Development of Geodetic GPS Infrastructure and Its Applications: The Malaysia Experience

BY

Abd Majid.A.Kadir, Shahrum Ses, Kamaluddin Omar & Abdullah Hisam Omar
Fac. of Geoinformation Science and Eng. Universiti Teknologi Malaysia

Kadir Taib, Teng Chee Hua, Azhari Mohamed, Chang Leng Hua & Soeb Nordin
Dept. of Surveying & Mapping Malaysia, Kuala Lumpur

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Summary of Presentation:

1. Introduction
2. Classical Geodetic Infrastructure
3. Modern Geodetic Infrastructure
4. Development of Geocentric Datum for Malaysia GDM 2000
5. Applications
6. Future Directions
7. Conclusion

South East Asia

Introduction

South East Asia region consists of ten (10) countries:

1) Malaysia
2) Singapore
3) Indonesia
4) Philippines
5) Brunei
6) Cambodia
7) Vietnam
8) Thailand
9) Laos
10) Burma/Myanmar

South East Asia Region

Malaysia

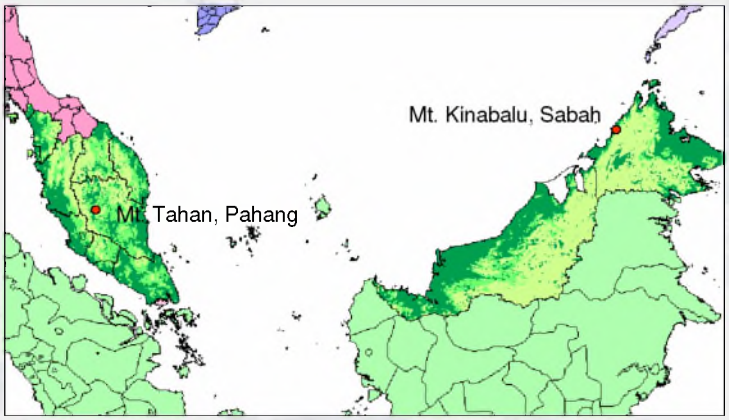
Introduction

People
Nationality: Malaysian.
Population (2000): 23.3 million.

Geography
Area: 329,749 sq. km
Terrain: Coastal plains and interior, jungle-covered mountains
Climate: Tropical.
The South China Sea separates Peninsular Malaysia from East Malaysia on Borneo (640 km.).

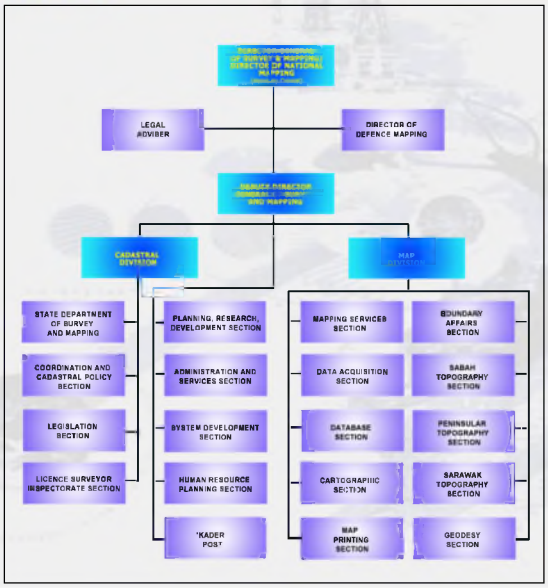
Government
Independence: August 31, 1957
Subdivisions: 13 states and three federal territories (Kuala Lumpur, Labuan Island, Putrajaya federal administrative territory)

Malaysia: Topographic Visualization



Highest Point in Peninsular Malaysia: Mt. Tahan (2,187 m)
Highest Point in East Malaysia : Mt. Kinabalu (4,101 m)

Department of Surveying and Mapping Malaysia (DSMM): Profile



The Past in Brief

1885:
The history of the Department of Survey and Mapping Malaysia (DSMM) began with the establishment of the Johor Survey Department and the Perak Trigonometrical Survey Department.

1909:
The formation of the Malay States Survey Department (Federated Malay States).

1946:
All state Survey Departments were unified under one single administration headed by the Surveyor-General.

1982:
The integration of JUPEM under the Ministry of Land and Regional Development (Ministry of Land and Cooperative Development).

