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Coordinates

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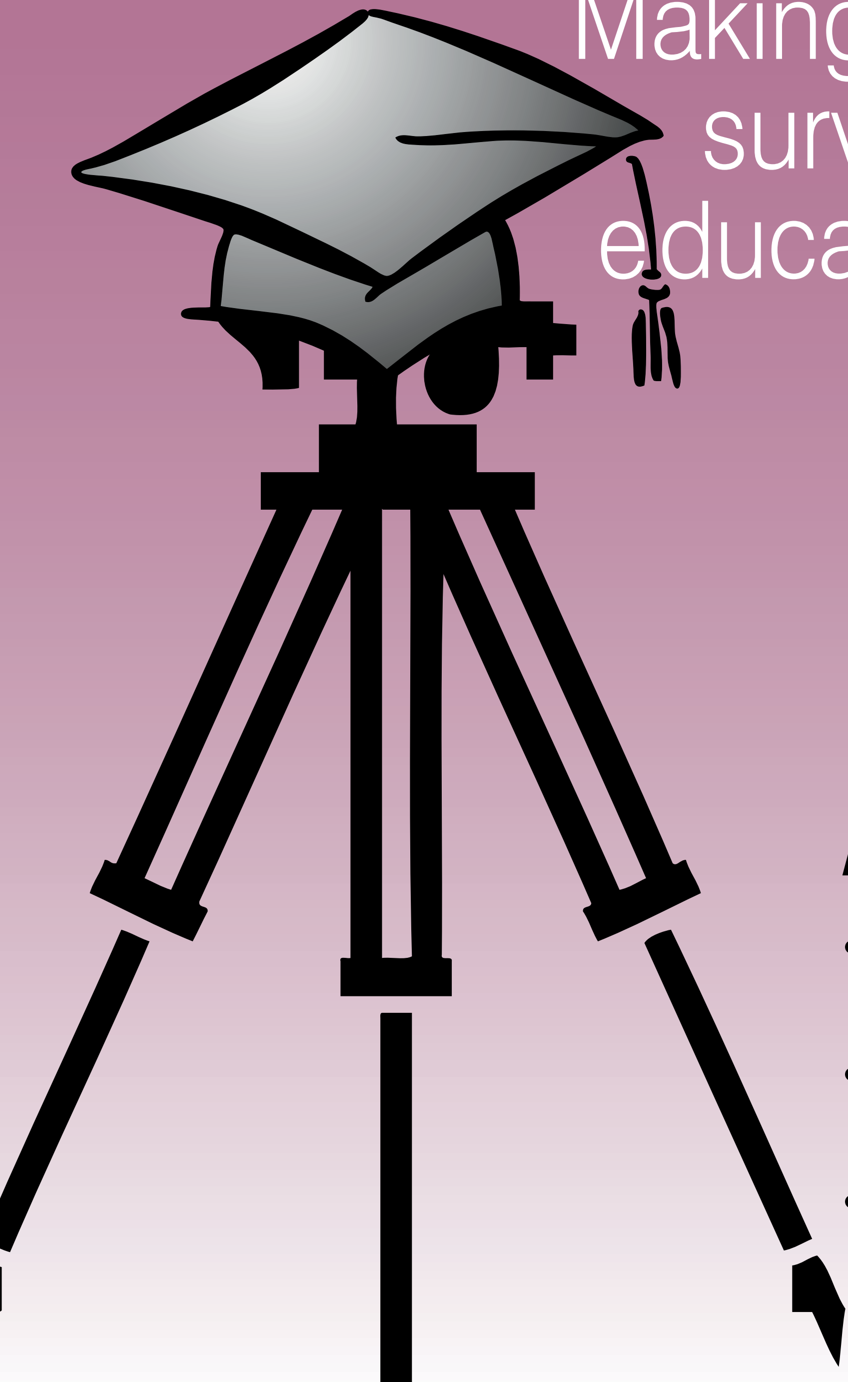
Making surveying education relevant



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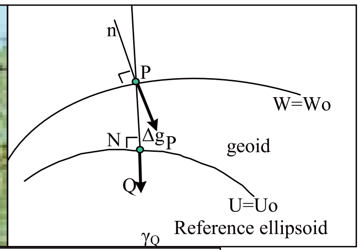
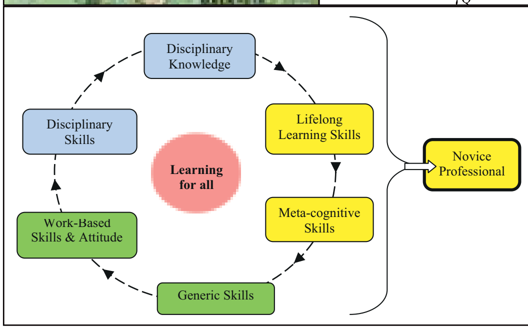
- **The challenges before surveyors and surveying**
- **Geocentric Datum for Brunei Darussalam**
- **LightSquared and GPS**





