FIG WORKING WEEK
Marrakech WW2011

GNSS HEIGHTING AND ITS POTENTIAL USE IN MALAYSIA

Hasan Jamil

DEPARTMENT OF SURVEY AND MAPPING MALAYSIA

PRESENTATION OUTLINE

- Introduction
- Vertical datum and Levelling Background
- GNSS Heighting
- Case Studies
- Conclusion


BRIEF: Malaysia - Morocco
United Kingdom
Ireland
Denmark
Polska
Poland
Беларусь
Belarus
Deutschland
Germany
Україна
Ukraine
Österreich
Austria
Bay of Biscay
France
România
Romania
Italia
Italy
España
Spain
Portugal
Ελλάς
Greece
Türkiye
Turkey
Mediterranean Sea
Tunisia
Syria
Iraq
Iran
Kazakhstan
Mongolia
Uzbekistan
Kyrgyzstan
Turkmenistan
Afghanistan
Pakistan
China
Nepal
India
Morocco
Western Sahara
Algeria
Libya
مصر
Egypt
Saudi Arabia
Oman
Arabian Sea
Myanmar (Burma)
Thailand
South China Sea
Vietnam
Philippines
Bay of Bengal
Laccadive Sea
Malaysia
Indonesia
Java Sea
Mauritania
Mali
Niger
Chad
Sudan
Yemen
Gulf of Aden
Burkina Faso
Guinea
Ghana
Nigeria
Ethiopia
Gulf of Guinea
Somalia
Gabon
Kenya
DR Congo
Tanzania
Angola
Zambia
Mozambique
Namibia
Zimbabwe
Botswana
Madagascar
Indian Ocean
South Atlantic Ocean
South Africa
WA


MAP OF MALAYSIA
Thailand
Vietnam
Cambodia
Andaman Sea
Philippines
Spratly Islands
Gulf of Thailand
Sulu Sea
Brunei
Malaysia
Celebes Sea
Malaysia
Singapore
Indonesia
Java Sea

MALAYSIA

- Location: South East Asia
- Land Area: 329,758 square km
- Maritime Area: 603,210 square km
- Population: 28 million
- Climate: Tropical, temperature from 23 ^{o}C - 32 ^{o}C

BACKGROUND

- Horizontal and vertical control in Malaysia falls under Department of Survey and Mapping

VERTICAL DATUM AND LEVELLING IN MALAYSIA

- 1908 : Earliest Vertical Datum at Port Klang
- 1912 : First National Vertical Datum (LSD)
- 1912 : First line levelled from Port Klang to Kuala Lumpur
- 1967 : First Order Levelling Network (FOLN67)

VERTICAL DATUM AND LEVELLING IN MALAYSIA

- 1984-1993 : Peninsular Malaysia Geodetic Vertical Datum (10-year tidal observation)
- 1985-1999 : Precise Levelling Network
- 2000 onwards : Upgrading of Precise Levelling Network

PRECISE LEVELLING NETWORK

Extent of Precise Levelling Network in Peninsular Malaysia

PRECISE LEVELLING NETWORK (contd.)

Methods Of Survey

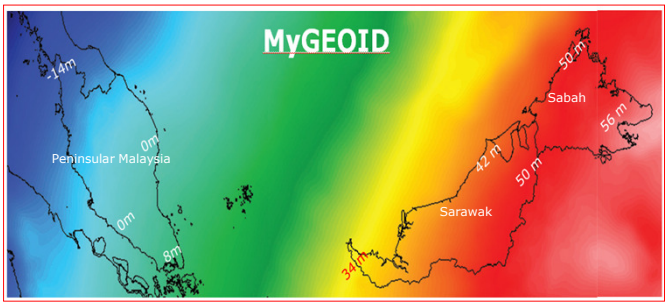
Conventional **Motorised** **Digital (bar coded)**

PRECISE LEVELLING NETWORK
(contd.)

