Establishing and Updating Vertical Datum for Land and Hydrographic Surveying in Dubai Emirate

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Key words: Hydrography, Spatial Marine Database, Marine information system (MIS), Vertical datum, Geoid modeling

SUMMARY

A vertical datum is a base measurement point to which all elevations are referred. Without a common datum it may have different elevations values for the same location. The vertical datum needs to be updated periodically because of the geologic changes to the surface of the earth due to the subsidence and uplift or gradual changes in sea level. Considering the massive constructions taking place near-shore and offshore islands of Dubai Emirate it become inevitable to define and update a unique vertical datum for land surveys and maritime activities. The Geodesy and Hydrographic Survey Section of Dubai Municipality had established a network of offshore and coastal tide-meteorological stations in the offshore and coastal area of Dubai Emirate and started monitoring continuous Tide / Meteorological data collected from all the stations. The data collected from the offshore as well as the coastal tide/meteorological stations are processed to generate a number of products such as monthly and yearly average mean tide and sea level, mean high and low water, mean range, lowest and highest astronomical tides etc. With respect to the data received from these stations and with respect to the Gravity measurements over the land area as well as over the offshore and near shore area, the Geodesy and Hydrographic Survey Section of Dubai Municipality is updating the vertical datum. This datum is now being used for Hydrographic investigations and maritime activities. The cartographic unit of Survey Department is updating the charts with respect to the changes in the shoreline, coastline and vertical datum.

This paper explains the details of sea level change and the necessity to update the vertical datum of Dubai with respect to the tidal variations and other factors. Also this paper outlines the following

- Need for establishing a unified marine database for Dubai Emirate.
- Determination of inland and offshore Geoid Model
- Transferring accurate vertical datum to offshore manmade islands
- Creating numerical modeling for tide and tidal stream
- Revising coastal boundary lines (coastline and shore line) based on tidal data, topography , bathymetry and satellite images
- Dubai Virtual Reference System (a real time RTK DGPS system, now being converted to a GNSS System)

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1. INTRODUCTION

All surveyed features depicted on a chart or map use a horizontal datum and vertical datum. The horizontal datum adopted by Dubai Municipality is WGS-84(International Horizontal Datum). For hydrographic surveys vertical datum always is referred to as chart datum. For navigational safety and for marine constructions, depth on a hydrographic survey chart is referred to the lowest low water ever recorded in that region. Hence the chart datum is the lowest level of water ever recorded in a region. Chart datum is so selected that the water level will seldom fall below it. It is very important to define a precise vertical datum or chart datum for Hydrographic Surveys

The urgent need to increase the knowledge of the natural process that threaten the coastal communities, the growing awareness of the fragile ecosystems that exist in the coastal zones, the requirement to manage marine species in a structures and sustainable manner and for the marine exploration & constructional activities requires seamless spatial data across the land and sea. A major constraint for the above mentioned activities is the lack of a consistent and unified vertical datum.

Sea level measurements in Dubai were performed by local port authorities by establishing different tide gauges. The data from these tide gauges are used only as an aid to make navigational charts. But continuous records of tide data are not available from these stations for analysis and also the vertical datum of reference is not fully traceable from historical records. This is the prime reason for Dubai Municipality to deploy its own permanent tide gauges in the coast of Dubai for the determination of mean sea level and a precise vertical datum for topographic and hydrographic surveying.

The Survey Department of Dubai Municipality had established a network of five fully automated Tide/Meteorological Stations along the coast of Dubai Emirate and an offshore tide/meteorological station deployed at a distance of 12 km from Dubai coast. From March 2004 onwards continuous tide / meteorological data are being collected from all these stations for establishing a precise vertical datum for Dubai Emirate. The tide data from the five coastal stations and an offshore station made possible for the determination and maintenance of a well defined marine vertical datum for Dubai Emirate.

Annual mean sea level is also computed from the tidal information. When the sea levels computed are compared, the variations or rise in the annual level can easily be determined. The main goal of this paper is to present the methodology adopted for establishing and updating the vertical datum of Dubai and the importance of the

vertical datum. The depth of water at a position is given by adding the charted depth and the height of the tide. Height of tide is measured relative to the chart datum. A chart datum is generally a tidal datum, which is derived from the phase of the tide.

