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PAPER 7462
Optimum Geoid Determination for Enugu Lifestyle and Golf City Estate, Nigeria
Nnam Victor Chukwuemeka , Nigeria,
Onwuzuligbo Chukwubueze, Nigeria,
Nnam Godwin Uchechukwu, Nigeria.

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ABSTRACT

The awakening in the mind set of West Africans for sustainable Estate development has gained momentum in recent times. The Enugu Lifestyle & Golf City Estate is arguably one of the most beautifully planned cities in Nigeria. It is set on 1,097 hectares in the Awkunanaw Hills. From the inception, the estates horizontal coordinate system was referenced to the Nigerian Minna Datum , but the vertical coordinates system has suffered some major setbacks because of the difficulties in the realization of the surfaces, so it caused some impediments in the engineering projects in the city. In Geodetic and Engineering activities, The Geoid has strong correlation with the direction of water flow; Orthometric heights are predominantly used because it has a humanly intuitive meaning. This Project aims at the Determination of a best fitting Geoid for Enugu Lifestyle & Golf City. The Geometric method (GPS/Levelling) was used because of its advantages over other methods for the determination of the geodetic surfaces. The Geometric method was applied in the study area in order to determine the local Geoid for the estate. This project covers the approximate area of 1,097 hectares. One hundred and thirty nine (139) first order control points were monumented and observed to derive all the required parameters for local Geoid determination at a density of about one control point per 500m. At each benchmark, both the Orthometric and ellipsoidal heights were determined and adjusted. Imperatively, all participants in the Estate project shall benefit from the Local Geoid Determination.

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Rational

The foundation of the physical development of every nation depends on its National Spatial information systems. These are the frameworks that enhance the reliability of geographic data for the spatial information management. Orthometric Height, the height of a point above the Geoid is one of the main variables of any spatial information system. Orthometric Heights are realised through the process of Geodetic Levelling. Global Navigation Satellite System (GNSS) provides an alternative means of determining this quantity. With the knowledge of the ellipsoidal height of a point from GNSS observations, the Orthometric height of the same point can be determined if the geoidal undulation of the point is known. This method of obtaining Orthometric height has been adopted by many nations around the world. This is because the approach is fast, less tedious in difficult terrain and relatively cheap when compared to the geodetic levelling technique. Unfortunately, this technique cannot be adequately used in Nigeria because the Nigerian Geoid is yet to be determined. There is therefore a need to embark on accurate Geoid determination for the Nigerian geodetic network, particularly in



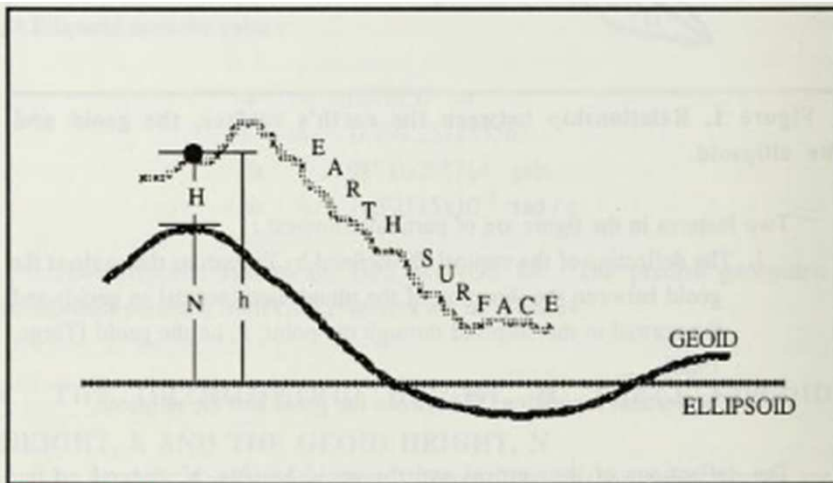
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Figure 1: Relationship between the Geoid height, N , the ellipsoidal height, h and the Orthometric height, H . $N = h - H$. (Source: EROL and ÇELİK, 2004)





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Overview of Study Area

Enugu Lifestyle & Golf City ranks among the most planned cities in Nigeria. It occupies about 1,097 hectares good terrain in Amechi/ Obeagu Awkunanaw communities, Enugu South Local Government of Enugu State; Located within Longitude 6°24'14.62"N to 6°24'26.94"N and Latitude 7°34'40.54"E to 7°30'53.5"E. The city delivers a lifestyle of luxury, serenity and security. The residential plots are surrounded with golf courses, lakes and reserved green areas. The plots sizes range from 300SqrM – 3,000SqrM.