Present:
Modern Data Provider

The Department Role

MISSION

To provide efficient and high quality survey and mapping services and a geographical information dissemination system suitable for national requirements

National Defence

Production of digital maps for use by the military

Geographic Information Systems

A major spatial data provider

Public Services

To provide efficient and high quality service to all

National Sovereignty

Determination of international land and maritime boundaries

National Development

To provide geodetic data for infrastructure development

Data Collection

Ensuring highest level of accuracy in mapping information

Classical Geodetic Infrastructure

Triangulation Network of Peninsular Malaysia

Malaysia Revised Triangulation (MRT)

- MRT has been used for geodetic, mapping, cadastral and several other activities since 1948 in Peninsular Malaysia
- MRT network consists of 77 geodetic, 240 primary, 837 secondary and 51 tertiary stations.

No.	Parameter	MRT
1	Reference Ellipsoid	Modified Everest
2	Origin	Kertau, Pahang
3	Semi-major axis (a)	6,377,304.063
5	Flattening (f)	1/300.8017

Classical Geodetic Infrastructure

Triangulation Network of East Malaysia

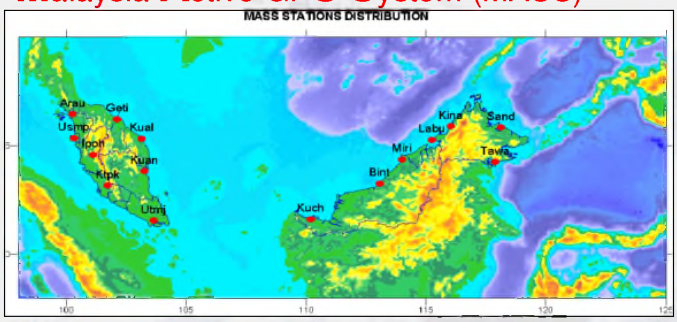
Borneo Triangulation (BT68)

- Timbalai Datum - Separate Network from Pen.Malaysia.
- Still used for geodetic, mapping and surveying

No.	Parameter	BT68
1	Reference Ellipsoid	Everest
2	Origin	Timbalai,Sarawak
3	Semi-major axis (a)	6,377,298.565
5	Flattening (f)	1/300.8017

Modern Geodetic Infrastructure

Malaysia Active GPS System (MASS)



- Malaysia Active GPS System consistent of 15 permanent GPS stations, which track GPS satellites at an attitude of 20,000 km away in space and allow users in Malaysia to have 24 hour access of GPS data.
- These stations are strategically located throughout the country .

Objectives

- To enable DSMM to carry out surveying and mapping functions more effectively.
- To maintain the National Reference Frame System at centimetre accuracy.
- To monitor and provide the user community with a coordinate system that is connected to the national and global reference frame.

Peninsular Malaysia Primary Geodetic GPS Network (PMPGN)

- Established in 1994 and provide a consistent set of coordinates in the WGS84 datum (PMPGN95).
- The network consists of 238 GPS stations with an average spacing of about 30km.
- Strengthening and readjustment of PMPGN95 to ITRF2000@0.00 : PMPGN2000
- The horizontal accuracy of the PMPGN2000 are 1-2 part per million (ppm) and 3 to 5 ppm for vertical component

Existing PMPGN95

East Malaysia Primary Geodetic GPS Network (EMPGN)

- Established in 1997 and provide a consistent set of coordinates in the WGS84 datum (EMPGN97).
- The network consists of 171 GPS stations with an average spacing of about 30km.
- Strengthening and readjustment of EMPGN97 to ITRF2000@0.00 : EMPGN2000
- The horizontal accuracy of the EMPGN2000 are 1-2 part per million (ppm) and 3 to 5 ppm for vertical component

Existing EMPGN97

Development of Geocentric Datum for Malaysia GDM2000

Problems With Classical Datum

- Historically, Malaysian geodetic datums has been established since 19th century using conventional surveying techniques and procedures
- Confined to small areas of the globe, fit to limited areas and to satisfy national mapping requirements.
- Local datums are not aligned with global geocentric coordinates frames.
- Existing datum not compatible with the wide spread use of satellite positioning systems and international recommendation.
- Two separate geodetic datums (Peninsular Malaysia and East Malaysia)

