Conference Paper

Development of Parameter Transformation of Indonesian Geospatial Reference System 2013

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Abstract

DGN95 is a static geospatial reference system, in which the change in the value of coordinates towards time as a result of tectonic plate movement and deformation of the earth's crust, is not considered. Changes in the value of coordinates towards time need to be considered in defining a geospatial reference system for the territory of Indonesia. This is because the territory of Indonesia is located between several tectonic plates which are very dynamic and active. This area of IndoneFor this reason, SRGI2013 was born, a national coordinate system that was consistent and compatible with the global coordinate system. SRGI considers changes in coordinates based on time functions. Problems arise when the coordinates of the old pillar still use the DGN95 datum reference system. Many published maps or geodetic control network use the old coordinate system, then the mapping user has difficulty getting the conversion of coordinates change aforesaid. The purpose of this study is to produce coordinate transformation parameters to change the coordinates of the old datum (DGN95) into coordinates in the SRGI2013 datum. The results of the transformation parameters resulted are used to change coordinates that are still in the old datum. In addition to making it easier for users to transform coordinates. The coordinate transformation method used uses the 3-dimensional coordinate transformation of the Bursa-Wolf model (7 parameters) and the Affinity model (10 parameters).

Keywords: reference system, DGN95, coordinate transformation, SRGI2013

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1. Introduction

In its journey, Indonesia once had several datum as a mapping reference system. One single geodetic datum that has ever been applied in Indonesia is Indonesia Datum 1974 (ID74). ID74 uses the SNI reference ellipsoid model (Indonesian National Spheroid) which has the same parameters as the ellipsoid Geodetic Reference System 1967 (GRS-67) parameter. In this era, the positioning uses TRANSIT Navy Navigation Satellite System technology or better known as the Doppler satellite. The realization of the geodetic control network whose points are determined by using Doppler satellites is already in one system but the accuracy is not yet homogeneous because the measurement methods (absolute positioning, translocation) and count methods (multi-station mode, short arc mode) are used differently although the coordinates of the points are the point on the geodetic control network is technically sufficient to meet the needs of a 1: 50,000 scale topographical mapping.

Geospatial Information Agency (formerly Bakosurtanal) defines new datum along with the development of Global Positioning System (GPS) technology for survey and mapping purposes. This new datum called the National Geodetic Datum 1995 (DGN-95) replaces the old datum ID-74. DGN95 is a static geospatial reference system, in which the change in the value of coordinates towards as a result of tectonic plate movement and deformation of the earth's crust, is not taken into account. Changes in the value of coordinates towards need to be taken into account in defining a geospatial reference system for the territory of Indonesia. This is because the territory of Indonesia is located between the confluence of several tectonic plates which are dynamic and active(1), including the Eurasian, Australian, Pacific and Philippine plates. This area of Indonesia, which is located at the confluence of several plates, causes all geospatial objects above it, including the geodesy control points that form the National Geodesy Control Network, to also move due to tectonic plate movements and earth crust deformation.

Satellite-based positioning technology such as GPS and Global Navigation Satellite System (GNSS) has developed rapidly so that it is possible to be used in the implementation of a national geodetic reference frame that is integrated with global reference systems and is able to provide adequate accuracy to monitor the movement of tectonic plates and deformation of the earth's crust which affects the coordinate values. If Indonesia uses static datum (without calculating changes in coordinates based on time), the map results obtained contain information that is not in accordance with real conditions on the ground because the coordinates of the pillars have changed. For this reason, on October 17, 2013 Indonesia Geospatial Reference System (SRGI 2013) was launched. SRGI (Indonesia Geospatial Reference System) is a modern terminology that is same as the National Datum Geodesy (DGN) terminology which was first defined, namely a national coordinate system that is consistent and compatible with global coordinate systems. SRGI considers changes in coordinates based on time functions, because of the earth dynamics. Specifically, SRGI 2013 is a geocentric 3-dimensional (X, Y, Z) Cartesian coordinate system. Practical implementations on the surface of the earth are expressed in terms of geodetic coordinates of latitude, longitude, height, scale, gravity, and their orientation along with the velocity values in planimetric (topocentric) coordinates. In practical terms, the fundamental differences between SRGI 2013 and DGN 1995 can be seen in Table 1.

Table 1: Differences between SRGI 2013 and DGN 1995.

