

Data Build Up and Transformation of Cadastral Data from Different Local Plane Coordinate System to Ppcs-Tm/Prs92

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Key words: Cadastral System, PPCS-TM/PRS92, Plane Coordinate Transformation, Cadastral Integration

SUMMARY

This research aims to develop operational methodologies in integrating cadastral data into the Philippine Plane Coordinate System – Transverse Mercator/ Philippine Reference System (PPCS-TM/PRS92) through evaluation of different methods of data conversion and transformation in five (5) municipal cadastres. The research was divided into four (4) major tasks each aimed to find effective methods in the area of cadastral data conversion from analogue to digital format; coordinate conversion; plane coordinate transformation and cadastral integration; and automation of cadastral data build-up.

The execution of the developed methodologies for each of the tasks resulted in findings which includes quality issues in the cadastral data and survey of some approved cadastre which do not permit effective cadastral transformation; severity of problem in the cadastral data record system which causes damage and lost of cadastral survey records necessary for the data build-up, transformation, and integration; and difficulty of integrating adjacent cadastral projects caused by unreliable boundary monument positioning. On the other hand, this research also yielded effective methods and procedure for transforming and integrating cadastral data.

The methodologies developed from this research which yielded the best results in terms of effectiveness and efficiency for cadastral data build-up and transformation were translated into procedural manual and guidelines.

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1. INTRODUCTION

The use the Philippine Reference System of 1992 (PRS-92) also known as the Philippine Plane Coordinate System-Transverse Mercator/Philippine Reference System of 1992 (PPCS-TM/PRS92) as the new reference (mapping) system for all surveys and maps in the country is mandated by the EO#45. This requires all surveys and mapping activities to use PPCS-TM/PRS-92 as the official (base) coordinate system including land surveys such as a cadastral survey.

In the Philippines, cadastral surveys were carried out and referenced using the Philippine Plane Coordinate System (PPCS) which was established in 1965, and to some extent, an assumed (floating) local plane coordinate system. The PPCS of 1965 uses the Luzon Datum of 1911 as its datum and the Philippine Transverse Mercator (PTM) as its projection.

On the other hand, floating local plane coordinate systems use plane surface having a floating origin (usually BLLM No.1 of the cadastral case or project) assigning 20,000 and 20,000 as its grid Northing and Easting respectively. A floating local plane coordinate system can be transformed to a PPCS by translating its floating origin to the system.

In preparing for the transformation and integration of a cadastre, the conversion from analogue to digital database format of these cadastral data is necessary. However, errors become inevitable in converting cadastral data to digital format particularly in the preparation, encoding, and build-up processes. Rigorous quality control techniques should be observed to ensure that the parcel data has acceptable horizontal accuracy and attribute integrity, intact topology. The parcel data converted into digital form must also be checked visually with measurement accuracy checks.

The main objective of this research is to develop transformation procedures and protocols from data encoding and buildup to integrate cadastral maps and data into the PPCS-TM/PRS92. Specifically it aims to:

- a. Develop an improved protocol of cadastral data encoding and buildup that involve a number of rigorous quality control checks to ensure the quality of the converted data.
- b. Assess and evaluate the accuracy and applicability of different Transverse Mercator (TM) formulation including that of the Technical Bulletin #26 in converting grid coordinates to geographic coordinates and vice-versa.

- c. Evaluate performance and identify contributory factors of applicability of different transformation methods in cadastral transformation.
- d. Validate the accuracy of the cadastral transformation procedure by testing it against representative sample areas.
- e. Recommend the most appropriate method for local transformation of cadastral maps and data from PPCS of 1965 to PPCS-TM/PRS92.
- f. Implement the most appropriate cadastral transformation to determine local transformation parameters for a certain area.
- g. Develop a cadastral data transformation environment (a specially designed program) for data encoding, management, and transformation of cadastral data.

This research was divided into four (4) subcomponents each tasked specific goals in order to achieve the set research objectives of this project.

Subcomponent 1: Data Build-up of Cadastral Information. An improved protocol of encoding cadastral data be formulated based on the evaluated sample data of the pilot areas. A database of cadastral information (textual and spatial) of selected pilot areas also be created and stored to serve as inputs for the cadastral transformation.

