REAL TIME BRIDGE DECK GUIDANCE USING GNSS SYSTEMS

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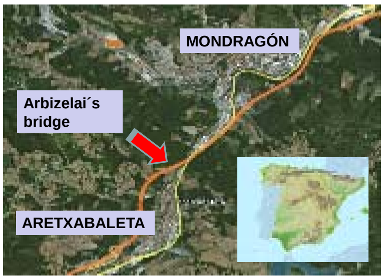
LEICA GEOSYSTEMS

1.1 Construction of the 'Autopista del Norte (AP-1)' (North Motorway)

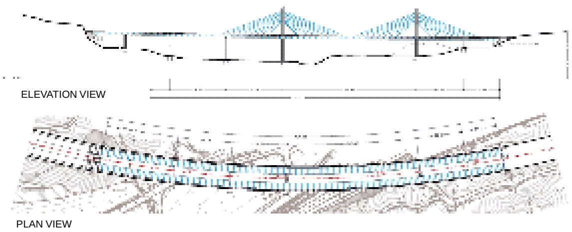
1. INTRODUCTION

1.1 Construction of the 'Autopista del Norte (AP-1)' (North Motorway) – Overview:

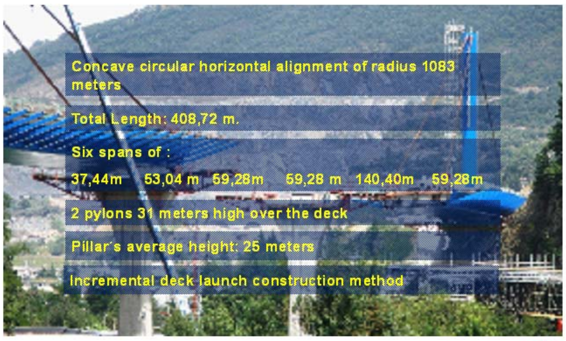
DRAGADOS MOYUA OBRAS SUBTERRANEAS Geotunel



1.1 Construction of the ‘Autopista del Norte (AP-1)’ (North Motorway) – Arbizelai´s bridge:



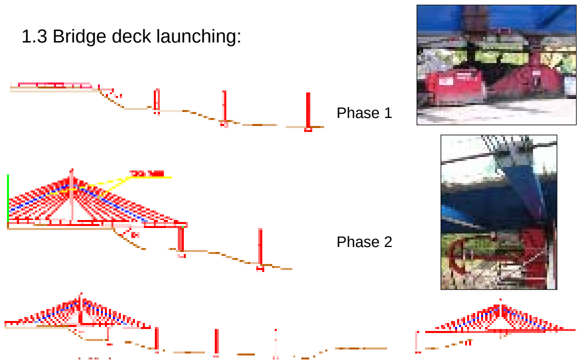
1.2 Technical data of Arbizelai´s bridge:



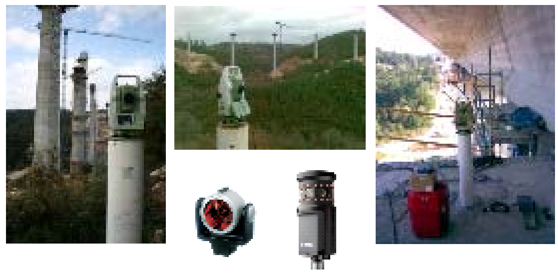
1.2 Technical data of Arbizelai´s bridge

1.3 Bridge deck launching

1.3 Bridge deck launching:



1.4 Traditional surveying methods to guide and monitor bridge deck launching:



NOT REAL TIME!!!!!

1.4 Traditional surveying methods to guide and monitor bridge deck launching

2. OBJECTIVES

2 Objectives - Specific requirements for the Arbizelai´s bridge guidance and monitoring system:

- Real time 3D guidance of the bridge deck during the incremental launching process.

- Real time monitoring of 4 control points (2 on the front, 2 on the rear) of the bridge deck during the incremental launching process. 3D trajectory of these points had to be continuosly checked versus the theoretical horizontal and vertical alignments.

- Central pylon´s Real time deformation monitoring.

- Real time remote access to the system anywhere in the construction site or even from Dragados central office in Madrid.

- User friendly software interface with data logging and Real time alarm system.

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3.1 Previous works

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3. DEVELOPMENT

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3.1. Previous works

- Satellite tracking and signal multipath tests
- WGS84 to Construction Site Local Coordinate System transformation using static GNSS techniques.
- GNSS reference receiver precise WGS84 coordinates determination
- GNSS antennas offset determination with respect to the deck structure
- Theoretical 3D trajectories calculation for each of the 5 points to be monitored on the deck.
- Radio communications configuration and fine tuning due to the complex orography and safety regulations
- Software installation and configuration
- Remote access configuration
- Initial tests before the start of the launching process