- Uses spirit levelling in determination of orthometric height
- Simple and effective but slow

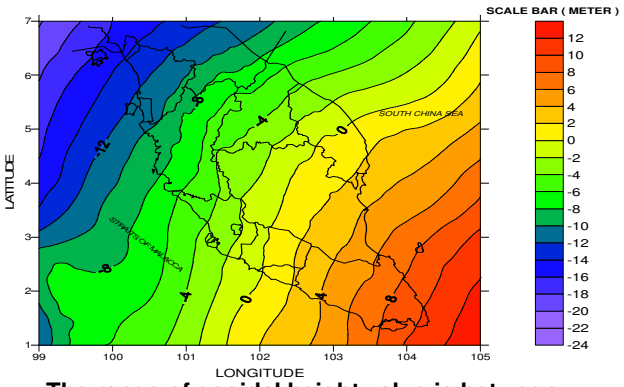
MALAYSIA GEOID MODEL

Malaysia has established its geoid model which is known as MyGEOID in 2004 and 2005



Peninsular Malaysia : WMGEOID04
Sarawak and Sabah : EMGEOID05

PENINSULAR MALAYSIA : WMGEOID04

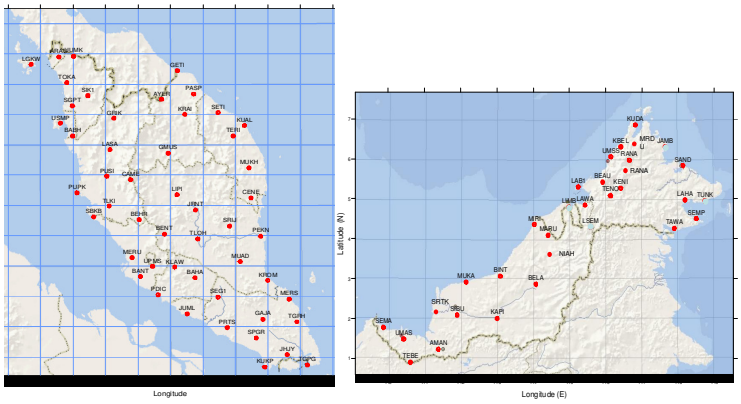


The range of geoidal height value is between -16 m (northern area) to 10 m (southern area)

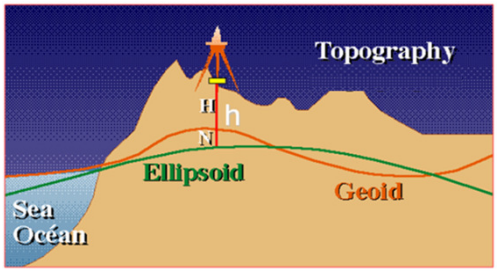
MyRTKnet

Malaysia has established Malaysia Real-time Kinematic GNSS Network (MyRTKnet) in 2006 - 2009

Peninsular Malaysia - 50 stations
Sabah and Sarawak - 28 stations



GNSS HEIGHTING



Relationship between orthometric height, geoid and ellipsoid

$$H = h - N$$

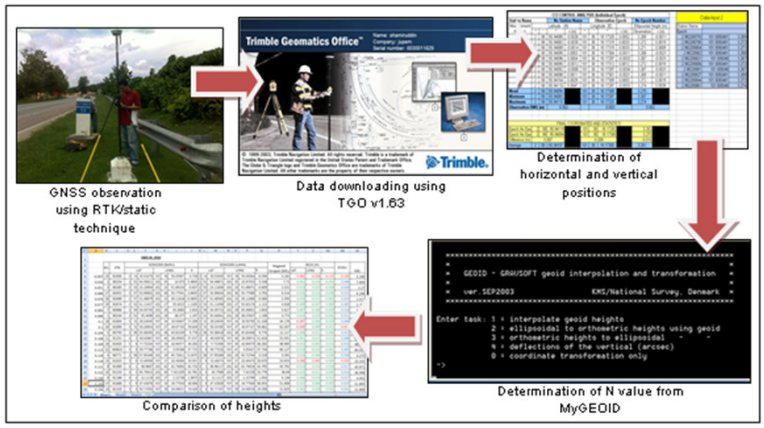
where:

H = Height above geoid (GPS derived orthometric height)

h = Height above ellipsoid (GPS height)

N = geoid-ellipsoid separation, geoid height from gravimetric geoid model (geoidal height)