Description	DGN95	SRGI2013
Nature of Reference System	Static	Calculates the change in coordinate values as a function of time
Coordinate Reference system	ITRS	ITRS
Coordinate Reference Frame	Geodetic Control Network that are bound to ITRF2000	Geodetic Control Network that are bound to ITRF2008
Geodetic Datum	WGS84	WGS84
Vertical Geospatial Reference System	MSL	Geoid
Access and Service Systems	Closed	Open and Self-service

source: srgi.big.go.id

SRGI is needed to support the One Map for Indonesia. By One Map Policy, all development implementation in Indonesia can go hand in hand without overlapping interests. The government considers that the one map policy is an urgent matter and is needed to unify all information on map production in the country. This policy is a presidential directive set out in presidential regulation No. 9 of 2016 concerning the acceleration of the implementation of KSP) at the level of map accuracy of 1: 50,000 scale. With the issuance of the regulation, BIG's duty as the main organizer of Basic Geospatial Information (IGD) in Indonesia becomes increasingly urgent, the IGD needed as a basic data in the KSP must be immediately resolved at a scale of 1: 50,000, maybe even going forward to a scale of 1: 1,000. In line with the mandate carried by BIG as stipulated in Law Number 4 of 2011 concerning Geospatial Information (2). In addition, BIG cooperation with other parties such as Ministries/Institutions and Local Governments as data officers is also important because the data will be used as Thematic Geospatial Information (IGT) in the preparation of One Map.One geospatial reference can be used as a guide for strategic policy making such as licensing, for this reason overlapping maps will lead to conflict disputes and will ultimately hamper the pace of the national economy. With the KSP, the Geospatial Data and Information in the form of a map will refer to One Geo-reference, One Geo-standard, One Geo-database and One Geo-portal at a map scale accuracy of 1: 50,000.

Problems arise since there are many coordinates of the old pillar from other agencies or private sector still use the DGN95 datum reference system. Many published maps or geodetic control network use the old coordinate system, so it is difficult for users to map the conversion to get the coordinates change. The transformation parameters are needed to convert the coordinates of the two datum. The parameters of this transformation are in the context of implementing a single reference system in Indonesia. Since the enactment of Regulation of the Head of the Geospatial Information Agency No. 15 of 2013 concerning the 2013 Indonesia Geospatial Reference System, the availability of these coordinate conversion parameters has become important because many old maps still had a reference system in force at the time.

The calculation parameters of the coordinate transformation are very complex (3), considering the velocity vector of the plates in Indonesia is not uniform and/or the distortions of the networks that realize the frames (4). The active plate pushes a position with greater speed, while there are areas that do not even get a boost. For this reason, a comprehensive research is needed to produce coordinate transformation parameters to the 2013 SRGI system. The purpose of this study is to produce coordinate transformation parameters to change the coordinates of the old datum (DGN95) into the new one (coordinates on the SRGI2013 datum). This research hopes that it can help Geospatial Data users generate coordinates on the new system, in this case SRGI 2013 which is still valid today in Indonesia.

2. Method

Changes in a coordinate with a specific datum into a coordinate with another datum is mathematically called the coordinate transformation process. Transformation can be done in two or three dimensions. This transformation process requires a number of common points. Common points are points that have coordinates in both the old datum system and the new datum system, so we get the values that describe the relationship between the datum being tested, this relationship is often called the transformation parameter (5). A study on the DGN95 to SRGI2013 transformation had done before using bursa wolf method to analyze 10 common points of DGN95 and SRGI2013 (6). These points were distributed nationwide and consisted of one until two common points in each major island like Sumatera, Java, Kalimantan, Sulawesi, Papua, and Bali. Therefore, it has not yet represented the good point distribution since the common points was only ten and located one or two in each major island.

The initial stage of the research is to collect data on the coordinates of the common points, which have coordinates in the two datum systems. The old DGN95 datum and the coordinates on the new SRGI2013 coordinates were obtained from the point descriptions issued by the Geospatial Information Agency resulted from GPS data processing using scientific satellite data processing software. Satellite data processing uses precise ephemeris information by modeling the ionosphere and troposphere using global models.

The accuracy of the coordinate transformation is very dependent on method choiced, the accuracy of the points, the number and distribution of common points. Therefore, we need a transformation model that connects between two different data. There are several factors that influence the selection of a transformation model, including (7):

1. The area covered by the network.
2. Distortion in the network.
3. Dimensions of the network, 2-dimensional (2D) or 3-dimensional (3D).
4. Accuracy required.The determination of transformation parameters in this study uses a similarity relationship between the data (similarity transformation model) by solving the parameter values into 3-dimensional coordinate. A similarity transformation preserves shape, the scale factor is the same in all directions, so angles will not change, but the lengths of lines and the position of points may change (8). The transformation process between the data uses several methods, namely the 3-dimensional Bursa-Wolf model (Helmert 7 parameters), Molodensky model (Helmert 10 parameters) and the 3-dimensional Affine model (12 parameters). The selection of the right model is adjusted to the Indonesian topography and the available data. Bursa-Wolf transforms its Cartesian coordinates so that all the common points used must be in the Cartesian coordinate system in their respective datum. If the coordinates are still in the geodetic coordinate system, the first step is to change the geodetic coordinates into 3D Cartesian coordinates. The same is done for common points using the new SRGI2013 datum. The advantage of the Bursa-wolf transformation is that it is suitable for transformation between two data (9). The stages of the coordinate transformation process in this study can be seen in the process diagram as shown in Figure 1.

