

塑造智慧变革



HEXAGON

海克斯康



北京
国家会议中心

2018年

9月10-12日

2018.hexagonchina.com.cn

Bridge and Tunnel Monitoring by Automatic and Manual Operation

Mr. T.N. Wong

FHKIS, FRICS, MNZIS, RISM, FInstICES

FIG, Vice President 2003-2006

HKIS President 1997/98

NZIS, Chairman of NZIS HK Branch since 2016



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Project Background



The Central - Wan Chai Bypass and Island Eastern Corridor Link (CWB) is a strategic road along the north shore of Hong Kong Island targeted to alleviate the traffic congestion along the existing Gloucester Road - Harcourt Road - Connaught Road Central corridor. The need was also reaffirmed in the statutory procedures and supported in the public engagement process.

Project Management:
Highways Department

Consulting Engineers:
AECOM Asia Co. Ltd.

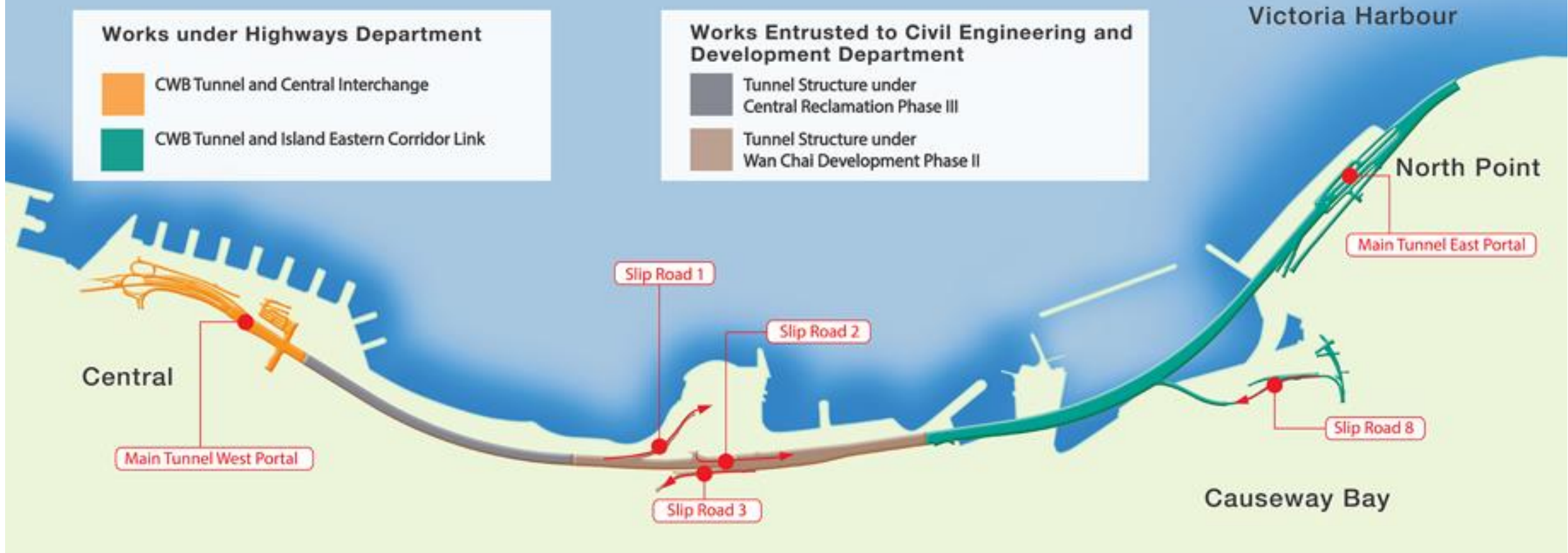
Estimated Project Cost:
HK\$36 Billion

Construction Commencement Date:
Dec 2009

Anticipated Commissioning Date:
Late 2018 / First quarter of 2019

Project Background

Central - Wan Chai Bypass and Island Eastern Corridor Link



ADMS Survey – Location 1 (Temporary Setup)

We have
Computer, UPS,
communication
device, Geomos
Monitor and
Geomos Analysis
inside the box



ADMS Survey – Location 1 (Temporary Setup)



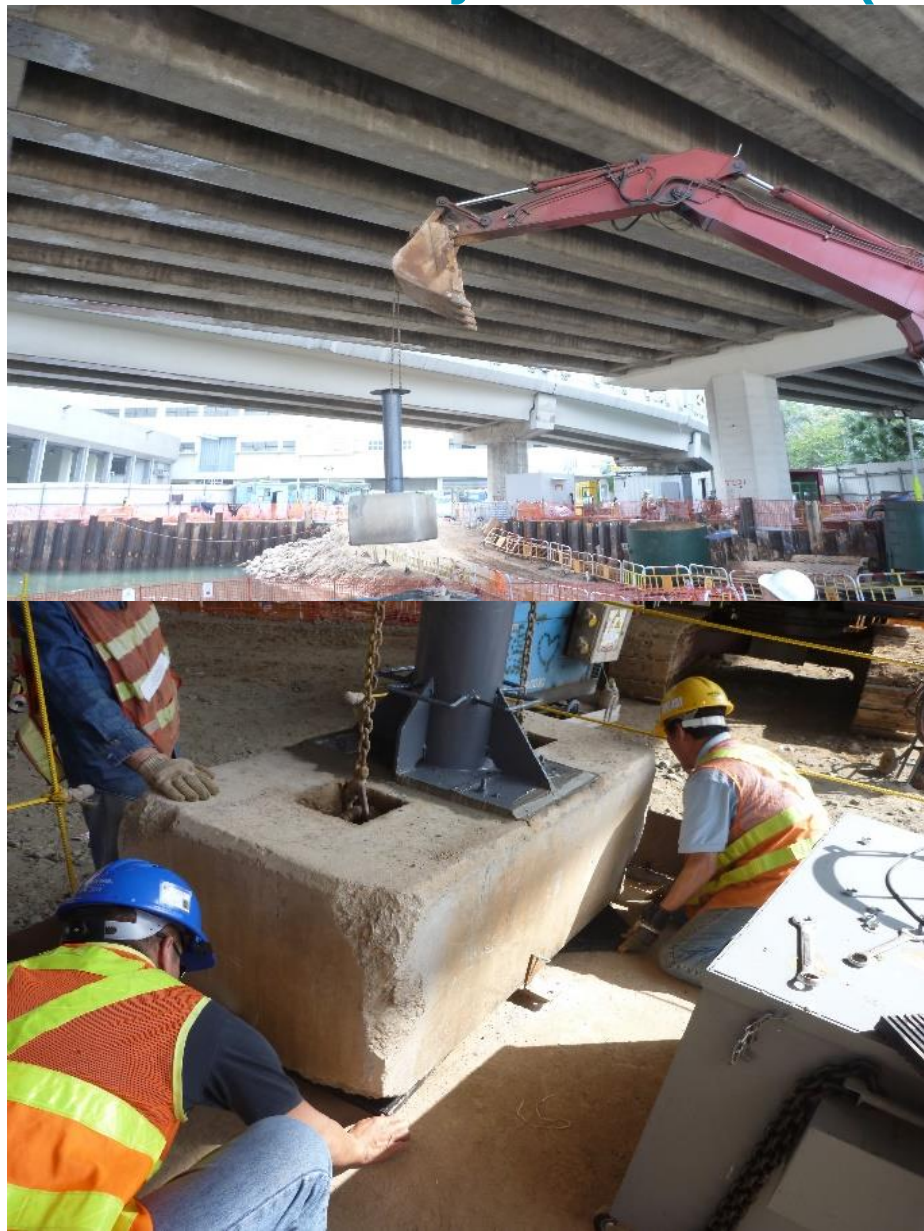
ADMS Survey – Location 1 (Permanent Setup)

This is Permanent Setup

This is Temporary Setup



ADMS Survey – Location 1 (Permanent Setup)



ADMS Survey – Location 2



ADMS Survey – Location 2



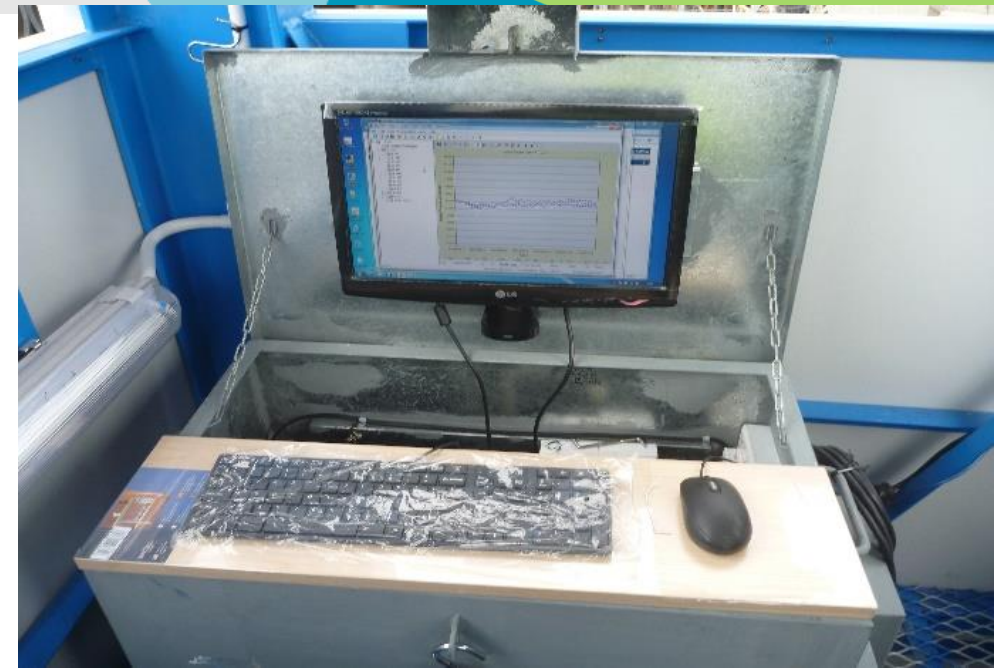
We have
Computer, UPS,
Geomos Monitor
and Geomos
Analysis inside
the box



ADMS Survey – Location 3



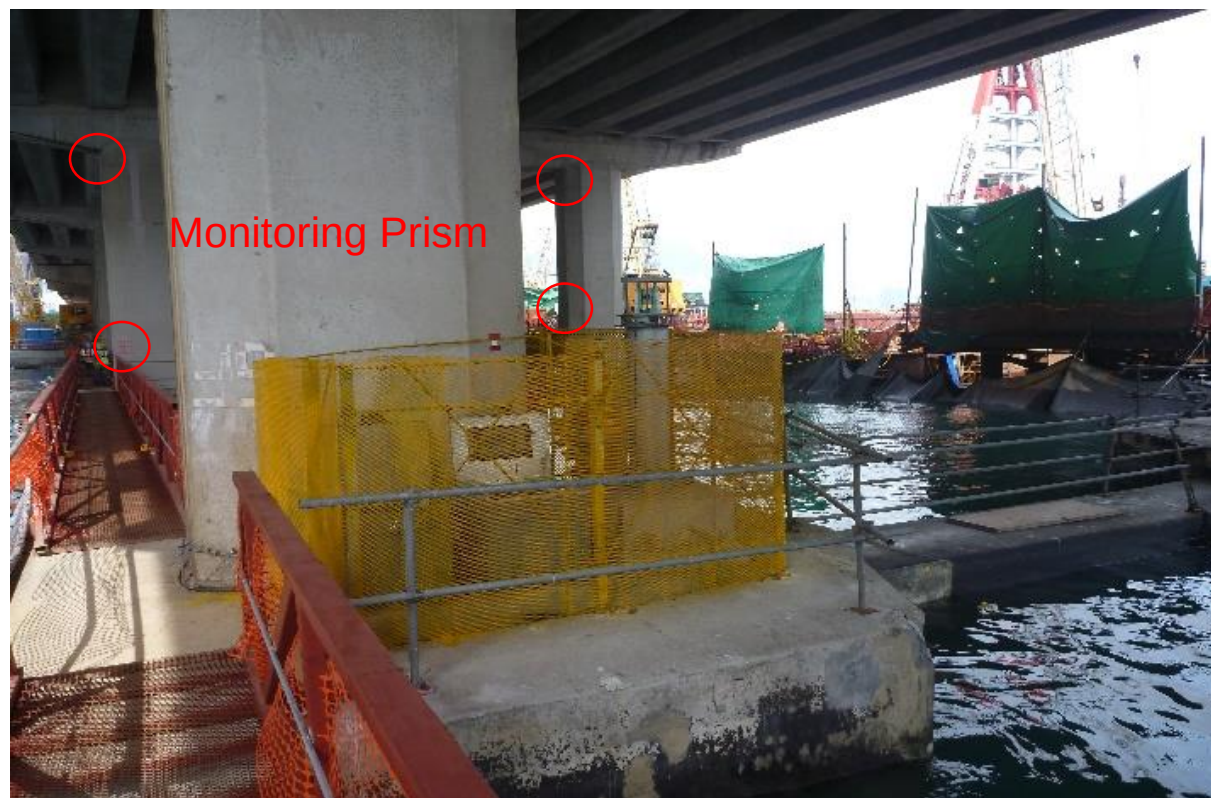
ADMS Survey – Location 3



ADMS Survey – Location 4



ADMS Survey – Location 4



ADMS Survey – Location 5 (CHT1)



