COORDINATED CADASTRAL SYSTEM FOR PENINSULAR MALAYSIA: FROM CONCEPT TO REALITY

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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 APPROPRIATE 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
CONSEQUENCES: UNCONTROLLED ERROR PROPAGATION IN COORDINATES

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

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

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Boundary Mark Layer in DCDB

How Accurate? cm? m?

ERROR PROPAGATION

Effect of error propagation on coordinates in digital cadastral database

HOW ACCURATE (N,E) AT THIS BOUNDARY POINT IN THE PRESENT DCDB?

N ± 50 cm
E ± 50 cm

2 km
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)*

- Linkage and Searching Mechanism
  - Legal Land Parcels
  - Property and Street Addresses

- Digital Cadastral Data Base (DCDB)

- Computerized Land Registration System
  - Coordination mechanism for state wide geographic information

- Other core spatial data sets
  - National Geodetic Reference Framework

- Legal
  - Lawyers
  - Surveyors
- Property
  - Vendors
  - Purchasers
- Fiscal
- Local Government
- Utilities
- Planning
  - Local Use

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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)

<table>
<thead>
<tr>
<th>LAYER</th>
<th>AGENCY</th>
</tr>
</thead>
<tbody>
<tr>
<td>A - Parcel &amp; Zone</td>
<td>Jabatan, Pejabat Tanah &amp; Jabatan Ukur dan Pemetaan</td>
</tr>
<tr>
<td>B - Zon</td>
<td>Majlis Daerah</td>
</tr>
<tr>
<td>C - Saliran</td>
<td>Jabatan Peril dan Saliran</td>
</tr>
<tr>
<td>D - Kawasan Pays</td>
<td>Jabatan Peril dan Saliran, Perhutanan</td>
</tr>
<tr>
<td>E - Utiliti</td>
<td>Majlis Daerah, Syariah Utiliti</td>
</tr>
<tr>
<td>F - Tanah</td>
<td>Pejabat Tanah dan Galian</td>
</tr>
<tr>
<td>G - Rujukan Geodetic</td>
<td>Jabatan Ukur dan Pemetaan</td>
</tr>
<tr>
<td>H - Tindihan Keseluruh</td>
<td>Kombinasi lapisan-lapisan</td>
</tr>
</tbody>
</table>
Solution: GEOCENTRIC DATUM OF MALAYSIA

Homogenous and accurate geodetic datum based on GPS technology

OLD AND NEW GEODETC INFRASTRUCTURE:

GEODETIC TRIANGULATION
PENINSULAR MALAYSIA

GPS BASED REFERENCE SYSTEM
Least Squares adjustment technique determines a unique set of coordinates for each boundary mark from a set of observed values (bearings & distances).

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

**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)  
Computation of Geocentric Cassini & RSO Coordinates  
Cadastral Control Infrastructure (CCI) (10km, 2.5km, 0.5km)
Coordinated Cadastral Survey System:  
*Rigid Coordinate Revisited*


“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

The Characteristic (Entity)

The Aspect (Attribute)

CCS IMPLEMENTATION MODEL

Legal Organizational Related Actions

Lawful Consequences of Legal Acts

New Cadastral Survey

GDM2000

Establishing State Cadastral Control Infrastructure (CCI)

Tie-Up of Selected Parcel Corners to CCI

Development of State Cadastral Control Database (CCDB)

Populating DCDB With Survey Accurate Coordinates

Automated Re-Coordination System

Finalize geocentric Based Cassini & RSO Coordinates to DCDB

Resurvey

Socio-Economic Related Actions

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SPECIFICATIONS FOR CCI

Specifications for Cadastral Control Network Densification

<table>
<thead>
<tr>
<th>AREA</th>
<th>PRIMARY GRID</th>
<th>SECONDARY GRID</th>
</tr>
</thead>
<tbody>
<tr>
<td>URBAN</td>
<td>2.5 km x 2.5 km</td>
<td>0.5 km X 0.5 km</td>
</tr>
<tr>
<td>SEMI-URBAN</td>
<td>10 km X 10 km</td>
<td>2.5 km X 2.5 km</td>
</tr>
<tr>
<td>RURAL</td>
<td>10 km X 10 km</td>
<td>2.5 km X 2.5 km</td>
</tr>
</tbody>
</table>

Control Network Hierarchy

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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:

<table>
<thead>
<tr>
<th>CATEGORY</th>
<th>Easting Std Dev</th>
<th>Northing Std Dev</th>
</tr>
</thead>
<tbody>
<tr>
<td>Urban/ New Development</td>
<td>&lt; ± 5 cm</td>
<td>&lt; ± 5 cm</td>
</tr>
<tr>
<td>Semi Urban/Rural</td>
<td>&lt; ± 10 cm</td>
<td>&lt; ± 10 cm</td>
</tr>
</tbody>
</table>

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CCS STUDY FRAMEWORK

IMPLEMENTATION OF CCS

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 HISTORICAL 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 RSCO 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
PROJECT METHODOLOGY

MELAKA CCS PILOT PROJECT

Establishing State Cadastral Control Infrastructure (CCI)

