COORDINATED CADASTRAL SYSTEM FOR PENINSULAR MALAYSIA: *FROM CONCEPT TO REALITY*

by:

Professor Dr. Abd. Majid A. Kadir
Associate Professor Ghazali Desa *PMP*
Dr. Abdullah Hisam Omar

Faculty of Geoinformation Science & Engineering
UNIVERSITI TEKNOLOGI MALAYSIA

International Seminar on Geoinformation 2005
27-29 September 2005
Park Royal Hotel, Penang

KEY-NOTE PAPER

PRESENTATION SUMMARY

- General Background
- Why Rigid (Survey Accurate) Coordinate?
- Why Geocentric Datum?
- Why Least Squares Technique?
- Whole to the Part Concept Revisited
- CCS Definition, Conceptual and Implementation Models
- CCS Study Framework
- Overview of CCS Pilot Project in Melaka
- The Way Forward

Objective of Cadastral Surveys

In Peninsular Malaysia, cadastral surveys are primarily concerned with the determination or definition of property boundaries, through their marking and description, and the preparation of associated plans and maps, for purposes of alienation and conveyancing. The system as practised is one of fixed and defined boundary whereby parcel definition is by the officially emplaced and mathematically coordinated boundary marks.

The main objectives of conducting cadastral surveys that had been promulgated in the early days of its practice have since been continually adhered to and later came to be adopted as amongst the principal functions of DSMM. They were stated in the *Survey Regulations* (DSMM, 1976) as follows:

"(a) To provide evidence which will completely and permanently identify the land conveyed by any title issued by government.

(b) To compile and make available records of alienation necessary for intelligent land administration."

Ahmad Fauzi Nordin (2001)

The spirit of Coordinated Cadastral Survey as described in Survey Regulation 1976

Survey Regulations Semenanjung Malaysia 1976…
APPENDIX VIII: INSTRUCTIONS FOR COMPUTERS

4. Coordinates

4.1 The general scheme of computation is based ultimately on the coordinates of trigonometrical stations and that the purpose of standard and control traverses is to confine errors and to prevent their accumulation. Coordinates must be computed and adjusted accordingly.

4.2 Cadastral survey coordinates are of two kinds:

4.2.1 **Rigid Coordinates** required for controls and the external boundaries of new surveys extending the *coordinated area*.

4.2.2 **Plotting Coordinates** used for subdivisions and in areas enclosed by rigid coordinates.

PROBLEM STATEMENT 1: LACK OF APPRORIATE TECHNOLOGIES PRIOR TO 1990's HINDER THE APPLICATION OF RIGID COORDINATES

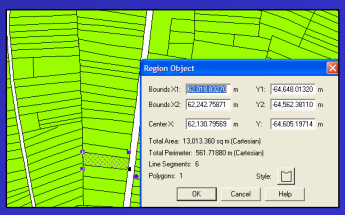
- Practical implementation of cadastral survey is to avoid cadastral boundary overlapping problems rather than to enforce Survey Regulation requirements on coordinates

CONSEQUENCES: DIFFERENT TYPES OF CADASTRAL COORDINATES

RIGID COORDINATE	Homogenous and Systematically Adjusted
PLOTTING COORDINATE	For cadastral map plotting purposes
SYSTEM COORDINATE	System/Software generated coordinate based on features location

