

Coastal Channel Data: Cooperative Production of a NOAA/USACE Data Framework

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Abstract

The United States Army Corps of Engineers (USACE) and the National Oceanic and Atmospheric Administration (NOAA) work closely to provide navigation information to the maritime community. NOAA is responsible for charting the coastline of the United States including the navigation channels that vessels use to transit in and out of the major ports of the United States. These navigation channels are portrayed and described on NOAA products including the Electronic Navigational Chart (ENC). The USACE is responsible for the maintenance and surveying of these navigation channels. The USACE channel data is a key component of the NOAA ENC and of vital interest to the mariner. The channel data includes hydrographic survey information as well as channel limits. The channel limits are referred to as the channel framework.

The channel framework is the basis for portraying information for navigation channels. Channel framework consists of the outside channel limits, quartered sections of the channel as well as reach locations within the channels. Given the advances in survey and navigation technology, accurate channel data and the portrayal of this channel data is even more important than ever. NOAA's ENC product is a part of the advancement in navigation technology and offers the mariner a level of detail that is not available on the traditional paper chart. Given the level of detail on the ENC and the accuracy of the Global Positioning System being used by mariners it is critical to have more accurate data than in the past. NOAA and USACE are working to meet the goal of accurately portraying the channel framework.

Toward the goal of accurately portraying the channel framework the USACE and NOAA are creating respective channel framework databases. NOAA's channel framework data base will aid in the automated processing of USACE data. This automated processing will aid in streamlining the production of NOAA ENCs. As both agencies work toward creating channel framework databases they are sharing data to ensure there are no discrepancies. Through sharing data and open communication between NOAA and the USACE both are meeting the common goal of better serving the maritime community.

National Oceanic and Atmospheric Administration

NOAA's ENC product

The National Oceanic and Atmospheric Administration's (NOAA) Electronic Navigational Chart (ENC) is a major component of its charting program and is to be the lead product in the future. The ENCs support safe navigation and coastal management with their highly accurate portrayal of topographic and hydrographic data. Originally to accelerate the production of the ENCs much of the data was compiled from the raster chart product. Given the inherent positional error that this procedure may have introduced into the ENC product NOAA is embarking on an effort to baseline the data portrayed on the ENC. This will better serve the ENC users who are increasingly utilizing more accurate positioning tools. A major component of this baselining effort is the accurate

portrayal of the United States Army Corps of Engineers (USACE) maintained navigation channels.

NOAAs partnership with USACE

NOAAs Marine Chart Division (MCD) is responsible for charting the territorial waters of the United States of America. MCD meets this responsibility by producing the traditional paper navigation chart, Raster Navigation Chart (RNC) and the ENC. A key component of these products are the navigation channels used to transit in and out of the ports of the United States. The USACE maintains and provides MCD with data for these channels. This data includes the location and hydrographic condition of the channels.

What USACE provides MCD

The condition of navigation channels is reported to MCD by USACE on a regular basis. As the USACE performs hydrographic surveys of the maintained channels they provide MCD with the results of these surveys. The survey results are provided on survey sheets and/or channel condition reports. Hydrographic survey sheets depict the hydrography within the maintained channel as well as the channel limits. The surveys are either a condition or after dredge survey. A condition survey, among other things, depicts hydrography prior to dredging operations and the after dredge survey shows the results of dredging operations. Channel condition reports are a tabulated format of the results of a hydrographic survey. The channel condition reports contain the names of all the reaches in a particular channel. Along with each reach name the project dimensions are listed and they include the reach's width, project depth and length. Additionally for each reach controlling depths are listed for the separate quarters of that reach and the date of the survey from which those controlling depths were taken. The controlling depths are determined by USACE and are the shoalest depths for that quarter of the reach. A channel condition report will also contain more detailed information concerning the location of extreme shoaling or obstructions that may be located in the channel.

In addition to data about the condition of channels USACE provides MCD with the location and geometry of channels. This includes the location of any new channels as well as the realignment of existing channels as project dimensions change.

MCD portrayal and analysis of USACE data

Using the data provided by USACE, MCD portrays this critical channel information on its products. Survey sheets and channel condition reports are received in both hard copy and digital format depending on the USACE district and the arrangement worked out with that particular district. MCD cartographers analyze this data and apply it to MCD products. The controlling depth information is portrayed either as a channel legend, note or tabulation. A channel legend is used to depict the controlling depth and the date of the survey which was used to determine that controlling depth. Legends are used on channels that have a project width that is less than 100 feet wide. Channel notes are also used to show the controlling depths for channels that are less than 100 feet. Channel tabulations are used to depict controlling depths for channels that are 100 feet or greater.

