Indonesian Geospatial Reference System 2013 and Its Implementation On Positioning

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Key words: Reference Systems, Reference Frame, Geodetic Datum, Coordinate Change, Positioning

SUMMARY

Since National Coordinating Surveys and Mapping Agency (BAKOSURTANAL) established on October 17th, 1969, Indonesia has many datum for mapping and surveying. Nowadays, after BAKOSURTANAL has been transformed to Badan Informasi Geospasial (BIG), we have released a new datum, that we called Indonesian Geospatial Reference System 2013 (Ina-GRS 2013), or in Indonesian is *Sistem Referensi Geospasial Indonesia* 2013 (SRGI 2013). An old datum, Datum Geodesi Nasional 1995 (DGN 1995) has been replaced by SRGI 2013. These datums are different, SRGI 2013 has coordinate changes with time function that included on it's calculation, while DGN 1995 has no coordinate changes with time function. Ina-GRS 2013/SRGI 2013 consists of horizontal and vertical geospatial reference system. This datum should be used easily and able to be accessed by users, then the access and service system for Ina-GRS 2013/SRGI 2013 has established on April 2014. All geospatial activity in Indonesia must be refer to Ina-GRS 2013/SRGI 2013, furthermore the deformation model should be included to get the coordinate on certain epoch.

SUMMARY

Sejak berdirinya Badan Koordinasi Survei dan Pemetaan Nasional (BAKOSURTANAL), sekarang Badan Informasi Geospasial (BIG), pada tanggal 17 Oktober 1969, Indonesia telah beberapa kali mengeluarkan datum yang dipakai sebagai acuan untuk kegiatan survei dan pemetaan, lebih luas lagi sebagai acuan dalam penyelenggaraan Informasi Geospasial (IG). Tanggal 17 Oktober 2013, Indonesia telah mengeluarkan datum baru yaitu, Sistem Referensi Geospasial Indonesia 2013 (SRGI 2013) untuk menggantikan Datum Geodesi Nasional 1995 (DGN 1995). Perbedaan mendasar antara SRGI 2013 dan DGN 1995 yaitu, SRGI 2013 memperhitungkan perubahan koordinat terhadap fungsi waktu. SRGI 2013 terdiri dari Sistem Referensi Geospasial Horizontal dan Sistem Referensi Geospasial Vertikal. Serta untuk mempermudah pengguna disediakan juga sistem akses dan layanan SRGI 2013. Berubahnya datum di Indonesia mengakibatkan pengguna harus mengacu pada SRGI 2013, demikian halnya dengan pengguna dalam bidang positioning. Pengguna harus menambahkan model deformasi, untuk mendapatkan koordinat pada epoch yang diinginkan.

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1. INTRODUCTION

Since National Coordinating Surveys and Mapping Agency (BAKOSURTANAL) established on October 17th, 1969, Indonesia has many datum for mapping and surveying. Nowadays, after BAKOSURTANAL has been transformed to Badan Informasi Geospasial (BIG), we have released a new datum, that we called Indonesia Geospatial Reference System 2013 (Ina-GRS 2013), or in Indonesian is *Sistem Referensi Geospasial Indonesia* 2013 (SRGI 2013). An old datum, Geodesi Nasional 1995 (DGN 1995) has been replaced by Ina-GRS 2013/SRGI 2013.

The background of datum transformation are single reference system has not been used consistently in every geospatial information enforcement by the various parties in Indonesia. It is evident from the diversity of the geospatial reference systems or geodetic data used by each geospatial information enforcement. Therefore, we need single reference system to accomplish national geospatial information for geospatial information integrity.

Furthermore, Indonesia lays on subduction zone of 3 major tectonic plate that moves continuously, and causes geospatial object including geodetic control pillars located on it have movement along the tectonic plate movement and crustal deformation. Coordinate changes over time due to influence of tectonic plate movement and crustal deformation. This phenomenon must be included on determination of geospatial reference system.