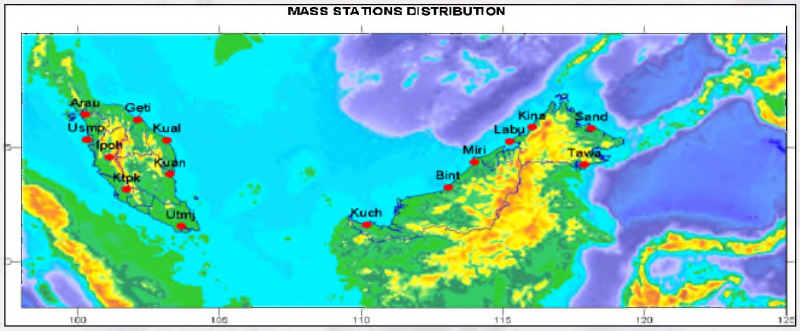
Realisation of GDM2000

Implementation of Geocentric Datum

- GPS Data Collection (MASS stations, 1999-2002)
- The data processing and adjustment of the MASS network
- Computation of the new geocentric datum coordinates at specific epoch.
- Determination of velocity model
- Strengthening and readjustment of Peninsular Malaysia Geodetic GPS Network (PMPGN95) and East Malaysia GPS Geodetic Network (EMPGN97)
- Transformation parameter computation.

GDM 2000

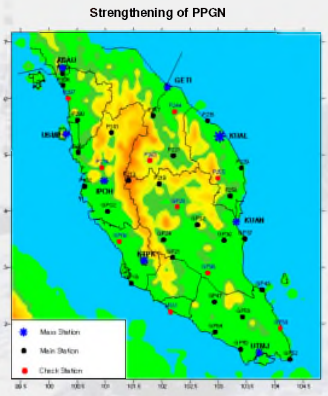
Processing and Adjustment of MASS Network (1999-2002)



- ❑ Internal Accuracy:
  - 1.7 –2.0 mm horizontal
  - 4.4 mm height
- ❑ Final Adjustment accuracy:
  - 3-16 mm horizontal
  - 8-13 mm height
- ❑ Final Coordinates: ITRF2000@0.00

GDM 2000

Strengthening and Readjustment of PMGSN and EMGSN



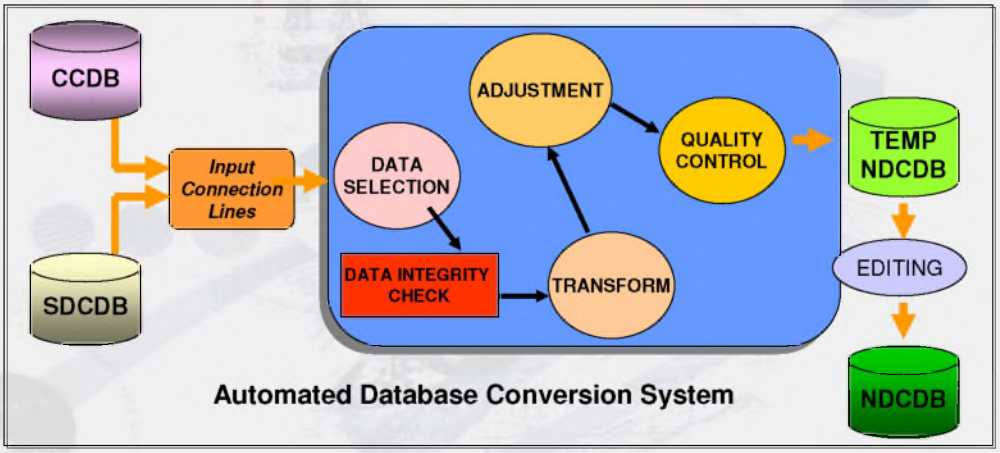
- ❑ To provide control in GDM datum
- ❑ GPS campaign: Oct-Nov 2000
- ❑ 36 stations observed
- ❑ Connecting to MASS network
- ❑ New PMPGN and EMPGN with ITRF2000 control coordinates