Rigid Coordinate

Plotting Coordinate



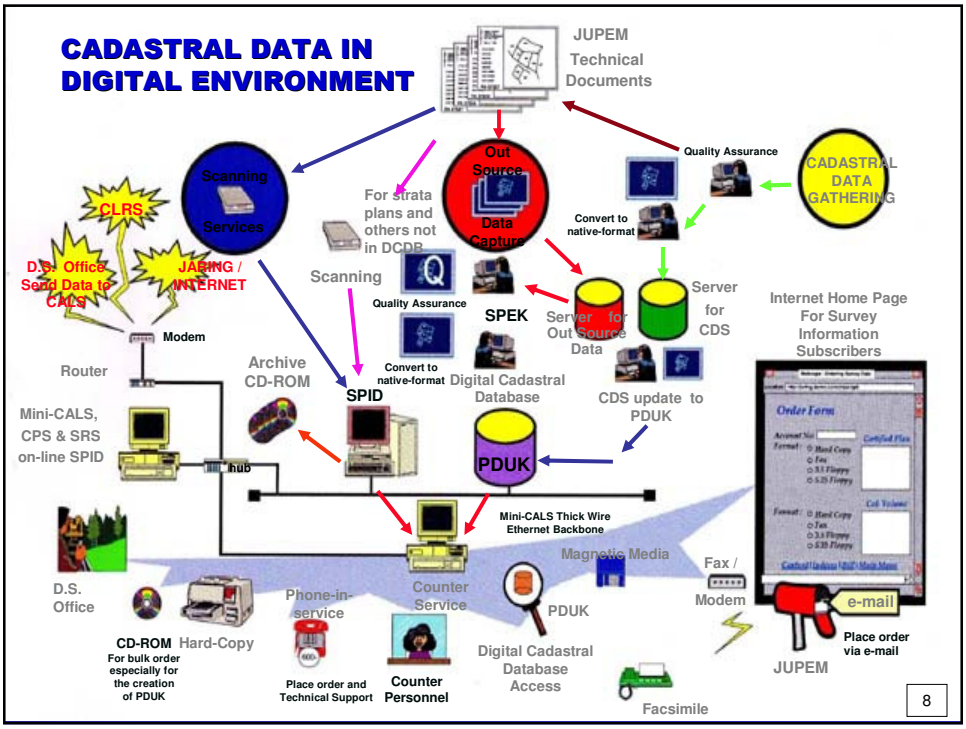
System Coordinate

CONSEQUENCES: UNCONTROLLED ERROR PROPAGATION IN COORDINATES

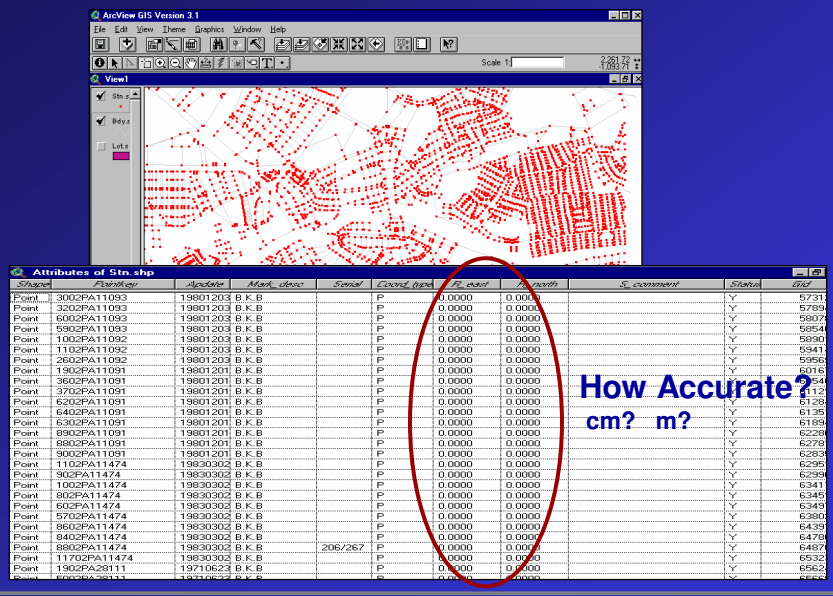
- Simple linear error propagation based on 1st and 2nd class cadastral survey

DISTANCE (km)	1:4,000 (0.25m/km)	1:8,000 (0.125/km)
0.1	0.025	0.010
0.5	0.125	0.063
1.0	0.250	0.125
2.0	0.500	0.250
5.0	1.250	0.625
10.0	2.500	1.250
20.0	5.000	2.500
50.0	12.500	6.250

