

# The use of high-resolution 3D Chirp for the reconstruction of a shallow archaeological wreck site: the Grace Dieu

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## 1. Introduction

Why are geophysical/acoustic methods the way forward for archaeological underwater site management?

- 1) Economically cost-effective: rapid and inexpensive.
- 2) Some sites are inaccessible to divers or have unfavourable excavation circumstances.
- 3) Leaves potential sites undisturbed: non-destructive.

This poster will discuss a seamless intermeshing of data from a shallowly buried shipwreck, Henry V's the *Grace Dieu* (1418). It was the largest ship of its time and sunk at its berth in the Hamble River (1439) (Fig. 1).

Although this wreck site has been known since 1850, the first full survey was not completed until the 1990's [1] (Fig. 2a).

Today, the site is covered by 2-5 m of water and is buried beneath a veneer of coarse silt. Only at exceptionally low tides are a few of the marginal timbers exposed.

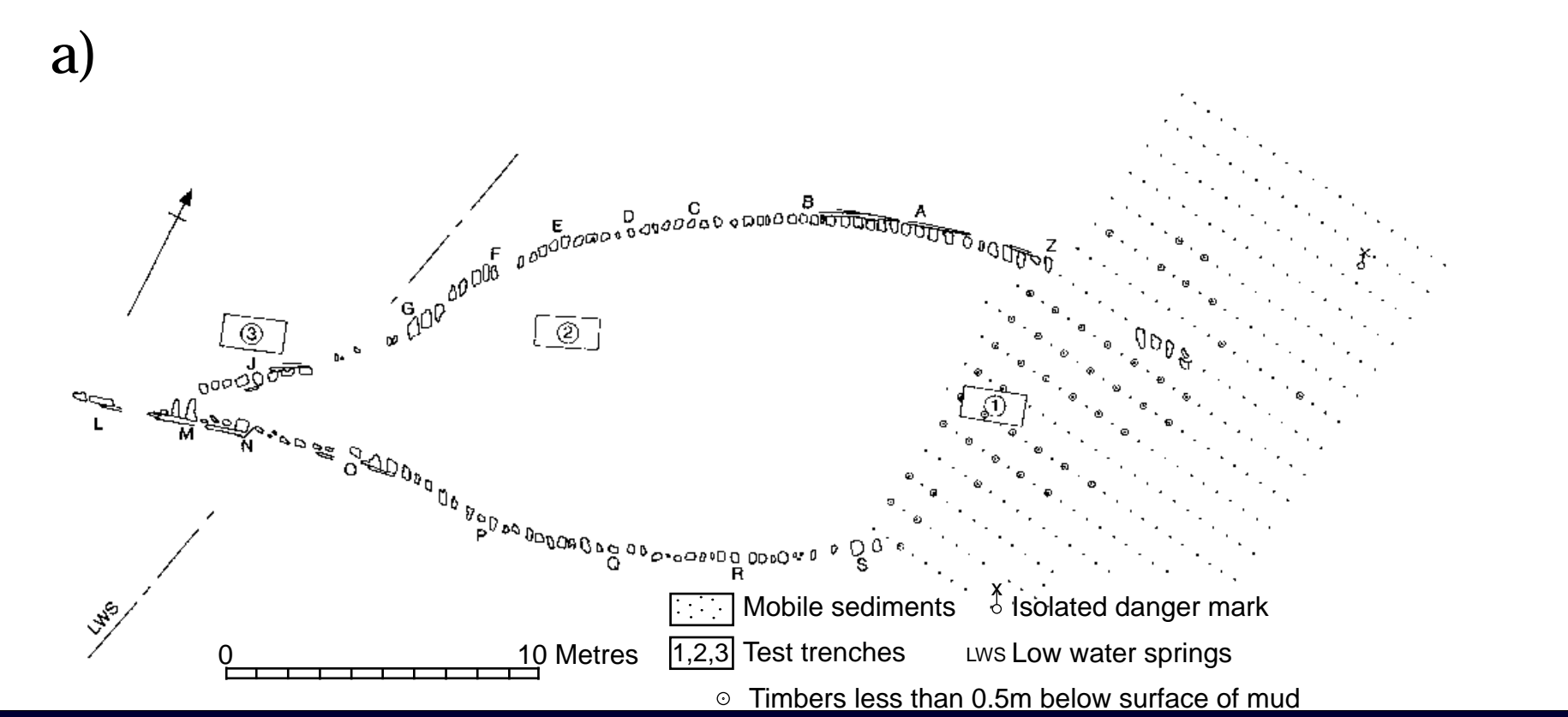


Fig. 1: Reconstruction of the *Grace Dieu*

## 2. Methods

The marine survey utilised a 3D-Chirp system, developed at the National Oceanography Centre in collaboration with GeoAcoustics Ltd, with funding from ISVR, EPSRC, English Heritage and GeoAcoustics Ltd [2].

