

# Vertical Datum Issues for Data Continuity from the Land to the Seafloor

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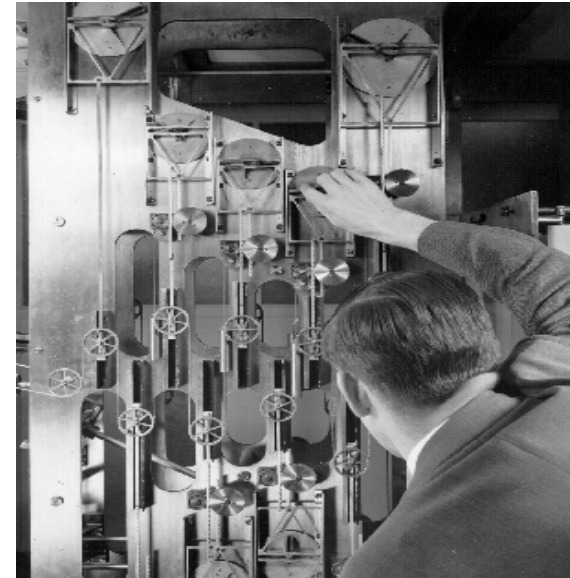
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# Early Prediction of Tides



- Clay model from Egyptian Tomb, ca 2000 BC (from Bass "A History of Seafaring")
- Non-harmonic predictions in China about 1,000 AD.
- Harmonic Tides evolved in the early 1900's.



# 1926 IHO Tides Committee Meeting

- The Netherlands: first nation with navigators to use harmonics tides
- IHO adopted use of harmonic tides
- IHO did not adopt Japan's proposal for use of Indian Low Water Springs
- Over the years since 1926, about 30 different tidal datums were adopted by IHO Member States



# Multiple Chart Datums

- Individual National datums were fine when navigation was only by paper charts.
- With electronic chart navigation, differing sounding datums over a display area and non-continuous contours become an aggravation for the user.
- In 1993, IHO asked Member States for their views on use of the geoid as a global reference surface.
- Responses opposed use of the geoid and favored use of the WGS84 ellipsoid.
- Members opposed use of the ellipsoid as a datum.



# Steps toward Adoption of the Ellipsoid and a Global Tide Datum

- 1997 IHO adopted LAT/HAT as the recommended tide datum.
- 1998 IHO S-44: tidal datums should be referenced to the WGS84 ellipsoid.
- 2004 CHS study: recommends use of the ellipsoid as the seamless reference surface for ECDIS display.
- 2005 IHO Technical Resolution: recommends reference of tidal datums to WGS84 ellipsoid.



# Steps toward Adoption of the Ellipsoid

- 2005 IHO Hydrographic Manual recommends high accuracy GPS observations at tide stations
- 2006 FIG publication No. 37 recommends ellipsoid as Vertical Reference for Hydrography.





# NGA concept Geospatial Knowledge Base- Elevation bathymetry (GKB-Eb)

- NGA has been studying the issues related to development of a continuous surface of elevation (topography & bathymetry) related to the WGS 84 ellipsoid with an intent to move away from local and regional vertical datums, i.e., Mean Sea Level datums and Nautical Chart datums of varying tidal epochs, to create a seamless depiction of the earth's surface.



