Hydrographic surveys

Anglian Coastal Monitoring

August 2016 1.1

This document describes the coastal hydrographic surveys and bathymetric data collected by the Anglian Coastal Monitoring project.

The Survey

How we collect bathymetry data

Bathymetry data for the Anglian Coastal Monitoring project is collected using a Multibeam Swath Bathymetry System. A multibeam echosounder (MBES) is used to collect bathymetric soundings and provide us with measurements of sea bed elevation as well other subsea features such as wrecks and infrastructure. The Environment Agency has one bespoke shallow water survey vessel called 'Sentry III', which is utilised for the majority of our survey work. A number of other vessels are also available to use when the required survey area is beyond the range of Sentry III. Sentry III is equipped with a Teledyne Reson Seabat 7101 multibeam echosounder and where necessary this equipment can be transferred on to another vessel.

To carry out a survey on the east coast, our proposed coverage areas are first split into survey blocks (polygons) of approximately 3 km x 1 km. Within each polygon the survey vessel will run a number of survey lines parallel to the shoreline until full seafloor coverage is achieved.

The sea bed depth is measured from the return signal of acoustic pulses emitted from the MBES. As the vessel navigates the survey lines, the MBES pulses (pings) at a frequency of 240 kHz along an angled swath. As these pulses reflect off the bed and back to the boat, a receiver measures the return from 511 individual beams across the swath for each pulse. The instrument's swath width is a function of the programmable maximum swath angle, typically 140 degrees, and the depth of water below the survey vessel.

Figure 1: Sentry III survey vessel

To calculate seabed elevation, the travel time of each acoustic beam is measured by the instrument. The speed of sound in water is typically around 1500 m/s but this varies depending on a number of factors including salinity, temperature and depth. Therefore, the sound speed is constantly measured at the multibeam transducer head using a Valeport miniSVS sensor. Periodically, a full speed of sound profile is also taken by lowering a Valeport miniSVP sensor from the surface to the sea bed. By knowing the speed of sound and travel time for each beam, the distance or 'range' that each travels can be calculated.

The vessel is also equipped with a Position and Orientation System (POS) including dual GNSS receivers and an Inertial Measurement Unit (IMU). This calculates the precise position of the vessel in X,Y,Z and also measures changes in pitch, roll and yaw. Where the vessel is impacted by sea conditions, accelerometers and gyroscopes in the IMU measure this and correct the multibeam data. Changes in tide are accounted for by the accurate measurement of the vessels elevation from the POS GNSS receivers and therefore a separate tide station is not required. All position data is logged and post-processed using POSMMS software with reference to the permanent active network of OSNET base stations around the UK in order to further improve the accuracy of the position and orientation data. The POS system is also responsible for synchronising the time of all sensors used for the survey and it uses a PPS signal as well as GPS time for this purpose.

Figure 2: Left: Transducer (installed on CSV Thames Guardian). Right: Installed Inertial Measurement Unit (IMU)

Specification

Surveys are conducted according to the latest version of the Environment Agency's *National Standard Contract and Specification for Surveying Services, Standard Technical Specifications*. Please see this document for more detail.

In order to meet with specification the multibeam system is calibrated at the start of every project through a ‘patch test’ calibration where the residual roll, pitch and yaw offsets of the sensor can be calculated. Where possible in intertidal zones, multibeam data is also compared to data captured using traditional landsurvey techniques and to LiDAR data where there is overlap between the data sets.

In order to continuously check multibeam bathymetry data is within specification, check lines are also surveyed in each polygon using an independent system from the same vessel. The check system consists of a Teledyne Odom CV100 singlebeam echosounder coupled with a separate Leica GS10 GNSS receiver. In each polygon this system is used to survey two lines perpendicular to the shore intersecting all multibeam data, and one line diagonally across the whole polygon and extending into neighbouring polygons for further comparison (Figure 3). This data is then compared to the multibeam surface to ensure that it meets with specification.

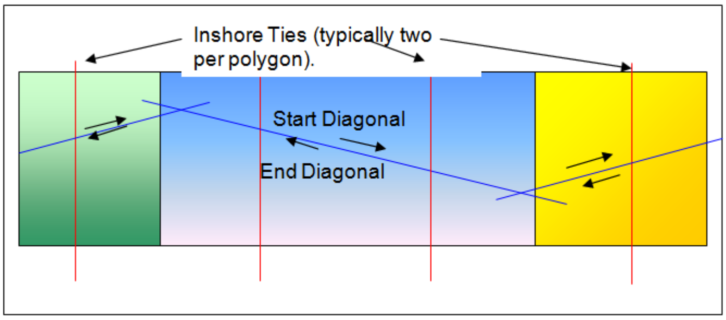

Figure 3: Diagram of survey check lines used to verify the multibeam data

All multibeam swath bathymetry data collected must also comply with the Civil Hydrography Programme survey specification (August 2013 or later). Additionally, all data collected in shallow water (defined as <40 m depth), and estuarine and riverine environments are required to meet the *IHO S44 ‘Special Order’ Specification*. Extra criteria apply in riverine environments where the total vertical uncertainty shall not exceed a maximum of 0.15 m.