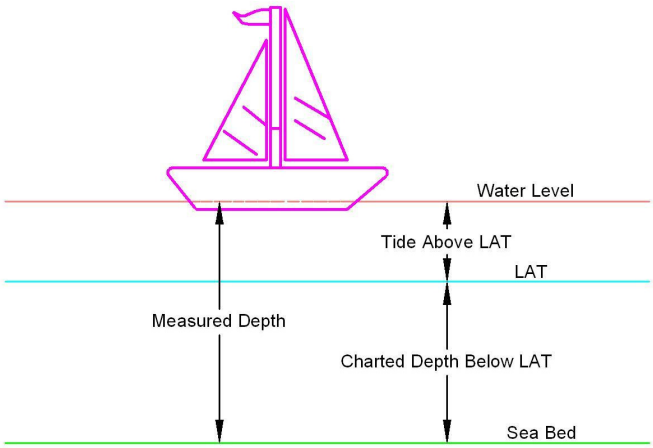

Fig. 1 Showing Charted Depth, LAT and Tide above LAT

The computed values from the raw data collected from the tide/meteorological stations includes Mean Sea Level, Lowest Astronomical Tide, Highest Astronomical Tide, Tidal Constituents and Tidal Stream Predictions. Besides that the raw data contains meteorological data which are directly connected with or affecting tidal variations such as Wind Speed, Wind Direction, Atmospheric pressure and Air Temperature. The meteorological data such as water temperature, visibility and humidity and the tidal information are distributed to the public / institutions according to the request in softcopy or harcopy format.

2. THE HISTORY OF VERTICAL DATUM IN DUBAI

A Mean Sea Level is an equipotential surface and it is this surface that is considered as an approximation of the geoid. Geoid is most commonly defined as the equipotential surface of the Earth's gravity field, which closely coincides with undisturbed mean sea level while ignoring oceanographic effects. The geoid reflects variations in the gravity field and has a designated value of gravity potential. It is smooth and continuous with high and low features due to geophysical phenomena. Traditionally undisturbed mean sea level has served as the reference for orthometric and dynamic heights and their differences, gravity potentials and other vertical heights. A reference bench mark (BM) is then established near a tide gauge station and by means of precise levelling, a height is derived for it. This BM acts as the national vertical datum. It is now known that the MSL is not completely coincident with the geoid. Due to a feature known as sea surface topography and as a result of sea dynamics and certain meteorological phenomena, the two surfaces are separated in some places by over a metre.

In 1954, Dubai needed to establish a vertical datum in the creek area for development works. At that time, it was decided to use the Admiralty Chart Datum in the creek, which was defined at a point 14.56 ft. below a benchmark cut in the eastern door pillar of the petroleum development in coast house of Dubai. That Datum was established by the British Royal Navy

with respect to a point 5.4 ft. below a brass plate embedded in a concrete block and marked H M S ORMOND 1933, situated in the NE corner of the Imperial Airways enclosure at Sharjah State.

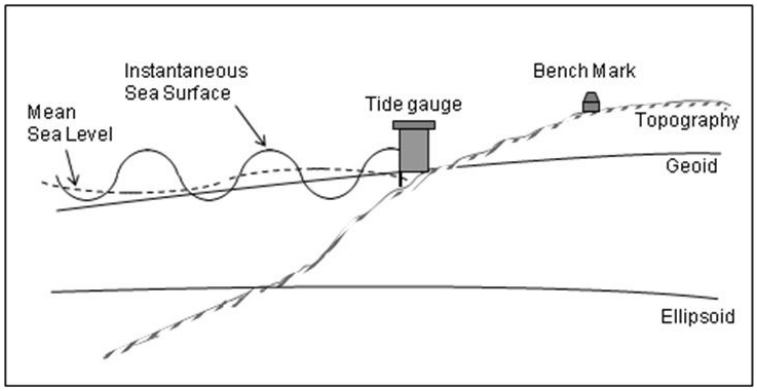

Fig. 2 showing the details of tidal variation, MSL, Geoid and Ellipsoid

The estimated Lowest Astronomical Tide for the open sea at Dubai was computed with the help of Admiralty Tide Tables of the creek and with respect to that a zero datum (chart datum) established 9.27 ft. below a benchmark on the center of the top step of Gray Mackenzie's warehouse doorway on the water edge. This datum was decided to be used by all contractors in the time of creek development works.

