CURRENT STATUS OF THE GEOCENTRIC DATUM OF MALAYSIA 2000 (GDM2000)

Sr Sohaime bin Rasidi,

Director of Geodetic Survey Division,

Department of Survey and Mapping, Malaysia (JUPEM)

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- 2. EXECUTION OF MyRTKnet
- 3. CURRENT ISSUES OF MyRTKnet SERVICE
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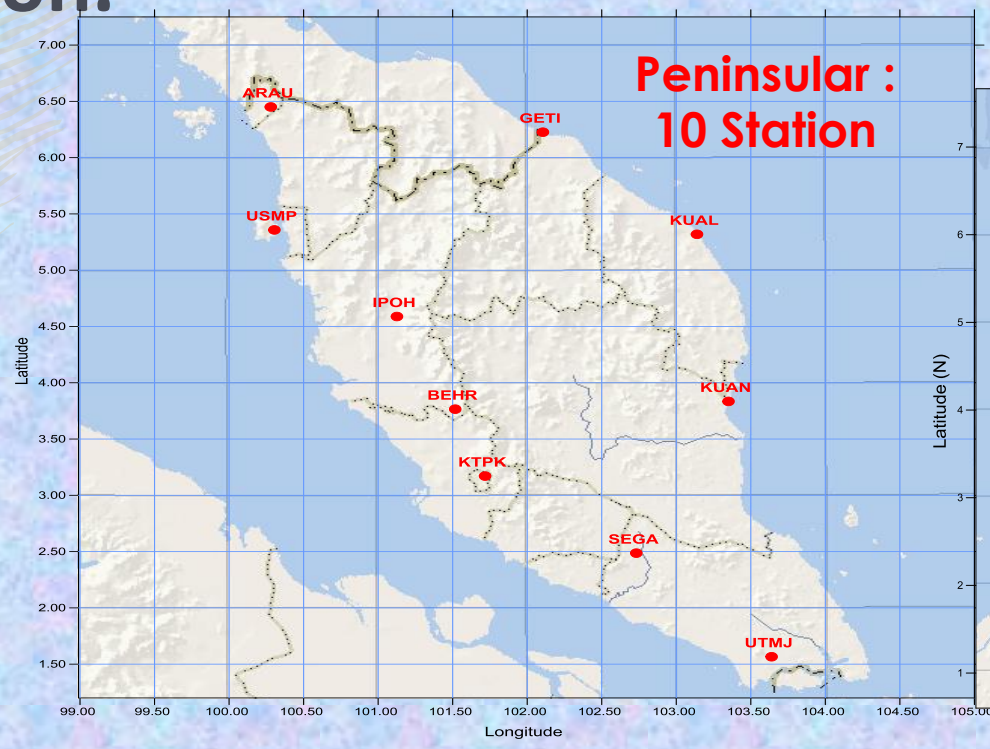
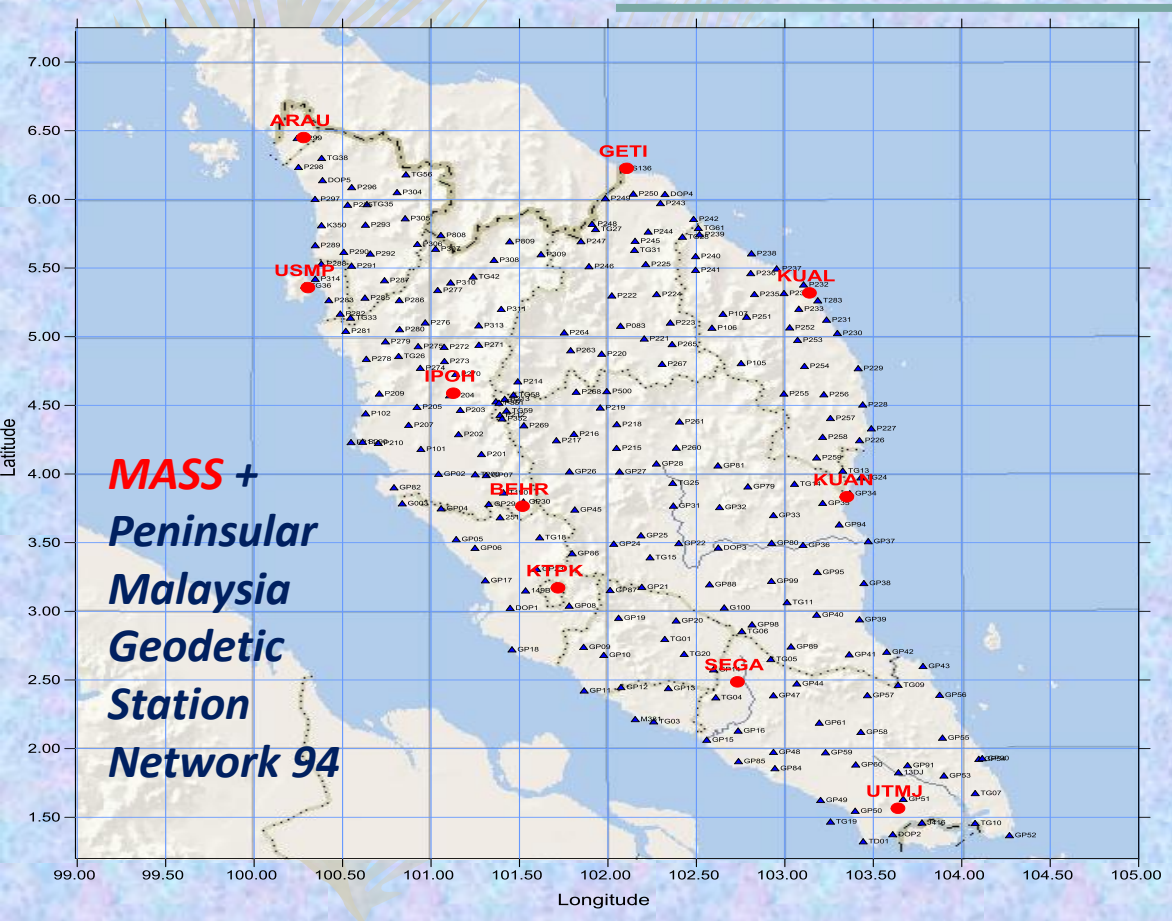
1. INTRODUCTION TO GDM2000

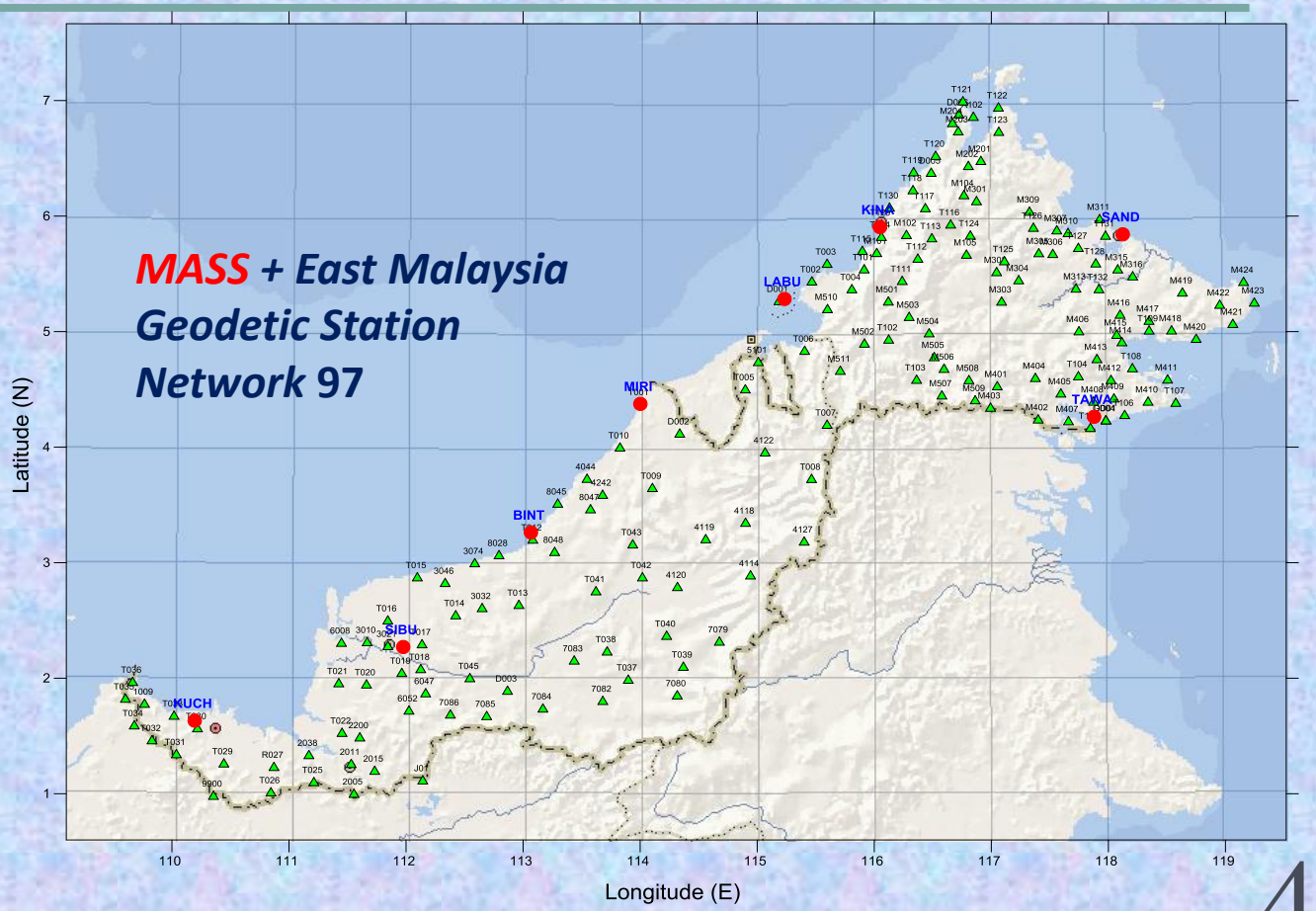
- Officially launched on 26th August 2003
- *Geocentric Datum of Malaysia 2000* (GDM2000) was created over a population of four (4) years of data with ties to eleven (11) IGS station.