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This issue of Coordinates is of 60 pages, including cover

GPS applications on cellular phone with geoid addition to height

The use of GPS in mobile phones became a common and can be used for survey purposes GCP

Dadan Ramdani
Geomatics Research Division, National Coordination Agency for surveys and Mapping (BAKOSURTANAL) Indonesia

Location Base Services (LBS) is service mechanisms that provides information about the location and take advantage of the location. Global Positioning System (GPS) is one of Devices that inform the position. Mobile phone GPS has the advantage because they can be used also as a means of communication and the completeness of the camera (photo and video) resolution good enough to take photos that have coordinates ((Geo) tagging photo) and can be sent directly to the office for more information .

GPS has higher accuracy than cell phones. Accuracy of GPS ranges from 5 to 30 meters, whereas for cellular phone a level of accuracy varies from 500 meters to 20 meters. The Information of position using a mobile can be used if it does not require a high degree of accuracy.

For programming in the manufacture of software that runs on mobile phones in this study used the Java Micro Edition (J2ME) which can produce a good application and flexible and can be run on other mobile devices like mobile phones, personal digital assistants (PDAs), and printers. Java ME includes flexible use interface, powerful security, network protocols contained in devices, and support for network applications can be downloaded dynamically. Java ME-based application can be used in many devices, and increase the original capacity of each device. For the purposes of use in location-based programming in Java Specification Request provided J2ME (JSR) 179

JSR 179

Java Specification Request (JSR) 179 has been created by the Java Community Process (JCP) to support location-based programming that has been connected in the Connected Limited Device Configuration (CLDC). Implementation of JSR 179 can be done in several positioning methods such as (Qusay, H. Mahmoud, 2004):

- Using a cellular phone network. Cell ID can be used to identify the Base Transceiver Station (BTS). A mobile phone has the accuracy of 2 to 20 kilometer radius. Another technique may have the accuracy of 150 meters.
- Using satellite. GPS is one of the techniques used this technology. In order to use this method the user must use a GPS receiver. Accuracy of this method to reach 4 to 40 meters.
- Using short-range position beacons. This method is used for areas that are not too large. This method may use Bluetooth technology.

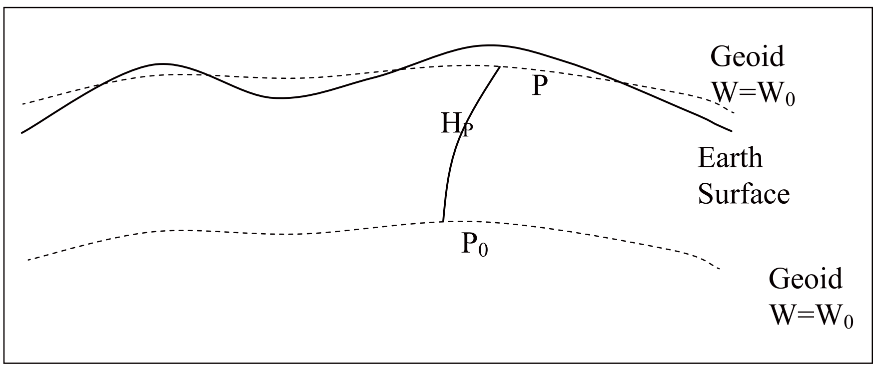

Fig 1. The LBS Location field and geoid equipotential

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API Location (JSR 179) in J2ME has optional package javax.microedition. location that has the ability to generate information on the position of equipment. Location API produces physical location information that can be used for landmarks that can be saved.

JSR 179 requires Connected Device Configuration (CDC) or the Connected Limited Device Configuration (CLDC) version 1.1. But CLDC not adequate, because it cannot perform floating-point calculations are used to represent coordinates and other measurements.

The methods are used depend on the types of devices. Applications can be requested to provide a variety of characteristics, such as minimum degree of accuracy. Class Abstract Location generates location. Each object produces the coordinates, speed and time stamp.

The coordinates are represented respectively by two classes:

- A Coordinate object shows a point latitude and longitude in degrees, and altitude in meters.
- A Qualified Coordinates object contains latitude, longitude and altitude and also shows the level of accuracy is represented in the area radius.

API Location J2ME provides a source of location information. Because there is security for accessing this method is provided SecurityException if there was no information to the desired position.

High

GPS height is used ellipsoid high, to turn it into orthometric high required geoid undulation. In general from the GPS satellite positioning with accuracy in mind that the horizontal position components (λ, φ) is more rigorous than the vertical position (h), approximately 3-4 times more accurate (Prijatna, 1997).