In 1959, an automatic Tide Recorder was setup on one of the Halcrow Groups's stilling wells with respect to the reference level from the benchmark previously mentioned for creek development works. Tidal readings were observed by this recorder between 1959 -1961. This tidal information was forwarded to the Admiralty in January 1960 for the calculation of Harmonic Constants. The Admiralty informed that the Halcrow's datum was approximately one foot below the Admiralty Chart Datum for Creek.

In 1967, with the commencement of construction of Port Rashid an automatic tide recorder was set on the Sheikh Ahmad Jetty in Jumeirah. The reference level for this Tide Gauge was also derived from the creek benchmark by direct leveling. This automatic tide recorder was changed in 1968 to a rotary type level and set to read on a 32 hourly basis. The tidal information obtained from this gauge during the period 4th May 1968 to 17th June 1968 was sent to the Admiralty. In August 1968, the Admiralty approved this datum as an Admiralty Datum for the open sea in Duabi. In March 1970, Halcrow received the Admiralty revised values for H.A.T, M.H.H.W, M.HW, M.L.H.W, M.W.L, M.H.L.W, M.L.L.W, and L.A.T. But the Values for Highest and Lowest Astronomical Tide were not considered as final.

In 1974, it became necessary to adopt a new metric system for Admiralty Charting, and hence the value of the benchmark was changed to +3.05 Meters.

In 1977, the benchmark was moved to the top of the transshipment berth. The benchmark value is marked as +3.05 on a brass plate. Subsequent tidal analysis during the period from 1972 to 1977 indicated that the difference between the Halcrow datum and predicted Lowest Astronomical Tide is less than 10 centimeters.

The Joint Managing Director of Halcrow Middle East Limited, by his letter, dated 12th

February 1978, submitted the details of Bench Mark No.001 (Federal Bench Mark, which was established at Port Rashid) to Dubai Municipality. The Survey Section of Dubai Municipality decided to accept that value and a loop of precise leveling was done from Port Rashid in Bur Dubai along the whole creek to Ras Al Khor and back to Deira and closing on the same Bench Mark (001) at Port Rashid within an accuracy of 4mm $\sqrt{K}$, where K is in Kilometers. Every time loops were observed as double tertiary leveling (12mm $\sqrt{K}$), assuming the Bench Mark No. (001) has the same known level. The Benchmark (No.001) was destroyed in 1979 due to the construction and development activities at Port Rashid.

The Survey Department of Dubai Municipality had transferred the level from Bench Mark No.0001 at Port Rashid to Mina Jebel Ali by direct leveling and established a Tidal Bench Mark called **A100** at Mina Jebel Ali. About 6000 Bench Marks in whole Emirate of Dubai were interconnected. Water levels from an established tide recorder at Maktoum Bridge (on the creek) were observed during 1978 to 1982 and forwarded to Admiralty for analyzing and calculating Harmonic constants.

Water levels at Mina Jabel Ali were measured during 1986 to 1992, by the Local Port Authority. In 1988, Halcrow launched tide tables for all UAE Ports.

In 1991, tide data of Mina Jabel Ali was analyzed by WIMPEY Environmental Company based on one-month tidal observations. On September 22, 1993, NEDECO (Netherlands Engineering Consultants) carried out Tidal analysis based on the tidal observation taken during June 1988 to October 1989 at Mina Jabel Ali.

Again water levels from 1994 to 1995, observed at Mina Jabel Ali, by the Local Port Authority were analyzed by the Admiralty. In 1997, Martin Mid-East LLC (a private company engaged in Maine and offshore surveys), was contracted by Mouchel International to undertake a tide monitoring survey for four years along the coast of Dubai. In February 2001, Jabel Ali Tide Pole was calibrated by the Port Authority and Cowi Almoayed Company.

Currently, the tidal information from Port Rashid and Jebel Ali tide gauges are used only as an aid to navigation. No continuous record of tide data is available from Port Rashid station for analysis and the vertical datum reference is not fully traceable. To analyze and finalize the discrepancy between difference vertical datums in Dubai emirate, Dubai Municipality had established five Tidal-meteorological stations along the coastal and creek area, and started continuous monitoring of tidal data information received from all the above stations.