18 MASS stations was build on 1999;



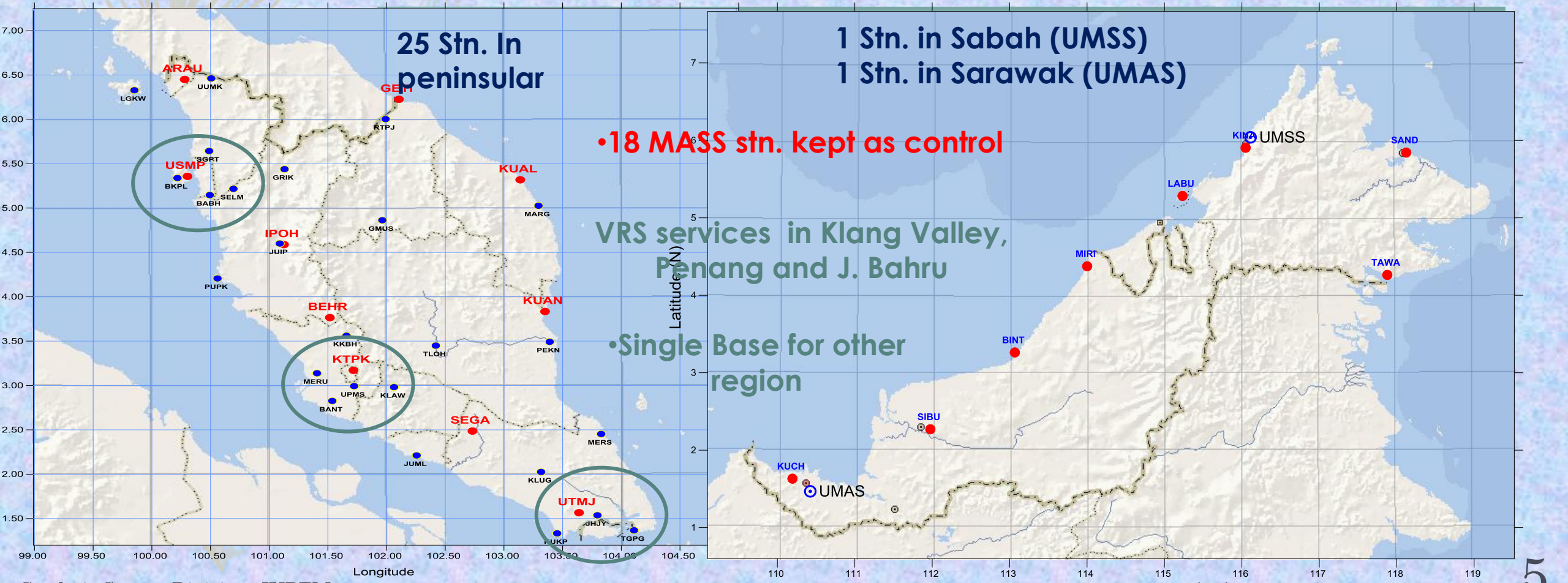
MASS together with passive GPS station PMGSN94 and EMGSN97 created a nationwide GPS control frame.





2. EXECUTION OF MyRTKnet

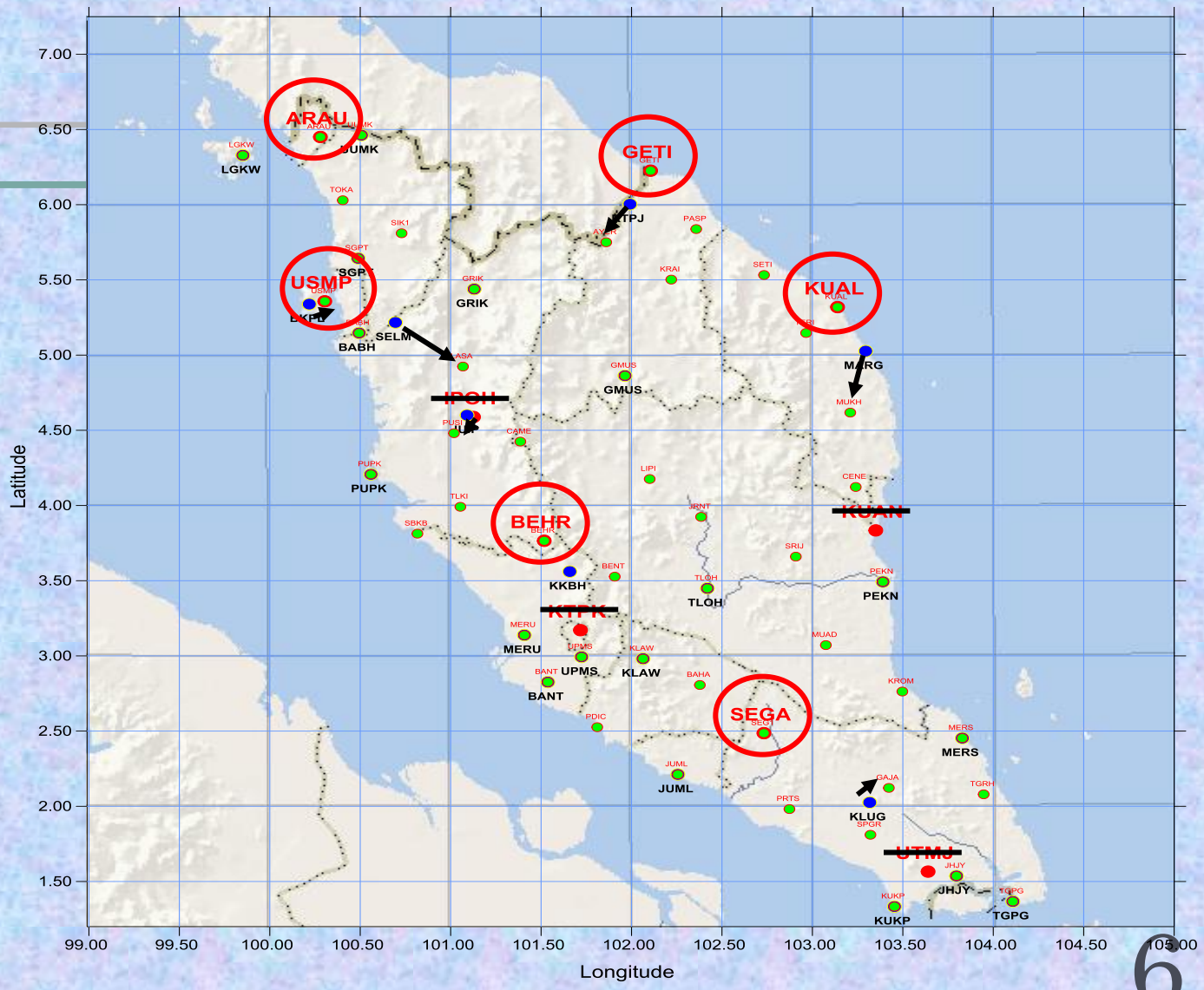
- Phase I of MyRTKnet was developed in 2003 with 27 new stations.
- Equipped with the Trimble 5700 and the Zephyr Geodetic antenna.
- Operation started in 2004.



- **Due to its efficiencies and increase in demand, MyRTKnet got updated and upgraded in 2007 and 2008 as part of the MyRTKnet phase II project.**

2007 (Peninsular Malaysia);

