

Ultra-high resolution 3D sub-bottom imaging for archaeological studies: results from different case studies in the southern North Sea

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Overview

Three test cases in very shallow water

- Ostend (B): drowned medieval harbour + city
- Domburg (NL): buried medieval house remnants
- Raversijde(B): Roman peat excavation + medieval remnants

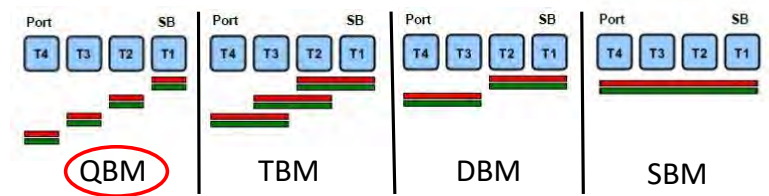


SES-2000 Quattro

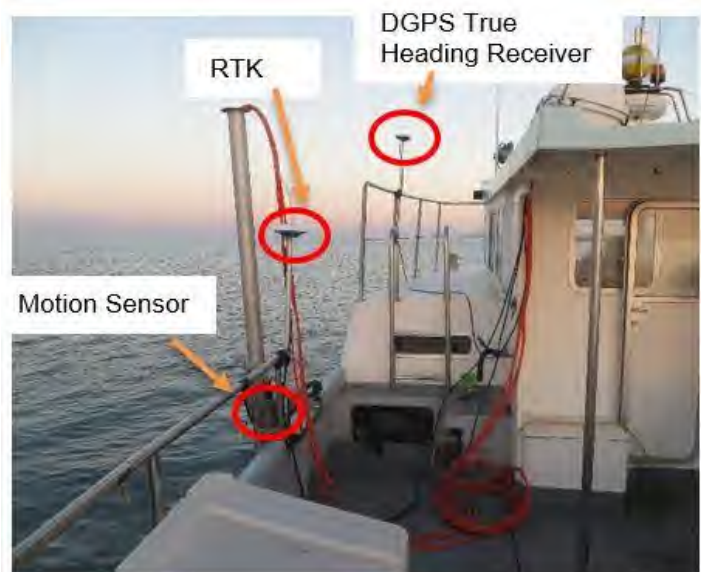
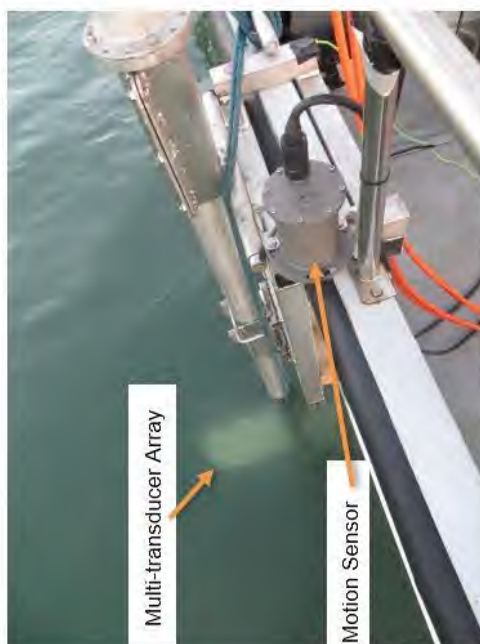


Multitransducer parametric echosounder

- 4 parallel transducers, total spread of 1 m
- High data density allows 3D visualization
- Different operation modes:

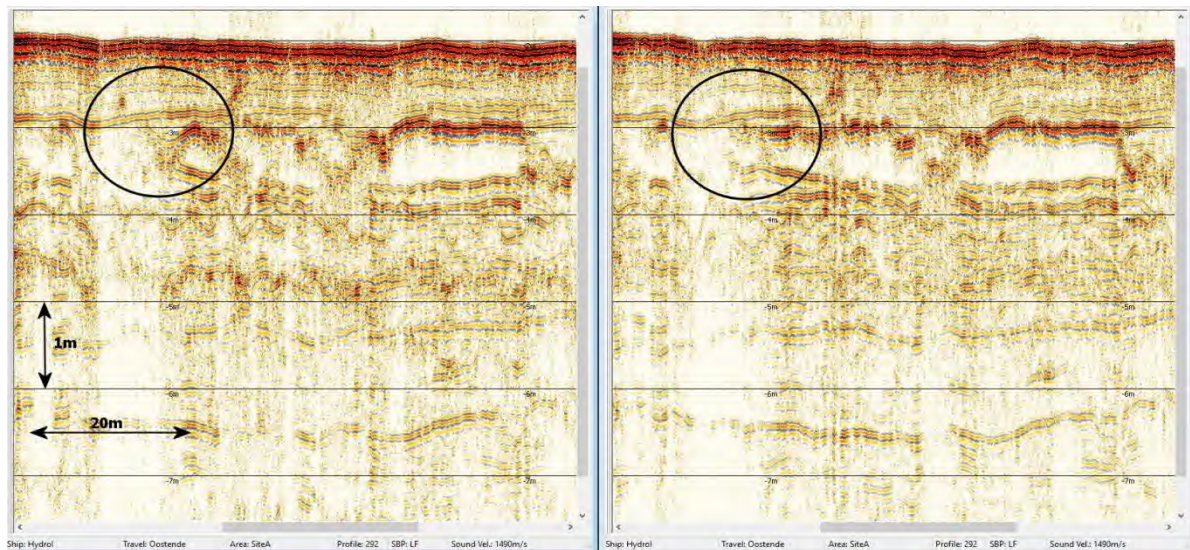


SES-2000 Quattro



- RTK positioning (cm precision) (Septentrio)
- DGPS dual heading receiver
- High-resolution motion sensor (SMC IMU-108)

