Developing an Integrated Radar System for Sustainable Port Operations and Coastal Resource Management.

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Abstract

Coastal environments are dynamic and highly energetic, covering large areas they are currently very difficult to cost effectively monitor over long periods of time. X-Band marine radar is a ubiquitous tool in the maritime industry and can be used in the remote sensing of a variety of coastal resources. This project aims to develop a radar system which integrates navigation and traffic management capabilities with remote depth and hydrodynamics measurement. Implementation of this technology will support effective decision making by port authorities and coastal managers. The method is currently able to map intertidal coastline areas over 8 km².

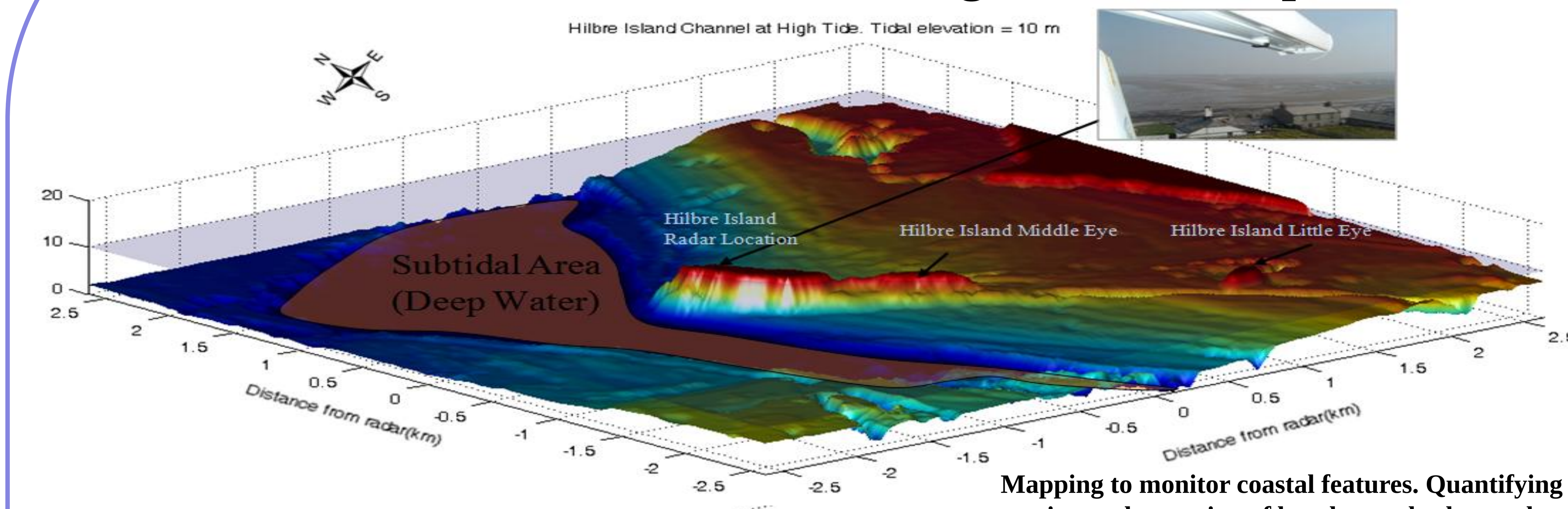
Background and Motivation

- Shallow coastal waters are important to commercial activities and are often the site of ports, harbours and recreational areas.
- A large variety of industries and communities depend on the resources available in the intertidal area.
- Coasts are very dynamic areas and their morphology is known to change significantly during high energy storm events, and gradually over longer periods of time (Sexton & Moslow,1981).
- A robust and cost effective method of monitoring these areas is required by port authorities.

