Research and Development in Support of PRS92:
Results and Recommendations

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About UP DGE/TCAGP

- Department of Geodetic Engineering
  - **Academic** unit of UP in Diliman (under COE)
  - Offers degree programs in
    - MS Remote Sensing
    - BS Geodetic Engineering
  - Since 1935
  - 17 Faculty members
  - 140 Undergraduate students 51 Graduate students
- Training Center for Applied Geodesy and Photogrammetry
  - **Research, training and extension** arm of the University of the Philippines (Under NEC umbrella) in mapping, surveying, earth observation and geographic information systems
  - Regularly offers training and short courses for engineers and allied fields.
  - Since 1964

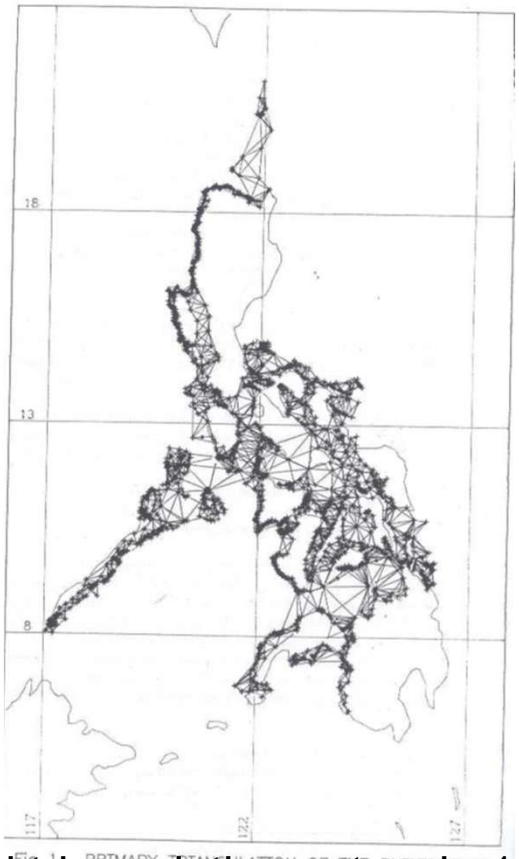
UP College of Engineering	UP National Engineering Center
DGE (Academic)	TCAGP (Training, Research, Extension)

Outline of this presentation

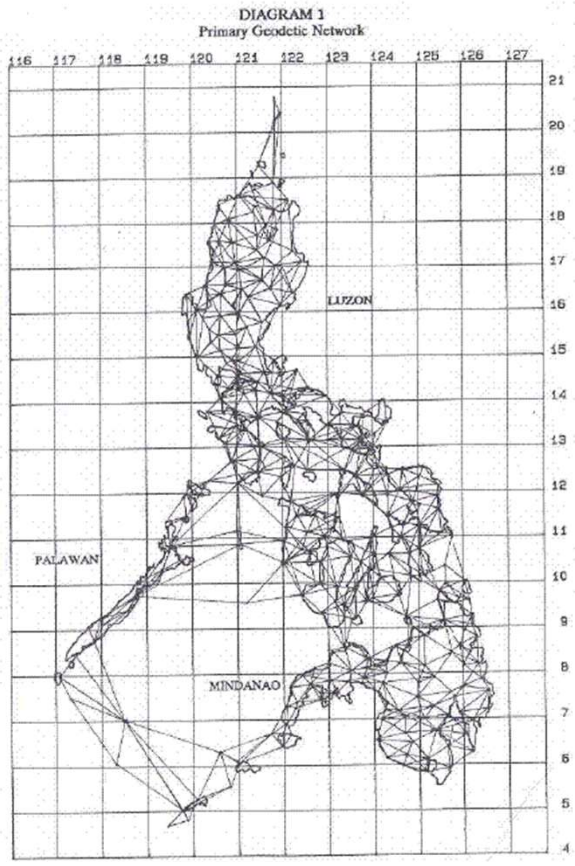
- Introduction to PRS92
- Objectives of the PRS92 R&D Project
- Results and Findings
- Recommendations
- Concluding Remarks

What is PRS92?

- The Philippine Reference System of 1992 (PRS92), a national network of geodetic control points is the current standard reference system for all mapping and surveying activities in the Philippines



