Geodetic Monitoring Solutions for large infrastructure projects,

An example from Cable-Stayed Bridge Health Monitoring in Korea

MALAYSIA GEOSPATIAL FORUM 2012

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Application Engineer

Trimble

Trimble Monitoring Solutions

Common request in all monitoring applications

Information

+ Time

Trend

Trimble

Trimble Monitoring Solutions

Different jobs require different sensors

- Optical Total Stations
  - High accuracy positioning
  - Can observe multiple points
  - Relatively short distances <2,5km

- GNSS Sensors
  - Large distances
  - High data rate
  - Precise differential positioning
  - Limited to one point

Trimble

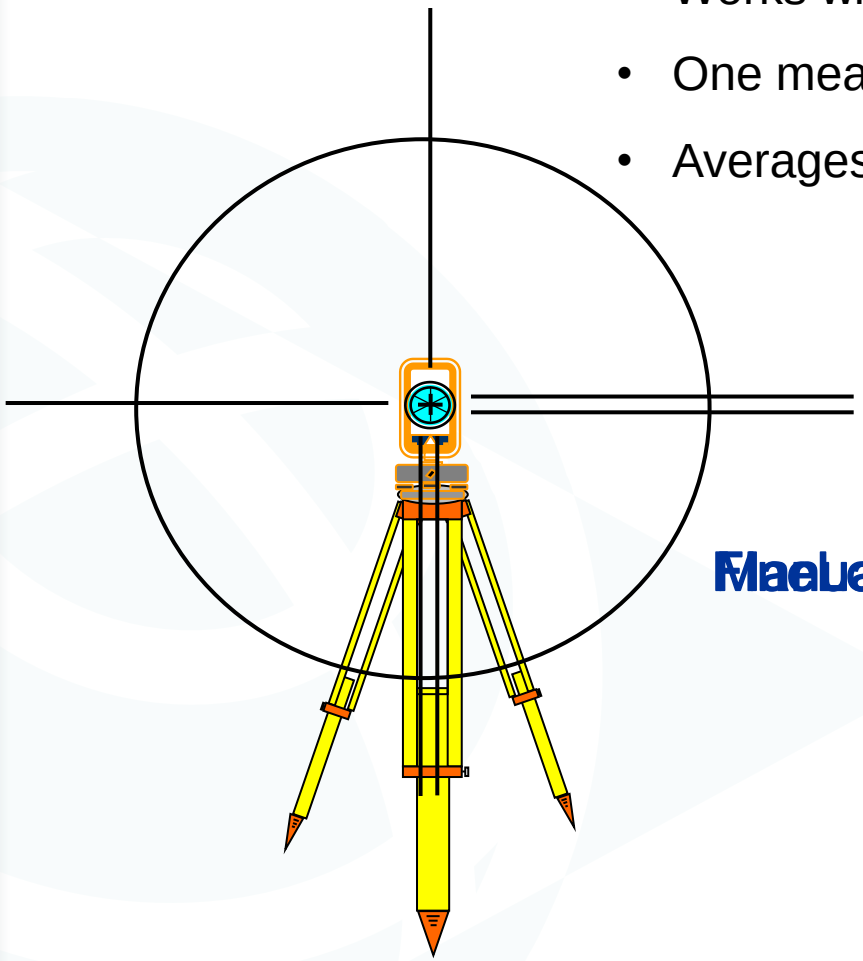
New Instrument and Technology

Trimble S8 with FineLock™

- Angle accuracy: 0.5” or 1”
- Distance accuracy: 0.8 mm + 1 ppm
- FineLock accuracy: <1 mm at 300 m
- Available as Autolock and Robotic
- MagDrive™
- SurePoint™
- Optional Long Range FineLock™
  - → Accuracy: <10 mm at 2,500 m

Trimble S8 Total Station

FineLock™



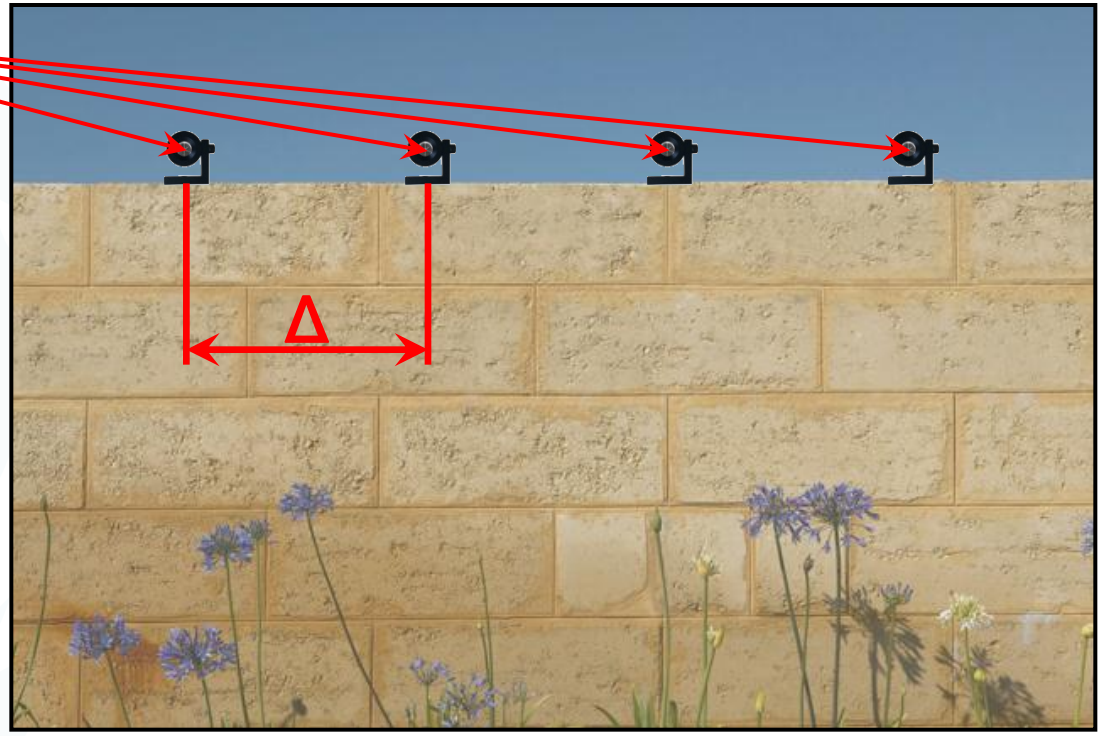
- Works with 333 Hz
- One measurement takes two seconds
- Averages 670 aimings per measurement

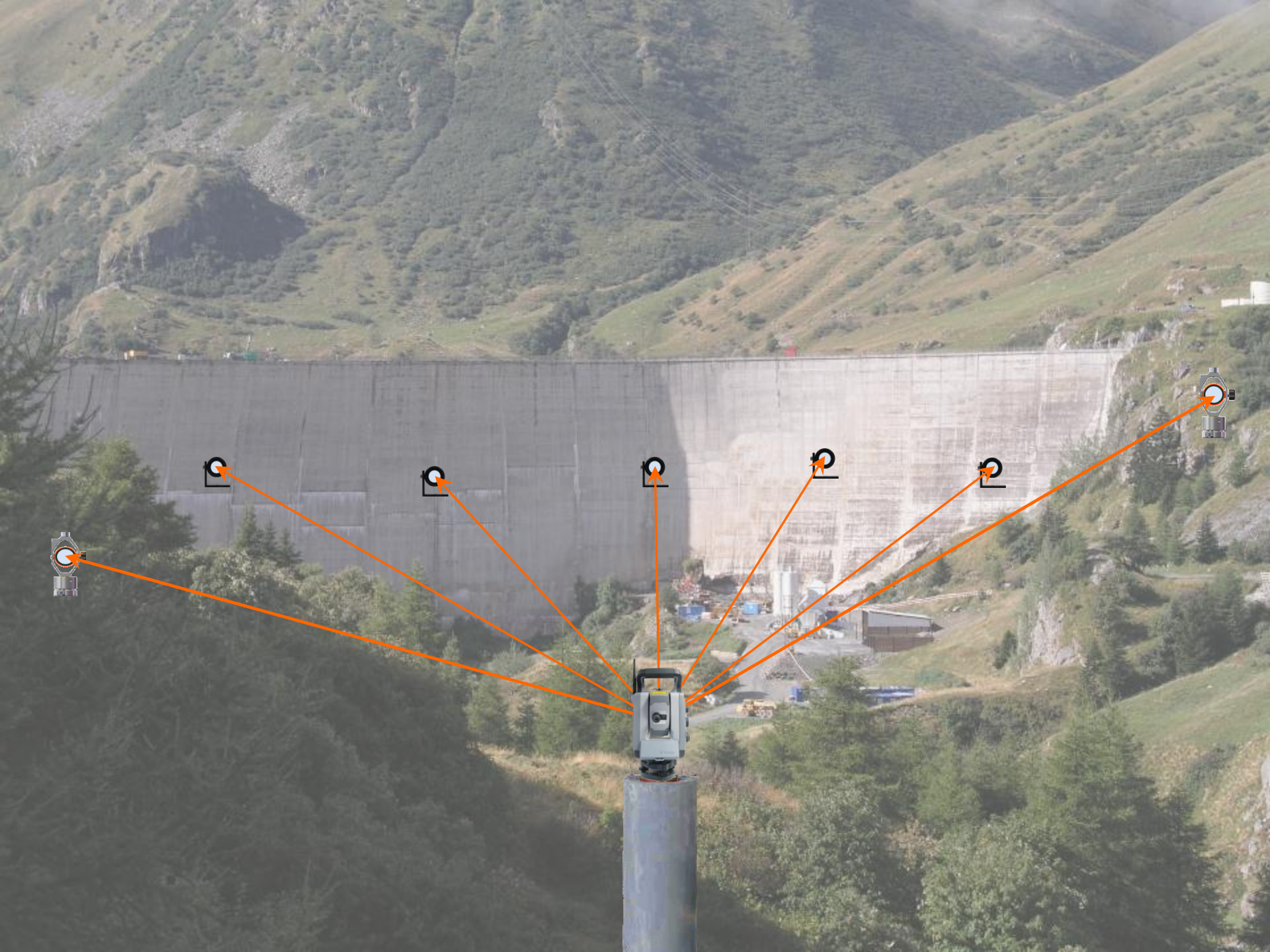
FineLock Aiming in „Slow Motion“!