Orthometric height of a point on the surface of the earth can be defined as the geometric distance between that point on the surface of the earth with her partner point on the geoid surface and measured along the plumb line (referring to the projection Pizzetti; Heiskanen and Moritz (1967), p. 180).

$$H_P = \frac{C_P}{g_P} \qquad (1)$$

with HP is a high orthometric at point P, Cp = WP - W0 is the potential at point P and the average gravity along the plumb line in point P (fig1).

Geoid height can be defined as the distance from the reference ellipsoid to geoid surface as measured along the ellipsoid normal. There are several methods to get the geoid height rates among geometric method and gravimetric method. In the geometric method of geoid height is calculated from a combination of altitude data of the satellite position with altitude measurement from leveling, whereas the gravimetric method, geoid height computed from terrestrial gravity data and global geopotential model (coefficients of potential global gravity). Stokes in 1849 has published geoid calculation equation. For the purpose of calculating the geoid height and gravity anomaly data needed throughout the Earth's surface with a continuous density (read: very tight). With this equation allowed calculation of geoid height based on gravity data. The Stokes equation (Hofmann-Wellenhof and Moritz 2006) are as follows:

$$N(P) = \frac{\delta GM}{R\gamma} - \frac{\Delta W_0}{\gamma} + \frac{R}{4\pi\gamma}\int_{\lambda=0}^{2\pi}\int_{-\pi/2}^{\pi/2} St\big(\Psi_{PQ}\Delta g(Q)\cos\varphi_Q\, d\varphi_Q d\lambda_Q\big) \qquad (2)$$

where: N (P): geoid height at point P, ΔW: The difference between the potential at the surface of the geoid (W_0) and the potential on the reference ellipsoid that used (U_0), δGM: GM difference (gravity constant x period) are not known between real and model earth ellipsoid, P: calculations point, Q: data gravity anomaly point Δg(Q): the gravity anomaly at point Q, St (ψ_{PQ}): Stokes function with ψ is the spherical distance from point P and Q, R: , average radius of the earth, γ: average normal gravity on the ellipsoid and λ, φ: latitude and longitude coordinates.

For the determination of Geoid (N) developed strategies to overcome them, by combining the global geoid models, N_L (to calculate the long waves signals of the geoid) and local geoid model results from local data in the vicinity of the calculations, Ns (to calculate the short wave signals of the geoid). So the calculation of geoid become N = NL + Ns (Khafid, 2000)

Of the three height (orthometric height, ellipsoidal height and geoid height/undulation) there can be expressed by equation

$$h = H + N \qquad (3)$$

Where H is the orthometric height, h is the ellipsoid height and N is the geoid height.

The combination of various data types used to create a global potential coefficient model becomes better. Yet the gravity field can be modeled with observation data are still limited. To obtain a more detailed or better model of the global potential coefficient is needed the data from the satellite trajectory analysis combined with all the data closely related to the potential gravity of the earth, (Rapp, 1992).

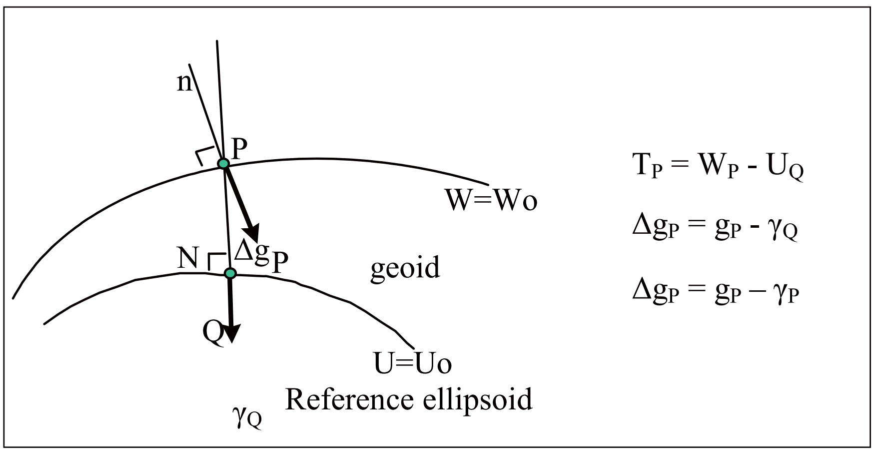

Fig 2. The geoid and reference ellipsoid

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Increase in resolution
Decrease in price

Part of Uno city, Vienna viewed by Cartosat-2+Resourcesat-1

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Potential at a point P with coordinates geocentric radius r, geocentric latitude and longitude respectively φ and λ can be presented as follows (Hofmann-Wellenhof and Moritz 2006):

$$T(r,\varphi,\lambda) = \frac{GM}{r}\left[1 + \sum_{n=2}^{\infty}\left(\frac{a}{r}\right)^n \sum_{m=0}^{n} (\Delta C_{nm}\cos m\lambda + \Delta C_{nm}\sin m\lambda)P_{nm}\sin\varphi\right] \quad (4)$$

Where GM: geocentric gravitational constant, a: half the long axis of: geocentric ellipsoid, r: distance to the center of the earth, φ: latitude coordinate of the geocentric ball, λ: longitude coordinate of the geocentric ball, ΔC_{nm}, ΔS_{nm}: is the difference between harmonic coefficient and coefficient fully normalized geopotential ball and P_{nm}: The Legendre function of The first fully associated and normalized type.