Transformation Parameter : PMPGN95 – GDN2000

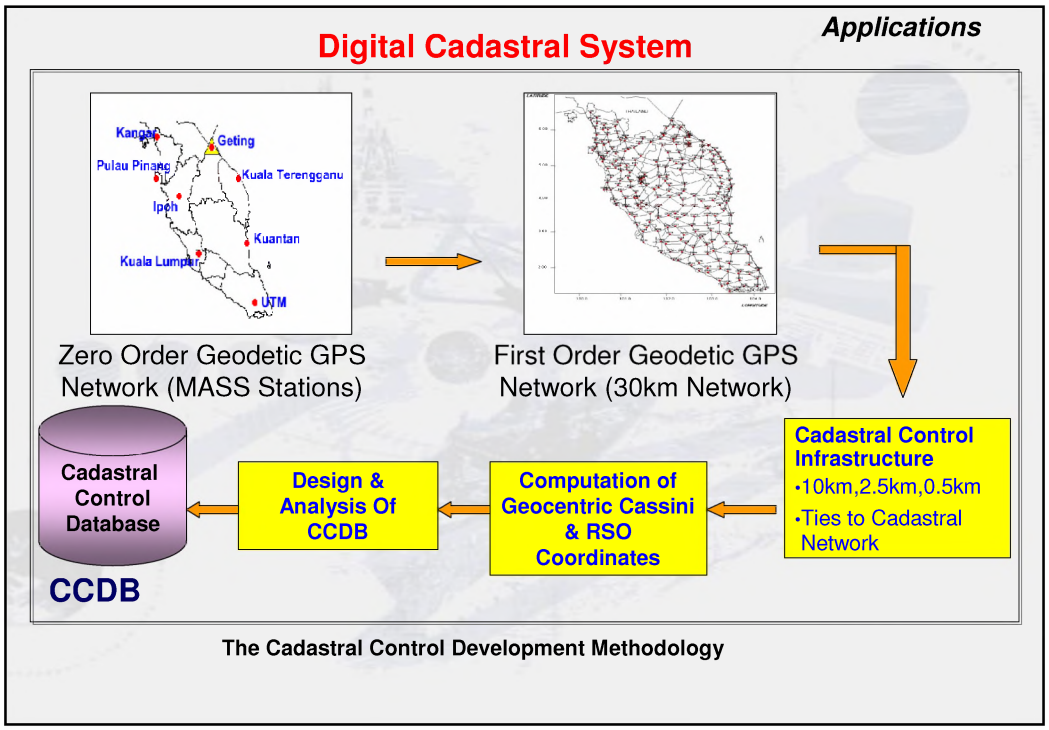
COMPONENT	PARAMETER	STD. DEV
DX	1.626737	0.3207
DY	-1.936201	0.2404
DZ	2.129729	0.2878
RX	0.036955 arc sec	8.3×10^{-9}
RY	-0.027860 arc sec	1.3×10^{-8}
RZ	-0.004068 arc sec	8.4×10^{-9}
SCALE	0.246403 ppm	1.6×10^{-8}

Applications

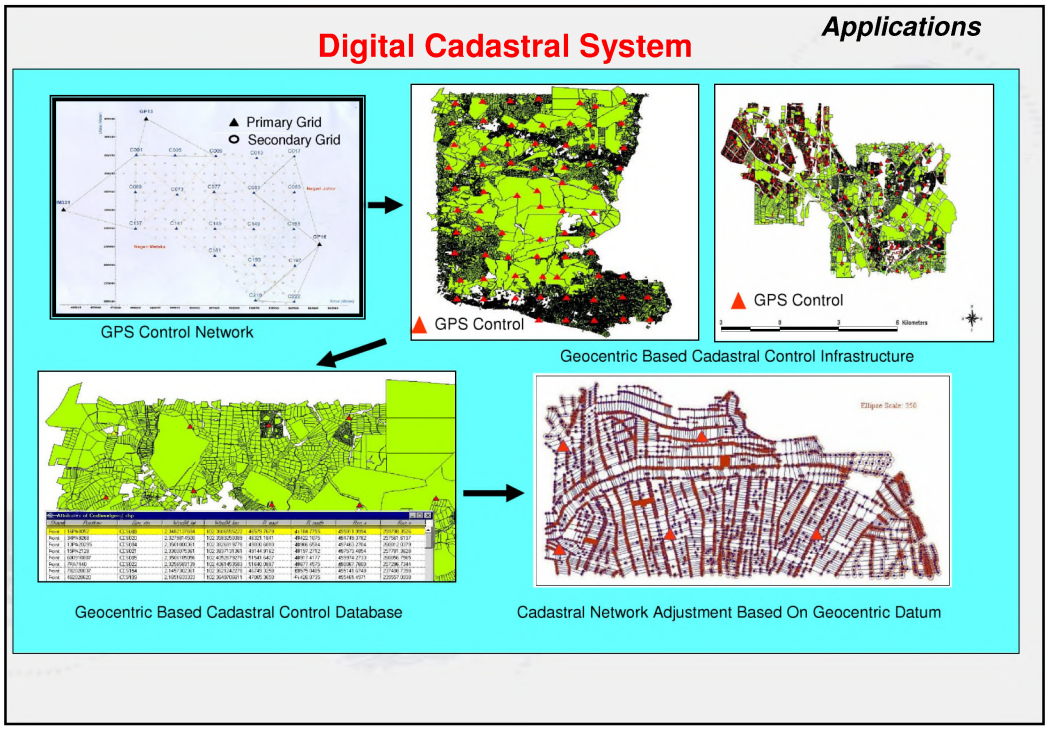
Digital Cadastral System



CCDB : Geocentric Based Cadastral Control Database
SDCDB: State Digital Cadastral Database
NDCDB : National Digital Cadastral Database (Geocentric)