FLOWCHART OF GNSS HEIGHTING



GNSS-DERIVED ORTHOMETRIC HEIGHT - Recommended Guidelines

Field Procedure		
No.	**Items**	**Parameter**
1.	Observation Technique	Static positioning
2.	GNSS Control	At least 3 stations
3.	Observation Sessions	At least 2 independent sessions
4.	Station Connections	At least 3 independent baselines
5.	VDOP	Less than 6 (90% of the observation session)
6.	Elevation Angle	Above 10°
7.	Satellite Tracking	At least 5 satellites with GDOP of less than 6
8.	Equipment Calibration	As regulated
9.	MyRTKnet Usage	As regulated

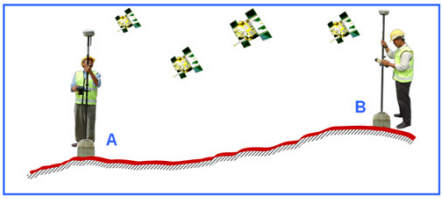
Recommended Guidelines (contd.)

Office Procedure		
No.	**Items**	**Parameter**
1.	General Procedure	Prescribed procedures as provided in manufacturer manual must be followed.
2.	Datum	GDM2000
3.	Ephemerides	Short baselines of less than 30 km: Broadcast. Long baselines: precise.
4.	Baseline Processing Quality	RMS less than 2 cm. Maximum data rejection - less than 10 %. Ambiguity fixed solution. Aposteriori variance factor is unity.
5.	Adjustment	Only independent baselines (n-1) should be included in the adjustment. Least square adjustment should be used.
6.	Minimally Constrained Adjustment	1 control station fixed in GDM2000 coordinates.
7.	Quality Indicator	Pass Chi-squares test at 95% confident region. All baselines must pass the local test.
8.	Test on Control Stations	Relative precision must be less than 2 ppm (2D) and 3 ppm on the vertical component.
9.	Over-constrained Adjustment	At least 2 control stations must be fixed in the final adjustment.

Note: The office procedures are carried out using Trimble Geomatic Office (TGO) software

CASE STUDIES

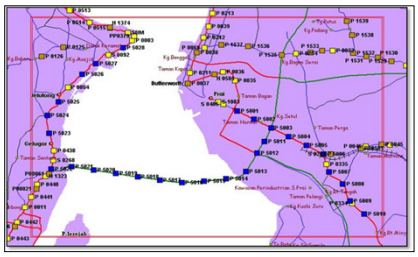
- Method - either RTK or static technique on BMs
- Results - horizontal positions (lat & long) and vertical positions (ellipsoidal height)
- Compare to the levelling height



GNSS observation in progress

CASE STUDY 1

Penang Bridge



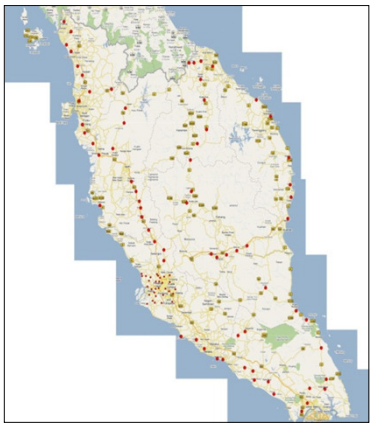
GNSS observations with static technique involving a total number of 3 bench marks (BM)

RESULTS - CASE STUDY 1

Difference Between GNSS Heighting & Levelling (cm)	No. of Observation
< 1	3

CASE STUDIY 2

Peninsular Malaysia

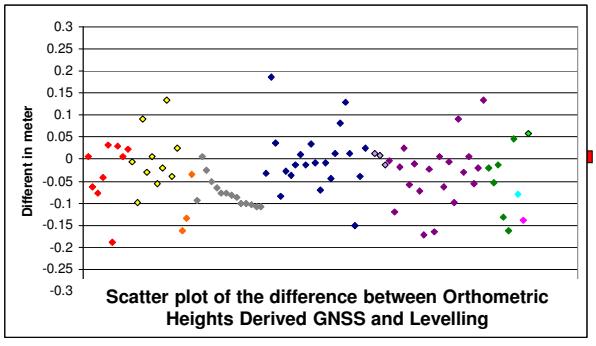


GNSS observations with RTK technique involving a total number of 77 bench marks (BM)

RESULTS - CASE STUDY 2

Difference Between GNSS Heighting & Levelling (cm)	No. of Observation & (%)
< 10	59 (77 %)
10 – 18.8	18 (23%)