The research flow chart can be seen in Figure 2, the calculation mechanism starts by determining the common point. The common point is taken from the points of the geodetic control network spread throughout Indonesia. The points of the geodetic control network are the results of measurements in the field and the results of data processing using scientific software. Common points used are points that have coordinates in the DGN95 and SRGI2013 coordinate systems. Then the common point data is filtered data to remove the blunder data which has coordinates difference of 0.75 meters in its geodetic coordinates. After the coordinates are filtered the next step is to transform the coordinates using the geodetic tools box in MATLAB (10). The residue is important to be considered to check the quality of processing. If the residual yield is still large, then iteration the transformation of the coordinates has to be done until the processing

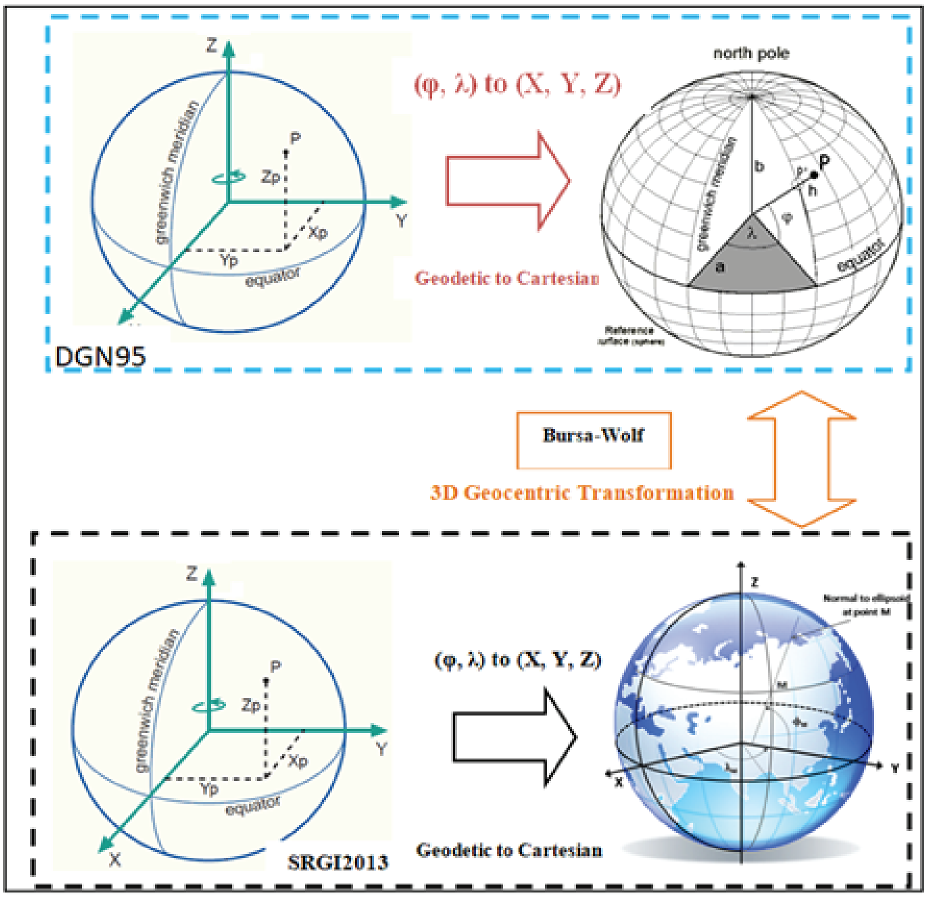

Figure 1: Stages of the Bursa-Wolf method transformation process.

residual value is below 0.2 meters. The processing transformation parameters are then used to determine the SRGI coordinate value at the check point. The result parameter transformation can be validated from a set of data using the measurements by cross validation (11). The difference between the processing results with the coordinates of the check point points is the deviation of the processing results. Then the next stage is to analyze the results obtained.

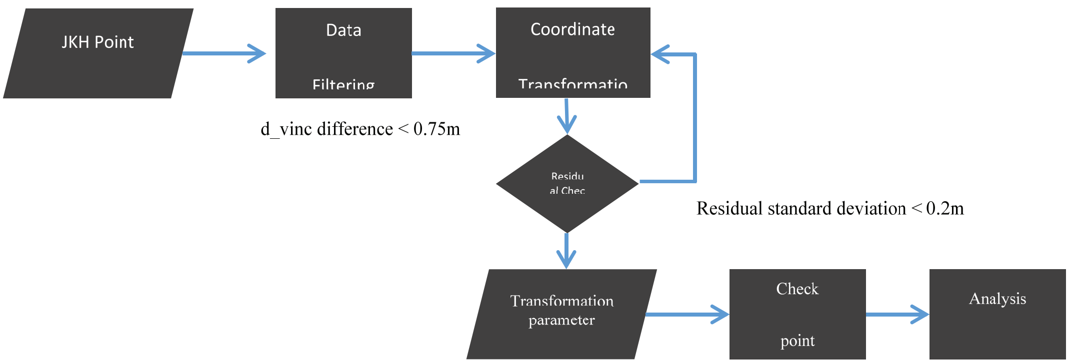

Figure 2: Research flow of coordinate transformation process.

