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Paper for consideration by HSSC

Dynamic Water Levels in S-57 based ENCs

Submitted by:	TSMAD
Executive Summary:	Consideration of the feasibility to enable the use of tidal and water height information to adjust charted depths in S-57 based ECDIS equipment
Related Documents:	S-57, S-101
Related Projects:	TSMAD, TWLWG, and DIPWG.

Background

During the S-101 Stakeholders workshop that took place between 4th and 6th of March 2008, the issue of implementing tides in ECDIS was discussed, and one of the conclusions and recommendations of the workshop was that "*dynamic tides should be implemented in S-57 ENCs A.S.A.P (with appropriate safeguards)".* This led to CHRIS 20 tasking TSMAD with the following action item (20/6); *"**TSMAD** in consultation with TWLWG, CSMWG and other relevant HO bodies are to develop proposals to enable the use of tidal and water height information to adjust charted depths in S-57 based ECDIS equipment for consideration by HSSC-1"*.

Analysis/Discussion

Before the depth information displayed in an ECDIS can be adjusted to take account of changes, the water level at that location must be known. This may be achieved using predicted tidal elevations or by receiving real time water level information from tide gauges. Consideration must be given to the accuracy of the underlying ENC depth data that is being modified by either method, predicted or real time. Given that the depth information may have been collected many years previously, depths may have changed, could be out of position and in extreme cases, be incorrect.

At the request of TSMAD Chair the issue of providing depths in ECDIS adjusted for tide was discussed at the March TWLWG and the May joint TSMAD/DIPWG meetings. As a result two primary options evolved and are based on the following methodology.

1. Using predicted tides (or real-time water level) values and additional (small interval) depth areas.
2. Using tidal input and gridded (or TIN) bathymetric datasets as an additional layer to the ENC.

1. Using predicted (and/or real-time) official tidal data and additional (small interval) depth areas.

The prediction of tides requires observations of sea level to be made by tide gauges over some minimum period of time. One month's data is the minimum from which analysis can be conducted, ideally the data should cover 18.6 years. One month is required to resolve the major tidal harmonic constituents and closure of the main periods of tidal forcing. Two main features recorded for non-harmonic tidal analyses are the change in range of tide, measured as the average height between successive high and low tides, and the period, or the average time lapse between one high (or low) tide and the next high (or low) tide. Tidal harmonic analysis of the data collected produces a set of tidal harmonic constants (amplitudes and phases) for a set of tidal constituents from which predicted sea-levels can be calculated using a standard tide prediction equation.. The reliability and number of the tidal constituents is directly related to the length of the tidal observations. These observations are subject to errors caused by meteorological factors such as atmospheric pressure and wind. The longer the dataset the more likely these meteorological effects will be averaged out by the harmonic analysis process. There are two major considerations in the application of tidal prediction methodology however:

1) Actual observed water levels have tidal and non-tidal components. Tidal prediction methodology described here uses provides only the component due to astronomical tide producing forces. In many ports and estuaries around the world, the tide producing forces are not the main factor in determining the actual water levels because the range of tide is very small and the effects of non-tidal wind stress and barometric pressure changes are dominant. These areas require real-time data streams rather than tide predictions for practical application to ECDIS.

2) Tidal harmonic analyses based on tidal observations provide tide predictions only for the location of the tide station from which the record was analyzed. Depending on the complexity of the geospatial variation in tidal characteristics, each station provides adequate water level information in the vicinity of the station and should not be extrapolated very far. Interpolation of tidal characteristics between locations can take the form of non-harmonic time and range corrections (discrete tidal zoning), geospatial interpolation of harmonic constants and observed residuals, or a tidal hydrodynamic model.

S-57 3.1 makes provision for data producers to encode tidal parameters for use in ECDIS when predicting tides and tidal streams by both harmonic and non harmonic methods. It is stated in the S-57 Object Catalogue 'the supplier of any parameters must be consulted on how to use data provided using this object class, and which calculation algorithms to use with the data'. This makes it very hard for ECDIS manufactures to implement a generic solution as data is produced by Hydrographic Offices across the globe each with very different requirements for calculation.