Old triangulation network, 1911~

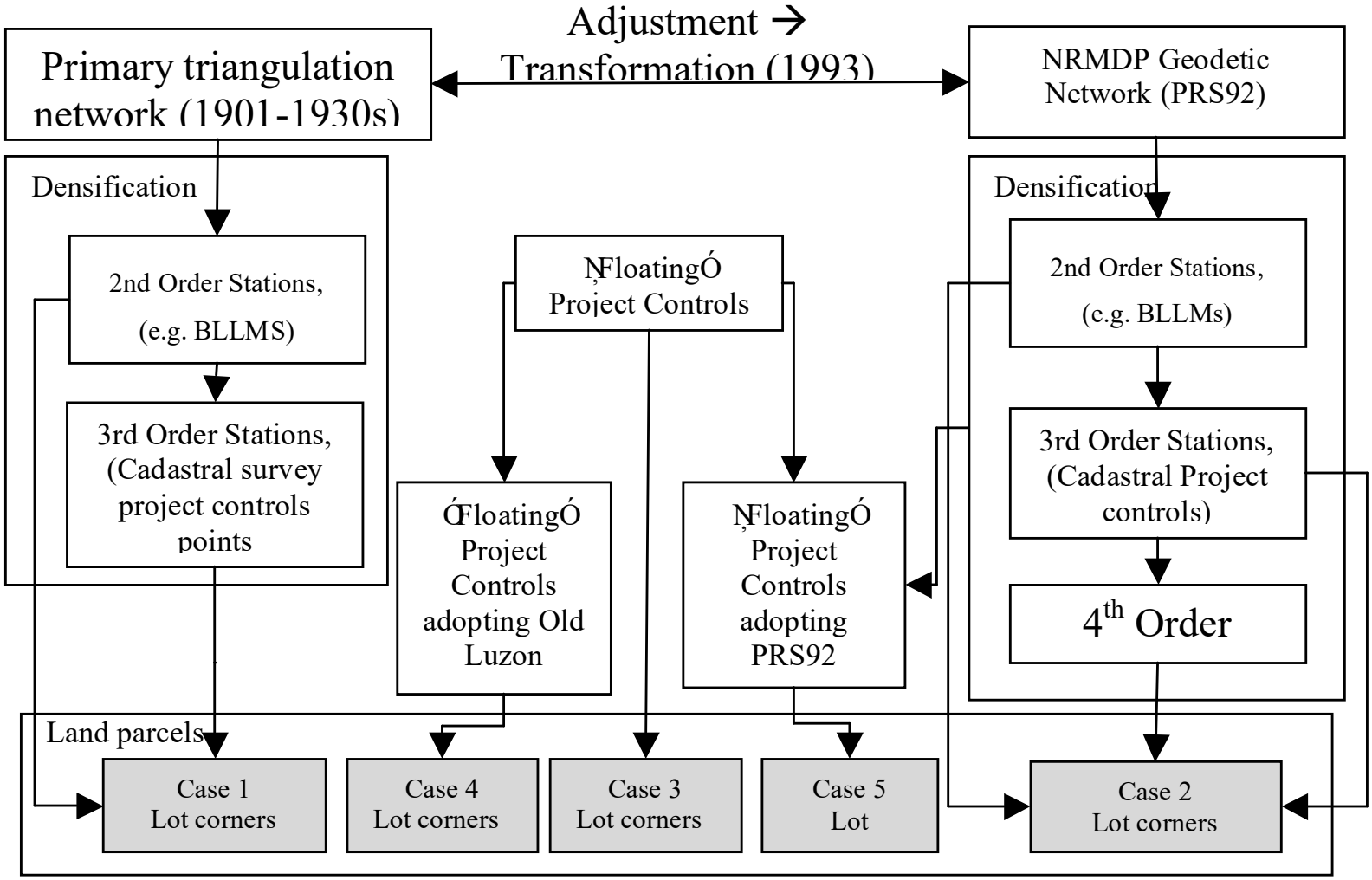


PRS92 GPS Reference Points (up to 1991)

PRS92 *Quo vadis?*

- Unprecedented intensity and rates in development resulted in increased demand for reliable (land) resource information
  - Government lacks resources to meet this demand
  - Most surveyors ill-equipped to adapt PRS92
  - Increasing symptoms of dysfunctioning spatial reference system

"Which reference system?"