3. NETWORK OF FULLY AUTOMATED TIDAL STATIONS.

A network of five fully automated tidal stations were established by the Survey Department of Dubai Municipality at Jabel Ali, Umm Sequim II(fishing Harbour), Al Mamzaar, Dhow Wharfage (inside creek area),and Al Jadaaf (innermost portion of Dubai Creek). The sites are so selected that they cover the coastal area evenly. The tide/meteorological stations are designed to meet the following requirements.

- The tide/meteorological stations have to be established in remote locations

- The sensor to measure tide should be a self reading type and the output should be in digital form.
- The stations should works on solar power.
- There should be ground based housing arrangements for data logging, data storage and accessories.
- A good mast should be provided with a housing to hold the meteorological sensors such as air temperature, air pressure, relative humidity, wind direction, wind speed and visibility
- A water pressure sensor should converts water pressure to direct water level, and this sensor has to be provided using a casing pipe and placed well deep into water for recording tidal variations in real time.
- The housing, mast, sensors, data logger and other parts of the Tide/meteorological stations should be rust free
- The logged data from all the station have to be communicated to a control room in the Dubai Municipality Office in real time using GPRS
- A backup of logged data should be in all tide/meteorological stations, which should be capable of storing all monitored data continuously for one month
- The location of the station should be in open places without any obstruction to sunlight, wind and water level measurements
- All the data have to be collected at a sampling rate of 2 minute interval
- Data monitoring facility should be provided in all tide/meteorological stations
- The real time data received in the control room have to be monitored using suitable software

As per the system design the measurements taken at a sampling rate of two minutes interval are stored in the memory unit fixed at each stations and also are transmitted to the control room at Dubai Municipality office in real time using GPRS. The content of the database mainly consists of water level and meteorological data. The data processing and analysis is a database management system, which receives water level and meteorological data from the stations and performs quality control and generate resulting products and archive the data. The data telemetry status report is generated every 24 hours for all stations that were expected to transmit the data. Tidal datum and associated tidal products are also computed by the software.

4. OFFSHORE BUOY

The Survey Department of Dubai Municipality deployed an offshore buoy fitted with meteorological sensors and an ADCP (Acoustic Doppler Current Profiler) in the offshore area of Dubai Emirate for updating vertical datum in the offshore area considering the massive construction taking place in the offshore area of Dubai. The WAVESCAN buoy is a wave directional buoy measuring waves, meteorological and environmental parameters. The buoy is equipped with several options regarding sensors and equipment. The Data is stored on board and on hard disk. The buoy is powered by a lithium battery pack and solar cell charger. The WAVESCAN buoy automatically collects raw data, process it in situ, store it on board and transmits processed or raw data using GPRS. The buoy is deployed 12 kilometers off the Jumaira Beach, north of World Island of Dubai Coast during 2008 and redeployed it in 2010.

The buoy is equipped with a sophisticated array of sensors which report half hourly data on

- Wind speed and direction
- Atmospheric pressure and humidity
- Significant wave height and period
- Air and Sea temperature
- Sea water quality parameters

The real time data increases the accuracy of forecasts and consequently contributes to improve safety at sea. Dubai municipality is planning to deploy a network of buoys which will provide vital data for weather forecasts, shipping bulletins, gale and swell warnings as well as data for general public information and for research works.

Fig.3 Offshore buoy deployed by the Survey Department of Dubai Municipality

Data from the buoy is helping for updating the vertical datum in the offshore area. The data from the offshore buoy is also helping to establish key baseline information such as temperature and salinity values which will, in time, allow researchers to monitor change and determine climatic patterns.

5. CONTORL POINTS AND BENCH MARKS

Bench marks are fixed elevation marks on the land against which the zero setting of the tide gauge is referred, and from which hydrographers may recover chart datum for future surveys, and through which surveyors and engineers may relate their surveys and structures to chart datum. Hydrographic Benchmarks denotes the elevation of benchmarks above chart datum and this procedure is basic to charting and gauging procedures. At each tidal station, a minimum of two benchmarks are established in the immediate vicinity of the gauge. Each tidal station has its own bench mark with standard specifications similar to the second order national leveling network. The horizontal datum for the Bench marks are already established with the reference to network of horizontal control points established in Dubai Emirate.