Transducer data

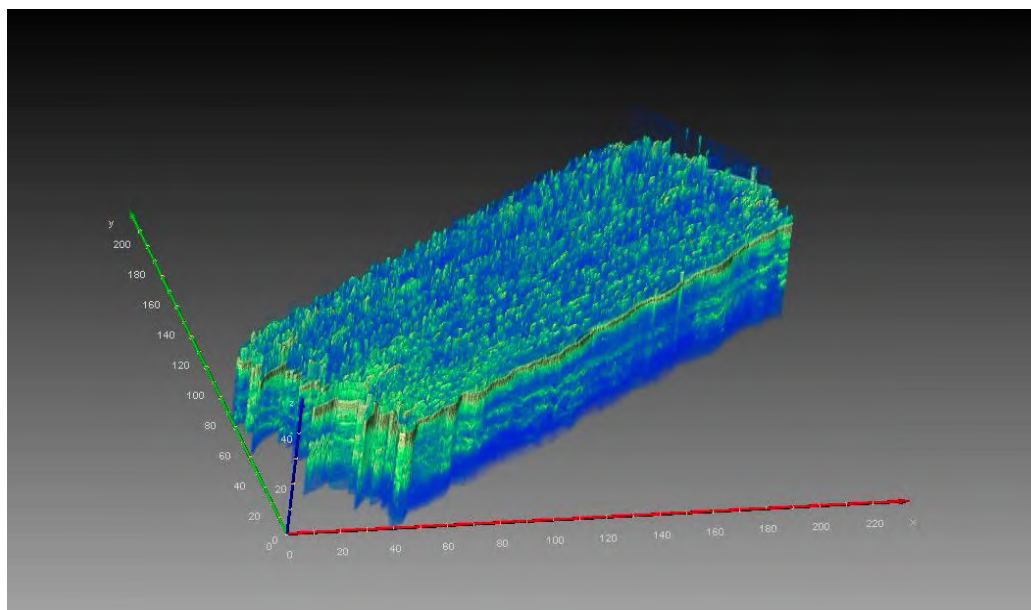


2 parallel sections from the same line (transducers T1 and T4)

Distance between transducers only 75 cm but differences in data are visible

Inner transducer far enough from the hull to avoid bubble effects

3D data volume



Line spacing optimally ± 1 m

High data density => grid cell size 25x25x1 cm possible (or smaller)

3D Visualisation with Avizo software

Oldest map ± 1560 (georeferenced)

house remnants?

recent coastline

harbour remnants?

Septentrio

Ostendae

Oxidens

Oriens

new harbour walls

old harbour wall

Focus area

recent sand suppletion

What is left over from the medieval harbour and city?

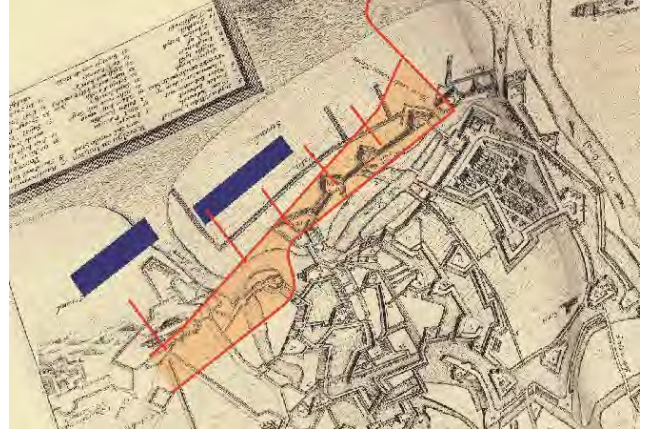
A photograph taken from the deck of a boat, looking out over a body of water. In the foreground, there are several large yellow and white plastic storage containers on the deck. A metal railing runs along the edge of the deck. In the background, across the water, there is a sandy beach, some buildings, and hills under a clear blue sky. A green object, possibly a life vest or part of the boat's equipment, is visible on the right side of the frame.

Two 3D networks in intertidal zone

Map 1581



Map 1652 (situation 1601-04)



Map 1652 (situation 1641)