Objectives

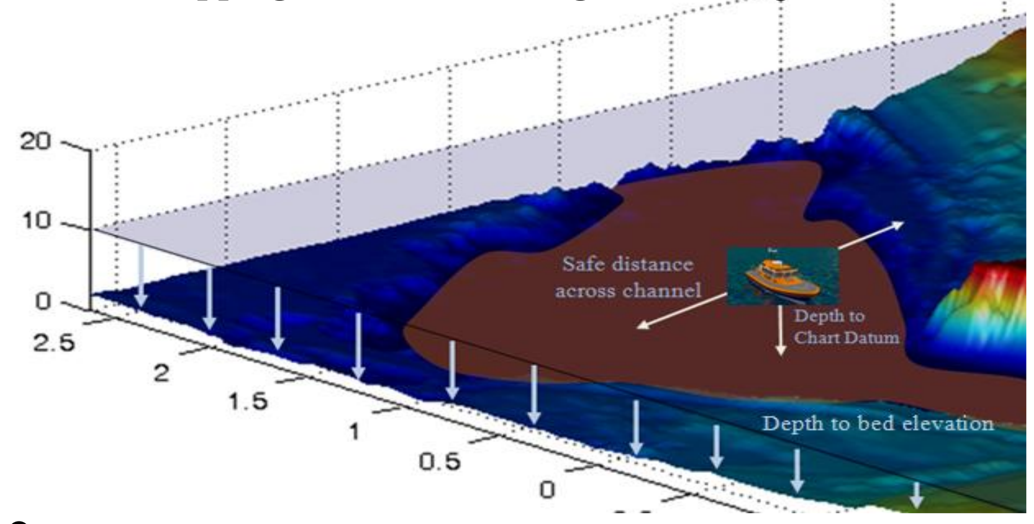
- Create a system able to locate shipping within a 3-D environment, including depth measurements and surface currents velocities.
- Provide the ability to monitor the "health" of the coastline, identifying areas of erosion and accretion both before and after high energy storm events, and over long time periods.
- Be able to track the movement of sedimentary features across intertidal areas, these features may encroach on navigation channels (FitzGerald et al. 2000), knowledge of this process will allow more efficient and targeted dredging operations.
- Integrate new developments with existing VTS (Vessel Traffic Service) AIS (Automatic Identification Systems) and ECDIS (Electronic Chart Display Systems) to provide a fully integrated radar system.

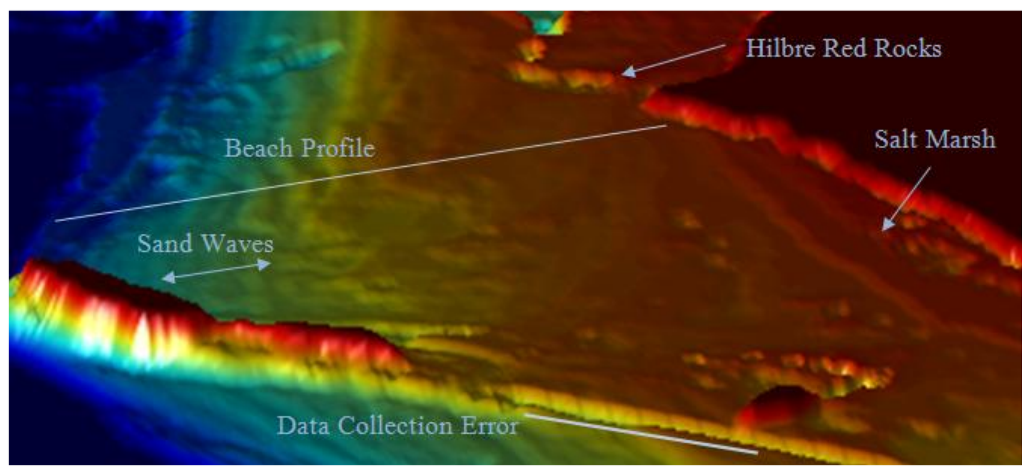
Outputs – Creating a 3-D Bathymetric Reference Frame to Increase Situational Awareness During Nearshore Operations



Mapping to monitor coastal features. Quantifying erosion and accretion of beaches and salt marshes

