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USING THREE-DIMENSIONAL SOFTWARE TO RECONSTRUCT FRAMES OF THE PAST BASED ON ARCHAEOLOGICAL EVIDENCE

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Using Three-Dimensional Software to Reconstruct Frames of the Past Based on Archaeological Evidence

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ABSTRACT

The usage of three-dimensional representations of artefacts has been widely adopted in humanities to demonstrate how humans lived in the past. An increasing number of researchers present their results through a digital environment in which the achieved conclusions are expressed in very motivating and enthusiastic ways. On the other hand, it seems that archaeological data is being readdressed to the second level of scientific investigation. Films and other digital representations are now considered as the most efficient way for dissemination. However, how accurate and scientifically robust is the data presented nowadays? Which techniques were used to collect the data and which are the aims that driven that task? Would it be for pure dissemination purposes (revealing the existence of an archaeological site) or to report evidence following the higher standards in science?

The present article intends to demonstrate one of the potential ways of using CAD 3D software within the higher standards, by adopting specific protocols designed to record archaeological data. The study aims to identify, record and analyse evidence of forest practice and its relation to the shipbuilding industry during the Iberian Age of Discoveries. This includes a definition of clear objectives and methodologies for the recording of conserved ship timbers and underwater archaeological sites.

Key-words: Maritime archaeology, 3D recording, tree reconstruction, wood studies

RESUMO

O uso de representações tridimensionais de artefatos tem sido amplamente adotado em humanidades para demonstrar como os humanos viveram no passado. Um número crescente de pesquisadores apresenta seus resultados através de um ambiente digital no qual as conclusões alcançadas são expressas de maneira muito motivadora e entusiástica. Por outro lado, parece que os dados arqueológicos estão sendo endereçados ao segundo nível de investigação científica. Filmes e outras representações digitais são agora considerados como a maneira mais eficiente de disseminação. No entanto, quão precisos e cientificamente robustos são os dados apresentados hoje em dia? Quais técnicas foram usadas para coletar os dados e quais são os objetivos que impulsionaram essa tarefa? Seria para fins de pura divulgação (revelando a existência de um sítio arqueológico) ou para relatar evidências seguindo os padrões mais elevados da ciência?

O presente artigo pretende demonstrar uma das maneiras possíveis de usar o software CAD 3D dentro dos padrões mais elevados, adotando protocolos específicos projetados para registrar dados arqueológicos. O estudo tem como objetivo identificar, registrar e analisar evidências da prática florestal e sua relação com a indústria naval durante a Era Ibérica dos Descobrimentos. Isso inclui uma definição de objetivos claros e metodologias para o registro de madeiras de navio conservadas e sítios arqueológicos submarinos.

Palavras-Chave: Digitalizadores para gravar madeiras de navios

1.Introduction

The use of three-dimensional digitisers to record ship timbers started during a project undertaken by a team from the National Museum Denmark in cooperation with Klaus Jensen of DKC (Hocke,r 2000: 30). Fred Hocker (2000: 8) states in the paper *New tools for maritime archaeology* that:

"(…) our [archaeologists`] task is to develop better methods of collecting and managing the raw material of archaeology. 'Better' means producing higher quality data that will allow archaeologists to answer current questions with more confidence as well as new kinds of data to enable exploration of new avenues of research. 'Better' also means finding ways to produce usable data more efficiently and to communicate the results of our research effectively. Finally, it means finding more efficient means of preserving the objects and sites we investigate so that they can continue to generate new data for future archaeologists (…)".

During the investigation of the Newport Medieval Ship, 3D digital timber recording became an established methodology shared with an international working group called FRAUG (Faroarm and Rhino Archaeological User Group. (JONES, 2008; NAYLING, JONES, 2014; RAVN et al., 2011). This project created a set methodology for recording and analysing timber assemblages using digital techniques. The recording of the complete set of timbers by using a Faro-Arm and the Rhino 3D, allowed the production of three-dimensional physical and digital solid 1:10 scale ship model by converting three-dimensional draw into "using modelling software packages including Rhino 3D and Solidworks" (JONES, 2008: 85).

