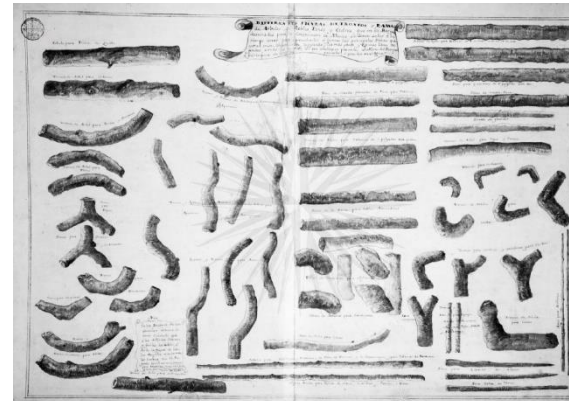
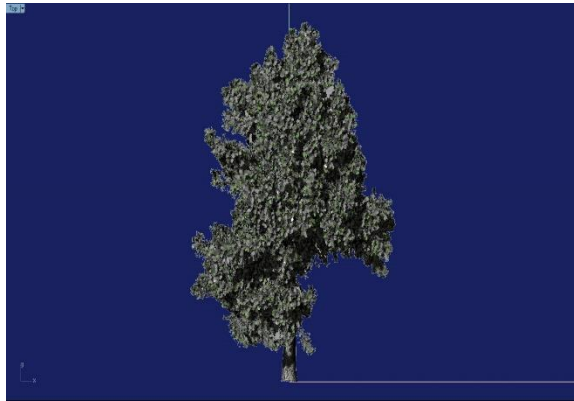
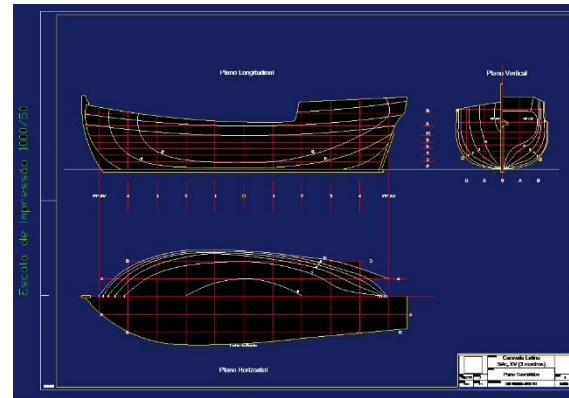
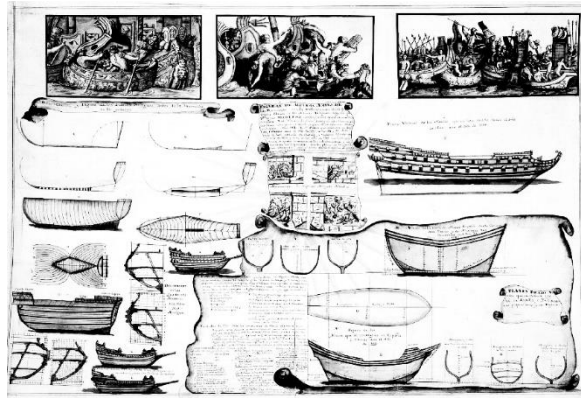


Engineering and reverse-engineering in wooden shipbuilding: The analysis of data collected from archives and seabed using a 3D CAD approach

Author: Adolfo Martins FSD – WP2 – ESR6.



ForSEAdiscovery Project
(PITN-GA-2013-607545)



ForSEAdiscovery Project network meeting 27th of May 2016
at UWTSO Lampeter Campus, Wales

ForSEAdiscovery Project

ForSEAdiscovery Project
(PITN-GA-2013-607545)



Aims
to reconstruct past
forestry management
and timber trade for
shipbuilding in the
Iberian Peninsula -
16th to 18th centuries

Engineering and reverse-engineering in wooden shipbuilding: The analysis of data collected from archives and seabed using a 3D CAD approach

Individual Project aims:

- **Aims:**
 - Model and **reconstruct parent tree forms** for each ship timber.
 - Develop **suitable methodologies based on 3D CAD** through an international and interdisciplinary approach.
- **Objectives:**
 - **Develop timber and shipwreck recording and analysis methodologies.**
 - **Exploring** historic timber supply and forest management in the Iberian Age of Discoveries.
- **Methodologies:**
 - Faro Arm **digital measuring technology.**
 - Rhino engineering **3D modelling software.**

Keywords: Maritime archaeology, dendrochronology, multidisciplinary, computing, shipbuilding.

Engineering and reverse-engineering in wooden shipbuilding: The analysis of data collected from archives and seabed using a 3D CAD approach

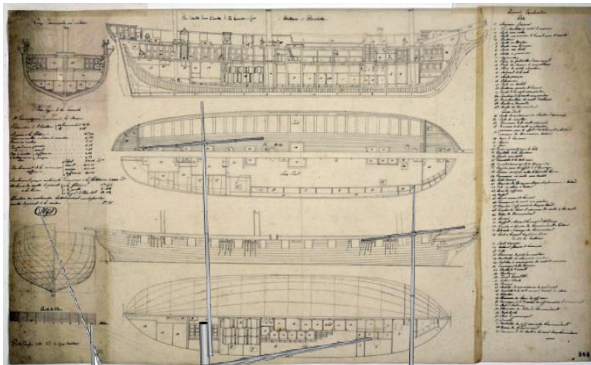
Individual Project, research question

**How can we see
trees in timbers?**

Engineering and reverse-engineering in wooden shipbuilding

Archive Collected Data

**Analysing the ship remains
based on the known archive
data**

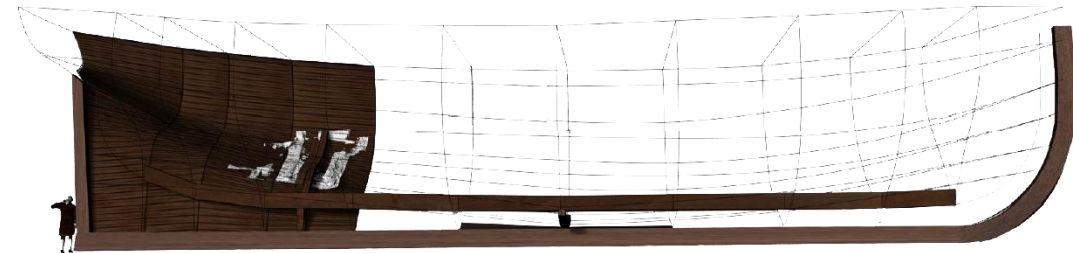


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Archaeological Evidence

**Analysing the ship remains
based on archaeological
evidence**



A wooden ship was, in reality, far more than a lifeless structure. It began as a desire for profit, a hope for victory, or a dream of exploration or conquest in the minds of its originators. The idea moved to the shipyard, where the efforts of ship-wrights, carpenters, and smiths ... (Steffy: 1994, 5)



Multi purpose ships

Suitable hull structure



A wooden ship was, in reality, far more than a lifeless structure. It began as a desire for profit, a hope for victory, or a dream of exploration or conquest in the minds of its originators. The idea moved to the shipyard, where the efforts of ship-wrights, carpenters, and smiths ... (Steffy: 1994, 5)

Hull structure vs ship purpose



A wooden ship was, in reality, far more than a lifeless structure. It began as a desire for profit, a hope for victory, or a dream of exploration or conquest in the minds of its originators. The idea moved to the shipyard, where the efforts of ship-wrights, carpenters, and smiths ... (Steffy: 1994, 5)

What carpenters did want from trees?

