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### Abstract

Considerable progress in the engineering of maritime structures occurred between the 18th and 20th centuries in Ireland. While major harbours have been well documented, there remain considerable structures that due to their small size have been overlooked. These minor harbours represent a considerable source of information, many having originated through local efforts only to be later modified through government works in the 19th and 20th centuries.

The danger posed to these structures from deterioration and rising sea levels is increasing and it is imperative to create accurate records for the appropriate management and conservation of these structures. An initial pilot study of Coliemore Harbour [1] was undertaken in 2014-15, which served to establish a provisional methodology for scanning procedures, using a Leica Geosystems LiDAR scanner, from which precise measurements and configurations of each structure can be catalogued and compared. The pilot study served to identify issues to be addressed to ensure the information captured is both complete and as widely transportable to alternative formats as possible for ease of access to a broader range of users.

*Index Terms*—Harbours, Coliemore, Ireland, Maritime Engineering, Heritage at Risk, LiDAR, Transportable Data

### I. Irish Maritime Heritage

Being a country surrounded by the sea, the harbour structures along Ireland's coastline represent a significant infrastructural system which has shaped local and national Irish culture. Their early development and later modifications document the evolving nature of engineering technologies, some being peculiar to Ireland particularly in the latter half of the 19th century. While major harbours have been well documented [2,3] there remain considerable structures that due to their small size have been overlooked. These minor harbours represent a considerable source of information, many having originated through local efforts only to be later modified through government works in the 19th and 20th centuries. Of the 94 structures identified on the east coast by the Underwater Archaeological Unit (UAU) of the Irish National Monuments Service [4] there are 83 minor structures for which limited documentation exists. Although some of these are recorded in the Irish National Inventory of Architectural Heritage (NIAH), it

is not comprehensive and little data on the configuration, dimensions and construction is recorded.

Though some knowledge on the minor harbours is found piece-meal in local history journals [5] or small booklets [6] they tend to be examined in an isolated fashion and from a non-technological perspective, failing to understand the broader trends in technological change that were influencing their building and modifications. The danger posed to these structures from deterioration and rising sea levels is increasing and it is imperative to create accurate records to support a comprehensive analysis of the evolution of maritime engineering in Ireland, similar to the work already undertaken in Scotland by Angus Graham in the late 20th century [7,8]. As clear from the work of Graham, these minor structures typically appropriate local topographical features and evolve incrementally, making their forms eccentric and difficult to capture using conventional survey tools. The use of LiDAR to scan the harbours three-dimensionally addresses this difficulty and, when coupled with historical research, provides the information necessary for a comprehensive comparative analysis to aid the management and conservation of these structures.

### II. The Pilot Study: Coliemore Harbour

Initial scoping of potential harbours was undertaken with reference to the UAU "Ports, Piers and Harbours" in concert with a review of historic and contemporary Ordnance Survey maps to identify suitably sized and historically relevant harbours for the pilot study. Coliemore Harbour, south of Dublin, was selected for the pilot because of the complex relationship of natural rock outcroppings to the incremental and irregular cut stone constructions that form the harbour. Preliminary LiDAR scans were undertaken of the harbour which, after considerable manipulation of the point cloud data, produced very credible sectional representations (Fig. 1).



Fig. 1. Coliemore Harbour point cloud section (Spratt-Murphy, 2015)

The scans were taken using a Leica P20 laser scanner, provided by the UCD Earth Institute, and processed using Cyclone 9.1 software. This data was then supplemented by photographs, an examination of construction techniques and historical research. The harbour has a very long history of use from the 14th century, as detailed by Smyth [1,6], but was little more than a natural cove until incremental additions were made from the early 19th century formalizing its boundary conditions as neighbouring land was developed. The final additions consisted of two pier structures founded on the rocky substrate in the late 19th century.

As can be seen from the three-dimensional image and plan (Fig. 2), the scans successfully captured the irregular interface of pre-existing rock surfaces to the constructed walls and slip-face, detail not available in conventional mappings of this harbour. The speed of data capture, with this level of detail, would not be possible with any other method. The methodology is not without difficulties however. Due to the tidal nature of the harbour the scans had to be taken at low water in an effort to capture the greatest extent of surface, which limited the time available resulting in less than complete data. As LiDAR is unable to interpret water the data at the leading edge of the water is fractional and unreliable, as is the discolouration of any water saturated stonework. The most significant shortcoming of using a land-based LiDAR is the inability to scan the exterior of the harbour walls and the lack of any data capture below the waterline.

Perhaps the greatest issue to address in the use of this data is the restrictions created due to the file format (.LAS) requiring specialist software to view, thus limiting accessibility to two dimensional representations and reducing the usefulness of the data.

### III. Future Directions

Having identified three critica issues to resolve in developing reliable scan data for harbours: access to exterior walls; lack of data below the water line; and accessibility of the data post-processing, the next stage of the project is to address these issues in a sample of three differently configured harbours. The first issue will be addressed by scanning from a boat, requiring the LiDAR equipment to be stabilized with a gyro-mount to negate the movement of the boat. The lack of data below the water line can only be addressed by the use of divers to document the depth and construction of the walls, which will not form part of the second phase of this research.

The last issue, of accessibility of the data, is critical if this work is to have value for national and local agencies responsible for the management of these harbours. Our intention is to translate the point cloud data acquired from the LiDAR scans into a digital 3D model using NURBS-based CAD software, which can better account for the irregularity of the surfaces encountered. This will ensure that the data can be viewed and manipulated by standard CAD programmes to enable greater access.

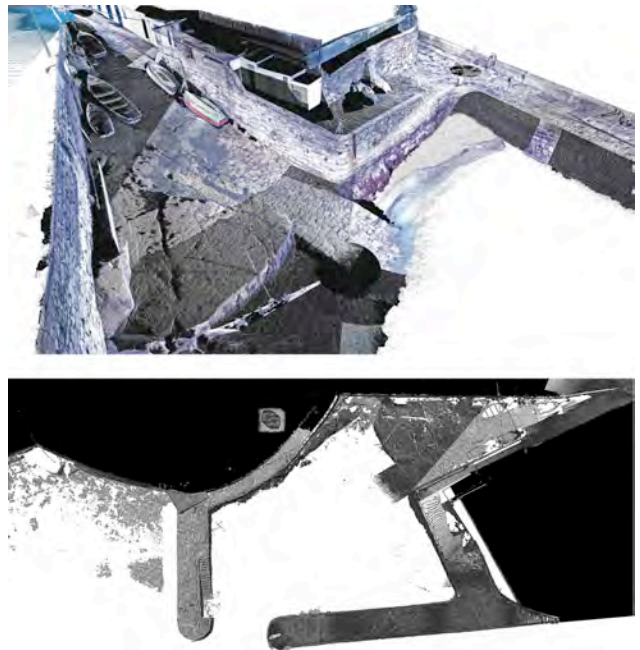


Fig. 2. Coliemore Harbour 3D and plan (Spratt-Murphy, 2015)

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