Subcomponent 2: Evaluation and Assessment of Philippine Transverse Mercator (PTM) Grid-to-Geographic Conversion. An integral component of the local plane coordinate system transformation is a coordinate conversion method from Geographic coordinates to Map-Grid coordinates and vice versa. Included in the scope of this project is to evaluate and assess the existing coordinate conversion technique (PTM coordinate conversion as prescribed by the DENR-LMB Technical Bulletin No.26) currently being used.

Subcomponent 3: Transformation of Cadastral Data from Different Local Plane Coordinate Systems to the PPCS-TM/PRS92. One of the main objective of the project includes the evaluation and assessment of different transformation methods applicable for the transformation of two different plane coordinate systems and then recommend and test the most appropriate method to transform cadastral data from different local plane coordinate system to the PPCS-TM/PRS92.

Subcomponent 4: Development of Cadastral Transformation Program. An end product of this project is a running specialized program that is capable of data input, storage, manipulation, transformation, retrieval, and creation of transformed cadastral data.

2. METHODOLOGY

2.1 Subcomponent 1: Data Build-up of Cadastral Information

Basically, there are three (3) general procedures needed to develop a database of cadastral information. With the use of the existing cadastral data, the first step in this process is the checking, assessment of quality and integrity, classification of data and evaluation of different encoding methods. Second would be the formulation of an improved protocol for encoding cadastral data. And lastly, the improved protocols were used to convert analogue files to digital format. The converted files served as the database of cadastral information. The general process flow of the data build up of cadastral information is shown in this flowchart:

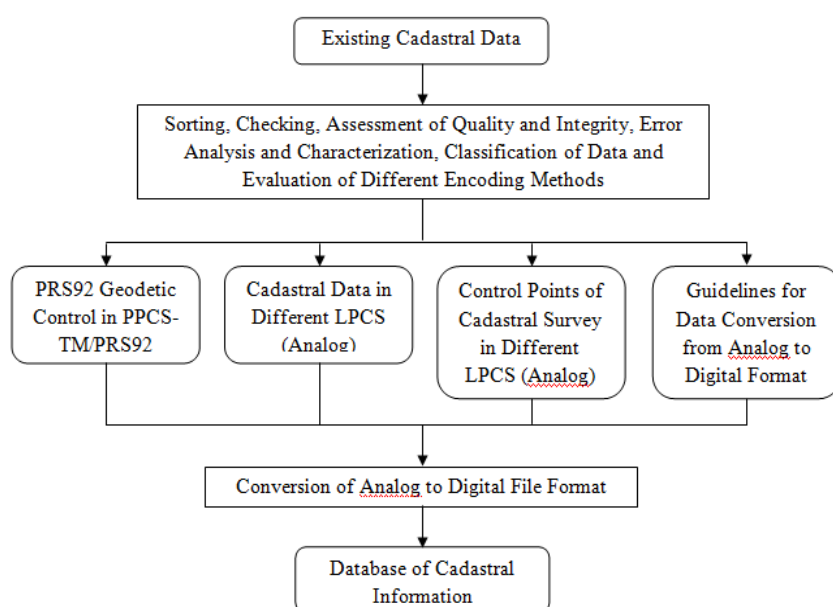


Figure 1. Process Flow of Data Build-up and Encoding of Cadastral Information

2.2 Subcomponent 2: Evaluation and Assessment of Philippine Transverse Mercator (PTM) Grid-to-Geographic Conversion

The methodology for this subcomponent dealt with six (6) general steps including: collection of secondary data such as the published Technical Bulletin No. 26 and its supplement publication; gathering and compilation of other Transverse Mercator closed formulations; encoding, filtering and identification of outlier values on the Grid Tables; regeneration of the Grid Tables and discrepancy analysis; automation of the prescribed and closed TM formulations for testing; and statistical analysis, validation and accuracy assessment for the obtained conversion results. The general process flow of the evaluation and assessment scheme is presented in the flowchart below.