ADMS Survey – Location 5



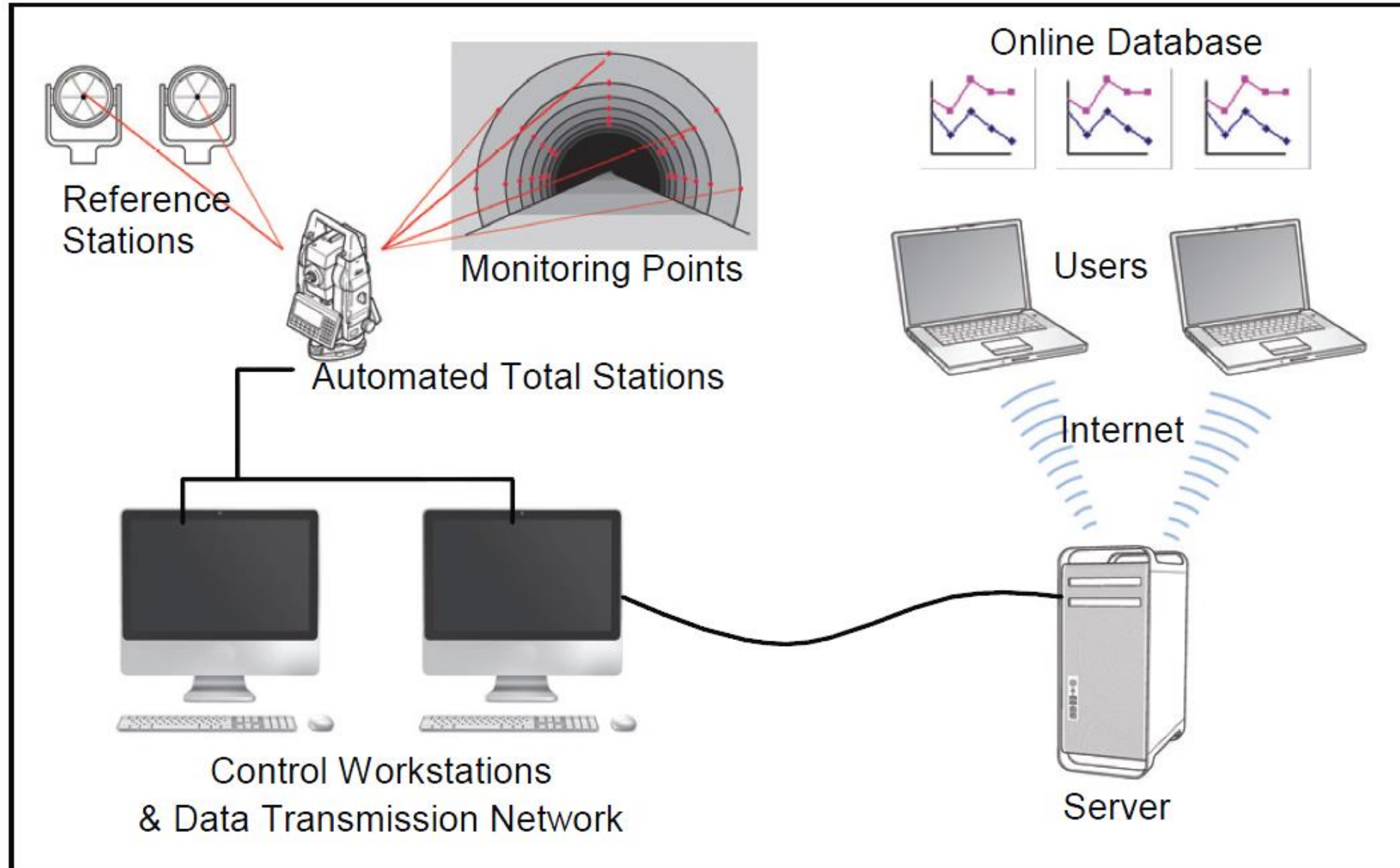
Reference Prism



Monitoring Prism

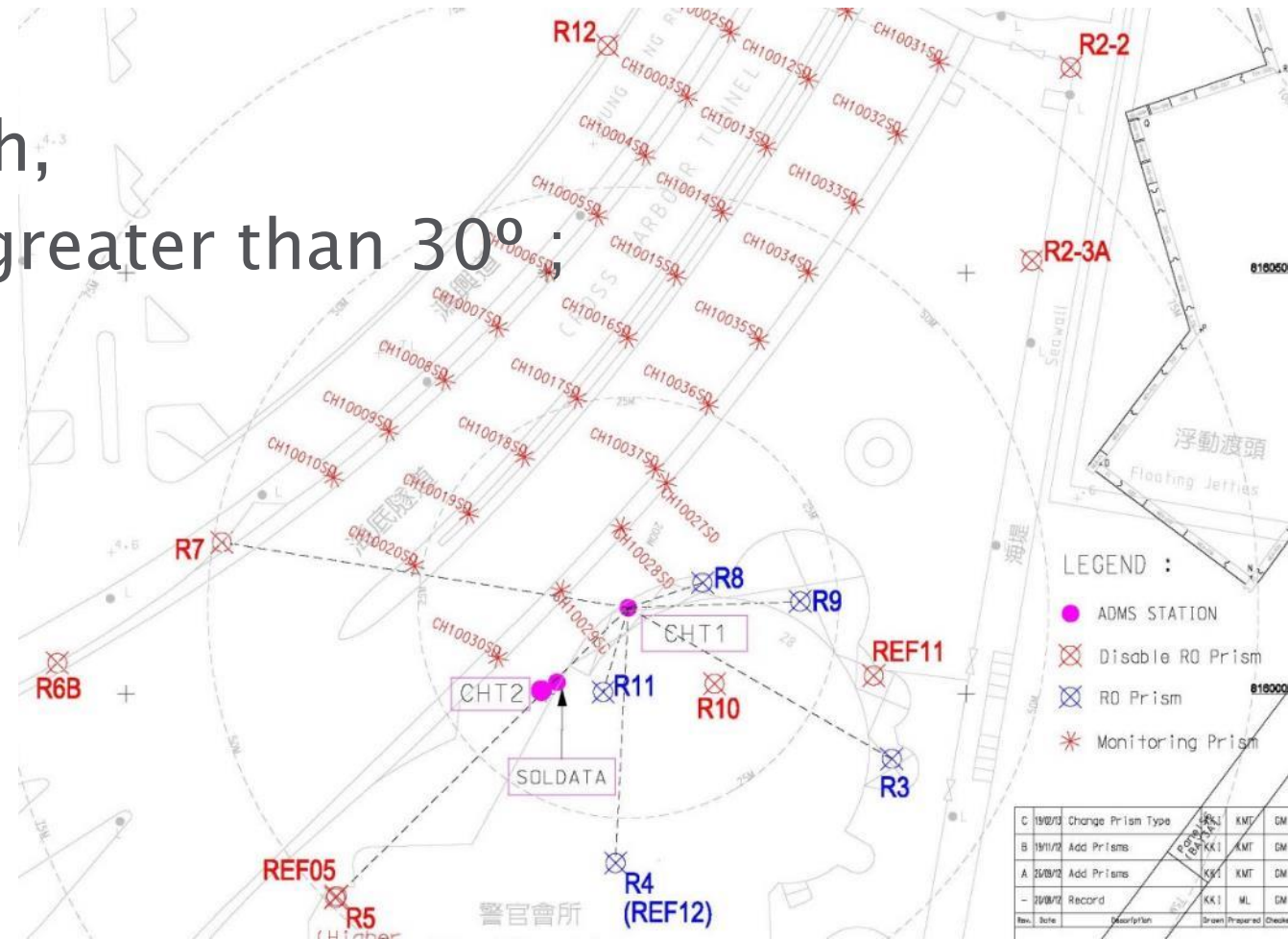


ADMS Survey – Location 5 (Components)



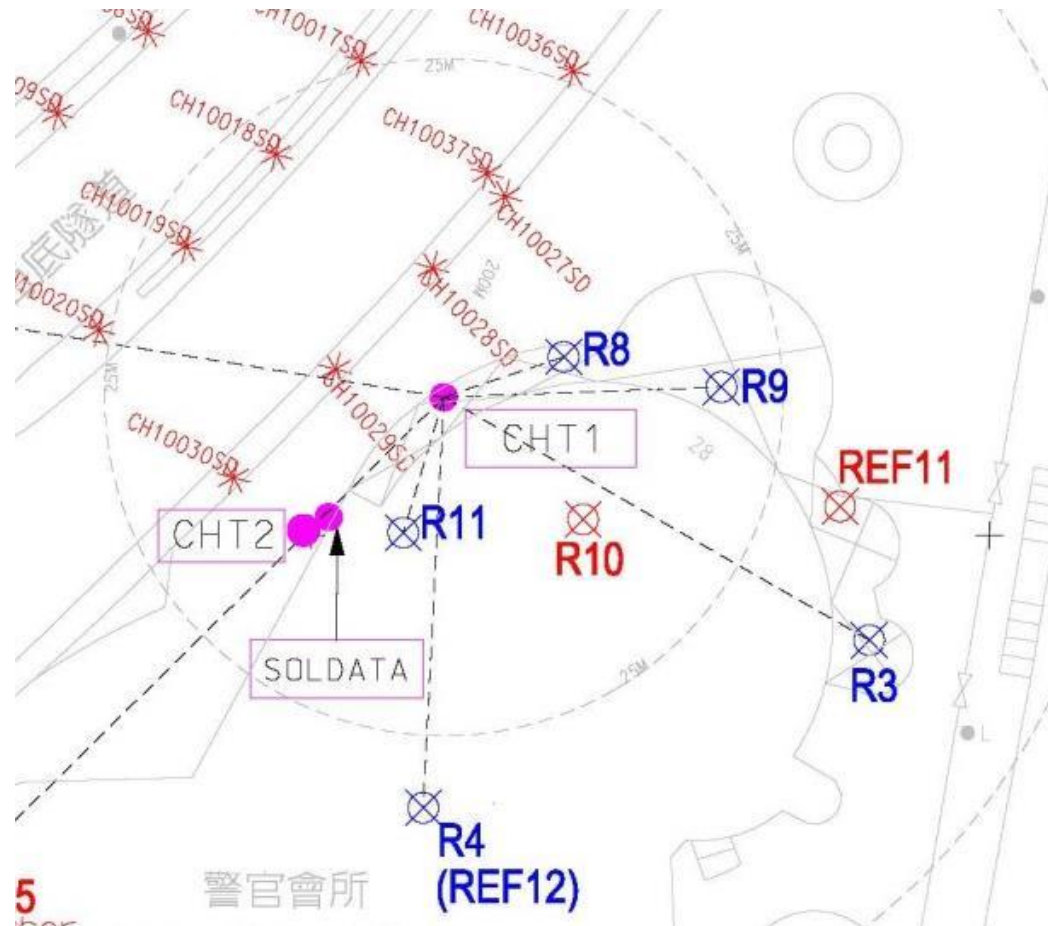
ADMS Survey – Location 5 (Network Design)

- Minimum 5 numbers of ROs
- Equal side of triangular length,
- Sizes of observation angles: greater than 30° ; less than 120°
- Coverage of Monitoring Zone



ADMS Survey – Location 5 (Freestation)

- To measure from a station point where we don't have the coordinates, to points that are defined in coordinates

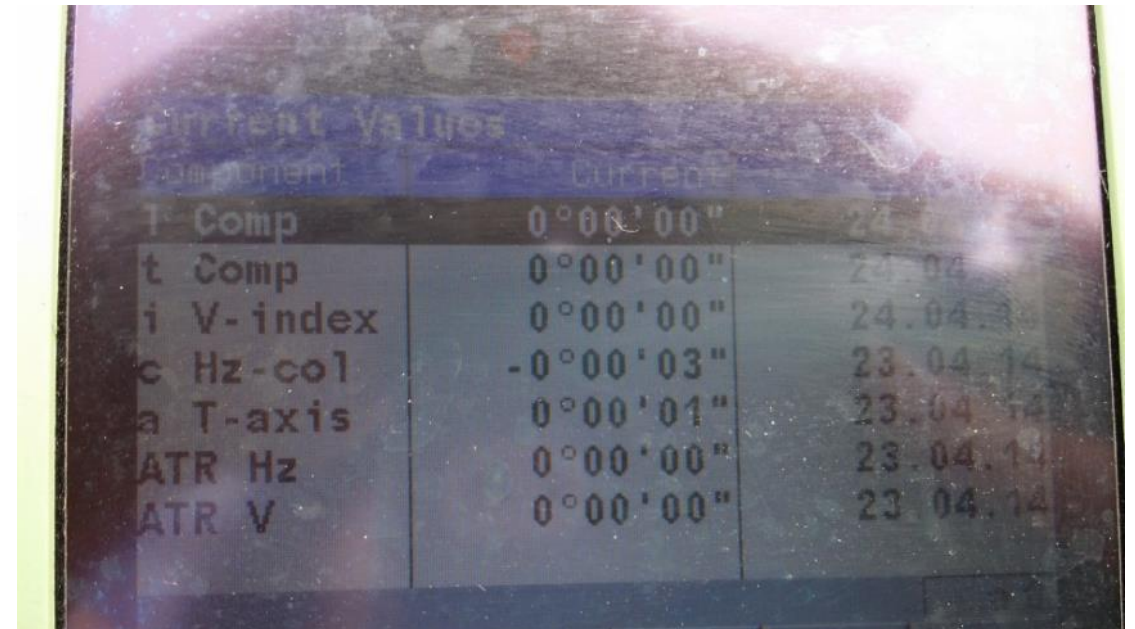


ADMS Survey – Location 5 (Independent Check)

- Verify the monitoring data on monthly basis
 - counter-check against the data produced by ADMS
- Manual Check by Conventional Survey Techniques
 - Traverse
 - Levelling