CADASTRAL DATA IN DIGITAL ENVIRONMENT

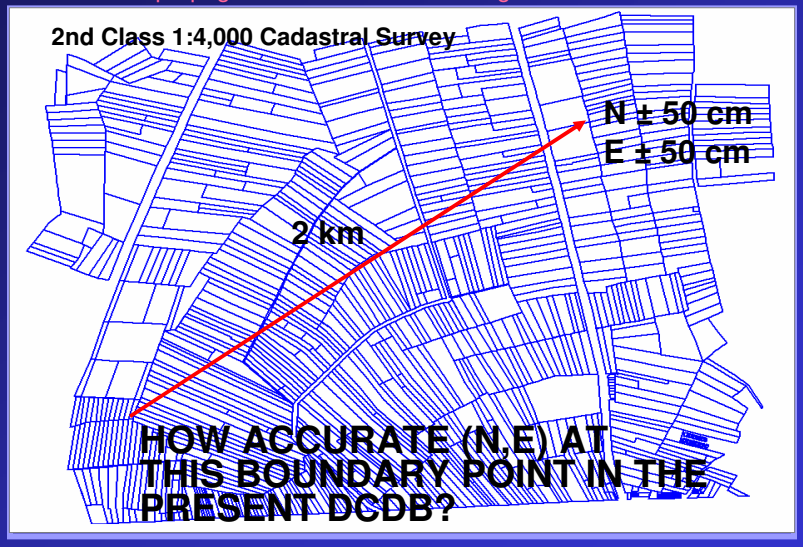


Boundary Mark Layer in DCDB



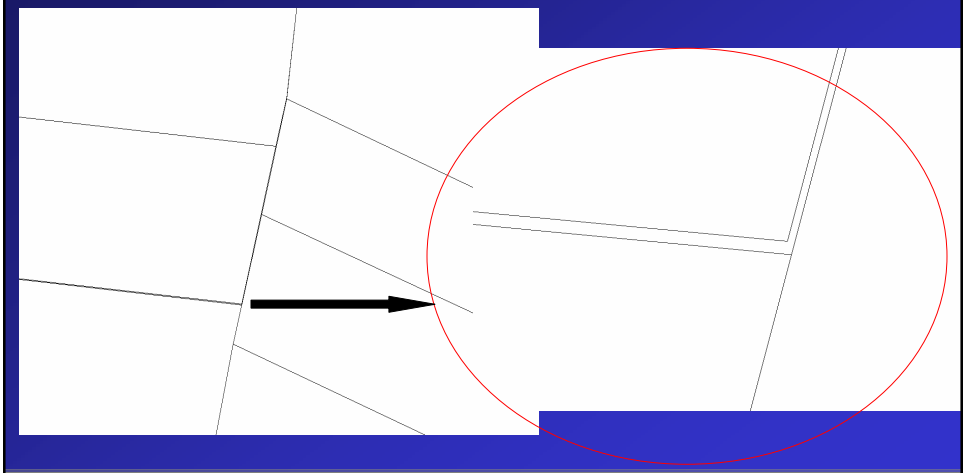
ERROR PROPAGATION

- Effect of error propagation on coordinates in digital cadastral database

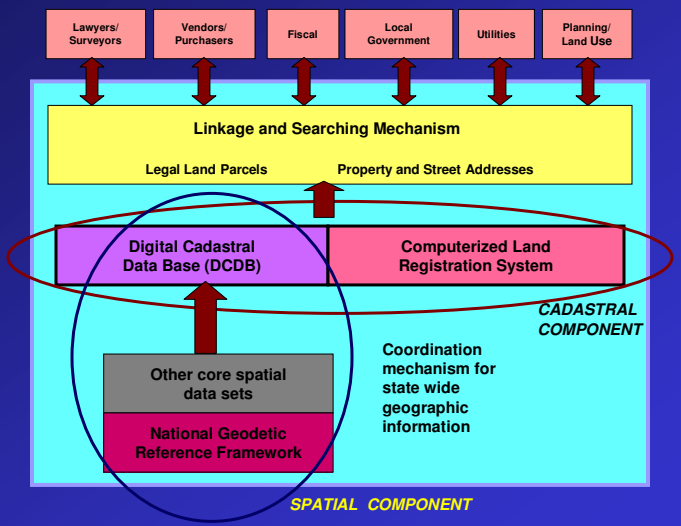


Consequences: Graphical Coordinate Error

- Results in non-uniqueness of coordinates of the same boundary point



CADASTRAL MODEL: The role of cadastre in a state's spatial data infrastructure *(Source: Ian Williamson)*

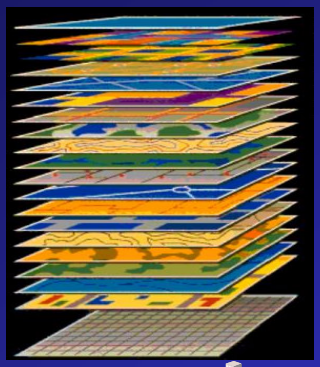


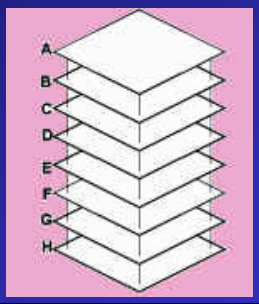
Problem Statement 2: Geodetic Datum Inconsistencies

- Different Geodetic Datum Used In Cadastral System In Peninsular Malaysia

Consequences: Hinder Integration of Spatial Data At National Level

- Multipurpose cadastre underpin a good Land Information System (LIS)

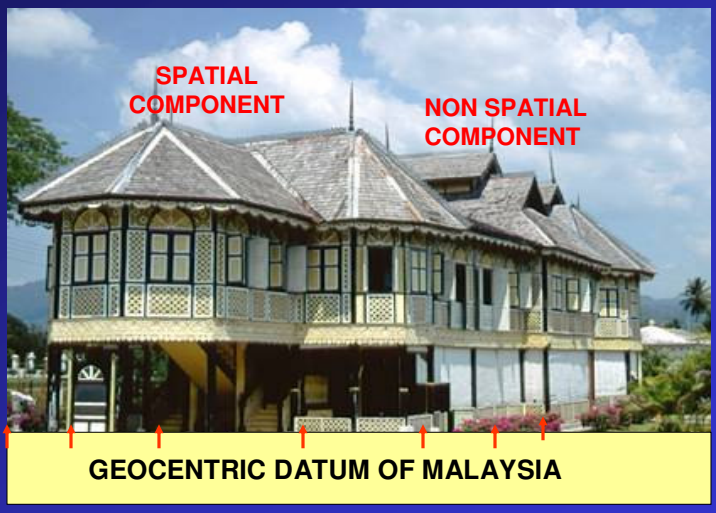




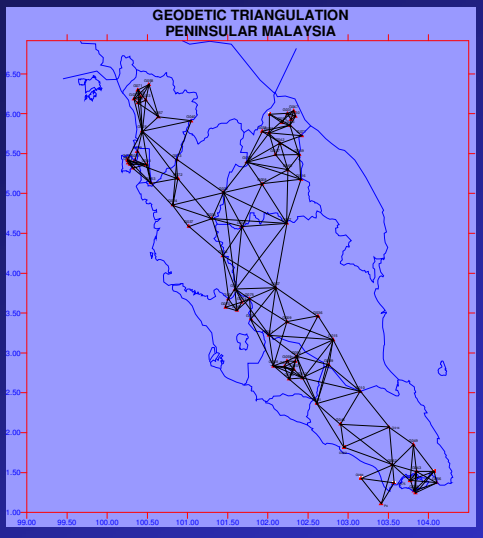
LAYER	AGENCY
A - Parcel B - Zon	Jurukur, Pejabat Tanah & Jabatan Ukur dan Pemetaan
B - Zon	Majlis Daerah
C - Saliran	Jabatan Parit dan Saliran
D - Kawasan Paya	Jabatan Parit dan Saliran , Perhutanan
E - Utiliti	Majlis Daerah, Syarikat Utiliti
F - Tanah	Pejabat Tanah dan Galian
G - Rujukan Geodetik	Jabatan Ukur dan Pemetaan
H - Tindihan Keseluruhan	Kombinasi lapisan-lapisan

