Geological Survey of Canada
Open File 8959

MAKING A THREE-DIMENSIONAL MODEL OF HALIFAX HARBOUR, NOVA SCOTIA, CANADA

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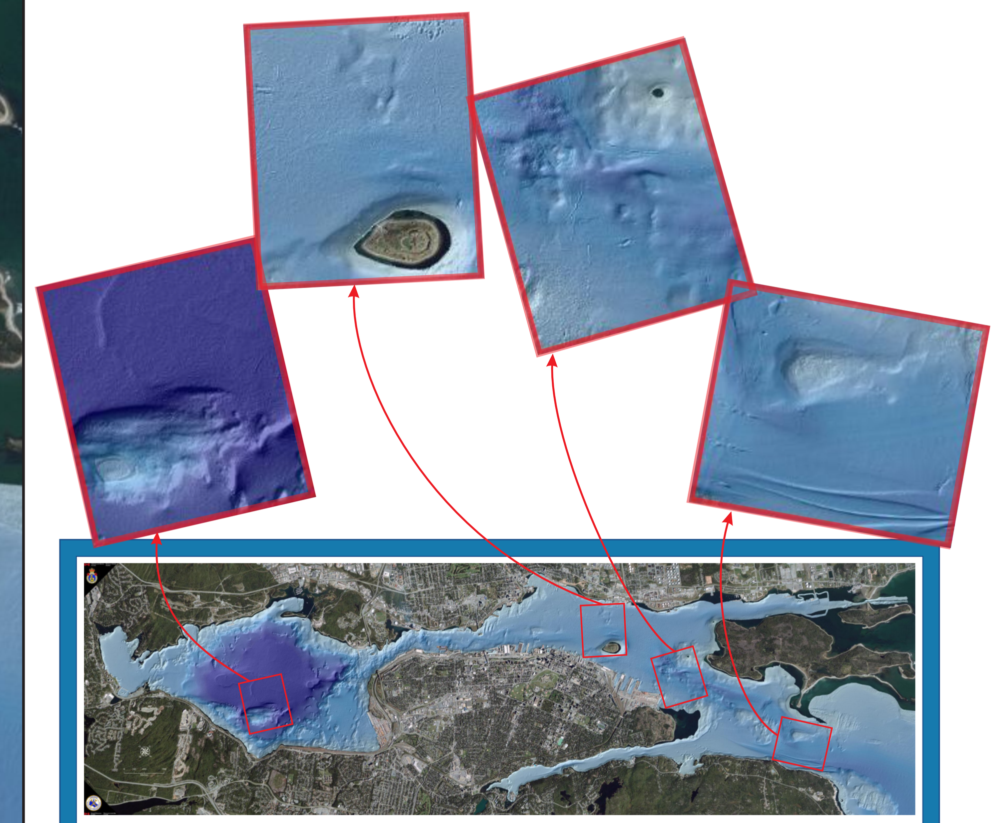
INTRODUCTION

Halifax Harbour is one of best-studied harbours in the world. Researchers at the Bedford Institute of Oceanography map the seabed, perform geochemical analyses of sediment core samples, measure currents and tides and study the effects of pollution on the biota.

To illustrate the complexity and intricate detail that exists on the seabed, a physical relief model of the harbour and surrounding area was constructed using the most recent technology. The model, which was milled from lightweight surfboard foam, shows underwater relief (bathymetry) as well as the land topography. Onshore, high-resolution satellite imagery was "draped" over the topographic relief using a specially designed 3-D plotter. In underwater areas, bathymetry is represented by a suite of colours ranging from light blue, to indicate shallow areas, to darker blue for deeper water. Computer generated shading was applied to emphasize detailed texture.

Four "zoom" panels were also produced to focus on some of the finer details that are evident in the seabed. These details help us understand more about the harbour's geological history as well as the processes that are active today, both natural and man-made.

This poster explains the many stages in the process of creating the Halifax Harbour relief model.



Locations of 1:3 000 scale models within the main harbour model.

Step 1

Discuss the available technologies and decide on which one to use. In our case, we chose Solid Terrain Modeling Inc. Decide on the aerial extent or coverage of the model, i.e. how large of an area the model will cover and what orientation the model will be with respect to the harbour (See Fig. 1).