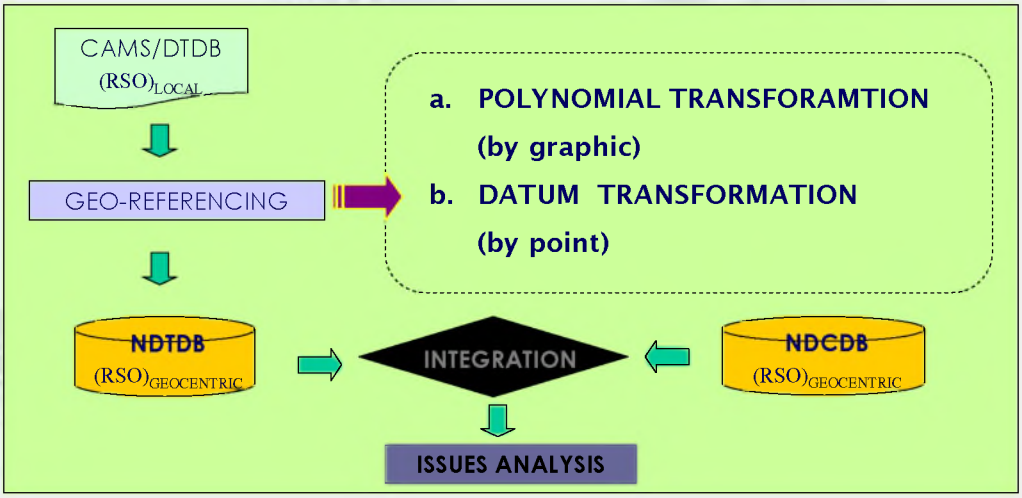


The Cadastral Control Development Methodology



Mapping: Georeferencing Topographic Data to Geocentric Datum

Methodology of Georeferencing



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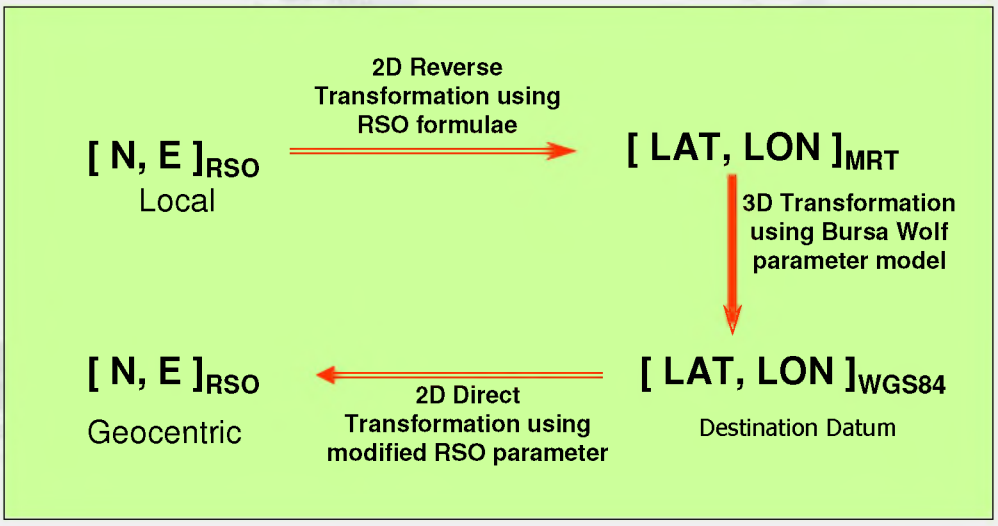
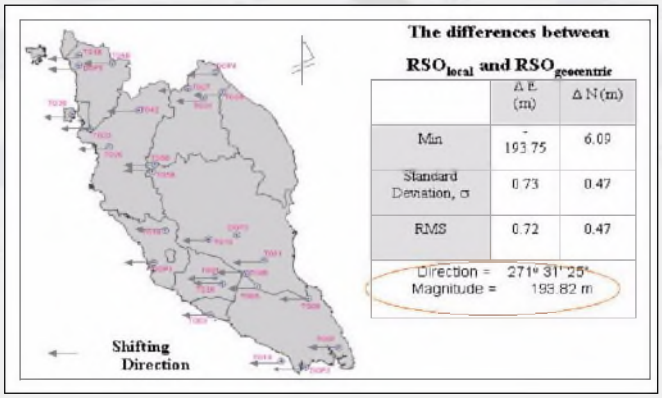