- We have as many 5 systems to reference land parcels

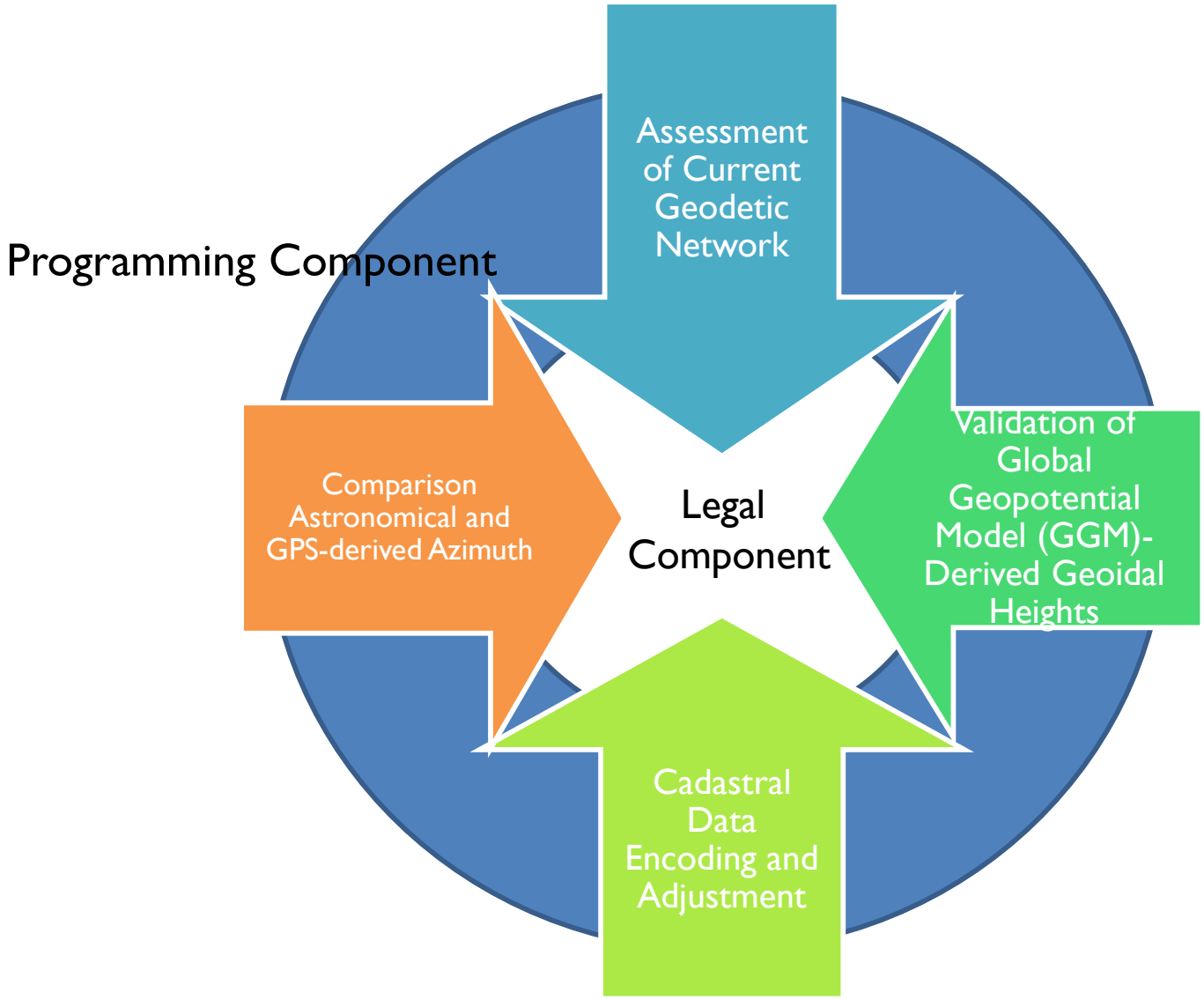
About the PRS92 R&D Project

- The National Mapping and Resource Information Authority (NAMRIA) was designated as the lead agency tasked to implement the full utilization of PRS92
- The agency has drawn an implementation plan which included a component on Research and Development (R&D).
- The UP-TCAGP, entered into a collaborative research agreement with NAMRIA to conduct the "Research and Development in Support of the Implementation of the Philippine Reference System of 1992", otherwise known as the PRS92 R&D Project to address the pressing issues.

Objectives of the PRS92 R&D Project

- Overall: To **develop operational methodologies** that will define, provide access to and maintain PRS92;
- Specific objectives include:
  - Provide sound **scientific basis** towards adoption of a common national horizontal and vertical datum
  - Analyze of the **applicability of well-known geoid model/s** as a basis for horizontal and vertical positioning using GPS
  - Examine different coordinate systems used in mapping and surveying and prescribe their **conversion to a single unified system**
  - Develop **practical and appropriate tools** to build and increase local capacity on accurate positioning using PRS92.
  - **Strengthen the national geodetic network** in preparation and support of a national spatial data infrastructure (NSDI).

Overview of the PRS92 R&D Project



Components of the PRS92 R&D Project

Research Activities

1. Gathering of relevant data
2. Field surveys
3. Data processing and analysis
4. Computer programming
5. Meetings with NAMRIA PRS92 R&D Technical Working Group and consultation with key interest groups
6. Report Write-up

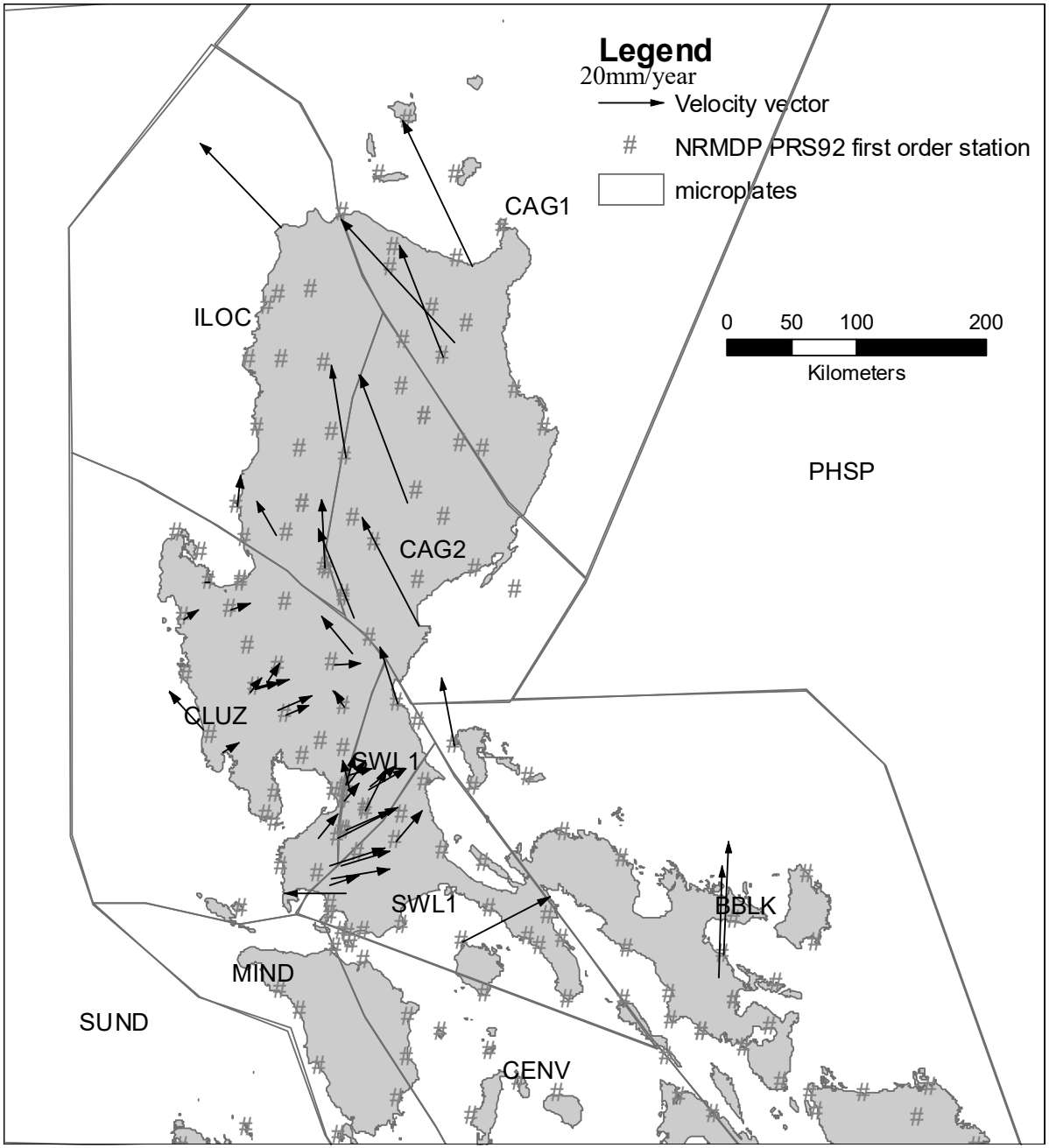
Results and Findings

Summary of Findings

- **On the Assessment of the Current Geodetic Control Network**
  - Observed current GNSS-based coordinates of points significantly deviated from published WGS84 values
  - The current geodetic control network has for years, remained static despite the dynamic nature of the Philippines geologic setting and in dire state of disrepair
  - Implementation of PRS92 was severely hampered by lack of educational and technical resources to enable those concerned to operationalize its application
  - Due to absence of enabling law and inadequate complementary policies, there is generally a very low confidence on PRS92 usage
  - Recently, there are encouraging indications that PRS92 has been given due attention in recent years.
    - NAMRIA in particular made great strides towards revitalization of the network through the PRS92 Project