The height difference between the preliminary gauge zero and each of the bench marks is determined by accurate spirit leveling. The elevation of chart datum is then chosen with

respect to the preliminary gauge zero, and the benchmark elevations are converted and recorded in the bench mark description as elevations above chart datum. The permanent zero of the water level gauge is set to chart datum. The Benchmarks are providing recovery of chart datum in the surveys and for checking consistency in setting of gauge zero for all water level measurements at the same site. Regular check surveys are performed at an interval of six months or whenever the water level sensors are changed for calibration. Monitoring of BM and tide pole with space techniques will solve the ambiguity of the computed annual mean sea level variations in many stations. Dubai Municipality has been performing regular precise DGPS/DVRS (Dubai Virtual Reference Stations, a RTK DGPS network in Dubai) measurements for connecting tide gauges to the Dubai Geodetic Network of Bench Marks and Control Points.

6. CHART DATUM AND MSL COMPUTATION

Tidal data and other meteorological data from remote stations are transmitted to the main office of Dubai Municipality using GPRS. This data is processed and analyzed and made for quality control. A senior Tide analyst makes the analysis and quality control and then computes the mean sea level and annuls mean sea level variation. Meantime the Geodesy and Hydrographic Section of the Survey Department of Dubai Municipality compares the discrepancies of Vertical datum with respect to the chart datum and means sea level variations.

Tidal information or water level data taken at a sampling rate of two minute interval from the tidal station network are used to generate heights of high and low waters, hourly heights, maximum and minimum monthly water level, monthly and annual mean seal levels.

The mean sea level computation of all the stations are performed annually and the level difference between mean sea level and chart datum is prepared for the updating the vertical datum. If some notable level difference is found in the mean sea level calculation than the previous value at a station, then all the raw data and processed data are cross checked and if again the difference exists, the difference in value is reported to the concerned higher authorities. The main aim of computation and observation of the sea level is to put an end to the conflicting issues and to have a common vertical datum, establish relationship between the existing vertical datum in Dubai Emirate and refines the value of Mean Sea Level (MSL), Chart Datum (CD) and Dubai Municipality Datum (DMD) and for updating the vertical datum for Dubai Virtual Reference System (DVRS). Determination of the accurate Chart Datum and Mean Sea Level shall be done by the above procedure.

No.	Date	Time	Reference No.	Wind Speed	Wind Gust	Wind Direction	Visibility	Air Temperature	Humidity	Air Pressure	Water Level	Water Temperature	Rain Fall
1	01-Dec-10	12:00:00	617	0.78	1.55	165.96	3000.04	19.04	75.66	1015.91	0.68	25.87	0
2	01-Dec-10	12:02:00	617	0.7	1.24	162.44	3000.04	18.95	75.16	1015.91	0.67	25.87	0
3	01-Dec-10	12:04:00	617	1.01	1.86	156.81	3000.04	18.86	74.65	1015.91	0.66	25.87	0
4	01-Dec-10	12:06:00	617	0.93	1.55	160.33	3000.04	18.86	74.65	1015.91	0.65	25.87	0
5	01-Dec-10	12:08:00	617	0.62	1.55	170.17	3000.04	18.95	75.36	1015.91	0.65	25.87	0
6	01-Dec-10	12:10:00	617	0.31	0.93	169.47	3000.04	18.86	75.46	1015.91	0.65	25.87	0
7	01-Dec-10	12:12:00	617	0.93	1.86	157.17	3000.04	18.86	74.75	1015.91	0.65	25.87	0

Table-1.showing the data collected from the tide/meteorological stations at 2 minute interval