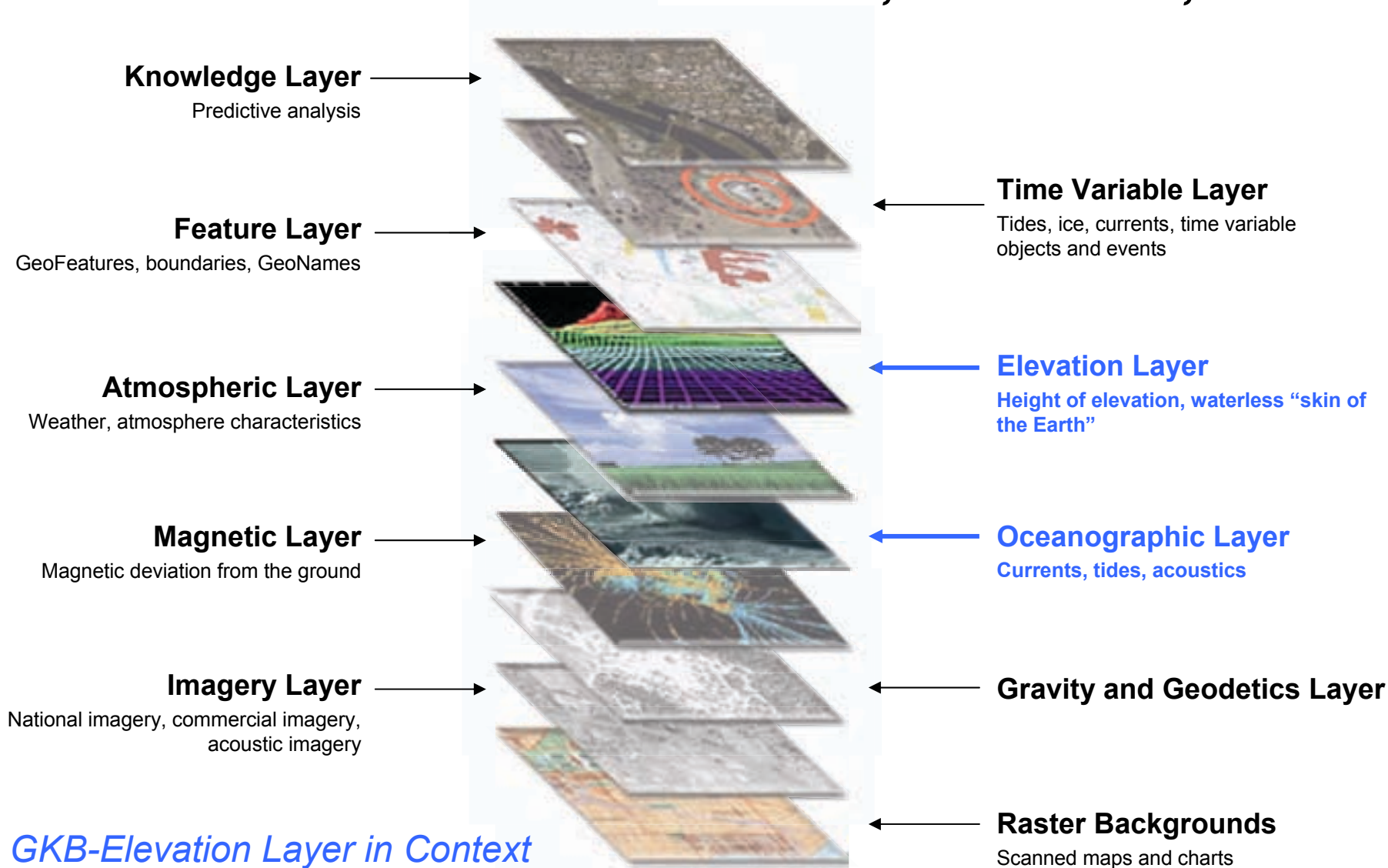
# Reference to Regional & Local Tide Datums Creates “Lumpy Data”







# GKB Model: *Seamless, Continuous, Current*





# Cooperative effort by NGA, NOAA, NAVO and UKHO to identify system Needs

- Need system to archive global data not as a product database but as a geodetic database.
- Need system that handles cross ocean tracklines.
- Need global system for cataloging area & trackline surveys
- Model including all metadata for both low water representations and reference to WGS 84 ellipsoid.



# Issues Continued

- Need capability for handling and archival of “navigation surface” data sets.
- Need to include capability to include VDatum transformations.