Solution: GEOCENTRIC DATUM OF MALAYSIA

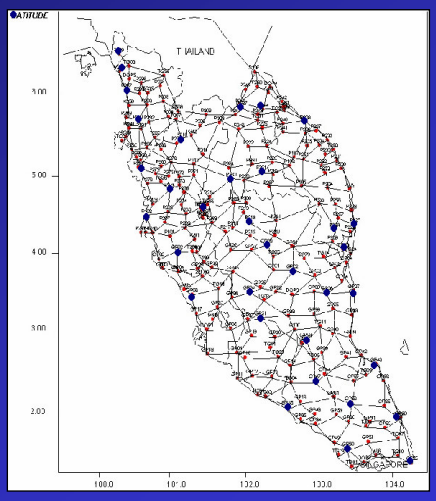
- Homogenous and accurate geodetic datum based on GPS technology



OLD AND NEW GEODETIC INFRASTRUCTURE:

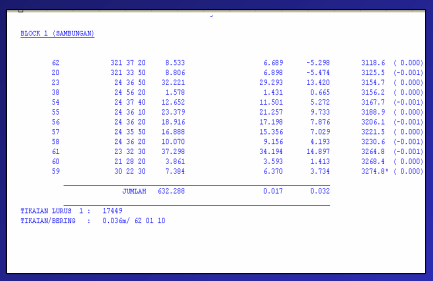


GPS BASED REFERENCE SYSTEM



Problem Statement 3: Non Rigorous Adjustment Technique for Coordinates Computation

Bowditch

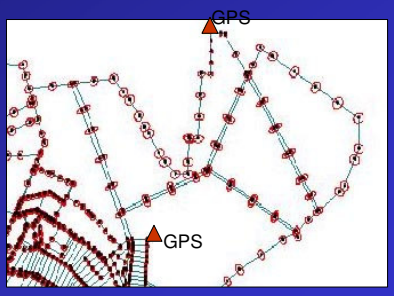


BLOCK 1 (BAMBUNGAN)

62	321 37 20	8.533	6.689	-5.298	3118.6	(0.000)
20	321 33 50	8.806	6.898	-5.474	3125.5	(-0.001)
23	24 36 50	32.221	29.293	13.420	3154.7	(0.000)
38	24 56 20	1.578	1.431	0.665	3156.2	(0.000)
54	24 37 40	12.652	11.501	5.272	3167.7	(+0.001)
55	24 36 10	23.379	21.257	9.733	3180.9	(0.000)
56	24 36 20	18.916	17.198	7.876	3204.1	(+0.001)
57	24 35 50	16.888	15.356	7.029	3221.3	(0.000)
58	24 36 20	10.070	9.156	4.193	3230.6	(-0.001)
61	23 32 30	37.298	34.194	14.897	3264.8	(-0.001)
60	21 28 20	3.861	2.593	1.413	3268.4	(0.000)
59	30 22 30	7.384	6.370	3.734	3274.8*	(0.000)
	JUMLAH	632.288	0.017	0.032		

TIKAIAN LURUS 1 : 17449
TIKAIAN/SEBRING : 0.036m/ 62 01 10

Least Squares

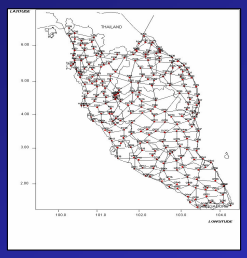


Bowditch adjustment distributes closing errors linearly but not able to provide a unique coordinates solution.

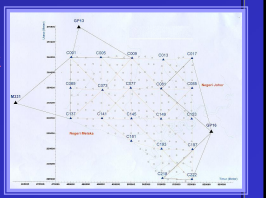
Least Squares adjustment technique determine a unique set of coordinates for each boundary mark from a set of observed values (bearings & distances).

Problem Statement 4: Whole To The Part Concept With The Aid of Current Positioning Technology Is A Reality

Zero Order Geodetic GPS Network (MASS Stations)



First Order Geodetic GPS Network (30km Network)