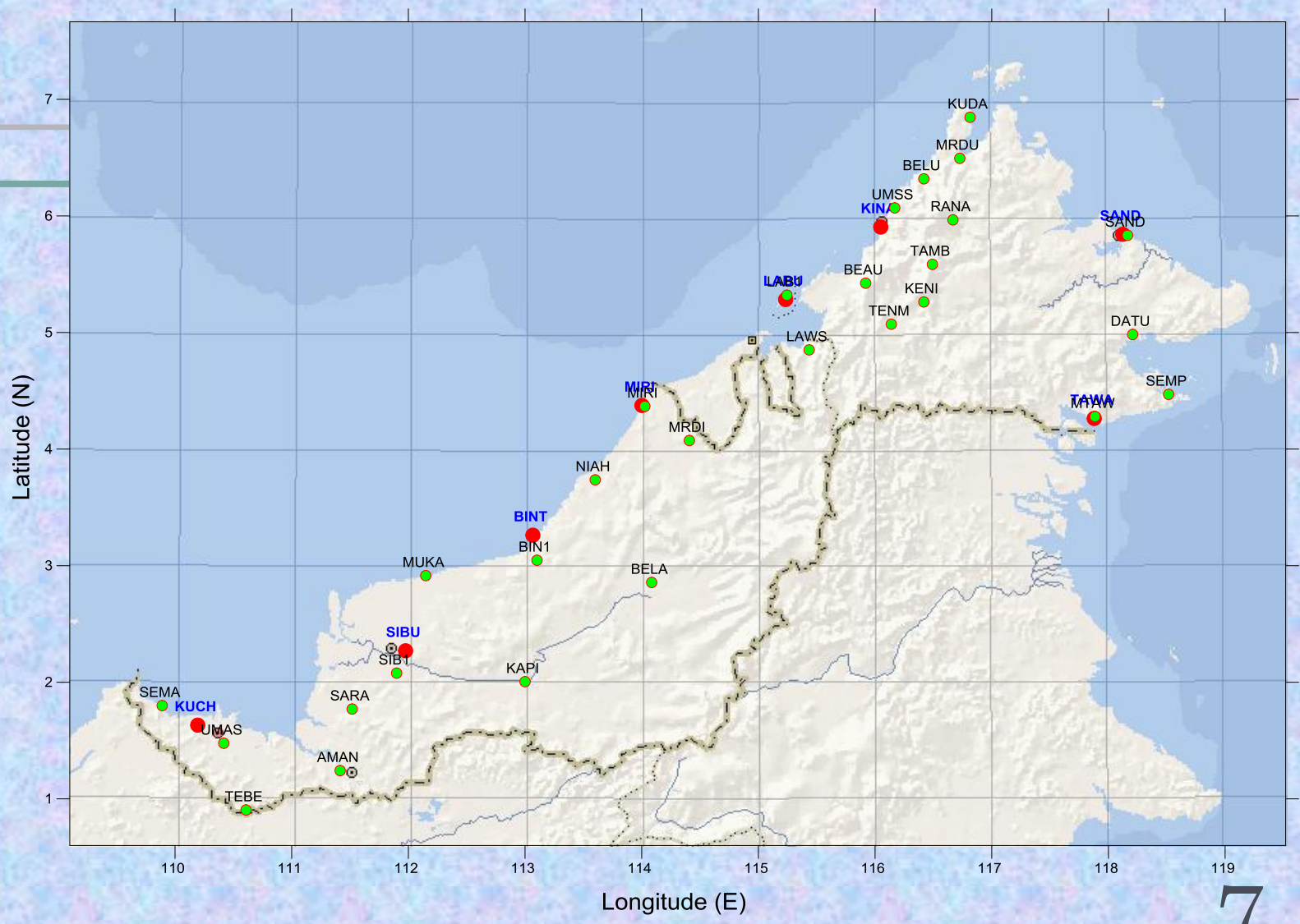
- 19 additional stations.
- 6 MASS stations were upgraded to RTK Station.
- Total of 50 RTK stations.



MyRTKnet Phase II;

2008 (Sarawak, Sabah and Labuan);

- Addition of 12 new stations in Sarawak and 10 in Sabah
- 4 MASS stations known as MIRI, SAND, TAWA and LABU were upgraded to RTK station.
- totals of 28 RTK stations.



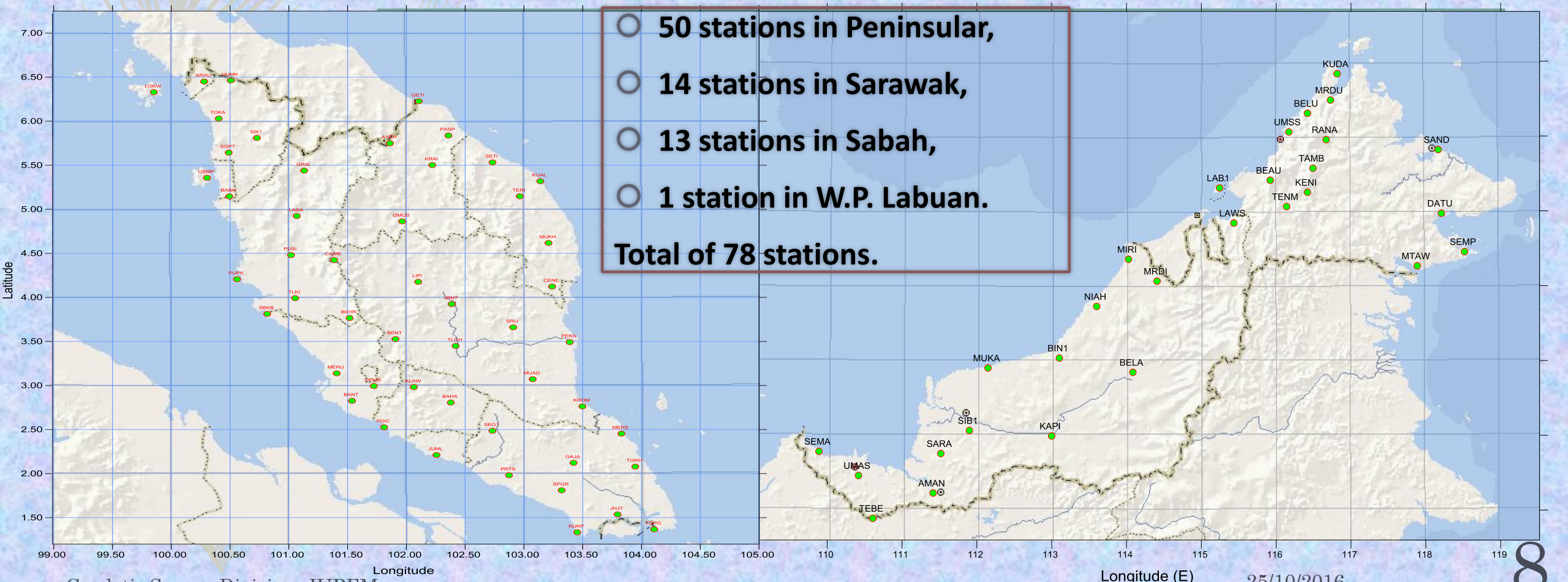
MyRTKnet Phase I and II;

TOTAL IN 2008 = 78 station

Using Reference Frame GDM2000 revised in 2006 [GDM2000(2006)]

- 50 stations in Peninsular,
- 14 stations in Sarawak,
- 13 stations in Sabah,
- 1 station in W.P. Labuan.

Total of 78 stations.



Development of MyRTKnet phase III (2014-2015) :

Objective 1:

Enhancing the MyRTKnet system by;

- Upgrading the Control Centre and Data Processing.
- Changing Data Processing System from the existing GPSNet system to the SpiderNet system capable of processing data from variation of GNSS receiver including Leica and Trimble.

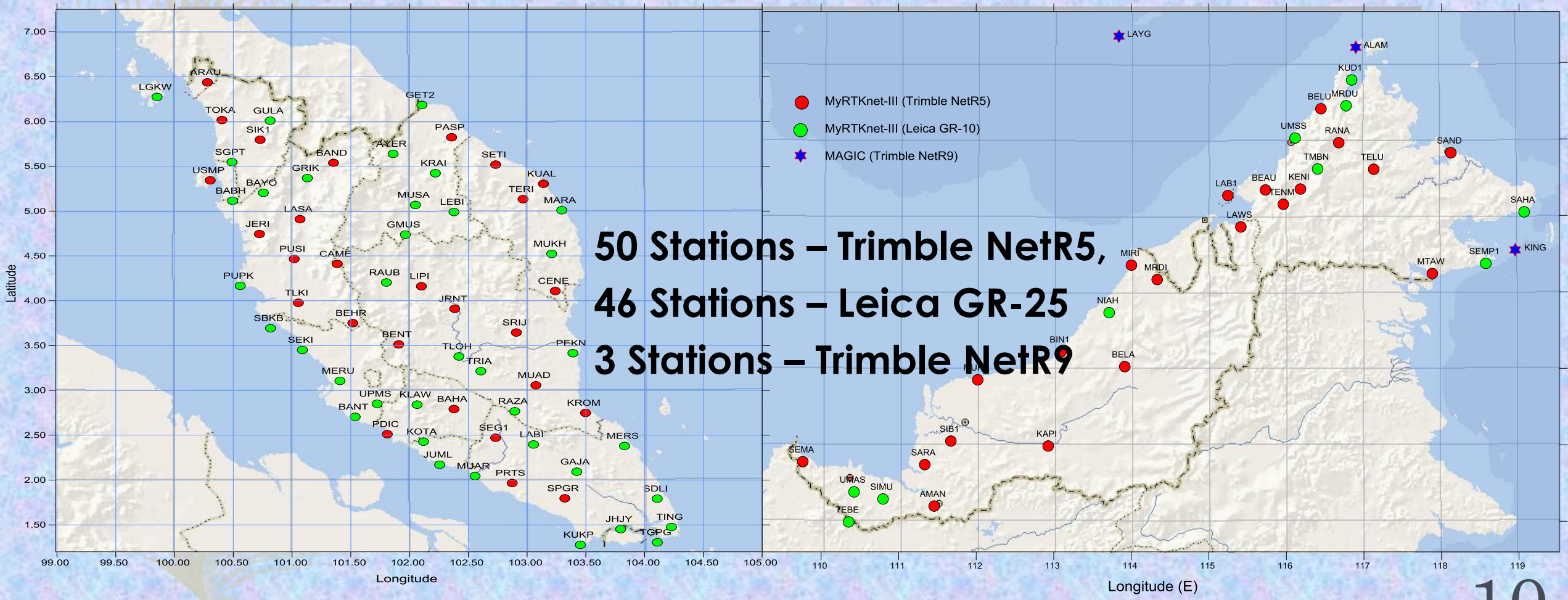
Objective 2:

Densifying of *Continuously Operating Reference Stations (CORS)* up to 99 stations nationwide involving;

- 65 Stations in the peninsular,
- 15 Stations in Sarawak,
- 15 Stations in Sabah,
- 1 Station in W. P. Labuan and
- 1 Station each on Pulau Layang-Layang, Pulau Balambangan and Pulau Mataking.