Mapping to aid vessel navigation through channels

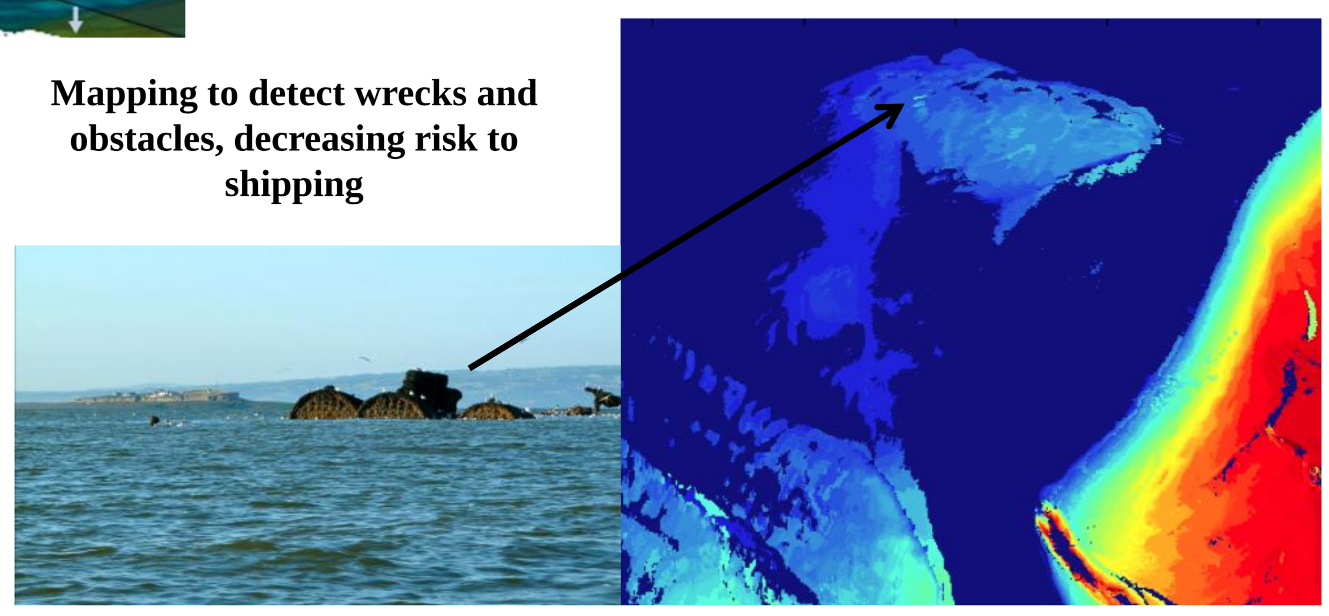




- Plots such as these can currently be produced every two weeks allowing the potentially dynamic intertidal bathymetry to be updated regularly without expensive surveys.

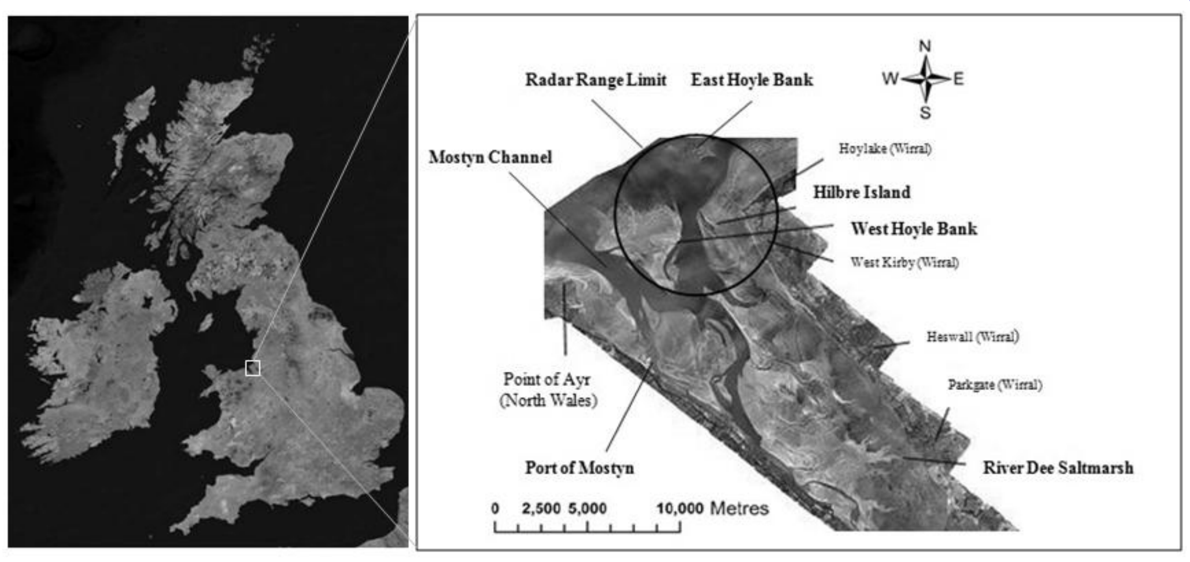
- This analysis technique will be integrated with existing radar Vessel Traffic Services (VTS) in order to accurately locate vessels and guide them through the intertidal area.