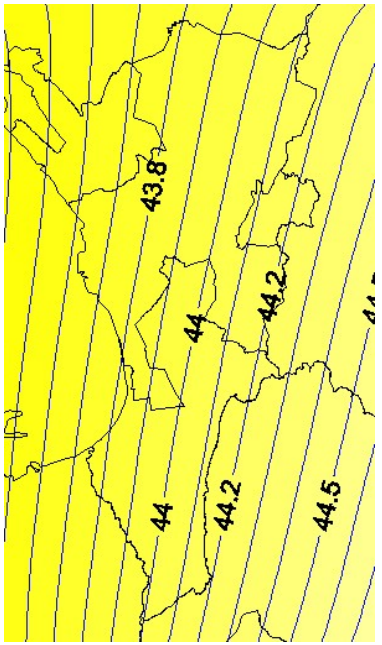
Microplate-based reference system

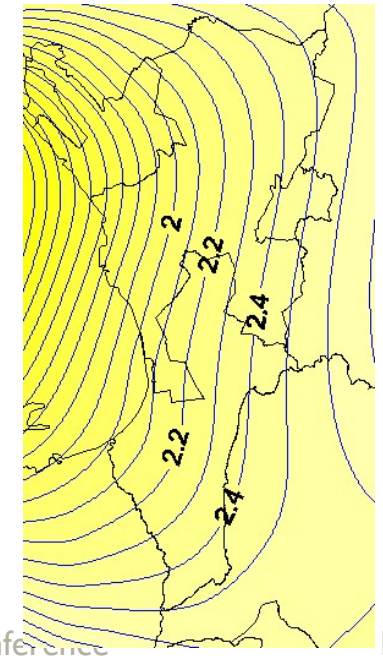
- 100 1st order geodetic control points
- 74 Segments
- 87 triangles
- ITRF referencing showed better correpondence between PRS92-ITRF2005 than WGS84-ITRF2005