This system works in a similar way to ultrasound scans used in the medical world, but operates at lower frequencies: the transducers transmit sound which penetrates the seabed, the acoustics waves reflect from buried objects in the sub-surface and these reflected waves are recorded by an array of 60 receiving elements (Fig. 3). In order to obtain accurate positioning information, RTK (Real Time Kinematic) - GPS technology is mounted on the 3D Chirp frame.

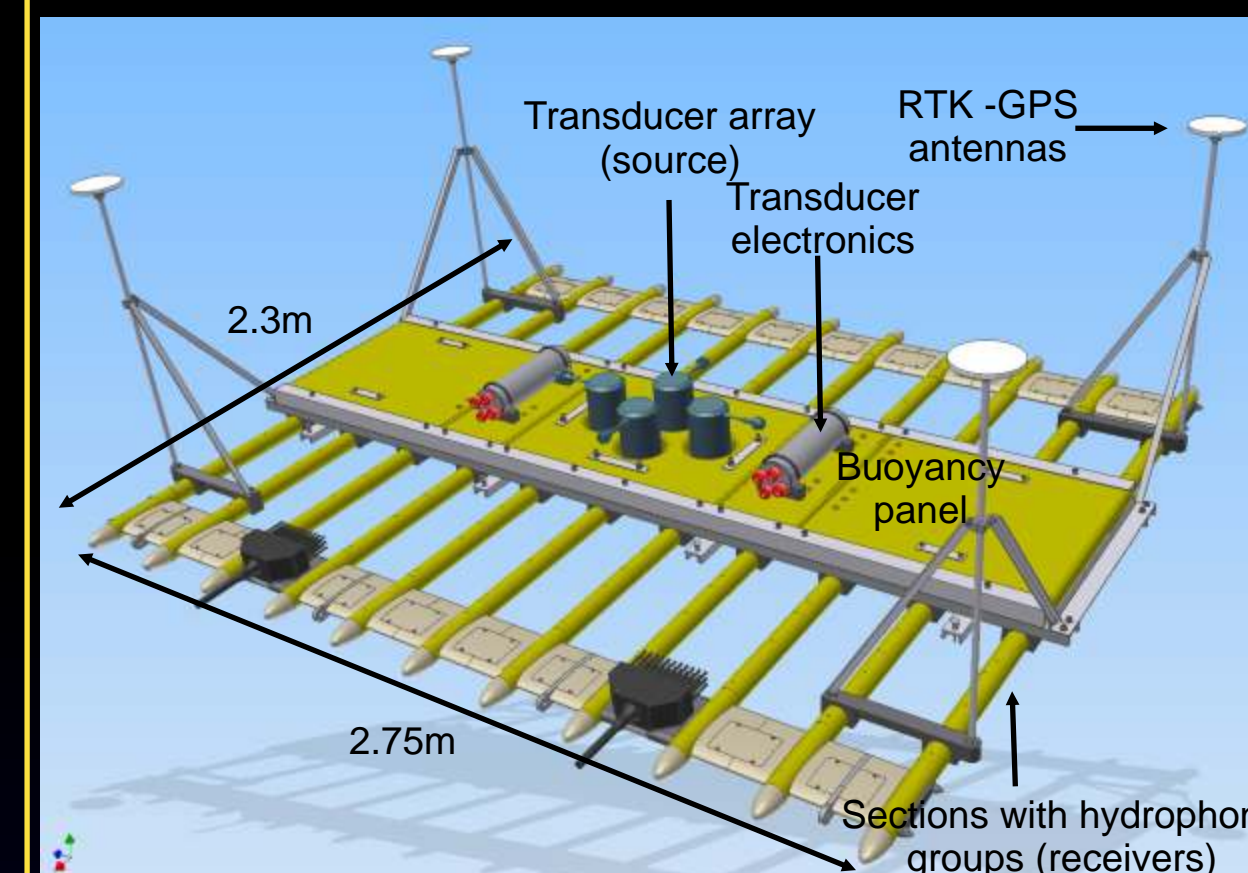


Fig. 3: Design of the 3D high-resolution sub-bottom system.