Mapping to detect wrecks and obstacles, decreasing risk to shipping

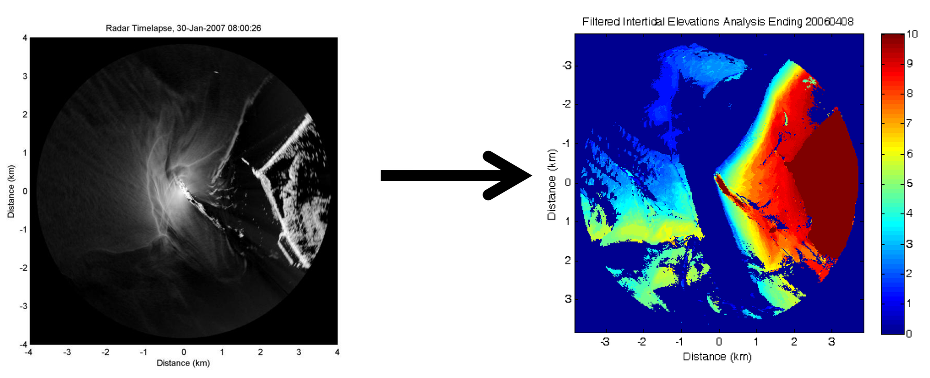


The method is sensitive enough to detect the wreck of the SS. Nestos a Greek cargo ship, stranded and sunk on the sandbank in 1941.

Study Area for Initial R&D and Method

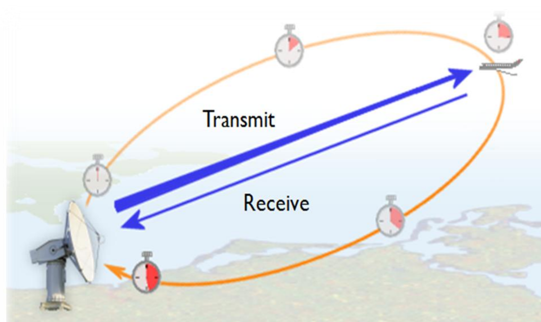


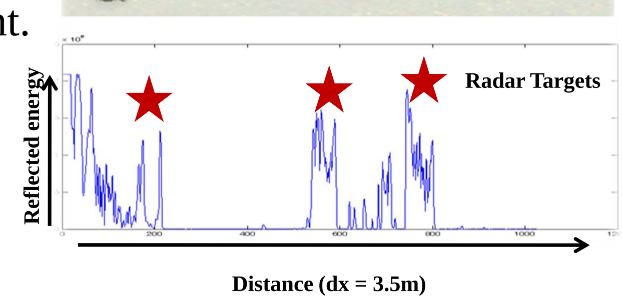
- A Kelvin Hughes X-Band radar was located at a weather station on Hilbre Island at the mouth of the Dee estuary, UK.
- This site features dynamic geomorphology in the intertidal area with extensive tidal flats and sandbanks. The figure shows the key features of the study area including the range of the radar analysis.
- The method used to derive bathymetry is currently awaiting patent and in the process of publication. Raw radar data is converted into images and time-lapse images are generated every 30 minutes over a 2 week Spring-Neap tidal cycle and an algorithm is used to generate an elevation value above chart datum (Lowest Astronomical Tide) for each point in the image.



