3D LASER SCANNING AND MODELLING OF THE DHOW HERITAGE FOR THE QATAR NATIONAL MUSEUM

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ABSTRACT

Curating boats can be difficult. They are complex structures, often demanding to conserve whether in or out of the water; they are usually large, difficult to move on land, and demanding of gallery space. Communicating life on board to a visiting public in the terra firma context of a museum can be difficult. Boats in their native environment are inherently dynamic artifacts. In a museum they can be static and divorced from the maritime context that might inspire engagement. New technologies offer new approaches to these problems. 3D laser scanning and digital modeling offers museums a multifaceted means of recording, monitoring, studying and communicating watercraft in their care. In this paper we describe the application of 3D laser scanning and subsequent digital modeling. Laser scans were further developed using computer-generated imagery (CGI) modeling techniques to produce photorealistic 3D digital models for development into interactive, media-based museum displays. The scans were also used to generate 2D naval lines and orthographic drawings as a lasting curatorial record of the dhows held by the National Museum of Qatar.

Keywords: 3D Laser Scanning, Dhow.

1. INTRODUCTION

The National Museum of Qatar holds a rich and diverse collection of watercraft representing the maritime traditions of Qatar, the Gulf region, and the wider Arabia Sea. The collection is among the most important in the region, and continues to grow through new acquisition. The vessels reflect the many aspects of maritime life in the region – fishing, passenger ferrying, pearling and long-distance trade. The collection is currently kept at a boatyard on the Doha corniche, adjacent to the Museum of Islamic Arts public park. The vessels were previously on display to the public at the old national museum, which closed mid-last decade in anticipation of the construction of its successor. Most of the larger craft are kept on the water – and are visible from the park – while others are stored on props on land, and currently out of public view. Whatever their ultimate curatorial destiny, the collection requires constant care and maintenance. Vessels in the water are subject to marine encrustation and shipworm attack. Those on land are prone to hull distortion. All require constant monitoring for structural integrity. 3D laser scanning can play an important role in this long-term monitoring process. The technique has rarely been used in maritime heritage contexts to date. Notable exceptions include the 3D recording of the timbers of the Newport medieval ship albeit with a 3D Faro arm [1,2,3,4,6]. Publications of the use of a 3D laser scanner in boat recording includes [5,7].

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2. PROJECT OBJECTIVES AND CONSIDERATIONS

The objective of the project was to use 3D laser scanning technology to survey and record 14 of the vessels in the national museum collection, and to use the data generated to produce a number of outputs serving various image-oriented objectives. The core output was a 3D point cloud model of each vessel being the principle repository of the survey data, comprising literally millions of measured points. From that basis, the output pathway splits, one route being to adopt computer-generated imaging technologies to build a photorealistic 3D digital model of each vessel. Such models have multiple applications: models rendered as a simple 3D PDF are a useful curatorial reference document that can easily be passed among others with no requirement for specialist software; high-quality still images can be generated; or the models can be animated within a landscape to generate a rendered movie. Alternatively they can be placed within a games engine to create an interactive user experience that is suited to museum display or net-based public interaction.

The second output pathway focused on traditional 2D formats more familiar to maritime archaeologists. The scans were used to reverse-engineer both 2D naval lines drawings and orthographic drawings of vessels that were not built from drawn plan, but according to knowledge transferred orally between generations. The naval drawings record the overall shape of the hull, and form the basis for modeling a vessel's hydrodynamic performance, while the orthographic drawings seek to reveal the vessel's construction via familiar plan, profile and end views that individuate structural elements. A final strand of the research has sought to assess 3D laser scanning as a means of recording traditional watercraft, and compare it to traditional approaches. The conventional approach to boat recording uses chain-and-offset methodologies, employing simple equipment, such a tape measures, line levels, and plumb bobs. It is highly effective and low cost, but slow in the field and difficult and hazardous on larger vessels. Such approaches have already been used to great effect on some boats within the NMQ collection, by Ahmed al-Saiegh, and Piotr Dziamski and Norbert Weismann.