Trimble S8 Total Station

FineLock™

- Narrow field of view
- No interference with surrounding prisms
- Minimum separation Δ: 80 cm at 200 m





Trimble 4D Control

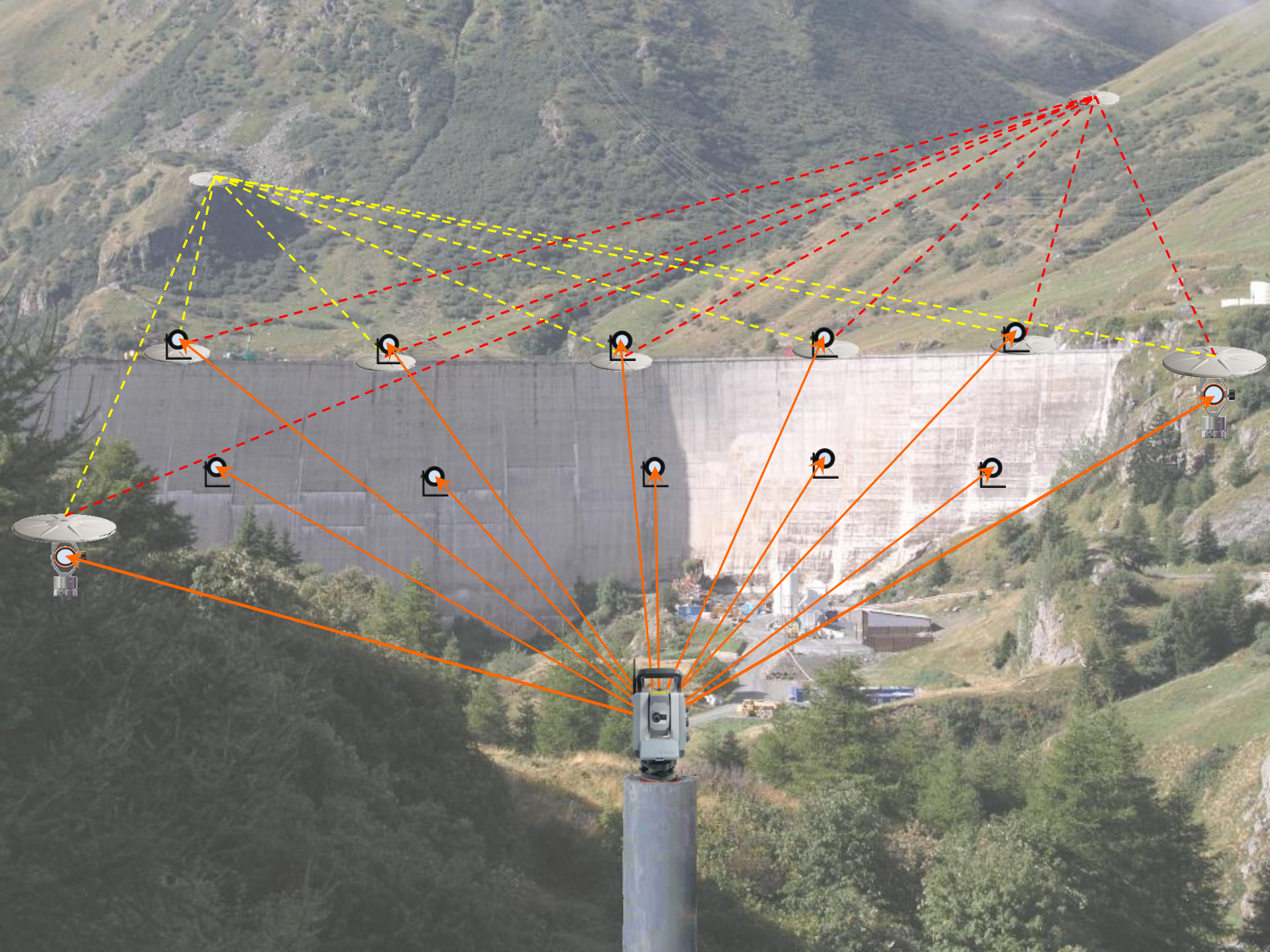
Applications for GNSS and optical sensors

- Optical total stations
- GNSS receivers

Trimble 4D Control

Applications for GNSS and optical sensors

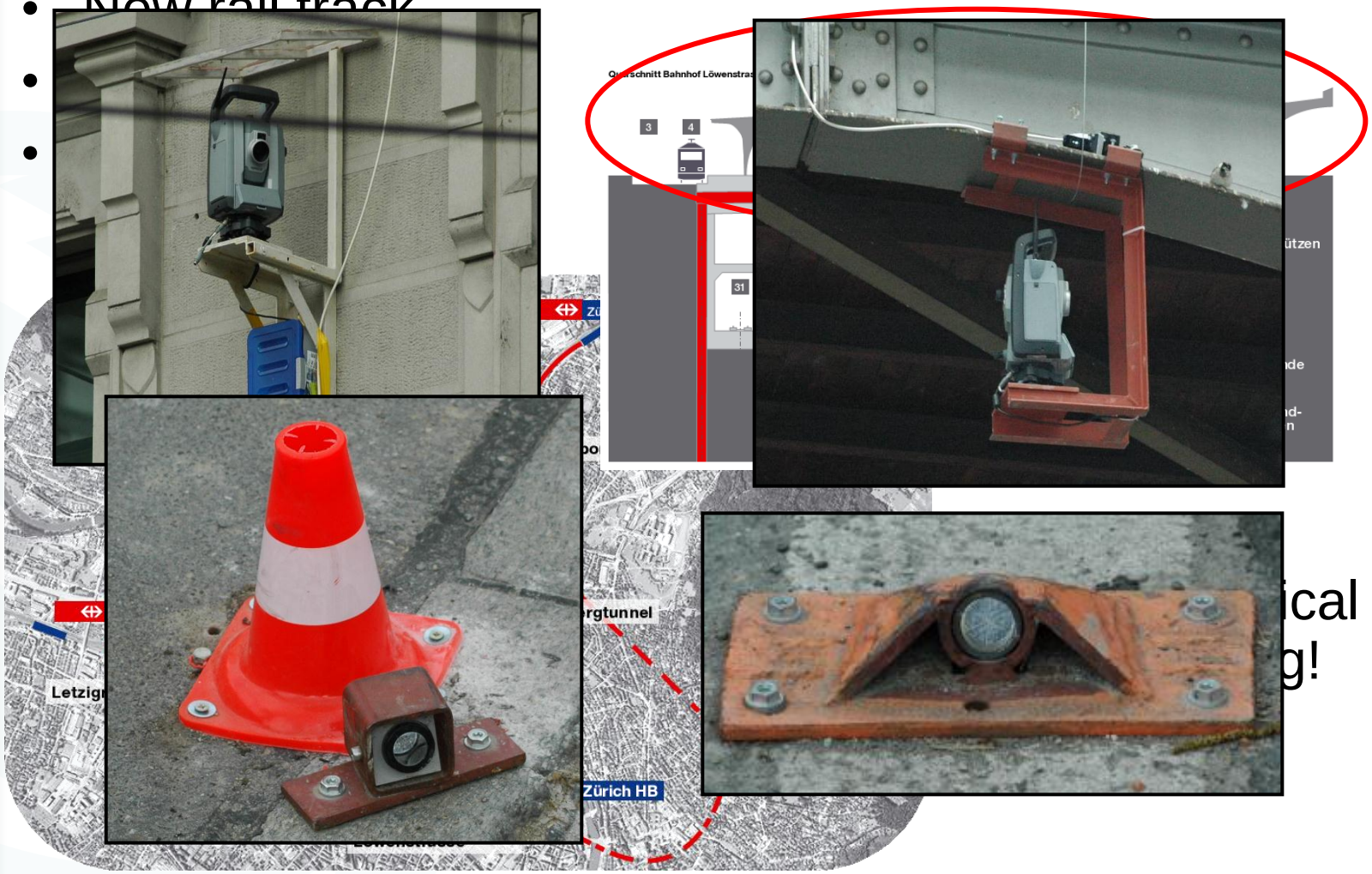
- Optical total stations
- GNSS receivers
- Optical total stations combined with GNSS receivers