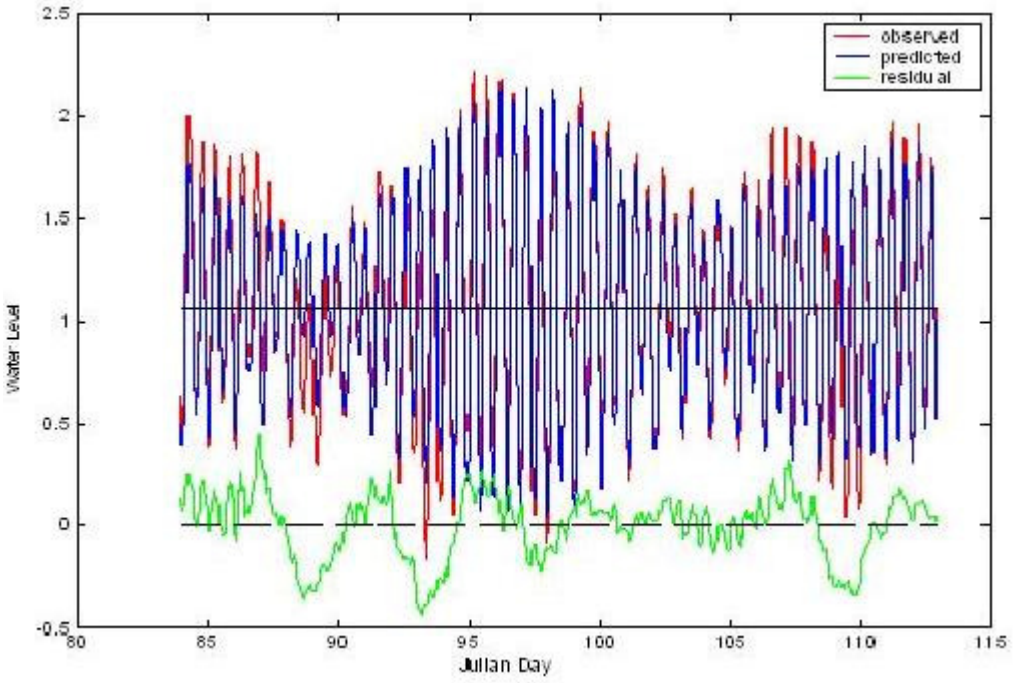

Fig. 4. Comparison of observed and predicted tides

Month	MSL	Correction	Corrected Level

Jan	1.06	0	0.97
Feb	1.05	0.1	1.06
Mar	1.06	0.1	1.07
Apr	1.12	0	1.12
May	1.19	-0.1	1.18
Jun	1.23	-0.1	1.22
Jul	1.29	-0.2	1.27
Aug	1.21	-0.1	1.20
Sep	1.19	-0.1	1.18
Oct	1.12	0	1.12
Nov	1.21	-0.1	1.20
Dec	1.03	0	1.03
	Average=1.16m		1.15

Table - 2. Showing different water levels computed at each station.

Location	LAT	MLLW	MHLW	MSL	MLHW	MHHW	HAT	Year
Umm Suqeim	-0.16	+0.43	+0.78	+1.11	+1.32	+1.66	+2.30	2006-2009

Table - 3. Showing MSL of UMM Sequim Station calculated for 2010

Constituents	Dubai Municipality (2009)
Sa	0.0809
Ssa	0.0330
Mm	0.0068
Msf	0.0048
O1	0.1709
K1	0.2471
M2	0.4545
S2	0.1770
Z0	1.1119
Number of derived Constituents	62
Based on one and fiveyears data from Umm Sequim station	

Table-4. Showing harmonic constituents

7. LAND & OFFSHORE GEOID MODEL OF DUBAI

The Dubai Geoid Model was developed by integrating a comprehensive set of gravity measurements with GPS, leveling and digital elevation data. The computed geoid is a wrapped surface that fits GPS/leveling at the 3-4 cm level RMS. The real-time reference network used, known as Dubai Virtual Reference System (DVRS), has external positioning accuracy of less than 4 cm and a precision of 3 cm in determination of the heights. It has

several operational advantages including cost-reduction, minimization of number of staff members (surveyors), and obtaining consistent coordinates

Height or elevation represents the length of the plumbline segment between two equipotential surfaces of the earth's gravity field. Equipotential or level surfaces are surfaces of constant potential in the earth's gravity field. Work is required to move it from one point on an equipotential surface to another point on the next surface.

Due to the earth's flattening and rotation and the fact that its crust contains masses of different density and distribution, these equipotential surfaces are not parallel. In fact they converge toward the earth poles, thus the plumbline or the vertical is not a straight line but curved.