"(...) A layer of alburnum is deposited each year, the process of transformation of it into perfect wood, otherwise heartwood, is slow and consequently the alburnum or sapwood comprehends many annual layers." This "(...) become more dense as the tree grows aged and when there is a great number in a tree of small diameter the wood is heavy and generally hard also." (Desmond: 1919, 8)

"The size and fine growth of a tree is not an infallible sign of goodness of quality in the wood. The connection of the age of a tree with its development and the nature of the soil in which it grew, ought to be inquired into to enable a judgment to be formed of the quality of the wood." (Desmond: 1919, 8)

"The oak, for example, raised in a humid soil, is more proper for the works of the cabinet-maker than for those of the ship-carpenter; because it is less strong and stiff, and is softer and more easy to work than the same wood raised in a dry soil and elevated situation: it is also less liable to cleave and split. Its strength, compared with that raised in a drier soil, is about as 4 to 5, and its specific gravity as 5 to 7." (Desmond: 1919, 9)

"Wet lands are only proper for alders, poplars, cypress, and willows. Several other species incline to land which is moist or wholly wet; but the oak, the chestnut, the elm, thrive only in dry situations, where the soil is good, and where the water does not stagnate after rain, but is retained only in sufficient quantity to enable the ground to furnish aliment for the vegetation." (Desmond: 1919, 8)

"(...) trees which grow in poor and stony soils, and generally in all such soils as oppose the spreading of their roots, and do not furnish a supply of their proper sap, are slow and stunted in their growth, and produce wood often knotty and difficult to work, and which is mostly used as veneers for ornamenting furniture." (Desmond: 1919, 8)

"Knotty and cross-grained wood is difficult to work and should be rejected especially for use in pieces subjected to great strains. The knots are always a source of weakness because the straightness of fibres which gives strength is interrupted." (Desmond: 1919, 8)

"Timber used for ship-building should be free from cracks radiating from the centre (called "clefts"), from cracks which partially separate the layers (called shakes), and from sap-wood (the light-coloured wood nearest the bark), and should be properly and thoroughly air seasoned." (Desmond: 1919, 9)

In search for perfection

What carpenters did want from trees?

“Perfect wood - more dense.” (Desmond: 1919, 8)

“Fine growth of a tree is not an infallible sign of goodness of quality in the wood.” (Desmond: 1919, 8)

“The oak, raised in a humid soil, is more proper for the works of the cabinet-maker than for those of the ship-carpenter; same wood raised in a dry soil and elevated situation: it is also less liable to cleave and split. Its strength, compared with that raised in a drier soil.” (Desmond: 1919, 9)

“*Wet lands are only proper for alders, poplars, cypress, and willows. but the oak, the chestnut, the elm, thrive only in dry situations, where the soil is good, and where the water does not stagnate after rain*” (Desmond: 1919, 8)

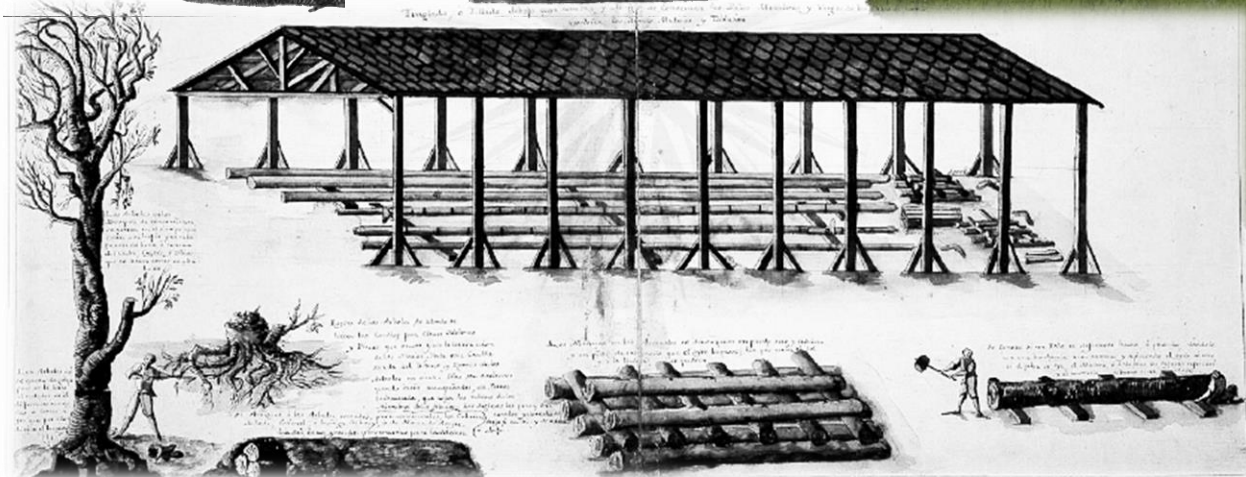
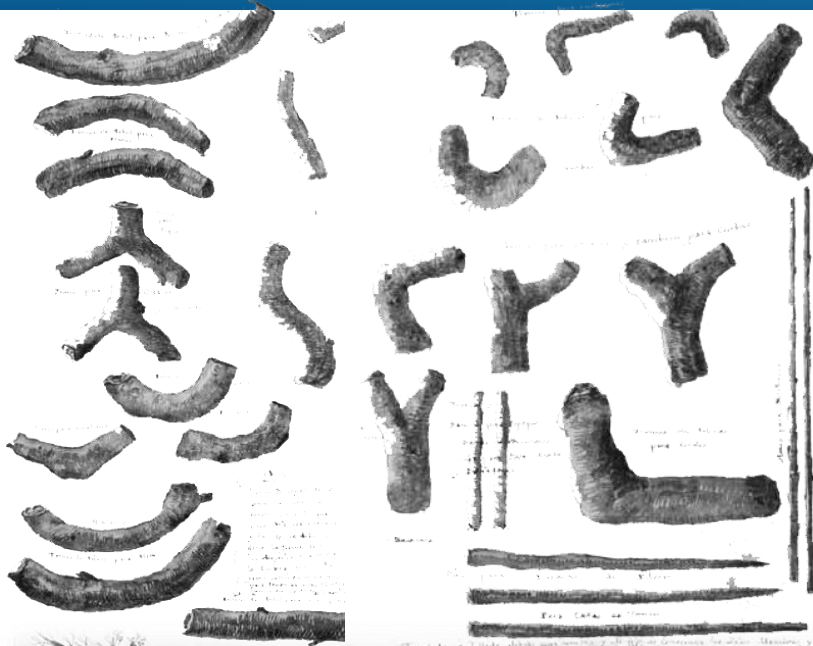
“Trees which grow in poor and stony soils are slow and stunted in their growth produce wood often knotty and difficult to work” (Desmond: 1919, 8)