Examples from the real world

Zurich Central Station, Switzerland

- New rail track
-
-



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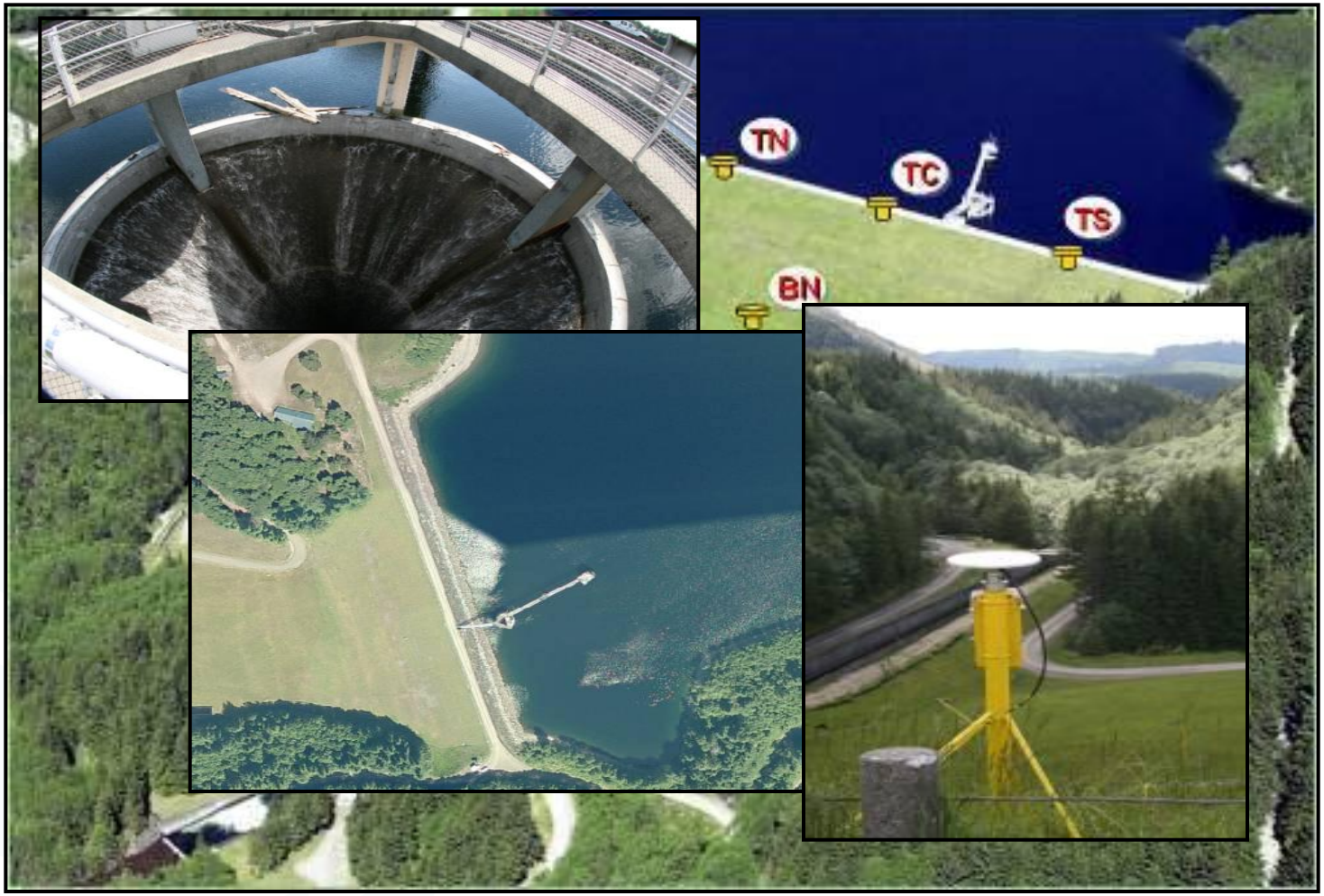
g!

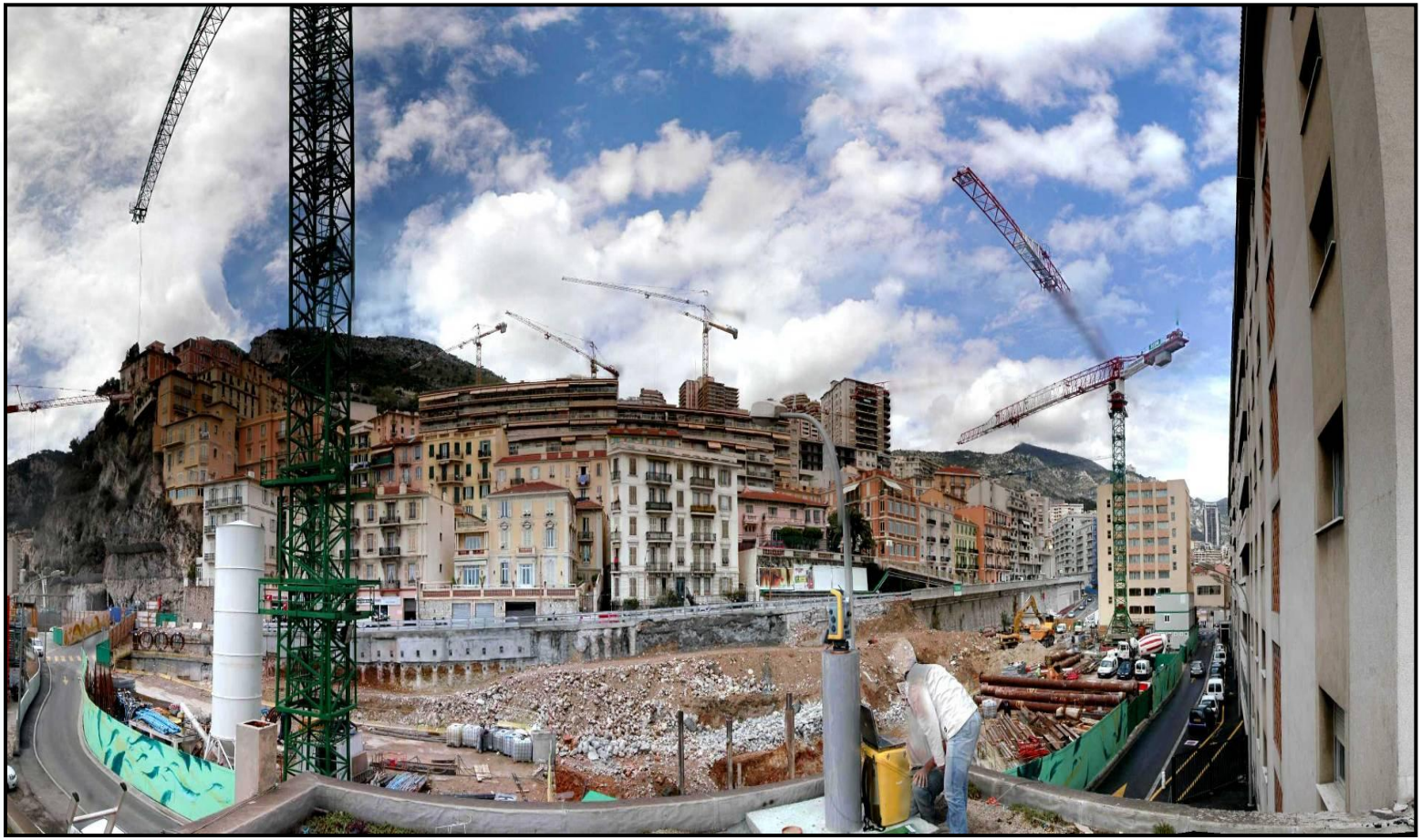
Examples from the real world

Tolt Dam, U.S.A.



Examples from the real world

Deep Foundation in Monte Carlo, Monaco



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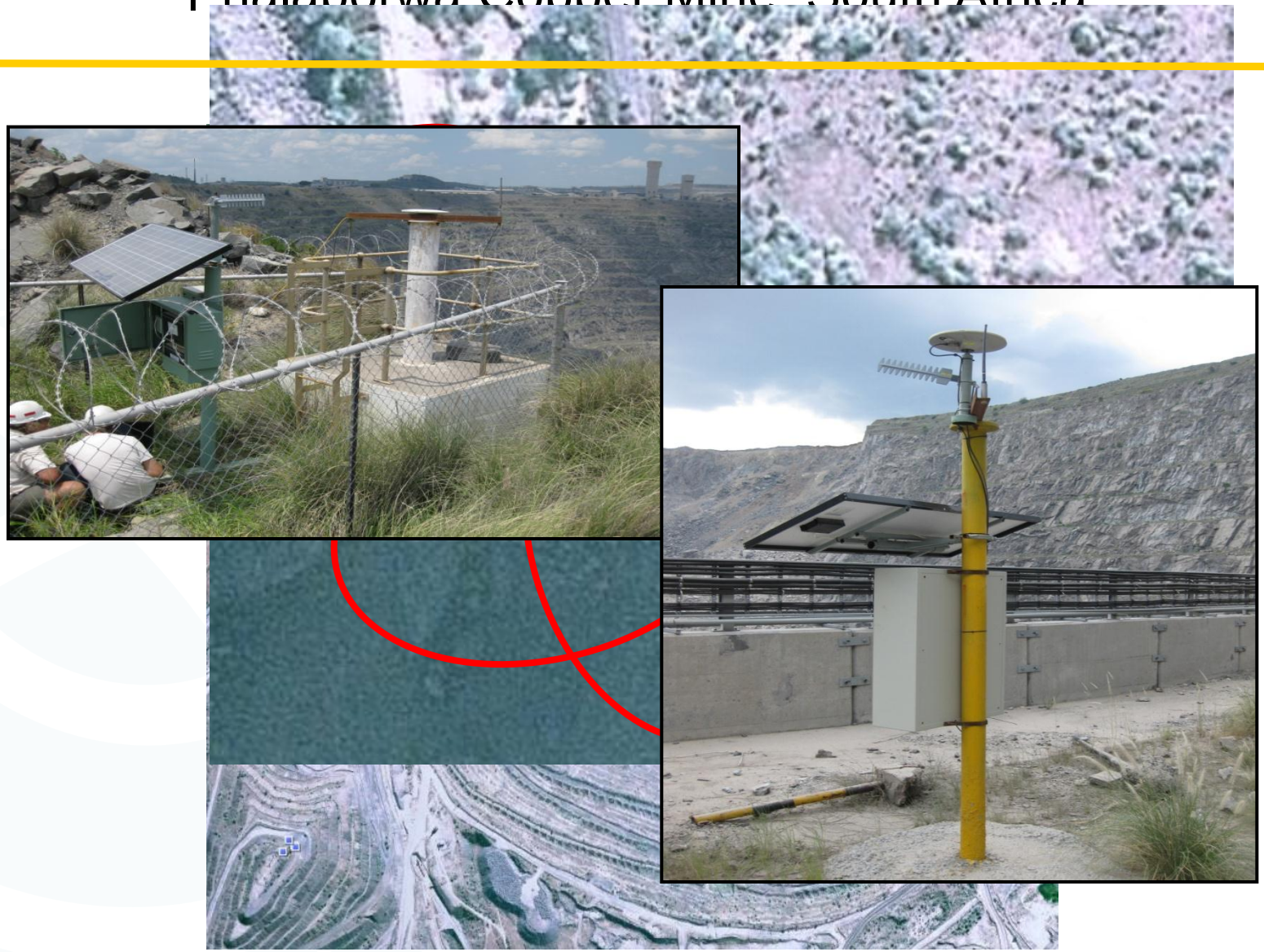
Examples from the real world