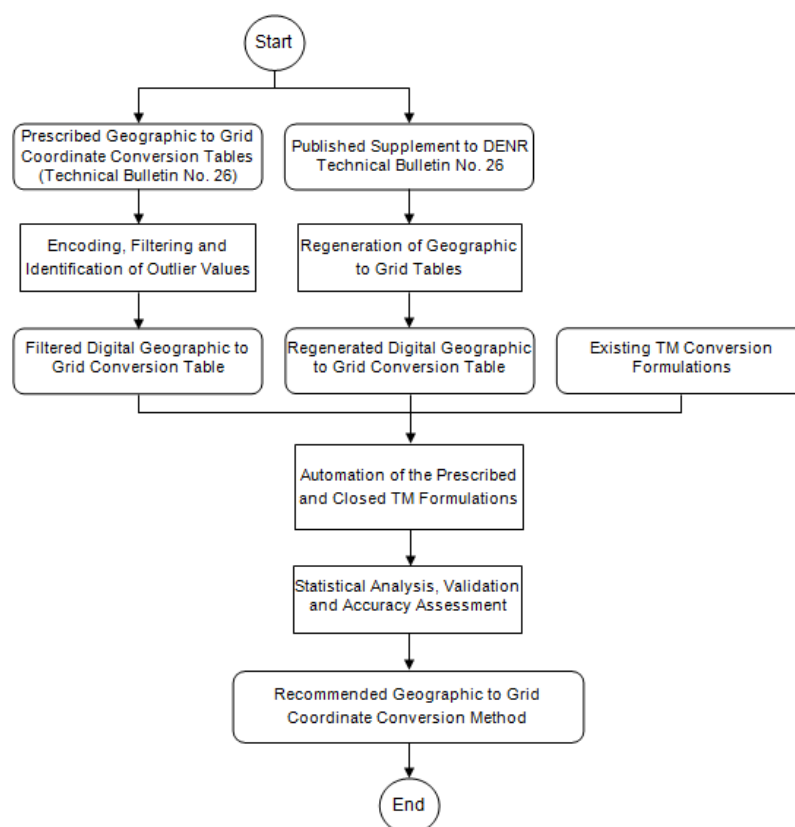


Figure 2. Process Flow for the Evaluation and Assessment of Technical Bulletin No. 26 Coordinate Conversion Tables

2.3 Subcomponent 3: Transformation of Cadastral Data from Different Local Plane Coordinate Systems to the PPCS-TM/PRS92.

In order to transform cadastral data from one local plane coordinate system to the PPCS-TM/PRS92 several major procedures were executed. The methodology developed for the cadastral transformation and integration involved four major phases each composed of a series of processes within. The methodology and general process flow implemented for the cadastral transformation and integration of the pilot areas is shown in Figure 5.1 and the expanded flowchart in Figure 5.2