“Knotty and cross-grained wood is difficult to work and should be rejected. The knots are always a source of weakness because the *straightness of fibres.*” (Desmond:1919,8)

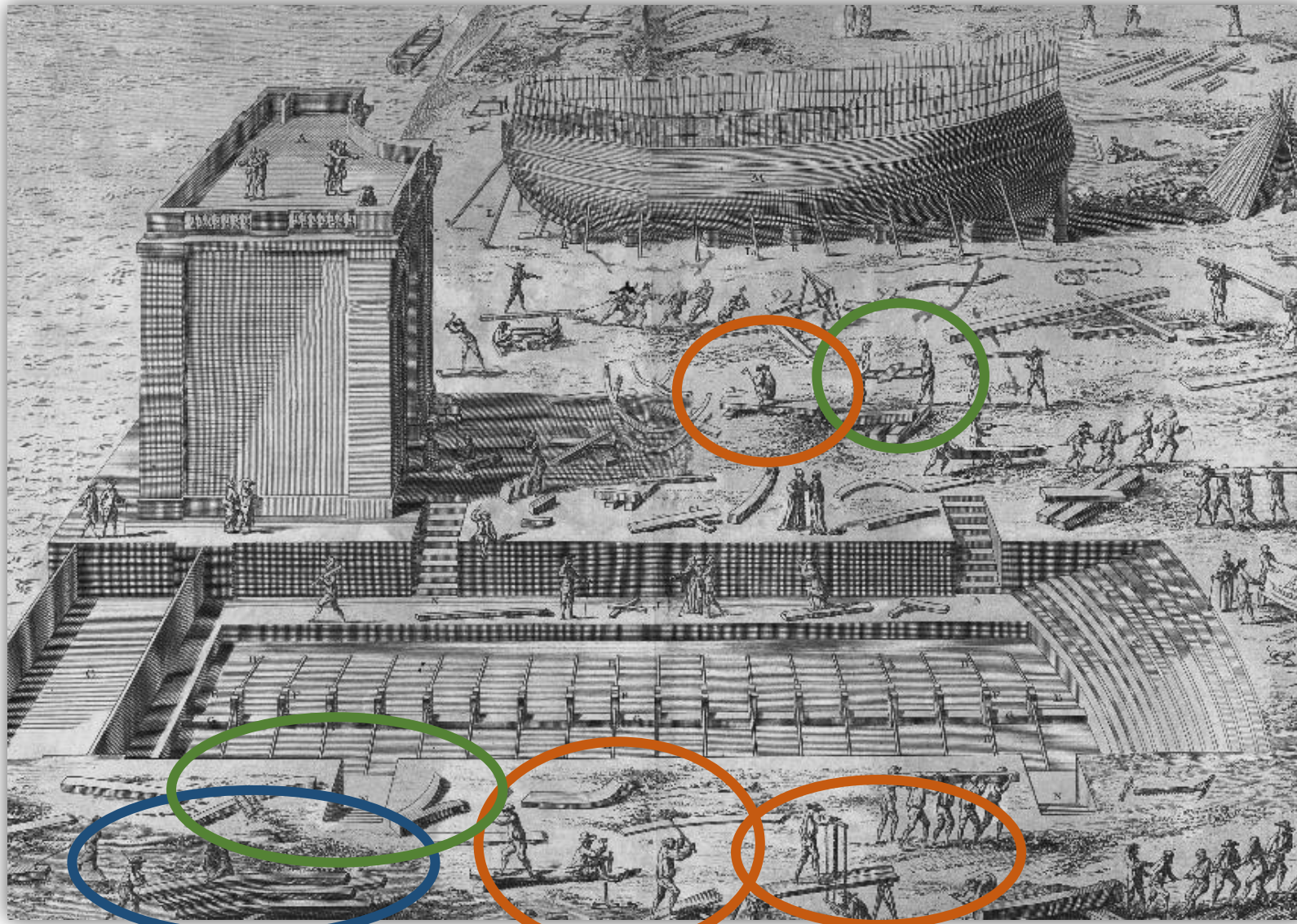
“Timber used for ship-building should be free from cracks radiating from the centre from cracks which partially separate the layers (called shakes), and from sap-wood and should be properly and thoroughly air seasoned.” (Desmond: 1919, 9)

In search for suitable shapes

Tree shapes & forest management

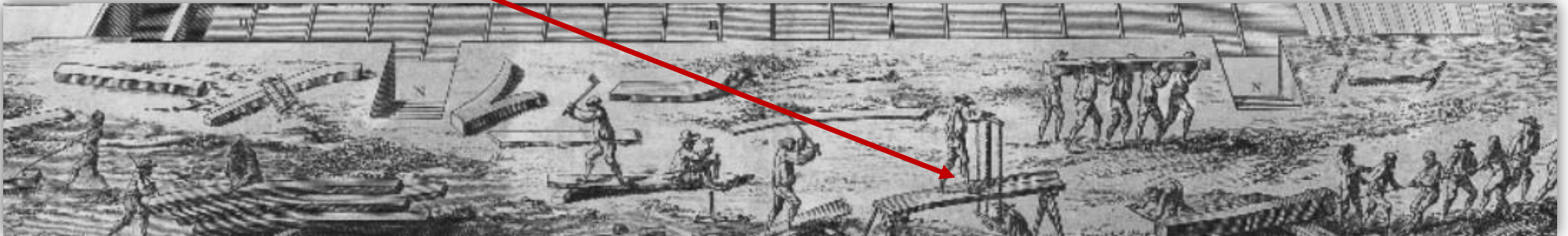
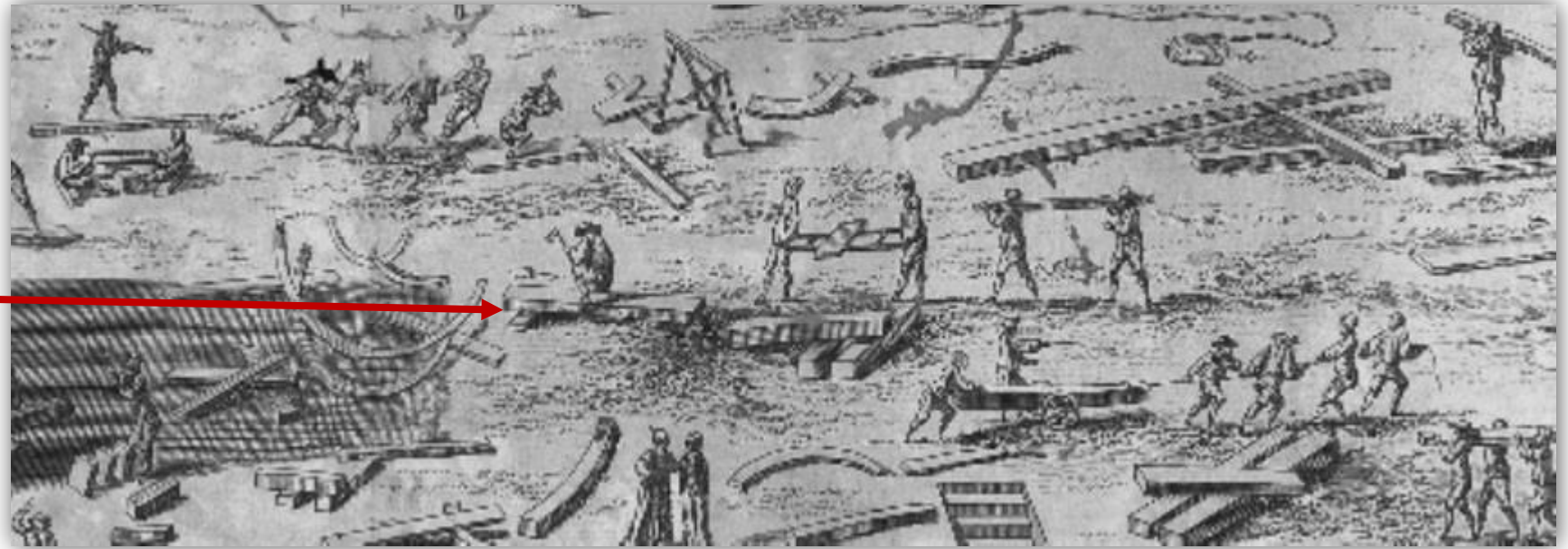
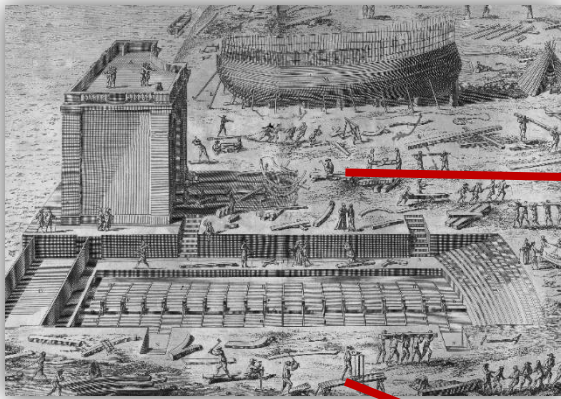


