3D digital study of the historic ship-model "ARIS" of Admiral Miaoulis from the 19th century – VHSS Project; Preliminary Report

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Abstract: The study of the ship-model of "Aris" of Admiral Miaoulis (Andreas Vokos) (1769–1835) was undertaken in the frame work of the VHSS project. The model was recorded and reconstructed by photogrammetry, laser scanning and conventional measurements. Although it was donated in 1933 (Benaki Museum/Athens), it is considered to have been built during the lifetime of the Admiral. It has a length of 64 cm and it is planked on the starboard side and unplanked on the port side. We propose that the model was built by a shipwright in a scale 1/75. The brig "Aris" was built around 1813 in the shipyards of the island of Hydra and became the flagship of the Greek fleet during the War of Independence.

Keywords: brig, ship-model, photogrammetry, laser scanning, Hydra, Admiral Miaoulis

1. The "VHSS" project

The study and 3D representation of the historic model of the brig "Aris" of Admiral Miaoulis was undertaken in the framework of the project VIRTUAL HISTORIC SAILING SHIPS-VHSS. The project aims to create 3D digital models of 19th century sailing ships based on contemporary 3D physical scaled models combined with drawings, old photographs, technical descriptions, and other contemporary artifacts from museums and archives. The project focuses on the appearance, the function and the construction of sailing ships. The results will be presented by means of virtual and augmented reality, during an exhibition at the Folklife and Ethnological Museum of Macedonia and Thrace in Thessaloniki in 2022. The project is a collaboration of the Institute of Mediterranean Studies (FORTH), the Department of Production and Systems Design Engineering (University of the Aegean), the Folklife and Ethnological Museum of Macedonian and Thrace, and the company TETRAGON. The project is funded by the EPAnEK 2014-2020 Operational Programme "Competition – Entrepreneurship – Innovation".

2. The ship-model

The physical 3D ship-model of "Aris" is in the permanent exhibition of the Benaki Museum/Athens (Fig. 1). The model was donated to the Museum in 1933 by Stephanos Pesmazoglou, a descendant of the Admiral Andreas Vokos, better known by his nickname Miaoulis. According to the records of the donation, the ship-model was probably built in the era of the Admiral, in the first half of the 19th century. It has a total length of about 64 cm (external points). It is planked on the starboard side and unplanked on the port side. Parts of the inside structure of the model are visible and directly related to the structure of the real ship. The model represents many elements of shipbuilding of the vessels that were built about that period. However, elements of masts and rigging are noticeable absent. It seems that the person who build this model was focused specifically on the hull and its structure and he was confident only on the appearance of this part of the ship.

The model represents the hull of the brig "Aris" of the Admiral Miaoulis. The brig "Aris" was built around 1813 in the shipyards of the island of Hydra, which was a prominent shipbuilding and maritime center of the Aegean before the Greek War for Independence (1821–1830). Under the Ottoman authorities, in the early 19th century, Hydra had a large fleet of merchant ships occupied mainly in trade between the Black Sea and the Western Mediterranean. At the end of the 18th century, many ships of the Aegean islands were built abroad, but in the two earliest decades of the 19th century Hydra had its own shipyards and most of the ships of the island were built there. The model represents that period and reflects the shipbuilding technology of the Aegean boatyards. This is actually the era of the Greek war of independence and "Aris", like many other merchant ships, was armed and took part in the war. She became the flagship of the Greek fleet during the War (1821–1830) and she was unregistered some time before 1834. The final disposition of the ship is unknown.