Recent map project at VLIZ

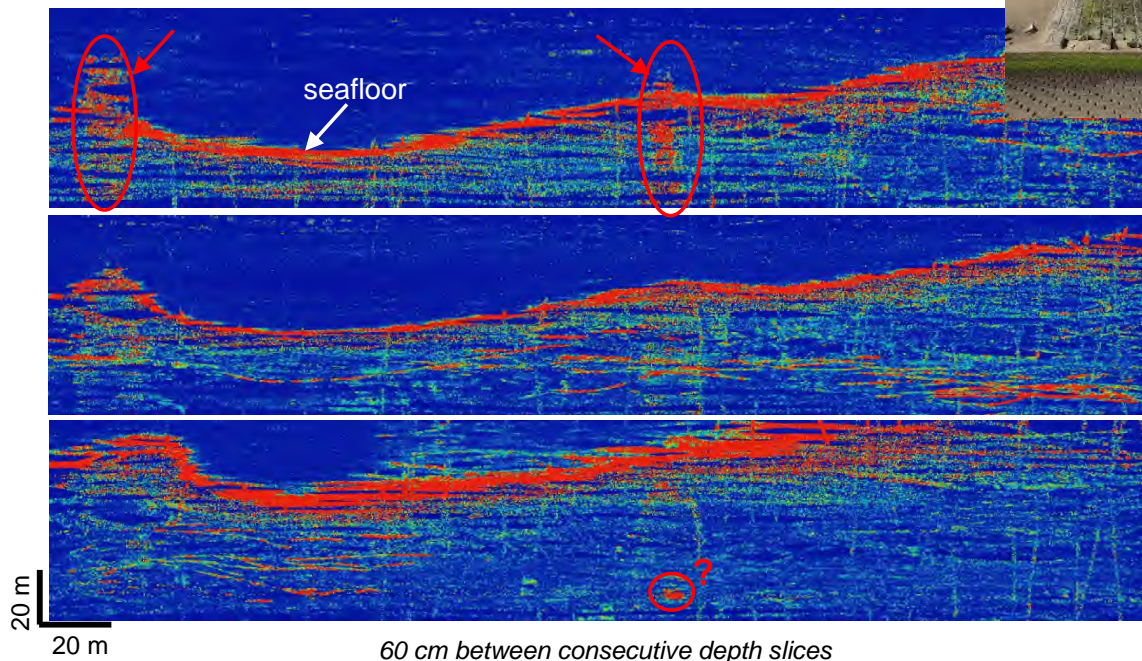


Location of late medieval harbour differs significantly between maps

Harbour construction uncertain (stone, wood, clay, peat, ...)