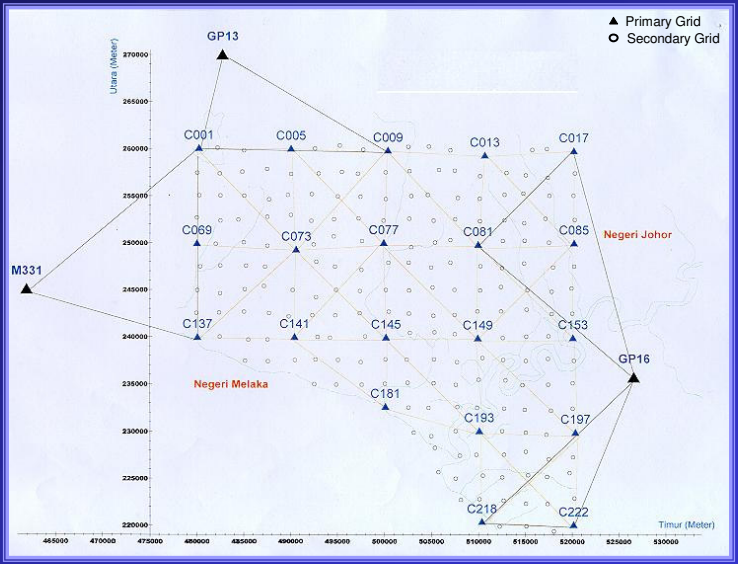
Cadastral Control Infrastructure (CCI) (10km,2.5km,0.5km)

Computation of Geocentric Cassini & RSO Coordinates

CCI Layer in DCDB

DCDB

Solution: CADASTRAL CONTROL INFRASTRUCTURE (CCI) EMPLOYING WHOLE TO THE PART CONCEPT & GPS TECHNOLOGY



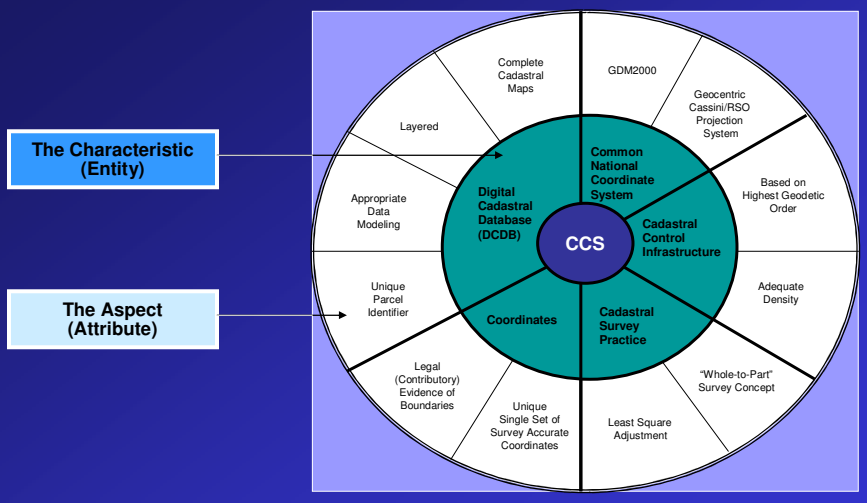
Coordinated Cadastral Survey System: *Rigid Coordinate Revisited*

Wolfgang Effenberg (Phd Thesis, Uni. Of Melbourne, 2001)

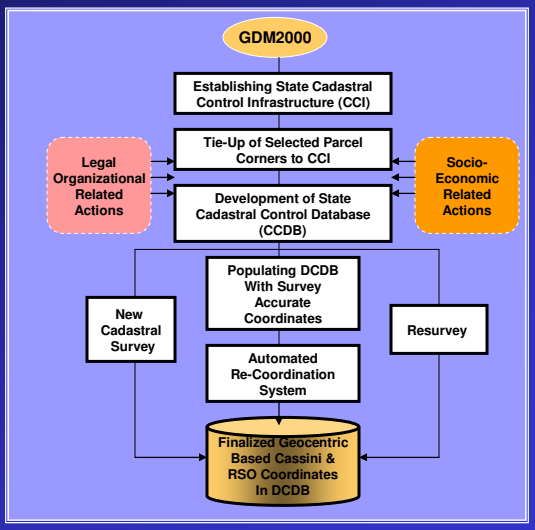
"In the survey accurate cadastral map the coordinates determined by survey are used to define the digital parcel boundaries. This requires a state coordinate system and sufficient density of control, along with the necessity of additional control as large areas are opened for subdivision. This is termed a fully coordinated cadastral survey system and is the most common understanding of coordinated cadastre.

The digital cadastral map update is tied closely to the land subdivision process and the cadastral system ensuring the continued integrity of land registration. The derivation from survey data means that the boundary coordinate accuracy, in urban areas, should be ± 0.03 meters or better, with respect to the nearest survey control; generally the level of accuracy decreases in rural areas."

CCS CONCEPTUAL MODEL FOR PENINSULAR MALAYSIA



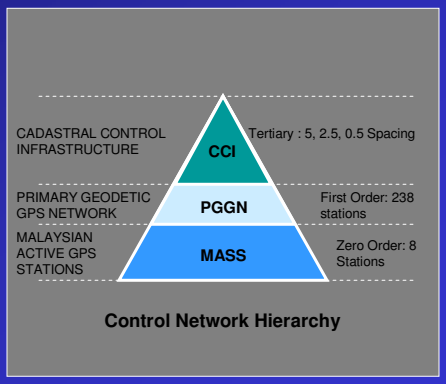
CCS IMPLEMENTATION MODEL



SPECIFICATIONS FOR CCI

Specifications for Cadastral Control Network Densification

AREA	PRIMARY GRID	SECONDARY GRID
URBAN	2.5 km x 2.5 km	**0.5 km X 0.5 km**
SEMI-URBAN	10 km X 10 km	**2.5 km X 2.5 km**
RURAL	10 km X 10 km	2.5 km X 2.5 km
	Connected to PGGN	**Connected to Primary Grid**
	Observation Technique: static Observation Period 1 – 1.5 hr	Observation Technique: Rapid Static. Observation Period: 15 – 30 min
	Baseline Relative Accuracy less then 3ppm Coordinates Diff. From 2 Bases Stn. Less than 2 cm	Baseline Relative Accuracy: Less than 3ppm Coordinate Differences From 2 Bases stn.: Less Than 3cm