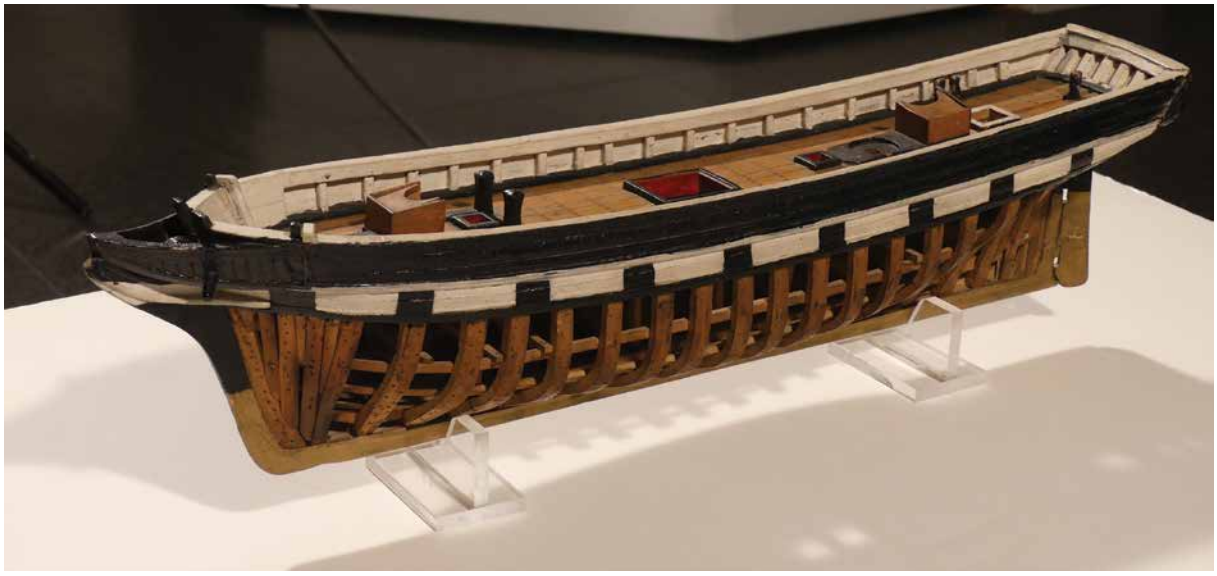

Fig. 1 The model of the brig "Aris" of Admiral Miaulis, Benaki Museum (photo: K. Damianidis)

2.1. Photogrammetry

The ship-model was digitally reconstructed using the Structure from Motion (SfM) method, a photogrammetric and computer vision technique. The first task, 3D reconstruction, was carried out by two photogrammetric software programs, Agisoft and Meshroom. Both were used to perform intermediate steps of the SfM process such as calibration, image alignment, and depth estimation. Finally, Meshlab, an open-source 3D manipulation software, was used to correct and refine the initial 3D reconstructed model. The final model has a 0.1–0.2 mm pixel size and 355 images were processed in total. The digital camera used was Nikon D5300 Kit (AF-P 18–55mm VR). Through photogrammetric 3D reconstruction, the colored texture of the model and several surface details were captured, enriching the 3D scanned data[1]

2.2. Laser scanning

In the second method the ship-model was scanned using the Creaform HandyScan 700 3D scanner which works based on laser triangulation, in conjunction with the VXelements software. Due to the size and detail of the model and the limitations of the hardware on site, a scanning strategy was devised, with numerous sessions, for optimal data acquisition. Special consideration was given to capture inside structural details of the model. A number of positioning targets were placed in order to ensure that each scanning session could successfully be merged with all the others later in the process, in case insufficient surface overlapping occurred. To further optimize the workflow as well as the end result of the digital model, a representative session of the model was first edited in the VXelements software so that the optimal scan parameters could be defined (resolution, optimization and decimation of the scan mesh). The selected method for merging the scanning sessions was 'Surface best fit alternating with the 'Target best fit' to ensure accuracy of the model.

[1] Special acknowledgment to Andreas El Saer, photogrammetry engineer.

Using the Geomagic DX software the digital model was oriented along a potential axis of symmetry and placed upright, to enable further processing. The working position of the ship-model was stabilized when the keel was theoretically horizontal and the level of the optimal symmetry was determined in upright position. Sections were extracted in order to produce the desired lines plan and 2D structural drawings. The sections were made every 50 mm, every 25 mm at the bow and stern part of the model in order to assist the drawing of the frames, and every 20 mm for the drawing of the water lines and bow and buttock lines, in order to support the 2D naval and structural drawings of the ship model.