Positioning technology based on sattelite has possible to be used for accomplishment of national geodetic reference frame that compatible to global reference. It has good accuracy to monitor tectonic plate movement and crustal deformation. The old datum, DGN 1995, is the static datum and does not account coordinate change with time function. It is should be enhanced due to plate tectonic movement, crustal deformation, and global reference system improvement.

All geospatial activity must be refer to Ina-GRS 2013/SRGI 2013 as it has been released. It has impact for all geospatial activities, one of which is positioning activity.

2. Ina-GRS 2013/SRGI 2013 COMPONENTS

Ina-GRS 2013/SRGI 2013 is a geospatial reference system that used on entire of Indonesia (NKRI) and compatible to global geospatial reference system. Ina-GRS 2013/SRGI 2013 consists of horizontal and vertical geospatial reference system. We has conducted access and service system for Ina-GRS 2013/SRGI 2013. This system allow users to access and using the datum as easily. This application system has established on April 2014.

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2.1 Horizontal Geospatial Reference System

Horizontal Geospatial Reference System (HGRS) is coordinate reference system that used to definition or positioning in the horizontal position. Whereas, HGRS components are:
- Coordinate reference system;
- Coordinate reference frame;
- Geodetic datum;
- Coordinate change as a function time.

2.1.1   Coordinate Reference System

Coordinate reference system used to define the horizontal geospatial reference system, referring to the global coordinate reference system. Coordinate reference system is 3 (Three) dimensional of geocentric coordinate system with provisions:
- Center point of axis coordinate coincides with center of earth, as defined by International Terestrial Reference System (*ITRS)*.
- Unit lenght of axis coordinate using international standart units.
- Orientation of axis coordinate is equatorial, where:
  - The z-axis coincides with the polar axis and is positive toward the north pole;
  - The x-axis is in the equatorial plane and intersects the prime meridian (Greenwich), and
  - The y-axis is also in the equatorial plane; it lies at right angles to the x-axis and intersects the 90-degree meridian.
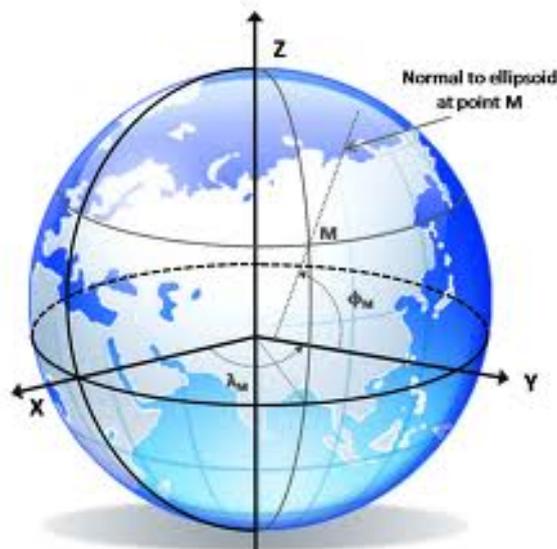

Figure 1. ECEF (Earth Centered Earth Fixed)

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2.1.2   Coordinate Reference Frame

Coordinate reference frame is realization of coordinate reference system, that is geodetic control network with coordinate values that defined at the epoch 2010.0 or January, 1st 2012, which is tied to global reference frame International Terestrial Reference Frame 2008 (ITRF2008) or the result of subsequent updating.
geodetic control network consists of:

- Distribution of continuous/permanent geodetic observation station; that is observation station located in the field and continuously recording data, and the data used to maintenance of coordinate reference system.
- Distribution of periodic geodetic observation pillar; that is observation pillar that spread in Indonesia and observed periodically.
- Distribution of other geodetic control point; that is temporary control point, e.g ground control point were used orthorectification at satellite image.