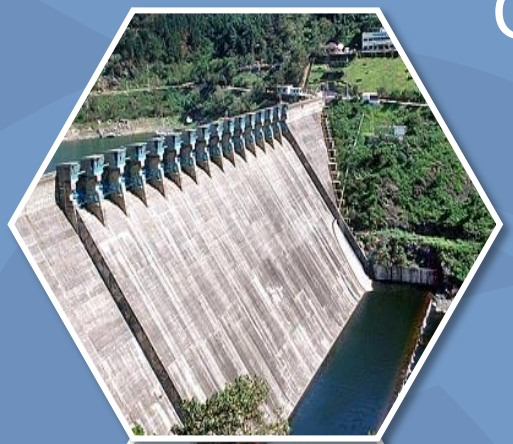
Phalaborwa Copper Mine, South Africa



Examples from the real world

El Romeral Iron Mine, Chile

GNSS System Application for Cable-Stayed Bridge Health Monitoring in Korea



EJtech

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1 Bridge Monitoring System

2 GNSS System of Incheon Bridge

3 GNSS System of Seohae Bridge

4 Research and Other Site

Trimble

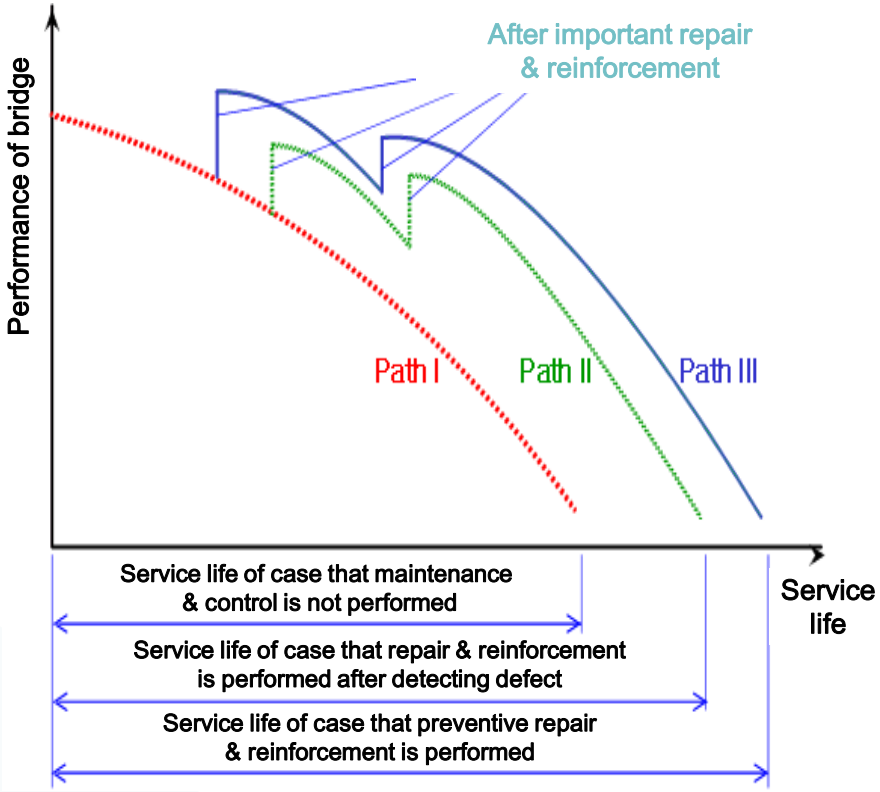
1 Bridge Monitoring System

Load

Wind, Earthquake,
Temperature, Traffic Load

Bridge Reaction

Cable Tension Force, Pylon Tilt, Pier tilt,
Reinforcing Deflection, Expansion Displacement, Bearing Displacement, Reinforcing Stress and Dynamic Characteristic



Stability Confirmed, lifetime prediction Extension,
Life and Property Protection by Accident Prevention

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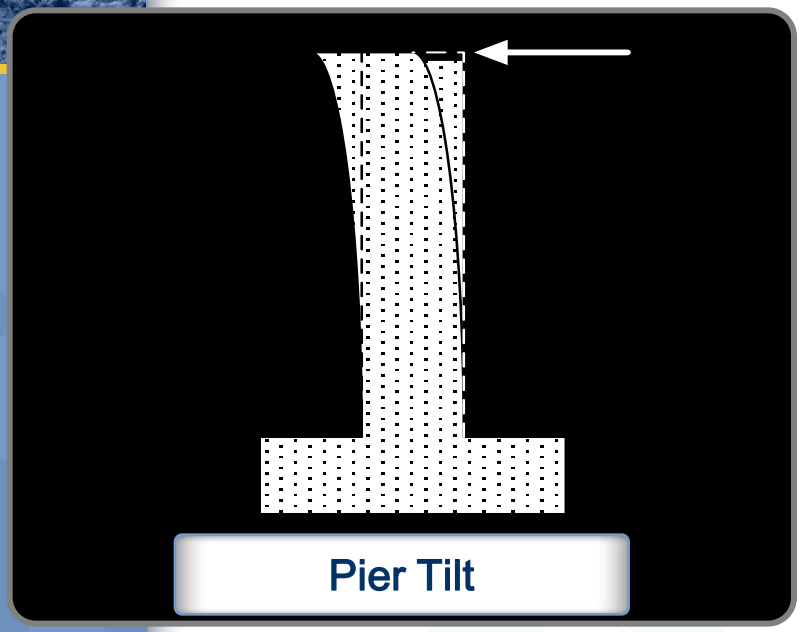
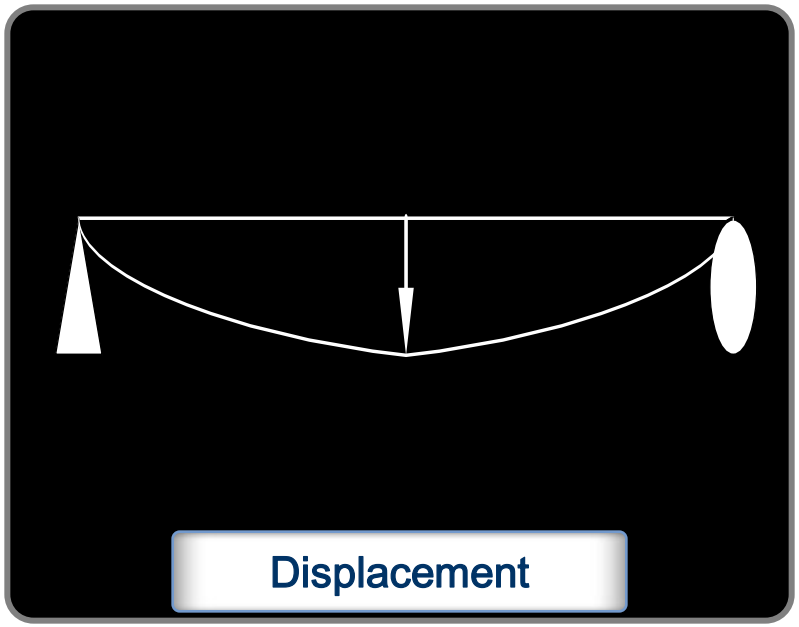
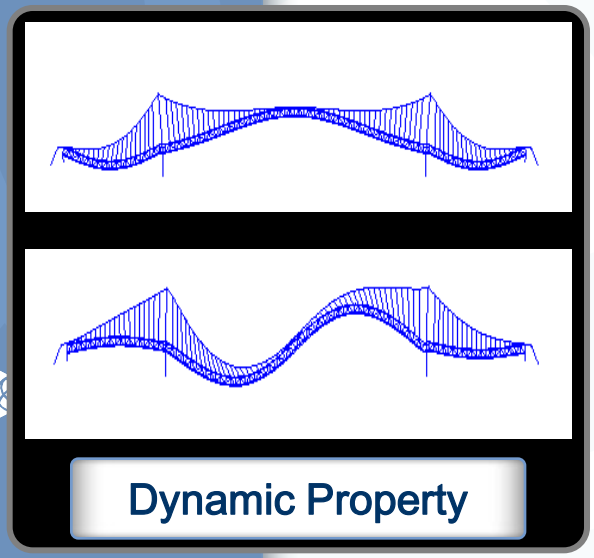
Bridge Movements