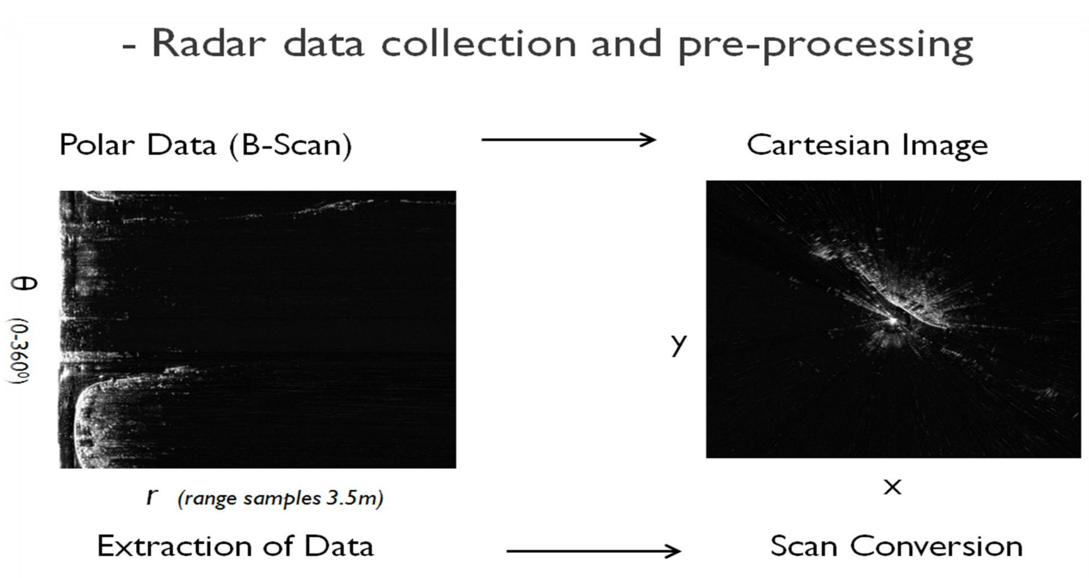
X-Band Marine Radar

- A 2.4 m antenna rotates at a rate of 25 rpm, generating an image every 2.4 seconds.
- At each angle of it's rotation, the radar antenna projects a pulse of electromagnetic energy at 9.4 GHz (X-Band) lasting 60 ns out to a distance of ~4 Km.
- Some energy bounces off objects along a path at that angle, some energy is lost to atmospheric attenuation and side lobes.
- The radar then "Listens" for returned energy at each range point.
- More energy from hard targets: ships, buildings, walls. Less from soft targets: trees, sand, water.
- A dynamic Sea surface causes "Sea clutter" (The useful part for monitoring Hydrodynamics).
- The raw data is converted into Polar, then Cartesian images.





- For more on radar basics see: Skolnick (1981) and Richards (2005).



$$r = sqrt(x^2 + y^2) \ and \ \theta = tan - 1\left(\frac{y}{x}\right)$$

Conclusions and Further Work

- During maritime operations, situational awareness and up to date information is paramount in maintaining safety and efficiency. The proposed radar system presents a novel method of providing this data.
- Algorithms to derive sea surface conditions including current directions and velocities are currently under development.
- Improvements to the depth mapping technique are currently being explored
- Deployment of a mobile radar system is under planning in order to test the techniques developed at a variety of sites.

References

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Acknowledgments

The author would like to thank the following for their contributions to the project.
The *European Regional Development Fund* (ERDF) & *The Centre for Global eco-innovation (CGE)* for funding this research.
Marlan Maritime Technologies Ltd. for providing training in radar signal processing and further funding of the project.
Prof Andrew Plater and Dr Paul Bell for supervising the project and providing the raw data for research and development.
Dr. John Hughes of Manchester University for the picture of SS. Nestos.
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EUROPEAN UNION
Investing in Your Future
European Regional Development Fund 2007-13

Centre for Global Eco-Innovation
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