3. THE FIELDWORK PROCESS

Fieldwork was conducted in Doha and Messaid between 10 February and 6 March 2013. The University of Exeter team comprised Dr Andy Wetherelt of the Camborne School of Mines, providing the technical scanning expertise, and Dr John P. Cooper and Dr Chiara Zazzaro for their extensive maritime archaeological knowledge. The vessels that were scanned had been carefully prepared ahead of time by QMA boatyard staff. Six vessels, the smaller ones, are customarily kept on dry land, and these were surveyed on props on level ground around the yard. QMA staff hauled the others vessels out one by one onto a slipway, and cleaned each ahead of scanning. The largest vessel was too large for the Doha slipway, and was instead sailed to Messaid, where it was scanned in an industrial dry dock. Three-D laser surveying of an object involves scanning it from multiple viewpoints in order to record all accessible surfaces. The individual scans were then registered together in order to create a single point-cloud model of the artifact. Particularly on boats with decks, a degree of blinding was inevitable, with parts of the vessel inaccessible to the scanner.

The team used a phase-based Leica HDS 6000 laser scanner with associated equipment (Figure 1). Phase-based scanners are faster than their time-of-flight counterparts – enabling the team to carry out over 350 scans over a 17 day scanning period. The range setting adopted was 360° x 310°. In a single scan, the laser took 5,050 passes, each with a 1,000 measurements; hence over 5 million points were measured in a single scan, in just over 3 minutes. At a distance of 10m the scanner recorded a point every 6 mm: many of the scans undertaken were typically closer than 10m. With each vessel averaging around 20 scans, some 100 million points were generated per boat: the whole fieldwork producing some 60 Gb of data.