ADMS Survey – Location 5 (Quality Control)

- Maintenance/ Annual Calibration
- Cleaning of both RO and Monitoring Prisms
- Calibration of Total Station
 - Compensator Index Error
 - Vertical Index Error
 - Horizontal Collimation Error
 - ATR Hz, ATR V



Component	Current	
I-Comp	0°00'00"	24.04.14
t-Comp	0°00'00"	24.04.14
i V-index	0°00'00"	24.04.14
c Hz-col	-0°00'03"	23.04.14
a T-axis	0°00'01"	23.04.14
ATR Hz	0°00'00"	23.04.14
ATR V	0°00'00"	23.04.14

I, t

Compensator longitudinal and transversal index errors

i

Vertical index error, related to the standing axis

c

Horizontal collimation error, also called line of sight error

ATR Hz

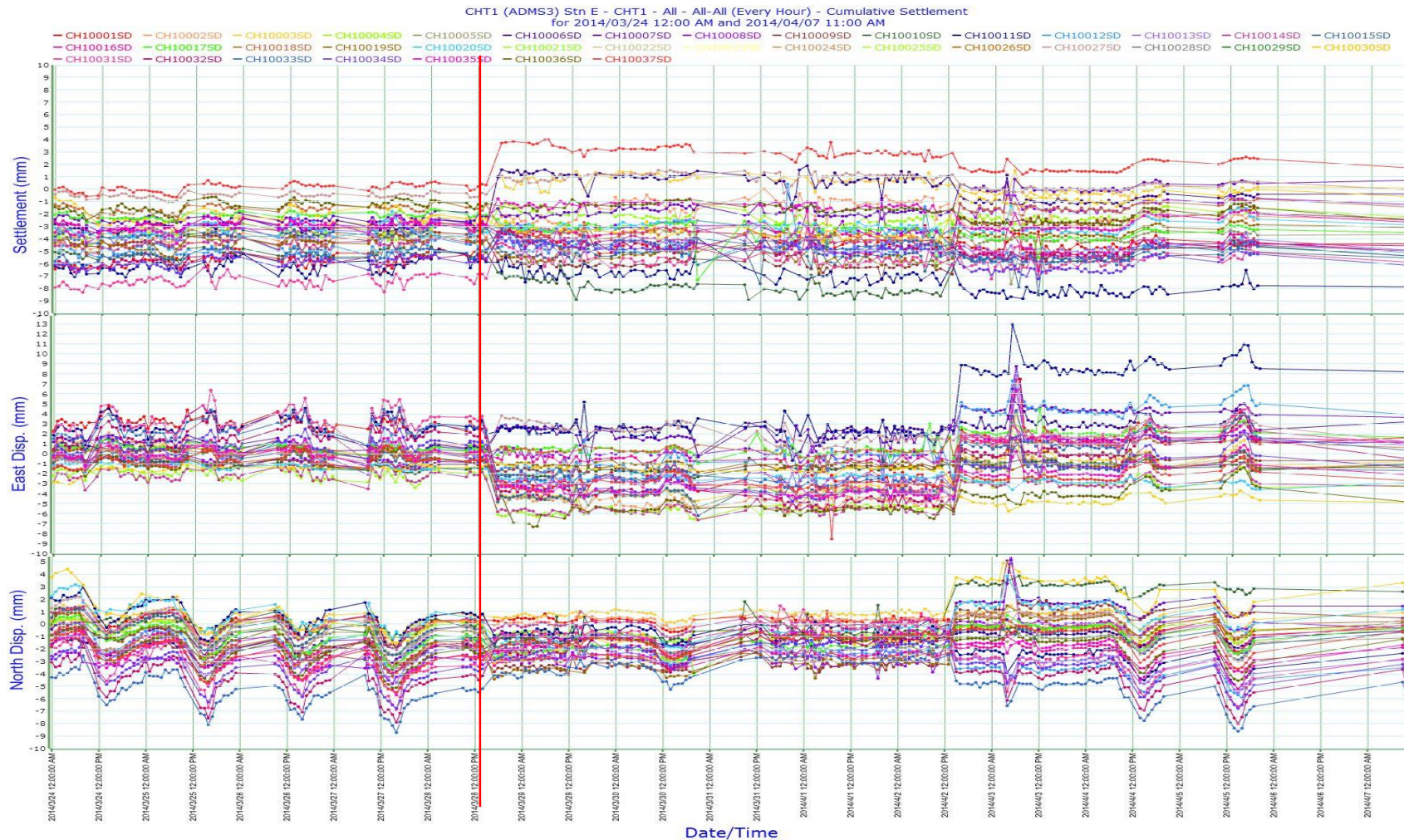
ATR zero point error for horizontal angle option

ATR V

ATR zero point error for vertical angle option

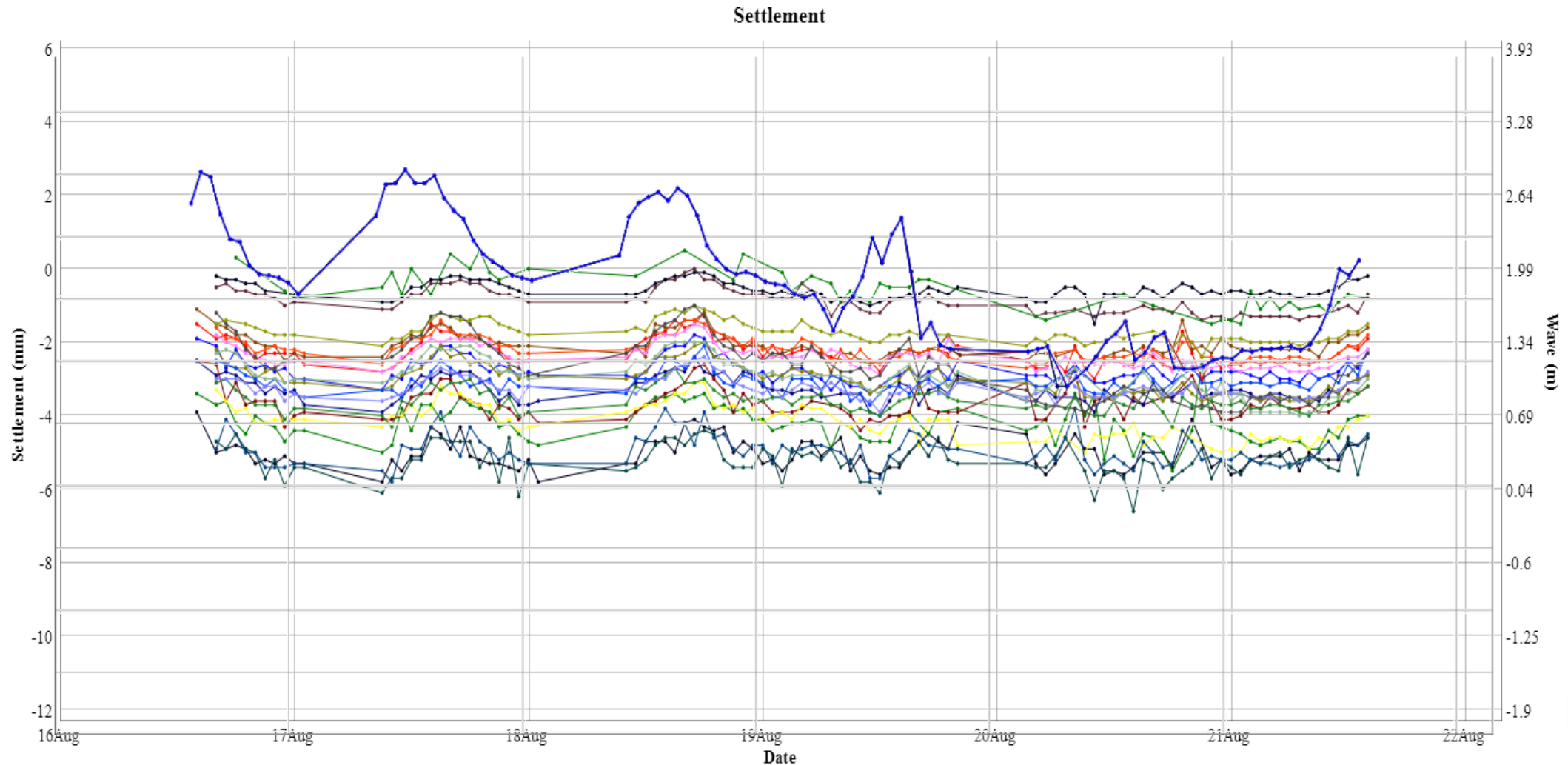
ADMS Survey – Location 5 (Implementation)

- Situation: Adding PVC Cover



ADMS Survey – Location 5 (Implementation)

- Situation: Effect of Temperature



ADMS Survey – Location 5 (Implementation)

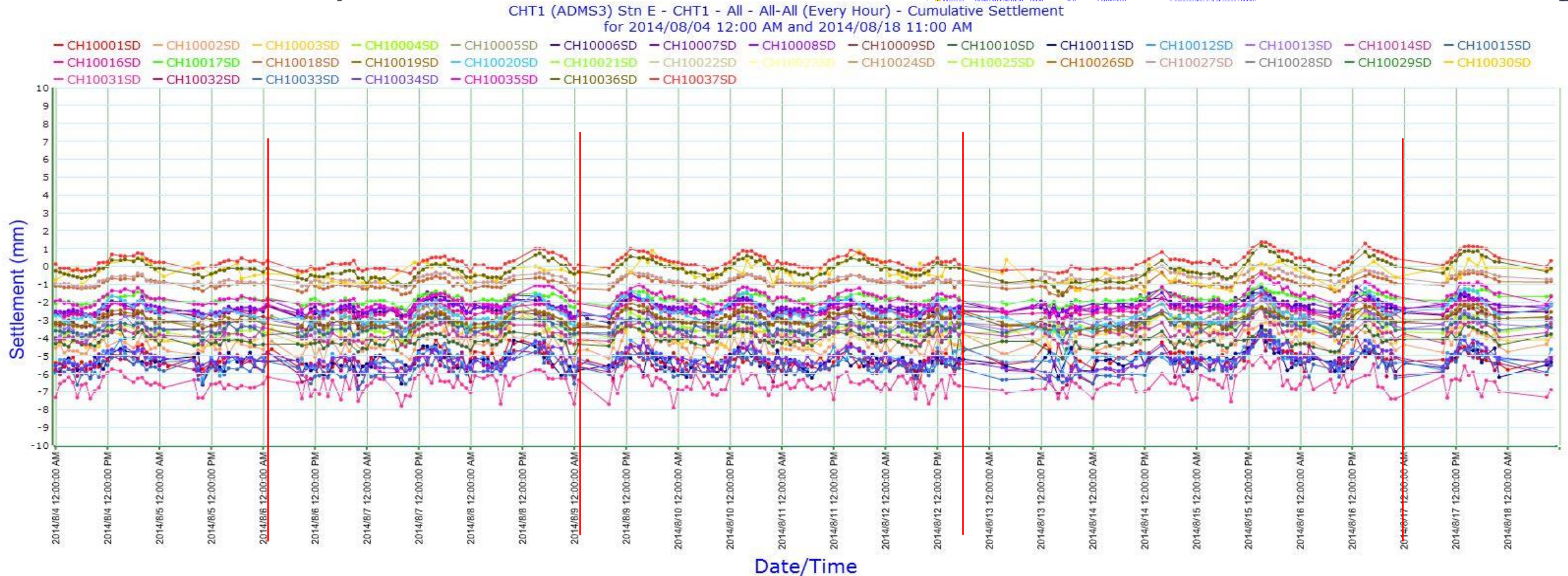
- Situation:
Compensator
out of range

GeoMos Monitor - Active Project: 'GeoMos Database'

