A Vertical Reference Surface for Hydrography – Status Report 2005

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SUMMARY

A coherent vertical reference surface is increasingly needed in a variety of marine applications. For example, in hydrography traditionally depths have been collected with respect to a local tidal datum. However with continued developments in high accurate satellite positioning hydrographers are looking to measure depths with respect to a reference ellipsoid. Similarly land and marine mappers are looking to merge topographic and bathymetric datasets and the current mismatch in vertical surfaces causes difficulties. The uses for seamless data across the land/sea interface are growing such as coastal zone management, marine boundary delimitation, flood and surge forecasting and other applications. To do this the relationship between the tidal datum(s) and a more stable reference datum needs to be established. The relationship(s) between these vertical surfaces is called a transformation model.

FIG Working Group 4.2 (WG 4.2), Vertical Reference Surface for Hydrography, has been exploring all these issues with an aim to producing guidance for those who need to develop a vertical reference surface for whatever purpose. The group is looking to provide help for those who need to secure support from senior members of their organisation as well as provide more detailed technical information for those who actually measure and develop a transformation model.

Papers from WG4.2 were presented at WW2003 in Paris and WW2004 in Athens where much debate occurred. This 2005 paper will present the latest progress of this Working Group and encourage further participation from the global audience.

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1. BACKGROUND

Over the past couple of years the FIG Working Group 4.2, Vertical Reference Frame, has been looking at the issue of seamless vertical data. This is in response to a perceived need to clarify (a) what a vertical reference surface is and (b) how to relate height and, particularly, depth data to it. In the past, bathymetric and topographic measurements have been collected independently to serve different purposes, with respect to different vertical datums, creating inconsistency across the land-sea interface. With the growing number of coastal applications, such as coastal zone management and marine boundary delimitation, a different solution needs to be defined.

The working group is addressing a number of issues including:

- Developing and promoting the understanding and realisation of a vertical reference frame;
- Examining the demand for a seamless vertical reference frame for use in hydrography, marine navigation, and coastal resource management;
- Developing an inventory of vertical reference surfaces used in various countries of the international community;
- Making some recommendations towards the establishment of a global seamless vertical datum.

Readers are strongly recommended to read the initial papers from this Working Group as background to this paper (Adams 2003, El-Rabbany 2003, Adams 2004).

2. PROGRESS TO DATE

The working group has presented at Working Weeks in 2003 and 2004 which are available to view on the FIG website www.fig.net. Alongside this there have been meetings and discussions, again which are documented on the Commission 4 section of the FIG website.

During the WG4.2 meeting in Athens, 2004, it was decided to produce two documents.

Executive Summary – this document will be a short, high level document which sets the scene. For example, what is the need for a seamless vertical surface separation model, what use is a vertical transformation model? The aim of the document is primarily for hydrographers needing to raise the profile of their work, obtain funding etc to senior management.

Technical Information – this document, which we envisage to be a user handbook, will provide full background details to the issues involved with a seamless reference data. It will contain technical info as to how you build a model, measure tides etc and will have a comprehensive glossary.

The Executive Summary has been written and is included, in full, below. The Technical Document will be written during 2005.

3. EXECUTIVE SUMMARY - A VERTICAL REFERENCE SURFACE FOR HYDROGRAPHY – DEVELOPING A TRANSFORMATION MODEL

3.1. Setting the Scene

A vertical reference surface for hydrography is one that does not vary over time or area. Development of a stable surface is a vital step in being able to handle modern bathymetric depth data and use it to its fullest potential.

In order to realise this vertical reference surface in a practical sense, a vertical transformation model needs to be developed to allow transformation of height/depth data from one reference surface to another. This will allow:

- Depth data to be more easily merged with land data (such as for Integrated Coastal Zone montoring)
- Increased efficiencies in hydrographic surveying.
- Easier merging of different databases such as realtime tides, surge monitoring, flood prediction.

The benefits of having data which can easily be output on different vertical datums are not to be understated.

There are various methods which can be employed to develop a vertical transformation model. The chosen method will depend on existing information, funding, hydrographic capabilities and area of coverage.

3.2. What is a Vertical Reference Surface for Hydrography?

A vertical reference surface for hydrography is one that does not vary over time or area. A stable reference surface which could be considered suitable for this is ITRF, International Terrestrial Reference Frame. Note that ITRF is a mathematical surface not necessarily a vertical datum to work to.

A vertical transformation model defines the relationship between the chosen reference surface and other extant references surfaces, such as tidal surfaces and geodetic datums.