Three Dimension Geocentric Transformation (Bursa-Wolf)

The Bursa-Wolf assumes a similarity relationship between datum (similarity transformation model). This transformation maintain the shape so that the angle does not change, but the line length and the point position may be change (8). The 3-dimensional Bursa-Wolf coordinate transformation uses seven parameters that must be solved including three translation parameters (Tx, Ty, Tz), three rotation parameters (Rx, Ry, Rz) and one scale. The compilation of the matrix for the Bursa-Wolf transformation can be seen in equation 1 (12,13).

$$\begin{bmatrix} X' \\ Y' \\ Z' \end{bmatrix} = \begin{bmatrix} dX \\ dY \\ dZ \end{bmatrix} + (1+\kappa)\begin{bmatrix} 1 & \vartheta_z & -\vartheta_y \\ -\vartheta_z & 1 & \vartheta_x \\ \vartheta_y & -\vartheta_x & 1 \end{bmatrix}\begin{bmatrix} X \\ Y \\ Z \end{bmatrix} \tag{1}$$

This 3-dimensional transform of the Bursa-Wolf is used to convert coordinates from old coordinates to new coordinates which are usually different datum or often referred to as transformations between datum. As can be seen in Figure 3, the old coordinate system consisting of XS, YS and ZS is shifted as far as ΔX, ΔY and ΔZ and rotated with the values a, b and q on each axis producing a different origin point at the OR point with the new system XR, YR and ZR.

2.1. Three Dimension Geocentric Transformation (Bursa-Wolf)

$$\begin{bmatrix} X' \\ Y' \\ Z' \end{bmatrix} = \begin{bmatrix} dX \\ dY \\ dZ \end{bmatrix} + (1+\kappa)\begin{bmatrix} 1 & \vartheta_z & -\vartheta_y \\ -\vartheta_z & 1 & \vartheta_x \\ \vartheta_y & -\vartheta_x & 1 \end{bmatrix}\begin{bmatrix} X \\ Y \\ Z \end{bmatrix} \tag{2}$$

3-Dimensional Affine Model

Illustration of the 3-dimensional Affine model can be seen in Figure 4. The Affine model uses initial coordinates to determine the center of rotation and translational change in coordinates. Affine transformation allowed the changes the position, size, and shape (1).

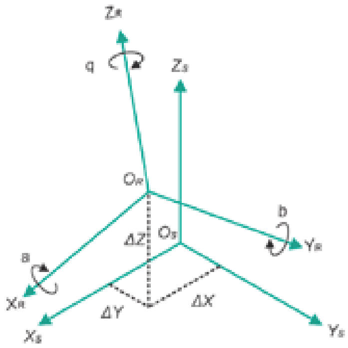

Figure 3: Illustration of 3-dimensional Bursa-Wolf transformation.

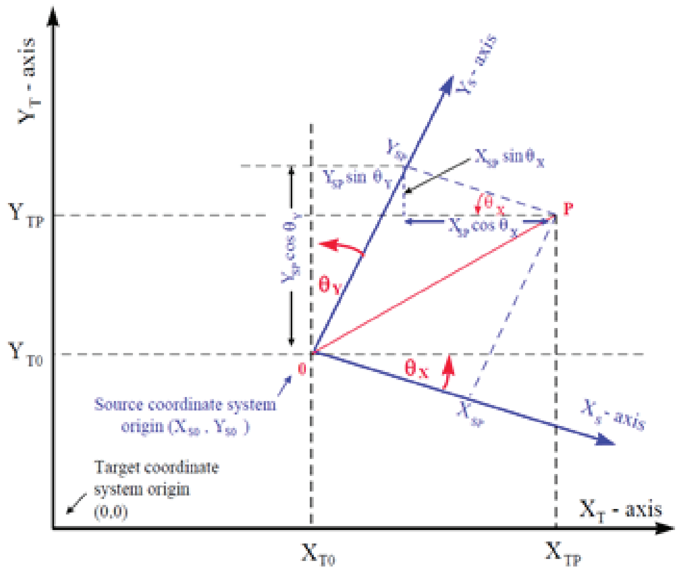

Figure 4: Illustration of 3-Dimensional Affine transformation.