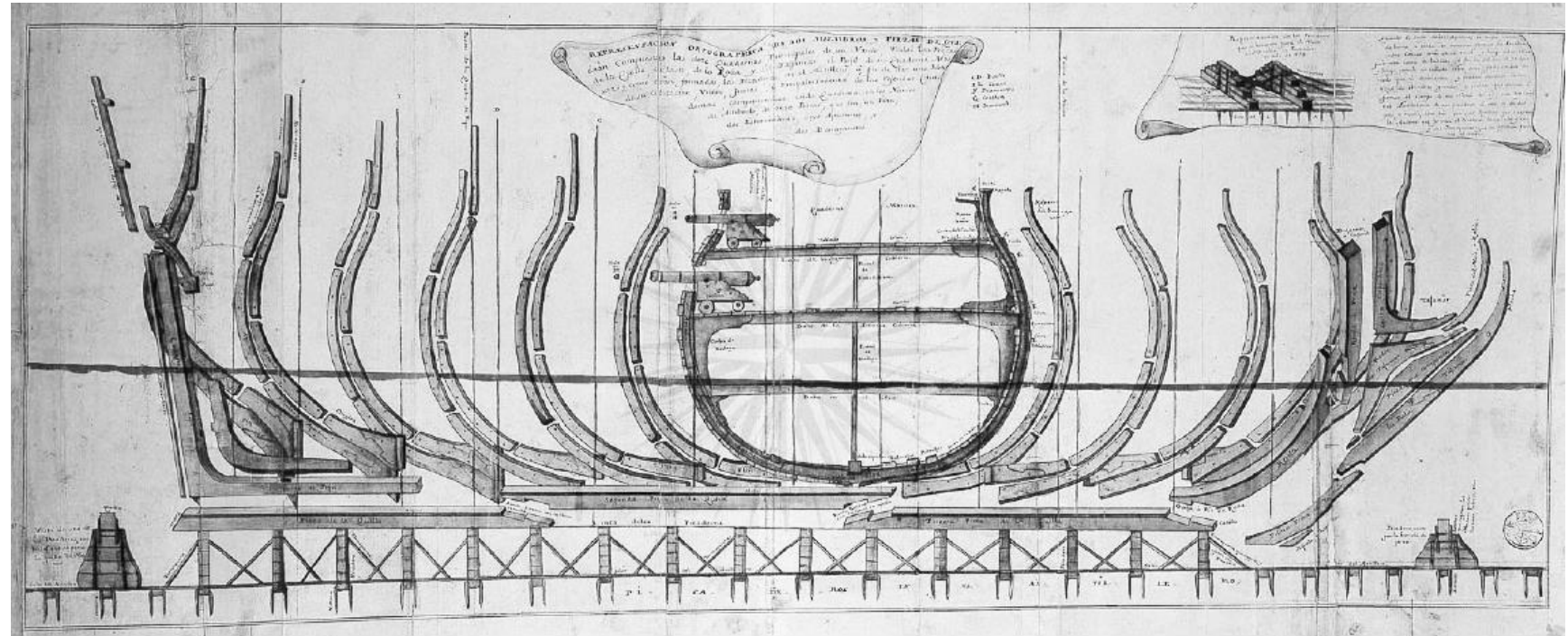
Moving to the shipyard



Royal Navy shipyard Lisbon 1763-1821 (unknown author)