Fig. 4: Divers pushing the system over the wreck site.

Fig. 5: Terrestrial RTK survey

Shallow water sites present unique challenges to geophysical investigations. One major issue is the creation of bubble clouds by the survey vessel. Therefore, to avoid bubble turbulence in the water column, the traditional surveying method has been adapted by using divers to push the system over the site (Fig. 4).

During the exceptionally low tides of the spring equinox, surviving timbers from the mud were exposed and accessible, and have been surveyed with a terrestrial Real Time Kinematic (RTK) - GPS system (Fig. 5). This provides  $\pm 0.02$  m positioning accuracy of the timbers. This data was used to georectify the scanned image of the extant survey plan [1], and provides an accurate basemap for comparison with marine geophysical data (Fig. 2b)

## 3. Results

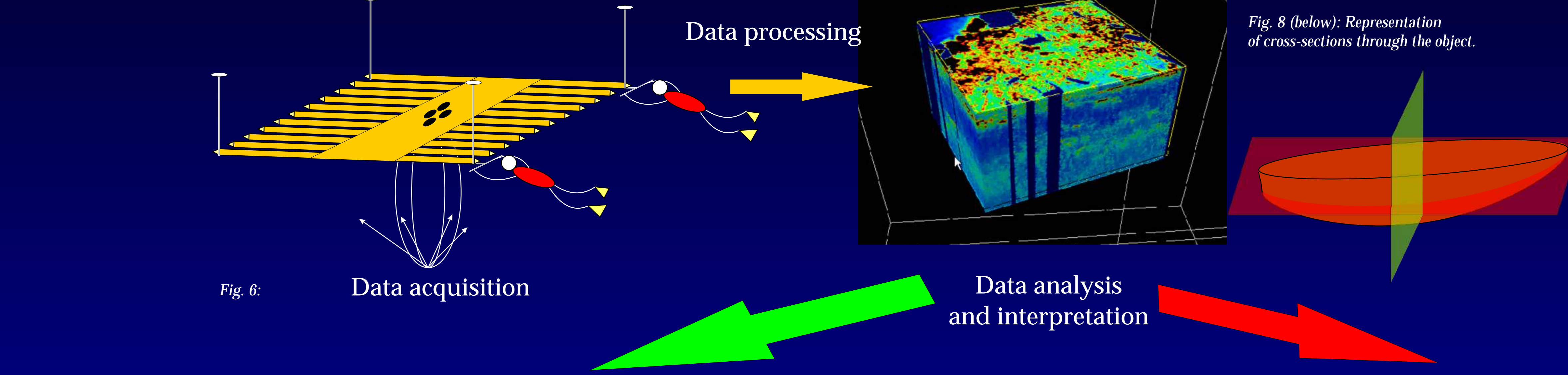


Fig. 7 (left): 3D data volume.

Fig. 8 (below): Representation of cross-sections through the object.

Once the geophysical information has been acquired (Fig. 6), the data is then processed into a 3D data volume (Fig. 7). This 'cube' of data can then be sliced in any orientation, independent of the original survey direction. For the detection of the remains of the hull of the *Grace Dieu*, horizontal and vertical cross-sections have been studied (Fig. 8).

Within the vertical cross-sections (Fig. 9), a high (red and black) amplitude acoustic anomaly, truncating the local geology, is recognisable in the shipwreck zone.

The horizontal cross-sections (Fig. 10a,b,c) illustrate a high amplitude zone with an ovate planform, coincident with the vessel's location. The breadth and width of this outline reduces with depth.