The application of harmonic or non-harmonic prediction methods has been implemented in a number of ECDIS products, however their tidal predictions are not official and hence do not fulfill the requirement of SOLAS Chapter V. To ensure that the results of tidal predictions are accepted as an equivalent to those in official tide tables, HOs would have to provide their full sets of tidal constituents, e.g. to populate the feature objects T_HMON (Tide - harmonic prediction) and TS_PRH (Tidal stream - harmonic prediction), and also make their prediction algorithms available. Clearly this is not viable, as tidal prediction methods vary greatly between hydrographic organizations.

An alternative method may be to make use of a generic prediction engine such as the UKHO TotalTide SDK, however many HOs would not accept this as being efficient nor sufficiently accurate for their tidal regimes.

It is therefore considered that any predicted or observed tidal data that would be used to change displayed depth areas within an ECDIS should be official predicted data and official spatially modeled water levels provided by the relevant hydrographic authority or official real-time water level data provided by the port authority or the national hydrographic authority The TWLWG has an action item to work on standards for electronic tide prediction table products.

Currently there are a number of countries using tide gauge instruments that can transmit real time tidal information either directly form the gauge or through a real-time centralized data quality control system. However there are drawbacks, real time information from a particular tide gauge observation station is often transferred in a proprietary format making it very hard for generic receiving system to ingest directly from the gauge. Alternatively, if the data are ingested processed and quality controlled in real-time by the host country hydrographic authority, the host country could disseminate a real-time observation product back to ECDIS (with perhaps a 6-12 minute delay).

A significant consideration is the fact that recorded tidal conditions at a shore-based observation location may not accurately reflect those being experienced by a vessel some distance away from the tide gauge. A possible solution would be to set up geographical zones of confidence with sufficient tidal information being broadcast to mitigate the associated error. This could take the form of modelled harmonic or non-harmonic tide corrections and tide predictions for each geographic zone.   If all ECDIS were enabled to receive real time tidal corrections, thought must be given to the data format, transmission of tidal gauge information or dissemination of predicted information.. To ensure interoperability a considerable amount of work would be need to done. The first stage would have to be the assessment the current scale of the problem and then initiate the production of a tidal data transfer standard for real time information, with the engagement of industry where appropriate. The standard would have to address the issue of vertical datums and accounting for changes in navigation and Chart Datums in various countries and various port systems. All observed and/or predicted water level data would have to be referenced to official chart datums as appropriate before depths are corrected.

Additional Depth Areas

Navigationally significant areas are usually determined from a combination of under keel clearance requirements and the tide-corrected vertical range of charted depths. The additional requirement to implement this tidal application solution is to produce datasets with increased numbers of depth areas for those ENCs where tidal influence is appropriately matched with navigationally significant areas(i.e. “tide aware” ENCs).   A greater number of depth areas will result in smaller depth intervals and finer granularity in portraying the influence of the tide. This will however also significantly increase the amount of work required to digitize ENCs and their size will also increase significantly. Some issues that would have to be considered when preparing specifications for tide aware ENCs include:

- What cells should be “tide aware” (approaches, harbour, berthing …)?
- What should the ideal depth area interval be?
- What level of “line smoothing” should be applied to depth areas?
- What will be the impact on ENC cell sizes, considering the mandatory 5Mb limit?
- How will ENCs be designated as being “tide aware”?
- Could automated methods of producing depth areas (e.g. gridding or tin derived depth areas) be employed?
- From an error budget perspective, what are the expected or required accuracies of the depths relative to the accuracies and resolution of the tidal data?