Specifically, channels that have a project depth of 100 to 399 feet are tabulated by two outside quarters and a middle half. Channels with project depths of 400 feet or greater are

tabulated by quarters. These tabulations list the name of the channel reaches, their project dimensions, controlling depths for the quarters in that reach and the date of the survey from which the controlling depths were determined. Given the data it is up to MCD to represent it in the above formats.

MCD examines the data received from USACE and portrays it a manner that will best serve the mariner. Channel surveys are examined by MCD cartographers for controlling depths. The MCD cartographer determines whether or not the channel is to be quartered. If the channel is to be quartered the cartographer quarters the channel then analyzes the data and determines the controlling depths for each quarter. If a channel condition report is available along with the survey sheets then the cartographer will make a comparison between the two to ensure there are no discrepancies. If a channel is not to be quartered then the cartographer will then determine the controlling depth for the entire width of the channel. For channels which MCD only receives a channel condition report and no survey sheets then the data is taken directly from the report and applied to MCD products. Any discrepancies or questions about the data are brought to the attention of USACE and once resolved the data is applied to the MCD products.

MCD is capable of ingesting the various formats of data received from USACE. Currently MCD receives data in hard copy and digital formats. MCD has built data translation into its production system that allows the cartographer to translate the digital data into a format that can be used in the current production system. Hard copy data is analyzed manually and sometimes scanned and imported into the production system. The digital data does provide an advantage over the analog data in that it can be more easily compared to the existing charted data. This is achieved by the cartographer converting the digital data into a format that can then be imported into MCDs production system. The cartographer can then overlay the USACE data on the previously charted data and perform the analysis. The availability of digital USACE survey data offers an opportunity to streamline the processing and verify the accurate portrayal of this data.

MCDs Channel Framework Database

The import, analysis and compilation of USACE data are a major component of MCDs production effort. Given the importance of the navigation channels and the amount of data MCD receives for these channels MCD is interested in automating the processing of the data it receives from USACE and streamlining the incorporation of this data. As more and more digital data is made available to MCD efforts to work toward an automated analysis system have begun. Toward this goal it is important to establish an accurate channel framework to which digital survey data can be compared and act as guide for selecting controlling depths.

MCD has established a channel framework database. The database consists of the outside limits of channels as well as the inside quarters with the most recent controlling depths for those quarters. The database is populated with channel data from the ENC cells. The data from the ENC cells is translated and stored in a shapefile format. The channel limits can be extracted from the database in a shapefile or design file format for chart comparison and compilation. The channel limits on the ENC cells were originally

compiled from the channel limits portrayed on USACE surveys as well as being digitized from the paper and raster chart. Ultimately the source of the channel framework data is USACE.

To ensure that the channel limits contained in the framework database are in agreement with the USACE channel information MCD has begun a baselining project. MCDs baselining project is coinciding with the USACEs own channel framework project. A list of priority channels was established and based on this list MCD has been requesting the channel frameworks from USACE. In addition to the channels on the priority list requests are made for channel frameworks as questions arise in the course of the application of USACE survey data. MCD receives the channel frameworks from the individual USACE districts or from the USACEs Topographic Engineering Center (TEC). Once the channel framework data is received it is applied to the raster and ENC product. Any discrepancies are resolved with the help of the USACE districts as well as the TEC. Once the data is applied to the ENC cell the channel framework database is automatically updated from the cell.

Currently MCD is concentrating on baselining the outside limits of the channels. This is being done due to the fact there are no set standards for quartering channels that are applicable to all situations. The difficulty in quartering arises in channels that have unusual or complicated geometry. It has been decided that MCD will accept the quartering determined by USACE. It is important that the quartering is consistent with that of USACE due to the fact the channel condition reports contain controlling depths based on quarters. Additionally, mariners sometimes use USACE survey data in conjunction with MCD navigation products and any discrepancy would cause the mariner confusion. The USACE is currently working on quartering guidelines. Once these have been established and the data made available MCD will ingest this quartering into the database. Until then channel quartering continues to be determined by MCD cartographers who match the quartering of USACE as best they can.