Survey timing

Hydrographic surveys are carried out to coincide with the time of High Water, usually on a Spring tide in order to achieve the required landward extent. Coastal surveys are usually completed during the summer months where the sea state is most favourable.

The data

Processing

The raw surveyed swath lines are input into a project within CARIS HIPS and SIPS™ processing software. The project contains a vessel configuration file, which contains all of the patch test calibration values, and the distance offsets and angles for all of the sensor installations. The lines are then blended with SBET trajectory (a combination of attitude and position data) and the speed of sound profile. The TPU error (Total Propagated Uncertainty) for each point is then calculated, and finally a Combined Uncertainty and Bathymetry Estimator (CUBE) surface is generated. The CUBE surface is generated by running a set of iterative calculations to determine the best representation of the terrain in the surveyed area.

The CUBE surface is then cleaned by automated filters to remove noise, outliers and any anomalies in the data. Any remaining outliers or anomalies can subsequently be removed during manual cleaning. During cleaning, the individual points are not deleted permanently, but rather assigned a designation of either ‘Accepted’ or ‘Rejected’. If data are rejected by the automatic filters, but are subsequently deemed to be acceptable, they can be re-designated.

The surface is visually quality checked for any remaining anomalies or data gaps, and then compared to the singlebeam dataset that was collected independently to confirm that it meets the error specification for the project.

The collected multibeam data also contains backscatter information. Backscatter is essentially the strength of the sounding return, and can be used to create an image of the sea floor that, when combined with other data such as grabs, can indicate the bed surface type. A tool within the CARIS software called Geocoder is used to create a grey-scale mosaic of the beam-averaged backscatter data.

Data outputs

The output surface data is normally supplied as a raster product of 1 mm x 1 km ASCII XYZ files. However can be supplied as ASCII Grid, HTF (Hydrographic Transfer format), STL (Stereolithography) or as a point cloud.

Swath lines can also be outputted individually in a number of formats, including ASCII XYZ, GSF (Generic Sensor Format), DXF (Drawing Exchange Format), or GML (Geography Markup Language).

Backscatter data are supplied as a raster surface GEOTIFF.

The data are delivered in the OSGB36 Easting and Northing coordinate system with Orthometric heights (Above Ordnance Datum) and transformed using the relevant Ordnance Survey Transformation algorithm.

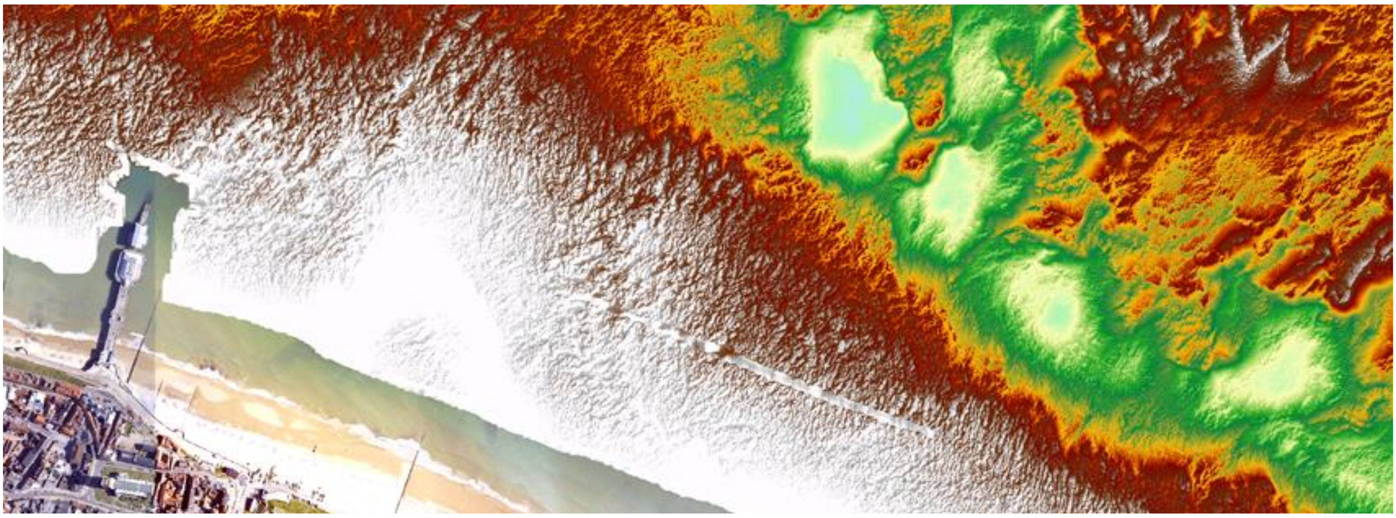

Figure 4: Multibeam bathymetry off Cromer, Norfolk.