Timber storage, shaping and moulding

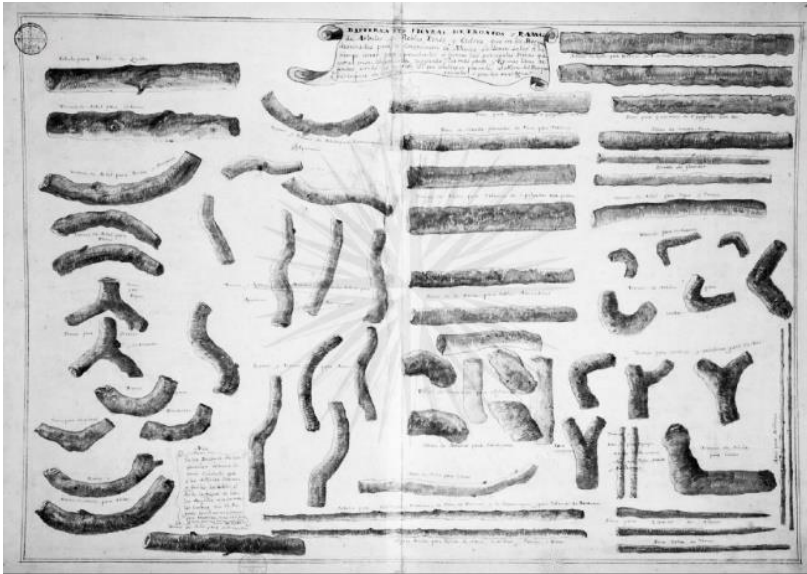




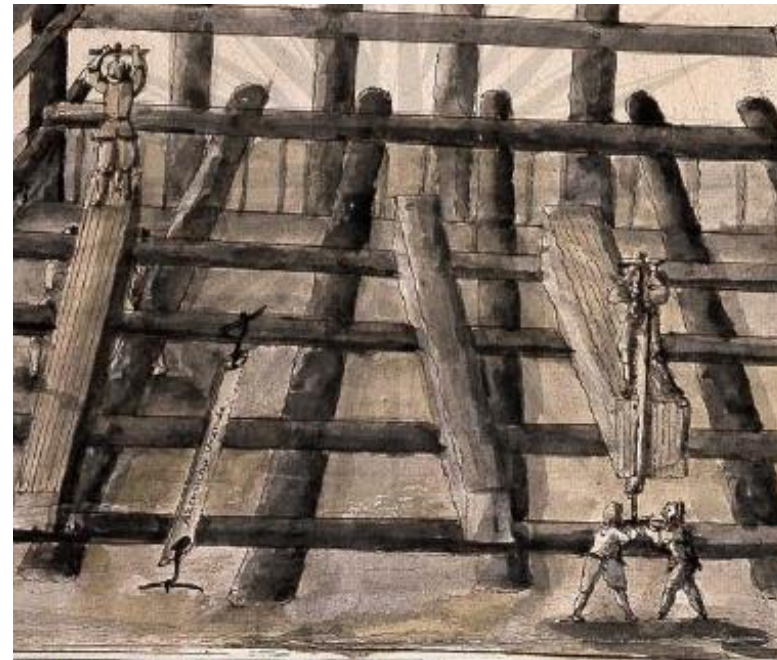
As Schweingruber (1998, 6) has said “A tree is a stationary living thing. Its crown, trunk and roots are capable of receiving to environmental factors: some parts of the tree receive signals from the surrounding while others react to them. (...) This ability to integrate is reflected in many different kinds of tree characteristics, such as geographical distribution, tree crown and tree rings. In the course of evolution plants have developed on every site, being best adapted to the particular conditions obtaining there”.

Timber storage, shaping and moulding

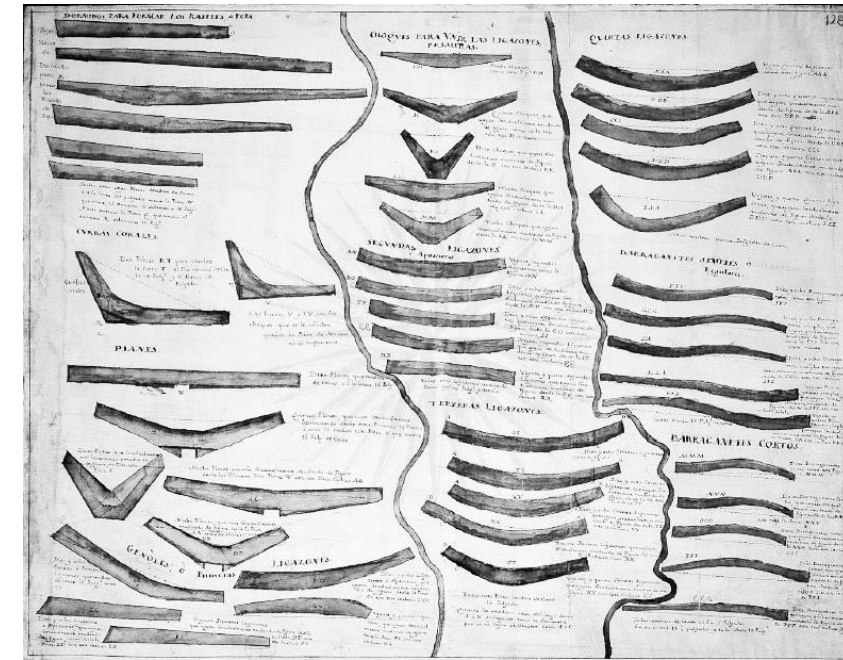
Needed shapes



Converting trees into timbers



Ship timbers



Storage

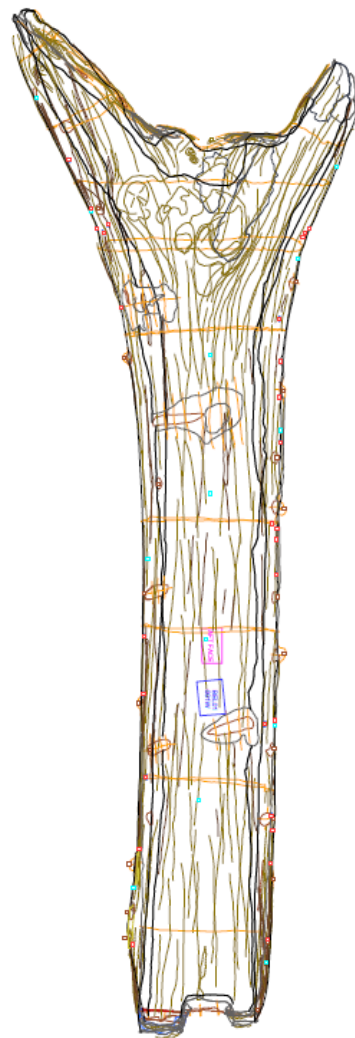


Going in Reverse ...