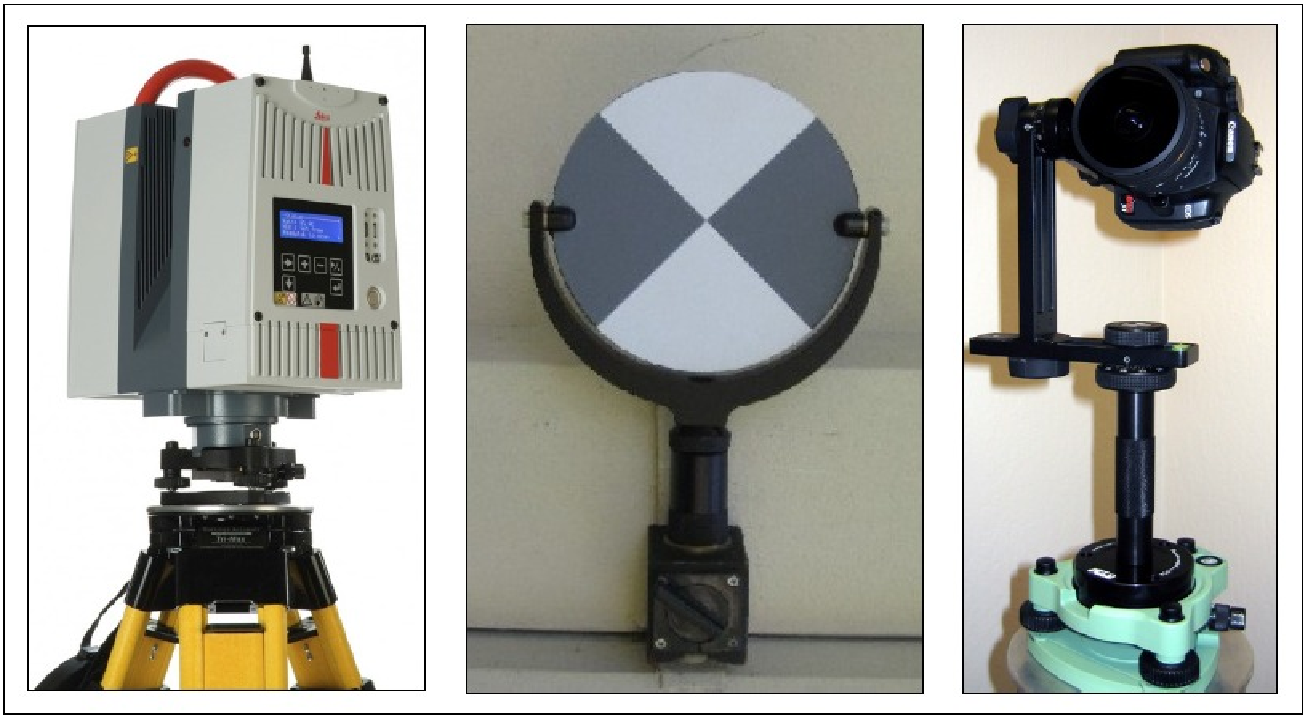

Figure 1: Leica HDS6000 laser scanner (left), a grey-and-white target (centre) and ninja arm with mounted camera (right).

The survey process involved leveling the scanner on a tripod at a location with a clear view of the desired section of the vessel (Figure 2). Eight targets were placed within its view, and a single scan of around 3 minutes duration initiated (Figure 3). On completion, the targets were gradually migrated as the scanner moved from location to location and some fell out of sight. This enabled the individual scans to be registered together automatically using targets scanned by more than one scan, producing a unified point cloud. The scanner was operated wirelessly from a laptop. Once a scan was completed, it was removed from the tripod and replaced with an SLR camera mounted on a ninja arm that positions the focal point of the camera at that of the scanner. A series of photographs were taken in the round with a fish-eye lens – these were used in subsequent post-processing to generate the photorealistic models of the vessel.

Figure 2: Setting up the scanner and tripod alongside the banūsh, the smallest of the vessels scanned.