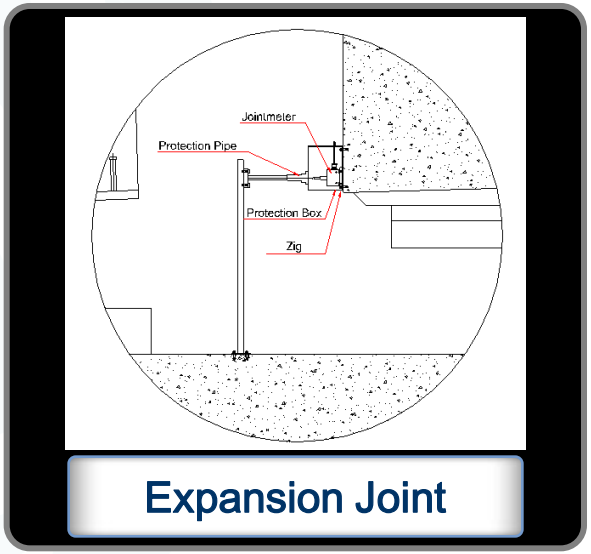
Pier Tilt



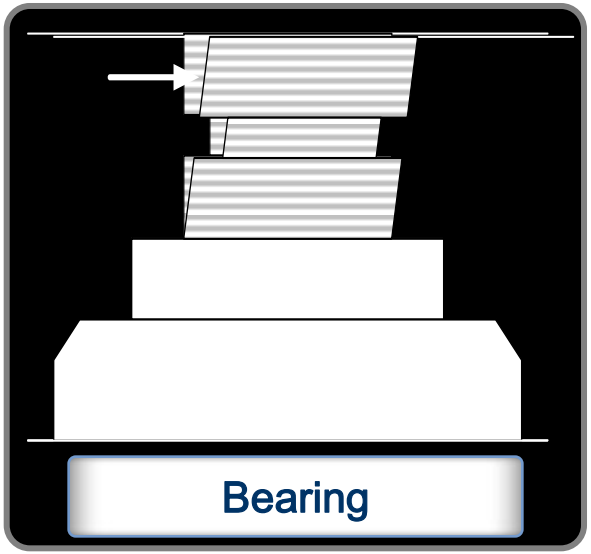
Displacement



Dynamic Property



Expansion Joint



Bearing

Type of Bridge

Cable-stayed Bridge

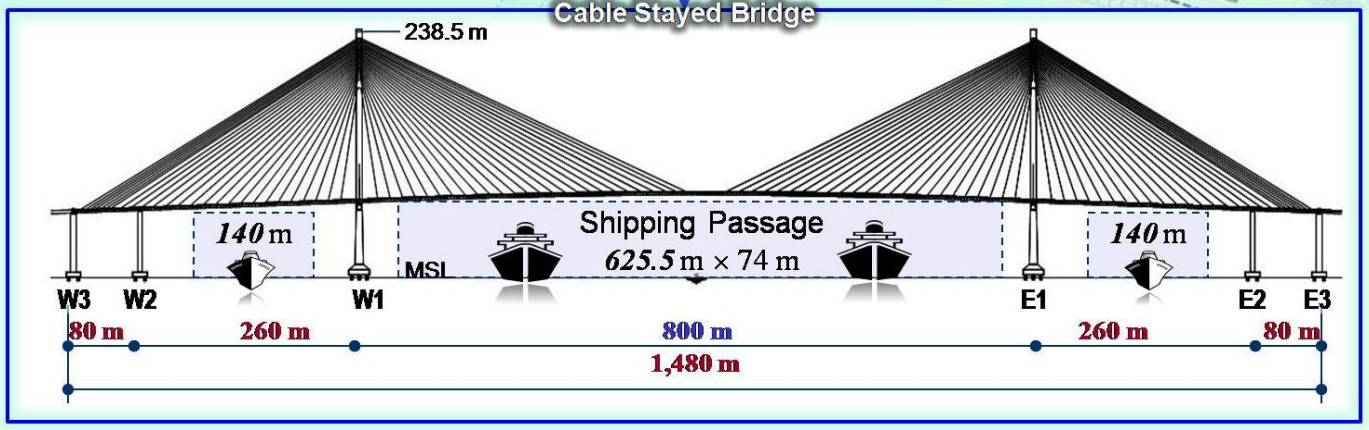
- A cable-stayed bridge is a bridge that consists of one or more columns (normally referred to as towers or pylons), with cables supporting the bridge deck.

Cable-stayed gider bridge & Suspansion bridge

Monitoring Item	Solution	
	Hardware	Software
Pylon Manage	Tiltmeter	◎ BHMS - Real-time Monitoring - Management function (ex SMS, alarm) - Trimble 4D Control
	Accelerometer	
	Strain gauge	
	Thermometer	
Cable Manage	Tension meter	
	Thermometer	
Real-time Shape Manage	GNSS	

GNSS System of Incheon Bridge

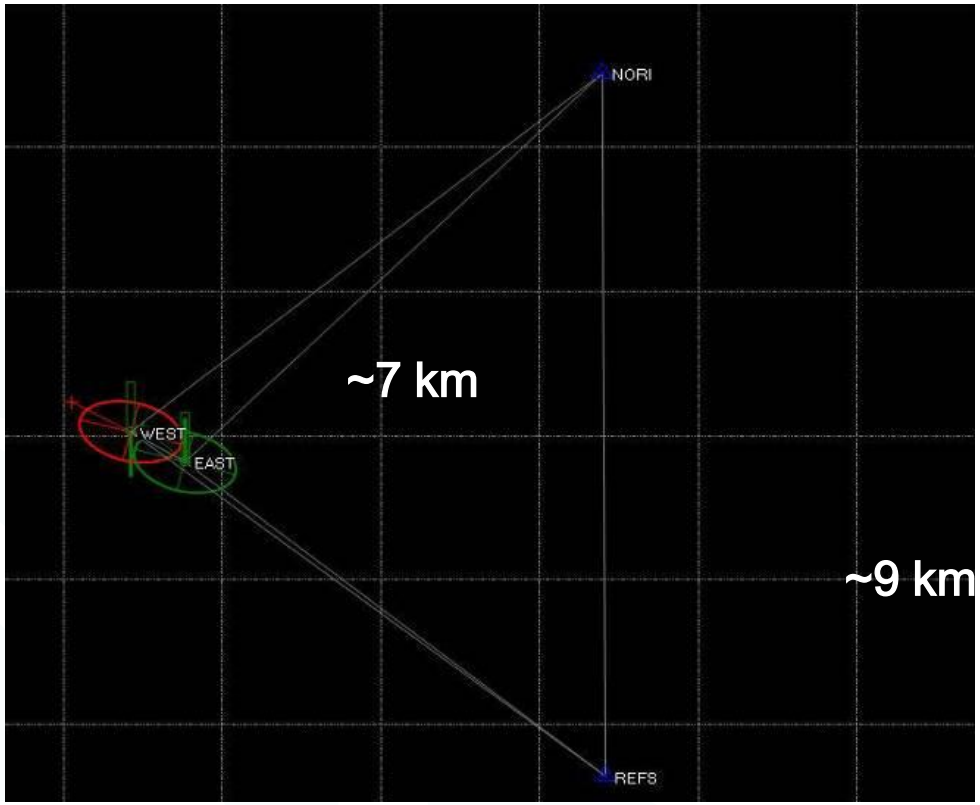
1) Total length of bridge : 18.4km
2) Connecting the Incheon International Airport (IIA) with New Songdo City crossing the Yellow Sea
3) Opened : October 2010 after the 52 month constructions



1) Main section of Incheon Bridge is the 1.48 km (80+260+800+260+80 m).
2) Main span length : 800m
3) Pylon's height : 230.5 m
4) The 3-cell steel box deck is 33.4 m wide and 3 m high
5) Approach bridge: 2.2km(PFCM)
6) The alignment slope of the bridge : 3%
7) Viaduct bridge : 8.4km(FSLM)

The world’s 5th largest cable-stayed bridge

Network dimension during the construction



GNSS

- Monitoring of Pylon displacement
- Control of Cable Tens
- Construction of deck