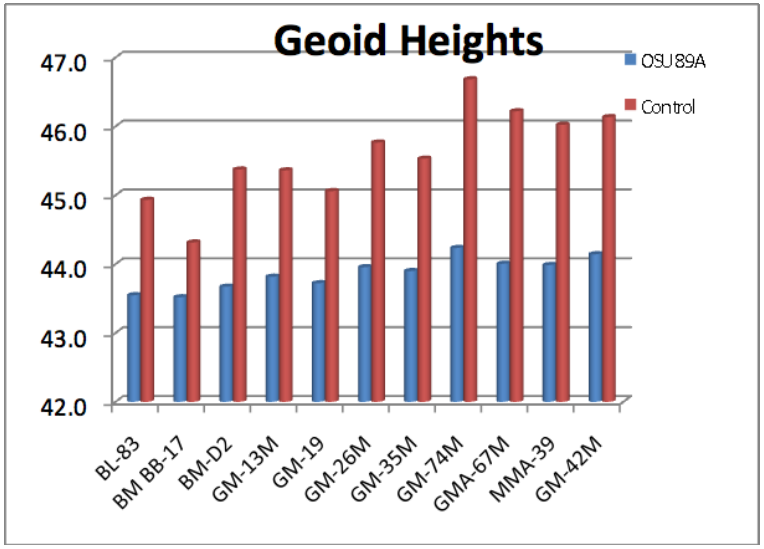


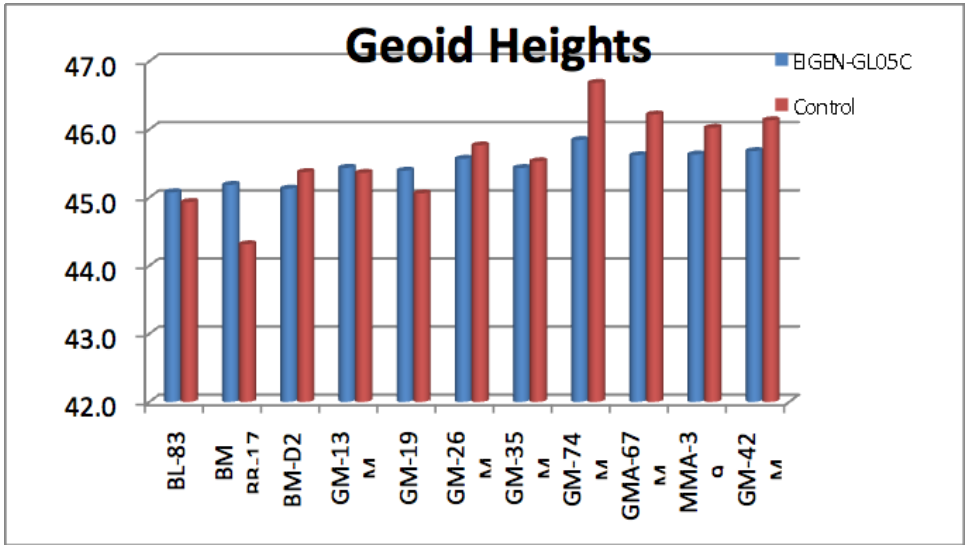
Summary of Findings

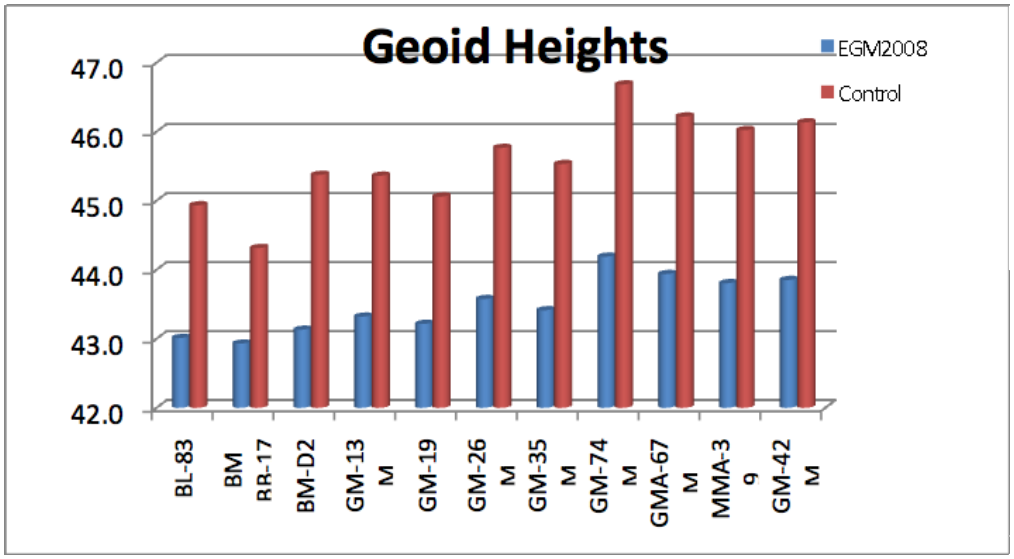
- **On the validity of Global Geopotential Models (GGM)**
  - Metro Manila as study area
  - Tested models include EGM96, Eigen-CG03, Eigen-GL05, GGM02C
  - Statistical analysis show that recent GGMs outperform OSU89A (PRS92 model) ***in the study area***
  - The EGM- 2008 model is the best model that can be adopted ***for the study area***
  - There is a need to adopt a new GGM for the development of a national geoid model











Relative verification of GGMs (in ppm)							
	egm96	**eigen-cg03c**	**eigen-gl05c**	**ggm02c**	**osu89a**	**pgm2000a**	**egm2008**
Max	74.884	94.737	98.058	106.350	94.650	74.819	63.552
Min	5.703	2.226	11.073	11.022	13.395	5.567	2.221
Mean	37.548	50.901	53.689	56.518	50.854	37.498	30.642
Stdev	20.096	25.252	24.742	26.723	23.641	20.098	17.698

Summary of Findings

On Stellar vs. GPS-derived Azimuth

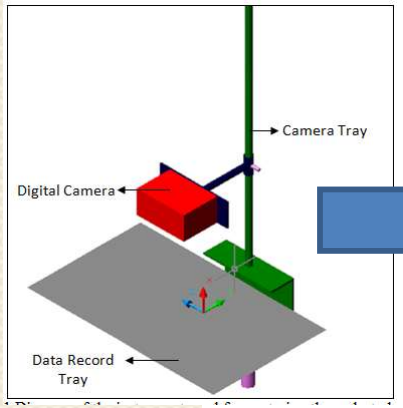
- Solar observation can produce results within the primary project control requirement.
- Unreferenced solution can be used in the determination of geodetic azimuth and is comparable to the output from the referenced solution.
- For project controls of primary, secondary and tertiary precision requirements the use of the geodetic latitude in the determination of the astronomic azimuth is sufficient at least for areas with flat topography
- For project controls, astronomic and geodetic azimuths can be used interchangeably
- See presentation in this conference for details

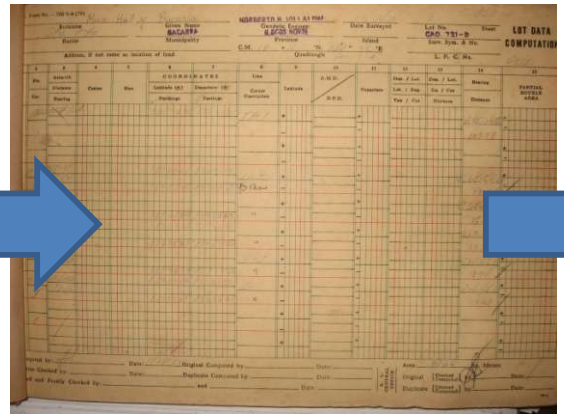
Study Area	Line	Distance (meters)	AstroGeodetic Azimuth (*)			GPS Azimuth (**)			Difference (Astro - GPS)			Probable Error			Remarks
			dd	mm	ss	dd	mm	ss	dd	mm	ss	dd	mm	ss	
Cebu	CBU76-CBU76B	98.65	105	9	25.13	105	8	54.17	0	0	31	0	0	10	within Tertiary , Astro>GPS
Laoag	ILN7-ILN7B	303.312	23	3	34	23	2	55.35	0	0	39	0	0	13	within Tertiary , Astro>GPS
Puerto Princesa	PLW35B-PLW35	228.462	152	58	6.25	152	58	25.35	0	0	-19	0	0	-6	within Secondary , GPS>Astro
Baguio	BPS01-BPS02	156.145	176	15	22.7	176	15	40.62	0	0	-18	0	0	-6	within Secondary , GPS>Astro

Summary of Findings

On the Cadastral Data Encoding:

- A Cadastral Data Encoding Template has been developed to provide the necessary tool to compute accurately the other details required in the Lot Data Computation Sheet
- Entry of coordinates instead of bearing & distances is more efficient and less prone to errors
- See presentation in this conference





		NORBERTO VILLALUNA	3/9/1982	14001	1
Surname	Given Name	Geodetic Engineer	Date Surveyed	Lot No.	Sheet
NAMBARAN	BACARRA	ILOCOS NORTE	LUZON	CAD 731-D C-19	
Barrio	Municipality	Province	Island	Surv. Sym. & No.	
		18-16 N 120-38 E 1A			
Address, if not same as location of land		Quadrangle		L. R. C. No.	