Coordinate reference frame that used for determine InaGRS 2013/SRGI 2013, are combination between permanent geodetic observation station and periodic geodetic observation pillar in Indonesia that connected to global network. The number of stations and pillars in indonesia that used to calculate are 954 local stations/pillars, as well as include 250 global network spread all over in the world.
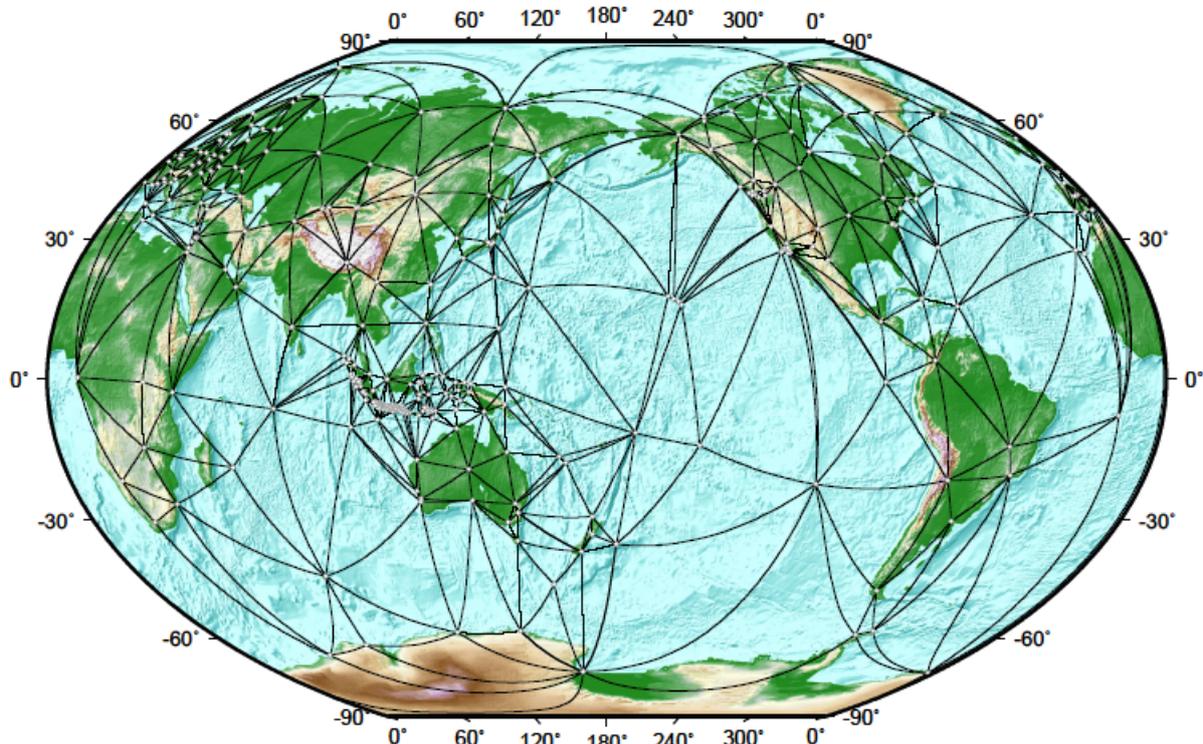

Figure 2. Local Control Network Connected to Global Network. Source: Rahmawan-2013

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Figure 3. Reference Coordinate Framework

2.1.3 Geodetic Datum

Geodetic datum is a model used as a reference for positioning on earth surface. Its defined geometric correlation between coordinate reference system and earth surface which is modeled by reference ellipsoid.

Geodetic datum using World Geodetic System 1984 (WGS 1984) reference ellipsoid, where reference ellipsoid center point coincides with center of earth that used in ITRS.