File View Configuration Measurement Services Tools Help

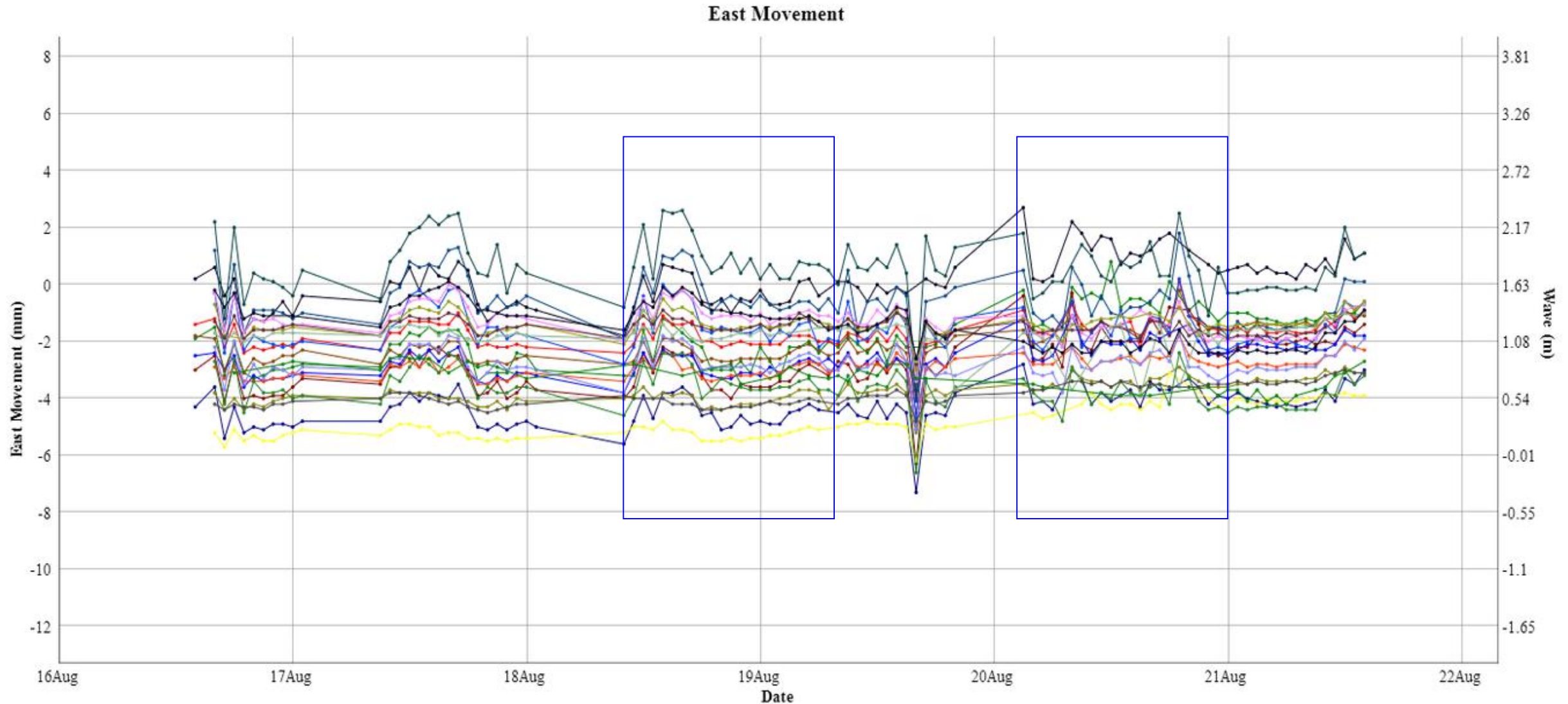
Point Group: Freestation

State	Time	Sensor	Profile	Point ID	Test
Info	18/08/2014 06:11:27	TM30			Point group measurement finished! (Pointgroup: 'Mon')
Message	18/08/2014 06:11:27	TM30	0-0	R5	Compensator out of range (TM30)
Message	18/08/2014 06:11:25	TM30	0-0	R2-3A	Compensator out of range (TM30)
Message	18/08/2014 06:11:22	TM30	0-0	R10	Compensator out of range (TM30)
Message	18/08/2014 06:11:20	TM30	0-0	REF5	Compensator out of range (TM30)
Message	18/08/2014 06:11:18	TM30	0-0	REF11	Compensator out of range (TM30)
Message	18/08/2014 06:11:16	TM30	0-0	R12	Compensator out of range (TM30)
Message	18/08/2014 06:11:14	TM30	0-0	R2-2	Compensator out of range (TM30)
Message	18/08/2014 06:11:12	TM30	0-0	R68	Compensator out of range (TM30)
Message	18/08/2014 06:11:10	TM30	0-0	CH10R21VB	Compensator out of range (TM30)
Message	18/08/2014 06:11:08	TM30	0-0	CH100M4VB	Compensator out of range (TM30)
Message	18/08/2014 06:11:06	TM30	0-0	CH100M2VB	Compensator out of range (TM30)
Message	18/08/2014 06:11:05	TM30	0-0	CH100M1VB	Compensator out of range (TM30)
Message	18/08/2014 06:11:03	TM30	0-0	CH10037SD	Compensator out of range (TM30)
Message	18/08/2014 06:11:01	TM30	0-0	CH10036SD	Compensator out of range (TM30)
Message	18/08/2014 06:10:59	TM30	0-0	CH10035SD	Compensator out of range (TM30)
Message	18/08/2014 06:10:57	TM30	0-0	CH10034SD	Compensator out of range (TM30)
Message	18/08/2014 06:10:56	TM30	0-0	CH10033SD	Compensator out of range (TM30)
Message	18/08/2014 06:10:54	TM30	0-0	CH10032SD	Compensator out of range (TM30)
Message	18/08/2014 06:10:52	TM30	0-0	CH10031SD	Compensator out of range (TM30)
Message	18/08/2014 06:10:50	TM30	0-0	CH10030SD	Compensator out of range (TM30)
Message	18/08/2014 06:10:48	TM30	0-0	CH10029SD	Compensator out of range (TM30)
Message	18/08/2014 06:10:47	TM30	0-0	CH10028SD	Compensator out of range (TM30)
Message	18/08/2014 06:10:45	TM30	0-0	CH10027SD	Compensator out of range (TM30)
Message	18/08/2014 06:10:44	TM30	0-0	CH10026SD	Compensator out of range (TM30)
Message	18/08/2014 06:10:42	TM30	0-0	CH10025SD	Compensator out of range (TM30)
Message	18/08/2014 06:10:40	TM30	0-0	CH10024SD	Compensator out of range (TM30)
Message	18/08/2014 06:10:38	TM30	0-0	CH10023SD	Compensator out of range (TM30)
Message	18/08/2014 06:10:36	TM30	0-0	CH10022SD	Compensator out of range (TM30)
Message	18/08/2014 06:10:34	TM30	0-0	CH10021SD	Compensator out of range (TM30)
Message	18/08/2014 06:10:32	TM30	0-0	CH10020SD	Compensator out of range (TM30)
Message	18/08/2014 06:10:30	TM30	0-0	CH10019SD	Compensator out of range (TM30)
Message	18/08/2014 06:10:28	TM30	0-0	CH10018SD	Compensator out of range (TM30)
Message	18/08/2014 06:10:26	TM30	0-0	CH10017SD	Compensator out of range (TM30)
Message	18/08/2014 06:10:24	TM30	0-0	CH10016SD	Compensator out of range (TM30)
Message	18/08/2014 06:10:22	TM30	0-0	CH10015SD	Compensator out of range (TM30)
Message	18/08/2014 06:10:20	TM30	0-0	CH10014SD	Compensator out of range (TM30)
Message	18/08/2014 06:10:18	TM30	0-0	CH10013SD	Compensator out of range (TM30)
Message	18/08/2014 06:10:16	TM30	0-0	CH10012SD	Compensator out of range (TM30)
Message	18/08/2014 06:10:14	TM30	0-0	CH10011SD	Compensator out of range (TM30)
Message	18/08/2014 06:10:12	TM30	0-0	CH10010SD	Compensator out of range (TM30)
Message	18/08/2014 06:10:10	TM30	0-0	CH10009SD	Compensator out of range (TM30)
Message	18/08/2014 06:10:08	TM30	0-0	CH10008SD	Compensator out of range (TM30)
Message	18/08/2014 06:10:06	TM30	0-0	CH10007SD	Compensator out of range (TM30)
Message	18/08/2014 06:10:04	TM30	0-0	CH10006SD	Compensator out of range (TM30)
Message	18/08/2014 06:10:02	TM30	0-0	CH10005SD	Compensator out of range (TM30)
Message	18/08/2014 06:10:00	TM30	0-0	CH10004SD	Compensator out of range (TM30)
Message	18/08/2014 06:09:58	TM30	0-0	CH10003SD	Compensator out of range (TM30)
Message	18/08/2014 06:09:56	TM30	0-0	CH10002SD	Compensator out of range (TM30)
Message	18/08/2014 06:09:54	TM30	0-0	CH10001SD	Compensator out of range (TM30)



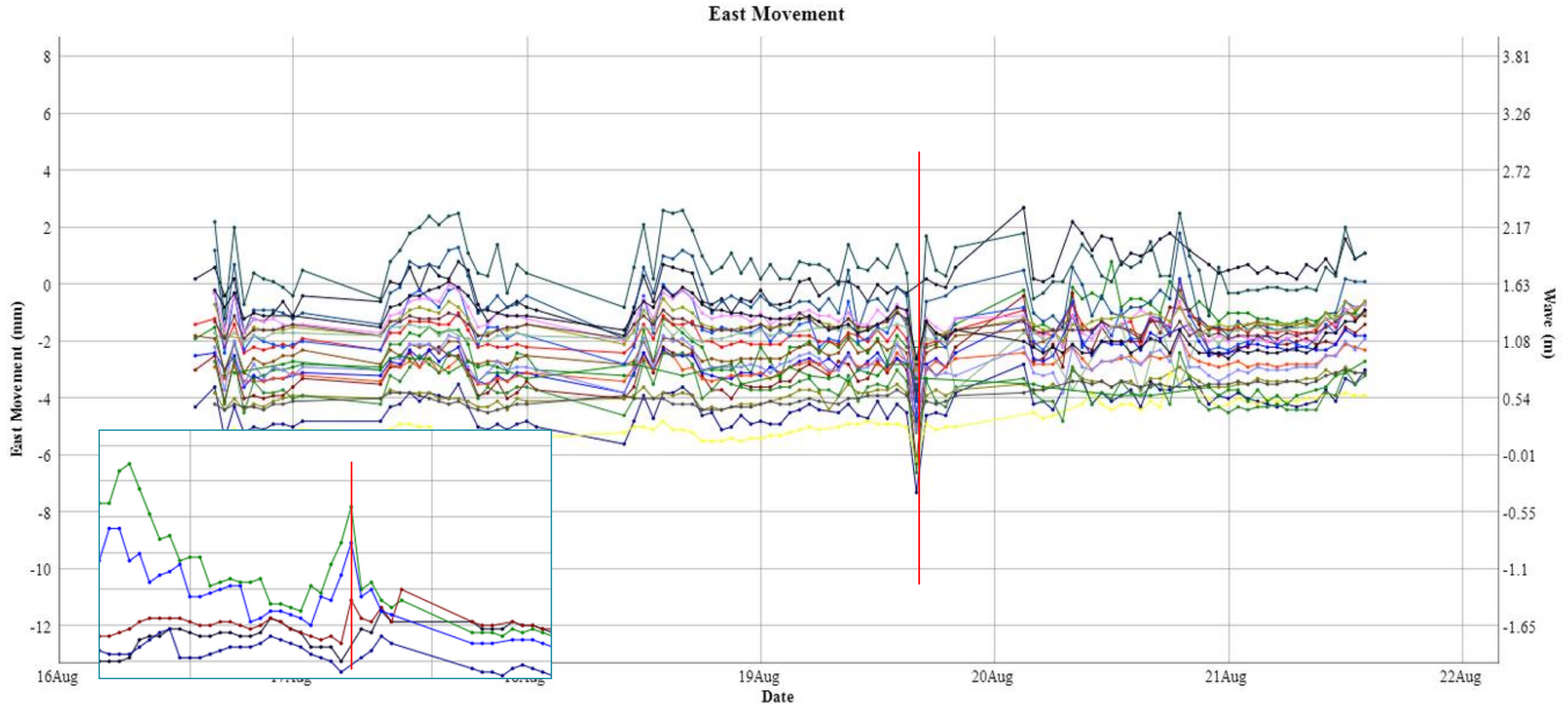
ADMS Survey – Location 5 (Implementation)

- Situation: Extreme Weather

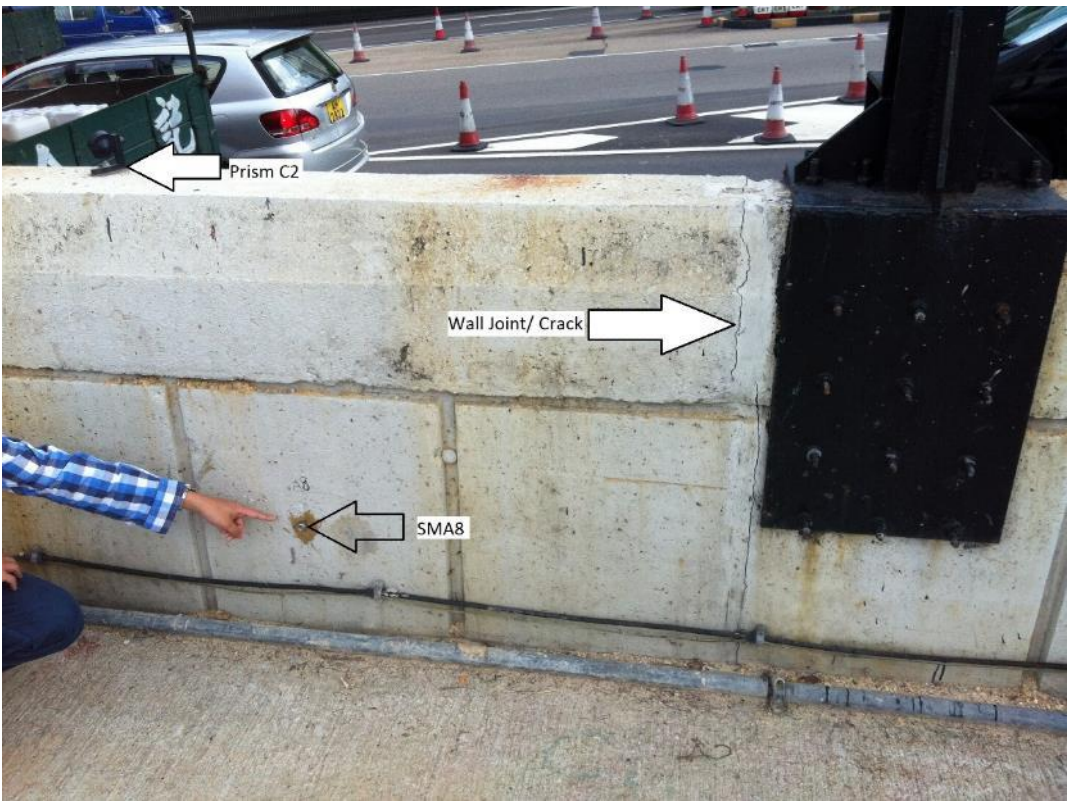


ADMS Survey – Location 5 (Implementation)