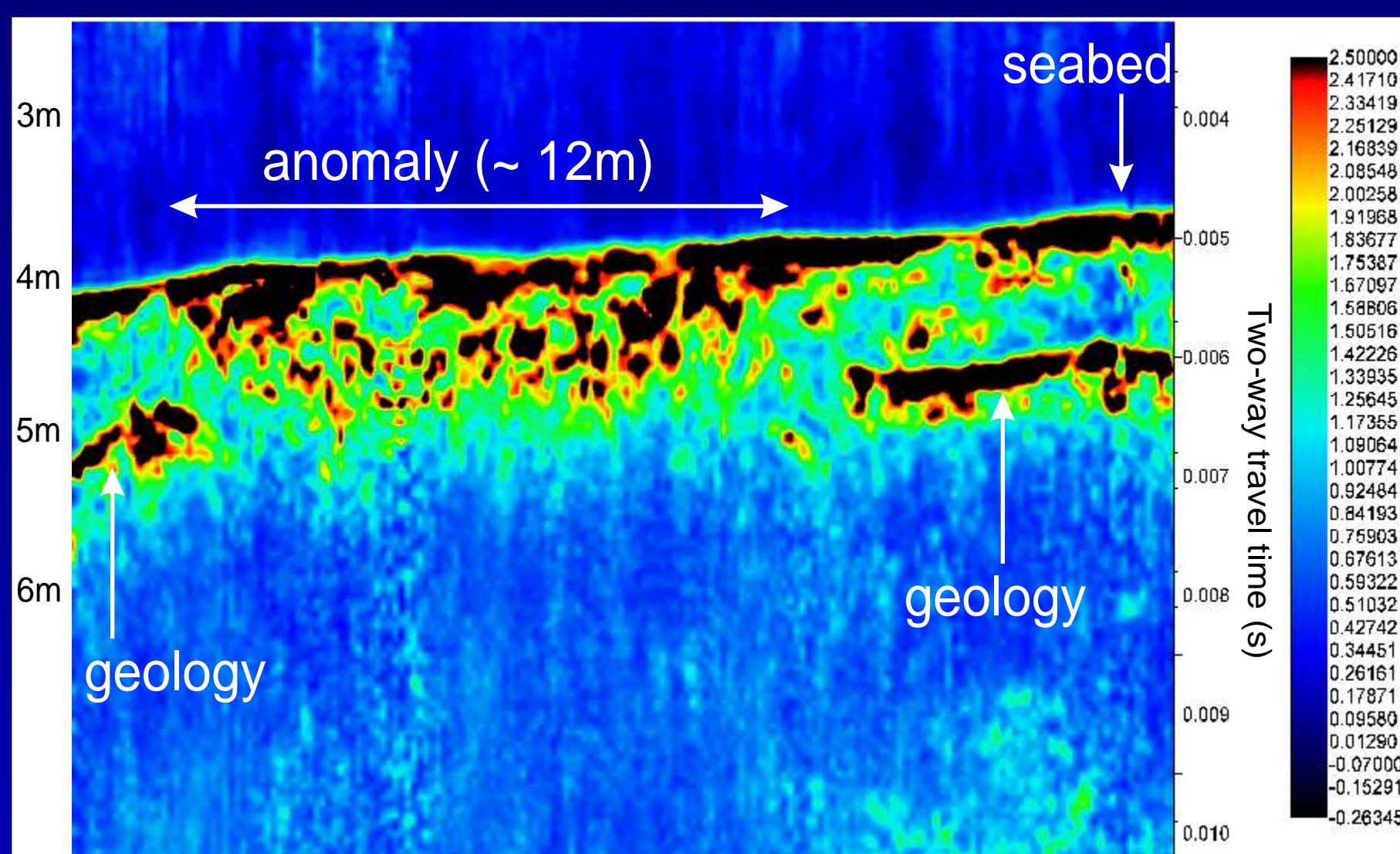


Fig. 9: Typical vertical 3D cross-section.