Chart Datum is the traditional surface to refer depths to. However Chart Datum is not a seamless reference surface as it varies from location to location. Chart Datum is established based on water level measurements at discrete locations.

3.3. Why do we need a Vertical Reference Surface for Hydrography?

Traditionally, bathymetric and topographic measurements have been collected independently to serve different purposes. Depth and height data were referred to different vertical datums. This creates inconsistency across the land-sea interface.

Development of a vertical transformation model will allow easier assimilation of land and maritime data sources resulting in seamless vertical data.

With the growing number of coastal applications, such as coastal zone management and marine boundary delimitation, it is desirable that a seamless vertical reference surface and transformation model be established.

For hydrographic surveying, in conjunction with high accuracy GPS, it will negate the need to measure tides, heave and vessel draught – a considerable efficiency.

It will allow data to be output and products delivered on various vertical datums as required by the customer.

Note. Establishing the relationships between the various vertical datums and consequently a seamless vertical reference surface will not be an easy task. The creation of seamless data is far more than just joining more than one digital dataset together. Ignoring technical issues such as datum types, projection, temporal changes, and error budgets will cause datasets of geospatial information to end up as meaningless and unreliable information.

3.4. The Challenge

The challenge is not so much to develop a vertical reference surface, but to develop a way of relating historical and future datasets to be connected in a seamless manner. Development of a transformation model(s) is key to this.

However, there are many problems related to the availability, volume, coverage and quality of both bathymetric and topographic data. Many regions of the world are either inadequately surveyed or have never been surveyed. Also, auxiliary data is needed so that the transformation function can be developed, eg. the ellipsoidal heights, referred to ITRF (WGS84), at the Chart Datum points or a geoid model.

3.5. What are the Costs?

The costs for the development of a vertical transformation model will vary depending on the folllowing:

- availability of underlying data (such as geoid model, tidal data);
- size of area to be covered by model;
- accuracy required; and
- available resources - local hydrographic survey capacity, GIS capability, funding
- ongoing maintenance needs

3.6. The International Scene

Some nations have already developed vertical transformation models, such as Canada, Australia, United States of America, France, Germany, and the Netherlands.

Alongside this, other bodies are addressing this issue. For example the IAG (International Association of Geodesy) have set up working group 1.2, called "Vertical Reference Frames". Their members include a hydrographer to ensure a link between land and maritime applications.

The IHO (International Hydrographic Organisation) is also focused on this issue and will in time, amend their documentation to ensure that whenever new tide stations are inserted a link is made to a global reference surface.

3.7. Further Reading

To tackle the subject of a vertical reference surface for hydrography, the FIG Working Group 4.2 (WG 4.2) was established.

Additional information can be found in papers from this Working Group – Adams (2003), El-Rabbany (2003) and Adams (2004). These can be found on www.fig.net.

4. NEXT STEPS

Once the Executive Summary has been aired at WW2005 in Cairo, it will be finalised. The user's handbook will be drafted during the Spring/Summer of 2005 and presented in draft form to the joint IAG, IAPSO (International Association for Physical Sciences of the Oceans) and IABO (International Association for Biological Oceanography) conference, Dynamic Planet 2005. This will be held in August 2005.

The final executive summary and user handbook will be presented at WW2006, Munich.

5. CONCLUSION

As the reader can see, WG4.2 has been steadily progressing with the issue of the development of a seamless reference surface. It is looking at the development of a vertical transformation model and providing tools to the surveyor (and others) to enable them to do this.

It has produced an Executive Summary, which is detailed above, and the fuller handbook will be produced during2005/2006.

As ever, readers are encouraged to continue to add to the experience and valued advice to this topic. WG4.2 members are always happy to receive any comments.

REFERENCES

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BIOGRAPHICAL NOTES

Ruth Adams works for the UK Hydrographic Office in Taunton working directly for the Director of Operations. For the last four years she led the Geodesy and Imagery Section providing geodetic and photogrammetry/remote sensing advice and products to many customers, including the armed forces and general public. During her career she has worked closely with the Royal Navy hydrographic surveyors and has had periods of duty at sea. Her geodetic and imagery expertise are particular strengths. Other career postings have included Project Management and charting for the Fleet Air Arm.

She has a degree in Surveying Sciences from the University of Newcastle upon Tyne and is a chartered surveyor with the RICS. She is the RICS UK delegate for FIG Commission 4, Hydrography and is heavily involved with Working Group 4.2 studying a vertical reference surface for hydrography. She has presented at various conferences and frequently contributes to surveying and hydrographic journals.

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