2.2. 3-Dimensional Affine Model

Mathematically, the 3-dimensional Affine transformation equation can be seen as follows:

$$V_T = V_{T0} + R * V_S \tag{3}$$

$$V_T = \begin{pmatrix} X_T \\ Y_T \end{pmatrix} V_{T0} = \begin{pmatrix} A_0 \\ B_0 \end{pmatrix} R = \begin{pmatrix} A_1 & A_2 \\ B_1 & B_2 \end{pmatrix} V_S = \begin{pmatrix} X_S \\ Y_S \end{pmatrix} \tag{4}$$

$$X_T = A_0 + A_1 * X_S + A_2 * Y_S \tag{5}$$

$$Y_T = B_0 + B_1 * X_S + B_2 * Y_S \tag{6}$$

3. Results and Discussion

The distribution of common points used can be seen in **Figure 5**. The total number of common points used amounted to 646 points. Theoretically, at least 3 common points are needed to complete solution of the 7-parameters transformation. If more points are known, a least squares adjustment can be performed to reduce the effect of errors in the given coordinates (14). The red dot is an independent test point (check point) that is the point that is not used in the process of determining the transformation parameters. The check point will later be used to check the results of parameter processing by comparing the SRGI coordinate values of the results of the transformation processing compared with the SRGI coordinate values of the check point points. While the green dot is a common point is a point that has coordinates in the two DGN95 and SRGI2013 datum systems, this common point will be used to obtain the coordinate parameter to change the DGN95 coordinates to SRGI2013. Using the total input of common points, namely 646 points with the input coordinates of common points as many as 620 points, 1 point is deleted because the difference between the old and new coordinates is too large, while 26 points are used as checkpoints that do not enter into the calculation of determining the coordinate transformation.

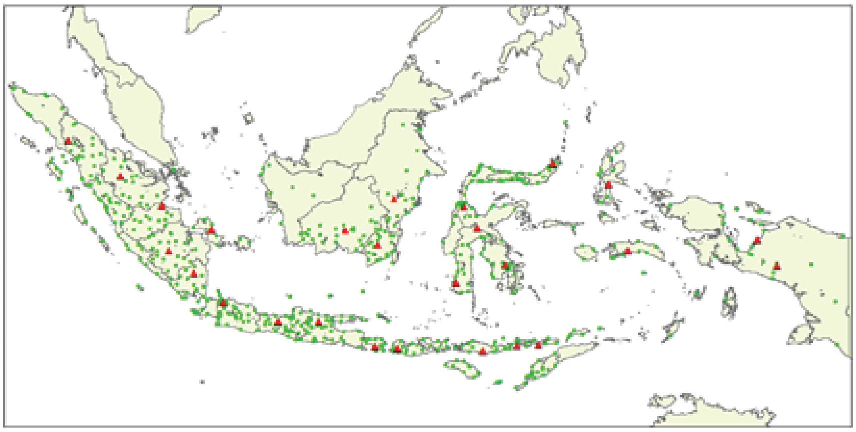

Figure 5: Distribution of common points and check points.

3.1. Determination of Check point

Figure 6 shows the historical earthquake records in Indonesia from 1990 to 2010 sourced from the USGS earthquake catalog. GPS measurements in Indonesia have been carried out since 1990 when satellite survey work was conducted to monitor deformation on the island of Sumatra. **Figure 6** shows that Indonesia's territory was shaken several times by a large earthquake, it can be seen from the magnitude of the earthquake that occurred. These earthquakes cause the position of coordinates in Indonesian territory to change following the impetus energy of each moving plate. Changes in the position of these coordinates are not uniform throughout Indonesia due to the complexity of the earthquake that occurred. Changes in the position of coordinates will affect the national mapping frame in this case is the geodetic control network. For this reason, a coordinate system is needed that is able to accommodate changes in the coordinates of the time function and the movement of tectonic plates in Indonesia.

The determination of the check point is important, because the check point is a validation point that is used to see the results of the success of the transformation that has been done. The selection of check points by overlapping earthquake history data with common points is available. The check point must be located in a location that is considered immovable, not disturbed by tectonic activities that have occurred in Indonesia. Check points must also be distributed evenly within the existing network of common points, to see the consistency of the resulting parameters. Common points are chosen as far as possible away from major earthquake events in the region

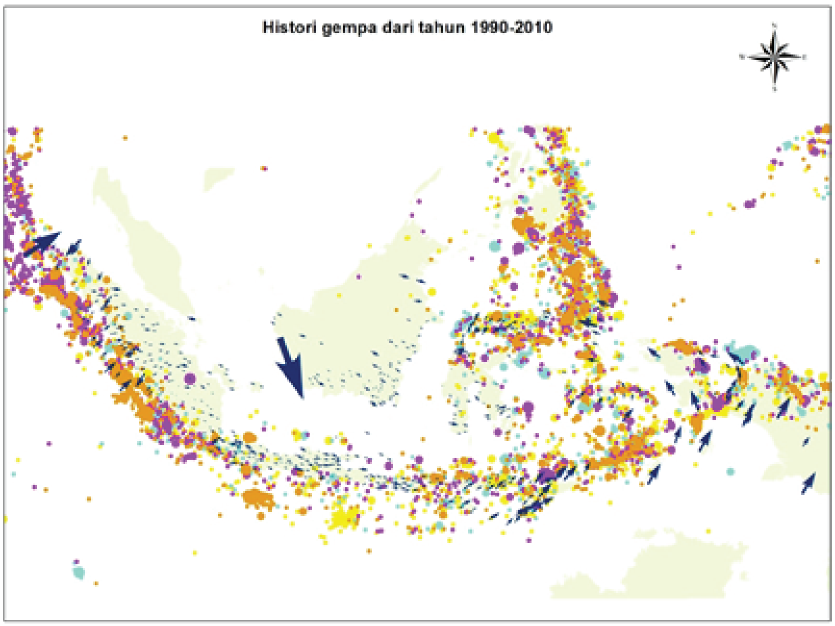

Figure 6: Earthquake Historical Record from 1990 to 2010.