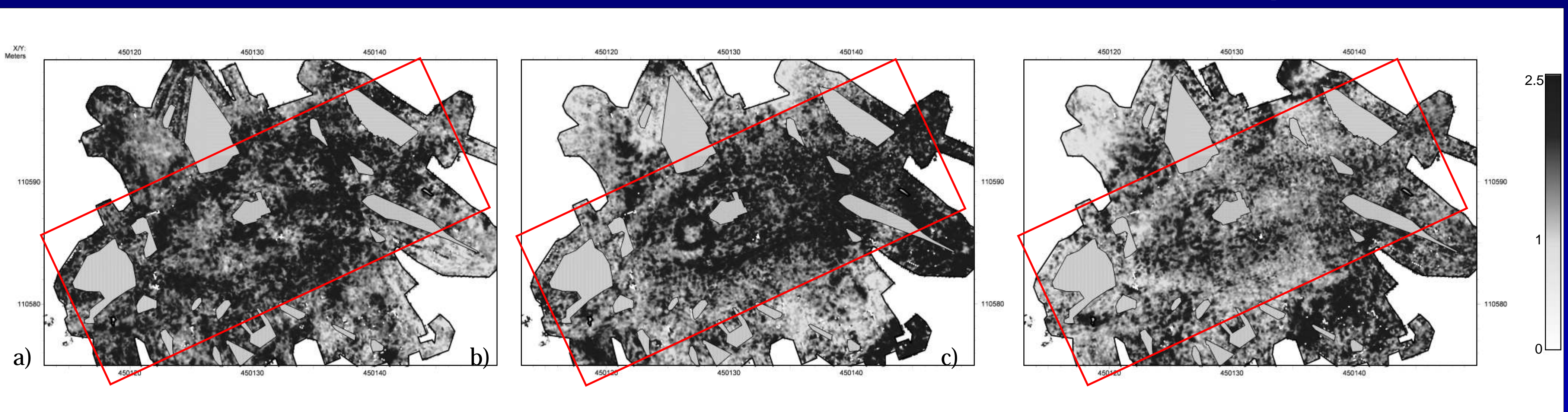
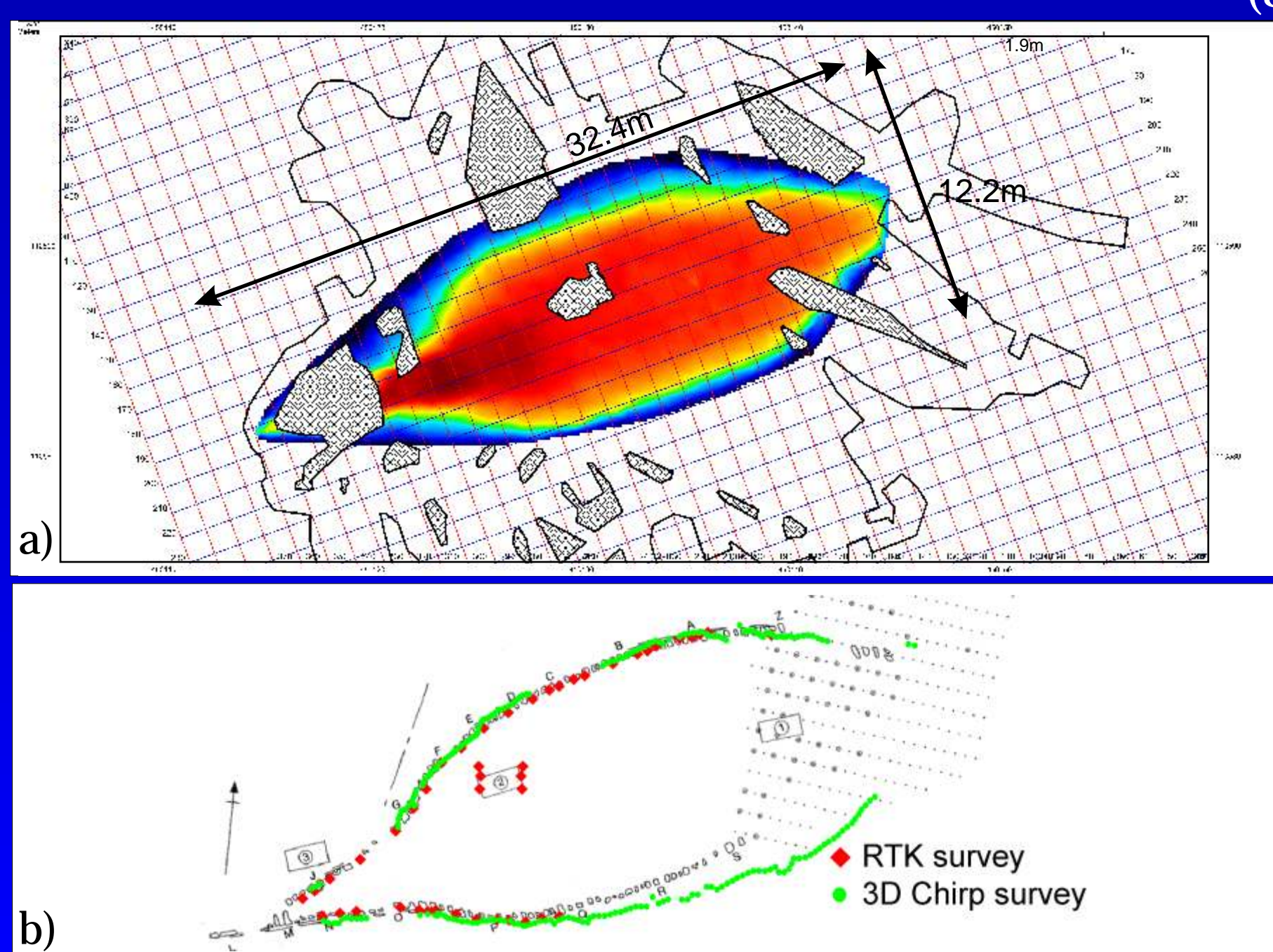


Fig. 10: Horizontal cross-sections a) 0.5 ms (~38 cm), b) 0.9 ms (~68 cm), c) 1.3 ms (~98 cm) TWT beneath the river bed. Red box indicates the area of exposed timbers. Note the square object in Fig. b).