Resolution

The Mulibeam and Singlebeam Bathymetry Systems map the sea bed at a 0.5m resolution.

Analysis

The project has aimed to survey the nearshore (Low Water to 1 km offshore) of the East coast and all of our estuaries. This has revealed what the seabed off our coast line looks like and what features exist. Subsequent surveys will capture how some of these features, such as sandbanks, have moved and changed. Understanding our nearshore helps us identify sediment transport pathways and assess how features influence our coast line. For example, the susceptibility of our coastline to storm wave impact is dependent on the nearshore wave transformations, the underlying morphology and how these features modify incoming waves. The multibeam data capture many of the features important to the dynamics of the coastlines and are therefore useful to a variety of stakeholders. For example combined with aerial LIDAR data (as seen in Figure 6) the datasets are used in the Environment Agency's models used to produce flood maps.

Figure 5: Multibeam bathymetry data merged with aerial LIDAR of Hamford Water, Essex.

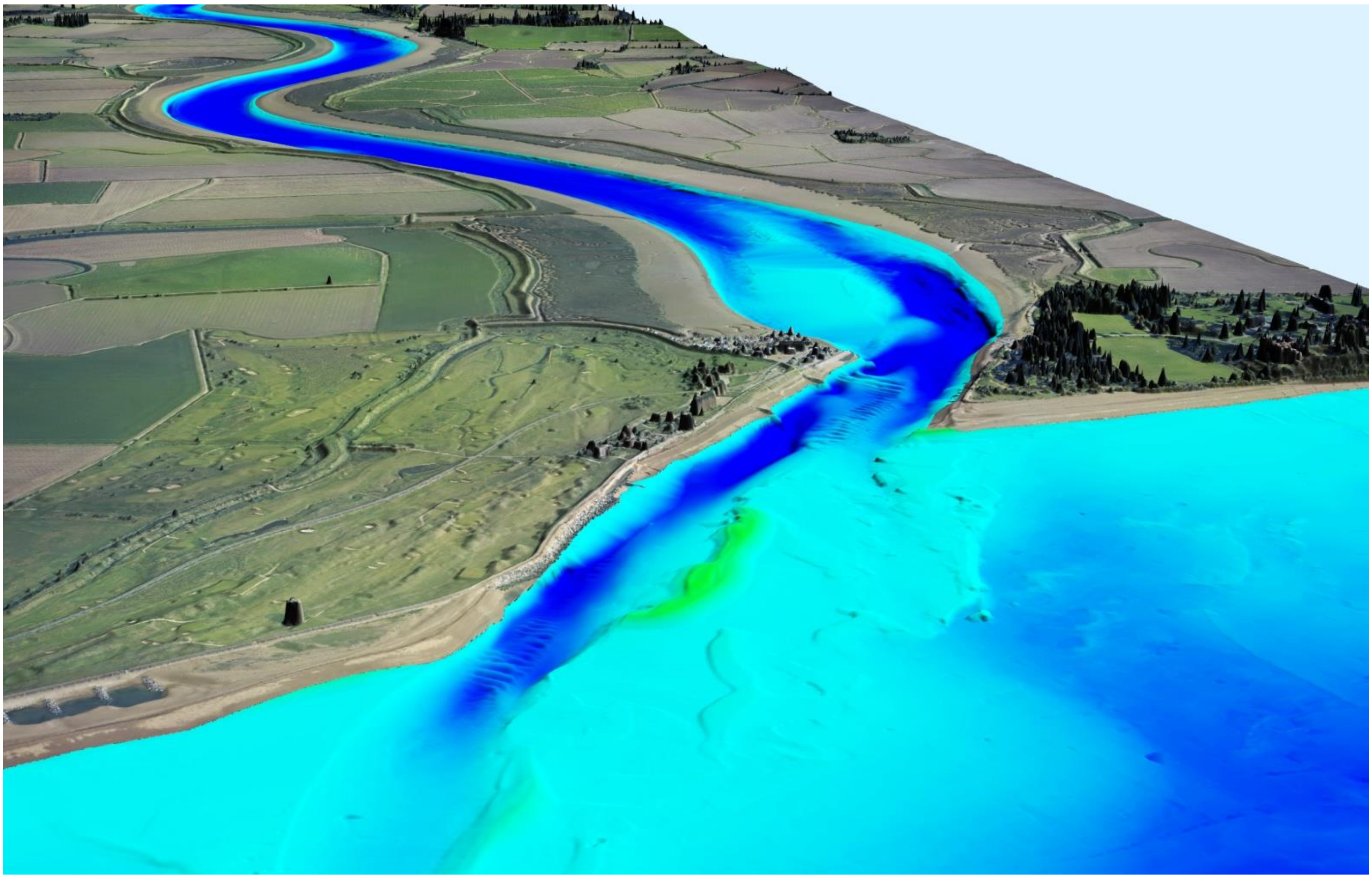

Figure 6: Aerial photography overlying multibeam bathymetry of the River Deben and The Knolls, Suffolk.