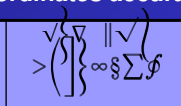
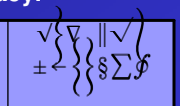
Control Network Hierarchy

ACCURACY STATEMENT FOR CCS

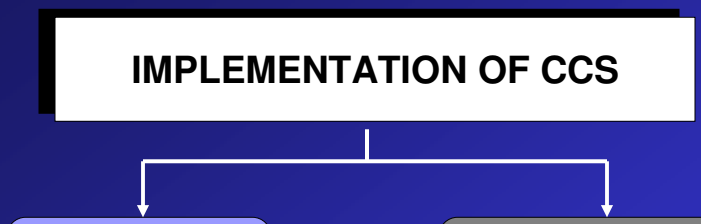
The two major tasks in CCS implementation:

- **REPOPULATING DCDB WITH SURVEY ACCURATE (RIGID) COORDINATES, and**
- **NEW COORDINATED CADASTRAL SURVEY**

MUST satisfy the following boundary coordinates accuracy:

CATEGORY		
Urban/ New Development	< ± 5 cm	< ± 5 cm
Semi Urban/Rural	< ± 10 cm	< ± 10 cm

CCS STUDY FRAMEWORK



TECHNICAL ISSUES

- Development of Geocentric Based Cadastral Control Infrastructure (CCI)
- Development of Survey Accurate National Digital Cadastral Data Base (NDCDB)
- Development of Guidelines for Coordinated Cadastral Survey Practice

INSTITUTIONAL ISSUES

- Organizational
- Legal
- Economic
- Social
- Cost-Benefit Analysis

CCS RESEARCH HISTORIAL BACKGROUND

1.	1996	**INITIAL PILOT STUDY IN STATE OF MELAKA** – test on the use of an adjustment technique and GPS for Cadastral Controls.
2.	1997 to 2000	**FEASIBILITY STUDY ON COORDINATED CADASTRAL SYSTEM FOR PENINSULAR MALAYSIA.** MODULE A: The Adjustment of Large Cadastral Network with reference to RSO Coordinate System MODULE B: On The Use of A Global Geocentric Datum MODULE C: Legal Traceability Issues, Standards and Specifications for GPS Cadastral Surveys.
3.	2000 to 2002	**STUDIES TOWARD THE DEVELOPMENT OF IMPLEMENTATION PLAN OF COORDINATED CADASTRAL SYSTEM FOR PENINSULAR MALAYSIA** MODULE A: Definition & Realization of A Geocentric Datum for Malaysia MODULE B: Methodology for the Development of Digital Coordinated Cadastral Database MODULE C: Techniques for Integrating the Digital Coordinated Cadastral Data with Mapping (CAMS) Data. MODULE D: Institutional Issues: Legal & Organizational Issues.
4.	2004-2005	**A PILOT RESEARCH PROJECT ON THE DEVELOPMENT AND IMPLEMENTATION OF COORDINATED CADASTRAL SYSTEM (CCS) FOR THE STATE OF MELAKA**

OVERVIEW OF MELAKA CCS PILOT PROJECT

PROJECT OBJECTIVES

1. To enhance the methods and techniques of developing Cadastral Control Infrastructure (CCI) and to develop CCI layer In DCDB,
2. To refine the techniques, methods and prototype for the re-population and re-coordination of Digital Cadastral Database,
3. To strengthen the practice of cadastral survey in order to cope with the CCS environment,
4. To perform an assessment of the economic implications of CCS by conducting a Cost-Benefit-Analysis (CBA) study.