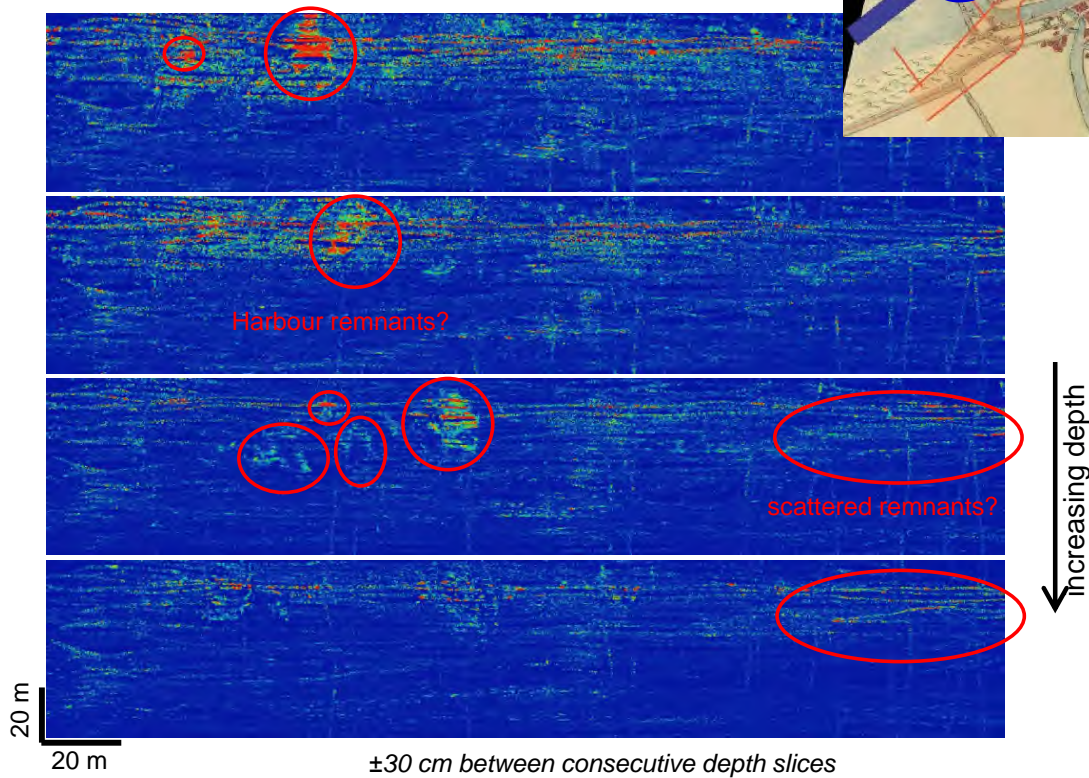
Ostend 3D East

Upper volume: groynes clearly visible

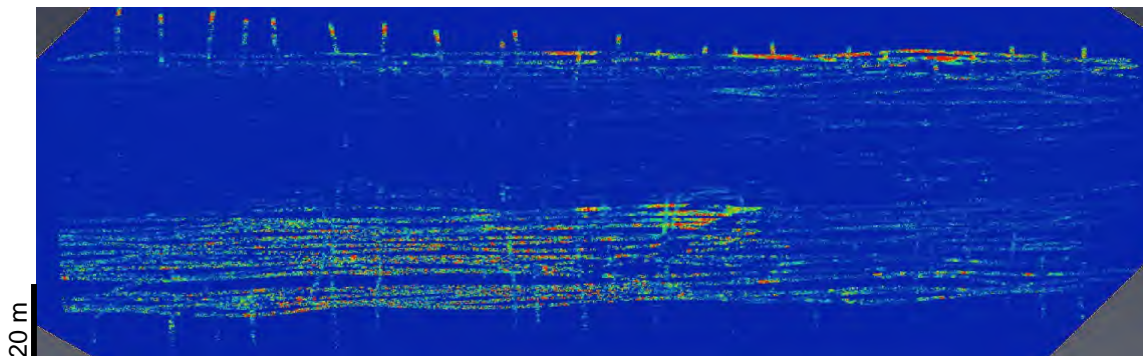


Ostend 3D East

Below the groynes different objects appear



Ostend 3D West

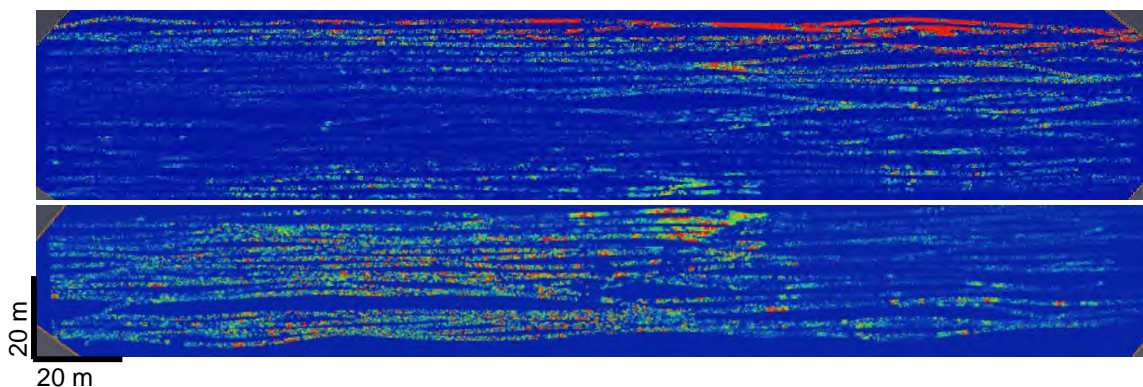


Triple beam mode recording

Perpendicular lines do not add much information

Different recording settings (upper / lower part) => amplitude variation

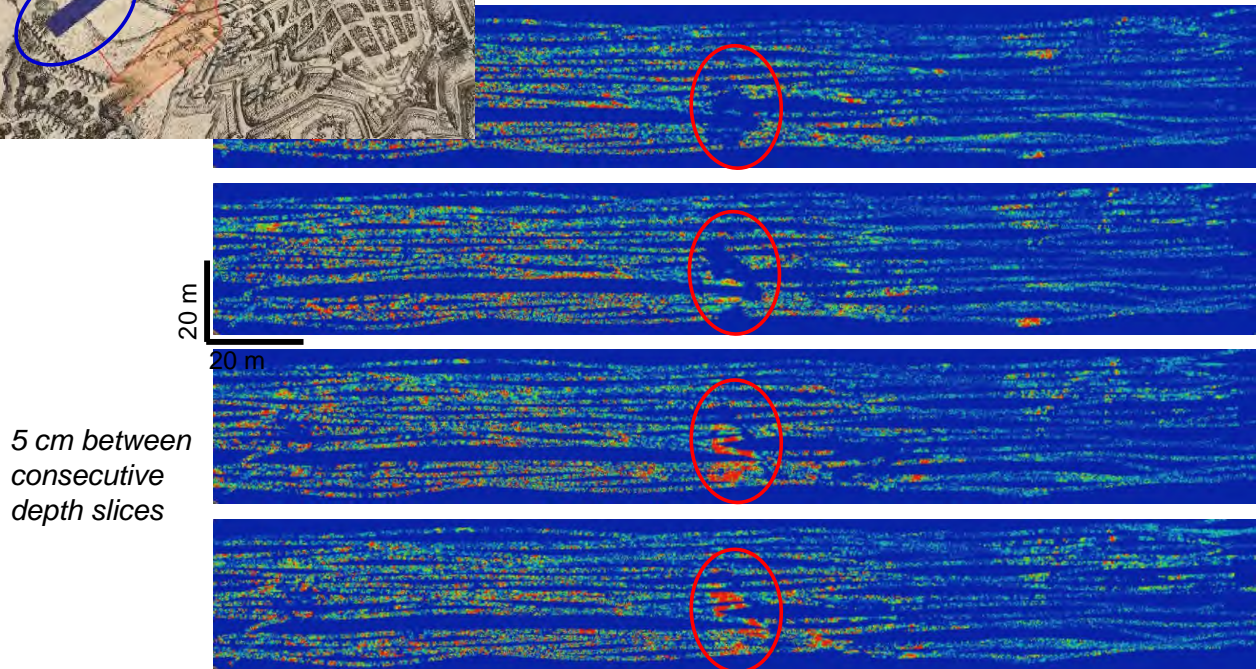
=> Processed in separate 3D volumes