The parameter of WGS84 are listed in **Table 1.**

Table 1. WGS 84 parameters

Parameter	Notation	Value
Semi major axis	a	6378137.0 meters
Semi minor axis	b	6356752.314245 meters
Inverse flattening	1/f	298.257223563
Angular velocity average of the earth's rotation axis	Ω	7292115×10^{-11} radian/sec
Earth gravvitational constant	GM	$3.986004418 \times 10^{14}$ $meter^3/sec^2$

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2.1.4   Coordinate change as a function time

Coordinate change as a function time is a vector of coordinate values change as a function of time of a geodetic control points caused by the influence of tectonic plate movement and deformation of the earth's crust. Its based on geodetic observations. If the vector coordinate values change as a function of time can not be determined based on the geodetic observations used a model of the earth's crust deformation derived from geodetic observations in the vicinity. And if there is a change of ITRS and other factors such as the presence of a large earthquake, then the vector changes must also be updated. And also the change vectors must be accessible to users with easy and fast.
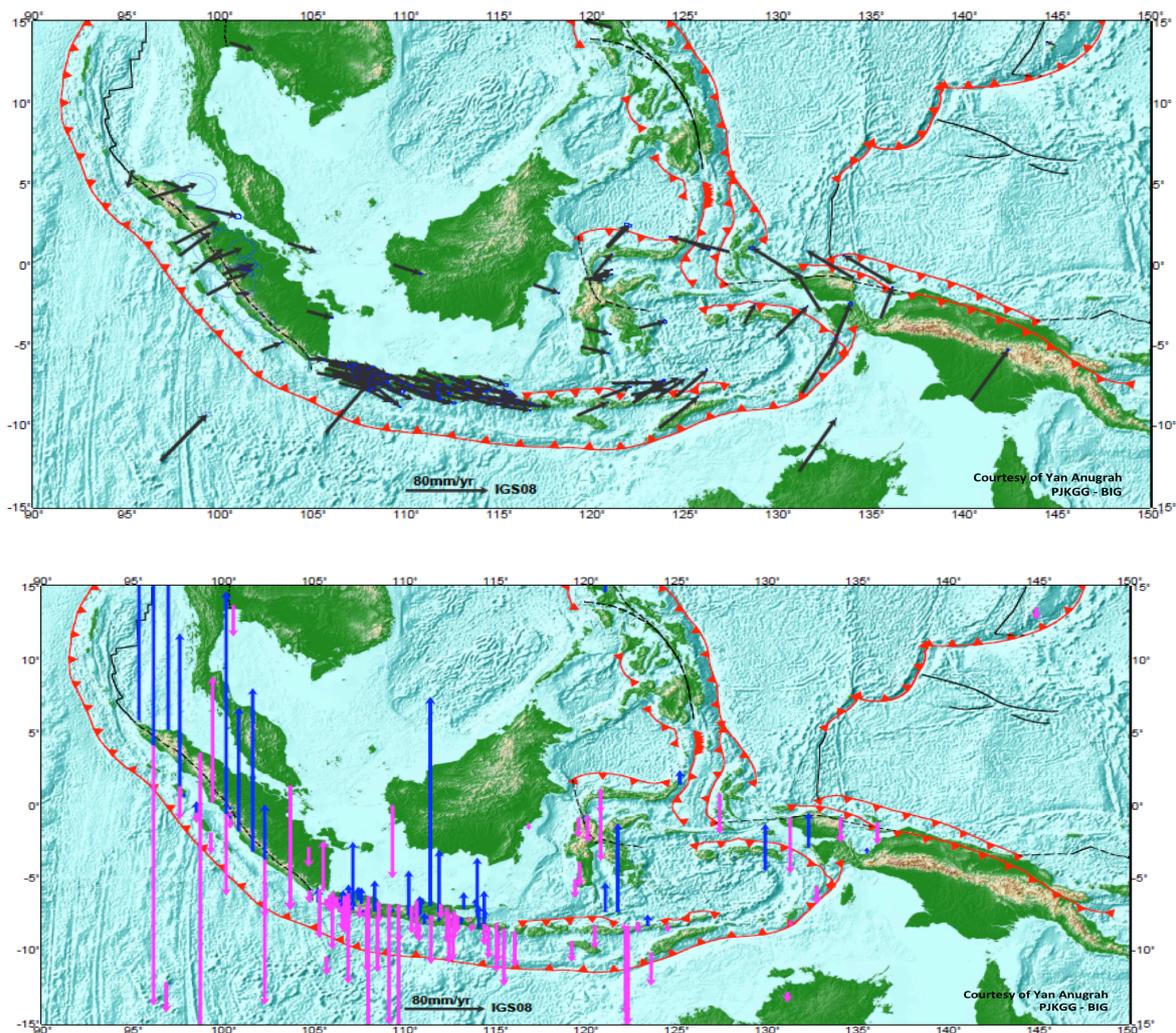

