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Augmented Maritime Histories: Text, Point, Line

Introduction
The coastline of Ireland has been embellished through the accretion of piers, jetties, quays and breakwaters to facilitate the ever-evolving nature of the shipping and fishing industries in the past millennium. These structures represent a significant infrastructural system that has shaped local and national Irish culture for centuries. While Ireland’s major ports have been carefully documented and researched, much of this infrastructure, though once intrinsic to the economic wealth and welfare of local communities, has fallen into disrepair as the industries that once generated their development have been centralized to the major ports. With damage from the seas ever increasing, it has become critical to document these minor harbour structures to describe and elaborate the entwined nature of their development with the communities they had once served.

The current project was conceived and funded as a pilot project to establish protocols for the capture and management of LiDAR-based surveys of these coastal structures in tandem with historic research on their development. Many of these structures have long, complex histories tied to the shifting patterns of governance, land tenure, material resources, technology and trade. Unravelling and visualizing these histories involves a complex negotiation between text-based archival documents, historic surveys and maps, other forms of pictorial representation such as topographical illustrations, all used in tandem with LiDAR-based surveys [Fig. 1] to articulate their evolution.

Methodology
Initial scoping of potential harbours was undertaken with reference to the UAU Ports, Piers and Harbours in tandem with a review of historic and current Ordnance Survey maps to identify suitably sized and historically relevant harbours for the pilot study. Based on this review a subset of harbours for further research was identified for this initial research stage:
- Port Oriel (Clogherhead), Co. Louth
- Ballbriggan, Co. Fingal
- Bullock, Co. Dublin
- Fethard, Co. Wexford
- Slade, Co. Wexford
- Dunbrattan (Boat Strand), Co. Waterford
These harbours were chosen based on the variation in geomorphological situation, harbour form and dates of development. This was intended to achieve two purposes; the first to ensure that sufficient variation in scanning procedures was trialled to identify critical issues and secondly, to enable a comparative analysis between differently situated harbours making use of the very coherent template for analysis developed by Graham in his study of Scottish vernacular harbours.²

The research has five phases of interrelated work: review of secondary published research to develop bibliographic data for each harbour; archival research; on-site scanning and inspection; modelling, documentation and record development; and historical comparative analysis. Of interest here is the manipulation of LiDAR pointcloud data post-scan, to interrogate the findings from the archival and desk-based research. The original intention had been to translate the point cloud data acquired from the LiDAR scans into digital 3D models using NURBS-based CAD software, which can better account for the irregularity of the surfaces encountered, retain the complexity of the construction detail, and ensure that the data could be viewed and manipulated by standard CAD programmes to enable greater access. Coupled to this is the need to link the results of the archival research and other source data, such as photographs or bibliographic notes, to the 3D computer model. There is considerable momentum among international researchers in this field at the moment, including the work of Stephen Fai, director of the Carleton Immersive Media Studio (CIMS) is a Carleton University in Canada and Anthony Caldwell at the UCLA Digital Humanities Group. In particular, Caldwell's use of Building Information Modelling (BIM) software to link this paradata to the digital image³ is a useful model to deploy in this context, as both archival, bibliographic, photographic and management data can be keyed into the digital model for future reference.

**Bullock Harbour Case Study**

Of the seven harbours [including the earlier study of Coliemore] surveyed to date a considerable number of pictorial representations have been sourced for Bullock harbour in County Dublin including a seventeenth-century topographical ink-wash by Francis Place⁴ and a painting by John Thomas Serres almost one hundred years later⁵ [Figs. 2 & 3], making Bullock a useful vehicle for initial trials for analysis and visualization. These images can be used as baselines to articulate the original geomorphological characteristics of the site prior to its embellishment with several layers of eighteenth to twentieth-century additions to form the harbour in its current condition.

![Figure 2 & 3: Bullock Harbour, left: Place, 1699; right: Serres, 1788. [Images courtesy of the National Gallery of Ireland]](image)

Bullock harbour also has a usefully complex and lengthy history, much of which has only been identified by virtue of the archival research interrogated in tandem with the information contained in the LiDAR scans. Although concise histories of Bullock have been published in the past by De Courcey⁶ and Gilligan⁷, in addition to an earlier work by D’Alton⁸ and a more recent, lengthier work by local historian Smyth⁹ in *Bullock Harbour: Past and Present*, the history of the building of the harbour is under-represented, being simplified to a
recounting of the ‘medieval pier’ on the west bank below the castle, variously described as either fourteenth or fifteenth century in origin, followed by a complete building of the harbour in circa 1820 by the Dublin Port and Docks Board [now Dublin Port Corporation] with quay walls, slip, and piers to both east and west. Aside from the improbability of a fourteenth century pier withstanding the ravages of time and the battering of the seas for five hundred years before it was rebuilt, these histories overlook the more complex evolution of this harbour, failing to account for the range of pictorial history available and formal government documents which expose a more elaborate history.