MELAKA CCS PILOT PROJECT AREA

AREA DESCRIPTION

Area: 40km X 70km

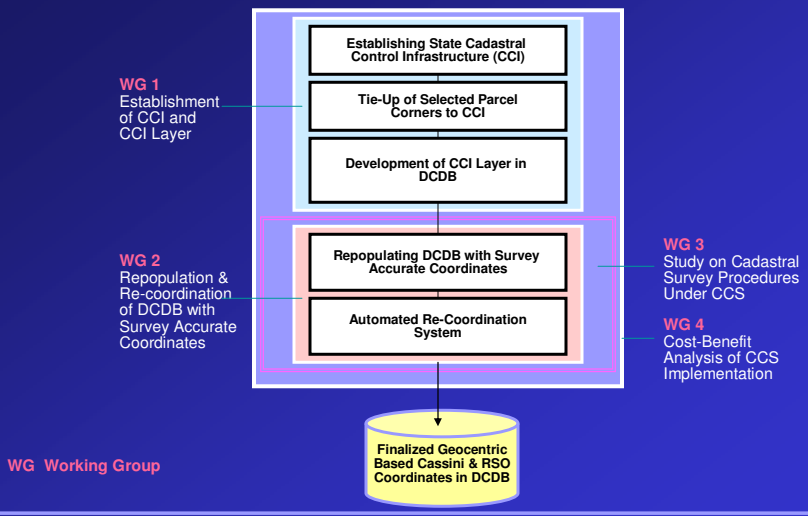
No. of Districts: 3

Total No. of Mukim: 109

Total No. of Lots: 225,112

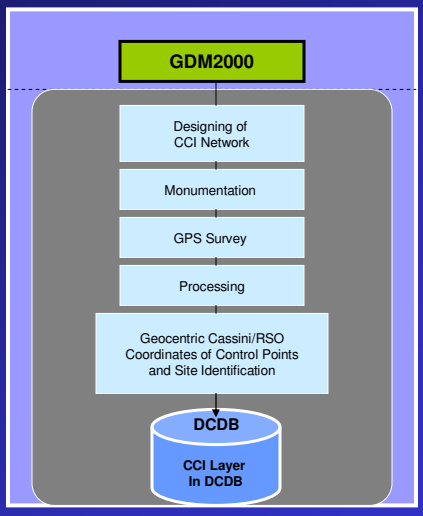
MELAKA CCS PILOT PROJECT

PROJECT METHODOLOGY

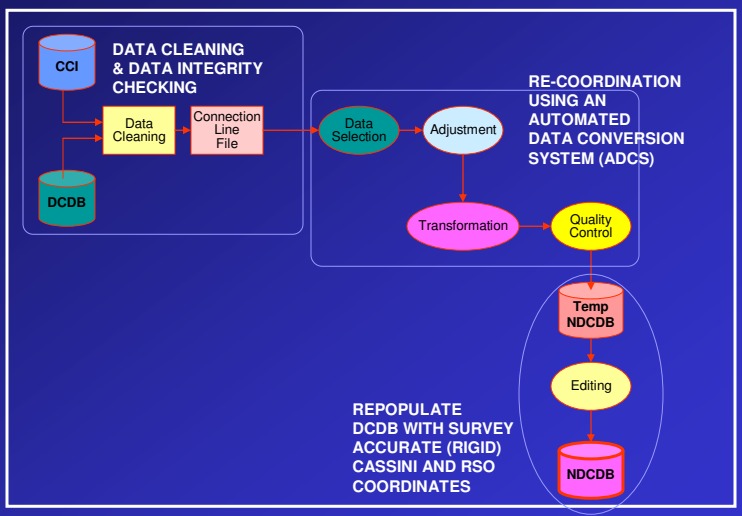


MELAKA CCS PILOT PROJECT

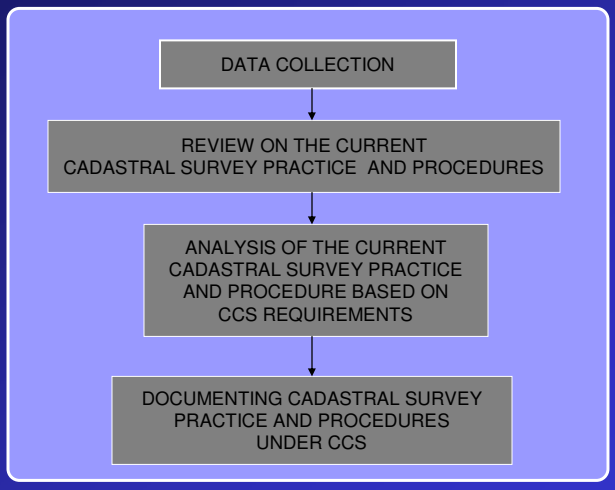
PROJECT ACTIVITIES OF WG 1



PROJECT ACTIVITIES OF WG 2



PROJECT ACTIVITIES OF WG 3

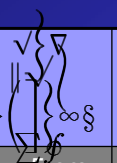
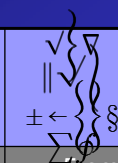


PROJECT ACTIVITIES OF WG 4

	ACTIVITY	TASKS
1.	DETERMINE/DEFINE PROJECT OBJECTIVES	
2.	DOCUMENTING CURRENT PROCESS	Customer Services, System Capabilities, System Architecture, System Costs.
3.	ESTIMATING FUTURE REQUIREMENTS	Determining Life Cycle Time, Estimating Life-Cycle Demands, Other Considerations.
4.	COLLECTING COST DATA	Historical Organization Data, Current System Costs, Market Research, Publications, Analyst Judgment.
5.	DOCUMENTING CBA ASSUMPTIONS	
6.	ESTIMATING COSTS	Activities and Resources, Cost Categories, Personnel Costs, Indirect Costs, Depreciation, Annual Costs.
7.	ESTIMATING BENEFITS	Define Benefits, Identify Benefits, Establishing Measurement Criteria, Classify Benefits, Estimating Tangible benefits, Quantify Intangible Benefits.
8.	EVALUATING ALTERNATIVES	Evaluating with all Ringgit Values, Evaluating with Intangible Benefit, Combination, Flexibility.
9.	PERFORMING SENSITIVITY ANALYSIS	