In this paper three case studies will be presented to describe the techniques and technology employed to record ship timbers. The Belinho 1 ship, the Barland's Farm boat, and the Graveney boat were the subjects of investigation using 3D techniques in order to collect accurate data for the purpose of ship and tree reconstruction exclusively from the archaeological evidence.

2.Recording the Belinho 1 Timber Assemblage Using 3d Digital Technology

During the ferocious storms of 2013/4, violent waves washed ashore a remarkable ship timber assemblage and hundreds of pewter plates onto the beach of Belinho in northern Portugal. The relevance of these artefacts triggered the establishment of an international research team comprised by experts from the Council of Esposende and the ForSEAdiscovery project. The main goal aimed to develop some innovative timber recording methodologies to allow the reconstruction of the Belinho 1 ship and its ship timbers` parent trees.

The recording strategy included the use of a 3D digitiser arm to allow accurate and detailed recording of the surviving timbers. This work was then complemented by a photogrammetric record. The first recording stage comprised the selection of ship timbers which would potentially provide relevant information in terms of ship architecture and wood morphology. This selection included the floors, Y-frames, a fragment of the keelson (mast step), a section of a keel, a stern knee and the stern post. The recording process followed the same protocol employed during the research undertaken on the Newport Medieval Ship, with minor adjustments made to the layer names in Rhino. Once a suitable work location was established, each selected timber was placed on a recording table and digitised.