CONTINUOUSLY OPERATING REFERENCE STATIONS (CORS) STATUS IN 2016

99 stations - (66 in peninsular, 15 in Sarawak, 14 in Sabah, 1 in Labuan and 3 Stations in islands around Sabah)

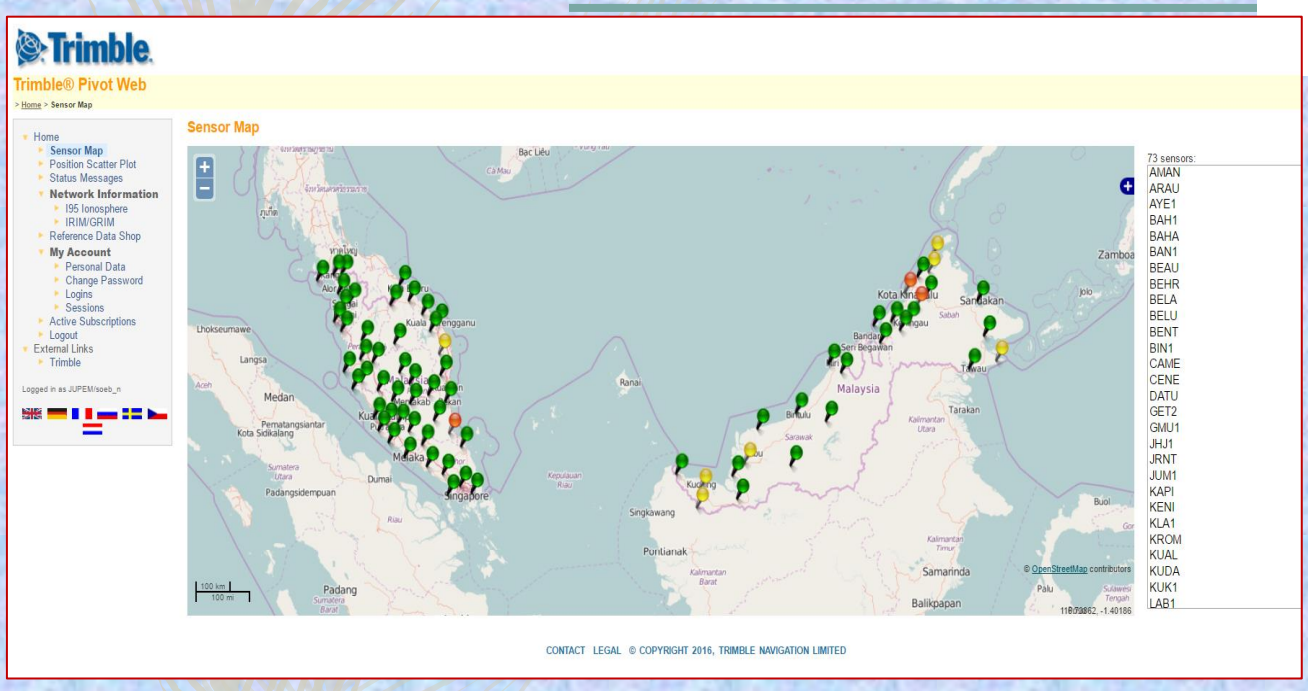


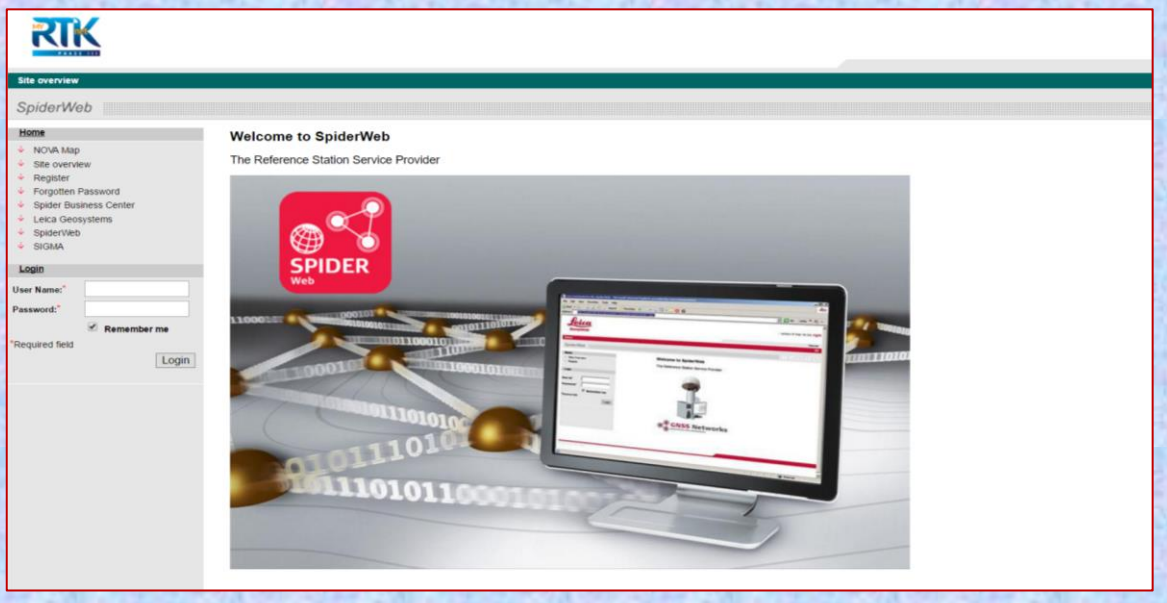
MyRTKnet SERVICES

2004 – 2014 : GPSNet package from Trimble

2014 – Present : Trimble Pivot Platform (TPP) Package

SpiderNet system will replace TPP once CORS coordinates which uses the coordinates in present Reference Frame (ITRF2014) is synchronised with coordinates from GDM2000(2006).





Since 2008, the MyRTKnet used in eCadastre environment results in;

- **25, 000 CCI points surveyed by Certified Land Surveyor (2008 & 2009)**
- **Near 200,000 Cadastral Reference Mark (CRM) surveyed by JUPEM since 2010.**

3. CURRENT ISSUES OF MyRTKnet SERVICE

- Recent MyRTKnet users, especially those who carry out cadastre works face these problems;
  - Fail to initialize or took too much time,
  - Fail to acquire fixed station coordinates,
  - Difficulty in acquiring Virtual Rinex Service (VRS),
  - Difficulty in obtaining Rinex data from nearby CORS,
  - Questionable on accuracy of observed coordinates.

GDM2000(2006) Coordinate Stability for MyRTKnet Stations

- *The main factor for MyRTKnet service problems appear due to unstable CORS coordinates using GDM2000(2006).*
- *CORS-based coordinate GDM2000(2006) is no longer reflect the actual position if referred to the recent ITRF.*
- CORS movement is caused by the movement of Tectonic Plates that changes the overall CORS position as follows;
  - The entire stations generally move about 3 cm per year from its original position towards the East-Southeast;
  - Without taking into account the effects of earthquakes, GDM2000(2006) coordinates could have moved about 30 cm in the last 10 years, between 2006 and 2016.

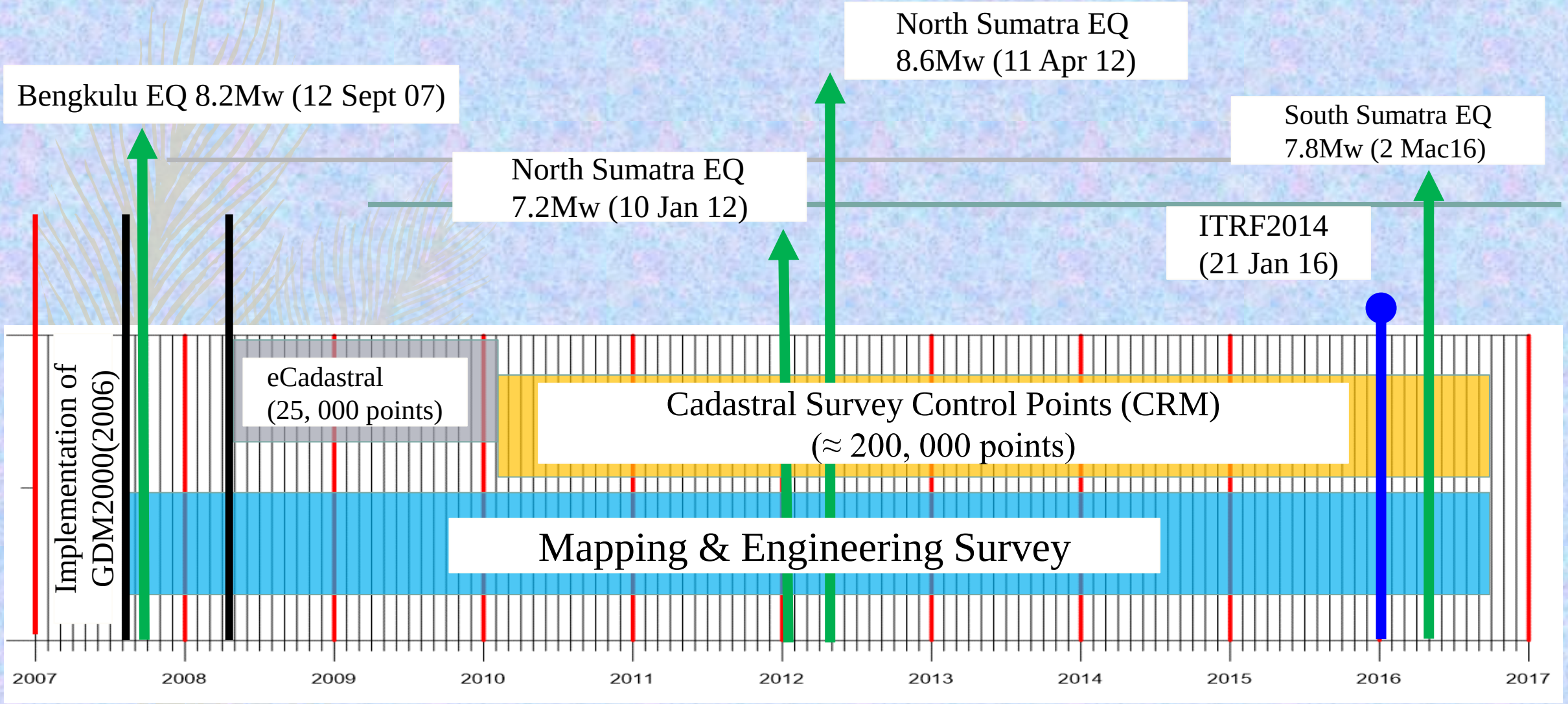
GDM2000(2006) Coordinate Stability for MyRTKnet Stations