Datum Transformation Procedure

Mapping: Georeferencing Topographic Data to Geocentric Datum

- ❑ Coordinates change of approx. 200 m
- ❑ Simple transformation process for mapping product but need dense GPS network for a higher accuracy fit.
- ❑ Change in coordinates of map features
  - 1: 50,000 --- 4 mm on the map
  - 1:10,000 --- 20 mm on the map
- ❑ Future mapping product will be base on GDM 2000



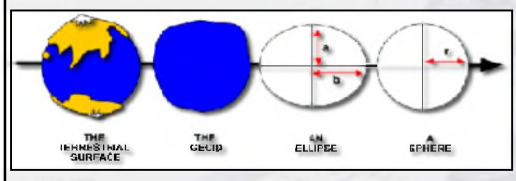
The differences between RSO_{local} and $RSO_{geocentric}$

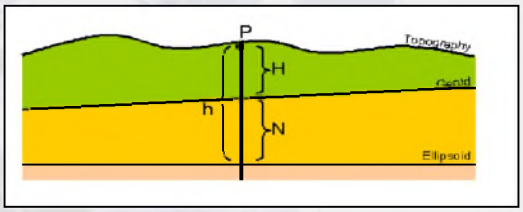
	ΔE (m)	ΔN (m)
Min	-193.75	6.09
Standard Deviation, σ	0.73	0.47
RMS	0.72	0.47

Direction = 271° 31' 25"
Magnitude = 195.82 m

GPS Levelling

GPS Levelling Concept





MSL height was derived from the ellipsoidal heights using the following formula:

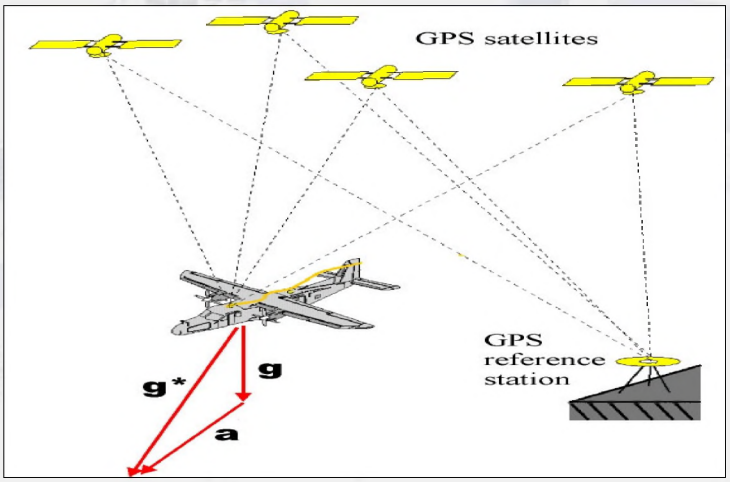
$$H = h - N$$

Where

H = Orthometric / MSL height derived from GPS/EGM96
h = Ellipsoidal (GPS) height
N = Geoid height (based on EGM96 Geoid Model)