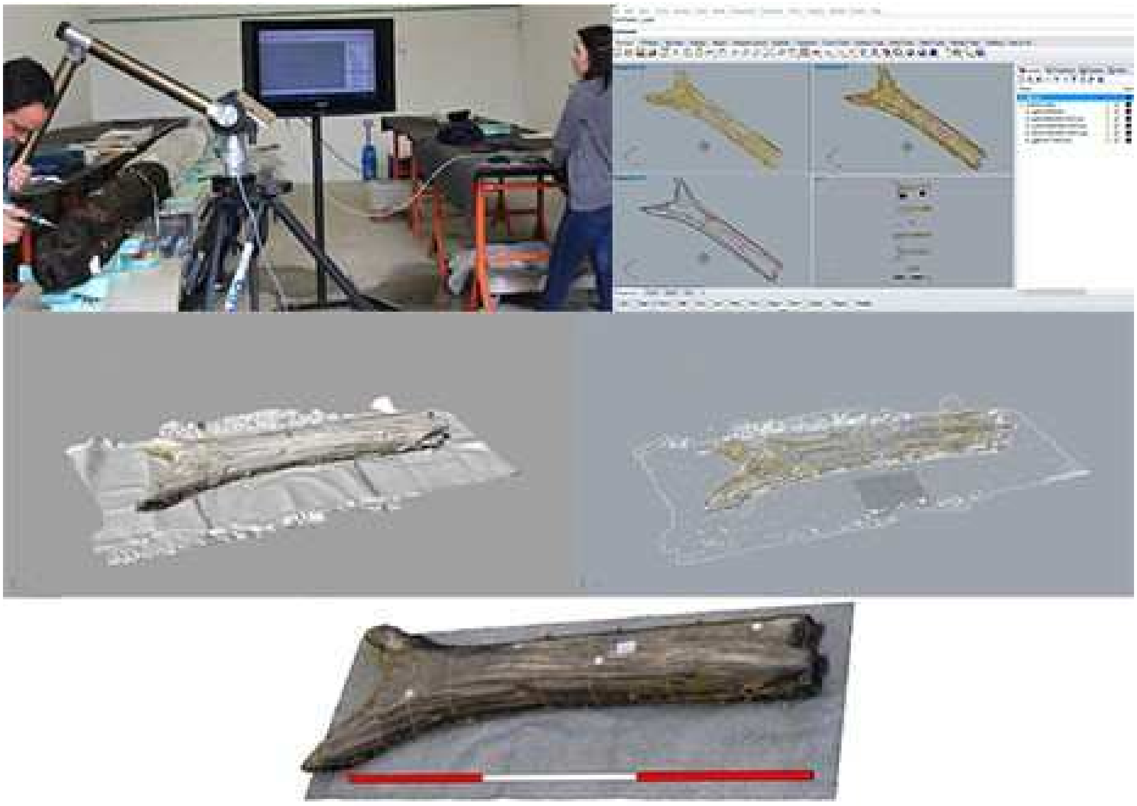

Figure 1. three stages for the recording of the Belinho 1 surviving timber – using a 3D digitiser arm to accurately record the timber surface, 3D digital drawing of a Y-frame, merging a photogrammetry model into a 3D digital drawing produced with a digitiser arm in a way to obtain an accurate record with the natural texture. **Source:** Adolfo Miguel Martins

3.3D Reconstruction of Ships and Trees

Evidence has shown that the Belinho 1 timber assemblage represents a unique shipbuilding technique. Each timber was first assessed by the archaeologist in order to identify interesting or diagnostic details about the timbers, this information was then recorded digitally, starting with the overall shape of the timber and ending with smaller details such as tool marks, fastening information and the growth pattern, using the 3D digitiser. Due to the high levels of erosion caused by site formation on the seabed and damage from the storms at the beach in Belinho, some features seemed to be lost. However, the wood features on the surviving timbers were still visible for recording. This includes information about wood morphology, such as knot location, cracks, and indications of growth patterns such as grain, pith location and natural edges. Special attention was given to the visible annual rings on the bottom of the Y-frames and how the tree`s stem divided into two branches.

The digital drawings comprise two types of layers in which one is related to the ship timber features including evidence of fastening and joinery. The second set of layers includes the wood morphologies such as evidence of growth pattern, knots, heartwood and sapwood boundaries and the location of the pith (first annual ring). The first set was used for the ship reconstruction studies. The drawing produced from the selected timber were copied to a single Rhino 3D file and analysed to identify a potential match within the surviving timber by correlating the fastening and joinery evidence. The second set allowed to gain a better understanding of the ship timbers` parent tree and provided the basis for tree reconstruction studies.

4. 3D Contact Tracing Suitable Techniques for Archaeology

During the Belinho project fieldwork researchers adopted 3D techniques to record ship timbers. A vast variety of tasks were included in this process, which enhanced the quality of the work accomplished. Collecting data from highly eroded timbers proved to be a complex task due to the lack of data.

This technique, paired with an understanding of historical shipbuilding, means digital data can be used to reverse engineer the key characteristics of the ship and the parent trees employed in the building process.

5. Archival re-examination in rhino 3D

Digital recording in Rhino is not only useful for current archaeological ship investigations, it can also lend a new perspective to legacy archaeological data that exists in the physical word as traditional 2D drawings. Information that is both published as books and reports, and that exists in archives around the country.

This part of the paper presents a short summary of work undertaken with this type of legacy data. This work was completed in partnership with the University of Wales, Trinity Saint David. The full reports of both these case studies can be found in Ali (2012) and Ali (2016).

6. Why Re-examine Archaeological Finds?

Archaeology is an inherently destructive science. Archaeologists attempt to counter-act this destruction by creating a detailed record of what they find and where they find items in the ground. This is done through photography, extensive record keeping, drawings, and descriptions. In the best-case scenario, these records go on to inform an academic publication that summarises the finds, site contexts, and archaeological conclusions, becoming a part of the archaeological discourse.

In nautical archaeology, it is commonly held that if enough evidence of an archaeological hull form remains, a theoretical reconstruction should be attempted (IFA 2014; COATES et al., 1995).