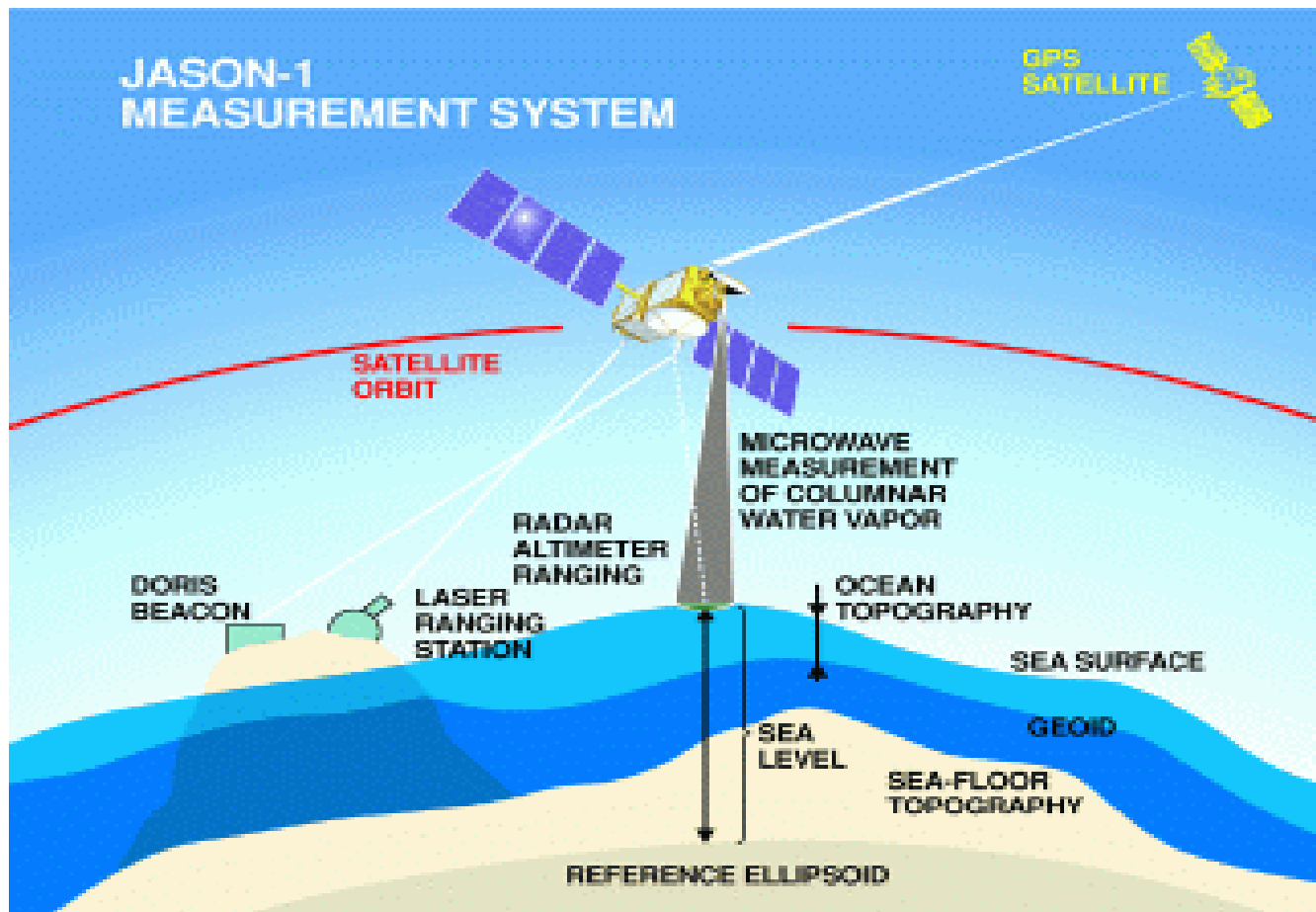


# Approach & Difficulties to Achieving the Seamless Solution

- Relating the land surface to the ellipsoid is a big job, but is within the “art of the possible”.
- Water areas deeper than 200 meters, beyond the application of tide, can be accomplished subtracting ocean bathymetry from Sea Surface Topography related to the ellipsoid.
- The challenge is to relate the 0 to 200 meter depth range where SST cannot be used due to the fact that tide varies continuously along the world’s coastline.



# Satellite Altimetry Measurement

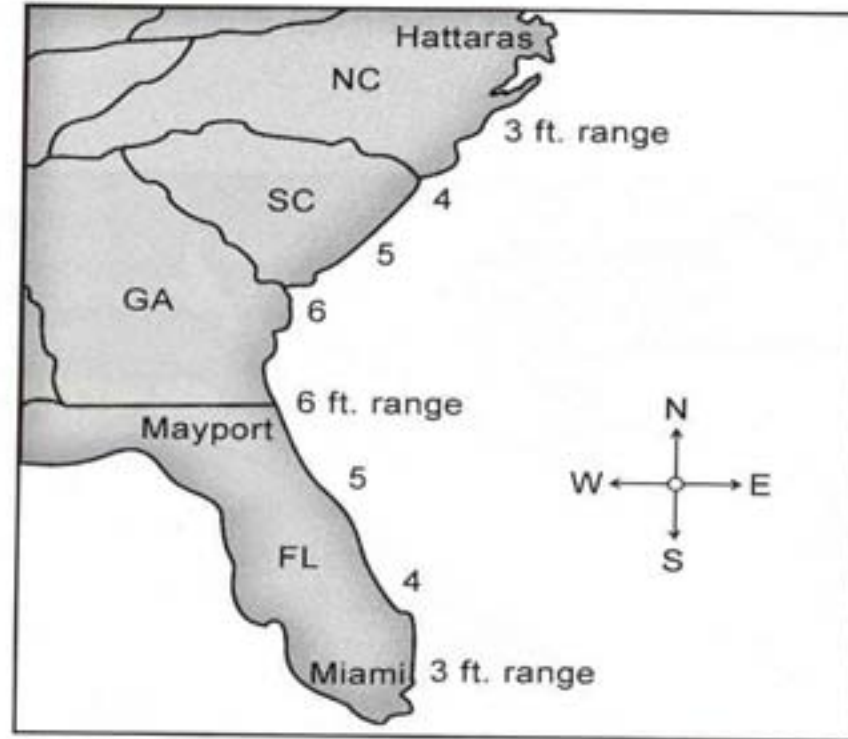




# Geospatial Factors such as Coastline Impact on Tide

Slide from "Beyond the Moon"

(8-6)







# Basin effect on tide

The highest tidal range on earth is at the head of the Bay of Fundy, shown below.