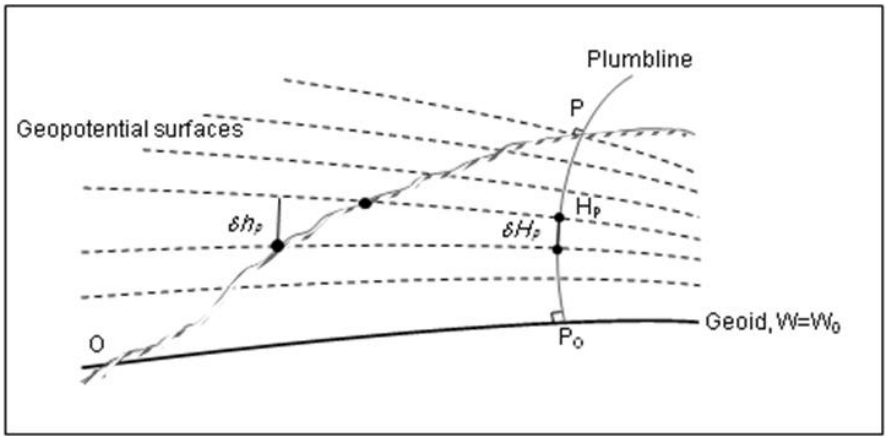

Fig.5. showing various aspects in Geoid Modelling

Work or potential difference is expressed as the product of vertical displacement δh and gravitational acceleration g, such that:

$$W_P - W_O = -\int_O^P g \ \delta h$$

The geopotential number C_P is expressed as geopotential units of a point *P* and it defines which equipotential surface passes through it. One geopotential unit (gpu) is equivalent to one kilogalmetre which has a value of 10 m^2/s^2. Unlike observed height differences, geopotential numbers are independent on the levelling path taken. They are functions of positions only and misclosures are therefore eliminated. Gravity measurements when combined with levelling yield potential differences or geopotential numbers.

The Dubai Geoid model was developed integrating a comprehensive set of gravity measurements with GPS, leveling and digital elevation data. Gravity data used in determination of the Dubai precise geoid consisted of gravity measurements collected at a network of 1 Km x 1 Km covering the whole Dubai Emirate, referenced to three absolute gravity stations. Other available gravity data were also included from marine gravity surveys in the Arabian "Persian" Gulf (provided by BGI, Toulouse) and KMS-01 gravity anomalies derived from satellite altimetry. The heights of the gravity points were measured with fast static GPS. All gravity data were checked for outliers, and the marine gravity data were

compared to the satellite altimetry to check for possible datum errors. As part of the gravity processing, gravity values and ellipsoidal heights of the gravity points were converted into conventional free-air and Bouguer gravity anomalies, using the EGM96 geoid model. The Bouguer anomalies were smooth in mainland Dubai, but a very large gradient went through Hatta. One should however note that with the new geoid model the gravity anomalies could change a fraction of a milligal, but with the GPS leveling fit applied, this will have no practical consequence for the geoid (Forsberg et al., 2001).

The Geodesy and Hydrographic Section of the Survey Department of Dubai Municipality had defined an offshore geoid model and land geoid model for Dubai Emirate in the year 2005 in view of updating the vertical datum of Dubai. A set of approx. 3750 leveled benchmarks with GPS ellipsoidal heights were made available by Dubai Municipality. The GPS data were tied into the ITRF base network of Dubai, and the leveling referred to a fundamental tide gauge at Port Rashid, Dubai. Most of leveling is third order, with some points leveled by trigonometric methods. Many GPS points were repeated RTK measurements (with a 5 cm acceptance limit); while other points in build-up areas were actually determined using classical techniques from nearby GPS points. At points with GPS and leveling a GPS geoid value was derived by

$$N^{GPS} = h^{GPS} - H^{levelling}$$

It should be pointed out that these geoid heights, opposed to the geoid heights determined from global models and gravity data, refer to as local vertical datum, due to the sea-surface topography at the reference tide gauge. In connection with the gravity observations, a leveling line was observed around the perimeter of the Dubai main area, and GPS observations (for gravity station heights) were done in connection with this. The eastern and southern part of the perimeter leveling line GPS was done using rapid static techniques. However, baselines were relatively short, and it appears that the accuracy was good enough also for geoid use (3-5 cm for most points). The perimeter GPS geoid data have therefore also been used for constraining the final geoid. Fig.6 shows Dubai Municipality GPS leveling geoid data, and the GPS geoid data from the gravity survey

