# VDatum and SBET to Improve Accuracy of NOAA's High-Resolution Bathymetry

**US HYDRO 2007**

**Extended Abstract**

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## Introduction

NOAA's Hydrographic Surveys Division (HSD) and Hydrographic Systems and Technology Program (HSTP) have recently worked together to test methods to improve vertical and horizontal accuracy of high resolution bathymetry. Findings from these assessments will allow for implementation within the standard data processing workflow aboard their fleet of hydrographic survey vessels. The methods tested were the application of Smoothed, Best. Estimated Trajectory (SBET) and reduction to a common datum using VDatum. This paper will discuss the process and analysis of these methods.

VDatum is a transformation tool developed by National Oceanic and Atmospheric Administration's (NOAA) National Ocean Service (NOS) and National Geodetic Survey (NGS) scientists to resolve discontinuities amongst data projections specifically bathymetric, topographic and coastal data products (Gersch, 2001). Topographic and bathymetric data are typically collected independently for different purposes making it difficult to use them together at the land/water interface. This is a result of differences in format, projection, resolution, accuracy, and different geoidal, ellipsoidal, and tidal vertical datums (National Research Council, 2004). Development of the VDatum geospatial framework software allows data sets acquired in numerous datums to be transformed into a common datum removing the inconsistencies between land and sea data products (Parker, 2003).

The Vdatum transformation tool was designed to accommodate 28 data transformations in three classes of vertical datums: orthometric, ellipsoidal and tidal (Meyers, 2005). Often the discontinuity between these datums renders the utility of data useless, particularly in dynamic near shore areas (Meyers, 2005). The solution is a seamless data product within a common geospatial framework consisting of a coordinate system, horizontal datum and vertical datum (Gesch, 2001). Vdatum has emerged as the best fit for this solution (Meyers, 2005).

This paper will detail VDatum and in particular it's potential to be used within NOAA field units' data processing regimes; more specifically how VDatum might improve the accuracy of high-resolution bathymetry. This paper will detail the results of analysis on a data set acquired on the Elizabeth River in Norfolk, Virginia and incorporates high-resolution multibeam and topographic LIDAR data.

## Background

In December, 1999 at a meeting of Tampa Bay coastal managers, a concern was loudly voiced about the difficulty using United States Geodetic Survey (USGS) and NOAA data concurrently (Gesch, 2001). While this consensus was not new by any means, it prompted the community to search for a way to integrate the varied data sources into one useable datum. This was particularly the case when using old sparse data with new more dense data. To most coastal managers data consistency is more important than accuracy (Gesch, 2001). The need for a solution encouraged the emergence of VDatum and the Tampa Bay test project as stated in a National Research Council's project recommendation:

> *In order to combine onshore and offshore data in a seamless geodetic framework, a national project to apply Vdatum tools should be initiated. This will involve the collection of real-time tide data and the development of more sophisticated hydrodynamic models for the entire US coastline, as well as the establishment of protocols and tools for merging bathymetric and topographic datasets (National Research Council, 2004).*

The first proof-of-concept project was performed on a dataset in Tampa, Florida (Parker, 2001). The diverse sample dataset incorporated USGS topography elevation data, NOAA bathymetry, and 3rd party topographic LIDAR (Gesch, 2001). Each data were from different eras of technology and different datums.