Figure 4. Vector of plate tectonic velocity, result by observation of GNSS station. In horizontal and vertical. Source: Rahmawan-2013

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2.2 Vertical Geospatial Reference System

Vertical Geospatial Reference System (VGRS) is a coordinate reference system that used for height determination. Indonesia is an archipelago, so the local high system based on Mean Sea Level (MSL) that currently used, possibilities inconsistent and difficult to establish in the nationwide height system unification. The solution of this problem is use the geoid as VGRS. Geoid is an equipotential surface that coincide with global mean sea level as least square. Geoid is an earth model that describe the real earth shape which concern with gravity variations as heterogenous lithology, structure, and terrain of earth. Geoid is derived from gravity measurement that refer to geodesy control network. Geoid is highly recommended for datum unification.

Now, Indonesian geoid model are covering Sulawesi and Borneo, by using airborne gravity measurement data. Test of geoid model accuracy in Sulawesi is 0.21 meters, while in Borneo is 0.36 meters.

When, Indonesian geoid model has not yet established for the entire of Indonesia, then we use mean sea level (MSL) for vertical reference that derive from tidal measurement for 18.6 years. When long time series data is not available, we use tidal measurement only for 1 year.
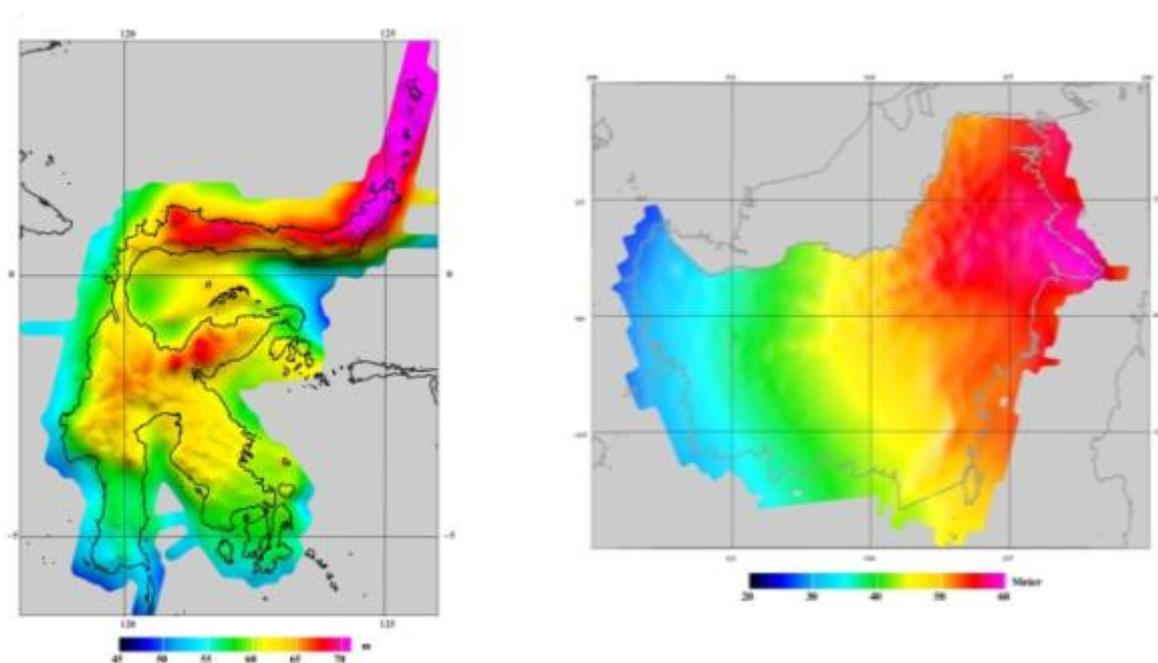