Tiltmeter

- Security of the accuracy construction

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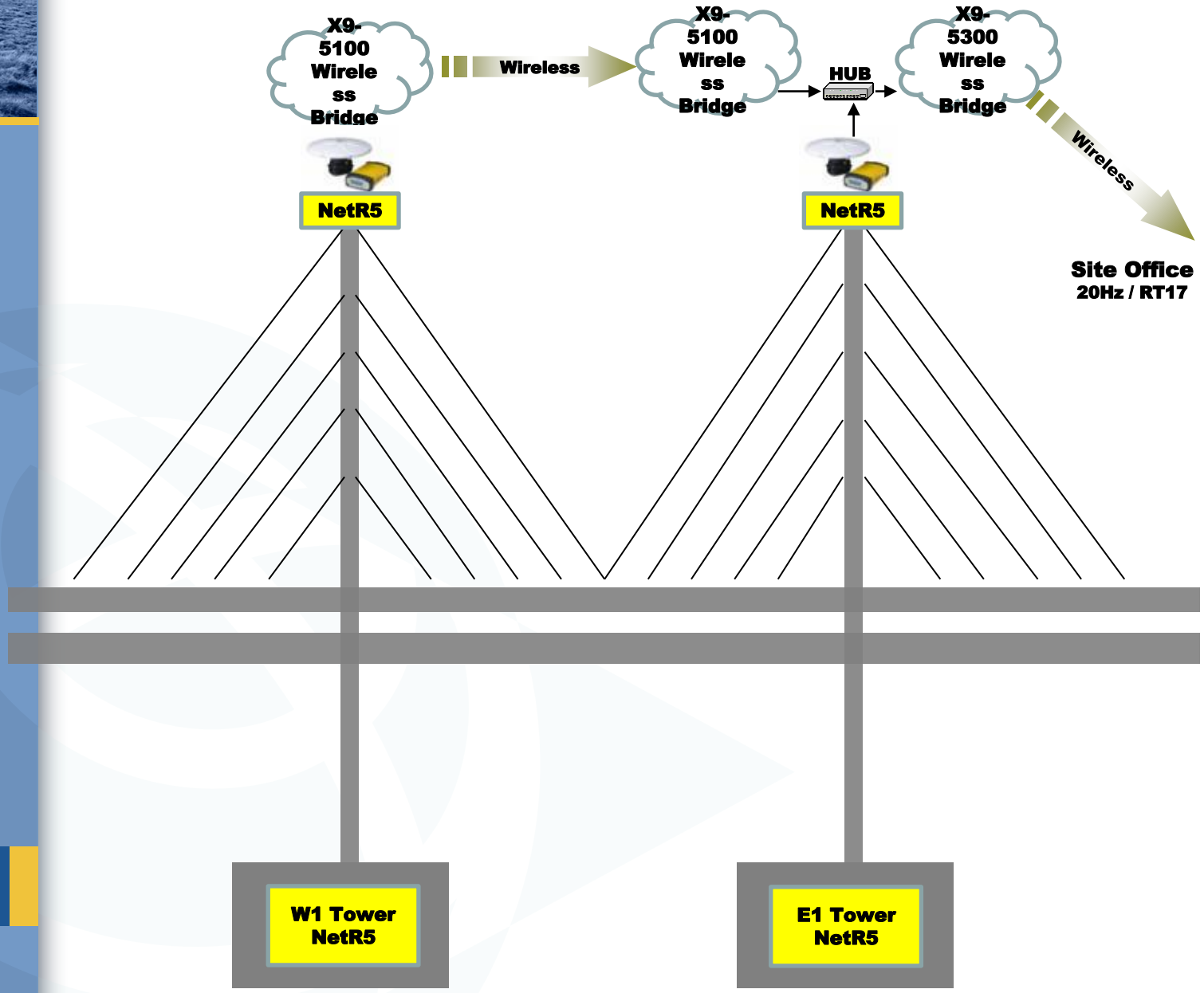
Hardware during the construction



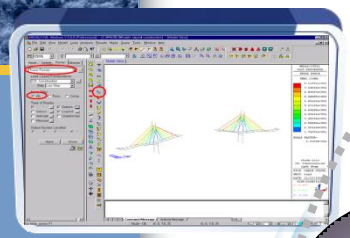
Monitored reference station

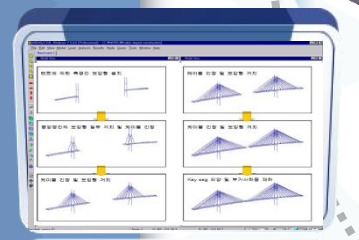
GNSS antenna point

Main Bridge Tower

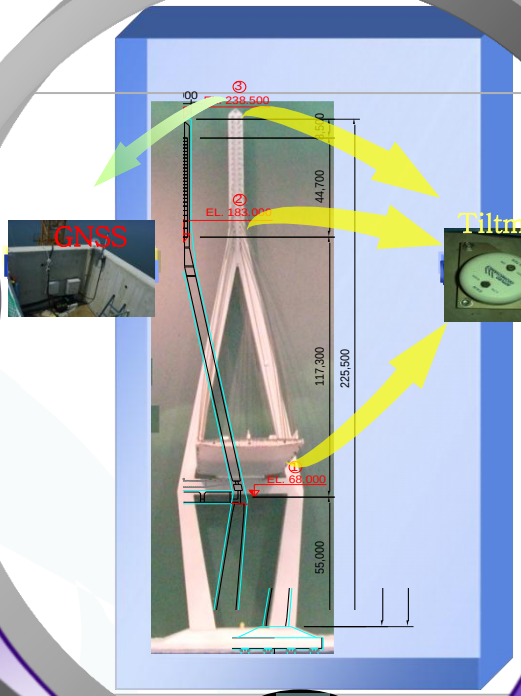
GNSS & Comm Ant installation

Wireless transmitter





Structural analysis
Design checking



Accuracy
construction

Monitoring of Pylon
displacement

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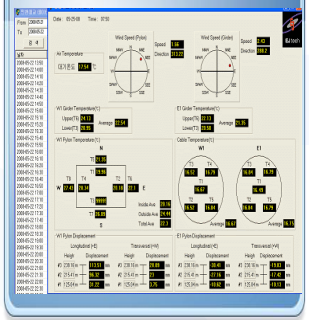
GNSS Tiltmeter

Wireless transmitter

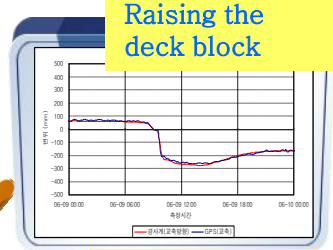
Real Time Monitoring



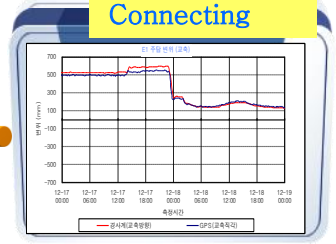
Comparison and analysis of data

- Change slop angle to displacement
- GNSS Bridge coordination
- Analysis of tiltmeter and Gnss displacement

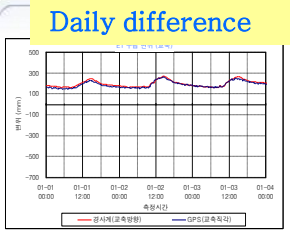
Raising the deck block



Connecting



Daily difference



- ±10mm Error range of GNSS and tilitmeter
- Comparison and check of the monitoring and design data

- Jacking the cable according to the constructing step
- Raising the deck block

- Highly effect on the efficient and accuracy constructing management

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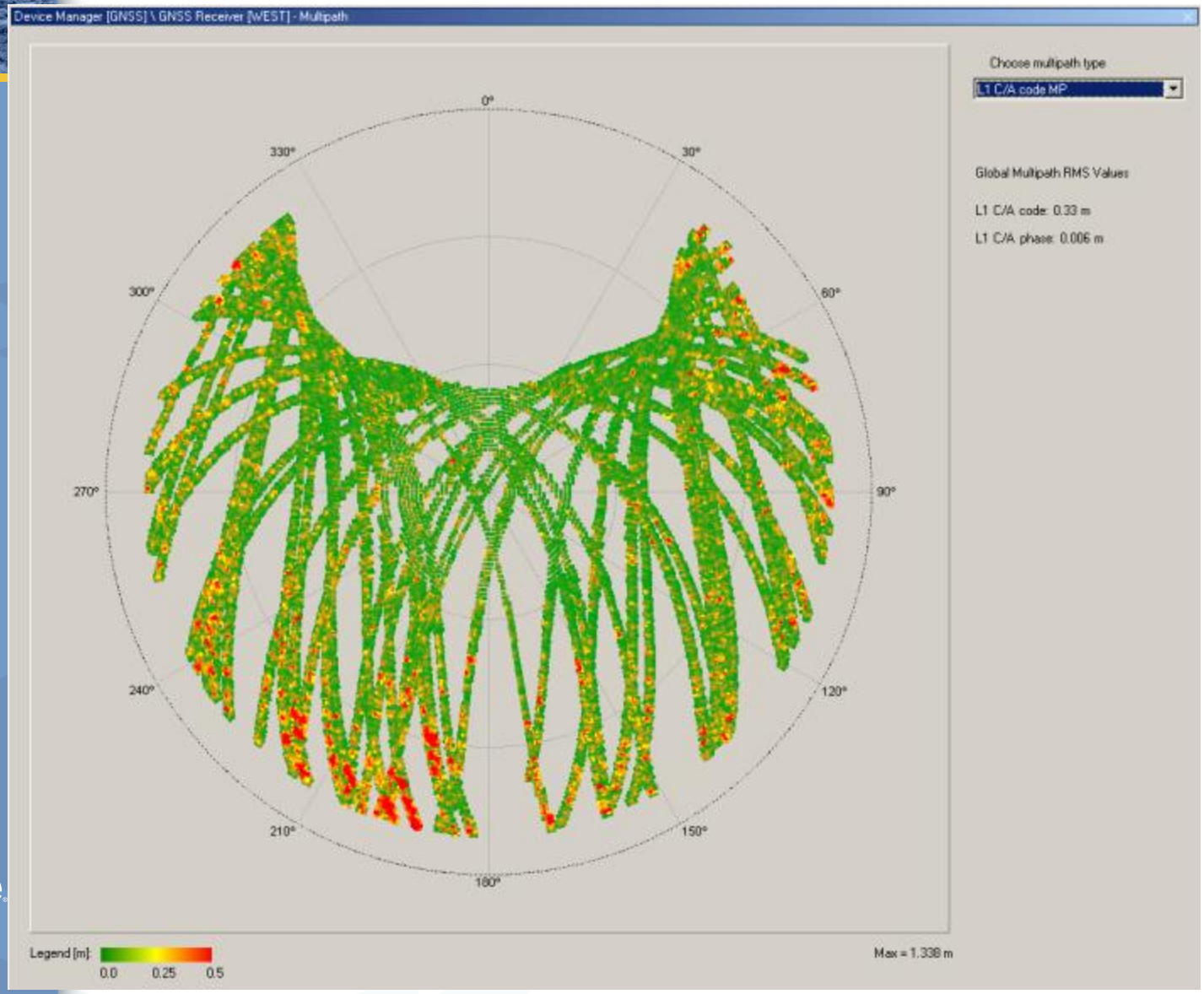
Multipath: Station WEST