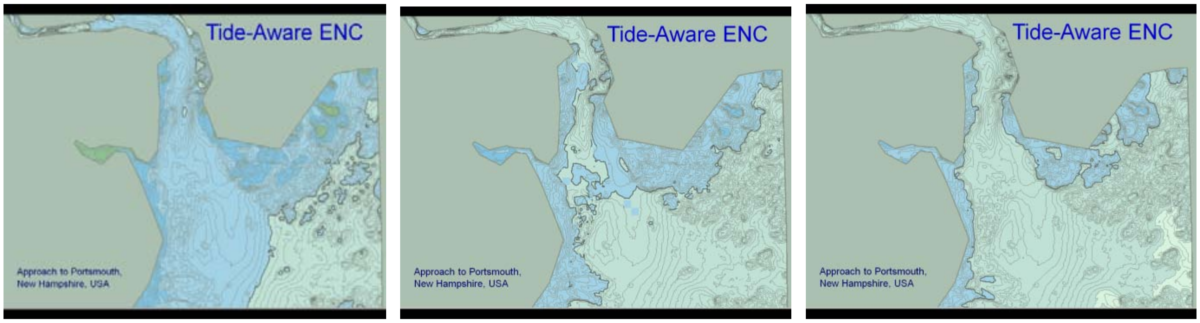

Figure 1 – Tide Aware ENC

Advantages

- No additional feature objects or underlying structures of S-57 are required to implement this option.
- ECDIS alarms would continue to respond normally to depth areas.

Disadvantages

- The requirement for data producers to digitize and maintain additional depth areas.
- There is not a facility within the ENC data to signal that a dataset is usable in a dynamic environment.
- Limitations imposed by the granularity of depth intervals (i.e. 0.5 meter depth intervals would limit the accuracy to 0.5 meters at best).
- Tidal regimes change with geographical extent and this will be difficult to implement within large (extensive) depth areas.
- Tidal prediction methods varies greatly between hydrographic organizations (This can be overcome, but would require official predicted, observed, and modeled water level data streams from the responsible hydrographic offices or port authorities on a continous 24X7 basis. TWLWG could assist in development of these standards.

2. Use an additional bathymetric layer – provided as a gridded (or TIN) bathymetric dataset.

This proposal considers the use of gridded (or TIN) bathymetric datasets intended for use as an additional layer, in conjunction with tidal data. As the gridded dataset would be used as an overlay to the existing official ENC, it would be possible to use predicted or real-time data. This solution would allow for a higher granularity of bathymetry and tidal (interval) data however it could not be considered as official data and would not trigger alarms in the ECDIS. At present there is no way for layers to interact with the base ENC data. Viewing of the layer would require the suppression of the base depth information. This solution presupposes the development of an S-57 data format for bathymetric grids and the provision of tidal prediction data, real-time tidal data, and water level data from interpolation models.

Advantages

- Higher resolution of bathymetry

Disadvantages

- No S-57 bathymetry data format
- No ECDIS Alarms

Some additional Issues for consideration

The IMO Performance Standards for ECDIS state at clause 4.3 that “It should not be possible to alter the contents of the ENC or SENC information.” It can be argued that the inclusion of tidal data in ECDIS does not violate this clause as changes are only made to the portrayal of data, and not the data itself.

With the imminent publication of S-100 comes the opportunity to produce high resolution gridded bathymetry layers, this is because S-100 has made provision for imagery and gridded data. S-102 the new IHO special publication for Bathymetric Surfaces is currently in the draft stage and using S-100 will provide the framework for these new layers. Through a close IHO working relationship these high resolution bathymetry layers can be built to ensure interoperability with S-101, resulting in an official IHO solution for the Mariner at sea.

Conclusions

From the discussions it is clear that technically the task of adjusting depths in ECDIS is not a difficult proposition. However it’s the inconsistent nature of the associated tidal data standards and the inability of ECDIS to rapidly alter it’s functionally that ultimately make both options demanding and untenable at this present time.

Recommendations

At this present time it is TSMADs recommendation that we do not adopt either solution, but continue with the implementation of dynamic depth adjustment in S-101. By adopting this approach we will be able to focus effort in one direction working with ECDIS manufactures to ensure the technological capabilities are built into the next generation ECDIS. If in the development of S-101 it becomes apparent a suitable solution could be implemented in S-57 then this would be the time to revisit the problem.

TSMAD recommend the IHO Tidal and Water Level WG work towards the preparation of a draft standard for the exchange of tidal predictions, real time tidal data, and the development of standards for water level interpolation/extrapolation models. This work should involve ECDIS, various country real-time web service providersand tide gauge manufactures to ensure compatibility issues.

Justification and Impacts

With pending publication of S-100 in early 2010 and the subsequent publication of S-101 and S-102 we would not want to spend time developing a supplementary gridded bathymetric module for S-57 an antiquated standard that is to be replaced. Focusing development effort towards development of S-101 and S-102 would be the best option to ensure that provision is made for this requirement.

Action required

The HSSC is invited to endorse the recommendations of TSMAD.