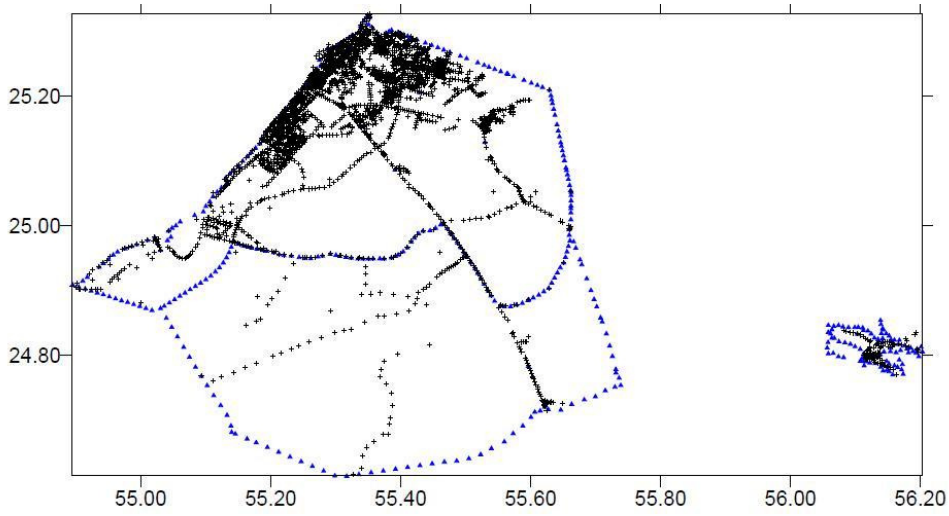

Fig. 6. Available GPS-leveling geoid data shown in black and gravity data is shown in blue triangles.

8. TRANSFERING VERTICAL DATUM TO OFFSHORE ISLANDS

Considering the massive contractions and developments taking place in the offshore area of Dubai Emirate, it become inevitable to establish vertical datum to offshore islands. Now the Geodesy and Hydrographic Section of the Survey Department is transferring the well defined vertical datum to offshore manmade islands, which involve establishing a series of tide gauges along the coast of these islands and monitoring the tide data simultaneously from the automated tide/meteorological stations and the tide gauges established along the coast of offshore manmade islands.

The coastal tide gauges BMs are now tied by precise leveling to maintain the same relative elevation as time progress, and then connected to the National Leveling Network. A network of tidal stations are being established which includes the existing coastal stations and the existing offshore stations (seabed pressure tide gauges). Tide models are being developed which contains harmonic constants in all grid points determined using tide measurements, depth and bottom roughness. Grid network are adjusted to get the blanket best fit for the whole area, from which we can precisely find the MSL and Chart datum, and producing co-tidal charts for remote areas.

9. CONCLUSION

This paper has setout to demontsrate the importance of a vertical datum and how it is updated making use of the advancements in information technology, marine & coastal engineering. Dubai Municiplaity had decided to instal permanenet tide gauge station network and to monitor the tides for a long period (19 years) for establishing a firm datum. Dubai Municipality being a centralized authority for quality assurance and control, it become essential to keep a standard vertical datum in Dubai Emirate and to keep a continuous monitoring on the stability of the constructions within the sea. Also it become mandatory for all the clients to contact the Survey Department of Dubai Municipality for getting Horizontal and vertical Coordinates within Dubai for land and marine related operations.

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BIOGRAPHICAL NOTES

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Mustafa Mohammed Baqer has over 5 years experience as a Hydrographer and is currently working as the Head of Hydrographic Survey Unit in the Geodesy and Hydrographic Section of Dubai Municipality. He is a graduate in Civil Engineering and is well trained in Hydrographic Surveying and Hydrographic Survey Data Analysis. He is in charge of a net work of Tide/Meteorological station and visibility stations in Dubai. He is an Emirati and authored a research paper in Marine Information system.

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