D’Alton is the only published author who recounts the remains of an eastern pier, in addition to the ‘medieval pier’ on the west bank, both of which are plainly recorded in the 1699 ink wash drawing by Place. D’Alton’s description is taken verbatim from a report of 1800 by Captain William Bligh on the state of Dublin Harbour who provides in his survey the precise dimensions of the ruined east pier in addition to the length and breadth of the harbour, the latter of which agrees quite well with Place’s representation when interrogated using the ‘Vanishing Grid’ command in Adobe Photoshop. Even more troubling is the lack of attention given to physical evidence on the ground, which is exposed in the high resolution LiDAR data [Fig. 4] in which the physical remains of a hewn stone pier is visible within the larger ashlar granite construction of the early nineteenth century.

Figure 4: LiDAR image of east pier with hewn stone construction highlighted. [Shotton, 2016]

The hewn stone construction highlighted in the LiDAR scan appears to consist of two independently constructed piers, which could serve to articulate the constructed history of the harbour. The lengthier section matches precisely to the dimensions quoted by Bligh for the ruinous pier in his report of 1800, and given the irregularity of its edge condition to the north [bottom of image], while the south edge is continuous, it appears likely that its seaward edge had collapsed. This would account for the rubble of stone illustrated in the Serres image made shortly before Bligh’s survey. This pier extension was likely funded by the Irish Parliament and built shortly following a petition made by the Merchants and Traders of Dublin in November of 1765 to make "a strong jette from the points of the rocks adjoining the continent, to the rocks of Old Bullock." The jette can be understood as the pier, though clearly not built as strongly as the Merchants had hoped as it lay in ruin less than forty years later, with the rocks of Old Bullock referring to a string of rocky outcrops on the east side of the inlet. The earlier original pier on which it extends was no doubt ruinous at this time, but was likely the remnant of the east pier illustrated in Place’s drawing as its position correlates substantially.

In addition to the petition for a jette, the Merchants and Traders also requested the continuation of “…the new quay, opposite the rocks of Old Bullock, which would include space large enough to contain several vessels in ten or twelve feet of water at the lowest spring tides.” That this work was undertaken is verified in 1770, five years following this
petition, when Wilson writes of Bullock, “A new quay faced with hewn stone, hath been lately built, for the convenience of conveying stones to the light-house-works.” There are two critical terms used in these documents that allow the pictorial works of Place and Serres to be better understood relative to each other, as well as to the later nineteenth century construction. When interrogated relative to the LiDAR scan data, in tandem with the perspective grid analysis, the western pier in these two illustrations are located differently, with the Serres’ pier located south of the pier in Place’s drawing. Topographical artists built their reputation on the accuracy of their representations and while there is cause to doubt Serres’ image, in that he has collapsed the perspective in an effort to include the eastern rocks for picturesque effect, Place’s reputation is considerable and holds up well to scrutiny. It appears probable that a new quay or pier was built on the western shore, prior to the petition of the Merchants and Traders of Dublin, as they petition for the continuation of the new quay. This suggests that the western pier in Place’s drawing had collapsed by this time, which may account for the loose rubble illustrated north of the pier in Serres drawing, and was rebuilt southward of the original site. This new location correlates closely to the position shown by Duncan in his 1804 survey of the Coast from Blackrock to Bray Head. The later continuation of the quay adjoining this pier by the Merchants and Traders, by an unknown length, would help to resolve a discrepancy between the known dimensions of the nineteenth century works which fall short of joining this pier.

The nineteenth century works are equally complex rather than singular as generally discussed, and again are revealed in the LiDAR scans. There is considerable diversity of construction techniques used in the visible surfaces of the harbour, including ashlar horizontally coursed stonework on both piers and part of the western quay, ashlar vertical partially coursed stone work on the eastern quay, and rough hewn, un-coursed stone work on the south end of the western quay and the original slipway. Although built by the same contractor George Smith, rather than being built at a single period the earliest date of the nineteenth century work was 1807-8, when the western quay wall was extended by 231 feet in rough hewn, un-coursed stone work, and later extended by an additional 80 feet, including a slipway, in 1815 using the same technique. The later ashlar work, undertaken 1818-1820 by Dublin Port introduces a curious angle in the western quay wall where it ties into the hewn stone wall of 1807. While this may reflect a preference to achieve a right angle with the new western pier on the part of the engineer George Halpin, as there appears less effort to ensure this geometric purity on the eastern quay it is also possible that this shift in geometry was necessitated by the still extant eighteenth century western pier illustrated in Serres’ drawing, suggesting the pier may still exist under the roadway adjacent to the quay constructed after this date.