Archaeological evidence

BELO1_001W



3D non-contact tracing

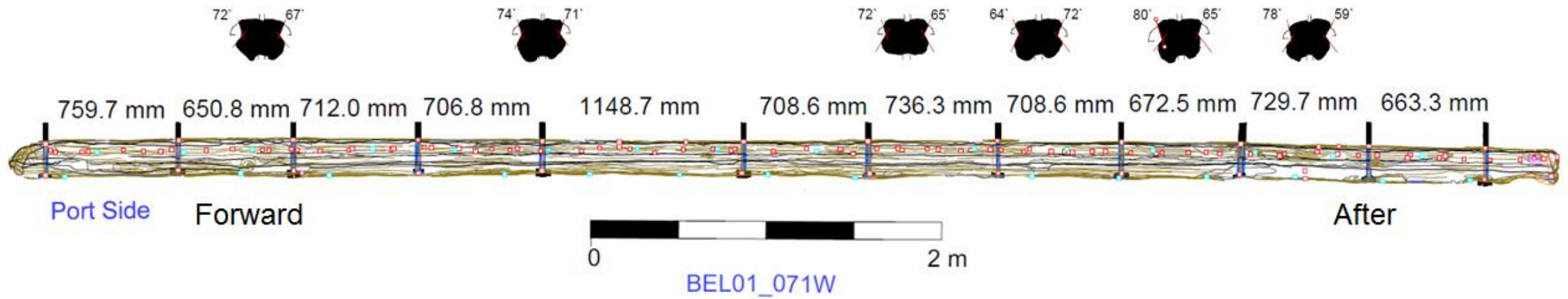


3D Tree reconstructing

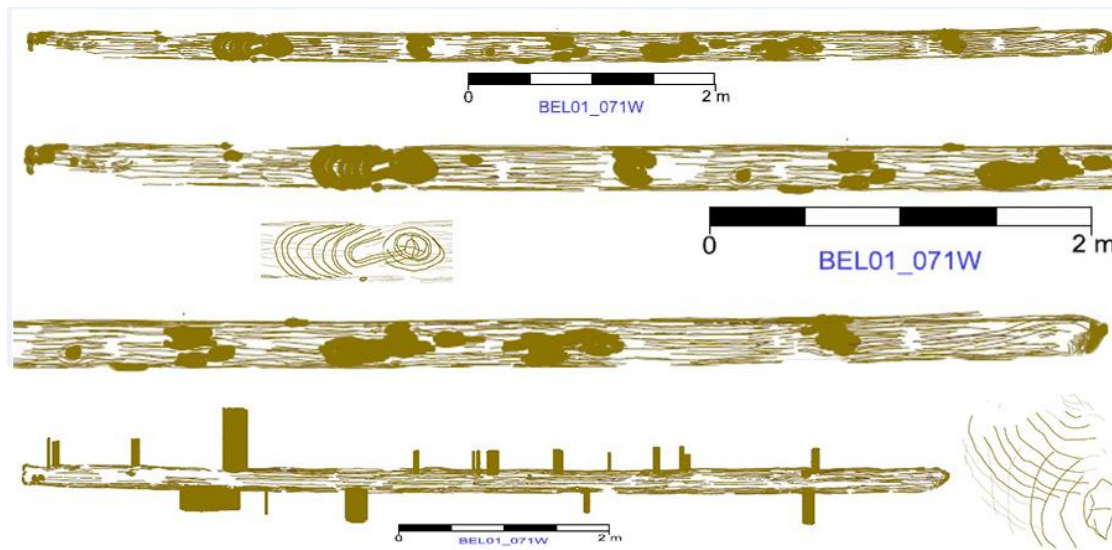


Reconstruction of the tree

Going in Reverse



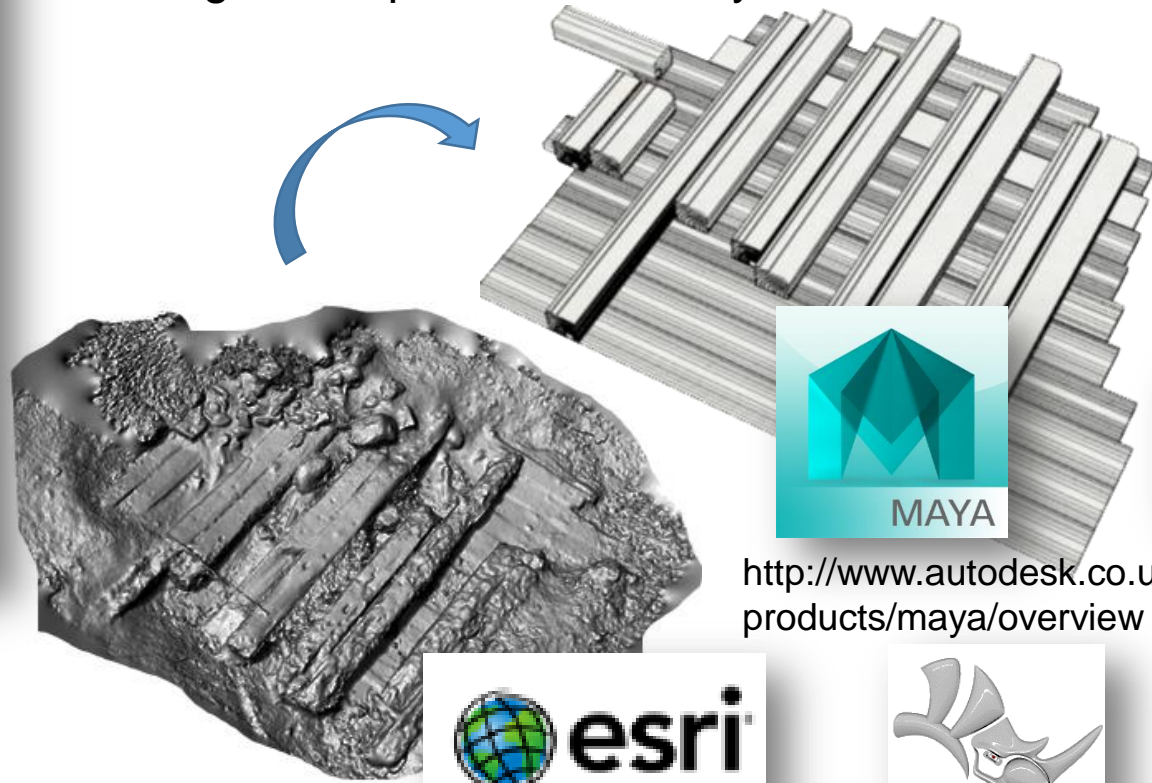
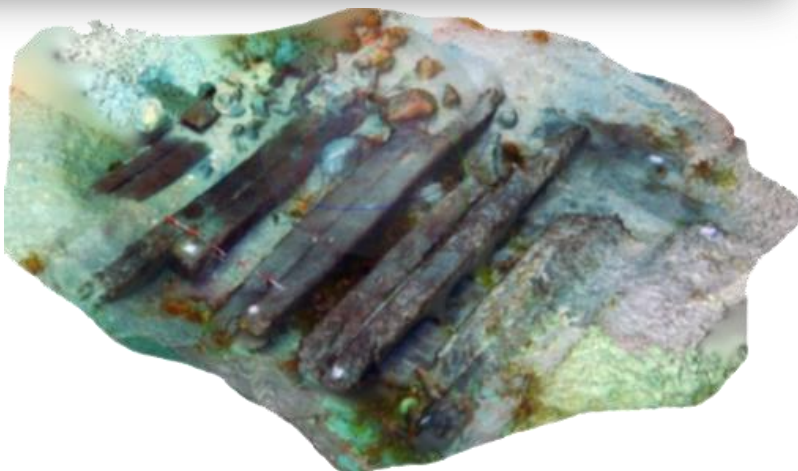
Reconstructing the ship



Reconstruction of the tree

Usage of multiple software

Recording techniques & data analysis



FaroArm
<http://www.faro.com/home>



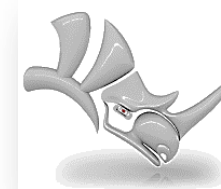
<http://www.autodesk.co.uk/products/maya/overview>