3.2. Schematic Determination of transformation parameters

Processing data transformation using several schemes to see the different results of each scheme used. The different schemes that are carried out due to the data used are complex, so it needs special treatment for certain types of data. The basis of the scheme is based on the distribution of points used and the quality of common points used. The determination of the scheme can be further elaborated as follows:

The first type 1 scheme: uses common points throughout Indonesia without filtering data.

In the first scheme, obtained 620 common points and 26 checkpoints, so the total points used are 646 points. The first scheme type 1 used all available data regardless of the quality of the input data. The process of determining the SRGI2013 transformation parameters using the MATLAB software by first preparing datum 1 and datum 2 input data. Datum 1 is the common points input data in the DGN95 system, while datum 2 is the common points input data in the SRGI2013 system, both are in Cartesian 3-dimension coordinates. The determination of transformation parameters uses 3 similarity transformation equations, namely the Bursa-Wolf, Molodensky and 3-dimensions Affine transformations.

Table 2: Examples of some of the coordinates of the common points used.

Point Id	X_DGN95	Y_DGN95	Z_DGN95	X_SRGI2013	Y_SRGI2013	Z_SRGI2013
PKAT	-2072875.37	6030511.22	130463.09	-2072875.57	6030511.46	130462.96
TABA	-2064804.78	6033942.53	95399.38	-2064804.81	6033941.82	95399.23
N.2007	-2119630.64	6015643.93	-16185.75	-2119630.96	6015643.99	-16185.83
N1.2012	-2176546.47	5991914.05	-201060.96	-2176547.66	5991914.16	-201063.86
N1.2015	-2107259.04	6018103.55	150906.45	-2107259.03	6018102.82	150906.28
N1.2013	-2244155.41	5970327.92	13510.30	-2244155.77	5970327.93	13510.19
N.2006	-2352621.21	5920864.05	-298927.34	-2352621.45	5920863.65	-298927.51

Examples of some of the common points coordinates can be seen in **Table 2**, coordinates arranged in advance into columns that contain coordinate information in two coordinate systems namely the DGN95 and SRGI2013 coordinates. Presentation of coordinates uses a 3-dimensional Cartesian system, so that the center's position is in the center of the datum. Datum 1 and datum 2 are stored using the ASCII format without information on ID numbers or headers above, just the arrangement of coordinates. Datum 1 and datum 2 must have the same number of points and arrangement of points, which will later be converted into an equation matrix when processing in MATLAB. Equation matrix n x 3, where n is the number of common points used when determining the transformation parameters. The output of this transformation parameter determination process is a set of transformation parameter sets along with the accuracy of the calculation parameters, the residual datum 2 and the rotation center vector in datum 1 (only in the Molodensky method). The transformation parameter set in the Bursa Wolf and Molodensky method contains 7 transformation parameters. While the Affine transformation parameter set contains 12 transformation parameters. Residual datum 2 is the difference in coordinates between the coordinates of datum 2 and the coordinates of the calculated parameters. The resultant residual value using the first scheme type 1 can be seen in **Table 3**.

Table 3: Residual resultant of the first scheme type 1.

	Affine	Bursa-Wolf	Molodensky
min	0.015219	0.020505	0.020505
max	7.880318	7.909852	7.909852
average	0.271466	0.284493	0.284493
standard deviation	0.383136	0.384926	0.384926

As can be seen in **Table 3**, the three methods for determining the coordinate transformation used produce a maximum residual resultant value at 7 m and a minimum value ranging from 0.015 to 0.020 m, meaning that there are input data that have a large difference between the two data. After filtering the input data, it is found that there are several common points having significantly different differences in the two datum. This significant difference is likely due to a large earthquake occurring at that point, so that the DGN95 coordinates shift away in its SRGI coordinates. Another possible factor in the processing of satellite data is the error in writing coordinates or blunders when processing data.

The first scheme type 2: using common points in all of Indonesia's filtered regions

The process of filtering the data of the first scheme type 2 is based on the DGN95 and SRGI2013 difference threshold, where the data used is data with a difference of less than 1 meter in its geodetic coordinates. Data filtering reference is the common point used which did not significant change in position due to the earthquake. In addition, it discards error input data so that it does not affect the quality of the resulting transformation parameters. From the results of the filtering process, there are 610 common points, the check points in amount of 26 points, so the total points used are 636 points.

As it can be seen in **Table 4**, the three methods for determining the coordinate transformation used produce a maximum residual resultant value at a value of 1.2 m and a minimum range of 0.019-0.020 m, it means that the input data used is much better compared to using type 1 without filtering data. Although there is still a resultant

Table 4: Resultant residues of the first scheme type 2.