Figure 5. Indonesia Geoid for Sulawesi and Kalimantan

2.3 Access and Services System Of SRGI 2013

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Access and Services System of SRGI2013 is a service and online application system for SRGI 2013 to be used by users as easily. Access and service system of SRGI 2013 consist of:

1. Introduction about SRGI 2013
2. Guidance for using SRGI 2013
3. Content of SRGI 2013 including the historical data
4. Geodetic control network, including coordinat value and its changes as time function
5. Another feature and application to support SRGI 2013
6. Helpdesk

Nowadays, access and system services of SRGI 2013 (as beta version) has established and can be accessed at wesite: www.srgi.big.go.id . It will be improved and updated continuously to give better service for users.
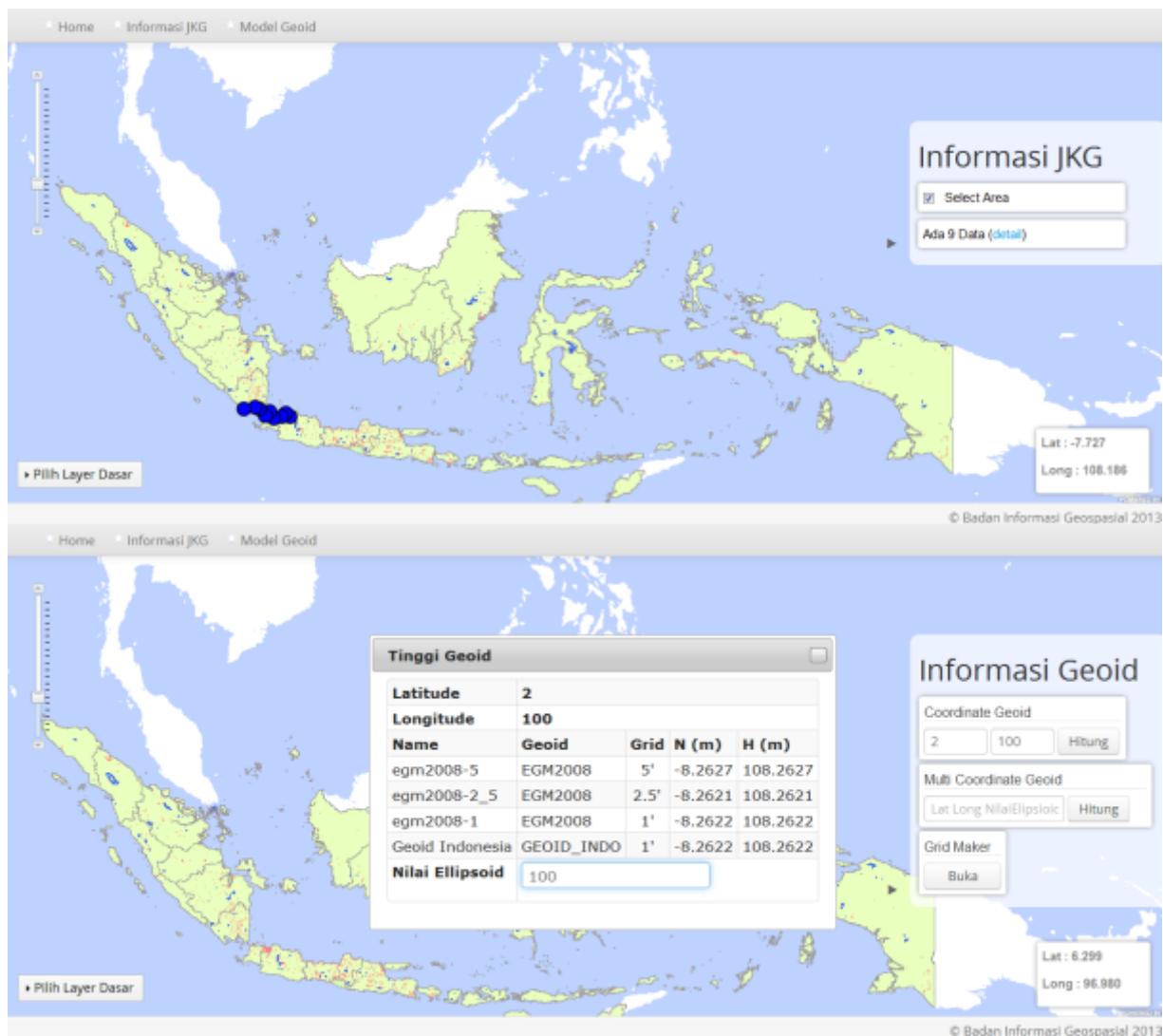