The discrepancies between MCD data and the USACE data have been for the most part minor. Occasionally there is a significant difference that must be resolved. Working closely with TEC and the individual districts MCD resolves these discrepancies to the benefit of both agencies and the mariner. The project is going a long way in updating MCD products and clearing up some long-standing errors.

To date MCD has baselined 22 channel frameworks for the outside channel limits. Included in these 22 channel frameworks are 14 of the 51 major ports. Channel frameworks include all the reaches in a port that are maintained by the USACE.

United States Army Corps of Engineers

Coastal Channel Framework Database Project

The creation of a centralized channel framework will provide a standardized source for channel data when needed by USACE managers and its partnering agencies. One benefit of this project will be better service of channel data to NOAA's Marine Chart Division.

A great part of this effort revolves around acting as a liaison between the MCD and USACE district survey offices. This coordination is meant to both relieve NOAA's burden of communicating directly with the district, and serve as a single point of contact for both the districts and NOAA as well.

Information Delivery to NOAA

The coastal channel framework database project grew out of the need to ensure timely and accurate data delivery to NOAA for the purpose of updating their electronic navigational charts. The USACE is required to deliver updates to NOAA any time channel conditions change, and regularly through the use of standardized channel condition reports. One USACE navigation and dredging manual calls for the delivery of "...[d]escriptions of changes in channel location and depth, or of obstructions that may be discovered, with such prints and other information as may be necessary to permit the existing charts to be corrected to date." (EP-1130-2-520, p. 2-2)

While the USACE's data requirements call for a movement towards delivery of all channel data digitally, most channel condition information is passed to NOAA in a format not directly accessible by geospatial systems. Delivering channel condition reports digitally should become easier after the completion of the channel framework database.

Building a Standardized Channel Framework Database within the USACE

With very few exceptions, USACE channel data exists at the district level as computer aided design and drafting (CADD) files of one flavor or another. While CADD is the preferred method of data storage for producing design drawings or survey reports, data built for CADD-friendly projects is not easily converted to a GIS compatible data structure unless that conversion was planned during data compilation. The coastal channel framework will house data with topology. Getting from a CADD format to a GIS format presents topological challenges that must be accommodated from the perspective of implementing standards.

CADD standards and GIS standards exist for USACE districts, but gaps exist for dealing with the creation of channel specific feature data. The USACE has been directed to be SDSFIE compliant (Spatial Data Standard for Facilities Infrastructure and Environment), which will greatly serve the needs of the coastal channel framework database. Change recommendations must be submitted to identify new feature types that match the coastal framework's feature requirements.

When comparing the International Hydrographic Organization's S57 data standard with the SDSFIE standard, other issues surface. Cross mapping of data features between standards has begun with great success, but how are channel specific features in both standards, that serve the needs of both the USACE and NOAA, defined? Consider channel quarters as an example. The IHO S-57 standard applies the 'dredged area' feature object to represent channel quarters, but there is no equivalent feature type in the SDSFIE standard. At least one district recommended the use of the channel tangent area feature

for the capturing of channel quarters, wideners and turning basins. However, growing the SDSFIE to incorporate these specific feature types is a better long-term solution.

The database that emerges from these efforts must improve the workflow of data creation and dissemination in the USACE, must serve the data needs of both the USACE and its customers, and must be able to adapt to future data requirements. One goal is to create a database that can provide data to customers as well as crews aboard survey vessels, reducing the number of different data sets maintained and distributed for the same channel features.

One USACE district designed a database that houses all channel data in a three dimensional, SDSFIE compliant database, capable of sending and receiving data over the internet. District survey managers can upload their most recent channel survey to the database via the internet, and also download the most recent feature files for the channel. This database is also capable of serving channel data directly to survey systems on survey vessels. This design has reduced labor costs associated with the creation of multiple survey files intended to serve slightly different data needs. Ultimately, one data file, housed centrally could serve most data needs, reducing labor costs significantly.

Channel Condition Reports and Channel Quartering

To date, the USACE continues to utilize a tabular system for reporting channel condition reports. This standardized form calls for the structuring of such reporting into either three, or four channel sections depending on the width of the channel in question. All channels 400 feet wide and greater will report each section, or reach of the channel in four quarters. Channels 100 feet to 399 feet in width will make use of three sections for reporting purposes.