2.3. Measurements with conventional methods

The digital recording of the ship-model was supplemented with some close observations of the structure and the use of some conventional measurements in some parts, especially inside the ship-model which was difficult to capture with digital methods. Furthermore, the thickness of some structural elements like the planks, the frames, the keel and the clamps were measured and further structural details were conventionally recorded in the inside part of the model.

The 2D drawings of the structure of the model were based both on extracted sections from the 3D digital models (laser scanning and photogrammetry) and on the conventional measurements by hand.

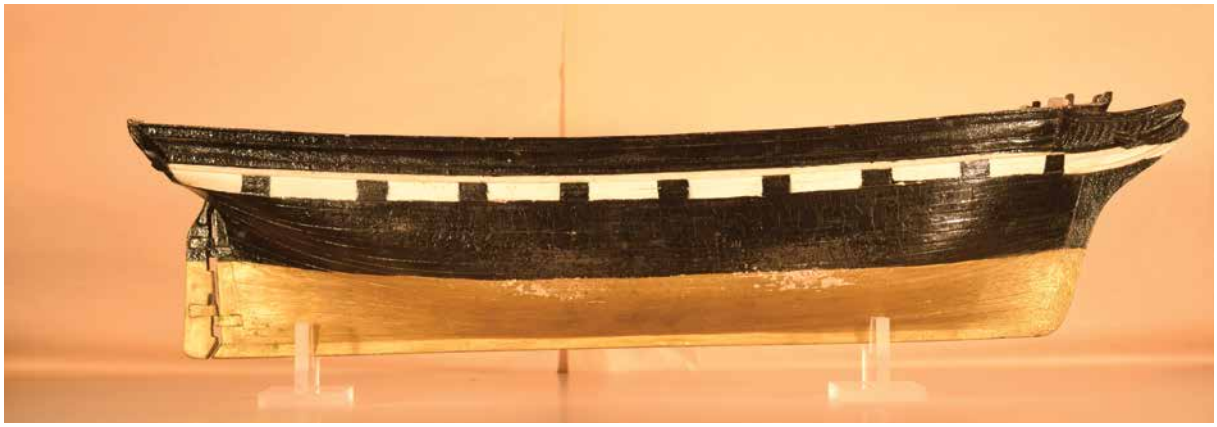

Fig. 2 The right side of the ship-model (orthophoto: V. Nikolakopoulou)

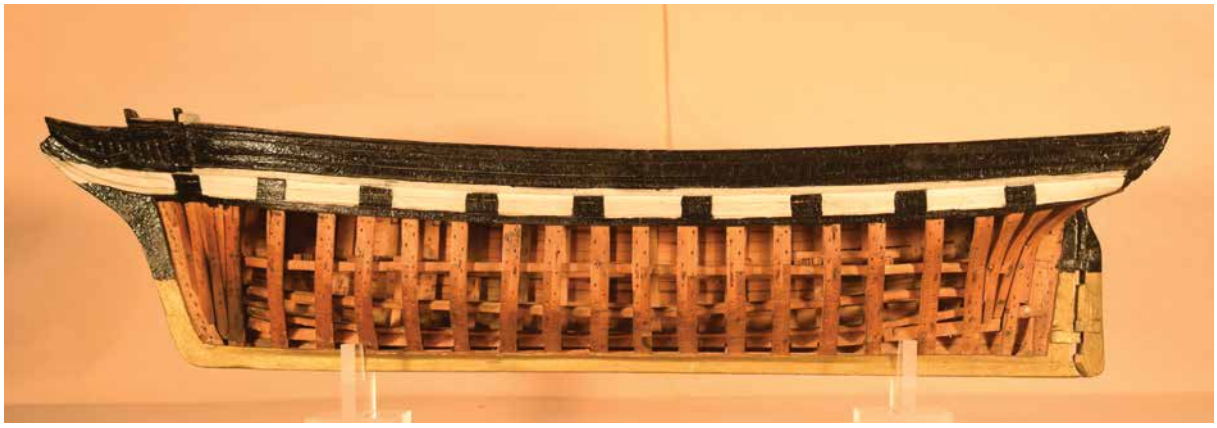

Fig. 3 The left side of the ship-model (orthophoto: V. Nikolakopoulou)

3. Study of the model

Several structural elements that imitate parts of the structure of the original ship appeared on the ship-model (Figs 2–5). However, the small size of the model put some limits to the realistic representation of the components of the original ship and gives uneven evidence for the study of the ships' structure. During the survey on the model, we had to discover whether the model was built according to a specific scale.