Furthermore, individual objects have been detected; eg. a square feature within the hull (Fig. 10b) which may be related to the position of the mast step. The anomaly was picked manually on each cross-section, the data then being interpolated to create an isopach map (Fig. 11a) and a full 3D image (Fig. 11c&d). The isopach map suggests the remains of 32.4 m x 12.2 m and a max. burial depth of 2 m. Comparison of the anomaly's outline from Chirp data with the RTK survey and published site plan shows good correlation (Fig. 11b).

### (3D) reconstruction

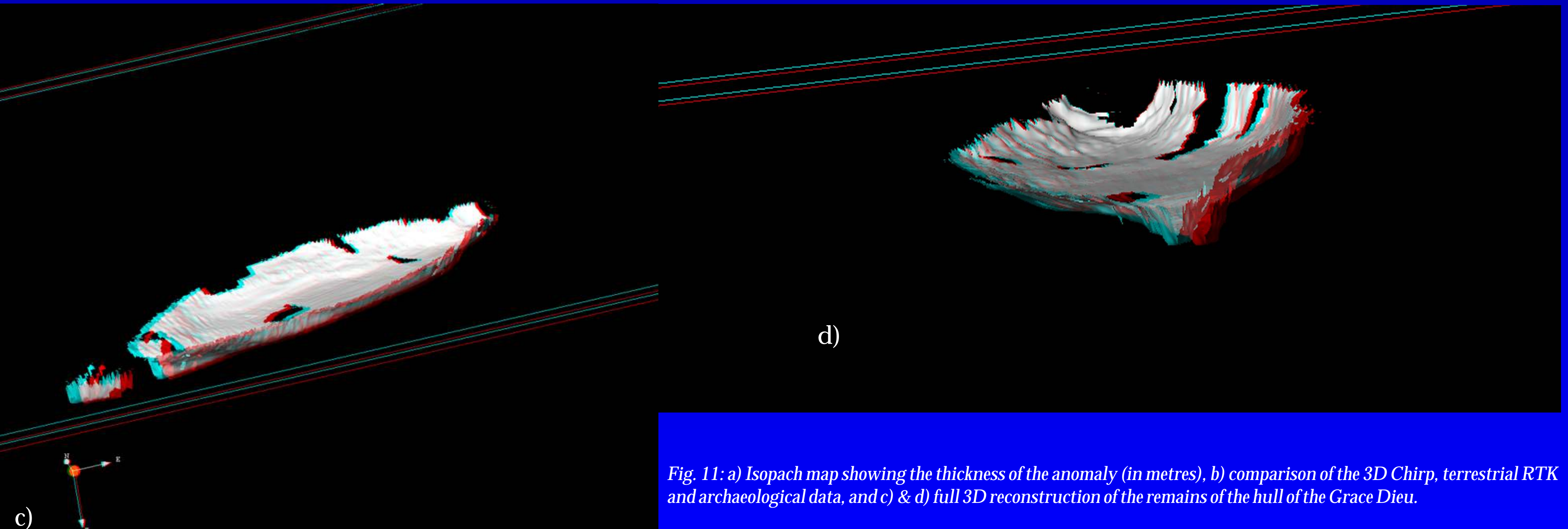


Fig. 12: 3D reconstruction of the *Grace Dieu*

## 4. Conclusions

- For the first time, a full 3D reconstruction of a buried ship wreck has been obtained, without any destructive interference or removing it from its original context.
- Overall, this is a very fast method (2 days of surveying, 2 months of processing) in comparison with traditional archaeological surveys (several years).
- This method is not dependent on visibility within the water.
- Geophysical methods are also very appropriate for investigating and managing larger marine sites (eg. for palaeo-landscape research).

### Acknowledgments

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### References

- [1] Clarke, R., Dean, M., Hutchinson, G., McGrail, S., Squirrel, J., Recent work on the R. Hamble wreck near Bursledon, Hampshire, *International Journal of Nautical Archaeology*, 22, 21-44, 1993.
- [2] Bull, J.M., Gutowski, M., Dix, J.K., Henstock, T.J., Hogarth, P., Leighton, T.G., White, P.R., Design of a 3D Chirp sub-bottom imaging system, *Marine Geophysical Researches*, 26, 157-169, 2005.