While this system of reporting allows for the delivery of data that matches the "dredged area" features in NOAA's S-57 compliant Electronic Navigation Charts, it is becoming widely accepted that a more densely populated collection of soundings would provide the mariner with a more detailed picture of the channel depth along the entire channel course. Depths are reported for long stretches of the channel called reaches. These reaches can be several miles in length. Passing only one depth for that entire channel reach has led to discrepancies in data reporting.

USACE districts generally have not incorporated these channel sections, or quarters into their digital data sets. While a district may have data accurate to within a centimeter for channel toe features, because they have been accustomed to report channel depths to NOAA using paper forms (delivered in *.PDF format in most cases), there has not been, to date, a call to transition toward digital reporting of these feature depths while structured within a dataset capable of being utilized in a GIS-friendly world. The channel framework project hopes to resolve that issue, but a standardized approach is needed. Of those few districts that do possess channel quarters for their channels, many suggest that assigning just one depth to an entire reach seems anachronistic, at best. Balancing the need to report channel "authorized" and "maintained" depths with the ability to pass

depth information at a higher resolution over the length of a channel is part of the USACE's challenge.

Metadata

Metadata remains a critical element to an accurately portrayed channel framework. Executive order 12906, established the need for metadata to be created, beginning in January of 1995, for all digital data produced. The USACE calls for the implementation of the metadata standard and also allows that no additional funds will be provided to implement the aforementioned executive order.

USACE data is extremely accurate, and great expense has gone into its production. Adherence to executive order 12906 will both protect this data investment and ensure accurate data is available to our customers and partnering agencies.

CADD Standardization to Ease GIS Transition

The USACE currently employs a CADD standard that guides creation of files at all levels of the agency. However, variation exists in the depiction of channel features of concern to this project. To import data into a GIS with the least amount of effort, channel features common to this project must be captured in a standardized fashion across the agency.

Like features must be stored in common layer types. Storing channel toes, centerlines, quarters, reach boundaries, wideners, turning basins, and stationing information in separate CADD layers is critical to streamlining data conversion tasks. Channel toes cannot be stored on the same CADD layer with line work meant to portray shoreline, and vice versa. Several districts have chosen to portray channel toes in layer fifty-one, but this choice has not been universally adopted.

Ultimately, dissemination of a set of standardized procedures for CADD file generation, specific to channel features, is needed to ensure all data producers are meeting minimal guidelines that will serve the database's import requirements.

Data Reconciliation Process

Quality assurance plays a major role in building the channel framework database. Before data is passed to NOAA's MCD it must be verified for accuracy and any discrepancies corrected. USACE's TEC imports district CADD data for a channel, as well as the NOAA ENC for that same channel into a common coordinate system in a GIS. Both data sets are visually scanned to determine whether discrepancies exist between channel features of the two data sets.

When discrepancies are found, a screen capture is saved with the original coordinate system's location annotated for reference. After the entire channel has been reviewed, any discrepancies are then discussed with the USACE district to verify data quality. No assumptions concerning error commissions are assumed at this point in the process. Errors could reside in the NOAA ENC, or in the USACE CADD file, or both. Internet meeting rooms are employed to improve communication about the data in question. This allows all parties to view the same screen capture over their internet connection and

discuss any issues simultaneously via conference call. If any errors are determined to reside in the district data, those errors are fixed and the new data file is reviewed as above.

Future Data Compatibility

Commercial off-the-shelf software exists that is capable of mapping CADD files to IHO S-57 feature types. This same software is capable of importing GIS files that are SDSFIE compliant and converting that data to S-57 compliant data as well, excepting those cases where no cross-mapping of data feature types exists. Having these options available allows the USACE the option to maintain its own data in SDSFIE format while at the same time addressing the needs of customers that need S-57 compliant data.

Conclusion

The United States Army Corps of Engineers (USACE) and the National Oceanic and Atmospheric Administration (NOAA) are working closely to provide navigation information to the maritime community. Each agency's respective coastal channel framework database stores accurate depictions of coastal channel features that are critical to updating NOAA's paper, raster, and electronic navigation charts, produced to ensure safe navigation of the nation's channels and waterways. While standardization issues have been a focus to date, resolution of these issues is expected to transition to greater data production capacity in the future. As the two agencies continue to cooperate in data sharing and quality assurance tasks, successful patterns for future operations will emerge that ultimately benefit the mariner.