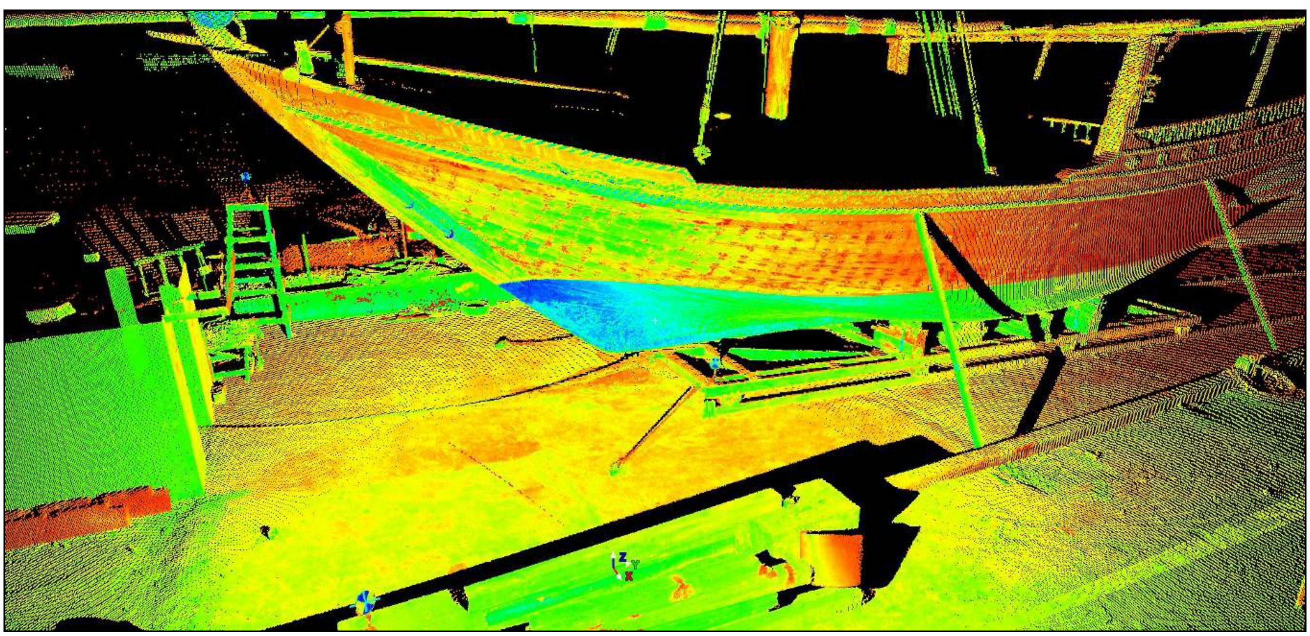

Figure 3: Point cloud generated by a single scan of the port bow quarter of the ghanja: the black areas indicate zero data caused by blinding.

The scanner was then moved to a new location, and the process repeated. In this manner the survey progressed around the exterior of the vessel, before continuing on to the deck itself.

The interiors of vessels presented a more problematic scanning environment. The complex topography demanded more intense scanning if blinding was to be overcome, yet low decks and uneven surfaces made scanner access and stability difficult. The team was able to scan the interiors of just five of the twelve fully decked vessels, always with a degree of blinding (Figure 4). However, by taking the costly and delicate scanner off its tripod and perching it, often precariously, on boards leveled over the interior framing, it was possible to conduct limited scans of the interiors of the remaining seven decked craft.

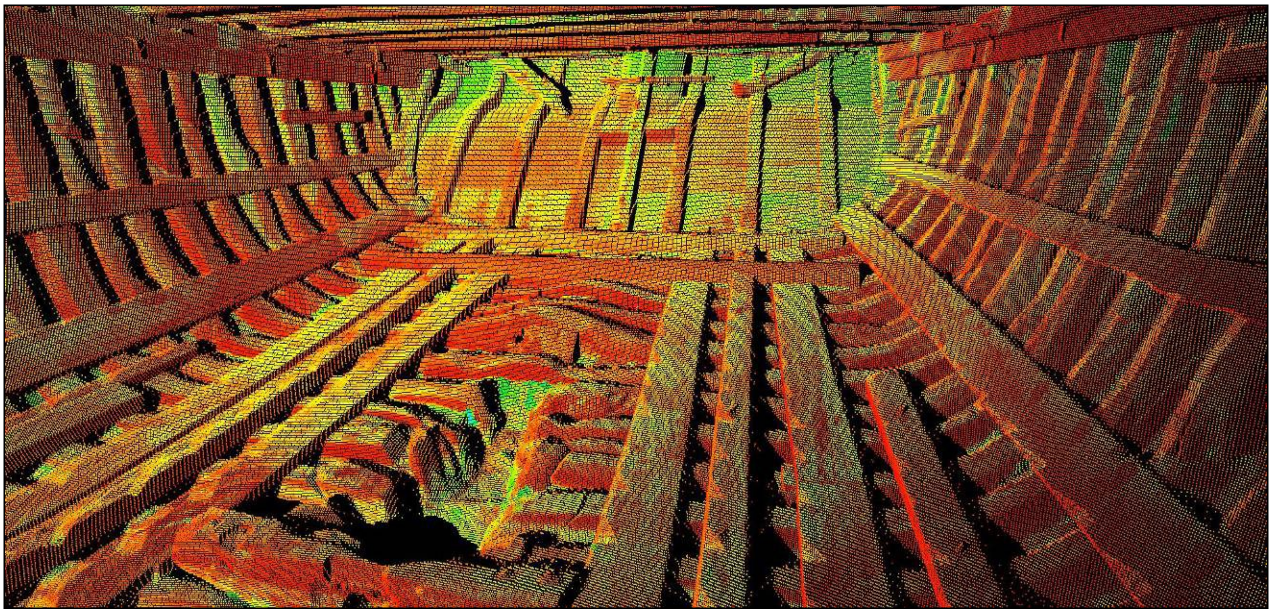

Figure 4: Point cloud generated by a single scan of the interior of the ghanja: the black areas indicate zero data caused by blinding.