Tie-Up of Selected Parcel Corners to CCI

Development of CCI Layer in DCDB

Repopulating DCDB with Survey Accurate Coordinates

Automated Re-Coordination System

Finalized Geocentric Based Cassini & RSO Coordinates in DCDB

WG 1 Establishment of CCI and CCI Layer

WG 2 Repopulation & Re-coordination of DCDB with Survey Accurate Coordinates

WG 3 Study on Cadastral Survey Procedures Under CCS

WG 4 Cost-Benefit Analysis of CCS Implementation

PROJECT ACTIVITIES OF WG 1

MELAKA CCS PILOT PROJECT

GDM2000

Designing of CCI Network

Monumentation

GPS Survey

Processing

Geocentric Cassini/RSO Coordinates of Control Points and Site Identification

DCDB

CCI Layer in DCDB
**PROJECT ACTIVITIES OF WG 2**

**DATA CLEANING & DATA INTEGRITY CHECKING**
- Data Cleaning
- Connection Line File

**RE-COORDINATION USING AN AUTOMATED DATA CONVERSION SYSTEM (ADCS)**
- Quality Control
- Transformation
- Adjustment
- Data Selection

**NDCDB**

**REPOPULATE DCDB WITH SURVEY ACCURATE (RIGID) CASSINI AND RSO COORDINATES**

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**PROJECT ACTIVITIES OF WG 3**

**DATA COLLECTION**

**REVIEW ON THE CURRENT CADAstral SURVEY PRACTICE AND PROCEDURES**

**ANALYSIS OF THE CURRENT CADAstral SURVEY PRACTICE AND PROCEDURE BASED ON CCS REQUIREMENTS**

**DOCUMENTING CADAstral SURVEY PRACTICE AND PROCEDURES UNDER CCS**

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PROJECT ACTIVITIES OF WG 4

<table>
<thead>
<tr>
<th>ACTIVITY</th>
<th>TASKS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. DETERMINE/DEFINE PROJECT OBJECTIVES</td>
<td>Customer Services, System Capabilities, System Architecture, System Costs.</td>
</tr>
<tr>
<td>2. DOCUMENTING CURRENT PROCESS</td>
<td>Customer Services, System Capabilities, System Architecture, System Costs.</td>
</tr>
<tr>
<td>5. DOCUMENTING CBA ASSUMPTIONS</td>
<td>Activities and Resources, Cost Categories, Personnel Costs, Indirect Costs, Depreciation, Annual Costs.</td>
</tr>
<tr>
<td>7. ESTIMATING BENEFITS</td>
<td>Evaluating with all Ringgit Values, Evaluating with Intangible Benefit, Combination, Flexibility.</td>
</tr>
<tr>
<td>8. EVALUATING ALTERNATIVES</td>
<td>Concluding, Evaluating with Intangible Benefit, Combination, Flexibility.</td>
</tr>
<tr>
<td>9. PERFORMING SENSITIVITY ANALYSIS</td>
<td>Concluding, Evaluating with Intangible Benefit, Combination, Flexibility.</td>
</tr>
</tbody>
</table>

CADASTRAL SURVEY PRACTICE

Boundary Coordinate Accuracy Requirements

<table>
<thead>
<tr>
<th>CATEGORY</th>
<th>Easti £std Devi £std</th>
<th>Northi £std Devi £std</th>
</tr>
</thead>
<tbody>
<tr>
<td>Urban/New Development</td>
<td>$\pm 5$ cm</td>
<td>$\pm 5$ cm</td>
</tr>
<tr>
<td>Semi Urban/Rural</td>
<td>$\pm 10$ cm</td>
<td>$\pm 10$ cm</td>
</tr>
</tbody>
</table>

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

![Diagram of Cadastral Network Adjustment]

<table>
<thead>
<tr>
<th>Std._Deviation</th>
<th>Std._Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>E (m)</td>
<td>N (m)</td>
</tr>
<tr>
<td>0.022</td>
<td>0.023</td>
</tr>
<tr>
<td>0.021</td>
<td>0.022</td>
</tr>
<tr>
<td>0.026</td>
<td>0.034</td>
</tr>
<tr>
<td>0.030</td>
<td>0.030</td>
</tr>
<tr>
<td>0.027</td>
<td>0.029</td>
</tr>
<tr>
<td>0.043</td>
<td>0.036</td>
</tr>
<tr>
<td>0.034</td>
<td>0.030</td>
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<tr>
<td>0.033</td>
<td>0.030</td>
</tr>
<tr>
<td>0.033</td>
<td>0.031</td>
</tr>
<tr>
<td>0.033</td>
<td>0.031</td>
</tr>
<tr>
<td>0.025</td>
<td>0.026</td>
</tr>
<tr>
<td>0.016</td>
<td>0.013</td>
</tr>
</tbody>
</table>

Cadastral Network Adjustment: Station Coordinates Accuracy

Error propagation based on adjustment results from Block M39 in Melaka

![Diagram of Cadastral Network Adjustment]

<table>
<thead>
<tr>
<th>Std._Deviation</th>
<th>Std._Deviation</th>
</tr>
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<tbody>
<tr>
<td>E (m)</td>
<td>N (m)</td>
</tr>
<tr>
<td>0.003</td>
<td>0.005</td>
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<tr>
<td>0.017</td>
<td>0.022</td>
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<td>0.033</td>
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<td>0.027</td>
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<tr>
<td>0.025</td>
<td>0.031</td>
</tr>
<tr>
<td>0.027</td>
<td>0.015</td>
</tr>
<tr>
<td>0.024</td>
<td>0.015</td>
</tr>
<tr>
<td>0.014</td>
<td>0.006</td>
</tr>
</tbody>
</table>
Boundary Mark Layer in DCDB

How Accurate?

±5 cm ..± 10 cm

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.