Figure 2: Town Planning Design of Enugu Lifestyle and Golf City. (Not to Scale)



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Methodology

The Geometric method was applied in the study area in order to determine a local Geoid for the city. A dual frequency GPS was used on static mode in determining the coordinated and the ellipsoidal heights of the grid points (i.e. control points) while spirit levelling method was used in transferring the orthometric heights from existing government control points to the study control points; two existing control point were used. Before the existing control points were used, an in-si-tu check was made to confirm their consistency; during the levelling operation, one of the existing control points were used for the determination and another loop was taken from the other existing control for checks on the study control points. In all, one hundred and thirty nine (139) control points were monumented and observed at a density of one control point per 500m to derive all the required parameters for accurate Geoid determination, Twenty (20) stations were used as test stations for the interpolation methods. The Polynomial Regression Method Model used Isioye and Youngu (2009) and Geometric Interpolation Techniques of interpolation used by Heiskanen and Moritz, 1967) were used for the estimation of the Orthometric heights of the test stations. The mean residual between the observed Orthometric heights and the estimated Orthometric heights were seen to be identical with the mean value.



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Data

Some of the used data for this study include:

- The geodetic coordinates (ϕ, λ, h) Existing Government Control points in the study area.
- The 1:5000 topographic map of the study area
- The EGM08 and EGM96 Geoid heights of the stations.

Parameters of the reference ellipsoid: Angular Unit: Degree (0.017453292); Prime Meridian: Greenwich (0.00000)0; Datum: D_WGS_1984(Minna Datum); Spheroid: WGS_1984; Semimajor Axis: 6378137.0000 b; Semiminor Axis: 6356752.3142451 a; Inverse Flattening: 298.2572235 1/f

Table 1 Existing Government Control points used (Source: OSGOF)

S/ N	Control ID	Latitude	Longitude	Othometric Height	Location
1	XSV 985	06 24 38.113	07 32 39.572	196.334m	Methodist Church ugwaji, Enugu South LGA.
2	XSV 997	06 24 30.591	07 29 59.133	210.436m	Igbariam Primary School II, Enugu South LGA.



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Results

This project delivered the following results at the end of the study;

- Digital maps showing the boundary of the study area, Geoid Undulation, Ellipsoid contour and orthometric height contour.
- Soft copies and hard copies of Digital map of the Benchmarks and their GPS coordinate/heights, computation Results and the Leveling lines/network.
- Geoid Database for Enugu Lifestyle and Golf city.
- A Comprehensive Technical Report.

Some of the results achieved in the study are shown in the figures and tables below;





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Table 2. Some of the established control points, their coordinates, Geoid undulations, Orthometric heights and ellipsoidal heights.

Control ID	NORTHING		GEOID UNDULATIONS		ELLIPSOIDAL HEIGHTS	
	GS	EASTINGS	ORTHOMETRIC HEIGHTS	ORTHOMETRIC HEIGHTS	DIAL HEIGHTS	DIAL HEIGHTS
LGS1	703005.507	335929.381	22.077	215.146	237.223	
LGS2	703502.346	335929.381	22.080	213.703	235.783	
LGS3	703005.507	336428.016	22.083	209.876	231.959	
LGS4	703502.346	336428.016	22.085	207.203	229.288	
LGS5	703005.507	336926.205	22.088	205.372	227.460	
LGS6	703502.346	336926.205	22.090	201.654	223.744	
LGS7	703005.507	337433.855	22.092	199.432	221.524	
LGS8	703502.346	337433.855	22.095	195.764	217.859	
LGS9	703005.507	337927.916	22.096	191.534	213.630	
LGS10	703502.346	337927.916	22.098	189.932	212.030	
LGS11	703005.507	338428.001	22.100	183.249	205.349	
LGS12	703502.346	338428.002	22.101	183.373	205.474	
LGS13	703005.507	338928.668	22.102	175.924	198.026	
LGS14	703502.346	338928.668	22.103	175.623	197.726	
LGS15	703005.507	339438.628	22.070	161.691	183.761	