Sketchfab
<https://sketchfab.com/>



ESRI ARGIS
<https://www.esri.com/>



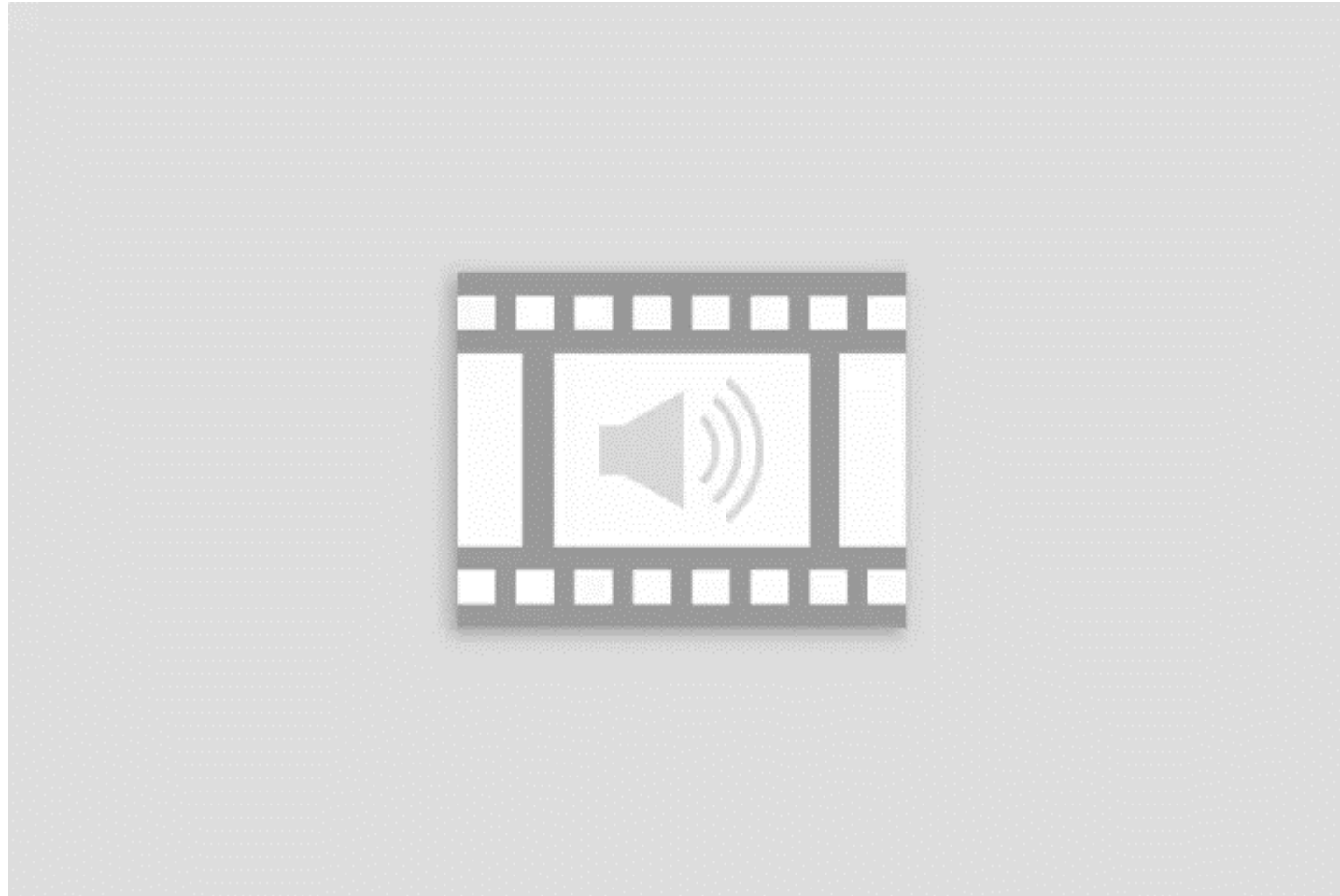
Rhinoceros 4.0 / 5.0
<http://www.rhino3d.com/>



Agisoft photoscan
<http://www.agisoft.com/>

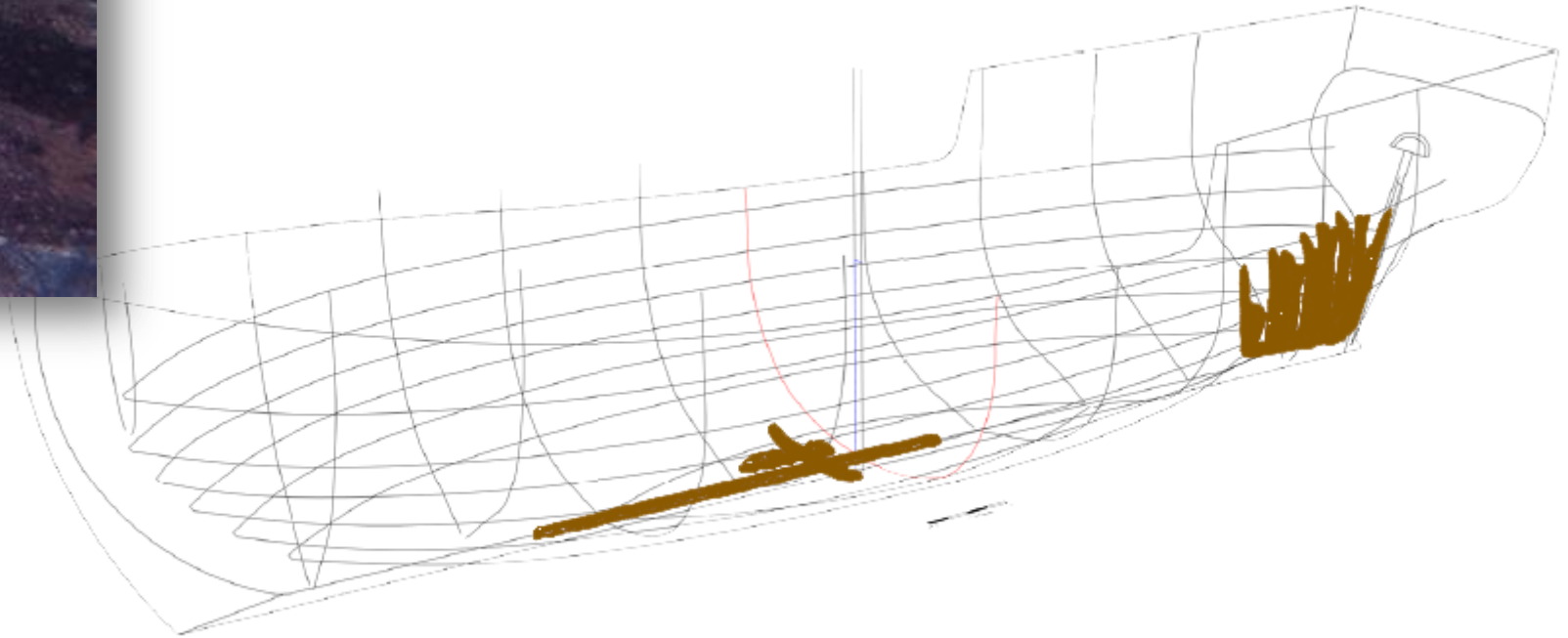
Usage of multiple software

Recording techniques & data analysis



Definition & concepts

Recording techniques & data analysis



Depende!!!
Maybe!!!

Is Belinho 01 an Iberian ship?

Recording techniques & data analysis

Iberian Shipbuilding?!!!!

Characteristics of 16th-century Shipwrecks Defining the Atlantic Vessel.