- Situation: Insufficient RO for Freestation



Manuel Survey Check



Manuel Survey Check



Manuel Survey Check



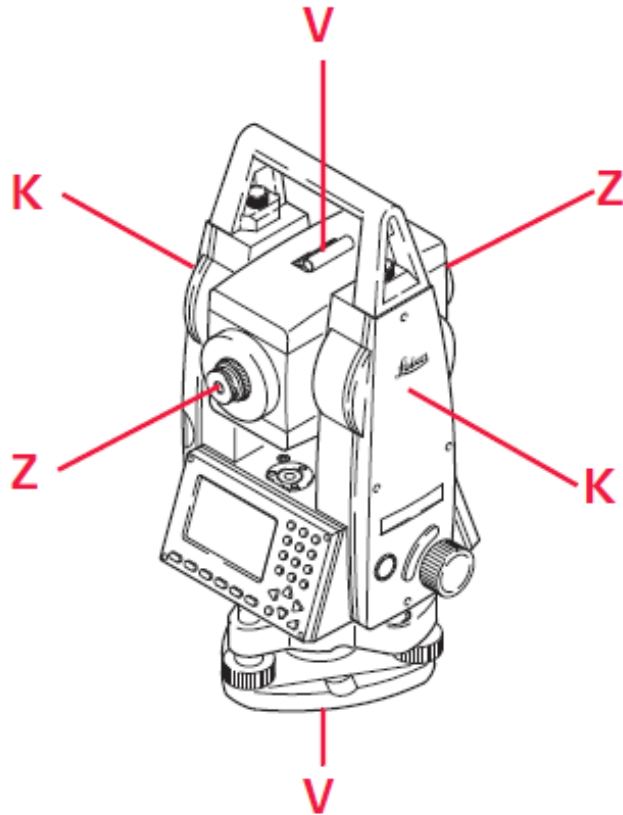
4 rounds 4 arcs precise measurement

- ▶ Face left & Face right observation
- ▶ 4 Rounds 4 arcs
- ▶ Horizontal closed (Horizontal angular closed method)

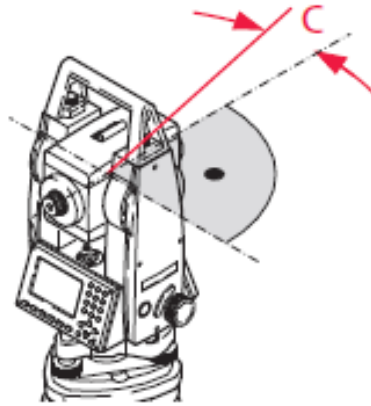
4 rounds 4 arcs precise measurement - Face left & Face right observation

- a) Line of sight ZZ perpendicular to tilting axis KK
- b) Tilting axis KK perpendicular to vertical axis VV
- c) Vertical axis VV strictly vertical
- d) Vertical-circle reading precisely zero at the zenith

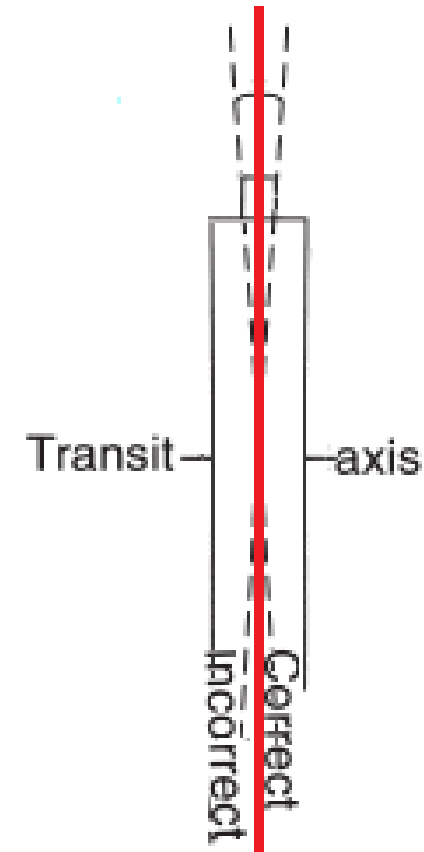
► Eliminate errors



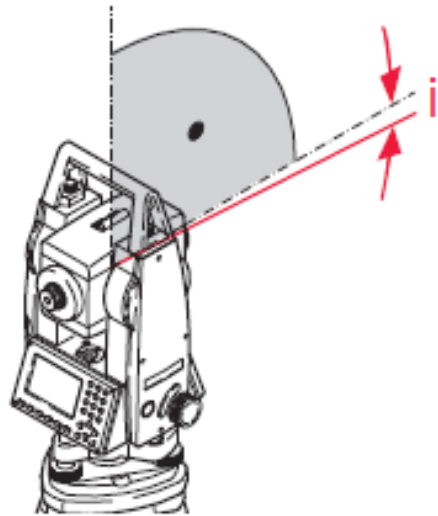
4 rounds 4 arcs precise measurement - Collimation error



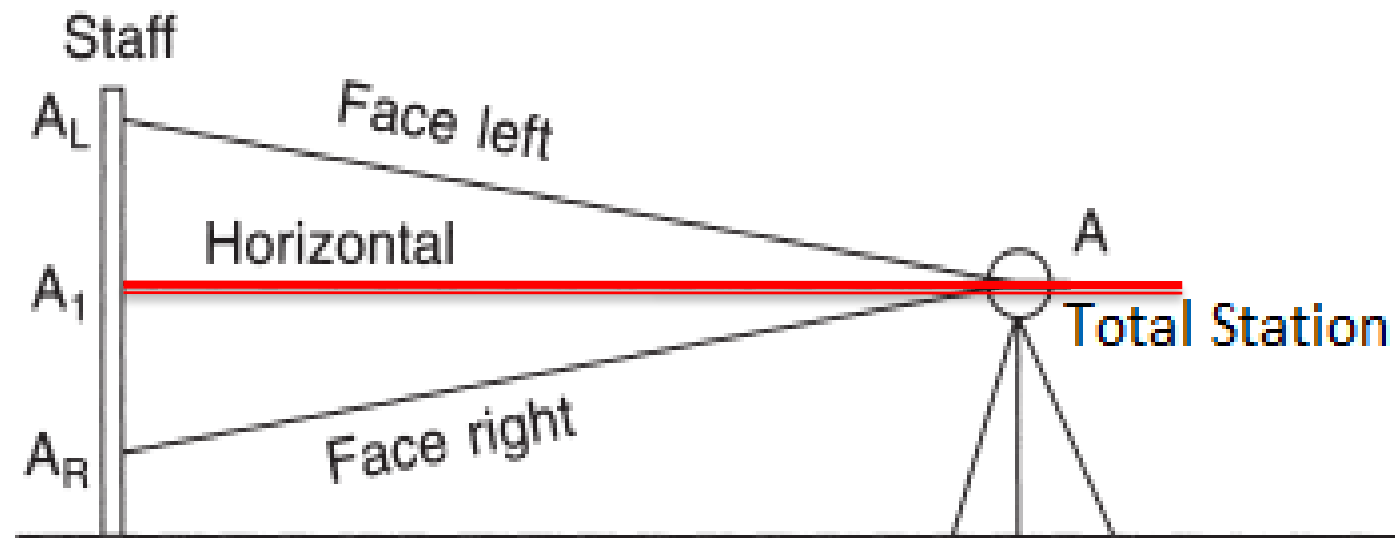
Line-of-sight error (c)
(Hz collimation)



4 rounds 4 arcs precise measurement - Height-index error

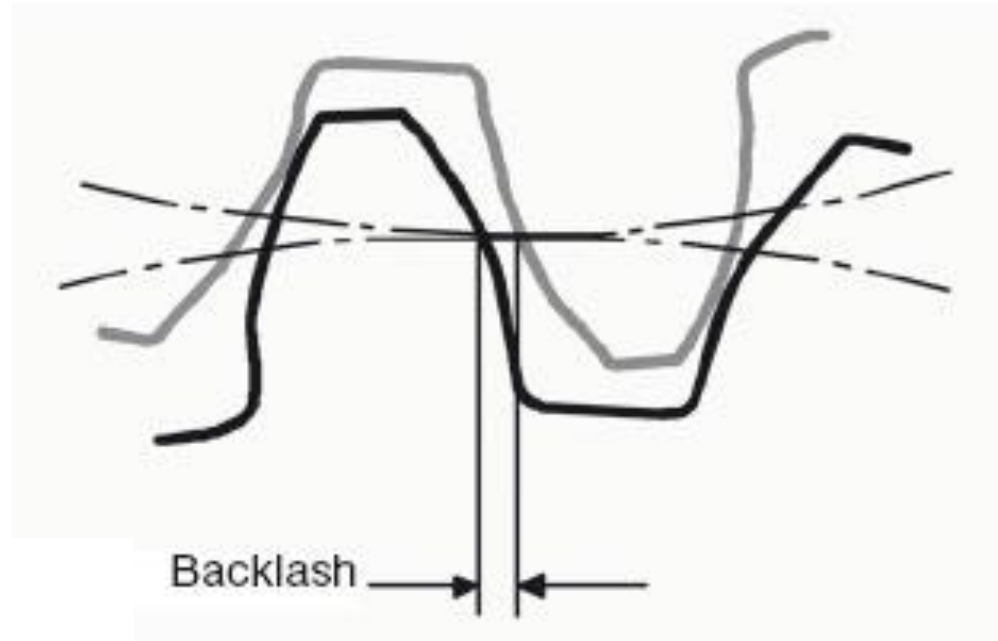
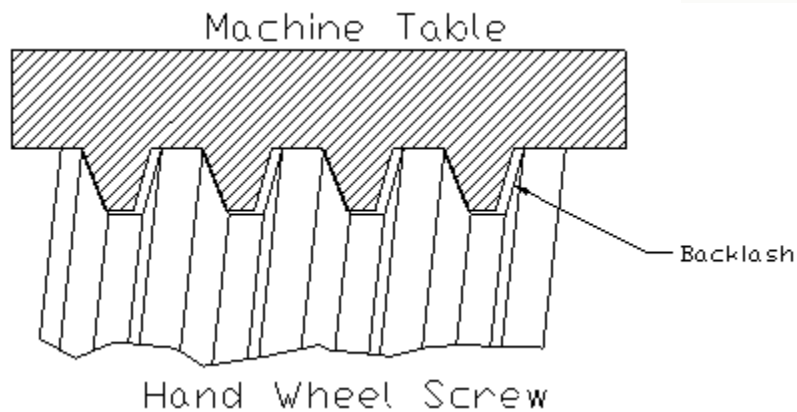


Height-index error (i)
(V index)



4 rounds 4 arcs precise measurement - Backlash

- ▶ Backlash is the clearance formed between a pair of gears.



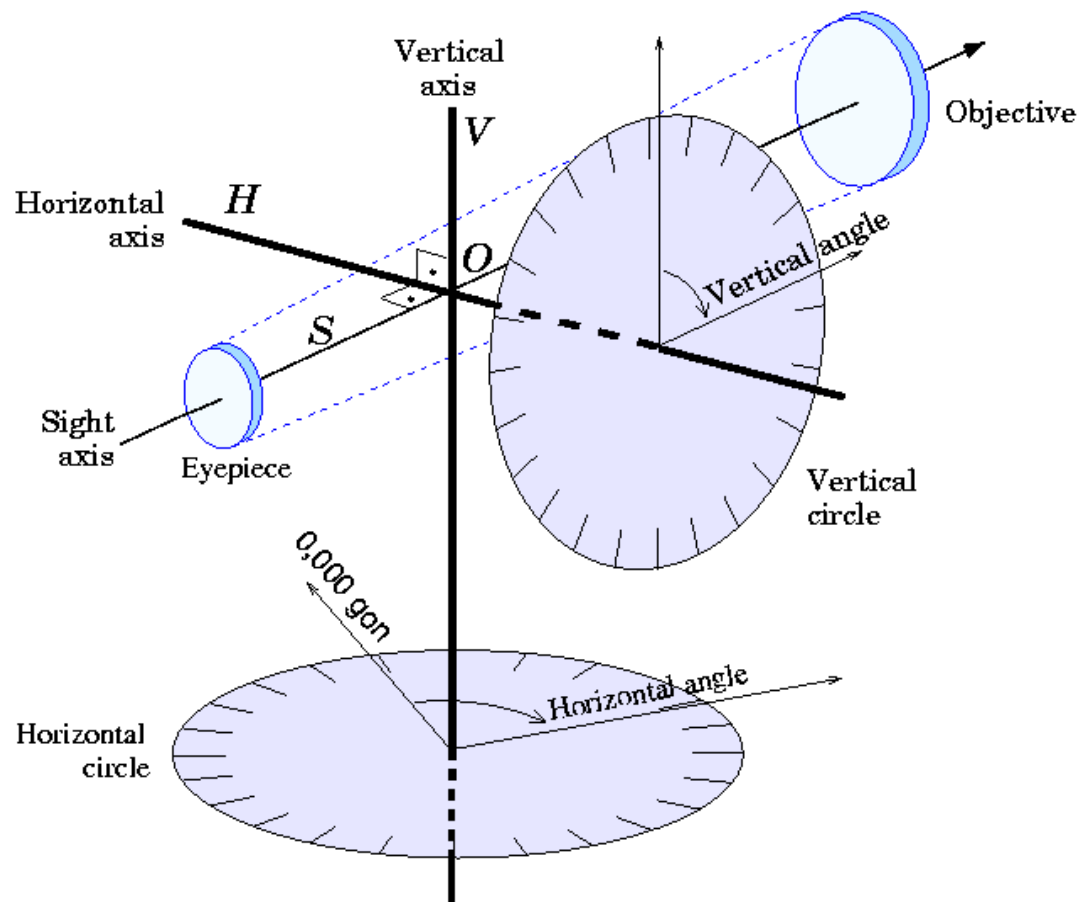
4 rounds 4 arcs precise measurement - Backlash

- ▶ Face Left observation: always turn in clockwise direction
- ▶ Face Right observation: always turn in counter-clockwise direction.