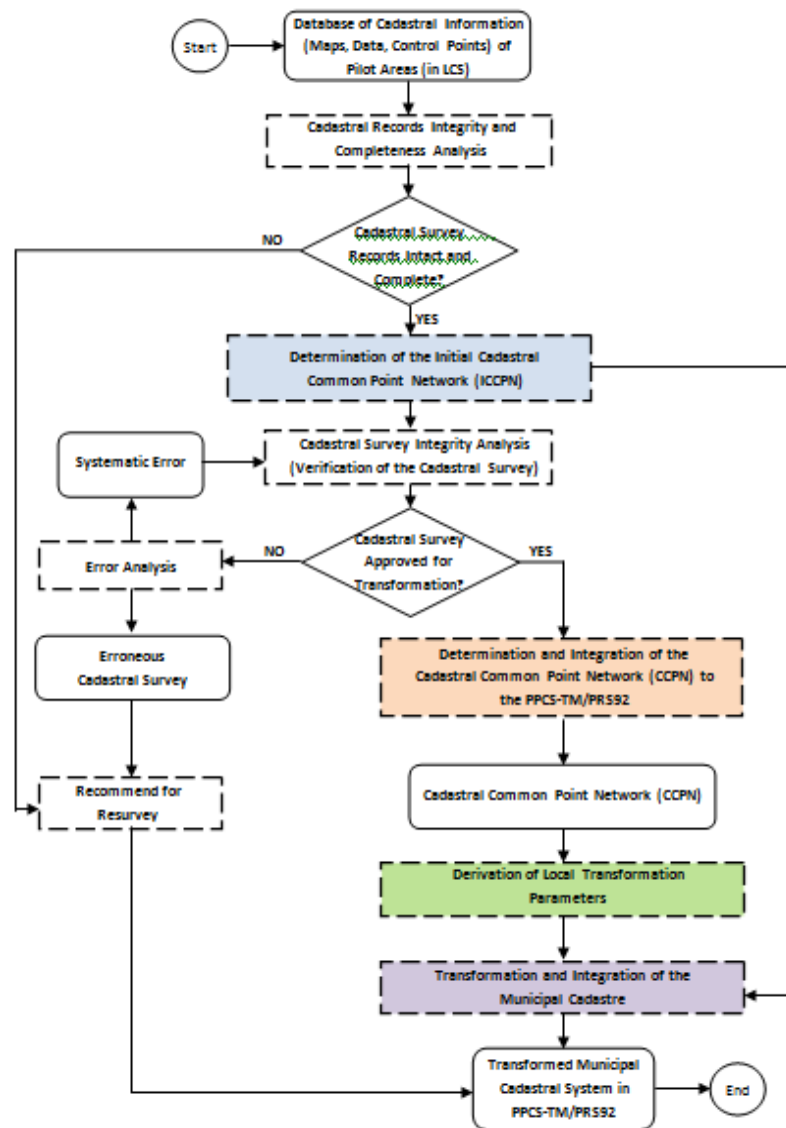


Figure 3. General Flowchart of Cadastral Survey and Data Transformation and Integration to PPCS-TM/PRS9

The project component considered three (3) different plane coordinate systems used by the cadastral system in the Philippines in the transformation: (1) the assumed local plane coordinate system; the (2) PPCS of 1965, as the initial coordinate system; and the (3) PPCS-TM/PRS92 as the final coordinate system.

There are four (4) widely used transformation methods in surveying (Wolf & Ghilani, 2006). These are the 2D conformal, 2D Affine, 2D Projective and 3D conformal transformations. The first three methods deal with two-dimensional coordinate system transformation. The three dimensional method is used to transform coordinate system in three dimensional space. Although cadastral data are treated in a plane surface, a three dimensional transformation

considers the extent of motion to the third dimension (along z-axis, elevation). Two (2) more additional coordinate transformation methods were developed to cater possible suitability of application to one or more of the target areas. These are the 2-parameter and 3-parameter coordinate transformations.

3. RESULTS

3.1 Data Build-up of Cadastral Information

3.1.1 Evaluation of Encoding Methods

After doing certain procedures prior to data encoding, digital images of the cadastral records were processed using any available software that enhance their visual quality in preparation for the data encoding. Data encoding is the process of converting textual data of cadastral records into digital format that can easily be used for information extraction and plotting of cadastral lots. These can be achieved through the use of the spreadsheet templates developed by the research team. The template was designed to easily encode these cadastral records in digital format. Moreover, there are two kinds of methods proposed in cadastral data encoding: (1) coordinate method and (2) bearing—distance method. As a result, there are two kinds of data encoding template created to cater the difference between the two methods. Table 3.1 shows the difference between the two methods in terms of data input and output during data encoding.

Table 3.1 Data Input and Output of Two Data Encoding Methods

Data Encoding Method	Coordinate Method	Bearing-Distance Method
Data Input	<i>Tie Point:</i> Name Coordinates (N,E)	<i>Tie Point:</i> Name Coordinates (N,E) Bearing* (N/S, DMS, S/E)
	<i>Boundary Corners:</i> Coordinates (N,E) Equivalent Corner # to Adjoining Lots	<i>Boundary Lines:</i> Bearing* (N/S, DMS, S/E) Corner Number Equivalent Corner # to Adjoining Lots
	<i>Data Entries:</i> Surname Given Name Geodetic Engineer Date Surveyed Lot No. Sheet No. Barrio Municipality Province Island Survey Symbol & Number Address, if not the same as location of land Quadrangle L.R.C. No.	<i>Data Entries:</i> Surname Given Name Geodetic Engineer Date Surveyed Lot No. Sheet No. Barrio Municipality Province Island Survey Symbol & Number Address, if not the same as location of land Quadrangle L.R.C. No.
Data Output	<i>Lot Area</i>	<i>Lot Area</i>
	<i>Boundary Lines:</i> Bearing Distance	<i>Boundary Corners:</i> Northing Easting

**Separate Data Input for N/S, Deg, Min, Sec, S/E*

All data gathered by the project component went through the general process that cadastral records need to undergo before data encoding. Data were sorted according to what type of data and where the data came from. It was verified that all cadastral data delivered by the regional offices complied with the requirements of the project component according to the component's specifications. Data were checked if the images of the lot data computation sheets correspond with the data logged by the personnel in charge for image acquisition.