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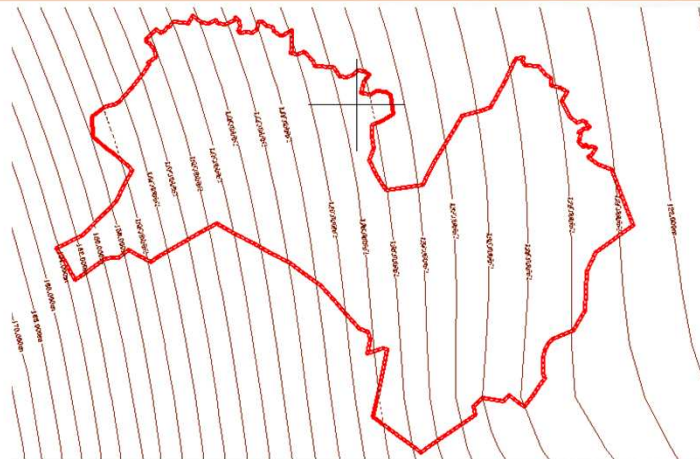
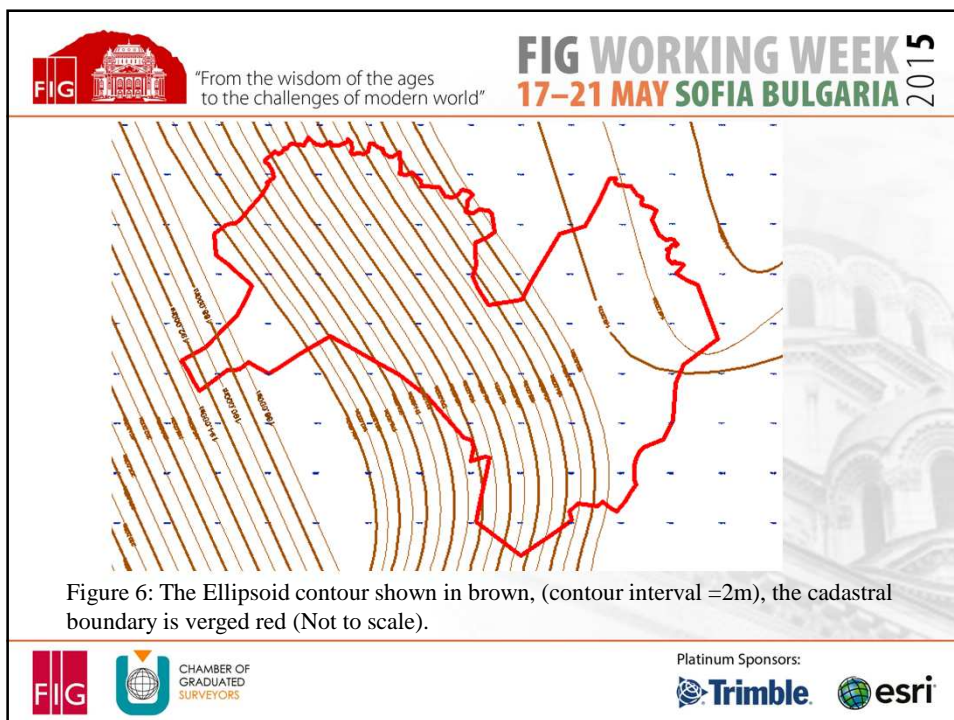
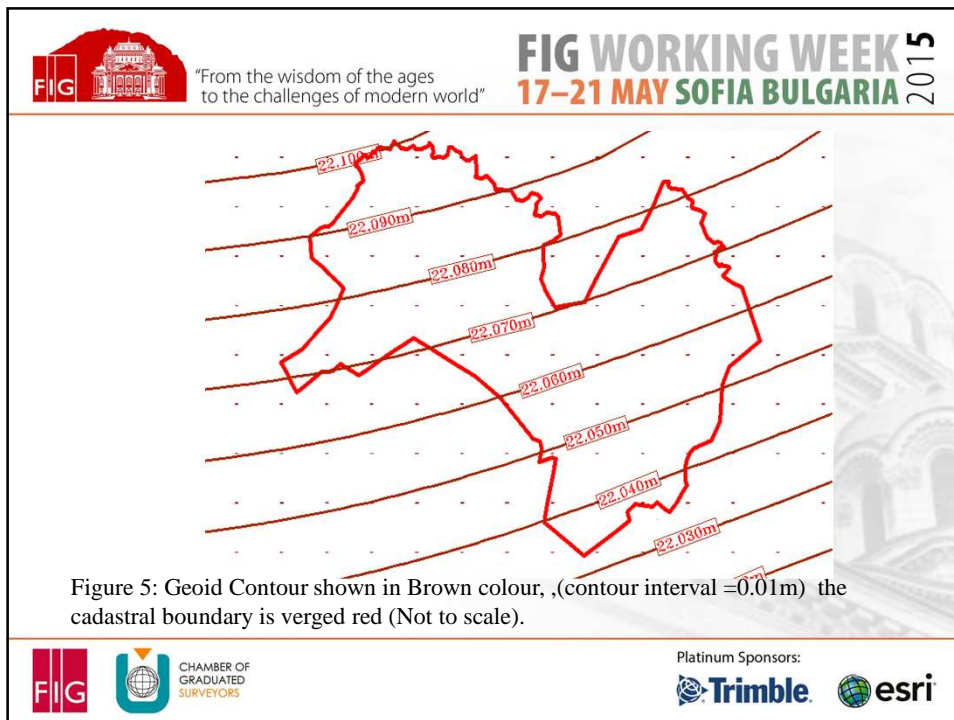