4 rounds 4 arcs precise measurement

- ▶ Eliminate Circle graduation errors
- ▶ Calculation S.Dev

$$\sigma = \sqrt{\frac{1}{N} \sum_{i=1}^N (x_i - \bar{x})^2}$$



4 rounds 4 arcs precise measurement

► Face left:

000-00-00

090-00-00

045-00-00

135-00-00

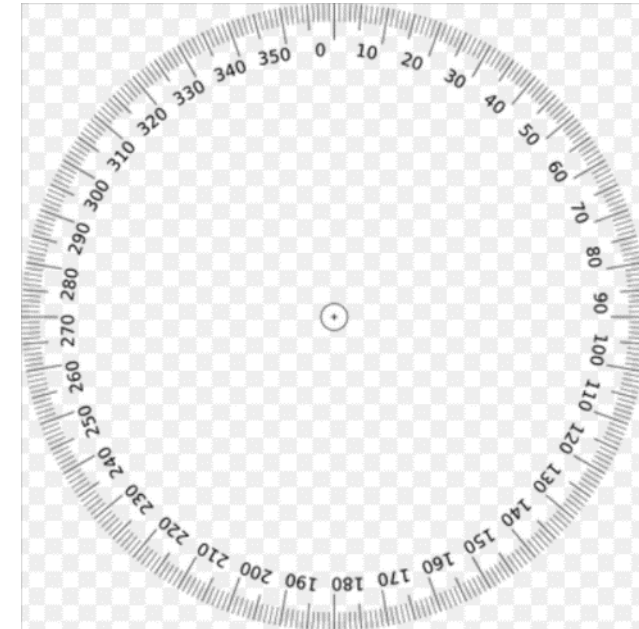
Face Right:

180-00-00

270-00-00

225-00-00

315-00-00

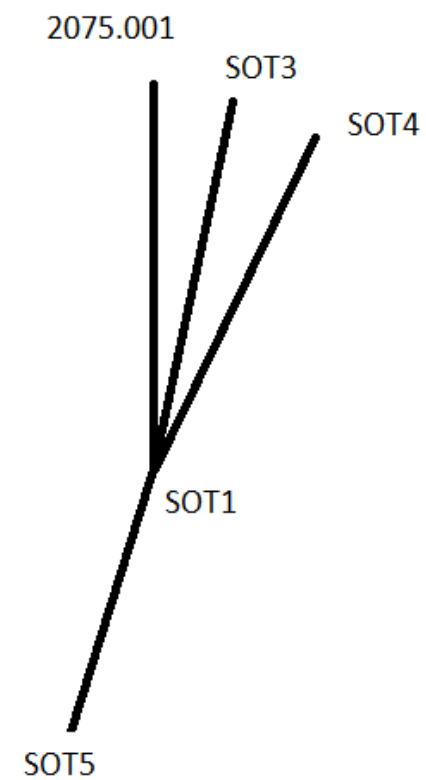


4 rounds 4 arcs precise measurement - Horizontal close

- ▶ To ensure the Total station have not been moved during the observation.
- ▶ Check to see if it is 360°

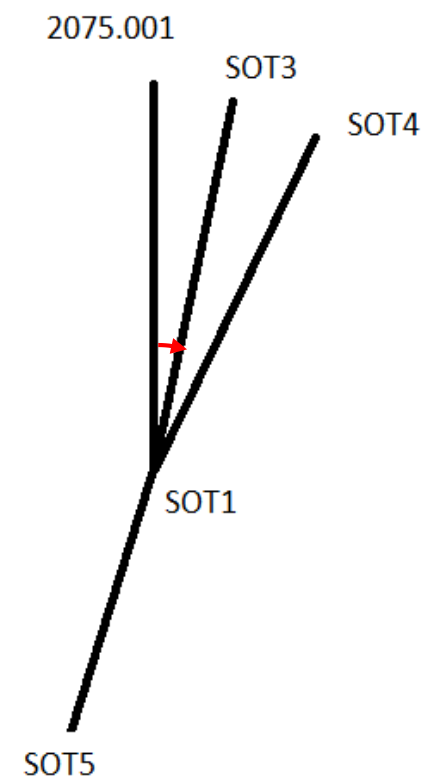
4 rounds 4 arcs precise measurement

		Observation (DD.MMSS)
@ At STN:	SOT1	
STN:	1L	
RO	2075.001	0.0000
	SOT3	
	SOT4	
	SOT5	
	2075.001	



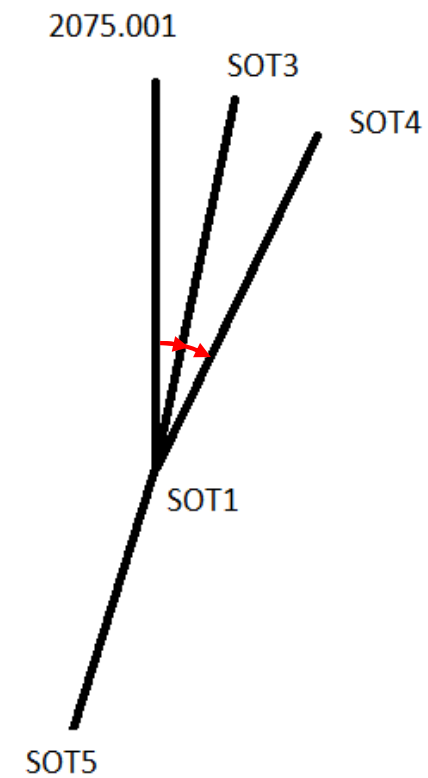
4 rounds 4 arcs precise measurement

		Observation (DD.MMSS)
@ At STN:	SOT1	
STN:	1L	
RO	2075.001	0.0000
	SOT3	8.1649
	SOT4	
	SOT5	
	2075.001	



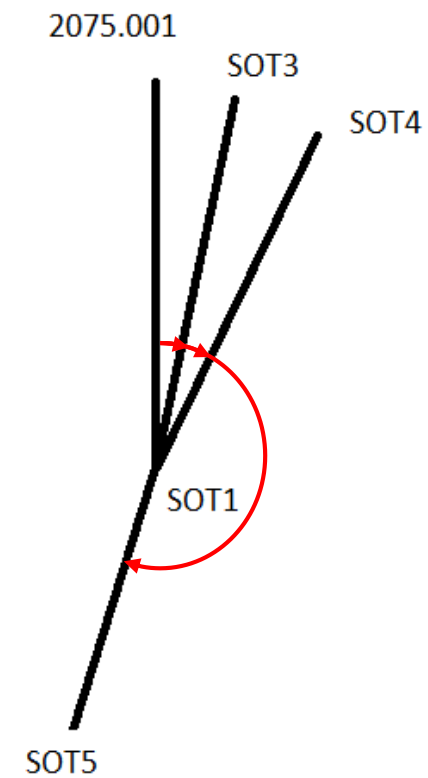
4 rounds 4 arcs precise measurement

		Observation (DD.MMSS)
@ At STN:	SOT1	
STN:	1L	
RO	2075.001	0.0000
	SOT3	8.1649
	SOT4	22.4313
	SOT5	
	2075.001	



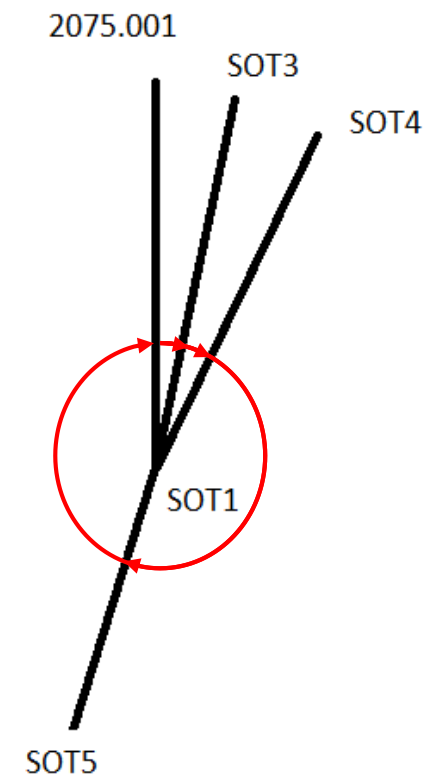
4 rounds 4 arcs precise measurement

		Observation (DD.MMSS)
@ At STN:	SOT1	
STN:	1L	
RO	2075.001	0.0000
	SOT3	8.1649
	SOT4	22.4313
	SOT5	192.4116
	2075.001	



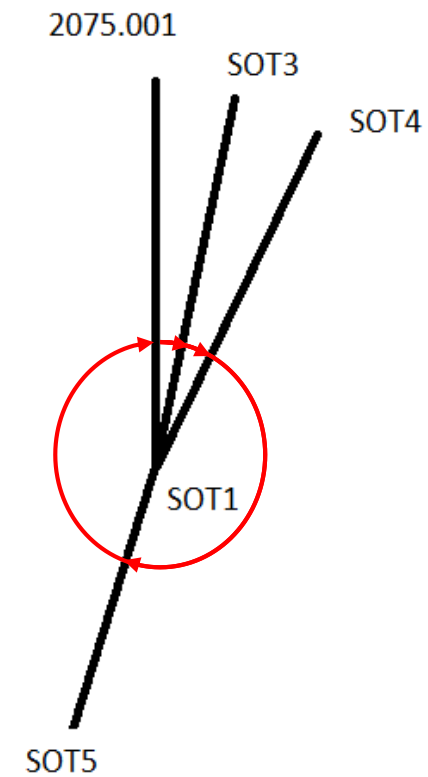
4 rounds 4 arcs precise measurement

		Observation (DD.MMSS)
@ At STN:	SOT1	
STN:	1L	
RO	2075.001	0.0000
	SOT3	8.1649
	SOT4	22.4313
	SOT5	192.4116
	2075.001	359.5958



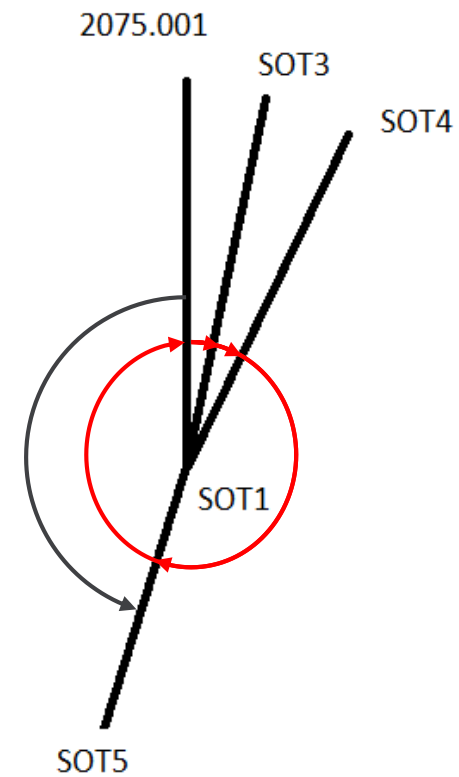
4 rounds 4 arcs precise measurement

		Observation (DD.MMSS)	
@ At STN:	SOT1		
STN:	1L		
RO	2075.001	0.0000	
	SOT3	8.1649	
	SOT4	22.4313	
	SOT5	192.4116	
	2075.001	359.5958	180.0002



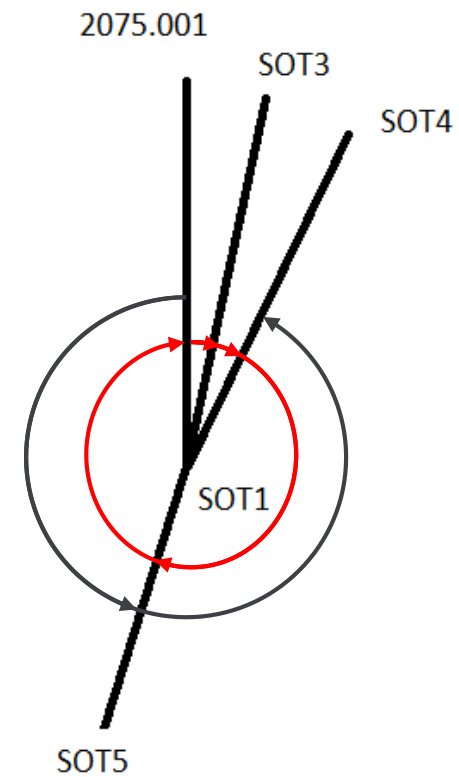
4 rounds 4 arcs precise measurement

		Observation (DD.MMSS)	
@ At STN:	SOT1		
STN:	1L		
RO	2075.001	0.0000	
	SOT3	8.1649	
	SOT4	22.4313	
	SOT5	192.4116	12.4116
	2075.001	359.5958	180.0002