**Partitioning, Imaging and Analysis**

A primary underlying ambition of the research has been to develop a more coherent history of the evolution of maritime construction technology in Ireland, which influenced the choice of LiDAR as a survey tool as it is possible to capture and preserve significant detail using this methodology. The information gathered on the scans has proven remarkable but the choice to retain this detail has lead to significant file sizes, in excess of 9GB for the complete Bullock Harbour [in excess of 298 million points]. Though the original intention had been to import the data to RhinoCAD where the point clouds could be surfaced to create smaller files in more commonly accessible formats, RhinoCAD has insufficient capacity to accommodate such file sizes, thus the work has taken a different trajectory.

To enable the surfacing of the point clouds [as yet incomplete] the data set for Bullock, once interrogated relative to archival information, has been partitioned by date of construction, a method that will also be used on the other harbour data sets. The subsets developed for Bullock include; rocks and castle [409MB]; early east pier [119MB]; west quay wall of 1807 [312MB]; west quay wall and slip 1815 [94MB]; west quay and pier 1820
[1.2GB]; east quay and pier 1820 [940MB]; road wall [132MB]; concrete slip and buttresses [242MB] which, though large, are sufficiently smaller to enable manipulation in RhinoCAD. Each partition retains the castle as a reference point for further analysis. The partitioning of the scan data in this manner requires a certain amount of interpretation and interpolation to articulate how each phase was constructed and later embellished. To date the point cloud data has been used in RhinoCAD to develop extruded 3D forms of the subsets, that lack construction detail, which have then been merged into a single file and used to confirm or dispel hypotheses regarding the information gleaned from historic sources, including text and images, and from which a series of three-dimensional models of subsequent building phases will be visualized and ultimately linked to the main point cloud data as a web-based record.

The use of perspectival grid analysis using the ‘Vanishing Point’ feature in Adobe Photoshop, verified against textual evidence from early coasting pilots and/or marine surveys for dimensional integrity, was trialled in an effort to correlate the information in the historic images with the scan data and confirm locations of built features. These vanishing point grids can be exported as .dxf [or .3ds] files and transferred to RhinoCAD to be reconciled with pointcloud data from the LiDAR surveys [Fig. 5]. In addition, it was hoped that from this data the original geomorphological condition could be hypothetically modelled as a three-dimensional representation to act as a base for further modelling within RhinoCAD of the construction time-line for each harbour.

![Figure 5: Analysis of Serres painting using Adobe Photoshop, RhinoCAD and LiDAR pointcloud data [Shotton, Semar 2016]](image)

Through the use of the ‘Vanishing Point’ tool the pier in relation to the castle [still extant] was modelled and dimensioned successfully in Photoshop and translated to RhinoCAD as a set of three-dimensional surfaces [green in image] which contained dimensional information on the castle, the distance [horizontal and vertical] from the castle to the pier, and the dimensions of the elevation of the pier as represented in the Serres drawing. The transfer of the Photoshop data was not without its problems, as the imported data requires rescaling and reorientation once imported. The dimensions used to properly rescale the imported model were taken from the ‘Vanishing Point’ tool in Photoshop. Within the RhinoCAD environment the partitioned pointcloud sub-model of the 1807 pier [including castle] was loaded [black] and the castle modelled as a three-dimensional form [yellow] where it was correlated with the model from the Photoshop tool. Based on the elevation surface for the pier in the imported Photoshop model a three-dimensional pier was modelled [red], though its breadth remains unverified, as Serres’ drawing does not contain this information. With this data modelled the image was rotated to simulate the view of the castle and pier represented in Serres’ painting, stripped of the Photoshop data, and re-exported as an image file to be overlaid on the Serres image in Photoshop to verify the
model. This sequence of operations allowed us to successfully pinpoint the location of this pier in plan view in the RhinoCAD model.