Furthermore, in error checking, if the area on the lot data computation sheet differs from the area generated by the data input worksheet, the two encoding methods have different ways of verifying where the error is in the encoding. In coordinate method, bearing and distance generated is compared with the data on the lot data computation sheet while in bearing and distance method, grid coordinates of the northing and easting generated is compared with the data on the lot data sheet.

Table 3.2 Summary of the Differences between the two Coordinate Methods

	Coordinate Method		Bearing and Distance Method	
No. of Data Inputs	Tie Point (3): <i>Northing, Easting and Name</i>		Tie Point (9): <i>Bearing(N/S, DMS, E,W) Distance, Northing, Easting and Name</i>	
	Corner (3): <i>Northing, Easting and Equivalent Corner No. to Adjacent Lot</i>		Corner (7): <i>Bearing(N/S, DMS, E/W), Corner No. and Equivalent Corner No. to Adjacent Lot</i>	
	Area (1)		Area (1)	
	Total No. of Data Inputs: 7		Total No. of Data Inputs: 17	
Average Time per Lot (Data Encoding)	<i>With knowledge about Lot Data Computation Sheet</i>	<i>Without knowledge about Lot Data Computation Sheet</i>	<i>With knowledge about Lot Data Computation Sheet</i>	<i>Without knowledge about Lot Data Computation Sheet</i>
First Few Data Encoded	4 minutes	5 minutes	5 minutes	6 minutes
Succeeding Data Encoding	2 minutes	3 minutes	3 minutes	4 minutes
Error Cheking (Comparison of Area)	Bearing and Distance Generated by the Data Input Worksheet is compared to Bearing and Distance on the Lot Data Computation Sheet		Northing and Easting Generated by the Data Input Worksheet is compared to Northing and Easting on the Lot Data Computation Sheet	

3.2 Evaluation and Assessment of Philippine Transverse Mercator (PTM) Grid-to-Geographic Conversion

There were four computation methods examined in performing the geographic-to-grid and grid-to-geographic coordinate conversion. These are:

- Conversion using the prescribed computation method stated in the Technical Bulletin No. 26, using the values of the Roman Numerals found on the published tables;
- Conversion using the prescribed computation method in the Technical Bulletin No. 26, using the re-calculated values of the Roman Numerals based on the published supplementary manual of the bulletin (DENR, 1967);
- Conversion using the closed formulation adapted from USGS Professional Paper 1395 (Snyder, 1987); and
- Conversion using the closed formulation in USCGS Special Publication #251 (Thomas, 1952).

3.2.1 Geographic to Grid Coordinate Conversion

All the discrepancies obtained from the published Grid Tables were just zero since the calculated Northings and Eastings using this method were set as the expected grid coordinates

or the benchmark values. It was also evident from the basic statistical parameters (including the minimum, maximum, range, mean and standard deviation) that the discrepancies in the Eastings were smaller than that of the Northings.

Table 4.9. Summary of Discrepancies on the Computed Grid Coordinates

Conversion Method	Discrepancies in Meters (Absolute Value)				
	Northings				
	Minimum	Maximum	Range	Mean	Stdev
Published TB 26	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
TB 26 Supplement	1.387E-06	1.181E-03	1.180E-03	3.429E-04	2.472E-04
Snyder	1.816E-07	1.178E-03	1.177E-03	3.422E-04	2.465E-04
Thomas	6.479E-07	1.547E-03	1.546E-03	4.901E-04	3.320E-04
Conversion Method	Discrepancies in Meters (Absolute Value)				
	Eastings				
	Minimum	Maximum	Range	Mean	Stdev
Published TB 26	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
TB 26 Supplement	1.153E-07	2.216E-04	2.215E-04	9.436E-05	5.472E-05
Snyder	1.163E-07	2.220E-04	2.219E-04	9.437E-05	5.473E-05
Thomas	1.474E-07	2.139E-04	2.138E-04	9.418E-05	5.462E-05

For the Northings, the range, standard deviation and mean of the discrepancies in the formulations of Snyder have the least values, followed by the prescribed method using the regenerated Grid Tables. The biggest discrepancies were observed on the method adapted from Thomas. Whereas for the Eastings, the values of the statistical parameters were smallest for the method from Thomas, then in the usage of prescribed formulas with the regenerated tables, and the last was for the formulations of Snyder, although the values were just very much close to each other.