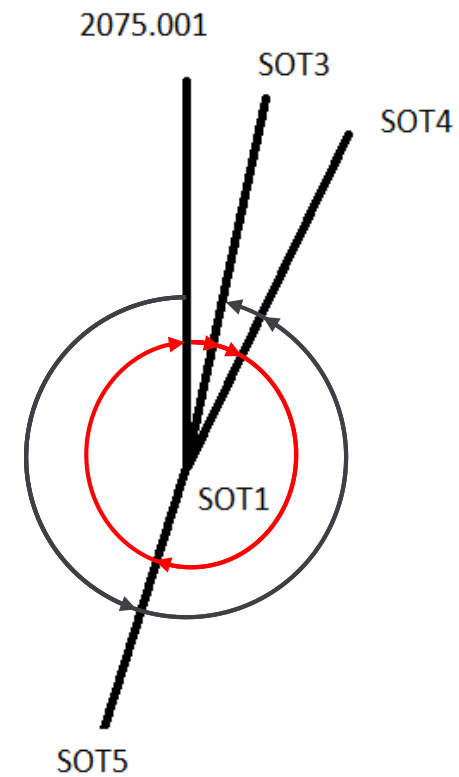
4 rounds 4 arcs precise measurement

		Observation (DD.MMSS)	
@ At STN:	SOT1		
	STN:	1L	
RO	2075.001	0.0000	
	SOT3	8.1649	
	SOT4	22.4313	202.4310
	SOT5	192.4116	12.4116
	2075.001	359.5958	180.0002



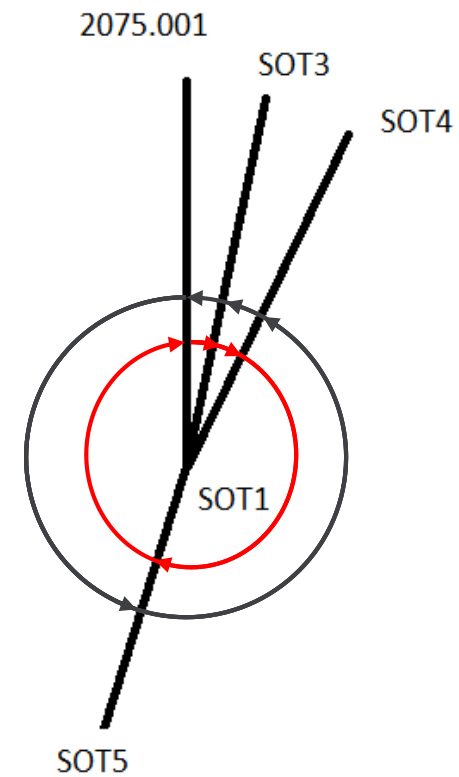
4 rounds 4 arcs precise measurement

		Observation (DD.MMSS)	
@ At STN:	SOT1		
	STN:	1L	
RO	2075.001	0.0000	
	SOT3	8.1649	188.1639
	SOT4	22.4313	202.4310
	SOT5	192.4116	12.4116
	2075.001	359.5958	180.0002



4 rounds 4 arcs precise measurement

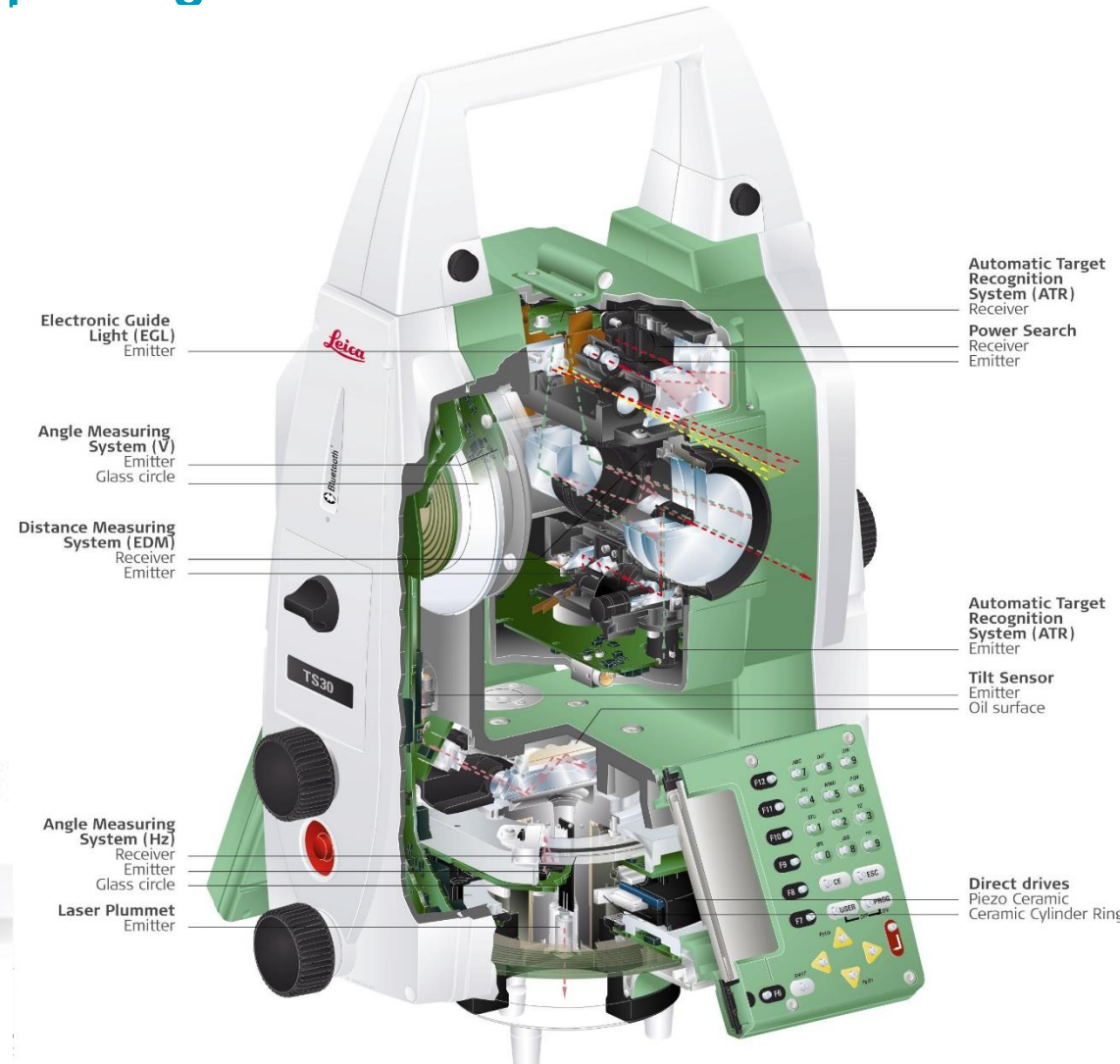
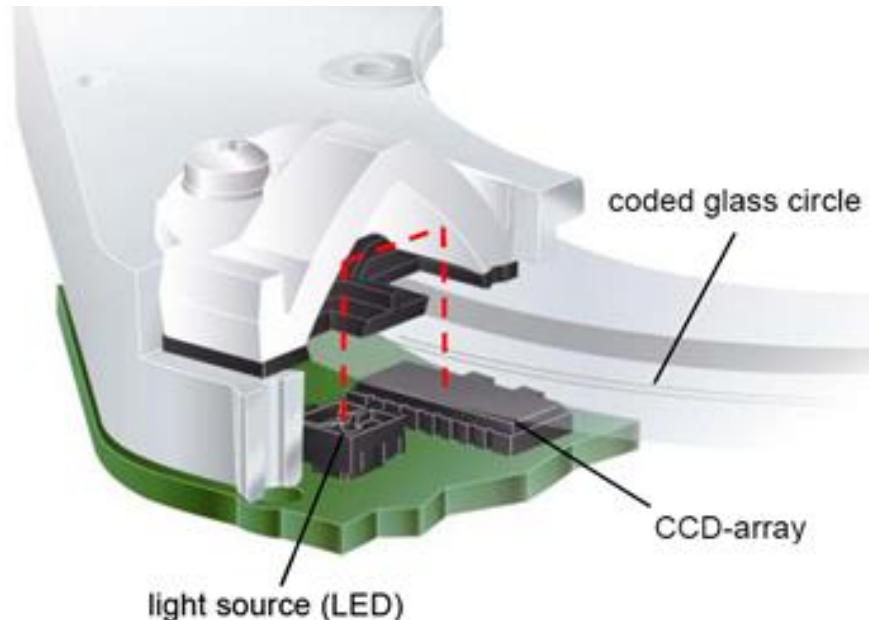
		Observation (DD.MMSS)	
@ At STN:	SOT1		
	STN:	1L	1R
RO	2075.001	0.0000	180.0001
	SOT3	8.1649	188.1639
	SOT4	22.4313	202.4310
	SOT5	192.4116	12.4116
	2075.001	359.5958	180.0002



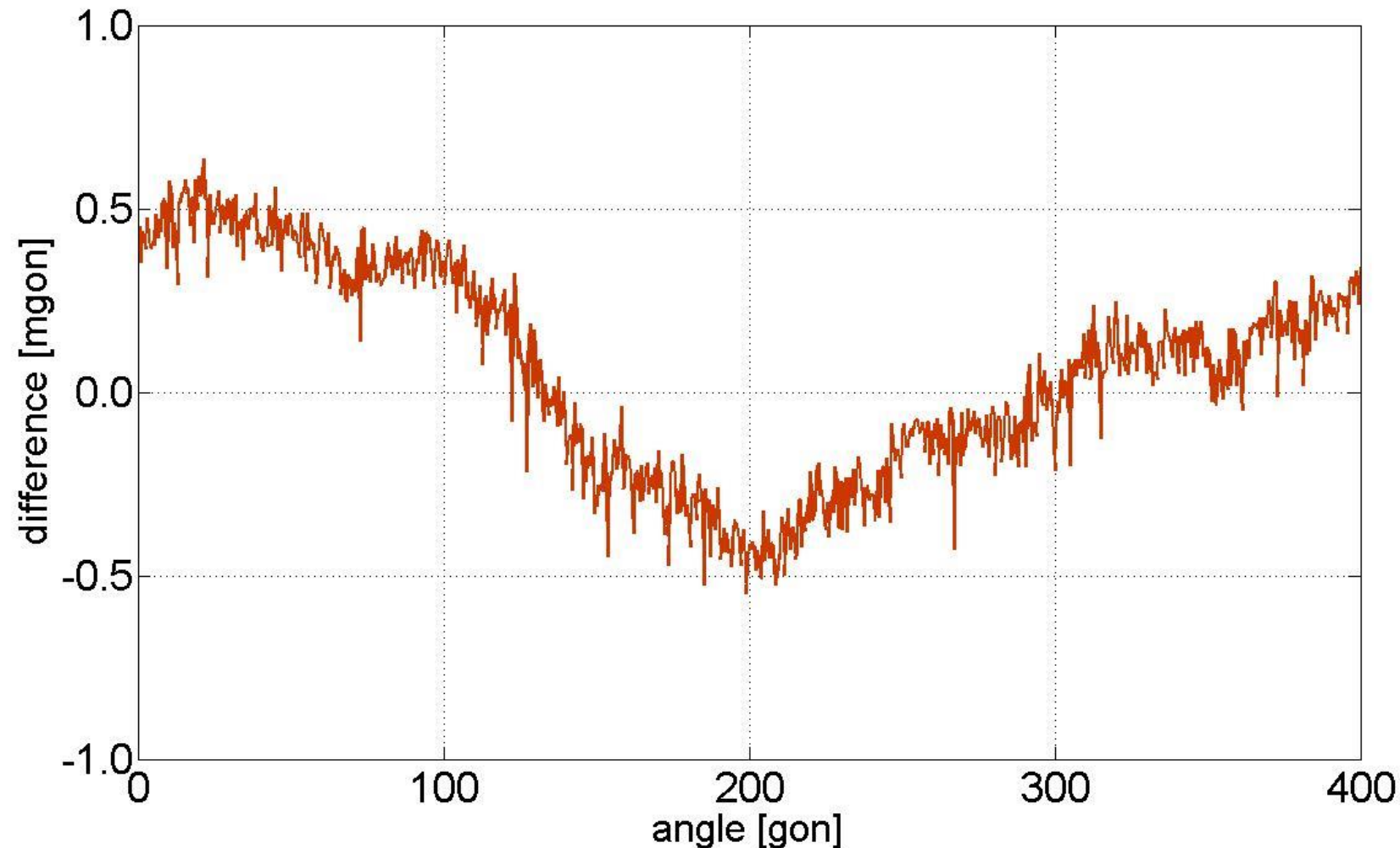
4 rounds 4 arcs precise measurement – Quadruple angle detection in TM/S 30/50