While the Serres painting proved amenable to the use of ‘Vanishing Point’ analysis in Photoshop, the Place drawing, due to the irregularity of the rock surfaces and the limitations of the grid analysis tool, which only allows for rectangular grids, proved impenetrable. An alternative methodology was employed in this case, and later used on the Serres image as well, in which the images were imported to Cyclone, the native pointcloud software for Leica scan data, and overlaid on the scan data in perspective view [Fig. 6]. The scan data could then be rotated until sufficient correlation with the castle view was obtained. In the Place drawing, this allowed us to ascertain that the location of these early piers correlated quite closely to the current piers built in the nineteenth century, as well as clarifying the location of the current west quay wall immediately forward of the rocky foreshore drawn by Place. This insight was used to model and position hypothetical ‘medieval’ piers in the RhinoCAD model and test the accuracy of their location against the Place drawing in the same manner as was undertaken with the Serres painting. It was using this methodology that confirmed that the piers drawn by Place aligned very closely to the fragments of the ruined east pier visible in the LiDAR scan data.

Figure 6: Bullock Harbour, Co. Dublin, Ireland, LiDAR scan data 2016 overlaid on Frances Place 1699. [Shotton, Semar and Place, 2016]

Preliminary Conclusions
The pilot project is not yet complete, thus results are currently provisional. We have been extremely fortunate in the study of Bullock to have the expansive range of historic images to work with in the analysis, all of which reference the still extant castle. It was likely the existence of this castle, in close proximity to Dublin, which incited such a degree of interest from artists. We are equally fortunate that the castle survives relatively intact, allowing it to be scanned and used as a reference point in the interrogation of the historical images. This is certainly not the case for the majority of small harbours in the survey, which have less imagery available [though often more archival information], and very few with a castle for a reference point. Thus, the analysis of each harbour will present its own challenges and demand modified procedures for interrogation and reconciliation of the information sources.
The limitations of the 'Vanishing Point' tool in Photoshop were disappointing and have obliged us to experiment with alternative forms of visual analysis. The superimposition of image on the LiDAR pointcloud is useful, but depends heavily on the judgment of the viewer and lacks any form of verifiable, mathematically derived dimensions. An alternative we intend to test on the Place drawing is a more conventional perspectival analysis, using a reverse two-point perspective analysis to derive a plan and elevation from the image. This plan and elevation will then be modelled in the RhinoCAD environment and exported as an image file to test its correlation with the original image.

We were also fortunate at Bullock that the harbour, including the seabed exterior to the piers, runs dry at low spring tides, which enabled a full scan of the built infrastructure and seabed using LiDAR. For the remainder of the harbours underwater sonar scanning will be necessary to capture both the seabed and the portions of infrastructure under the waterline, which will be merged with the terrestrial LiDAR pointclouds to create comprehensive three-dimensional forms. Fortunately, for a selection of harbours [Port Oriel, Balbriggan, Fethard] this seabed data has been made available to us from Hydrographic Surveys Ltd. The remainder will be surveyed later this summer.

Future plans for enabling more accurate interpretations of the historic data will also involve the use of ground penetrating radar to obtain profiles of the internal construction of the built elements, which in the case of Bullock may confirm the presence of the eighteenth century western pier visualized in Serres’ painting.

The extraordinary level of detail present in the LiDAR scan files is imperative to retain, though difficult to manage due to the file sizes. Options for web-based pointcloud viewers, which can scale the data to the appropriate resolution as one orbits and zooms to particular parts of the cloud, are currently being investigated by the University's Digital Library team to facilitate placing the original scans on the library site for public access. The ambition to create a fully linked information database with the model, as described in Caldwell’s work, may be difficult to achieve in tandem with a scalable pointcloud interface, thus may require an additional form of visualization to be included in the digital record such as a three-dimensional timeline model. Thus, the appropriate form of digital record configuration for the digital library is still in a development phase.

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**Endnotes**


**Figures**

*ElizabethShotton_DrawingFutures_01.tif*

Figure 1: Bullock Harbour, Co. Dublin, Ireland. LiDAR scan data. [Semar, 2016]

*ElizabethShotton_DrawingFutures_02.tif*

Figure 2: Bullock Castle and Harbour, Frances Place, 1699. [Image courtesy of the National Gallery of Ireland]

*ElizabethShotton_DrawingFutures_03.tif*

Figure 3: Bullock Castle, John Thomas Serres, 1788. [Image courtesy of the National Gallery of Ireland]

*ElizabethShotton_DrawingFutures_04.tif*

Figure 4: LiDAR image of east pier with hewn stone construction highlighted. [Shotton, 2016]

*ElizabethShotton_DrawingFutures_05.tif*

Figure 5: Analysis of Serres painting using Adobe Photoshop, RhinoCAD and LiDAR pointcloud data [Shotton, Semar, 2016]

*ElizabethShotton_DrawingFutures_06.tif*

Figure 6: Bullock Harbour, Co. Dublin, Ireland, LiDAR scan data 2016 overlaid on Frances Place 1699. [Shotton, Semar and Place, 2016]