- CORS also detected shift resulting from the "Co-Seismic" movement during several strong earthquakes as in;
  - Earthquake in Bengkulu on September 12, 2007 with a strength of 8.2 Mw (moment magnitude) caused the displacement between 1-3 cm towards SSW.
  - An earthquake on the West Coast of North Sumatra on January 10, 2012 with 7.2 Mw power also caused a shift towards SSW.
  - An earthquake on the West Coast of North Sumatra on April 11, 2012 with strength of 8.6 Mw cause displacement between 1-5 cm towards ENE.
  - An earthquake on the West Coast of South Sumatra on March 2, 2016 with the power of 7.8 Mw cause displacement between 0-1 cm towards ENE.

GDM2000(2006) Coordinate Stability for MyRTKnet Stations

- In addition, the CORS also detected shift resulting from the movement of "Post-Seismic" after the earthquake.
  - Studies show that "Post-Seismic" shift after the Sumatra-Andaman earthquake (Banda Aceh) on 25 December 2014 with a magnitude 9.2 Mw earthquake also in Nias on March 28, 2005 with a magnitude 8.7 Mw still continues today.
  - Coupled with the "Post-Seismic" effect of the earthquake , another study found that up to 2012, Thailand, Malaysia and Vietnam has moved up to 25 cm in different directions. With Thailand being stretched more than 60 cm towards NE/SW.

GDM2000(2006) Coordinate Stability for MyRTKnet Stations



MAJOR EVENTS SINCE 2006

4.SOLUTION ANALYSIS

❖ Short-Term Solution (STS)

- Generate new coordinate system based on ITRF2014 Reference Frame named "Malaysian Geodetic Reference Frame 2016 (MGRF2016)" to replace GDM2000 as a base coordinate for MyRTKnet.
- Provides a correlation between MGRF2016 with GDM2000 (2006) using seven (7) Transformation Parameters based on analysis of daily data.
- Supplying the corrected and transformed coordinates in GDM2000(2006) to the user's.

4.SOLUTION ANALYSIS

❖ Long-Term Solution (LTS)

- Using the same method as a short term solution that generates new coordinate system based on the ITRF2014 Reference Frame named "Malaysian Geodetic Reference Frame 2020 (MGRF2020)" to replace GDM2000 (2006) as the basic coordinate for MyRTKnet.
- However the relationship between MGRF2020 with GDM2000 (2006) should be provided using 14 Parameter Transformation Model together with Grid Correction **or** using 14 Parameter Transformation Model together with Post-Seismic Deformation Model.
- Those models will be generated based on the analysis of daily data for a longer period, starting from 1999 until now.

4.SOLUTION ANALYSIS

❖ Long-Term Solution (LTS)

- ➢ Selection of epoch will be determined based on the analysis of all the daily data.
- ➢ Strengthening the relationship between MGRF2020 with GDM2000 (2006) to allow all existing products to be transformed and synchronised with MGRF2020.
- ➢ To suggest that synchronisation of all products to be made before the use of MGRF2020 which will be realized in full on early 2018.

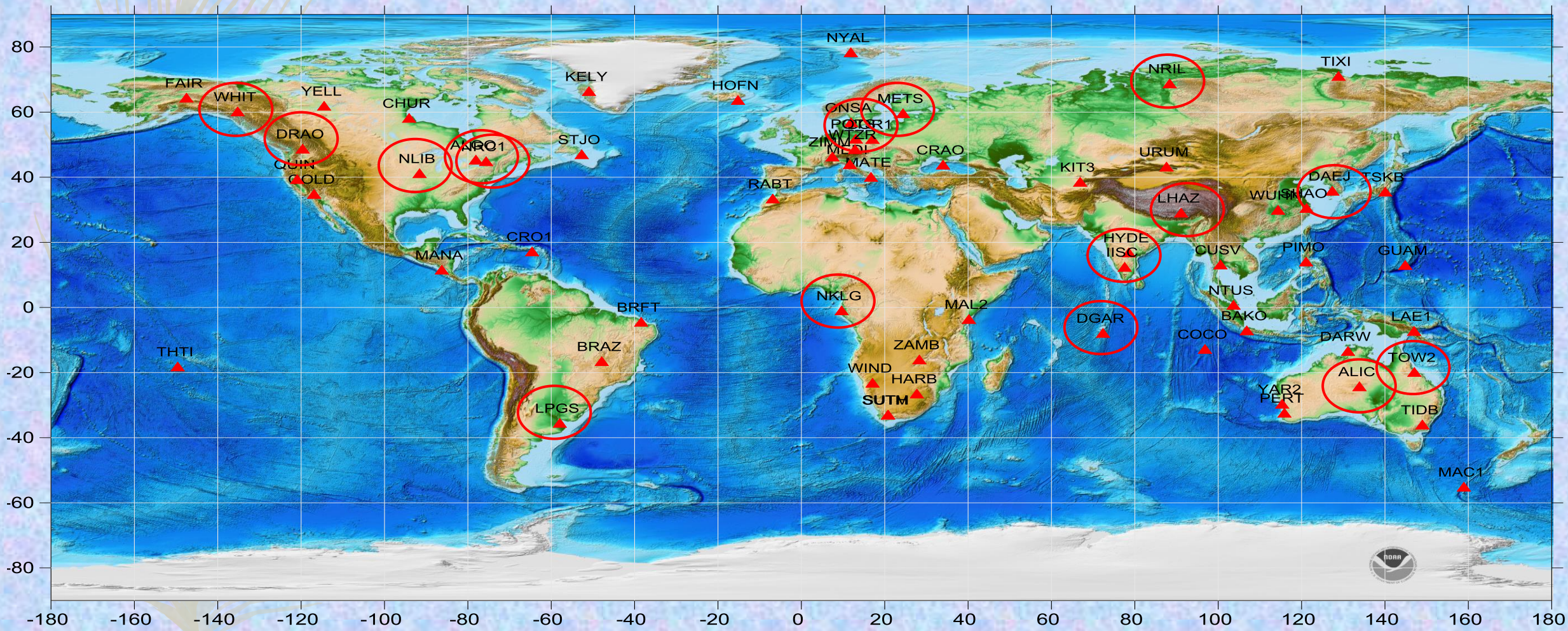
5.SOLUTION MEASURES

❑ Short-Term Solution (STS) Status

1. Study on the stability of observations at MyRTKnet stations was conducted using existing observation data for the period from March 2016 to July 2016.
2. There were two (2) problematic stations, namely in Sri Aman, Sarawak indicating the occurrence of tilting and deposition also a station in Kuala Krai that changes in position due to reconstruction after the flood damage in 2014.
3. The station stability studies were performed to reduce the cause of errors ensuring that the observations were from CORS that are in good shape for the purpose of analysis.

STS: DATA PROCESSING FOR MGRF2016

Processing is made in correlation with 62 IGS stations where 16 of the stations were Core station for ITRF2014.