Figure 7. Interface of access system and services SRGI 2013

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2.4 UPDATING SRGI 2013

Updating SRGI 2013 is possible when force major is happened or there is global reference system improvement. When we updating SRGI 2013, we will label SRGI 2013 with name of updating year, followed by the epoch date. Label is written by 4 digits of year with parenthesis which written behind SRGI 2013. Epoch is written in decimal format of year where decimal number states julian day of certain year when updating SRGI 2013 is applied. The example can be seen as below:

SRGI 2013 (2017) Epoch 2016.35

That means, we updating SRGI 2013 at 2017, which the coordinate defined at epoch 2016.35, that is mei 8th. 2016 (number of julian day 128).

3. IMPLEMENTASI ON POSITIONING

SRGI 2013 has replaced DGN 1995. All users who used DGN 1995 must transform their data to datum SRGI 2013. One of them is positioning users. Some users about positioning purposes is positioning for navigation, positioning for stacking out, and positioning for reference geospatial information accomplishement.

For navigation, not too pose a problem, it is due to the precision positioning equipment (GNSS Navigation) approximately + / - 5 meters. So the datum change and shift vector changes either horizontal or vertical direction that an average of 70 mm/year, had no significant effect.

Whereas for positioning in stackingout applications can be described in **Figure 7.** In the picture if we have measured data in 2012 or earlier epoch, then by adding the model deformation and re-calculating the current epoch, then produce coordinates of the reference in the current epoch, and processing of stacking out.

For determination of a new point or accurate position as reference of geospatial information accomplishement, illustrated in **Figure 8**. In the picture if we take measurements at control point, then do calculation at the time of measurement epoch, to get the results on the epoch 2012.0 calculation by entering the model deformation and geoid models.

With SRGI 2013, which include change of coordinates as function of time, it is important to do the recording time measurement and measurement metadata completeness, submission of information to the user should be accompanied by time / epoch (4D coordinates), accompanied with discipline and good documentation (refer to Standart Operating Procedures and standard), access to information and coordinate reference frame model of deformation (velocity rate).