Incheon Bridge system in maintenance

- Installation

Ref. Stn.			Location
1	**YJDO**	**Ref.**	
2	WFSO	Rover	
3	WSSO	Rover	Side Span
4	WPSO	Rover	Pillar - West
5	MSNO	Rover	Middle Span -left
6	MSSO	Rover	Middle Span -Right
7	EPSO	Rover	Pillar - East

Incheon Bridge

- System Overview

	Items	Qty	Remark
H/W	GNSS Receiver	7	Trimble NetR5
	GNSS Antenna	7	Trimble Zephyr Geodetic Model 2
	Server – Master	1	CPU : x86 (Xeon 1.87 GHz) RAM : 10 GB HDD : 1.0 TB (Raid-5)
	Server – Slave	1	CPU : x86 (Core2Duo 3.16 GHz) RAM : 8 GB HDD : 300 GB
S/W	T4D	1	Version : 2.0
	MS-SQL Server 2005	1	
	Windows Server 2003	2	Ver : Professional

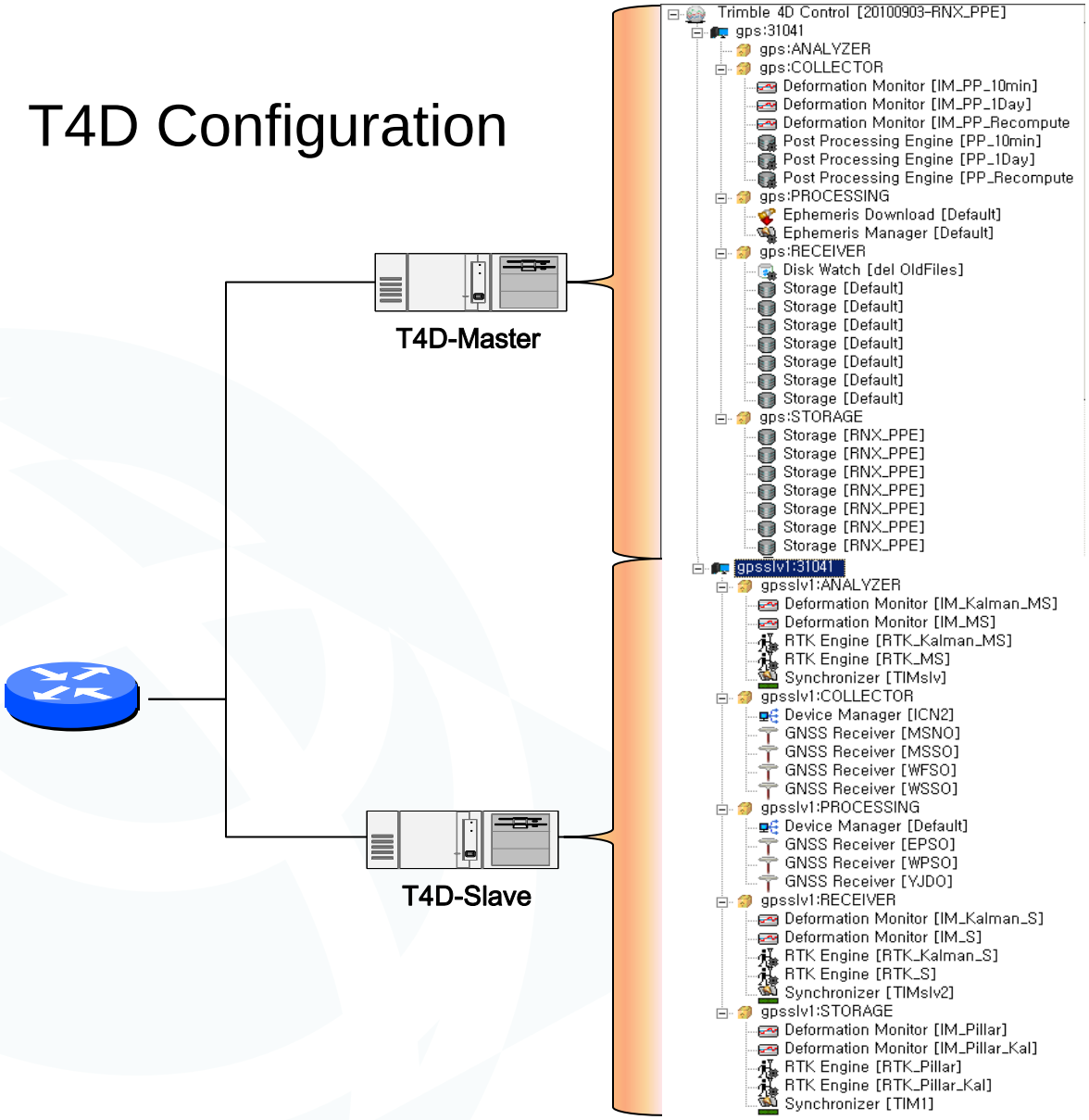
Incheon Bridge

- Coordinate

Stations			Coordinates		
1	**YJDO**	**Fixed Stn.**	**37-28-13.23679**	**126-30-49.93564**	**58.865**
2	WFSO	Rover	37-25-01.27621	126-33-34.00404	89.609
3	WSSO	Rover	37-24-57.85110	126-33-41.02325	95.692
4	WPSO	Rover	37-24-56.20277	126-33-45.59180	261.037
5	MSSO	Rover	37-24-49.03600	126-33-59.14223	107.090
6	MSNO	Rover	37-24-50.01035	126-33-59.88800	107.083
7	EPSO	Rover	37-24-42.68629	126-34-13.36955	261.115

