The white ribbon zone

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Toby Driver and Dan Hunt explore how LiDAR maps are helping a study of the islands, reefs and headlands of Ireland and Wales to understand climate change impacts on coastal and maritime heritage

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On 1 January 2017, work began on Climate, Heritage and Environments of Reefs, Islands and Headlands (CHERISH) , a 5-year project that will receive more than ?4m funding through the EU?s Ireland Wales Co-Operation Programme 2014?20 , priority 2 ? adaption of the Irish Sea and coastal communities to climate change.

CHERISH is led by the Royal Commission on the Ancient and Historical Monuments of Wales in partnership with the Discovery Programme: Centre for Archaeology and Innovation Ireland , Aberystwyth University?s Department of Geography and Earth Sciences , and the Geological Survey of Ireland . The key objective of the project is to increase knowledge and understanding of the impacts ? past, present and near-future ? of climate change, increased storminess and extreme weather on the cultural heritage of reefs, islands and headlands of the Welsh and Irish seas. The project seeks to address gaps in both data and knowledge for these remote coastal landscapes and develop a greater understanding of climate change impacts on fragile coastal heritage sites. The commissioning of new, high-resolution, light detection and ranging (LiDAR) surveys at the start of the project was designed to establish accurate 3D baseline data for the Welsh islands, against which coastal change could be measured in the future.

CHERISH brings together a cross-disciplinary team of experts who are working as an integrated, international survey team. This team, in collaboration with government, academic and business partners, will link previously disparate data sets for land and sea tackling the 'white ribbon zone', a traditional term used by hydrographers to refer to the nearshore area, and reconstruct past environments and weather history. Christopher Catling, Secretary of the Royal Commission , describes CHERISH as:

'an exciting new project, bringing a strong partnership of archaeologists, geoscientists and maritime specialists to bear on the significant challenges posted by climate change'.

Making good the data gaps

At the start of the CHERISH project, data coverage for the more remote stretches of the Welsh coastline and islands was poor or non-existent, especially LiDAR. Significant stretches of coast lacked any accurate 3D data, while others only had older 2-metre resolution LiDAR data sets available. LiDAR at a resolution of 0.5 metres ? the minimum required for archaeological interpretation and landscape mapping ? was mainly absent, and there was none at all for principal Welsh islands including Skerries, Bardsey, the St Tudwal?s Islands, Ramsey and Grassholm.

LiDAR at work
In order to capture highly accurate LiDAR data, a survey aircraft equipped with a system of lasers is used. These lasers are trained on the ground, and the time taken fortheir beams to bounce back to the aircraft-mounted receivers is recorded. The distance between the aircraft and the ground is then calculated using the aircraft?s position, derived from on-board satellite positioning equipment, as well as the time taken for the beam to return and the known value of the speed of light. Readings can also be taken to determine the height of buildings, vegetation and other surface structures, such as above-ground pipelines, highways, street furniture, power lines and railway tracks.

Around two-thirds of Puffin Island in north Wales was covered with existing 1-metre LiDAR data, which was insufficient to show the archaeological earthworks of a medieval monastery below the scrub vegetation. Further south, 0.5-metre LiDAR data covering the Welsh islands of Skomer and Skokholm had been purchased by the Royal Commission in 2011 to enable the renowned prehistoric field systems here to be mapped in detail as part of a long-running landscape research project with the universities of Cardiff and Sheffield.

So, in early February 2017, the Royal Commission asked Leicestershire-based Bluesky, a company specialising in the acquisition of aerial survey data, to collect 0.25m LiDAR data from 6 Welsh islands at low tide in winter conditions with low vegetation and bare trees. Bluesky flew from its East Midlands base and collected the data using its Teledyne Optech Galaxy LiDAR system on 24 February 2017. Wardens on both Bardsey and Ramsey islands watched the survey aircraft above, and even tweeted a photo of the flight.

Building on the Bluesky data, a series of baseline coastal monitoring flights was carried out by CHERISH staff in a light aircraft, establishing a library of high resolution, low-level aerial photographs for coastal Wales and southern Ireland. These show the current level of erosion at key archaeological sites, with the process repeated at intervals, particularly following major weather events such as Storm Ophelia in October 2017.

Aerial photographs taken include stereo pairs and overlapping images in orbit around a site; these can be used to create highly detailed digital 3D terrain models, which are particularly helpful for offshore properties and nature reserves where drone access may still be difficult. These remote-sensing approaches inform surveys on the ground, including archaeological mapping, terrestrial laser scanning and palaeoenvironmental sampling to develop models of climate history and past storminess.

Processing the data

The data was processed by the commission using the Relief Visualization Toolbox , a standalone application for visualising elevation models developed by the Institute of Anthropological and Spatial Studies at the Research Centre of the Slovenian Academy of Sciences and Arts, funded through the Slovenian Research Agency and the ArchaeoLandscapes Europe project.

For each of the 6 Welsh islands, 12 visualisations were produced, including single-directional hill shades created with light projecting from four angles and a sun elevation of 30 degrees, and hill shades in 16 directions ? both colour and black and white ? from the same elevation. The LiDAR-based visualisations also included slope, simple local relief models, sky view factor, sky illumination and local dominance. Each retained its original positional data, which means it can be imported into desktop mapping and geographical information systems software such as ArcGIS as georeferenced raster images.

Revealing the landscape

During summer, 2017 work began in earnest to field-check the results of these new LiDAR data sets and discuss the results with island managers. This was the first time the wardens of Bardsey National Nature Reserve and RSPB Ramsey Island had seen their islands modelled in 3D.

The LiDAR data has an immediate value for the management of the natural environment, showing everything from the precise extents of bracken and scrub to scatters of bird burrows on the Skerries Islet and the positions of individual gannet nests on RSPB Grassholm Island. For the archaeologists investigating the landscape on the ground, meanwhile, there is no substitute for having such high-resolution LiDAR to hand. Extremely subtle or low-lying archaeological earthworks may be invisible under bracken or in dull, overcast conditions; however, the LiDAR shows all of these with perfect clarity.

The precision of the cliff-edge mapping in the new data is also important for monitoring long-term coastal change on these vulnerable islands, while more immediately the LiDAR plots will form the basis of attractive new interpretation panels in the island visitor centres. Dr Toby Driver, Senior Investigator at the Royal Commission, comments:

'The Bluesky LiDAR offers unparalleled views of these key Welsh Islands. Processing has allowed deeper interrogation of the data and revealed new monuments. This will be combined with drone photogrammetry and detailed ground surveys to provide an absolute fix on eroding coastlines for future climate change monitoring.'

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Further information

- Related competencies include Management of the natural environment and landscape , Mapping , Remote sensing and photogrammetry , Surveying land and sea
- This feature is taken from the RICS Land journal (February/March 2018)
- Related categories: Climate change: adaptation and mitigation ;