62 IGS Stations Including 16 Core ITRF2014 Stations

STS: DATA PROCESSING FOR MGRF2016

Date: 29.05.2016 – 04.06.2016 GPS Week: 1899

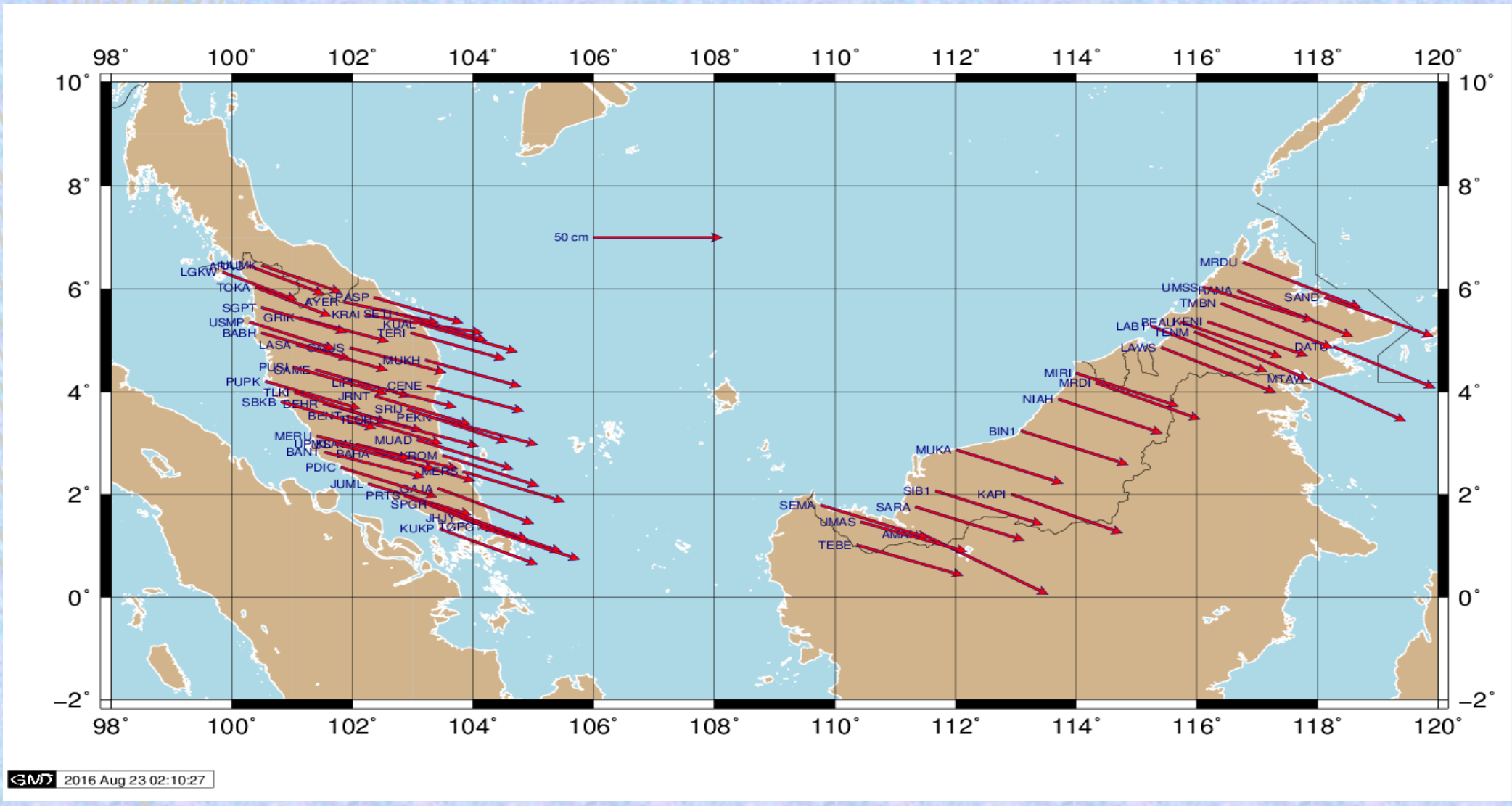
IGS Data: 62 Stesen MyRTKnet data: 90 Station

WEEKLY COMBINATION

Date	:	01.06.2016
GPS Week	:	1899-3
Reference Station	:	14 Stesen ITRF2014-CORE
Data Filter	:	30 Daily Solutions
RMS Combination	:	2.63, 3.19, 5.98 mm
Residuals	:	< 4 mm & 14 mm

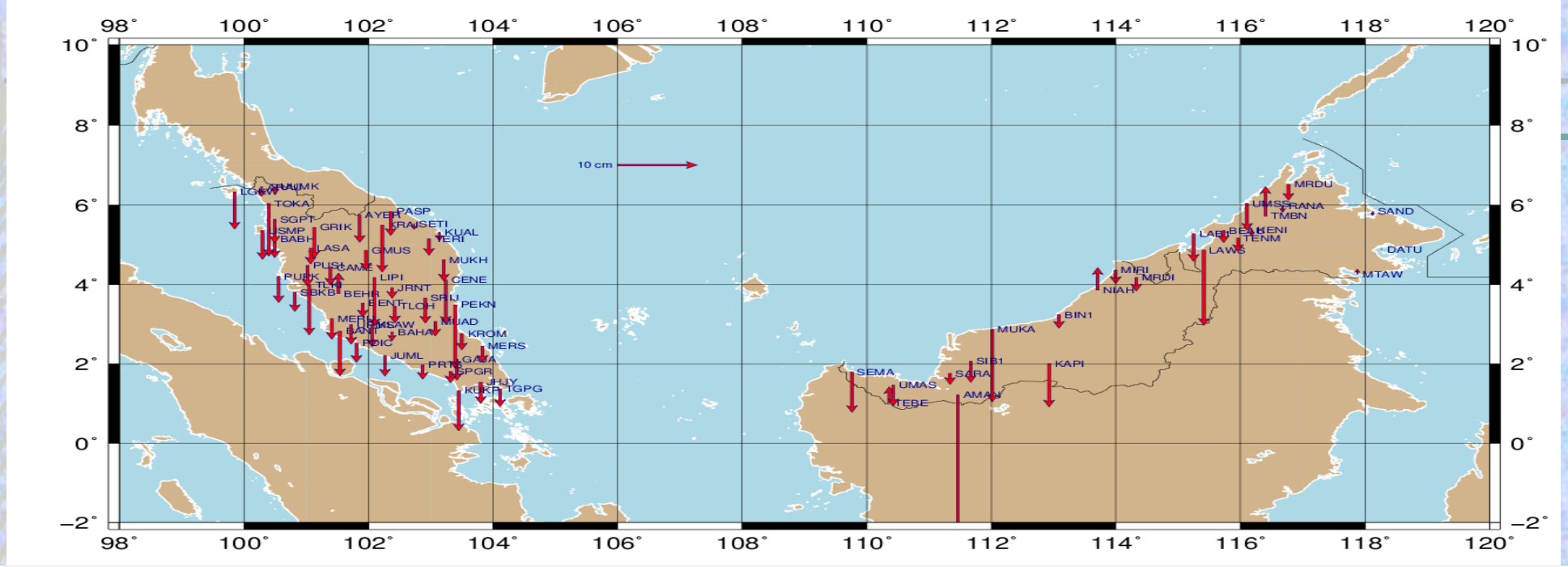
STS: Direct Comparison (Horizontal)

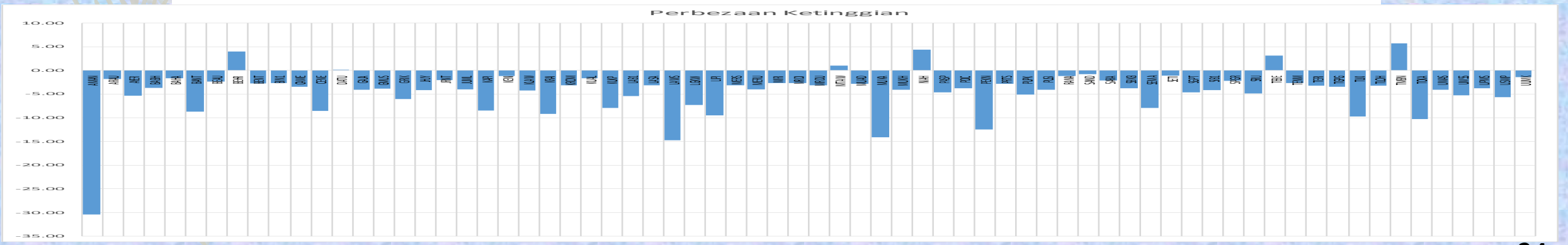
The shift averages about 50 cm towards the East and Southeast (ESE)



STS: Direct comparison (Vertical)

The Magnitude and Direction of the Shift as Shown in Figure.



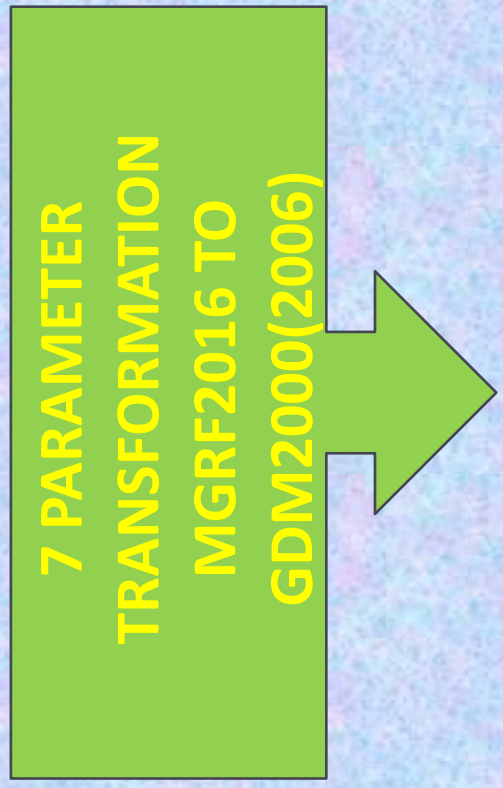


STS: TRANSFORMATION PARAMETERS PRODUCTION

Approach : 7- Parameter
Filter : < 50 mm (H) < 75 mm (V)