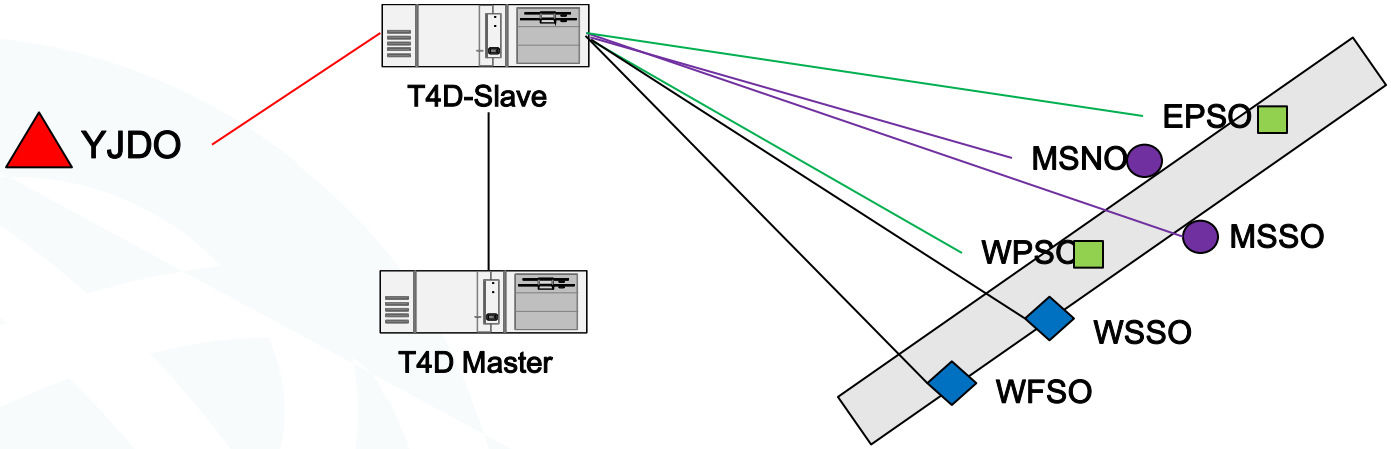
Incheon Bridge

- T4D Configuration



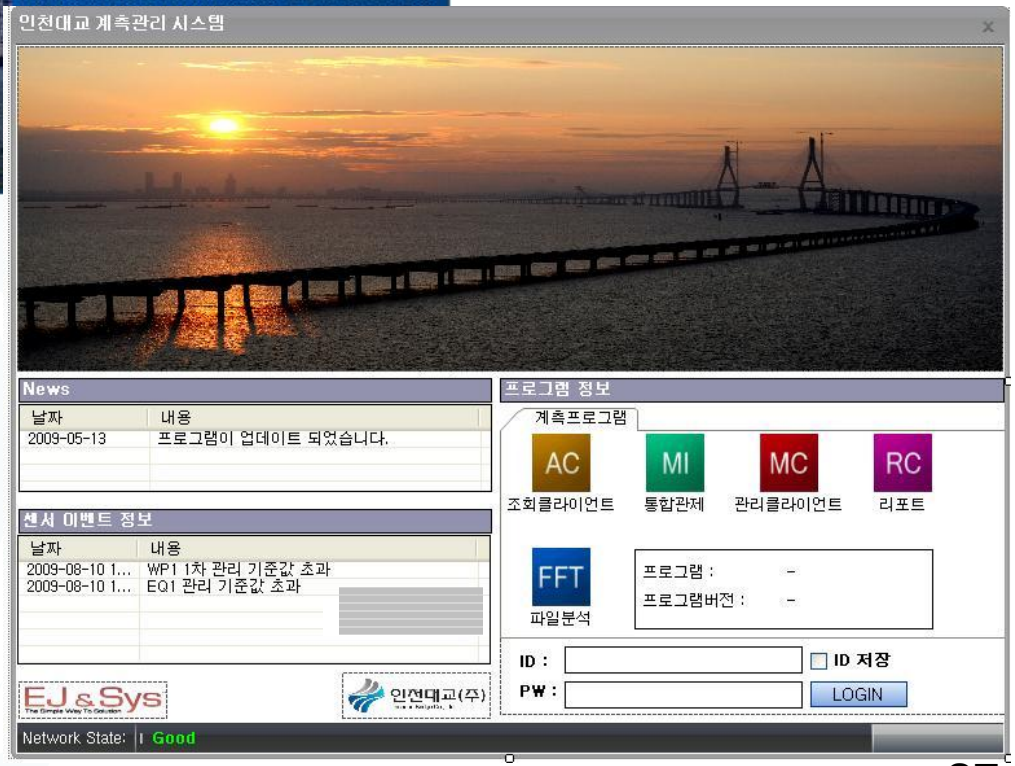
Incheon Bridge

- T4D Configuration
  - RTK Engine w/ Kalman Filter

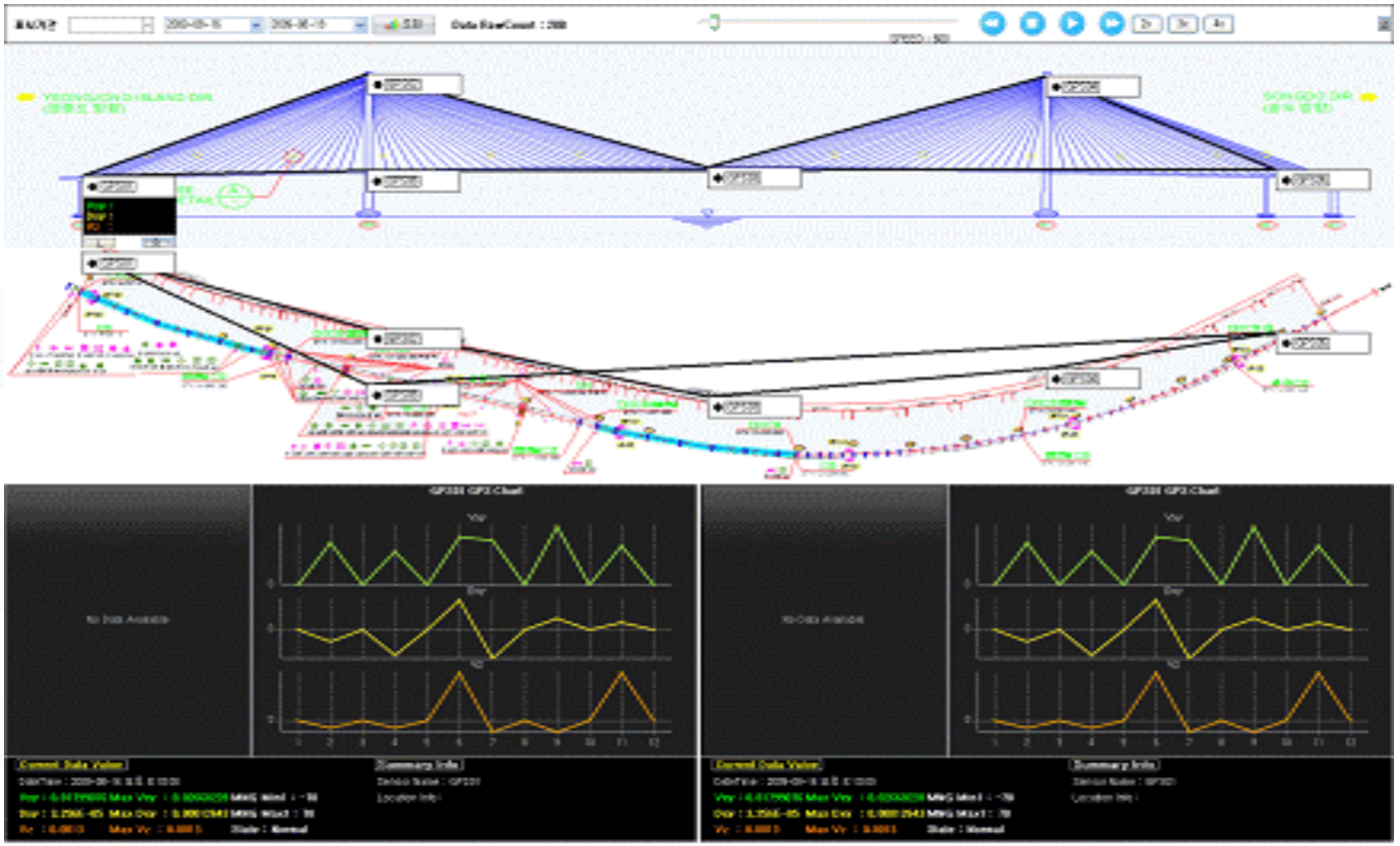


Server	Modules	Station	Remark
T4D Master	- Storages, Ephemeris - Post Processing Engine	All	
T4D Slave	-RTK Engines and Kalman Filter - Deformation Monitor Modules	EPSO, WPSO MSNO, MSSO WFSO, WSSO	Pillar Middle Span Side Span
	- Receivers and Synchronizer	All	

Login Screen

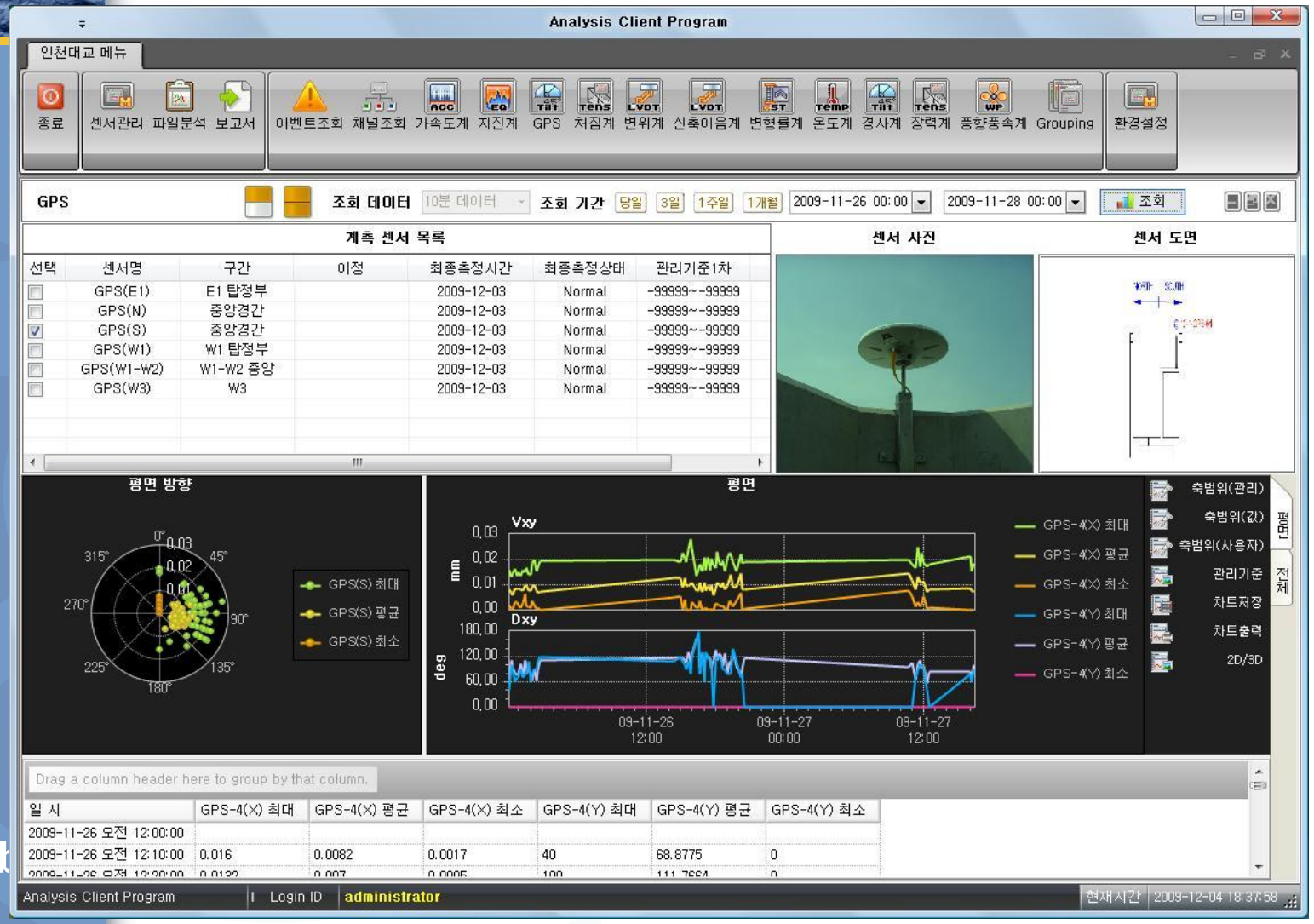


GNSS Data Acquisition Program



1) Private software is used for collecting 20 GNSS data samples per second by RTK.
2) Collected data is the whole coordinates so it should be changed into bridge coordinates for shape management.

GPS Monitoring Screen



Thank You!

Trimble