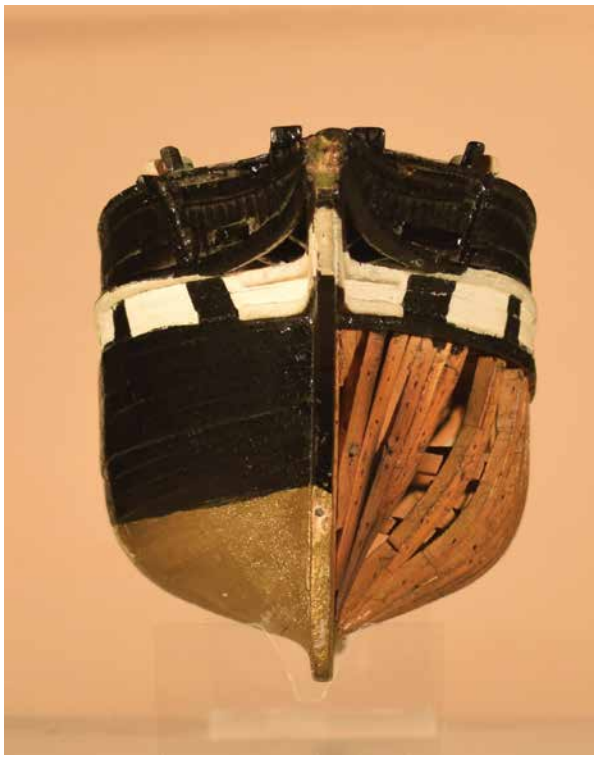

Fig. 4 The bow of the ship-model (orthophoto: V. Nikolakopoulou)

Fig. 5 The stern of the ship-model (orthophoto: V. Nikolakopoulou)

3.1. Dimensions and scale

The basic dimensions of the model, according to the digital measurements, are:

Total length: 64.2 cm;

Length on deck: 55 cm;

Length of keel (on the rabbet): 46.5 cm;

Maximum width (about the water line C and the frame no.11): 13.5 cm;

Total height: 14.9 cm;

Height from the keelson to the deck (underneath the deck and at the frame no. 10): 8 cm.

In the Historic Archive of Hydra, where the ship "Aris" was built and registered, there is a list of ships from the island that participated in the War of independence. "Aris" was registered in this list under the name of the owner Andreas Miaoulis. It is mentioned that captain of the ship was the son of Andreas Miaoulis and the length of the keel of the vessel was 38 yards (34.75 m). If we considere that the model in the museum was built in a particular scale then the length of 34.75 m should have some relation with the length of 46.5 cm (length of keel) on the model. Indeed, the length of 34.75 m could be represented in 46.3 cm if reduced on a scale of 1/75. This is very close to the 46.5 cm measured as the length of the keel of the model. Furthermore, the scale of 1/75 was a common way of analogical reduction of lengths, when the system of measurement in the Greek shipyards was that of the yard, the feet, the *parmak* (Ottoman unit of measurement equal to 31.57 mm) and the finger.

In this case if we consider that the model was built on a scale of 1/75, then the rest of the dimensions of the ship "Aris" of Andreas Miaoulis, could be derived from that model as following:

Length overall (on deck) = 41.25 m (118.68%);

Length of keel (at rabbet) = 34.75 m (100%);

Maximum width (about the water line C and the frame no. 11) = 10.12 m (29.12%);

Height from the keelson to the deck (underneath and at the frame no. 10) = 6 m (17.27%).

These dimensions and specifically the percentages of them are very close to the percentage dimensions of other brigs that were built in the first half of the 19th century (Damianidis 2014: 327; Delis 2014: 342; Tzamtzis 1987: 29).