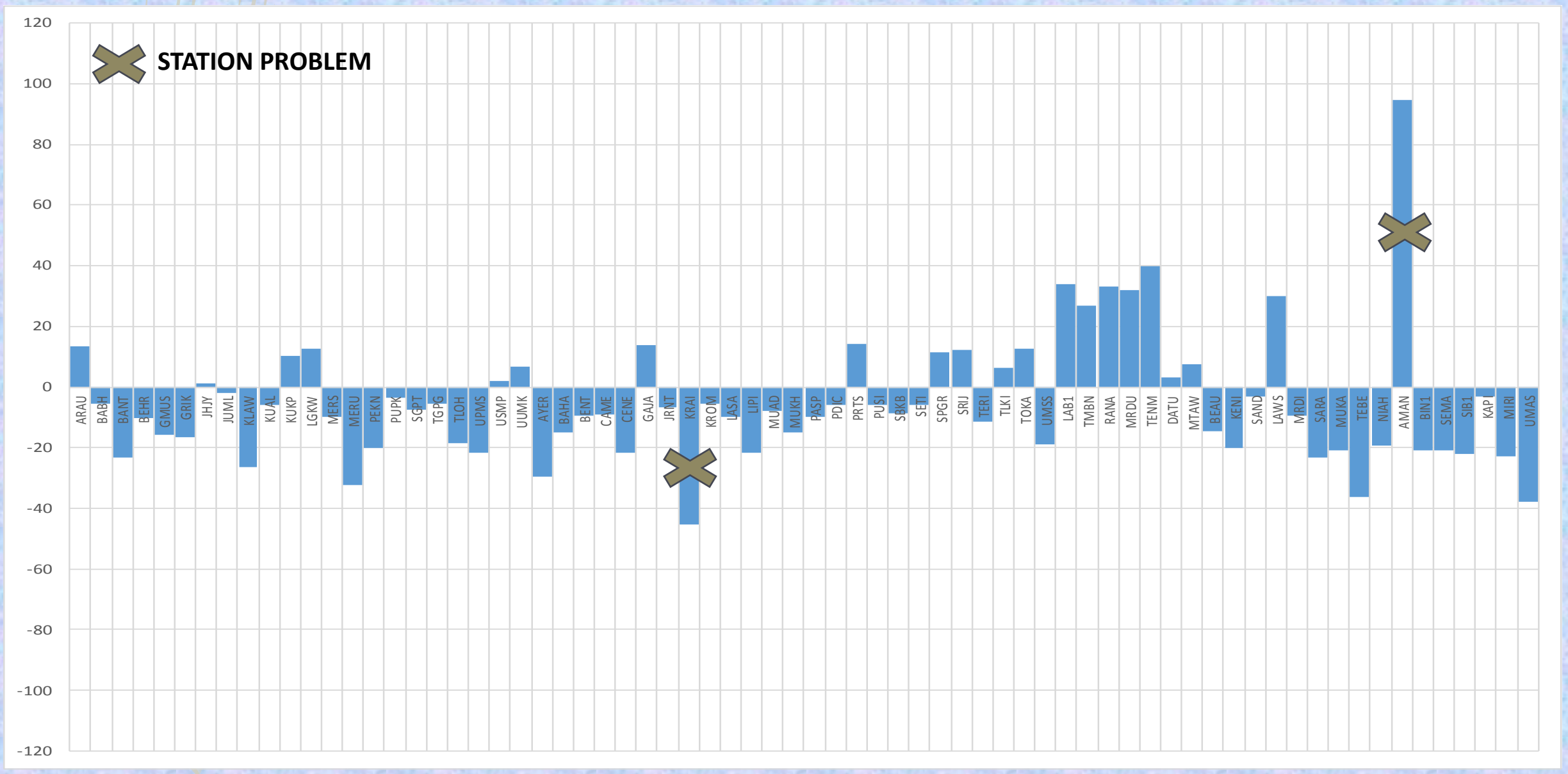
Selected Stations : 11 Station

1. ARAU(Arau)
2. BANT(Banting)
3. LGKW(Langkawi)
4. SGPT(Sg. Petani)
5. TGPG(Tg. Pengelih)
6. TLOH(Temerloh)
7. UUMK(UUM Sintok)
8. BAHA(Bahau)
9. MRDU(Kota Marudu)
10. MTAW(Tawau)
11. UMAS(Unimas, Kuching)

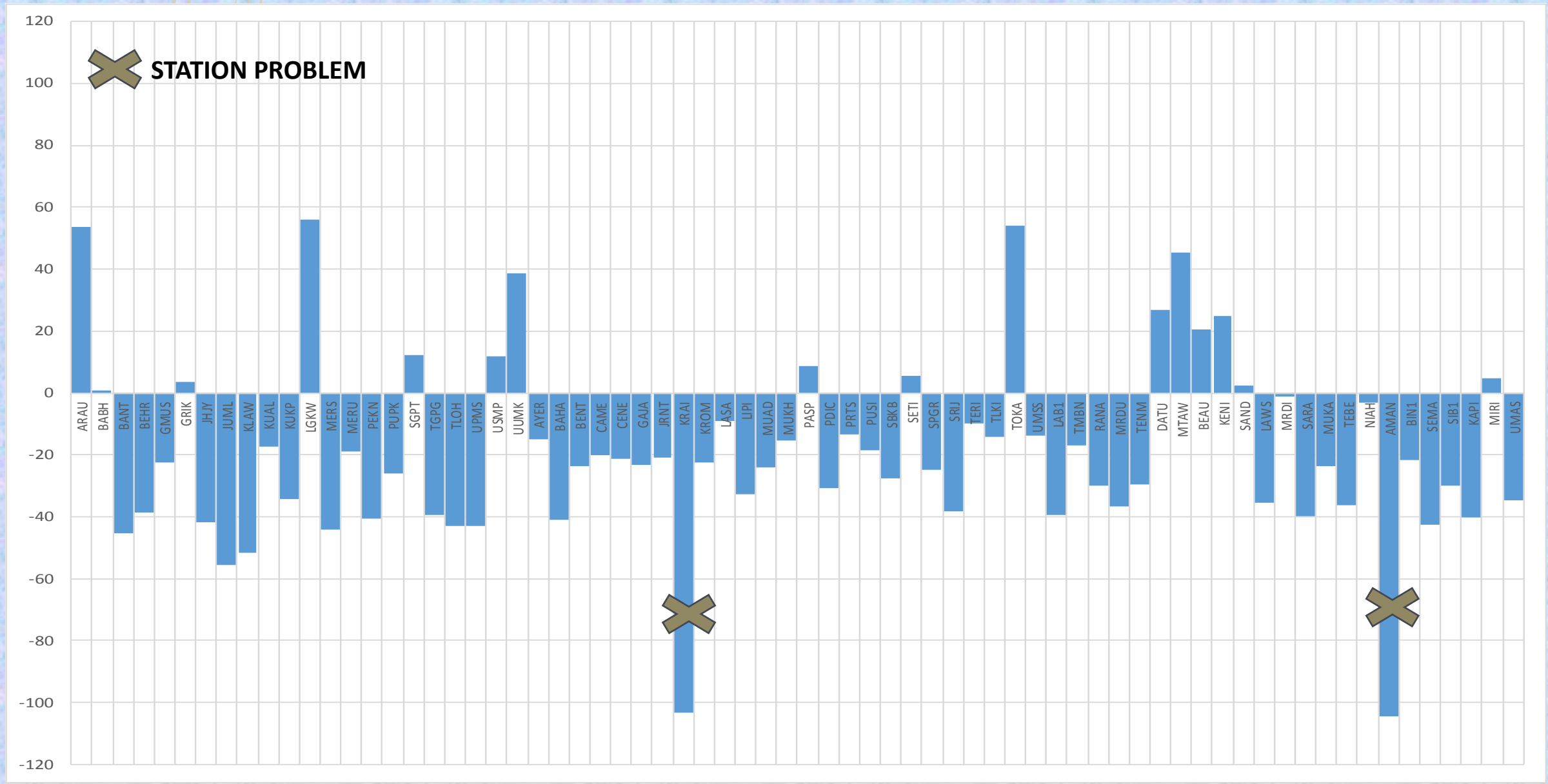


Tx = ---.-- mm
Ty = ---.-- mm
Tz = ---.-- mm
Rx = -.------”
Ry = -.------”
Rz = -.------”
Sc = -.------ ppm