To do this however, an accurate and detailed record of the remains *in situ* must be compiled (ibidem). This includes a 1:1 scale drawing of all the archaeological remains, achieved either through contact tracing, as in the case of the two vessels studied here, or by non-contact tracing, a methodology used on ship remains such as the Skuldelev find (FENWICK, 1978; NAYLING, MCGRAIL, 2004; CRUMLIN-PEDERSEN, OLSEN, 2002). These drawings are then generally condensed into their precise counterparts otherwise known as scaled drawings. Following this, the archaeological remains are assembled as a 1:10 scaled research model to aid in the creation of a minimum reconstruction (COATES et al., 1995).

It is always the aim to create a minimum reconstruction of the archaeological vessels. A minimum reconstruction makes the least amount of assumptions from the archaeological remains while remaining consistent with them (NAYLING, MCGRAIL, 2004; CRUMLIN-PEDERSEN, 2006; McGRAIL, 2006; COLES, 1977; COATES, 1977; COATES et al., 1995). Only objects that there is direct evidence for, or objects that are needed to form a full working boat, are included in the end interpretations (ibidem). These interpretations are traditionally presented as a series of scaled drawings and architectural lines plans (McGRAIL, 1981). Several reconstructions can be presented from the same archaeological remains, depending on the extent and survival of the remains (McGRAIL, 1986). "In the spirit of scientific inquiry" these reconstructions should be tested repeatedly to either refute or acknowledge their validity (McGRAIL, 1986: 9; COATES et al., 1995). A resource underutilised by archaeologists appears to be site archives. These excavation records can provide valuable information to the researcher. Looking at a paper archive with the aid of 3D programs such as Rhino can offer a different perspective that may validate or disprove previous hypotheses and conclusions drawn in the past.

The following study examines two such reconstructions for their validity by digitising the archaeological paper record and comparing the archaeological remains to the proposed reconstruction, in Rhino 3D. Rhino 3D is an ideal program to test ship reconstructions because Rhino objects lack the ability to interact with each other. This allows for surfaces to run through each other in a way that cannot be done with real, physical models. This is useful in determining and demonstrating the change of the archaeological remains and allows every stage of the reconstruction data to be layered a top each other digitally.

7. Research Questions

The main research question asked for this study is as follows: Does the different perspective afforded from programs such as Rhino 3D affect our understanding of archaeological boats- either in terms of construction of theoretical reconstructions? Is this a meaningful exercise? (I.e. are we learning anything new)?

8. The Vessels

The Barland's Farm boat and the Graveney boat reconstructions are tested for validity in this study. The Barland's farm boat is a unique example of a Romano-British vessel found in the Severn Estuary in South Wales (NAYLING, McGRAIL, 2004). The boat find consists of the remains of a flat bottom, flush laid boat with evidence of 7 port side strakes, 3 starboard strakes, 16 framing stations, 8 side frames on the port side and 1 side frame on the starboard, a stem post, and a forward mast step dated to the late 3rd century C.E. (ibidem). The Graveney Boat was excavated in the 1960's in Kent, where the remains of a clinker constructed vessel was found under more than 2 metres of clay. There remain 10 framing timbers, 7 starboard strakes and 8 port planks. The vessel is dated to the 10th century C.E. (FENWICK, 1978).

9. Methodology

The Graveney Boat data was gathered from the paper archive of the find, located at the National Maritime Museum in Greenwich, UK. The Barland's Farm data was gathered from the published scaled timber drawings and reconstruction drawings. These scaled drawings for both vessels were scanned and modelled in Rhino 3D. Using the archaeological site plans and the reconstruction drawings, the archaeological timbers were placed inside the reconstructed hull forms to examine whether they demonstrate a plausible progression of thought from the archaeological remains.