3.2. The lines

The lines plan of the model that was produced from the digital records has seventeen frames, four water-lines, and three bow and buttock lines (Fig. 6). The model has some distortion, because of its age, especially at the bow. Thus, a lines plan was produced for each side of the model, and after some corrections a final lines plan incorporating both sides of the model was produced.

It seems that the shape of the hull is very carefully determined for the entire length of the model. The bow is wide on the deck but going further down, below the water line D, the frames become flared and give a moderately sharp entry. The middle part of the hull is fairly wide from the water line B up to the top. However, the body below water line B has a moderate reduction of the breadth and it gives a slightly wider V-shape bottom floor. It is remarkable that the maximum widths of the different water-lines are located in different vertical positions on the hull. The stern has the typical wide transom of the brigs of that period, and the deck remains considerably wide as far as the very aft part of the ship. Bellow water line C, the bottom of the stern becomes markedly narrow giving a fine run aft.

Considering that the model was built with frames and 'planks' like the building of real ships, it seems unavoidable that the model-maker used some kind of lofting technique, possibly from the original lines plan of the ship.

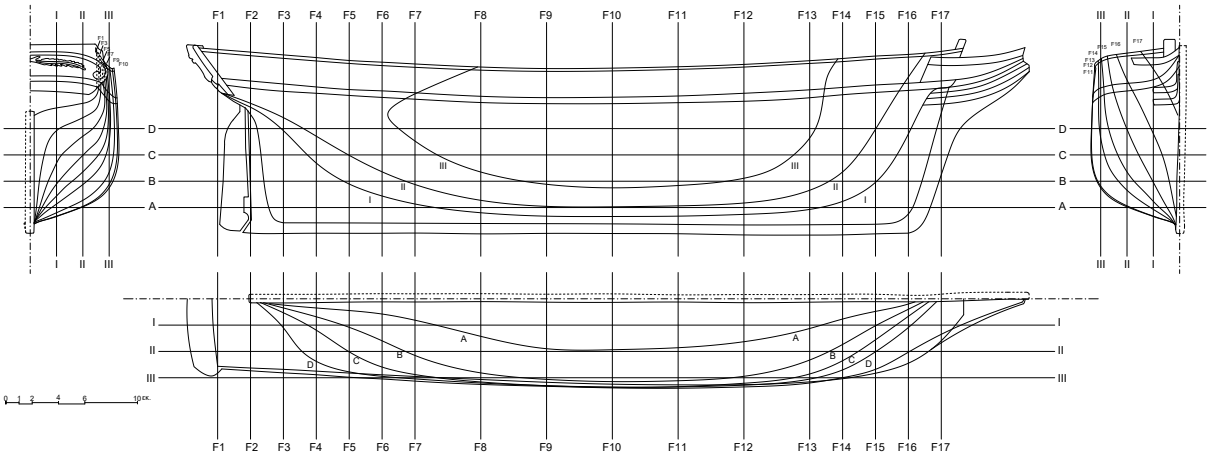

Fig. 6 The lines of the ship-model (drawing: G. Tzavaras, K. Damianidis)

3.3. Structural components

The structural components of the model can be dimensioned following the scale 1/75 of the whole model. The keel has a cross section 6.8 × 10.4 mm on the model, and that could be about 51 × 78 cm for the original ship (this large cross section of the keel it is not easy to be formed by a single tree trunk and probably indicates that it was consisted of at least a false keel, a main keel and a deadwood).

The model in the museum has 18 full double frames (Fig. 3) and six cant frames on the bow (Fig. 4) and another five cant frames on the stern (Fig. 5). The cross section of the double frames of the model is 9.1 × 5.4 cm. The double frames consist of 11 pieces (probably like the original ship) in a double row with an overlapping assembling of the joins (Fig. 7). The pattern of the pieces overlapping assembling "changes at the middle frames. The frames fore amidships have the floor timbers on the aft row of the double frames while the frames aft amidships have the floor timber on the fore row of the double frames. This structural detail, which is still in use in the Aegean boatyards, is another indication that the model-maker of this model was very familiar with the technical process in the shipyards. The model doesn't represent the full number of frames that would be on the original ship. This is because of the scale of the model and perhaps the model-maker deliberately decided to reduce the number of frames on the model. However, he was able to produce other structural details that he considered critical and they are related directly to the construction of the real ship.