Ostend 3D West

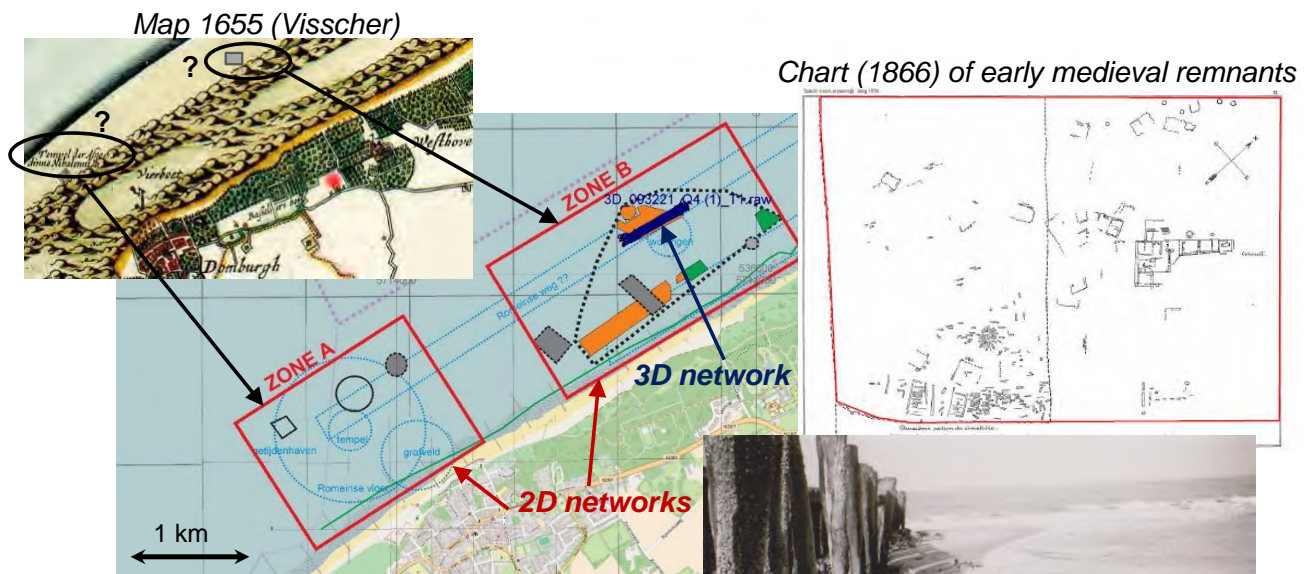
At ± 1 m bsf: marked feature (lower network)
 => related to medieval harbour?



Strong amplitudes in western part
 No clear pattern

Weak amplitudes in eastern part
 = eroding channel(s)?

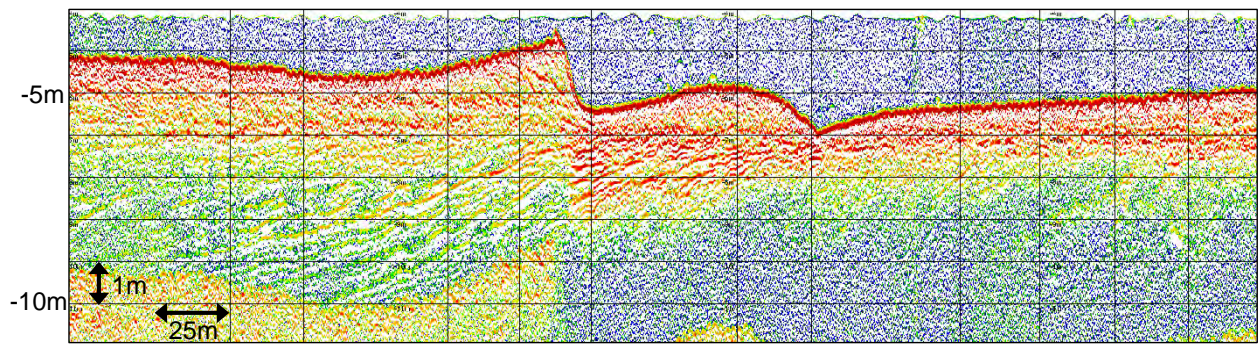
2. Domburg case study



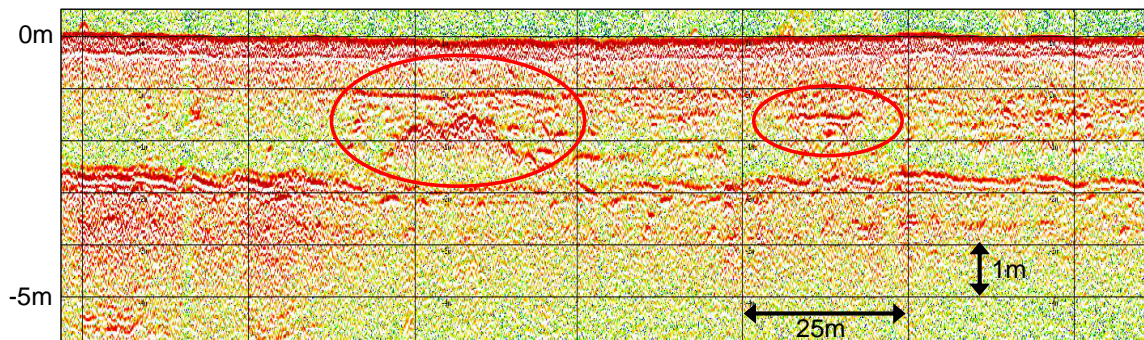
2D networks in areas A & B (total 55 profiles)

- A: Roman temple (uncertain location)
- B: Medieval remnants (houses, graveyards)