The correlation analysis between the different coordinate conversion methods was done by assessing the basic statistical parameters of each pair of method. It was apparent that the results obtained from the prescribed method using the regenerated Grid Table (TB 26 Supplement) and the method using the Snyder formulas yielded the closest and most highly correlated values. The discrepancies were only in the sixth and seventh decimal places of a meter, for the Northings and the Eastings, respectively.

3.2.2 Grid to Geographic Coordinate Conversion

The discrepancies on the latitude were least for the Snyder's conversion method as described by the very small values of the minimum, maximum, range, mean and standard deviation, followed by the method adapted from Thomas. The discrepancies from the two other methods were very close, explaining the overlapping plots as explained beforehand on the presented graphs.

Table 4.12. Summary of Discrepancies on the Computed Geographic Coordinates

Conversion Method	Discrepancies in Seconds (Absolute Value)				
	Latitude				
	Minimum	Maximum	Range	Mean	Stdev
Published TB 26	3.359E-04	1.698E-03	1.362E-03	1.049E-03	3.938E-04
TB 26 Supplement	3.224E-04	1.713E-03	1.391E-03	1.053E-03	3.956E-04
Snyder	1.527E-08	3.690E-05	3.689E-05	1.090E-05	7.787E-06
Thomas	2.009E-04	1.121E-03	9.199E-04	6.846E-04	2.574E-04
Conversion Method	Discrepancies in Seconds (Absolute Value)				
	Longitude				
	Minimum	Maximum	Range	Mean	Stdev
Published TB 26	2.666E-03	7.692E-02	7.426E-02	3.179E-02	2.191E-02
TB 26 Supplement	2.669E-03	7.694E-02	7.427E-02	3.179E-02	2.191E-02
Snyder	4.604E-09	7.327E-06	7.322E-06	3.143E-06	1.826E-06
Thomas	1.800E-01	1.800E-01	1.683E-05	1.800E-01	3.806E-06

For the discrepancies on the longitudes, it was apparent that the statistical parameters computed were larger than that of the latitude's, except for the method of Snyder. All the three methods yielded larger discrepancies, especially for the Thomas method, in which the discrepancies were around a tenth of a second. Again, the values from the two methods using the Grid Tables were very close, similar to the case of the discrepancies in latitudes.

3.3 Transformation of Cadastral Data from Different Local Plane Coordinate Systems to the PPCS-TM/PRS92.

3.3.1 Summary Performance of Different Transformation Methods

The table below shows the average RMS of the different transformation methods using the 15 accepted control points in Bacarra, Ilocos Norte and 5 from Masbate City.

BACARRA, ILOCOS NORTE

Method	RMS (m)
2-Parameter*	1.793
3-Parameter A*	1.785
3-Parameter B*	1.795
4-Parameter (Helmert)	1.784
6-Parameter (Affine)	1.718
7-Parameter (Similarity)	1.784
8-Parameter (Projective)	2982.227

* customized

MASBATE CITY, MASBATE

Method	RMS (m)
2-Parameter*	0.667
3-Parameter A*	0.483
3-Parameter B*	0.637
4-Parameter (Helmert)	0.414
6-Parameter (Affine)	0.338
7-Parameter (Similarity)	0.414
8-Parameter (Projective)	187.144

* customized

Transformation Parameters (Bacarra, Ilocos Norte)