4. POST-FIELDWORK MODELING

The principle stage in modeling is to register the respective scans for one particular vessel to form a single scan world, using the grey-and-white targets and shared geometry within the point clouds to produce a unified point cloud. The software used to undertake the data capture and scanning registration was Leica's Cyclone ver. 8.0. The unified cloud is then cleaned of all extraneous data, until just the vessel's point-cloud data remains (Figure 5). At this stage, the data may well comprise some 10 million measured points. This point cloud constitutes the central output of the survey, regularly with a registration error of just 1mm.

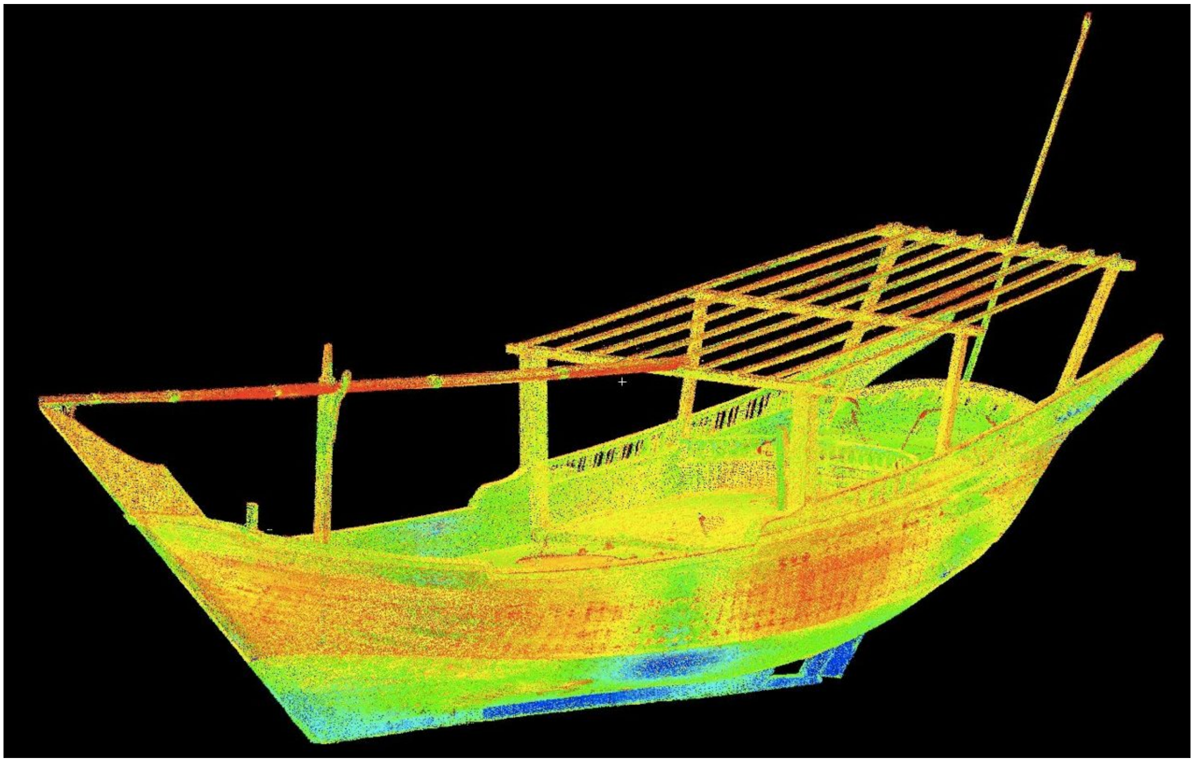

Figure 5: Screen-grab image of the registered point cloud of the large sanbuq.