Domburg 2D data



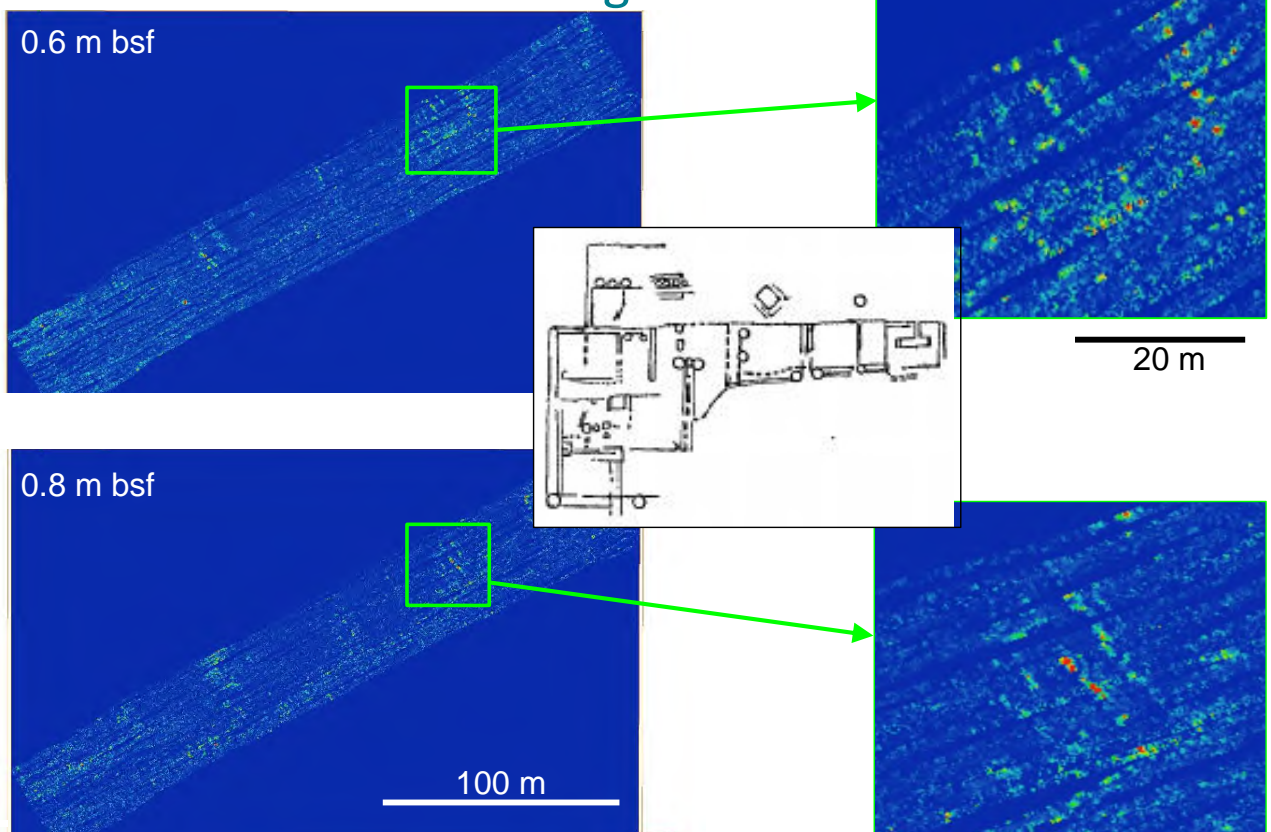
2D area A: large tidal channels – largely eroded Roman remnants?



2D area B: marked features in nearshore zone coincide with graveyard location

Too shallow for 3D survey => further north

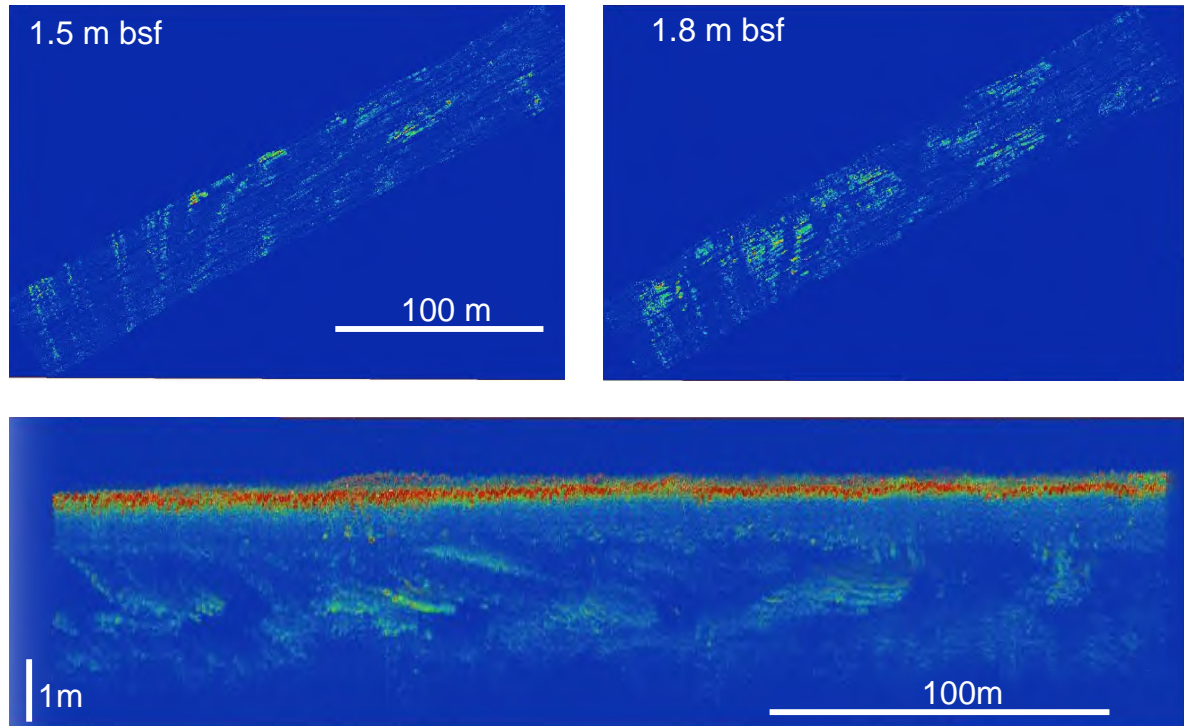
Domburg 3D data



3D area 280 x 70 m

Distinct linear features 0.5 - 1m bsf
Dimension + orientation agrees with old maps