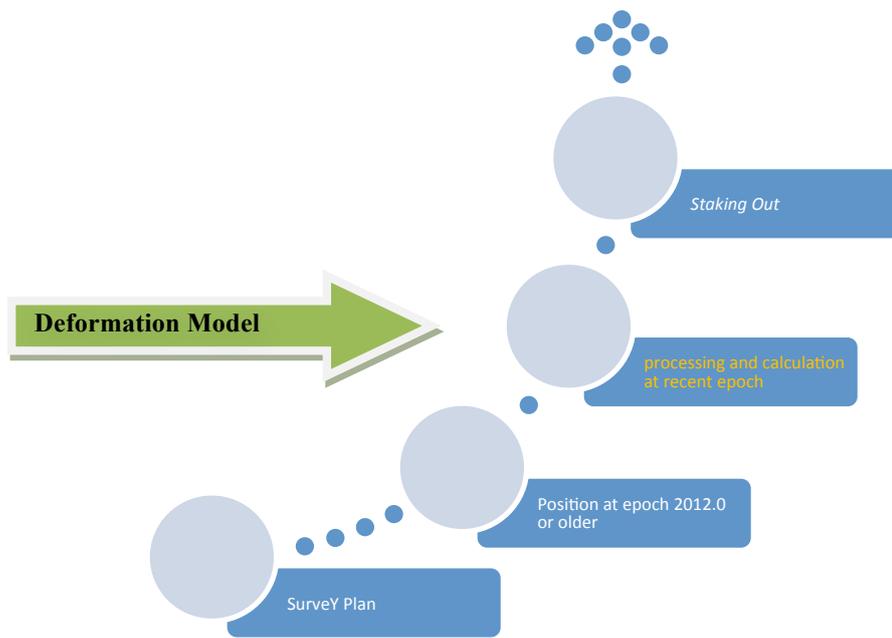Indonesian Geospatial Reference System 2013 and Its Implementation of Positioning, (6894)   9/12
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Figure 7. Implementation on Stacking Out. Source: Riqqi-2013
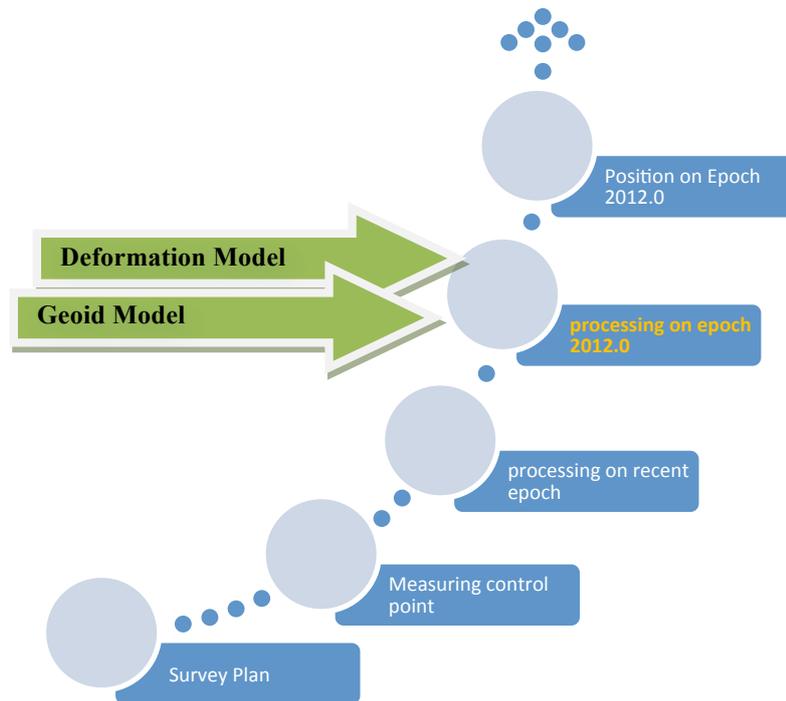
Figure 8. Implementation on determination of new point. Source: Riqqi-2013

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4. CONCLUSION

With new national datum, SRGI 2013, the old national datum, DGN 1995, no longer used as a reference in the geospatial information accomplishment in Indonesia. SRGI 2013 has coordinate change as a function time and consists of horizontal and vertical geospatial reference system, and for user there are facilitate to access and services of SRGI 2013. Implementation in the positioning are for navigation is not too significant, for determination of new point or reference of geospatial information accomplishement, need to re-calculation at eoch 2012.0 by adding deformation model and geoid model. Meanwhile, for stackingout, after getting a reference coordinate at epoch 2012.0, needs re-calculation in the current epoch, then carried stacking out

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6. BIOGRAPHICAL NOTES

Arisauna Maulidyan Pahlevi has been working at Geospatial Information Agency (Badan Informasi Geospasial (BIG)) as Mapping Surveyor for four (4) years. She has responsibilities in data processing and data management control networks.

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