In the case of most boat finds, the archaeological remains are compressed and broken apart by the weight of the sediments and soil atop of them, resulting in a wider, flattened hull shape in the ground. Once the timbers are reassembled by re connecting nail holes to each other, the hull form tightens as it pulls itself together. What one would expect from placing the archaeological remains in a reconstruction, is for the remains to be flatter and run through the reconstructed hull form. This is demonstrated best by the archaeological timber R9 from Graveney that was placed in the Graveney reconstruction taken from the publication of the find (FENWICK, 1978).

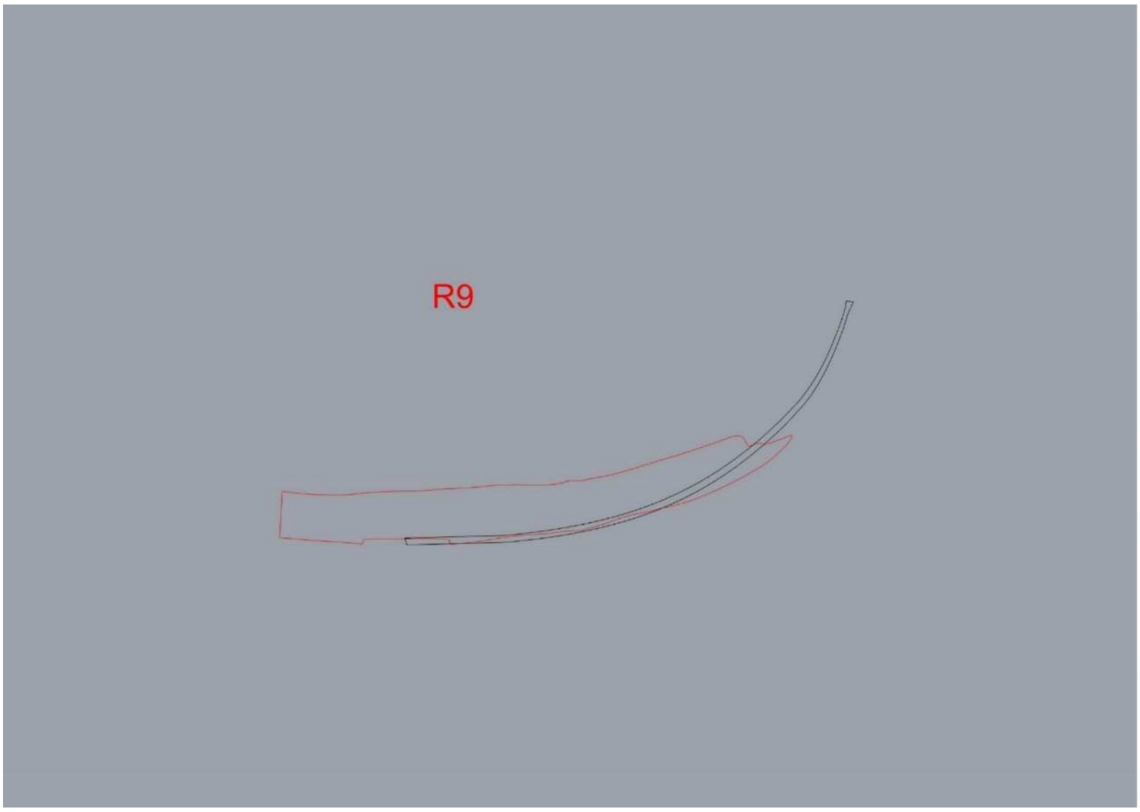

Figure 2. modelled archaeological timbers (red) placed inside published reconstructed hull form (black). **Source:** Adolfo Miguel Martins

The reconstruction allows for some tightening of the hull form and takes into account the compression of the archaeological remains. This result lends confidence to the Graveney reconstruction published by McKee in 1978. What one does not generally expect is what was found with the Barland's Farm boat.