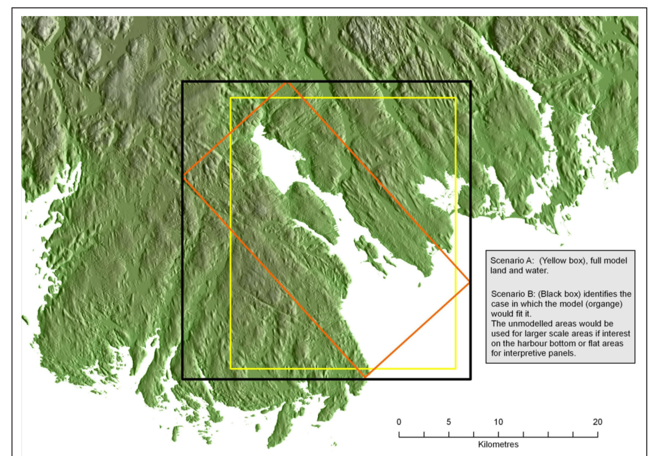


Fig. 1: Different options for orientation and coverage of terrain model.

Step 2

Find the available data sources: in our case, they are Canadian Hydrographic Service multibeam data archives (see Fig. 2), Service Nova Scotia and Municipal Relations Digital Elevation Model (DEM) (see Fig. 3) and air photos, photo mosaic or satellite imagery. An available Department of National Defense (DND) air photo mosaic (See Fig. 4) was tested for coverage against the area we wanted to build the model of, however, the coverage did not suit our needs. We chose a single satellite image from Digital Globe (Quickbird™) to provide the imagery (see Fig. 5).

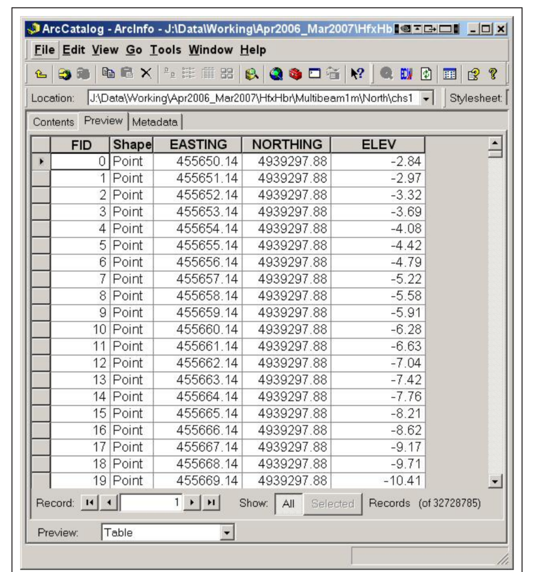


Fig. 2: 1 m multibeam tabular data for the northern half of the data within our model area.

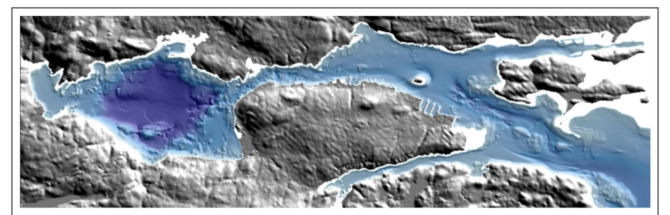


Fig. 3: 20 m DEM with multibeam bathymetry.

Fig. 4: Department of National Defence aerial photo mosaic of Halifax. Note the orientation of the mosiac does not work for our model.

Fig. 5: Digital Globe Quickbird™ satellite image (60cm resolution).

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Step 3

Build the multibeam bathymetry coordinates and elevations into a digital elevation model (DEM). We chose to build a 1 metre DEM as this was close to the resloution of our satellite image (60 cm) and gave us sufficiently high quality imagery that revealed details of the harbour bottom (see Fig. 6).

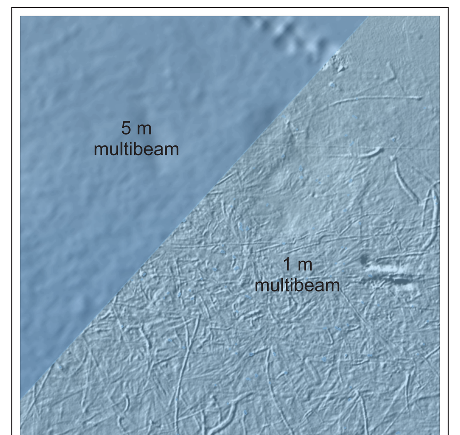


Fig. 6: Note the information available in the 1 metre multibeam vs. the 5 metre multibeam.

Step 4

Create a coastline that can be used to trim the multibeam bathymetry so that it does not overlap important features in the satellite image such as wharves, docks, shipyards and piers.