Post-processing followed three pathways – digital modeling, and the production of naval lines and orthographic drawings of each craft. Digital modeling was conducted by a commercial team at 3Dmsi Ltd. – a spin-off company from the University of Exeter. The process involves the draping of a depleted version of the point cloud with a virtual skin, or mesh, in effect applying a surface to the model (Figure 6).

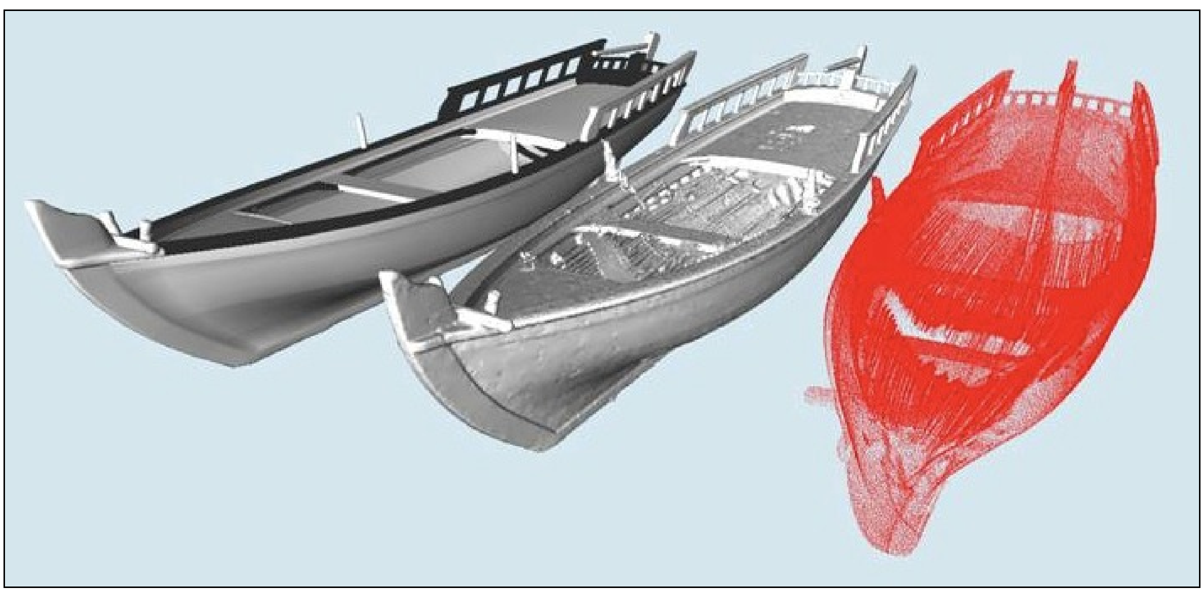

Figure 6: From right to left showing the progressive stages of the modeling the data: point-cloud (right); meshed model (centre), retopologised model (left).

From here, work moved to a world of CGI modeling: the mesh model underwent a process called retopologisation – providing a smoothed surface onto which the final texture is applied. This texture is photorealistic, with the photographs taken from the ninja arm guiding the pasting-on of photographs taken during the fieldwork. The results, once this is applied, are spectacular (Figures 7-8). These are not simply beautiful, however: they remain accurate models from which measurements can be taken. Furthermore their generic file formats allow them to be taken forward for full animation treatment.

Figure 7: Two dimensional still image of the 3D photo-realistic model of the small batīl.

Figure 8: Completed array of photorealistic models of the QMA collection.

The second pathway involved the generation of naval lines drawings – a task to which the point clouds lent themselves readily. By applying a co-ordinate system to the cloud in line with the cardinal structures of the hull, the cloud can be sliced through to isolate curves that would otherwise have to be painstakingly measured in the field. These can then be traced and rendered into the conventions of the naval line drawing (Figure 9).