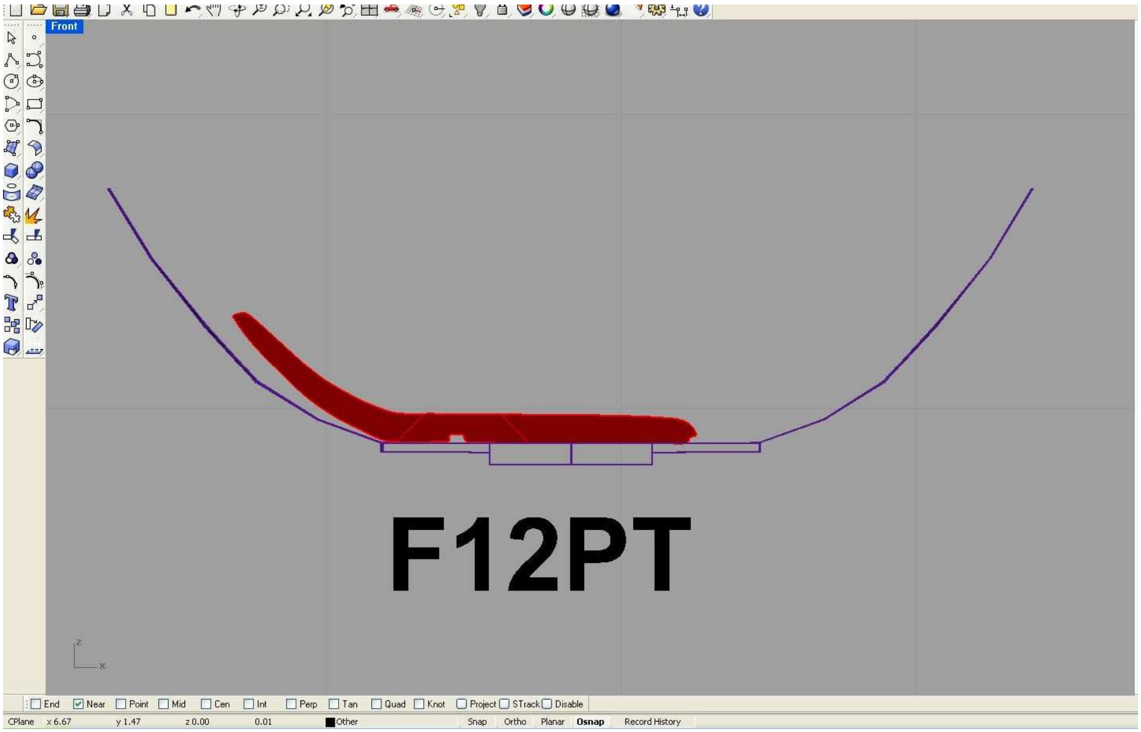

Figure 3. Modelled archaeological timbers (red) inside published theoretical reconstruction lines (purple). **Source:** Adolfo Miguel Martins

The archaeological timber F12PT is tighter than the reconstruction drawing, leading to the conclusion that the reconstructed hull form of Barland's Farm is potentially problematic, and does not follow what one would expect.

A new question arose from this finding, is there a mistake in the method of thinking for the modelling of the Barland's Farm timbers? The original 1:10 scale model used to create the published Barland's Farm reconstruction was laser scanned using a Faro ScanArm and compared to the modelled archaeological timbers created using published scale drawings. The results demonstrate that the method of modelling the timbers is sound and accurate, meaning the problematic result in the above illustration is indeed from the reconstruction lines and not the methodology.