Method	SCALE			TRANSLATION (m)			ROTATION (sec)			NON ORTHO (sec)	RMS (m)
	Sx	Sy	Sz	Tx	Ty	Tz	θx	θy	θz	ε	
2 Parameter	0.999986524						-1.0659722				1.7930736
3 Parameter A	0.999913785			22.89114	149.387						1.78518804
3 Parameter B				-64.62758	-13.9828		-4.899088908				1.7949195
4 Parameter	0.999913795			-25.11839	160.2539		-4.899446911				1.78436059
6 Parameter	0.999737	1.000168		202.8167	-347.763		10.11060231			17.45743648	1.71825193
7 Parameter	0.99991			-25.118	160.254	0	0	0	-5.04		1.78447182
8 Parameter	a1	a2	a3	b1	b2	b3	c1	c2	RMS (m)		
	1.531433	-0.52052	-2.6E-07	0.118973	2.16333	2.57161E-07	-295744	-1300992	2982.226538		

Note: No. of CPs is 15 from Bacarra

Table 3.3.1.a. Transformation Parameters of each Coordinate Transformation Method with their corresponding average RMS for Bacarra.

Transformation Parameters (Masbate City, Masbate)

Method	SCALE			TRANSLATION (m)			ROTATION (sec)			NON ORTHO (sec)	RMS (m)
	Sx	Sy	Sz	Tx	Ty	Tz	θx	θy	θz	ε	
2 Parameter	1.000012168						1.293055049				0.6671039
3 Parameter A	1.00017734			-84.13205	-229.138						0.48273926
3 Parameter B				139.3057	-37.8031		18.71118546				0.6371770
4 Parameter	1.000177344			39.80136	-280.056		18.71118925				0.41438788
6 Parameter	1.000227	1.00012		-49.57021	-261.44		9.442159404			-31.33154859	0.33839696
7 Parameter	1.00018			39.749	-280.048	0	0	0	18.72		0.41396208
8 Parameter	a1	a2	a3	b1	b2	b3	c1	c2	RMS (m)		
	-0.25414	-1.48924	-1.1E-06	-0.014599	0.323166	-2.5819E-08	360984	876600	187.1440683		

Note: No. of CPs is 5 from Masbate City

Tables 3.3.1.b.b. Transformation Parameters of each Coordinate Transformation Method with their corresponding average RMS for Masbate City.

3.3.2 Effects of Plane Coordinate Transformation to the Lot Data Computation

Table 3.3.2 shows the performance comparison between the 3-parameter and 4-parameter transformations in terms of difference in test lot areas before and after transformation.

Method	Test Lots	AREAS (m ²)			
		Original	Transformed	Difference	% Change
3-Parameter Least Square	Lot 13416	1319.791	1319.791	0.000	0.000
	Lot 14004	2286.569	2286.568	-0.001	0.000
	Lot 15818	1263.935	1263.935	0.000	0.000
	Lot 14607	1726.188	1726.187	-0.001	0.000
4-Parameter Similarity	Lot 13416	1319.791	1319.563	-0.228	0.017
	Lot 14004	2286.569	2286.177	-0.393	0.017
	Lot 15818	1263.935	1263.717	-0.218	0.017
	Lot 14607	1726.188	1725.891	-0.297	0.017

Table 3.3.2. Performance comparison of 3-parameter and 4-parameter transformations based on area difference.

Figures 3.3.1.a and 3.3.1.b show the effects of the 3-parameter and 4-parameter transformations on the technical descriptions of test lot 14607 in Bacarra, Ilocos Norte.

14607			14607 Transformed		
Date Surveyed	Lot No.	Sheet	Date Surveyed	Lot No.	Sheet
Island			Island		
Survey Symbol & Number			Survey Symbol & Number		
angle			angle		
L. R. C. No.			L. R. C. No.		
8a	14a	14b	8a	14a	14b
Line	Bearing	Distance	Line	Bearing	Distance
1-2	S 17-41 W	27.85	1-2	S 17-41 W	27.85
2-3	N 74-4 W	15.26	2-3	N 74-3 W	15.26
3-4	N 22-20 E	24.40	3-4	N 22-20 E	24.40
4-5	N 14-9 E	22.12	4-5	N 14-10 E	22.12
5-6	N 21-31 E	58.49	5-6	N 21-32 E	58.49
6-7	S 72-52 E	17.07	6-7	S 72-51 E	17.07
7-8	S 18-43 W	36.83	7-8	S 18-43 W	36.83
8-1	S 25-49 W	40.19	8-1	S 25-49 W	40.19

Original Technical Description

Transformed Technical Description

Figure 3.3.1.a. Effect of the 3-parameter transformation on the technical description of lot 14607.