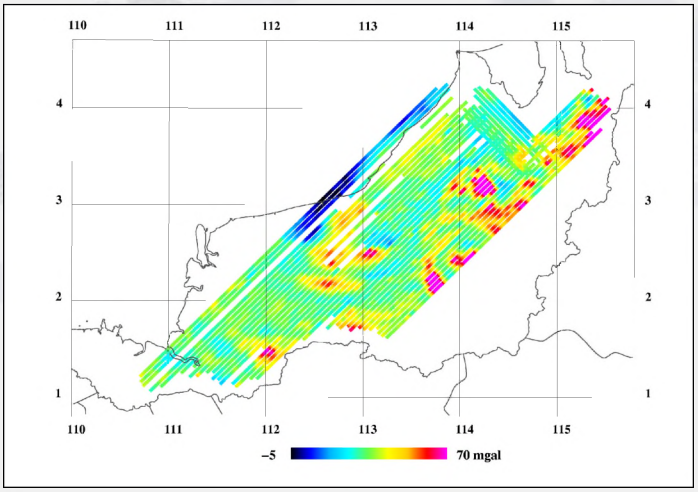
GPS Levelling

Principle of Airborne Gravimetry System



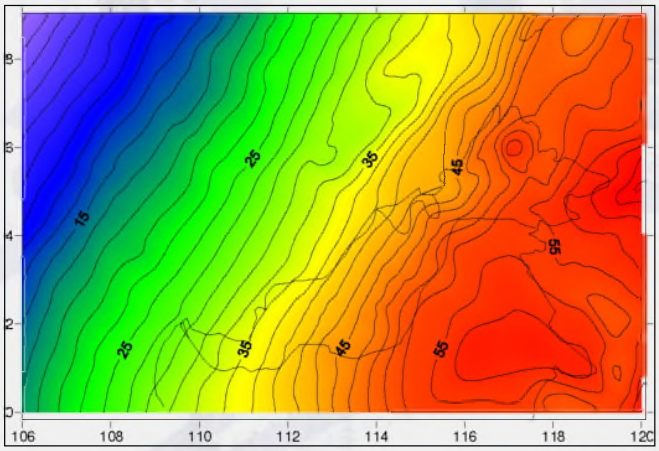
GPS Levelling

Airborne Gravimetry Flight Paths

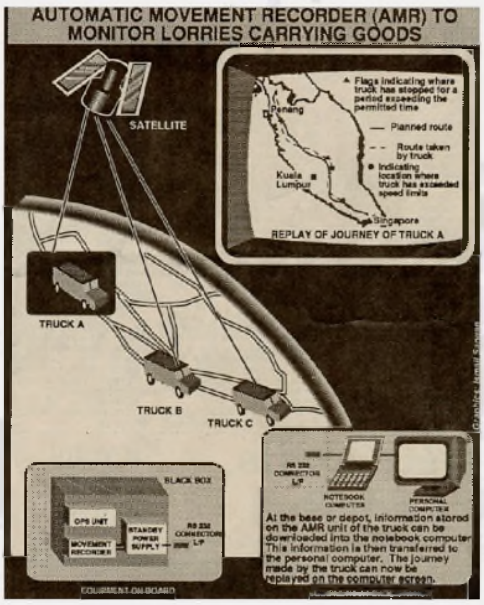


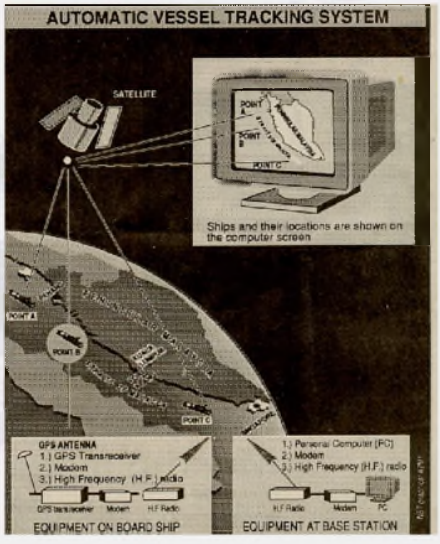
GPS Levelling

Geoid of Sarawak and Sabah from downward continued gravity.