	Affine	Bursa-Wolf	Molodensky
min	0.026637	0.019696	0.019696
max	1.217512	1.20661	1.20661
average	0.24601	0.256951	0.256951
standard deviation	0.177239	0.177644	0.177644

residue which shows a value of 1.2 meters. SRGI2013 transformation parameter values along with the accuracy of the calculation of the first scheme type 2 parameters can be seen in **Table 6** (a) -6 (c). While, table 5 displays the results of the check point using the scheme first scheme type 2.

Table 6 (a) shows the value of SRGI 2013 transformation parameters using the Affine method in the order of 3 components in xyz translation (in datum units) and 9 Affine parameter components. **Table 6** (b) shows the SRGI2013 transformation parameter values of the Bursa-Wolf method with the order of 3 components in xyz translation (in datum units), 3 rotational components (in radians units) and 1 scale factor component. **Table 6** (c) shows the SRGI2013 transformation parameters of the Molodensky method in the order of 3 components in xyz translation (in datum units), 3 components rotation (in radians units), 1 scale factor component and rotational center vector.

Table 5: Check point result of the first scheme type 2.

	Affine	Bursa-Wolf	Molodensky
min	0.021053	0.034128	0.049094
max	0.539933	0.560164	0.577867
average	0.205452	0.22118	0.224271
standard deviation	0.1389	0.142597	0.14422

Second scheme: use common points per large island area

The second scheme divides common points into several regions per large island in Indonesia. The distribution of the determination of common points can be seen in **Figure 7**. Indonesia's territory is divided into 6 regions namely Sumatra, Kalimantan, Java and Bali, Sulawesi, Nusa Tenggara and Papua and Maluku. Based on these criteria the common points are divided as follows:

- Sumatra Island: 150 common points
- Kalimantan Island: 72 common points
- Java and Bali: 135 common points
- Nusa Tenggara Island: 77 common points

Table 6: Value of the first scheme type 2 parameters: (a) Affine method; (b) Bursa-Wolf method; (c) Molodensky method.

Affine	parameter	accuracy
Translation-x	0.904546533	3.41E-16
Translation-y	0.400779202	3.41E-16
Translation-z	4.170496672	3.41E-16
a1	1.000000031	6.22E-09
a2	-1.60E-07	2.94E-09
a3	1.38E-07	1.80E-08
a4	1.95E-08	6.22E-09
a5	0.999999919	2.94E-09
a6	7.70E-08	1.80E-08
a7	1.92E-07	6.22E-09
a8	-6.37E-07	2.94E-09
a9	0.999999981	1.80E-08

(a)

Bursa-Wolf	parameter	accuracy
Translation-x	-0.19779323	0.04345
Translation-y	0.097910004	0.04071
Translation-z	0.381551691	0.11167
Rotation-x	9.33E-08	1.63E-08
Rotation-y	-7.29E-08	9.53E-09
Rotation-z	-1.37E-09	6.82E-09
Scale factor	0.999999965	6.30E-09

(b)

Molodensky	parameter	akurasi
Translation-x	-0.14669836	0.00731
Translation-y	-0.14053115	0.00731
Translation-z	5.04E-02	0.00731
Rotation-x	9.33E-08	1.63E-08
Rotation-y	-7.29E-08	9.53E-09
Rotation-z	-1.37E-09	6.82E-09
Scale factor	1.00E+00	6.30E-09
Rotation Center	-2567497.21	
	5707481.302	
	-406877.105	

(c)

- Sulawesi Island: 119 common points
- Papua and Maluku Islands: 57 common points.

The number of point in Nusa Tenggara is 77 point, a combination of 5 points from the Maluku region which is geographically very close to Nusa Tenggara. Table 7 displays the results of the check point using the second scheme. Java produces the smallest standard deviation compared to other regions.

Table 7: Check point result of the second scheme for Affine method.

Result	Sumatera	Java and Bali	Kalimantan	Sulawesi	Nusa Tenggara	Papua and Maluku
MIN	0.101529733	0.024309	0.086584053	0.112017513	0.050801387	0.047943888
MAX	13.23939238	1.578189	4.313032685	9.537730582	8.193018121	4.160877301
AVERAGE	3.10538789	0.42699	0.826084734	2.705240323	1.771771358	1.266624205
STDEV	2.544697643	0.311194	0.705472341	2.149967178	1.548239502	0.93035368