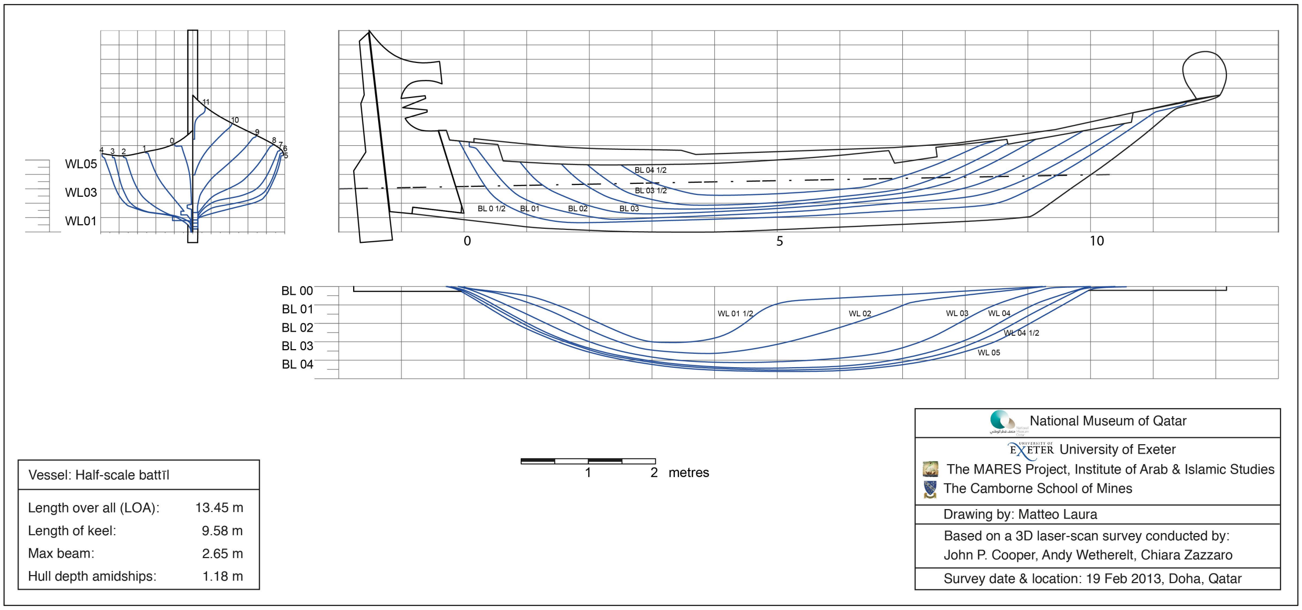

Figure 9: Naval lines drawings of the half-scale batīl.

However, the generation of orthographic lines drawings proved altogether more challenging. Simple viewing and cross-sectioning of the point cloud produced revealing insights into the structure of the vessel. Unfortunately there is no automaticity in the generation of traditional pen-and-ink style projections from the scan data, and there appears to be no alternative to painstaking tracing detail by someone who knows naval architecture (Figure 10).