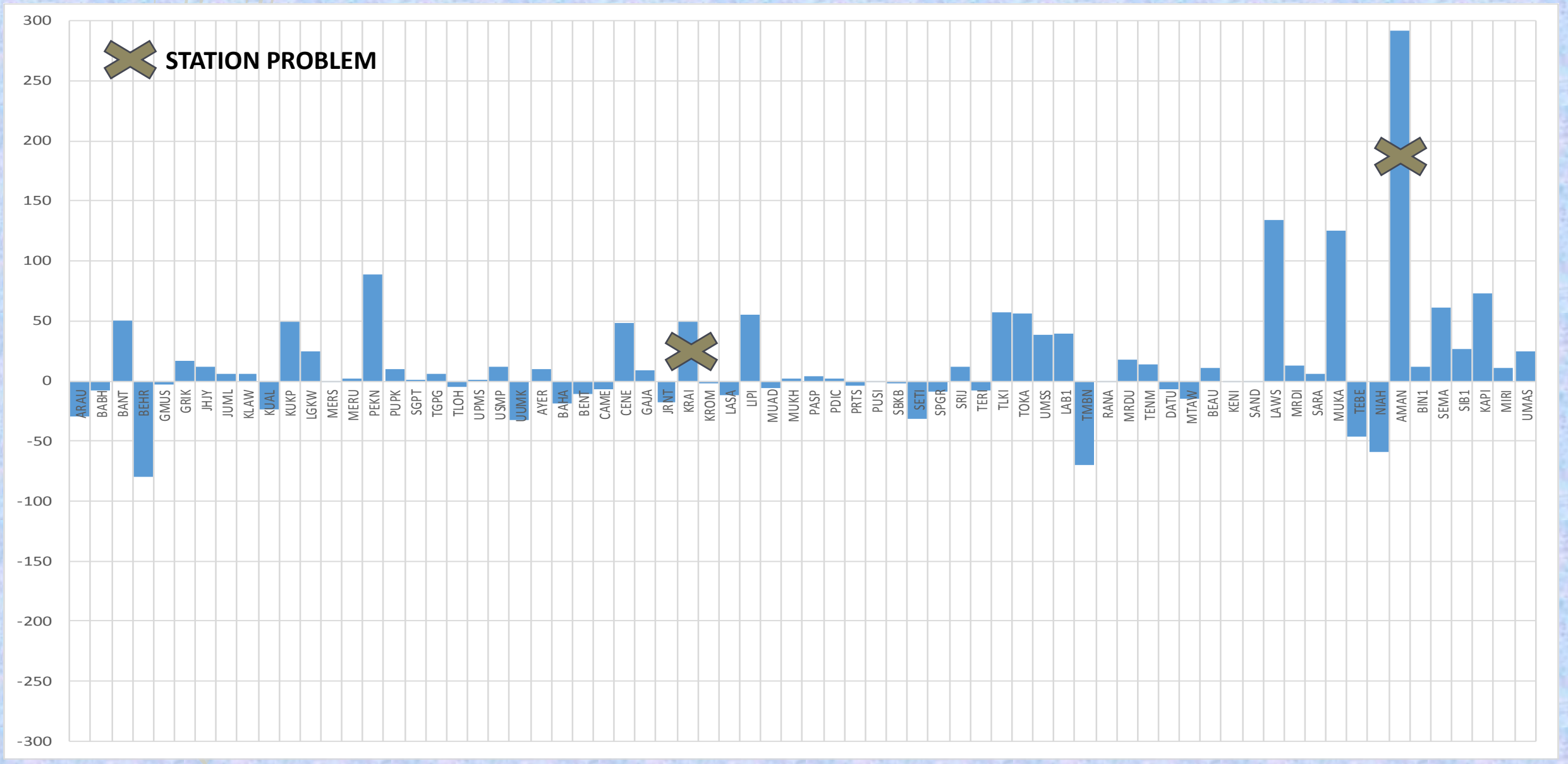
STS: COMPARISON OF TRANSFORMATION – Northing



STS: COMPARISON OF TRANSFORMATION – Easting



STS: COMPARISON OF TRANSFORMATION – Heights



STS: The results of the accuracy test shows that;

i. The use of seven (7) Transformation parameters developed by the Geodetic Survey Division was able to resolve MyRTKnet consumer problems temporarily until all products are made compatible with MGRF2016.

ii. Comparison of the accuracy of coordinate measurements made after the transformation of MGF2016 to GDM2000(2006) compared to the original coordinates in GDM2000(2006) were in acceptable limits of the cadastral survey of **+/- 3 cm in most places**.

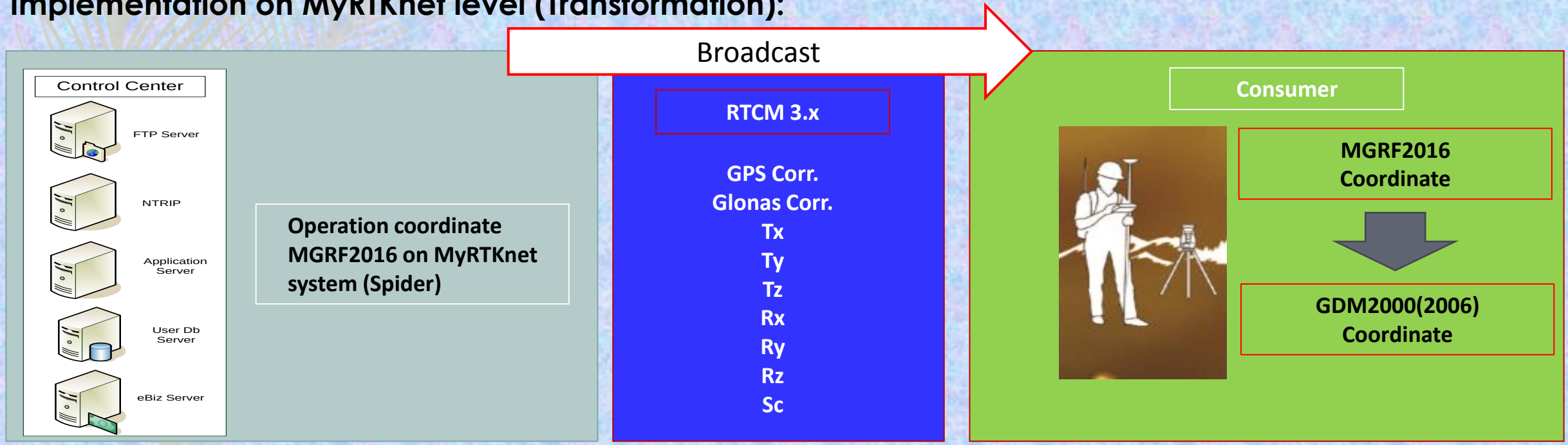
iii. However in **some areas** the difference is somewhat larger, but not more than **+/- 5 cm**.

iv. Nevertheless, the **relative accuracy** between stations in the same area can be maintained within the limits of **less than 1ppm**.

Short-term Solution Implementation

After an analysis of the accuracy of the test results, the use **of SpiderNet system in MyRTKnet will be open** to all users and all **transformation parameters will be supplied** to the consumer together with the VRS correction. This means that **no changes** need to be made to the user's equipment and software provided that the GNSS equipment were integrated with RTCM 3.0 or latest.

Implementation on MyRTKnet level (Transformation):



6. Revision of GDM2000

Long-Term Solution (LTS)

1. Given the supply of transformation parameters to the user in a short term solution can not ensure high accuracy so JUPEM have to take a step forward to **convert all the data available from GDM2000 (2006) to MGRF2020** with one of the methods to be implemented, namely the combined transformation model 14 parameter method and grid correction model **or** 14 parameter transformation model 14 with post-seismic deformation.
2. To provide the stated correction models and obtain the values of transformation parameters to MGRF2020, Geodetic Survey Division is and will perform a more detailed processing and testing of CORS data by using more credible observations data.

Long-Term Solution(LTS)

Steps for creating MGRF2020 for long-term solutions are being and will be continued as follows;

No.	Action	Status
1.	**Reprocess all the GNSS data of MASS/MyRTKnet on a daily basis since 1999 until 2017.0.**	
1.1	Setup and use the most recent IGS-type strategy, including the most up to date models.	Completed
1.2	Check and consolidate the metadata & log sheets for all the stations following the IGS standards, including the IGS Core sites (through IGS).	Completed
1.3	Establish a catalogue of all earthquakes with their epochs and locations(epicenters)from MET Malaysia & USGS.	Completed
1.4	Careful handling of data time interval at the earthquake events.	<30.11.2016
1.5	Study and check the monument stabilities for suspected stations.	Completed
1.6	Download and locally archive the IGS Core sites RINEX files since 1999.0 to date.	<30.11.2016
1.7	Generate free solution SINEX files: Normal Equations and Variance-Covariance, using Bernese software V5.2.	<30.6.2017
1.8	Optionally: generate the same type of solution using a different software for comparison.	<30.6.2017
1.9	Provide 3 years of daily solutions (1999.0 – 2002.0) for analysis by Dr. Zoher Altamimi in stages.	<30.6.2017

Long-Term Solution(LTS)

Steps for creating MGRF2020 for long-term solutions are being and will be continued as follows;

No.	Action	Status
2	**Data Processing using the most recent version of ifort Fortran and it's MKL library for a LINUX machine.**	
2.1	Analysis of the daily time series using CATREF Software andLINUX Server (80 processor)	<30.8.2017
2.2	Specify the definition of the MGRF2020and its relationship with the ITRF2014.	<30.8.2017
2.3	Produce the coordinates of the CORS stations at the agreed reference epoch (TBD) and expressed in the new MGRF..	<30.9.2017
2.4	Provide Transformation Parameters between MGRF2020 and GDM2000(2006).	<30.9.2017
2.5	Conducting field test and analysing the accuracy of transformation process.	<30.10.2017
2.6	Migrating all product coordinate into MGRF2020	2018 onwards

7.CONCLUSION

1. The use of MGRF2016 based on the seven (7) Transformation Parameters can solve MyRTKnet user problems temporarily until all products are compatible with the new MRGF2020 datum.
2. SpiderNet system developed in MyRTKnet Project Phase III will be fully utilized and is ready to be launched for use by all parties involved by **November 2016**.
3. Sufficient financial are needed to transform all products coordinates into the environment of new MGRF2020 datum that will be used starting **2018**.

8. APPRECIATION

I extend my gratitude to everyone involved in the success of this study primarily to;

YBhg. Datuk Ahmad Fauzi bin Nordin,
Ketua pengarah Ukur dan Pemetaan Malaysia,

Dato' Hasan bin Jamil, TKPUP I and ,

Dato' Mohd Noor bin Isa, TKPUP II,

who contributed a lot of their ideas, advice and guidance.

My thanks are also given to the parties directly involved in assessing and proposing methods and solution that can be used.

Terima Kasih