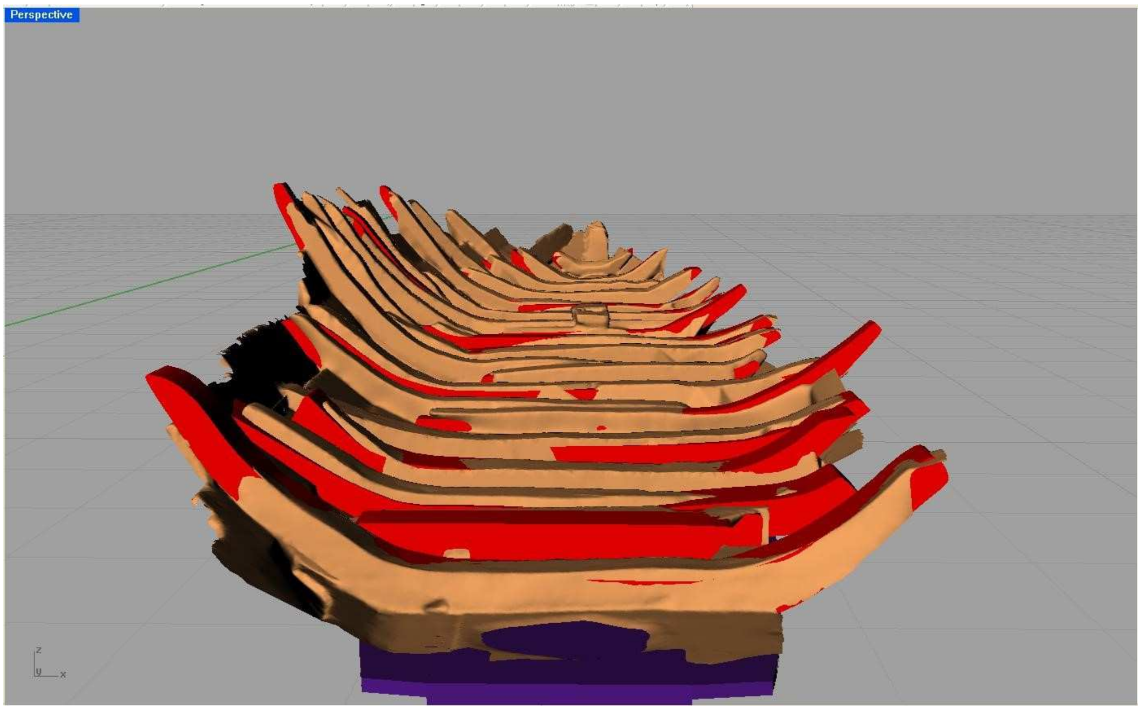

Figure 4. Reconstructed timber (Red) with Laser Scanned research model (Brown). **Source:** Adolfo Miguel Martins

10. Brief Case Study Conclusions

There are pros and cons to working in Rhino to re-examine archival archaeological information. Rhino allows the user to layer multiple data sets atop each other, without having to worry about the Rhino objects interacting with each other. It is hyper-accurate and allows the user to re-evaluate previously held conclusions about the archaeological remains. In this case study, Rhino gave further confidence to the reconstructed Graveney Boat hull form proposed in 1978 and shed light on potential problems with the Barland's Farm reconstruction, proposed in 2004 (FENWICK, 1978; NAYLING, McGRAIL, 2004). However, the 3D objects are only as good as the 2D drawings. In nautical archaeology we are often working with complex 3-dimensional objects, and the very act of condensing this information into 2D leads to a loss of data resolution and confidence. One must always keep this in mind when working with either scaled drawings or 2D drawings of complex 3D objects. In this case, the confidence of the 2D drawings were strengthened by a laser scan of a 3D research model, which confirmed our interpretation of the 2D drawings.

11. Conclusions

Digital recording, following clear and published methodologies, can allow the capture of high-resolution initial data of archaeological objects. This data can later be simplified for traditional publications, but it allows the researcher to ask a wide range of questions that previously could not be answered by employing traditional methods. By keeping complex 3-dimensional objects in 3D by recording them with digitisers, we now have the most accurate representation of the artefacts. That is not to say that these techniques are only good for 3D data. Using digital programs can also allow a fresh approach to re-examining traditional 2D data, allowing us to re-examine previously held beliefs and views of archaeological finds.

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