Domburg 3D data



Deeper: large linear features that shift with depth

=> likely natural origin

Confirmed by perpendicular cross sections through 3D volume

3. Raversijde case study

3D areas of ~200 x 80 m

Between groynes, 1-4 m wd

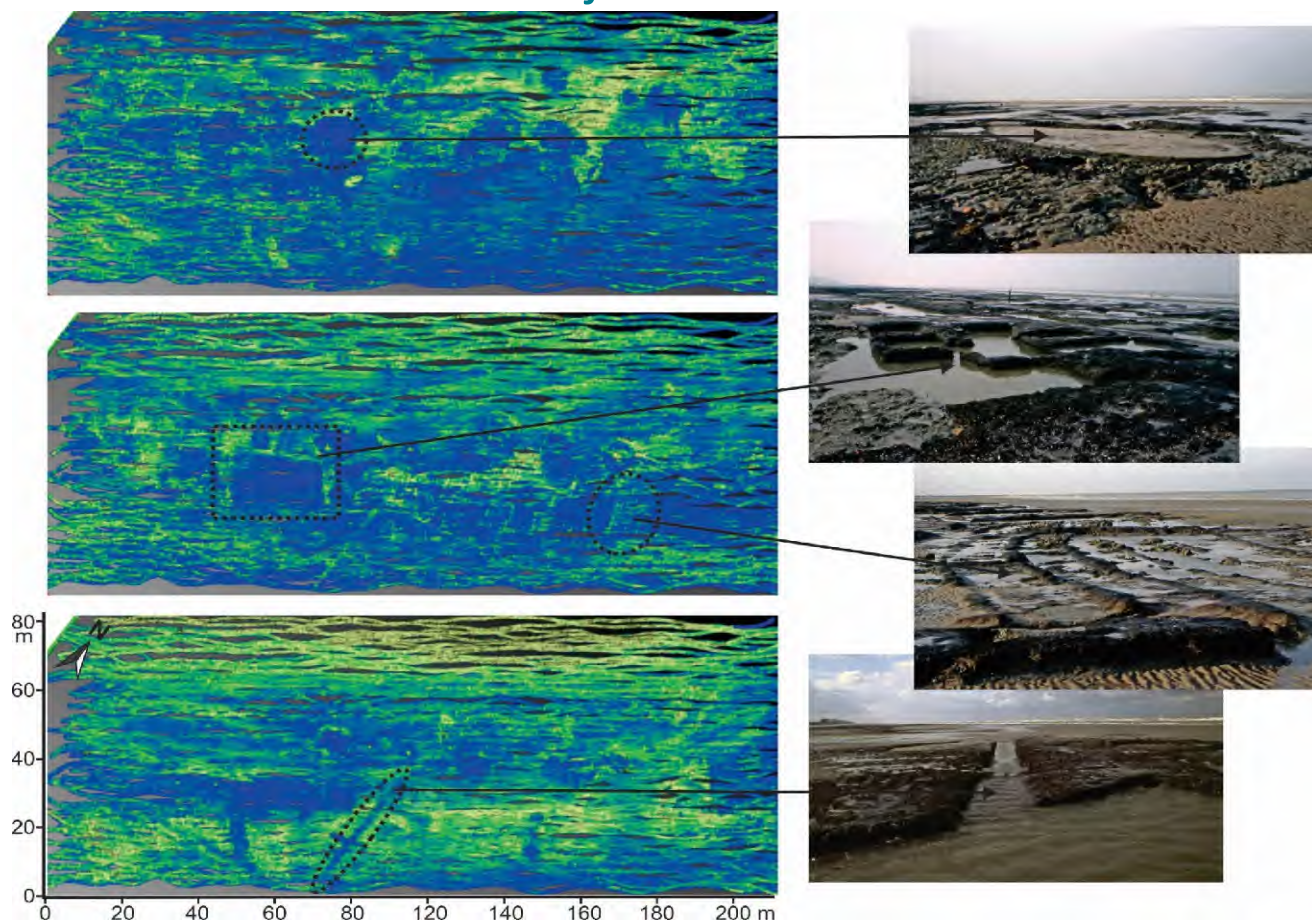
- R1: peat excavation
- R2: medieval house remnants?