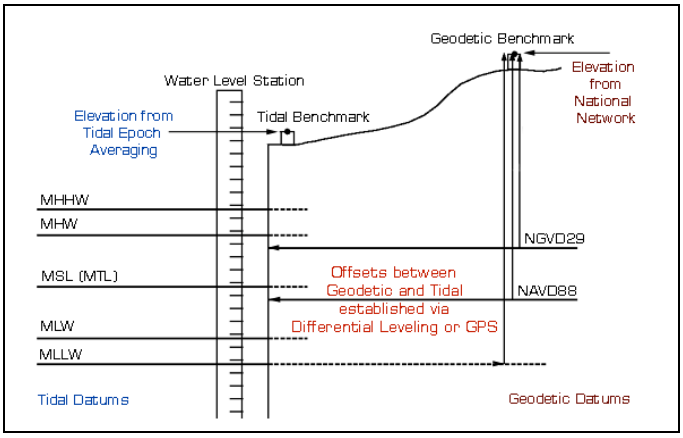
The topography for the Tampa Bay region was extracted from the USGS' National Elevation Dataset (NED) (Gesch, 2001). The NED is a seamless raster elevation dataset at 30-meter grid spacing. Elevations are referenced to the North American Vertical Datum of 1988 (NAVD – 88). The bathymetry was extracted at varying resolutions from NOAA's Hydrographic Survey Database at the National Geophysical Data Center (NGDC). The reference vertical datum was either Mean Low Water (MLW) or Mean Lower Low Water (MLLW). A vertical datum transformation was required to place both data sets into a common vertical reference frame for mapping. This was accomplished using Vdatum (Gesch, 2001). Once a common vertical datum was accomplished with the combined data, a digital elevation model (DEM) was generated at a resolution of 30-meters.

**Project Information**

The Office of Coast Survey (OCS) operates the Coast Survey Development Lab (CSDL) where technologies such as VDatum have emerged. Analysis of SBET and Vdatum was performed using the common data set acquired for the OCS 200-year Anniversary and the US Hydro 2007 conference in Norfolk, VA. High-resolution bathymetry and topographic elevation data were transformed using SBET and Vdatum. This area was the ideal setting. There is minimal sea action as it is an enclosed area; there is quality adjoining topographic elevation data readily available.

The bathymetry for the common data set was acquired aboard the Bay Hydrographer. This is a 57' vessel built specifically for nearshore hydrographic surveying and is outfitted with hull-mounted Reson 7125 multibeam sonar. This system collects 256 beams of sounding data each 0.5° x 1.0° at a frequency of 400 kHz (Reson, 2006). This system provides near 100% ensonification of the seafloor depths up to 300m (Reson, 2006).

Using the Tampa Bay project as a template for this research, the common dataset incorporates bathymetry and topographic LIDAR. Typically NOAA's high-resolution bathymetry is reduced to the Mean Lower Low Water (MLLW) tidal datum. The variance between MLLW and other tidal and geodetic datums is portrayed below and clearly depicts the need for a transformation solution.



The bathymetry was processed using two methods: standard processing methods which reduce soundings to a MLLW tidal datum with discrete tidal zones and the SBET and Vdatum tools which reduce the common dataset to North American Datum 1983 (NAD83). The SBET/Vdatum dataset was corrected for tides using a tool called Tidal Constituent and Residual Interpolation (TCARI).

**Data Workflow**

The data were acquired summer, 2006 and received by HSTP shortly after. Data were inspected to ensure coverage and some initial quality control was performed. Later the data were gridded using the CUBE algorithm in CARIS HIPS.

Position data were acquired aboard the Bay Hydrographer as a separate file during the acquisition of the bathymetry data. This was done using a program called POS/PAC which extracts a data string the POS/MV. This information was integrated with the multibeam echo soundings motion compensation data, to eliminate the effects of vessel movement, and provide accurate position and orientation information (Applanix, 2006).

The POS/PAC position data string was reduced to chart datum using the POS/PAC software. From there it was transformed to the common datum of NAD83 using Vdatum. The bathymetry was then processed using the standard processing software CARIS HIPS. Each of the three processing methods was then compared using a differencing algorithm in MapInfo.

During the process of comparing the three transformation methods, great detail was noted in the workflow so to create a working document for field users who intend to process data using this method. Once the LIDAR data were available and reduced to the common NAD83 datum, analysis was performed on the agreement between the different data sources using the differencing algorithm in MapInfo.

Using Vdatum to transform data types acquired on separate datums we considerable and improved vertical agreement between the sample data within the common dataset was noted.

**Conclusion**

There is a great hope that integration of SBET and Vdatum into NOAA's hydrographic processing regime will improve vertical accuracy to within 5cm (National Research Council, 2004). As is often the case with emerging technology, the start is slow and in need of testing and repeatable proof. In addition to the benefits offered to the various data processed with these methods their implementation would move ever closer toward the development of a mutually agreed upon "national shoreline".

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