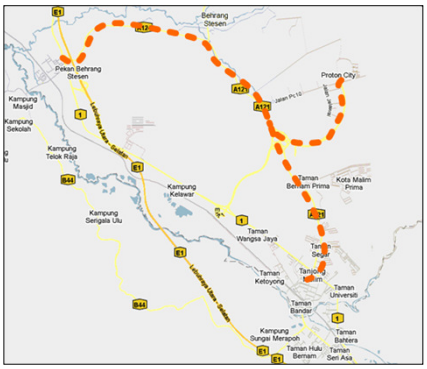
RESULTS - CASE STUDY 2 (contd.)



- BMs observed in Pahang
- BMs observed in Johor
- BMs observed in Melaka
- BMs observed in Selangor
- SBMs
- BMs observed in Kedah
- BMs observed in Perak
- BMs observed in Kelantan
- BMs observed in Negeri Sembilan
- BMs observed in Terenganu
- BMs observed in Perlis

CASE STUDY 3

Tanjung Malim, Perak

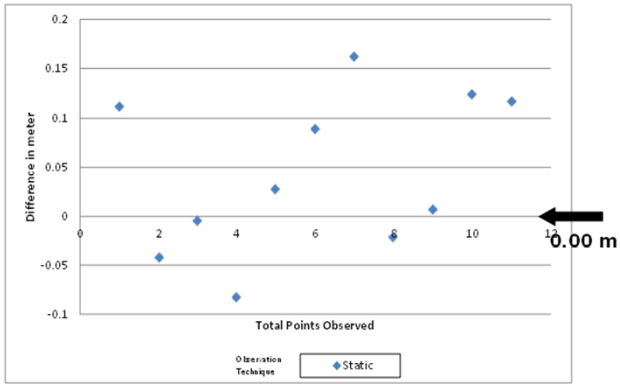


GNSS observations with static technique involving a total number of 11 bench marks (BM)

RESULTS - CASE STUDY 3

Difference Between GNSS Heighting & Levelling (cm)	No. of Observation & (%)
< 10	7 (64 %)
10 – 16.2	4 (36%)

RESULTS - CASE STUDY 3
(contd.)



Scatter plot of the difference between Orthometric Heights Derived GNSS and Levelling

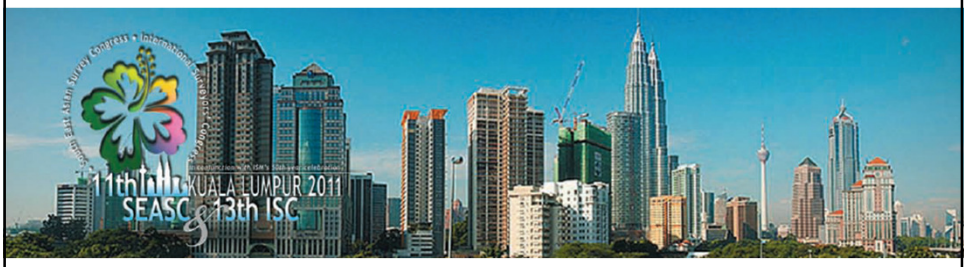
CONCLUSION

- **The development of geodetic infrastructures such as MyRTKnet and MyGEOID has given great opportunity in enhancing the determination of heighting using GNSS.**
- **The conventional spirit levelling requires a lot of time and is a costly operation as well as involves a lot of manpower as compared to GNSS heighting.**

CONCLUSION

- Based on the initial studies that have been carried out, the results indicate that the accuracy achievable by GNSS heighting in Malaysia can provide second order levelling standard.
- However, more case studies need to be conducted regarding GNSS heighting.

Look Forward To Meeting You In Kuala Lumpur In June 2011 and 2014



22 – 24 June 2011

PUTRA WORLD TRADE CENTRE

Kuala Lumpur, Malaysia

www.seasc2011.org

Look Forward To Meeting You In Kuala Lumpur In June 2011 and 2014

XXV FIG Congress
KUALA LUMPUR 2014
Fédération Internationale des Géomètres
International Federation of Surveyors
Internationale Vereinigung der Vermessungsingenieure

Thank you for your attention ....