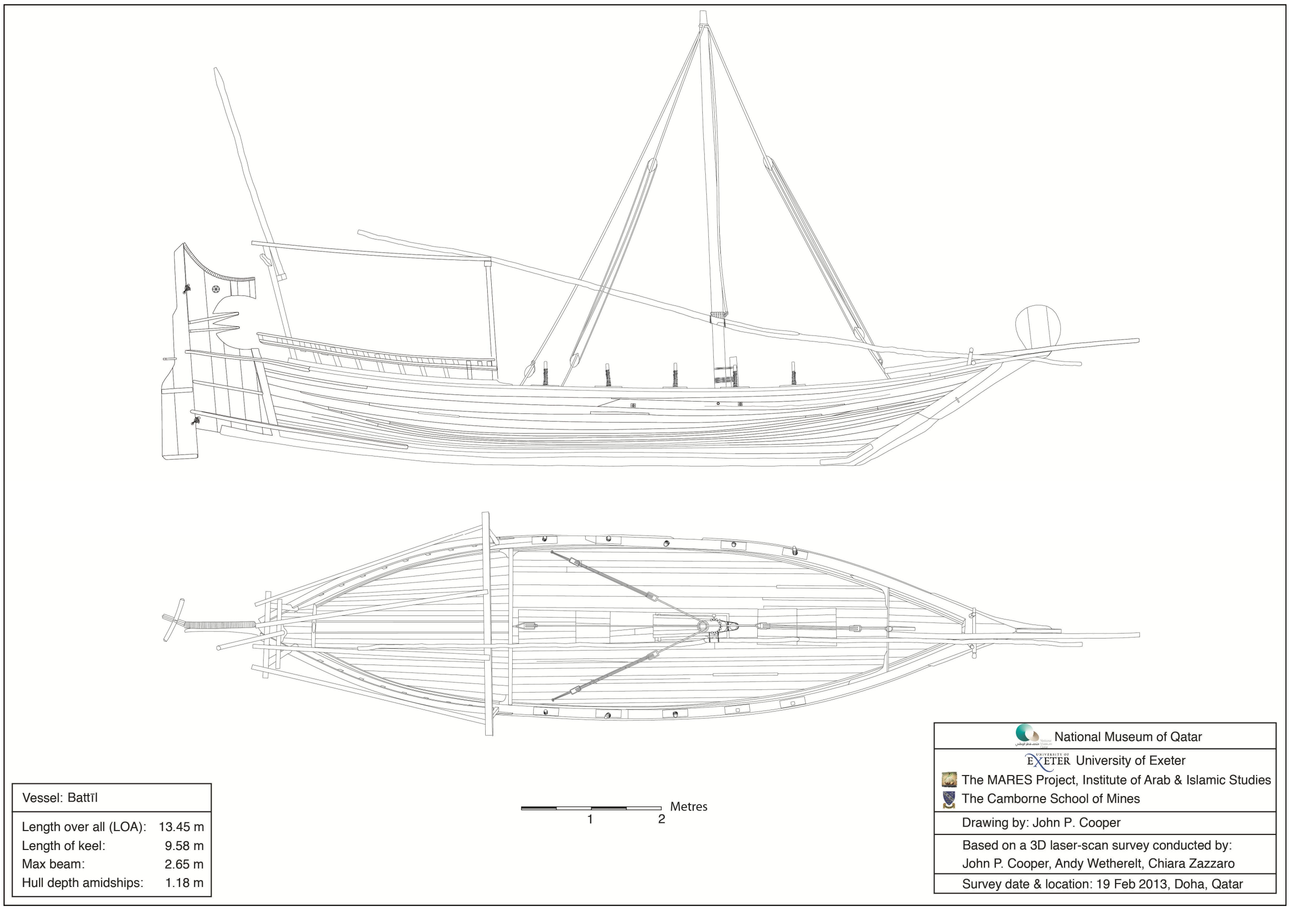

Figure 10: Orthographic plan and profile view of the batīl.

5. CONCLUSIONS

The positives are many: rapid data-gathering in the field; unprecedented detail and accuracy; and the boundless possibilities for developing the data into rich scholarly and outreach formats. However there are downsides. Scanners and post-processing softwares are expensive, and require specialized operators. Moving laser equipment across national borders can be difficult, and scanning in uncontrolled environments, such as a public beach, problematic. And while laser scanning is much faster than traditional survey *in the field*, the post-processing time is significant. The ratio of field time to post processing was probably close to 1:20. It is suggested that we should not confuse high technology with automaticity: this is still a labour-intensive process.

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Project Director, NMQ, Dr Emin Balcioglu.
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Curator, NMQ, Mohammad Abu Hindi.
Curator of Maritime History, NMQ, Dr Lynne Newton.

3Dmsi Ltd.

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