(8-5)



The Bay of Fundy is an arm of the Gulf of Maine. The average tidal ranges are shown in meters.



# Possibilities for Development of a Continuous Surface in the 0 – 200 meter zone

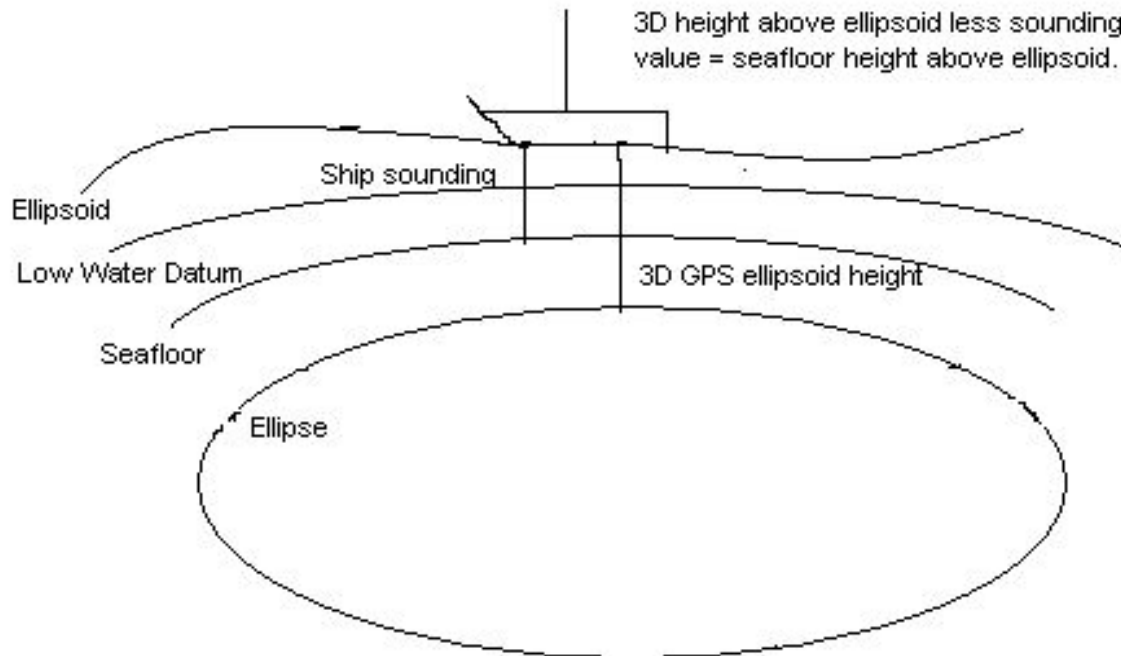
- Conduct 3D GPS hydrographic surveys to relate the seafloor to the ellipsoid in addition to relating the hydrography to a tidal datum
- Use VDatum transformation to relate historic data sets
- Check the validity of VDatum using 3D GPS survey lines
- Possibly relate historic data sets by statistical comparison to 3D GPS transits through existing data.



# Ship determination of seafloor height above ellipsoid

SHIP OBSERVATIONS PROVIDE SEAFLOOR HEIGHT ABOVE ELLIPSOID

NAVO USING WIDE AREA 3D GPS PROVIDED BY JOHN DEERE/C&C TECHNOLOGIES  
APPLYING EARTH TIDE MODEL TO SHORE, REFERENCE STATION  
ATTAINING 0.1 METER AT 1 SIGMA and 0.2 METER AT 2 SIGMA





# Benefits of a Continuous Land-Water Surface

- Continuous contours for nautical charts
- Improved Tsunami and Storm Surge modeling & prediction
- Improved tide and current modeling
- Better Coastal Zone management/monitoring
- Improved Maritime Limits & Boundary delineation
- Improved amphibious operations
- Improved gravity modeling



# Issues for the Future

- IHO should specify GRS 80 as the Vertical Reference Surface in its publications.
- Hydrographic Offices need to place increased emphasis on relating data to the ellipsoid.
- Tidal experts need to provide defined polygons for areas of tidal application.
- Marine data systems need to be enhanced to provide for better archival, display & cataloging.



# Issues for the Future

- High accuracy 3D measurements need to be made at tide gauges as specified in IHO S-44.
- 3D GPS observations should be as accurate as possible through ties to the IGS (International GPS Service for Geodynamics) stations or to regional stations with ties to the IGS stations





# Conclusion

- Hydrographers need to change their way of thinking and “relate the surface of the seafloor to the ellipsoid” in addition to relating the hydrography to local or regional tide datums.

# Questions ?