Fleet Navigation



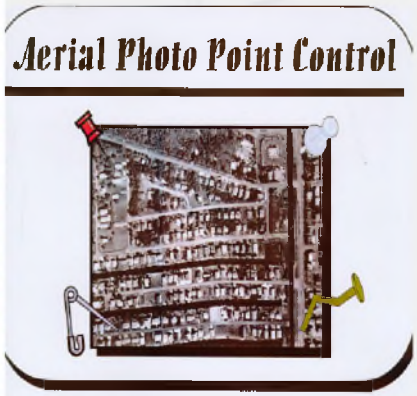


Applications

Hydrographic Surveying

Applications

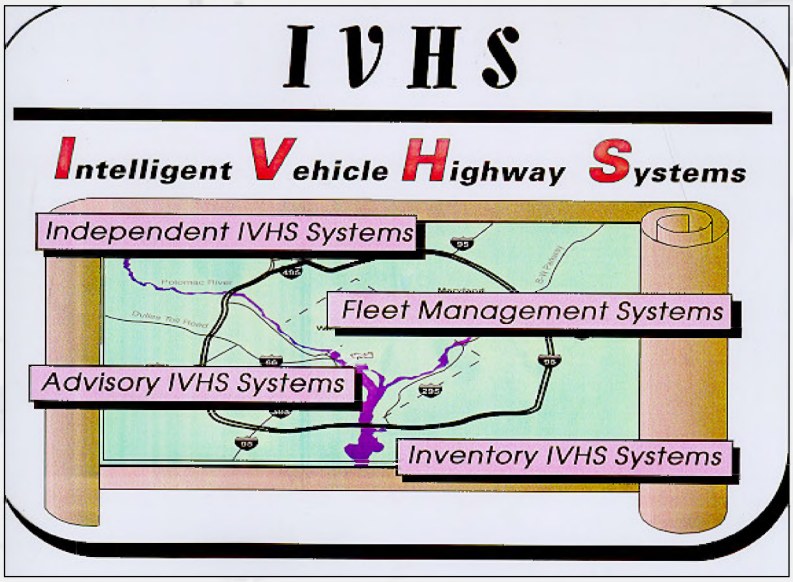
Airborne Photography



Kuala Lumpur Base Map

Applications

Intelligent Transportation System



Applications

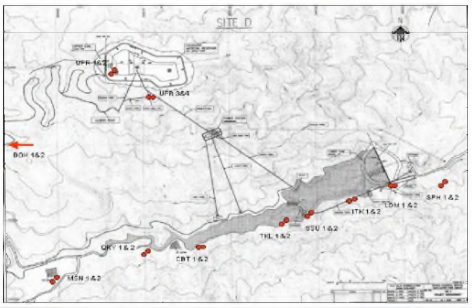
Petroleum Company

PETRONAS

Applications

Electric Power Supply Company

TENAGA NASIONAL BERHAD (200888-W)



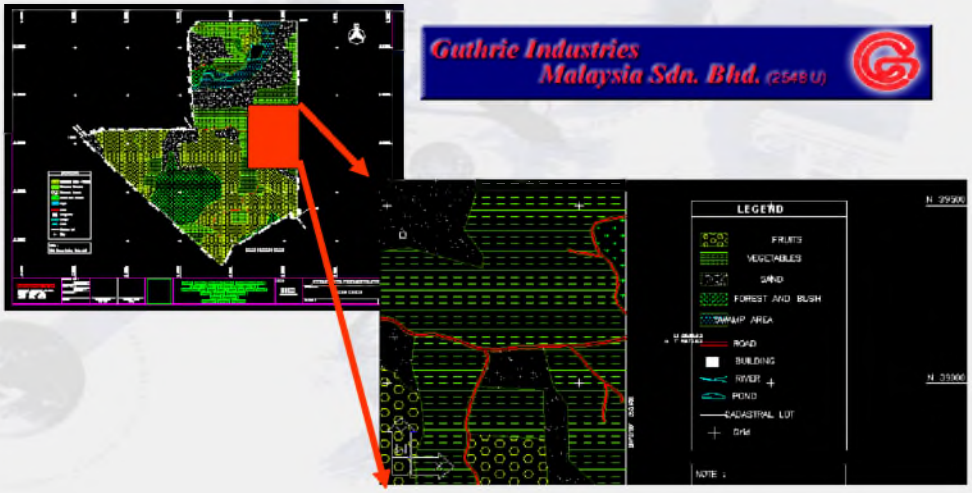
Control Station For Hydroelectric Dam

Hydroelectric Dam

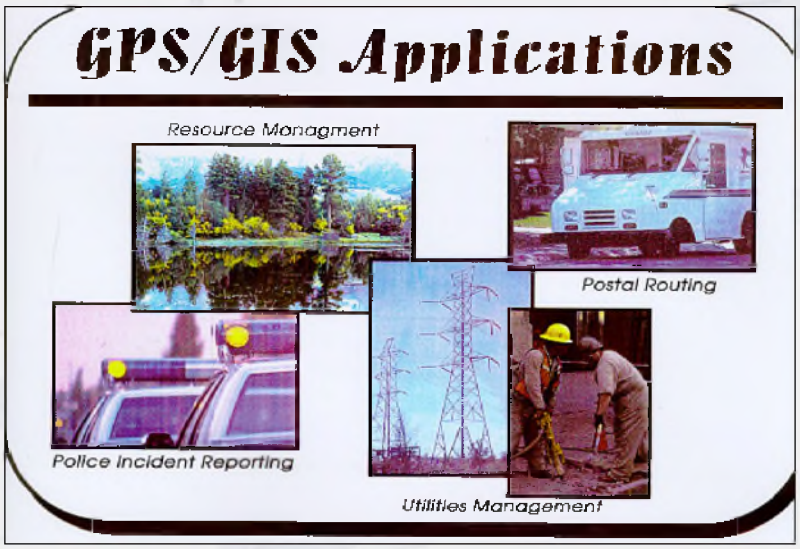
Applications

Telecommunication Company

Precision Farming



Mapping: GIS Applications



Future Directions

- Development of GPS RTK Network for Sabah & Sarawak (SSRTK Net) – 2004/2005
  - •Sparse network: 18 stations covering the whole Sabah & Sarawak
  - • Two denser : covering Kuching and Kota Kota Kinabalu
- Development of GPS RTK Network for Peninsular Malaysia (PMRTK Net) – 2003/2004
  - • Sparse network: 20 stations covering the whole Peninsular Malaysia
  - •Two denser : covering Kuala Lumpur and Penang