Geoid is the equipotential surface closest to the average sea level. Geoid height, N is defined as the distance between the surface of the geoid and reference ellipsoid. According to equation Brun, geoid undulation defined as, (Hofmann-Wellenhof and Moritz 2006):

$$N_0 = \frac{T_P - (W_0 - U_0)}{\gamma_P} \quad (5)$$

where γ_P is normal gravity at point P. T_P is a disturbance potential, W_0 is the potential at the geoid and U_0 is the potential in ellipsoid.

Or geoid height can also be written by (Hofmann-Wellenhof and Moritz 2006):

$$N_P^L = N_0 + \frac{GM}{r_P\gamma_P}\sum_{n=2}^{\infty}\left(\frac{a}{r}\right)^n \sum_{m=0}^{n} (\Delta C_{nm}\cos m\lambda + \Delta C_{nm}\sin m\lambda)P_{nm}\sin\varphi \quad (6)$$

$$N_0 = \frac{GM - GM_0}{r_P\gamma_P} - \frac{W_0 - U_0}{\gamma_P} \quad (7)$$

where N_0 is usually ignored in practice, especially in terms of regional geoid height computation. The ignored N_0 based on assumptions that $GM = GM_0$ and $W_0 = U_0$, or if $No \neq 0$ errors caused only a refractive error that can be eliminated with relativism the calculation of geoid height to a reference point in the calculation.

For points on the mainland, the calculation by equation (6) is less precise (Rapp, 1994). More accurate equation is as follows (Hofmann-Wellenhof and Moritz 2006):

$$N_P = N_0 + \frac{GM}{r_P\gamma_P}\sum_{n=2}^{\infty}\left(\frac{a}{r}\right)^n \sum_{m=0}^{n} (\Delta C_{nm}\cos m\lambda + \Delta C_{nm}\sin m\lambda)P_{nm}\sin\varphi + \frac{\Delta g_B}{\gamma}H \quad (8)$$

Where ΔG_B is the gravity anomaly Bouguer and H is orthometric height. The Bouguer correction term in equation (9) is significant, especially for Mountain areas.

Geoid height calculation is done by using equation (8) to find the N_L. To calculate the geoid height at a point in the data is needed the geodetic coordinates (latitude, longitude) and a global geopotential model.

To enter a correction on the geoid height is the GPS application program on the mobile phone needs a special approach because of the memory on the mobile phone is very limited. For this purpose geoid height can be searched by using the approach by way of linear interpolation.

High geoid calculated using equation (8) for specific areas with sufficient area so as not to burden the memory of the mobile phone. The linear interpolation equation is:

$$y = y_a + (y_b - y_a)\frac{(x - x_a)}{(x_b - x_a)} \quad (9)$$

Thus for the geoid height interpolation equation becomes:

$$N = N_0\left(1 - \frac{\theta - \theta_0}{\Delta\theta}\right)\left(1 - \frac{\lambda - \lambda_0}{\Delta\lambda}\right) + N_1\left(1 - \frac{\theta - \theta_1}{\Delta\theta}\right)\left(1 - \frac{\lambda - \lambda_1}{\Delta\lambda}\right) + N_2\left(1 - \frac{\theta - \theta_2}{\Delta\theta}\right)\left(1 - \frac{\lambda - \lambda_2}{\Delta\lambda}\right) + N_3\left(1 - \frac{\theta - \theta_3}{\Delta\theta}\right)\left(1 - \frac{\lambda - \lambda_3}{\Delta\lambda}\right) \quad (10)$$

Where N_0, N_1, N_2, N_3 is the geoid height at the position (θ_0, λ_0), (θ_1, λ_1), (θ_2, λ_2), (θ_3, λ_3) and $\Delta\theta$, $\Delta\lambda$ is the difference in distance on the grid.

The Geoid Height for the GPS application in the mobile phone uses EGM 2008 (Pavlis, NK. et al. 2008)

Conclusions and suggestions

Use of JAVA ME is so much easier in making software for mobile phones. JSR 179, which is one of the applets in Java ME-based programming that helps position. The use of GPS in mobile phones became a common and can be used for survey purposes GCP. Geoid Height is needed for the height usage information on the GPS height. For this purpose geoid height can be searched by using the approach by way of linear interpolation.

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