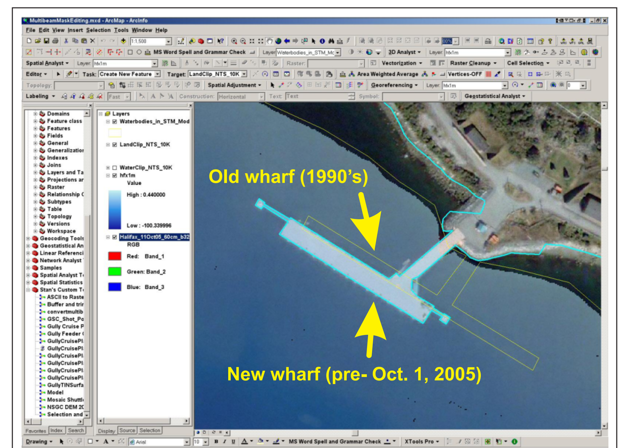


Fig. 7: Editing the 1:10 000 scale coastal map series to fit the multibeam trimming boundary to the satellite image.

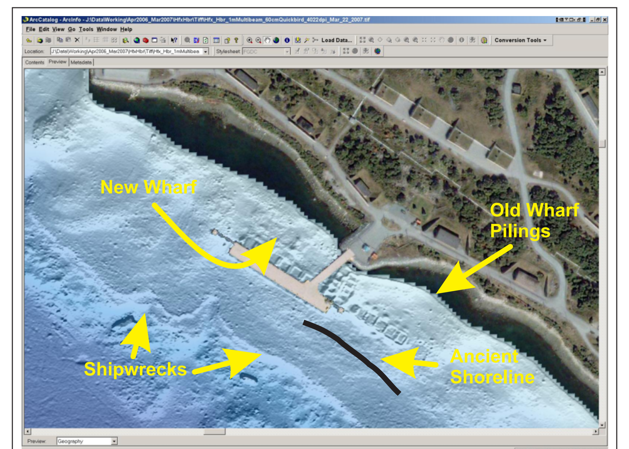


Fig. 8: Visualizing changes to wharves along the harbour through time. Note the old wharf pilings in the multibeam image compared to the modern wharf. This change was within a few years, between when the multibeam was collected and the satellite image was taken.

Step 5

Merge the land DEM and the bathymetry DEM at the two scales for the models we are constructing; the small scale for the full harbour model (See Fig. 9) and the large scale for each detailed model.

Fig. 9: 12 m DEM for the full Halifax Harbour model.

Step 6

Edit the merged DEM to fix locations where the DEM of the wharves, docks or piers did not create a level elevation surface for the satellite image of those locations. We did not want locations like the BIO wharf to have mountains on it (See Figs. 10, 11).

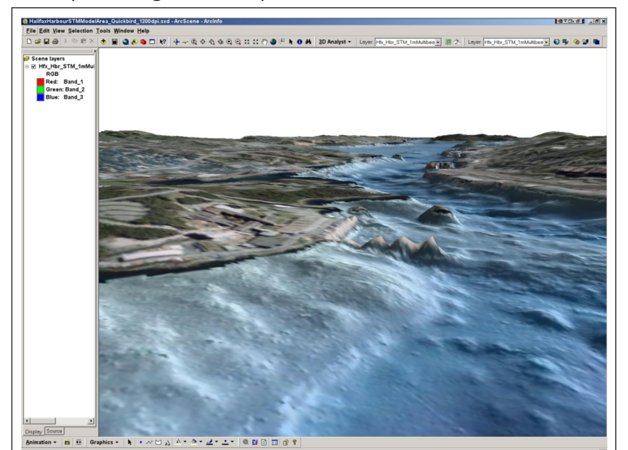


Fig. 10: Obviously the wharf at BIO should be horizontal in the finished model, although this rendition would make a case for all terrain vehicles at the institute!

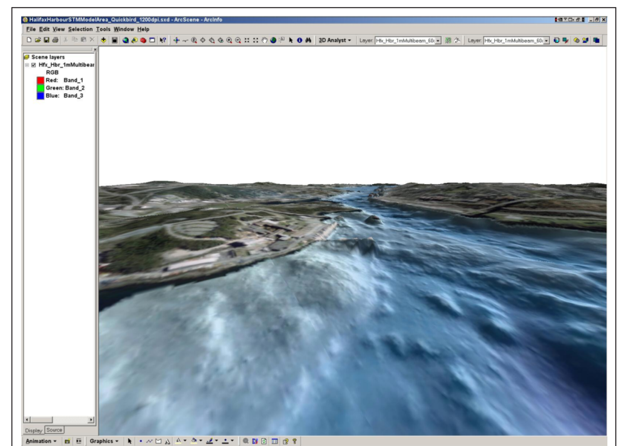


Fig. 11: Post DEM correction, the wharf is level enough and close enough to sea level so that in the finished model it will look correct.