2b	6	7	8a	14a	14b
tion	COORDINATES		Line	Bearing	Distance
orner	Northings	Eastings			
BLLM 1-A	2,018,879.35	458,622.62	BLLM 1-A -- 1	N 63-35 E	3,145.75
1	2,020,278.56	461,440.06	1-2	N 35-35 E	1.25
2	2,020,279.58	461,440.79	2-3	S 85-29 E	11.92
3	2,020,278.64	461,452.67	3-4	S 20-48 W	19.27
4	2,020,260.63	461,445.83	4-5	N 86-23 W	13.64
5	2,020,261.49	461,432.22	5-1	N 24-40 E	18.78

Summary of Findings

On the Current Geo-Grid Conversion method:

- PTM projection formulation found in the Bulletin Supplement consistent with Gauss-Schreiber Transverse Mercator (TM) formulation based on cited literature and references.
- A number of “outliers” are found in the Technical Bulletin (1st published 1965) causing erroneous conversion on specific points
- Direct coordinate conversion methods are more or less accurate, or at least having discrepancies which are insignificant based on the three-point criteria assessment
- The closed formulation adapted from Snyder (1987) gave the least amount of discrepancies for both the forward and backward solutions

Summary of Findings

- **..on the Coordinate Transformation Technique**
  - the Least Squares 3-parameter and 4-parameter (Similarity) transformations are the only methods suitable for cadastral survey and data transformation.
  - Various cases of cadastral data condition might require specific approaches
  - The 3-parameter and 4-parameter transformation has the following advantages and disadvantages:

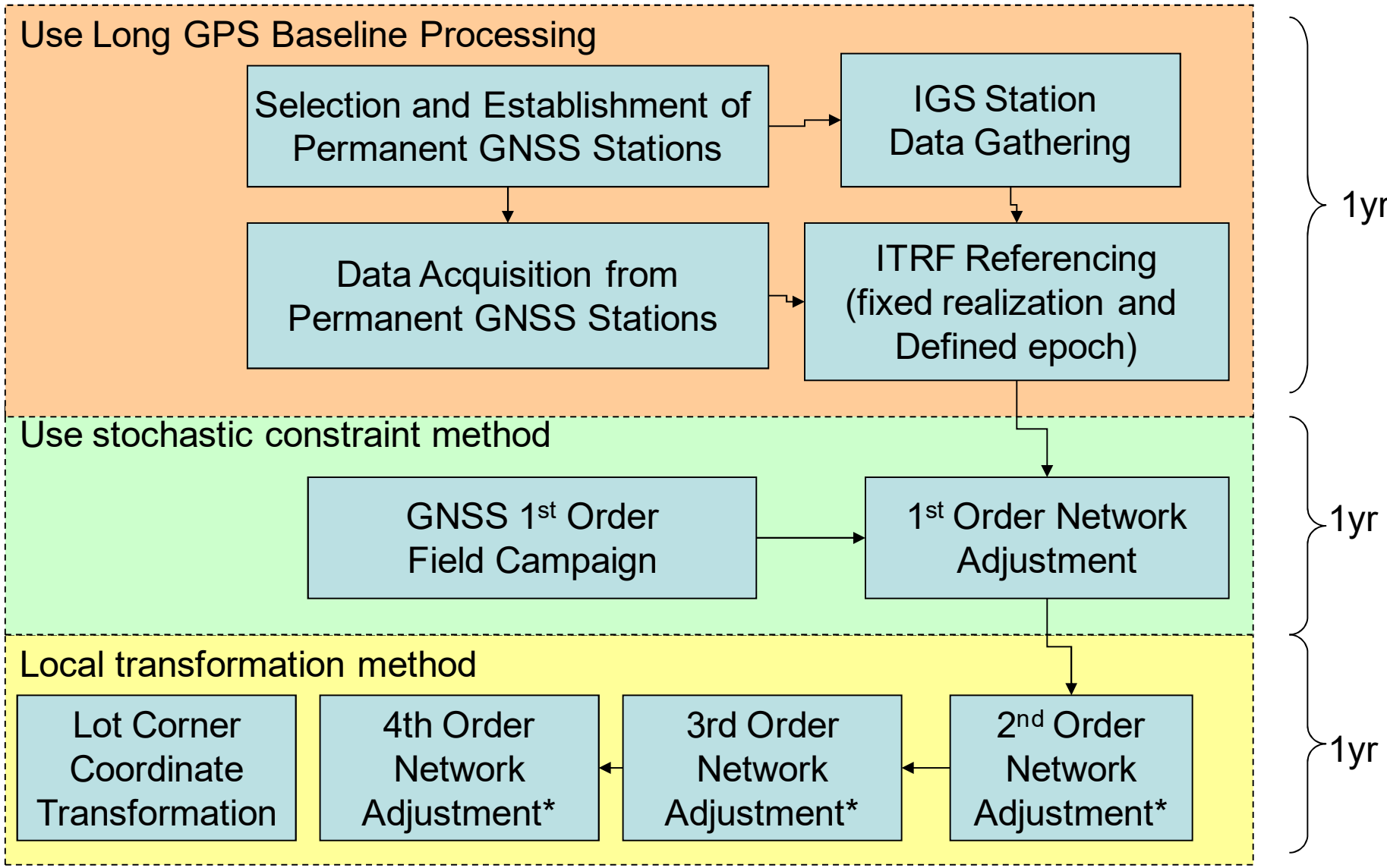
Method	RMS Yield	Effect in Area	Effect in the TD of a lot	Legal implication
LS 3-Parameter	Good	Negligible	may change bearings; retain distances	Title amendment
4-Parameter (Similarity)	Better	±0.01% (1sqm/5000sqm)	changes bearings; changes distances	Title amendment