14607			14607 Transformed		
Date Surveyed	Lot No.	Sheet	Date Surveyed	Lot No.	Sheet
Island			Island		
Survey Symbol & Number			Survey Symbol & Number		
angle			angle		
L. R. C. No.			L. R. C. No.		
8a	14a	14b	8a	14a	14b
Line	Bearing	Distance	Line	Bearing	Distance
1-2	S 17-41 W	27.85	1-2	S 17-41 W	27.84
2-3	N 74-4 W	15.26	2-3	N 74-3 W	15.26
3-4	N 22-20 E	24.40	3-4	N 22-20 E	24.40
4-5	N 14-9 E	22.12	4-5	N 14-10 E	22.12
5-6	N 21-31 E	58.49	5-6	N 21-32 E	58.48
6-7	S 72-52 E	17.07	6-7	S 72-51 E	17.07
7-8	S 18-43 W	36.83	7-8	S 18-43 W	36.83
8-1	S 25-49 W	40.19	8-1	S 25-49 W	40.19

Original Technical Description

Transformed Technical Description

Figure 3.3.1.b. Effect of the 4-parameter transformation method on the technical description of lot 14607.

The different transformation methods suggest that the method with the lowest RMS indicates the best transformation possible, in this case, the 6-parameter Affine transformation. However, this transformation method includes parameter for orthogonality of the axes of the plane coordinate system which does not support the properties of a plane coordinate system used for cadastral surveys. Plane coordinate systems for cadastral surveys are assumed to be orthogonal whatever is the case. Since the results show an indication of non-orthogonality of the axes of the original system, this then may mislead the transformation. Considering 6-parameter Affine not valid for cadastral transformation, the second lowest RMS yield is the 7-parameter and 4-parameter similarity transformation where it can be noted that the 7-

parameter transformation being 3-dimensional in nature only reduces to 4-parameter similarity lacking parameter for delta z and rotation about the x and y-axis. The next method having the least RMS yield is the 3-parameter B* which includes a rotation about the z-axis.

4. CONCLUSION

On Data Build-up of Cadastral Information:

1. The Cadastral Data Encoding Template is an efficient environment to convert lot data to digital form. It provides the necessary tool to compute accurately the other details required in the Lot Data Computation Sheet.
2. The use of imaging assembly can be a fast method for converting cadastral data records into raster image which can be archived in a database for future retrieval and conversion to digital form.

On the Evaluation and Assessment of Philippine Transverse Mercator (PTM) Grid-to-Geographic Conversion:

1. It is evident from the results of the evaluation and assessment of the coordinate conversion method as prescribed by the Technical Bulletin No. 26 that upon the elimination of the entries with significant discrepancies, the use of the Grid Tables is a correct and effective means of converting between geographic and grid coordinates in Philippine Transverse Mercator (PTM).
2. All the values obtained by using the direct coordinate conversion methods are more or less accurate, or at least having discrepancies which are insignificant based on the three-point criteria assessment. However, the closed formulation adapted from Snyder gave the least amount of discrepancies for both the forward and inverse solutions, as well as it provides good cyclic conversion capability.

On the Transformation of Cadastral Data from Different Local Plane Coordinate Systems to the PPCS-TM/PRS92.

1. Transformation of Cadastral Survey and Data to PPCS-TM/PRS92 must be done only to cadastral projects (approved) with intact and complete cadastral records with verified correct ground control survey.
2. Verification and validation of correctness of cadastral survey plays an important role in approving cadastral survey for transformation and integration to PPCS-TM/PRS92.

3. Among of the available methods for plane coordinate system transformation, the Least Squares 3-parameter and 4-parameter (Similarity) transformations are the only methods suitable for cadastral survey and data transformation.
4. The 3-parameter and 4-parameter transformation has the following advantages and disadvantages:

Method	RMS Yield	Effect in Area	Effect in the TD of a lot	Legal implication
LS 3-Parameter	Good	Negligible	may change bearings; retain distances	Title amendment
4-Parameter (Similarity)	Better	$\pm 0.01\%$ (1sqm/5000sqm)	changes bearings; changes distances	Title amendment

Table 5.1.1 Performance of the 3-parameter and the 4-parameter transformation methods

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