	RYE	SJ	PI	HCW	MRW	CW	STB	EPW	RAA	WLW	SJB	AGD	NSM	CDS	CST
1. Pre-assembled central frames, dove-tailed mortises, transverse treenails	-	Y	-	Y	Y	Y	Y ¹	Y	Y	Y	-	Y	Y ¹	Y	-
2. Planking nails: treenails per plank/frame join at midship	0-2	2-2	stern 2-3:0	-	2+2	2:2	2:1-2	2:1	2:1	?	3:2	?	2:0	2:0	stern 2:1
3. Sternpost scarphed to upper arm of keel knee	-	Y	Y	-	-	-	Y	N	Y	Y	-	?	-	-	Y
4. Single stern deadwood knee	-	Y	Y	-	-	-	Y	Y	Y	Y	-	?	-	-	Y
5. Y-timbers tabbed to deadwood	-	Y	Y	-	-	-	N	Y	N ⁴	Y	N	Y	-	-	N ⁴
6. Keelson notched over floor timbers	Y	Y	-	Y	-	Y	?	Y	Y	Y	-	Y	-	-	-
7. Mast step is expanded part of the keelson	Y	Y	-	Y	-	Y	?	Y	Y	Y	-	Y	-	-	-
8. Buttresses and stringers	Y	Y	-	Y	-	N	?	Y ⁵	Y ⁴	Y ⁴	-	Y	-	Y	-
9. Ceiling and filler planks	Y	Y	-	Y	Y	Y	Y	Y	N	Y/?	-	Y	-	Y	-
10. Rigging chain assemblies	-	Y	Y	Y	Y	-	Y	?	N	?	Y	-	N	N	-
11. Flat transom, sternpost proud of transom	-	Y	Y	-	Y	-	Y/?	N	N	Y	-	Y	-	-	N
12. Carved garboard	-	Y ⁶	Y	-	-	N	N	-	N	?	-	?	N	-	Y ⁶

IDENTIFICATION KEY:

- Information not available. That portion of the wreck was either not found or not preserved.
- ? Information was not recorded, but could be recovered at a later time.
- RYE Vessel A, Rye, Sussex, England.
- SJ The San Juan, Basque whaler at Red Bay, Labrador, Canada.
- PI The San Esteban of the 1554 New Spain Fleet, Padre Island, Texas.

- HCW The Highborn Cay wreck, Exumas Islands, Bahamas, BWI.
- MRW The Molasses Reef wreck, Turks & Caicos Islands
- CW The Cattewater wreck, Plymouth, England.
- STB The Studland Bay wreck, Poole, England.
- EPW The Emanuel Point wreck, Pensacola Bay, Fla.

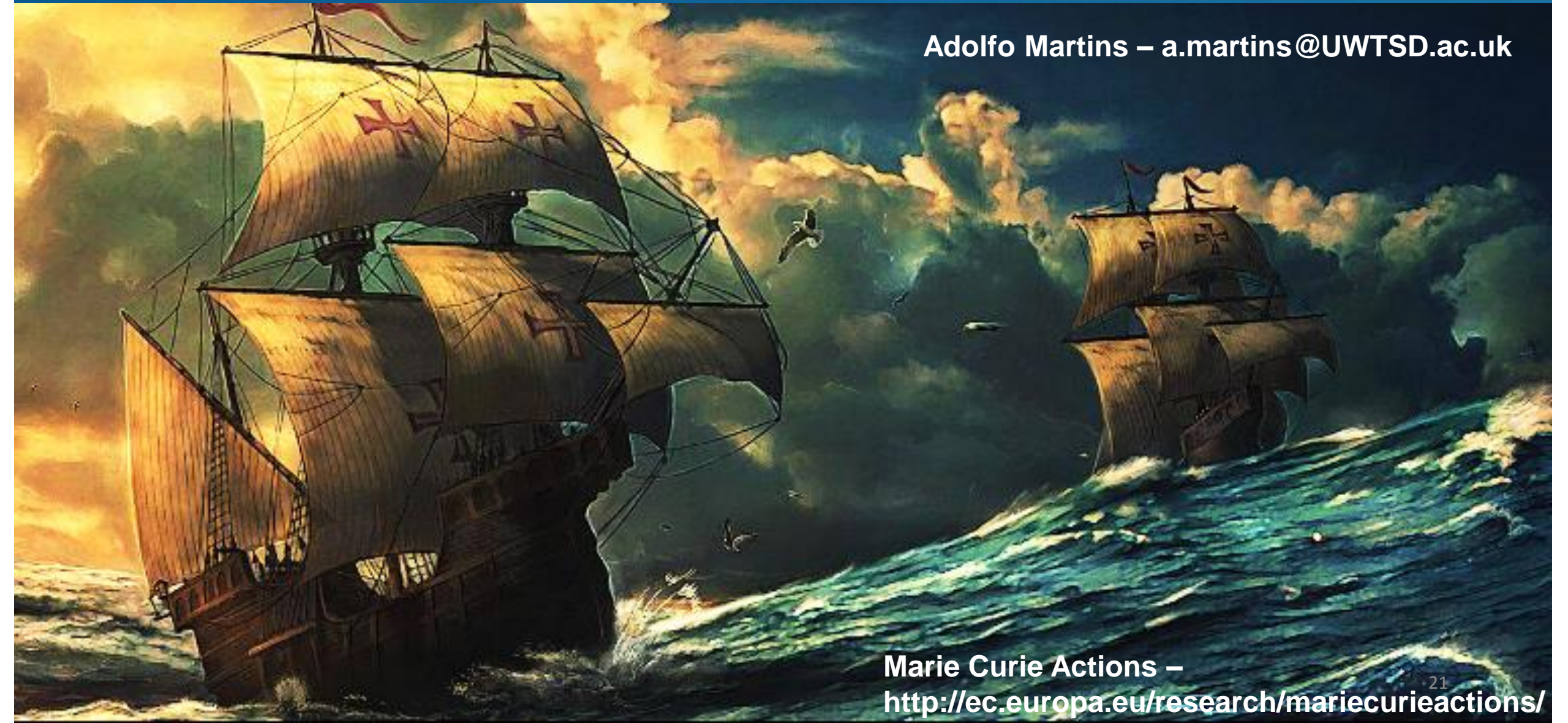
- RAA The Ria de Aveiro wreck, Portugal.
- WLW The Western Ledge wreck, Bermuda
- SJB The St. John's Bahamas wreck, Bahamas, BWI.
- AGD The Angra D wreck, Azores.
- NSM The Nossa Senhora dos Mártires
- CDS The Cais do Sodré wreck, Lisbon, Portugal
- CST The Corpo Santo wreck, Lisbon, Portugal

- 1 Although not dove-tailed, the floor and futtock are scarphed together and fastened transversely.
- 2 The San Juan possessed an unusual carved keel which was "T"-shaped at midship and "V"-shaped at its ends (Waddell, 1986: 139) obviating the need for a garboard.
- 3 The mortises in this case are not dove-tailed, but square with male and female on each timber.
- 4 There are no tabs. The frames are toe-nailed into the deadwood.
- 5 In these cases the buttresses do not touch the stringers.
- 6 The garboard has a carved top internal edge (Francisco Alves, pers. com. 2/10/99).

Oertling (2001, 234).

Thanks for Your attention

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<http://ec.europa.eu/research/mariecurieactions/>