R1: simultaneous multibeam

R2: shallow gas



Raversijde 3D Area R1

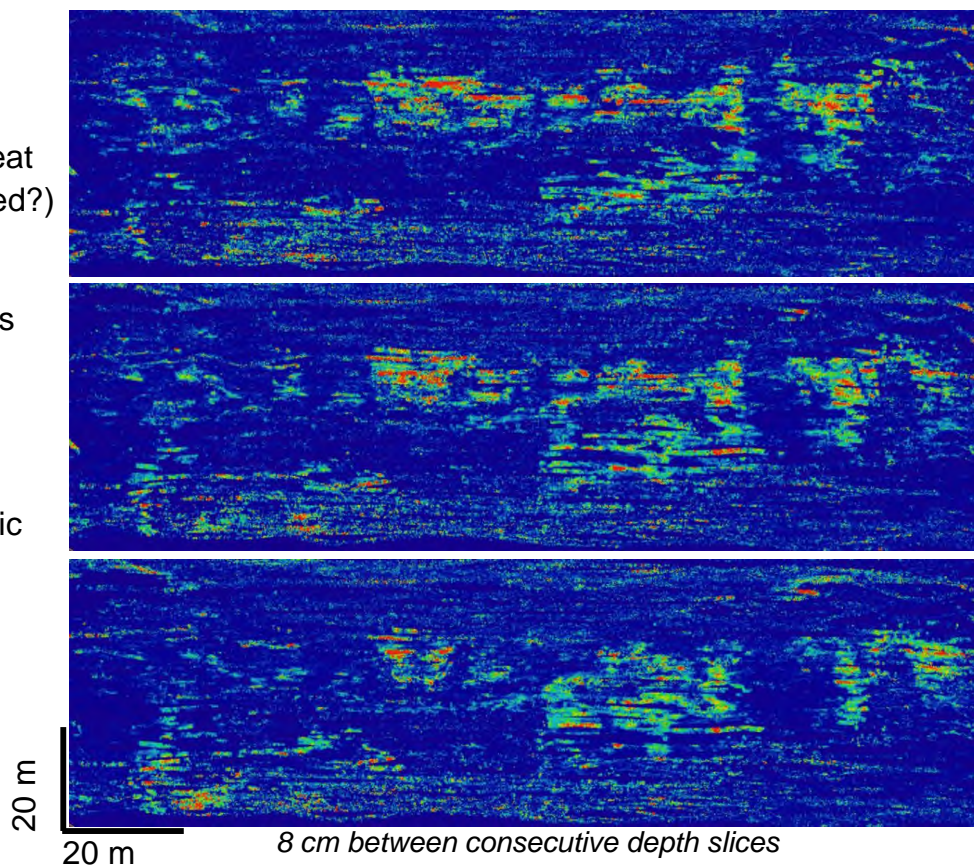


Raversijde 3D Area R2

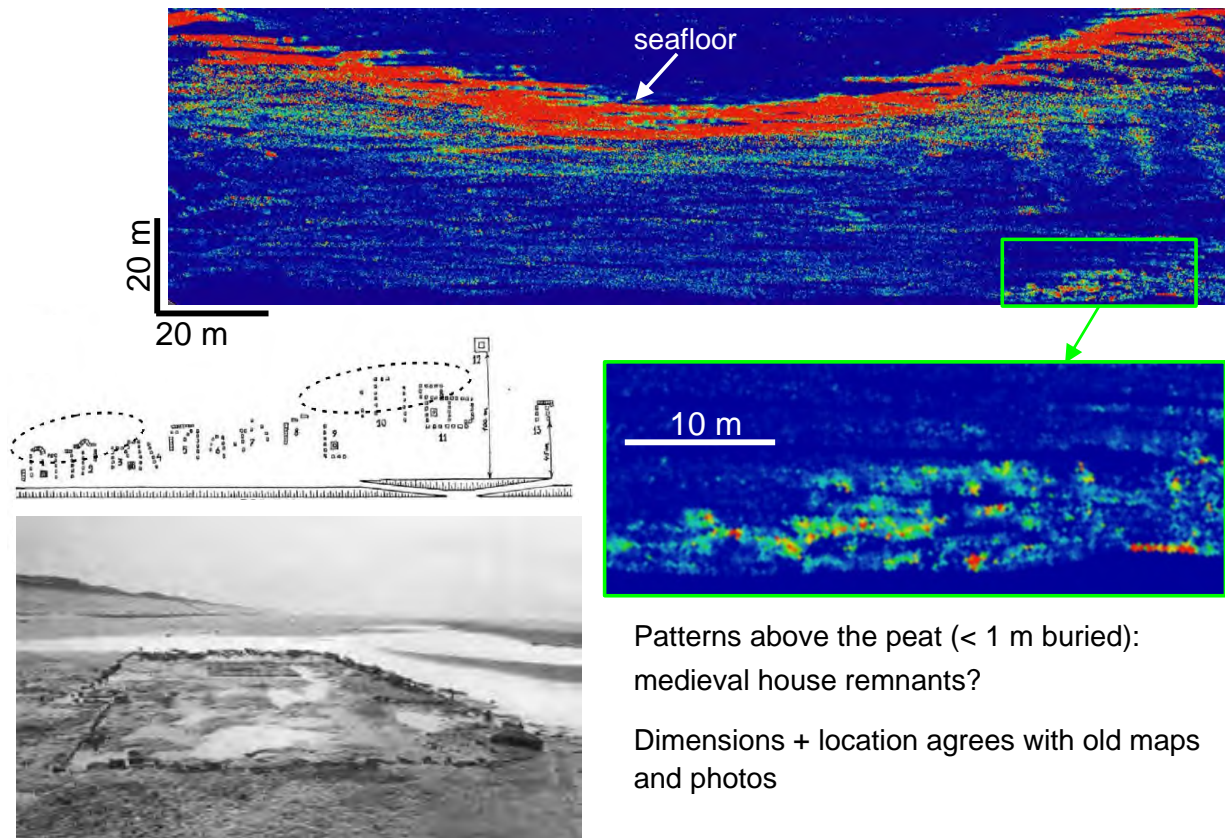
Thin & patchy peat
(largely excavated?)

Digging pattern is
less clear

Lower resolution
due to small static
errors & gas



3D Area R2



Conclusions

- Multitransducer PES allows to image small-scale buried features in 3D
- Precise positioning & high-res motion sensor is crucial for high resolution
- Good weather! Multibeam can remove small static corrections
- Avoid changes in settings when recording over several days
- 2D reconnaissance before 3D (palaeolandscape indicator)
- Further 3D surveys in B & NL planned for 2018

Special thanks to Ricardo Marte for his help in processing the data