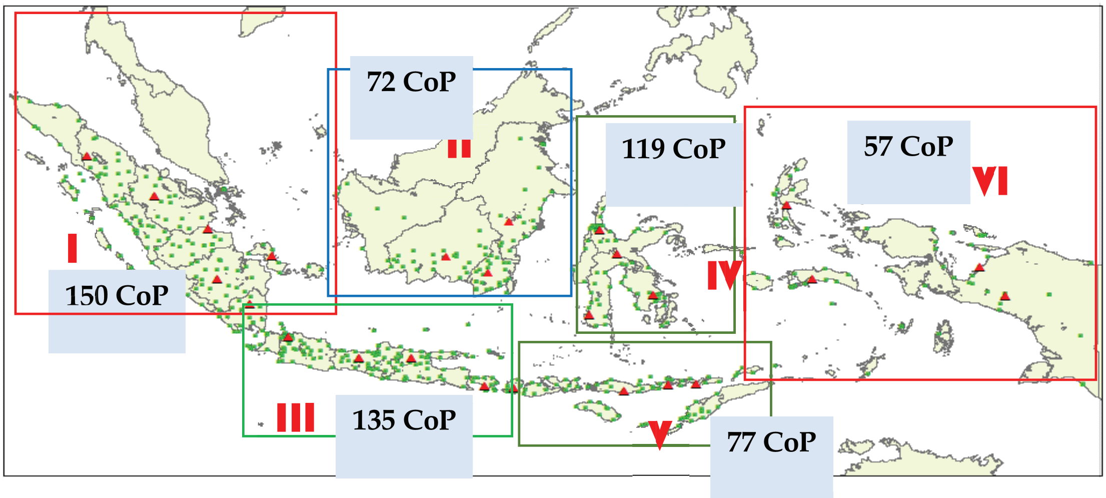

Figure 7: Scenarios for data processing division per large island.

As can be seen in **Tables 6** to **Table 8**, the three methods for determining the coordinate transformation that are used produce a variable residual resultant value. From this common point sharing scheme per large island, the Affine method gives a smaller average and standard deviation than the Bursa-Wolf and Molodensky methods. For the results per island, common points from Java and Bali produce the lowest average and standard deviation compared to other common points per island. Similar to the results of a study conducted by Handoko & Abidin, it is explained that the affine transformation model provides better results than the transformation of the Bursa-Wolf model. In that study, it was also mentioned that the distribution of common points and the number of common points greatly influenced the results obtained (15). So, it was indeed necessary a policy from BIG especially to be able to determine which strategies could be used to obtain the best parameters in the datum transformation from DGN95 to SRGI2013.

Table 8: Resultant residual parameters by using the Affine method.

Residual	Sumatera	Java and Bali	Kalimantan	Sulawesi	Nusa Tenggara	Papua and Maluku
MIN	0.030658515	0.015446075	0.034990097	0.040053446	0.034307681	0.063344591
MAX	1.052934471	1.08659199	0.55323736	1.127801209	0.770527371	0.739911382
AVERAGE	0.188990979	0.136492203	0.206781377	0.237786534	0.20664269	0.276989035
STDEV	0.155740134	0.11604897	0.145461676	0.179863614	0.157332204	0.147239242

Table 9: Resultant residual parameters by using the Bursa-Wolf method.

Residual	Sumatera	Java and Bali	Kalimantan	Sulawesi	Nusa Tenggara	Papua and Maluku
MIN	0.035246926	0.012292735	0.036222785	0.008794144	0.033846732	0.02560823
MAX	1.169124052	1.087427201	0.551118986	1.211253607	0.801845595	0.885801392
AVERAGE	0.222651335	0.137442827	0.214120286	0.241124008	0.230608024	0.343660251
STDEV	0.180988545	0.117027542	0.143641321	0.189647282	0.151574467	0.174943235

Table 10: Resultant residual parameters by using the Molodensky method.

Residual	Sumatera	Java and Bali	Kalimantan	Sulawesi	Nusa Tenggara	Papua and Maluku
MIN	0.035246926	0.012292736	0.036222786	0.008794144	0.033846731	0.025608229
MAX	1.169124053	1.087427202	0.551118987	1.211253607	0.801845595	0.885801392
AVERAGE	0.222651335	0.137442827	0.214120286	0.241124008	0.230608024	0.343660251
STDEV	0.180988546	0.117027542	0.143641321	0.189647282	0.151574467	0.174943235

4. Conclusion

Common points that have been grouped according to scheme 1 to scheme 3 produce coordinate transformation parameters to change the coordinates of DGN95 to SRGI2013. Based on the research results obtained, a good method with a small residual value is to use the 3-dimensional Affine model to change DGN95 to SRGI 2013. The division of the common point region is very influential on the results of the residual check point. Common point input data that has large errors will affect the results of the transformation parameters obtained. Common point errors can be seen from the difference between the old datum coordinates and the new datum coordinates. This error is due to a large earthquake in the region or an error when processing satellite data, needs to be further explored. Based on the results of the check point of the second scheme for Affine method, the transformation parameters of common points using data scattered in Java produce better accuracy values compared to other islands. Java and Bali is considered more stable than the effect of plate movement and the distribution of data on Java and Bali is very dense to produce transformation parameters. Difficulties in the process of distinguishing the effects of deformation in determining coordinate transformations are a concern for the future to make a more comprehensive study by including the Indonesian deformation model.

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Conflict of Interest

The authors have no conflict of interest to declare.

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