The stern has a transom (square stern) and several reinforcing components (Fig. 5), like counter timbers, taffrail, wing transom, fashion frame and filling transom pieces. This kind of stern for sailing ships was very common in the first quarter of the 19th century and later was replaced by the elliptical or counter sterns. The records about this kind of stern are limited in the Greek sources and the model is very valuable from this point of view.

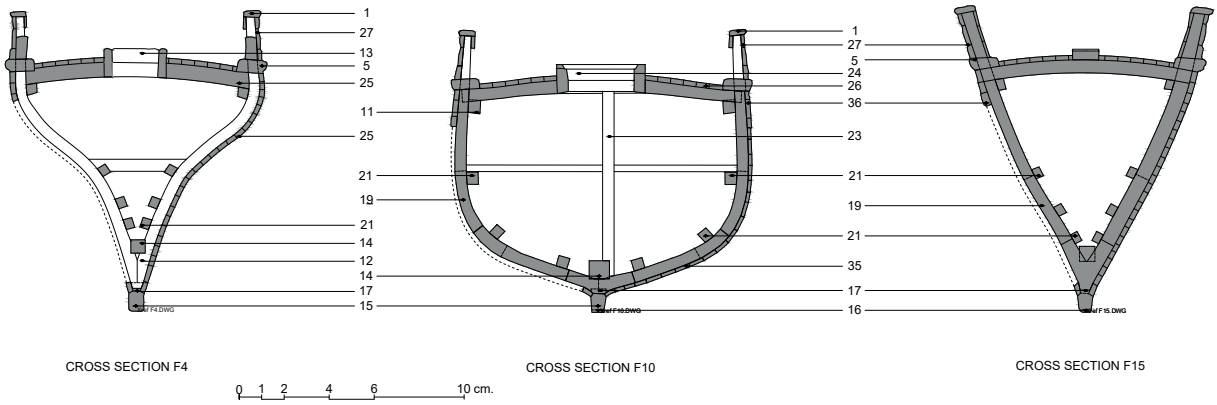

Fig. 7 The cross sections of the ship-model (drawing: G. Tzavaras, K. Damianidis)

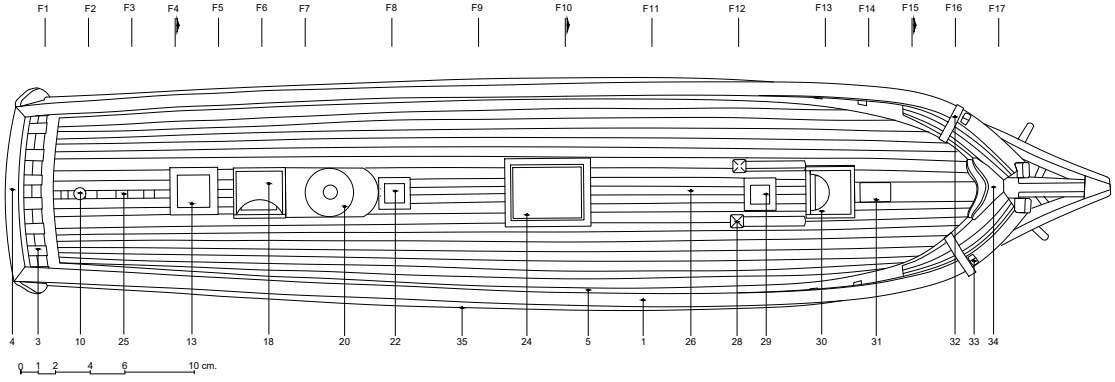

Fig. 8 The deck plan of the ship-model (drawing: G. Tzavaras, K. Damianidis)