Figure 4: Orthometric Height contour shown in brown colour, (contour interval =2m) the cadastral boundary is verged red (Not to scale).



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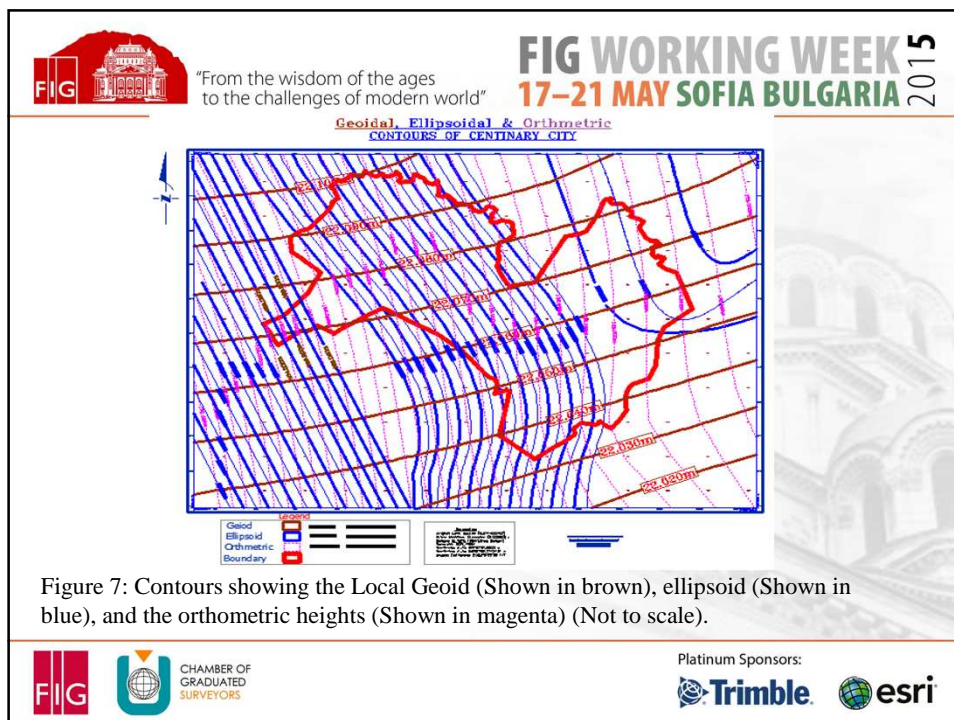


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Contribution to Knowledge and Capacity Building

This study was proposed to achieve the major Aim of determining the best fitting Geoid for Enugu lifestyle and Golf city, and more than that, it shall helped the researchers to understand why the Geoid height has no direct relationship with the land form and therefore does not get affected by development. This also enlightened us more on how the GPS can be used to determine the orthometric height if a local geoid model is in place. It also proved that whereas the different interpolation method will yield different height values, that their mean ΔH are identical and that irrespective of the estimation model used, the height relationship between the derived orthometric heights should be identical.

Undergraduate and Graduate Students from some of the universities offering surveying and Geoinformatics around the study area were employed in some of the field campaigns, thus it developed their field skills.

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CONCLUSION

In conclusion, the necessity of this study in Enugu lifestyle and Golf city can never be over emphasised. In order to determine the Geoid model of the city, the Orthometric height of the survey control points were established at the grid points. These points were observed through spirit Levelling and GNSS methods. Two existing first order control points were located within the local Government and used in order to transfer value to the newly established points. The GNSS observations determined ellipsoidal coordinates while the spirit levelling will transfer Orthometric heights from the known to the unknowns control points. The geoid undulations were generated by finding the difference between the GPS observed ellipsoidal heights and the spirit levelling observed Orthometric heights. When these were done, a best fitting Geoid for Enugu lifestyle and Golf city shall emerged. This will solve a lot of problems pertaining to Surveying, geodesy and engineering in Enugu lifestyle and Golf city and its environs.



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THANKS FOR LISTENING!!!

ANY QUESTIONS ??



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