Recommendations

Summary of Recommendations

- …**on the Geodetic Control Network**
  - A new datum should be established and based on, and aligned with, the International Terrestrial Reference System (ITRS) using Global Navigation Satellite System (GNSS) technology
  - Develop a set of transformation parameters to relate PRS92 coordinates to the new datum derived from GNSS campaigns and permanent GNSS observation stations using international protocols.
  - A system to update and maintain control points coordinates in terms of the new datum to account for new observations and predictable regional mark movement.
- A **proposed set of Guidelines** has been prepared to accomplish the above recommendations

Proposed Road Map to a Modern Reference Frame

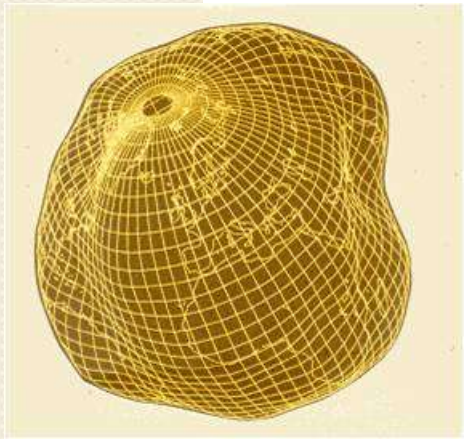


*Adjustment will require minimum constraint method

Summary of Recommendations

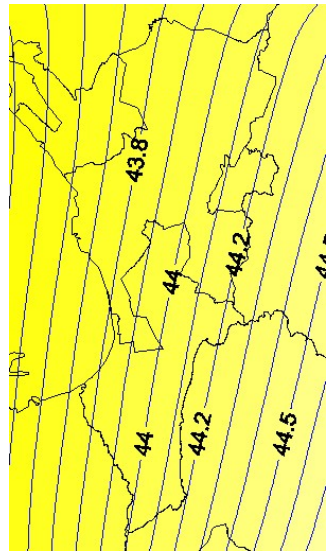
- ***…on the vertical datum connection***
  - Reconcile inconsistencies in the different sources of data
  - Update the Philippine Geoid model using recent gravity data or geopotential models to improve accuracy of the computation of the parameters.
  - Update the data and additional stations needs to be established around the fundamental tide gauging stations.
  - The computed height difference at a single landmass can be validated more appropriately if leveling and gravity profile connecting the two datum is available.
- A **Technical Manual** has been prepared for establishment of geodetic vertical control network for to meet the purpose of the connection

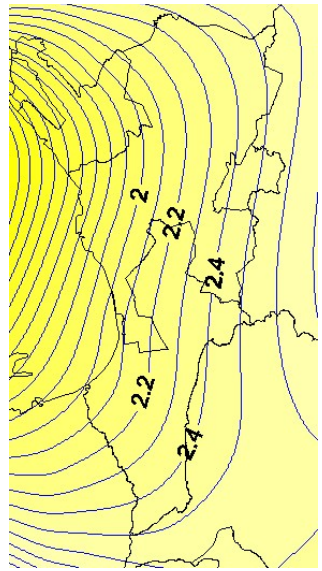
Summary of Recommendations



…on Geoid Modeling and Gravity Measurements

- Extend the research to the national level
- Strengthen benchmark data holdings thourgh aggressive recovery and densification
- Establish a country-wide continuously operating GNSS that would provide control for such endeavors
- Renew gravity data holdings
- Extend the research to a preliminary computation of a geoid model
- Reopen channels for consultation





Summary of Recommendations

- ***…on Azimuth Obtained from GPS and Astronomic Observation***
  - Validate the proposed astronomic latitude and astronomic azimuth determination method using at least two redundant set of observation done in the morning and in the afternoon **by direct measurement of latitude**
  - **Validate** astronomic longitude obtained by using the Laplace correction should **by direct measurement of longitude**
  - **Adopt a standard baseline** which will be observed both by GPS and astronomic observation periodically shall be established. a check on the values obtained from the geodetic engineers' almanac.
  - **a training on proper astronomic observation** be done and a certification of completion be required if astronomic observation will be required on the approval of survey plans.
  - immediately communicate results o the proper stakeholders.

Summary of Recommendations

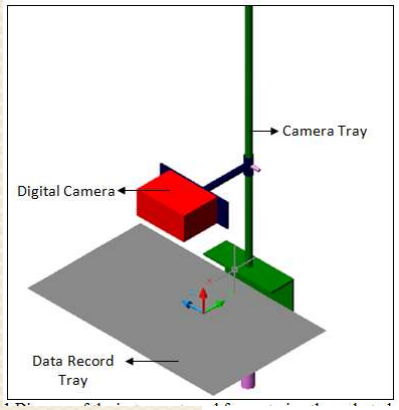
On the Technical Bulletin on Geo-to-Grid Conversion

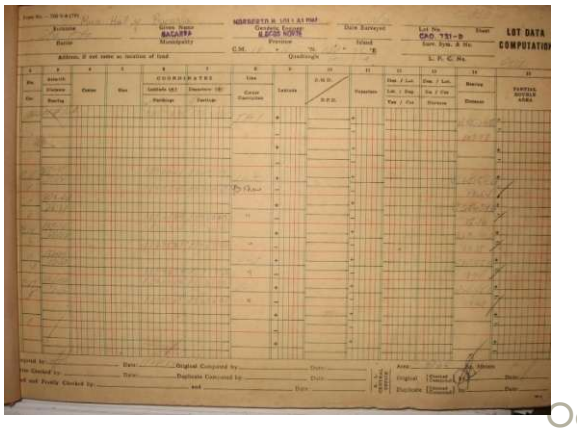
- Republish the Bulleting with the corrections found in the Coordinate Conversion Table.
- Republish of the Bulletin Supplement for reference.
- Incorporate of a close formulation based on a cited literature for coordinate conversion in the republish technical bulletin.