Step 7

The data for all five models was exported in the requested format consisting of a file of coordinates for the elevation surface for each model, as well as the image file which is used to paint the satellite image and coloured and shaded multibeam image onto the cut model.

Step 8

The digital coordinate file is input into the Solid Terrain Modeling Inc.'s computer controlled cutting machine which proceeds to cut the model out of high density foam (see Fig. 12).

Fig. 12: Example of cutting the high density foam for a solid terrain model, via computer controlled drill press with three axis of movement.

Step 9

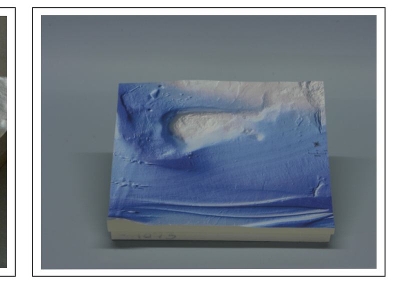
The cut model then has the imagery painted on the surface using something similar to an ink jet printing system, although it is highly specialized for this purpose only, using industrial, large format printing technology (see Fig. 13).

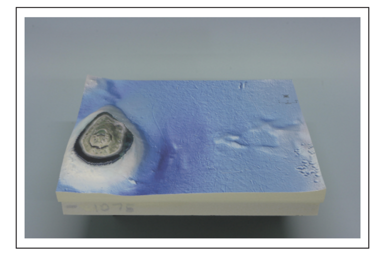
Fig. 13: Printing the colour imagery on top of the terrain model using a specially designed inkjet printing system and inks. The print heads have to stay extremely close to the surface to create sharp photo-realistic images on the model surface.

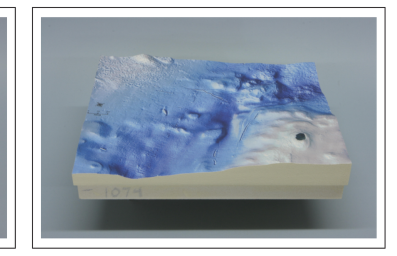
Images of the Halifax Harbour pre-painted and painted models:

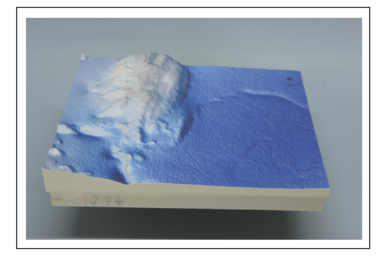
Halifax Harbour main and detailed models freshly cut and ready for the printing process.

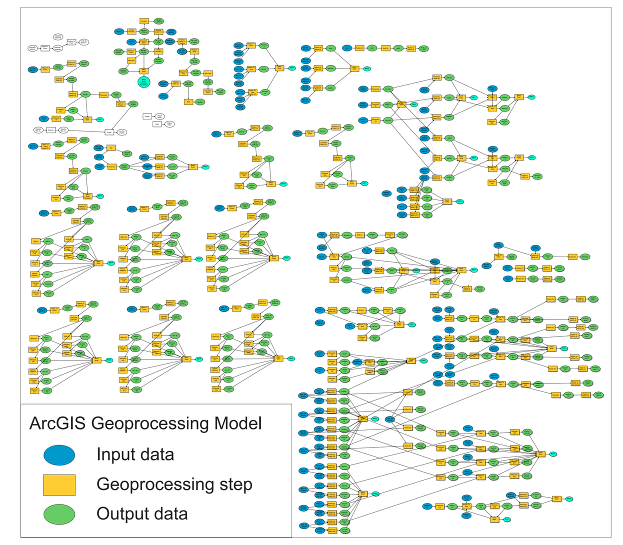
Pre-image printing close up of Point Pleasant Park and Georges Island on the main harbour model.











ArcGIS Geoprocessing Model created specifically for the purposes of processing all necessary data for the Halifax Harbour model. Several hundred hours of processing were needed within the model builder to accomplish the necessary automated steps for the project.

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