- ▶ Quadruple angle detection
 - 4 encoders: elimination of further minor π -periodic errors
 - 5000Hz, absolute, continuous
 - Precision improvement about 30%

$$\sigma_{4encoder} = \frac{1}{\sqrt{2}} \sigma_{2encoder}$$

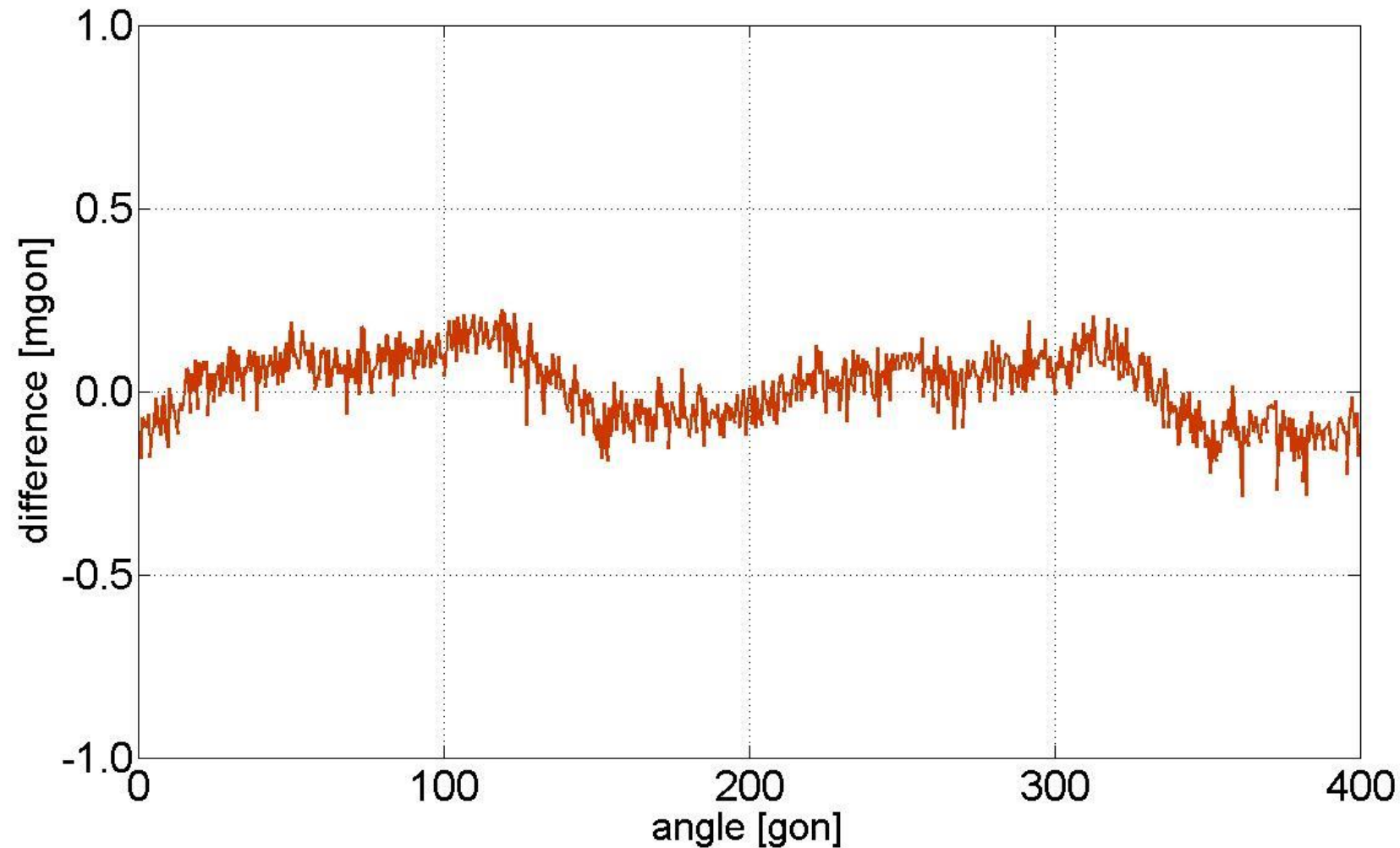


4 rounds 4 arcs precise measurement – Quadruple angle detection in TM/S 30/50



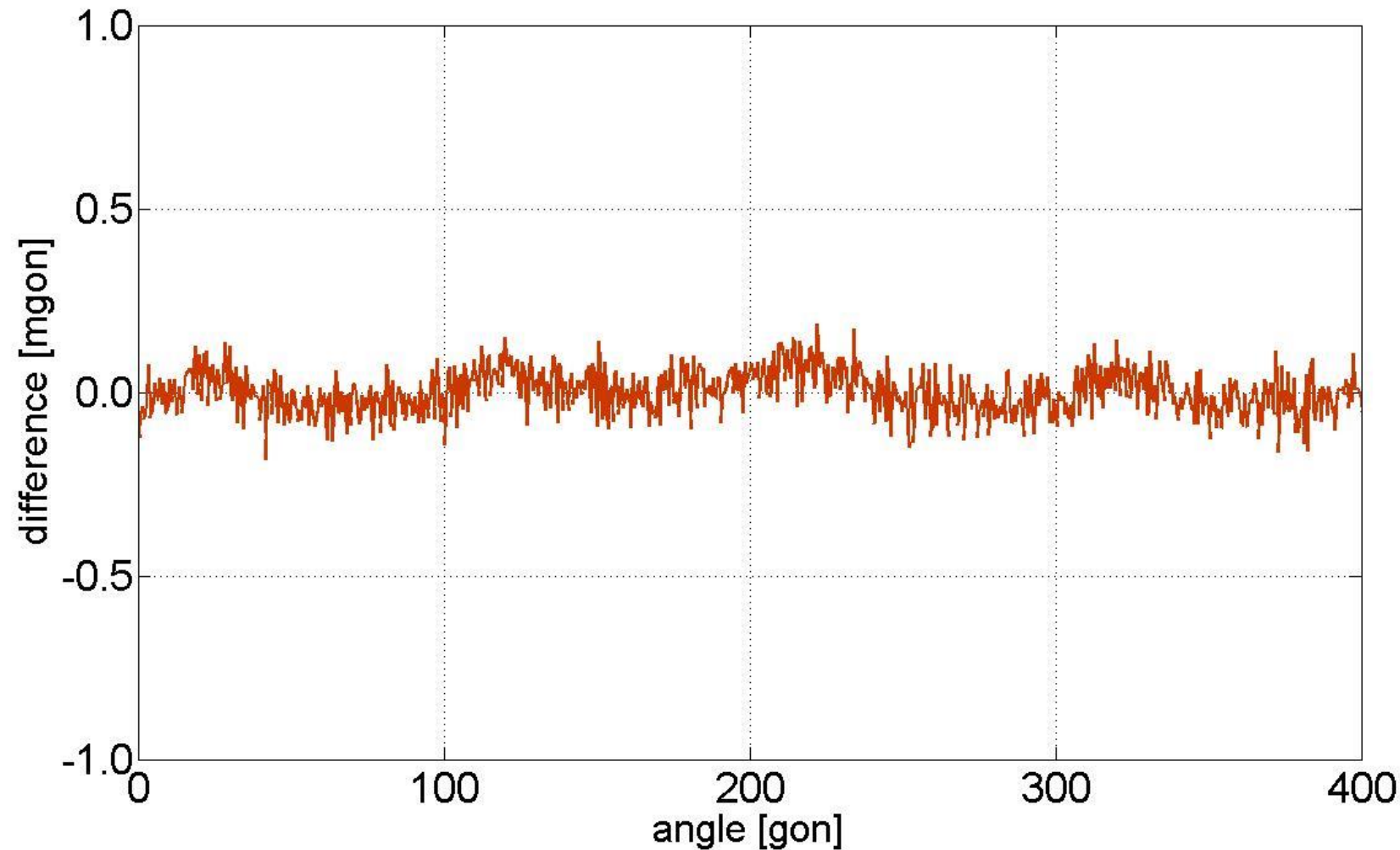
1 Encoder
 $\sigma = 0.981''$ (0.303mgon)

4 rounds 4 arcs precise measurement – Quadruple angle detection in TM/S 30/50



2 Encoder
 $\sigma = 0.301''$ (0.093mgon)

4 rounds 4 arcs precise measurement – Quadruple angle detection in TM/S 30/50

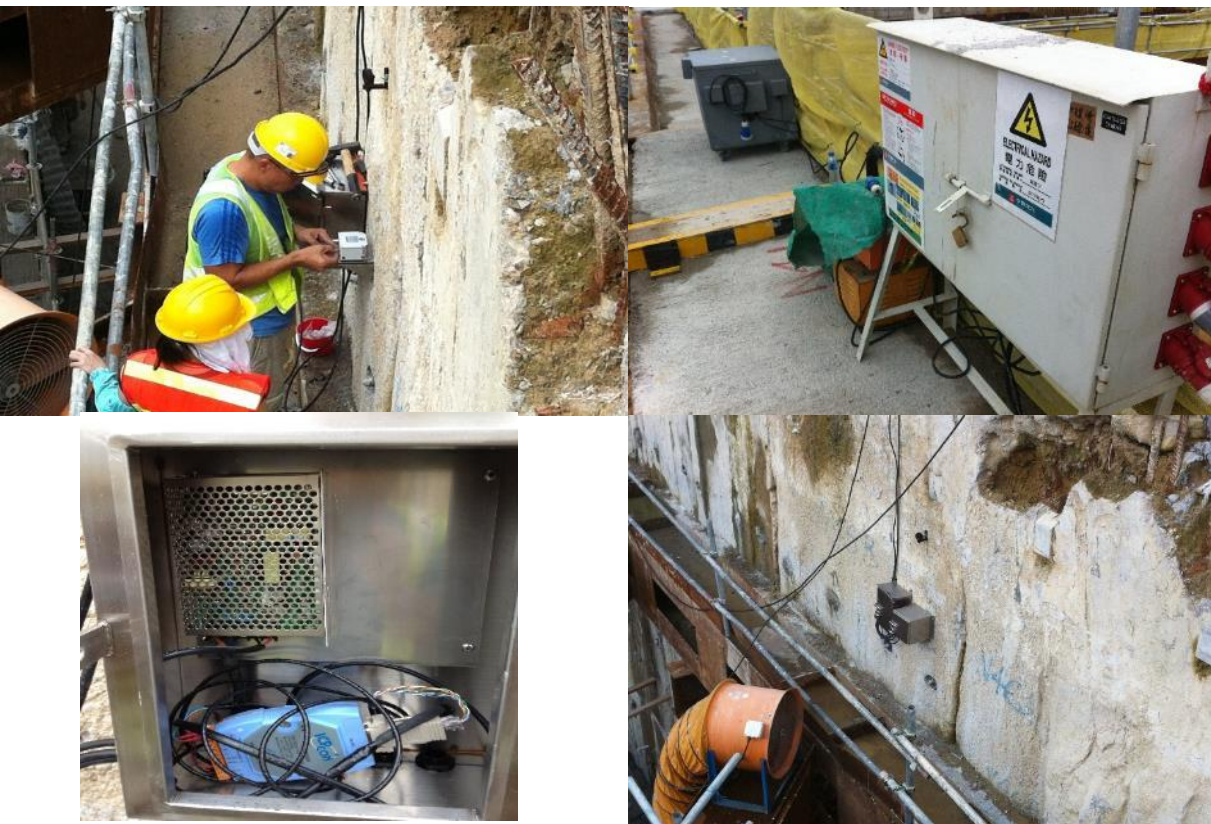


4 Encoder
 $\sigma = 0.203''$ (0.063mgon)

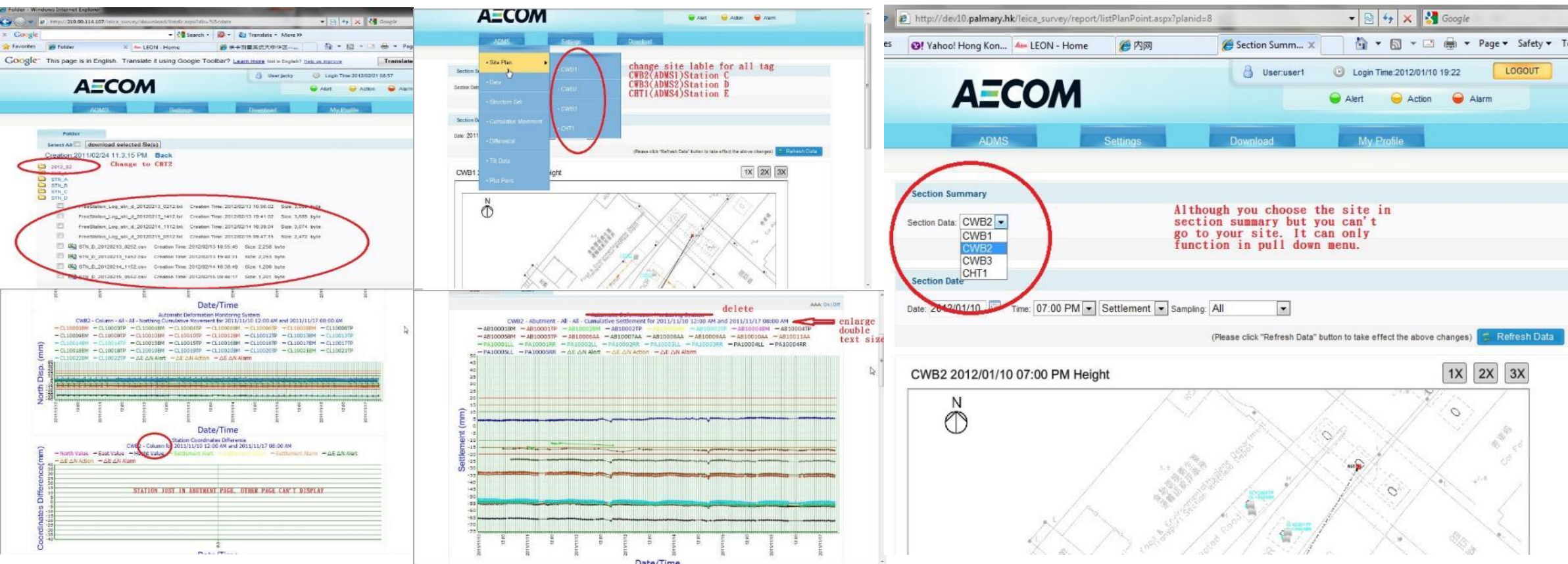
GNSS Reference Station



Monitoring using Nivel



Web Interface



—— 谢 谢 ——

A decorative graphic at the bottom of the slide consisting of several overlapping triangles pointing upwards. The triangles are in various shades of blue and green, creating a layered, mountain-like effect.