- A **draft Technical Manual/Bulletin** has been prepared to meet this purpose with a computer program for doing the conversion

Summary of Recommendations

- ***On Build-up and Encoding of Cadastral Data***
  - Produce image files of all Lot Data Computation Sheets to minimize the exposure of such documents to wear and tear
  - Implement the Cadastral Data Encoding Template for an efficient and quick lot data conversion





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Summary of Recommendations

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

- Implement a cadastral survey verification and validation before the transformation and integration to the PPCS-TM/PRS92.
- Implementation of the cadastral transformation and integration methodologies

- A **draft Technical Manual** has been prepared for this purpose

Output from Supporting Components

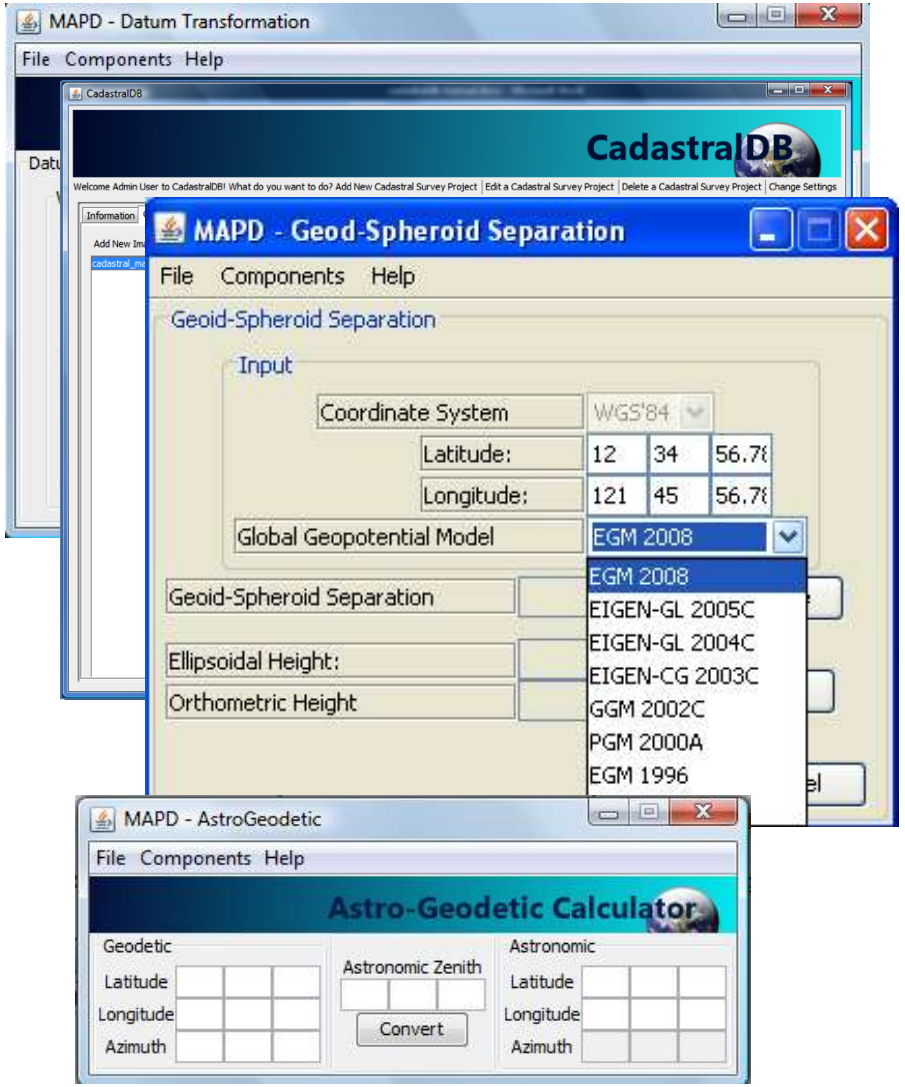
- **Legal Component**
  - Draft bills for submission to Congress on adoption of PRS92
  - Draft administrative issuances at various level of the Executive Branch
  - Compendium of laws relating to PRS92
- **Programming Component**
  - Computer Program/Software that implements the systems developed
    - These can be used to meet the operational requirements of government as well as users of PRS92 in the private sector

Computer Programs for Geodetic and Cadastral Data Processing

Programmed in Java™ language

- Datum Transformation

1. Geoid-Spheroid Separation
2. Astro-geodetic Computations
3. Geographic-to-Grid (Philippine Transverse Mercator) and vice-versa
4. Cadastral Data Encoding



Proposed Collaborative Research

- Many “loose-ends” in the first research phase
- A **Second Phase for the PRS92 R&D Project** might be in order
- Proposed research will tackle:
  - Migration, Updating Monitoring, and Maintenance of a New Integrated Reference Frame
  - Development of *gravimetric geoid model* from combined GPS, leveling and *gravity* measurements
  - Development of protocols for transformation of maps and other ENR Datasets
  - Detection and analysis of errors in cadastral survey data and remedies for transformation
- Establishment of the **UP-NAMRIA Geospatial Infrastructure Development and Research Laboratory (GeoID Lab**)

Concluding Remarks

- This paper presented the results and findings of the research and development activities undertaken to support the implementation of the PRS92 collaborated by an academic institution (UP Diliman) and a government agency (NAMRIA)
- Engage other equally important stakeholders
  - the **Industry** to enable adoption
  - **Beneficiaries** to foster acceptability and support
  - **international community of experts** to gather comments and solicit suggestions


Thank you for your kind attention!

Acknowledgments

- Our colleagues at UP TCAGP and NAMRIA for their individual and collective contributions to the project
- various regional offices of the DENR and other cooperating agencies for their assistance during the conduct of the field works and data gathering
- The Engineering Research and Development for Technology (ERDT) for the research dissemination grant