailing Junks, an Overview.*

[20] Chen Yanhang, Yang Qiuping, Chen Xiao, 1986. A Study For The Peplica Of Zheng He's Treasure Ship. *Ship History Studies,* Vol. 1986 (2).

open a new space for the need of Chinese traditional sailboat. At the same time the resource of craftsmen continues.

5.2 Discussions

Reconstruction of ship remains must be based on archaeological and historical evidences, integrated with methods of ship design and building acquired from ethnographic field work in traditional shipbuilding centres. The organization of all the resultant studies is the important part of reconstruction experiments. Some academic studies collect and sort domestic navigation documents of Chinese history, however the documents scattered in libraries and museums aboard have been neglected. To improve the effectiveness of retrievers and studies a visual database of documents organized by database including images and available on the internet need to be created. Classification could be according to use, time, region and type.

Unlike shipbuilding of other indigenous areas, Chinese shipbuilding traditions changed little through time, and the last capable traditional shipbuilders are still alive. Western classifying studies of Chinese sailboats in the early of 20th century are just based on field investigations and interviews with the successors of traditional naval architecture. Projects need promptly undertake field investigation, with the case of the Manchuria railway being a precise and standard model of these studies.

The terminology of traditional shipbuilding and navigation is usually passed on orally, and so are not always recorded in documents, and now some of have no equivalent word. Furthermore, the meanings of the words have changed through time and place. This continues to puzzel both Chinese and Western scholars[21]. Through the interviews we can distinguish the dialect, this must be the first step to syncronizing traditional andmodern-day terms. And the glossary of Chinese terms relevant to traditional Fujian junk should be authorized and translated to English and other languages for better communication.

Besides the basic works mentioned above, the index of drawings, photos and models of traditional Chinese sailing junks need to be done, with the documents stored aboard copied and sorted. For example, the neglected series drawings made in Guangzhou in 19th century collected by Victoria and Albert Museum are the best illustrations of Western scholar's classification. The scripts of François-Edmond Pâris[22], Louis Audemard23, Etienne Sigaut[24], Barbosa Carmona[25] still have no Chinese versions, and some of them even have no English versions. These translation works are urgently needed.

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[21] There is an old adage in Fujian province that "Master of a particular shipyard builds ships exclusive to that shipyard." Even in southern Fujian and speak idiographic Minnan dialect, different township have their own glossary system.

[22] Musee de la Marine, 1992. Le voyage de la Favorite. Paris.

[23] L.Audemard, 1957,1959,1960,1962,1963,1965,1969,1970a,1970b. *Les Jonques Chinoises,* (10 volumes), Museum voor Land- en Volkenkund en Maritiem Museum Prins Hendrik, Rptterdam.

[24] Etienne Sigaut (1887-1983) spent more than thirty years in China to investigate South Chinese junks since 1911, his manuscript and sketch however, have never been published and remain in National Maritime Museum of France.

[25] Artur Leonel Barbosa Carmona, 1990. *Lorchas,Juncos E outros Barcos no sul da China*, repaint Museu e Centro de Estudos Maritimos de Macau.

The current experimental reconstruction project is the replica of a 10 meter length, later 19th century to early 20th century, Fujian style sea-going sailing junk. The original ship came from the manuscript on *Junk-building of the Zheng Family of Haicheng in Zhangzhou in early Republican Period* (1937). The detailed redesign was made by an 88 year-old master shipbuilder named Zheng Liangzhao. We aim to reconstruct this double-masted sailing junk for a trial voyage so as to grasp the sail manipulation methods and the navigation techniques which unavailable in any documents.

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