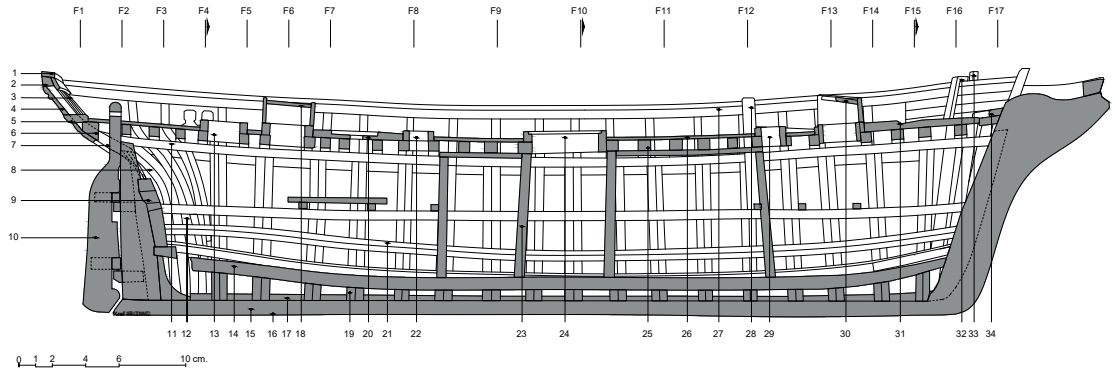

Fig. 9 The longitudinal section of the ship-model (drawing: G. Tzavaras, K. Damianidis)
1-taffrail, 2-gunwale stringer, 3-stern knee, 4- transom, 5-waterway, 6-wing transom, 7-counter timber, 8-fashion frame, 9-filling transom pieces, 10-rudder, 11-shelf, 12-cant frame, 13-aft hatchway, 14-keelson, 15-keel, 16-false keel, 17-deadwood, 18-aft ladderway, 19-double frame, 20-capstan bed, 21-clamp, 22-main mast cleat, 23-stanchion, 24-main hatchway, 25-beams, 26-deck planks, 27-gunwale, 28-riding bitt, 29-fore mast cleat, 30-fore ladderway, 31-recess for the bowsprit, 32-cathead, 33-timberhead, 34-knees, 35-planking, 36-wales

Several internal elements are visible inside the model, including the keelson, shelfs, clamps, beams, and stanchions (Figs 3 and 7). The planking of the model (Fig. 2) on the one side consists of 22 strakes below the waterway and probably were deliberately decided to reduce the number of the strakes on this scaled model. Thickness of planking is about 1.5 mm which indicates a thickness of planking of the original ship about 11 cm (scale 1/75). There is a thinner planking on the gunwale and three slightly thicker planks (wales) below the waterway timber.

The arrangement of the deck is of particular interest (Fig. 8), because it seems that it represents specific real elements on it. These include the waterway timber and 19 rows of deck planks. At the bow the central deck plank is wider and it has a recess to support the bowsprit. In the same area there are catheads together with timberheads, the fore ladderway to the lower deck, the fore mast cleat and two riding bitts with supporting knees. In the middle part of the deck there are the main hatchway, the main mast cleat, and the capstan bed or step. At the stern there are the aft ladderway to the lower deck, the aft hatchway and the rudder. The transom on the stern is square with eight stern knees, taffrail and gunwale stringer.

Conclusion

The study of the model of the brig "ARIS" of Admiral Miaoulis casts some light on the structure and the form of the Mediterranean brigs, locally build during the early 19th century. The model of the ship seems simple but very carefully designed, with all lines of outstanding workmanship. There is a 'full body' on the fore part of the hull and a very flared shape on the aft part of the hull. It is probable that the shapes of the frames and the rest of the structural elements were produced with some kind of scaled lofting technique, imitating the construction of the ship. Although the deck arrangement seems simple, it includes all the main elements at the right positions. The study of the model of "Aris" of Admiral Miaoulis continues by comparing it with other models and drawings of contemporary brigs. We believe that this model is a construction made by a person who had experience building ships and might have been personally involved with the construction of brigs like "Aris". This conclusion makes the model very valuable for the study of the Greek shipbuilding industry during the early 19th century. We would like to thank the Benaki Museum for the permission to study and publish the model of "Aris" of Admiral Miaoulis.

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