CADASTRAL SURVEY PRACTICE

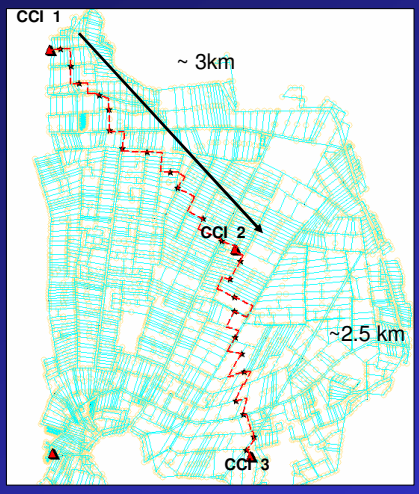
Boundary Coordinate Accuracy Requirements

CATEGORY		
Urban/ New Development	< ± 5 cm	< ± 5 cm
Semi Urban/Rural	< ± 10 cm	< ± 10 cm

Note: The above accuracies compatible with the refixations requirement in the current practice

Cadastral Network Adjustment: Station Coordinates Accuracy

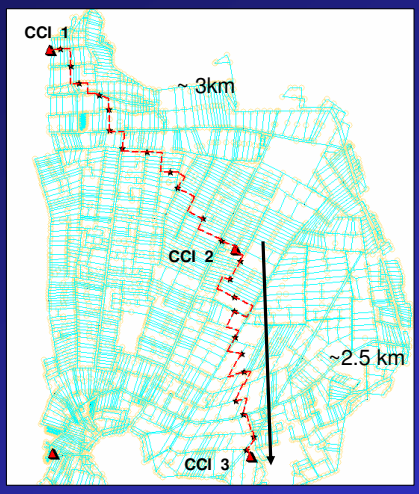
- Error propagation based on adjustment results from Block M27 & M31 in Melaka



Std_ Deviation E (m)	Std_Deviation N (m)
0.022	0.023
0.021	0.022
0.026	0.034
0.030	0.030
0.027	0.029
0.043	0.036
0.034	0.030
0.033	0.030
0.033	0.031
0.033	0.031
0.025	0.026
0.016	0.013

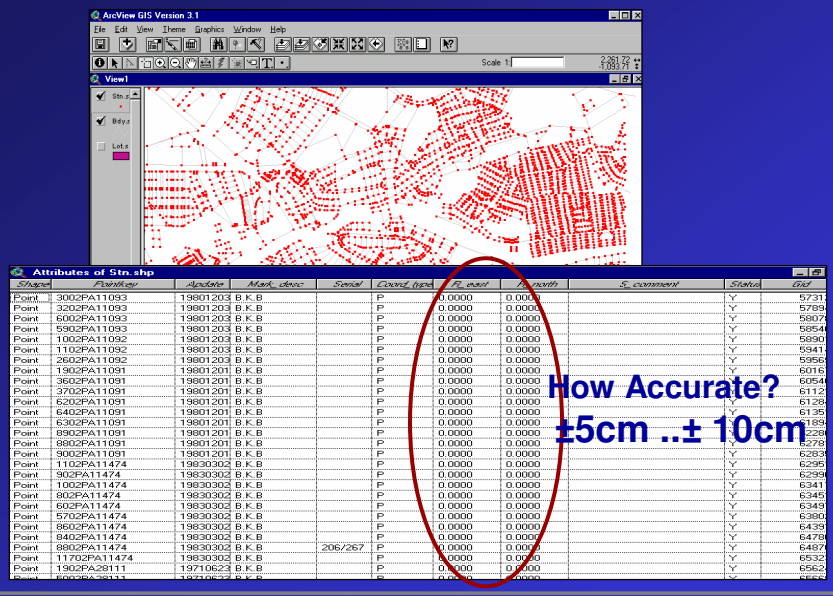
Cadastral Network Adjustment: Station Coordinates Accuracy

- Error propagation based on adjustment results from Block M39 in Melaka



Std_ Deviation E (m)	Std_Deviation N (m)
0.003	0.005
0.017	0.022
0.021	0.027
0.022	0.029
0.022	0.029
0.024	0.029
0.033	0.031
0.029	0.030
0.027	0.031
0.025	0.031
0.027	0.015
0.024	0.015
0.014	0.006

Boundary Mark Layer in DCDB



The Way Forward

In view of the successful implementation of the CCS Pilot Project in Melaka, we anticipate that JUPEM will address on the following issues in order for the CCS to be implemented for the whole of Peninsular Malaysia:

- **Securing the budget for the implementation**
- **Preparation of technical and organizational implementation plan for Peninsular Malaysia**
- **Formation of Implementation Team**
- **Execution of CCS project for Peninsular Malaysia**

Acknowledgements

We gratefully acknowledged the opportunity, trust, and support given by the Y. Bhg. Dato' Ketua Pengarah Ukur dan Pemetaan Malaysia throughout the duration of the study on the implementation of Coordinated Cadastral System for Peninsular Malaysia.

Special thanks go to Tuan Dr. Abdul Kadir Bin Taib, Tuan Muhamed Kamil Bin Mat Daud, Tuan Ahmad Fauzi Bin Nordin and not forgotten the late Mr Chia Wee Tong for all the guidance, encouragement and support given.

The financial support for the study by Board of Licensed Land Surveyors Peninsular Malaysia is gratefully acknowledged.