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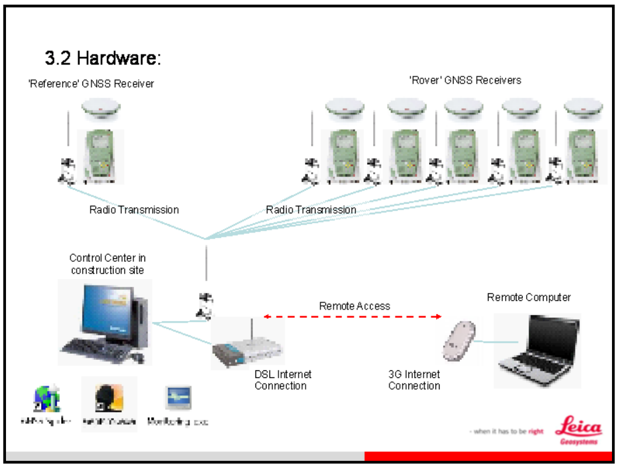
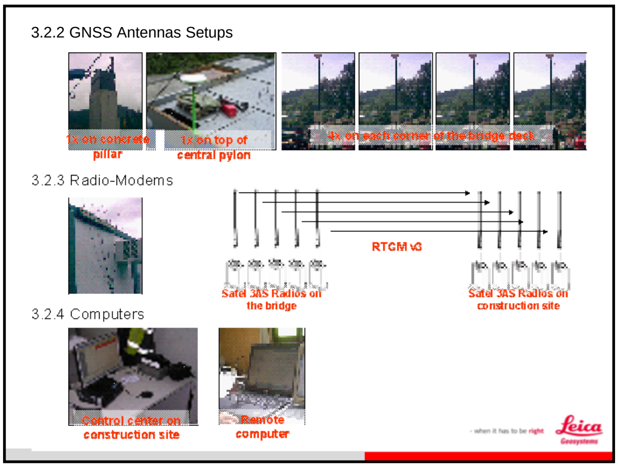
3.2 Hardware


3.2.1 GNSS Receivers:
Antenna
LEIAX1202GG
Leica GX1230GG
Radio-Modem
406.425 MHz

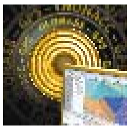

3.2 Hardware:
'Reference' GNSS Receiver
'Rover' GNSS Receivers
Radio Transmission
Radio Transmission
Control Center in construction site
Remote Access
Remote Computer
DSL Internet Connection
3G Internet Connection


3.2.2 GNSS Antennas Setups
1x on concrete pillar
1x on top of central pylon
4x on each corner of the bridge deck
3.2.3 Radio-Modems
RTCM v3
Satel 3AS Radios on the bridge
Satel 3AS Radios on construction site
3.2.4 Computers
Control center on construction site
Remote computer

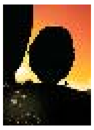
3.3 Software

3.3.1 Leica GNSS Spider

3.3.1 Leica GNSS Spider:



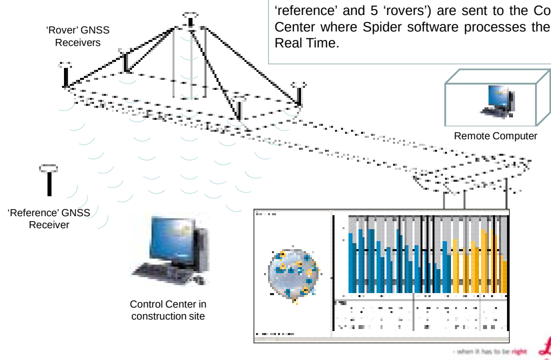
3.3.2 Leica GeoMoS:

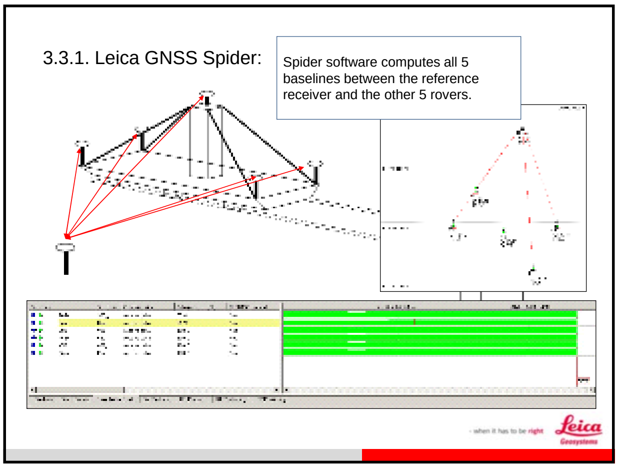


3.3.3 Leica Alignment Monitoring:

3.3.1. Leica GNSS Spider:

GNSS raw observations from all 6 receivers (1 'reference' and 5 'rovers') are sent to the Control Center where Spider software processes them in Real Time.




3.3.1. Leica GNSS Spider:
Spider software computes all 5 baselines between the reference receiver and the other 5 rovers.
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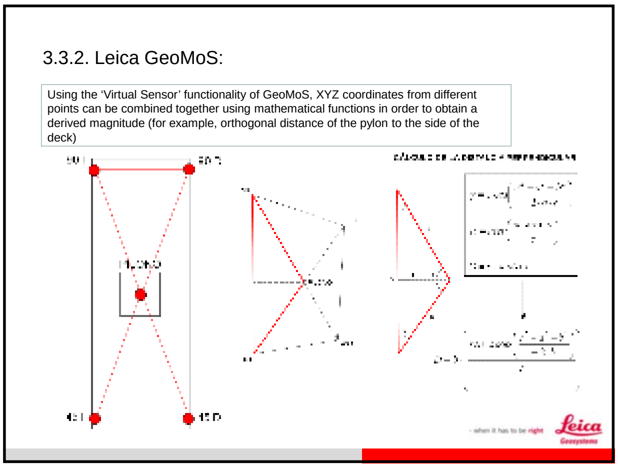
3.3.2. Leica GeoMoS:
Using the 'Virtual Sensor' functionality of GeoMoS, XYZ coordinates from different points can be combined together using mathematical functions in order to obtain a derived magnitude (for example, orthogonal distance of the pylon to the side of the deck)
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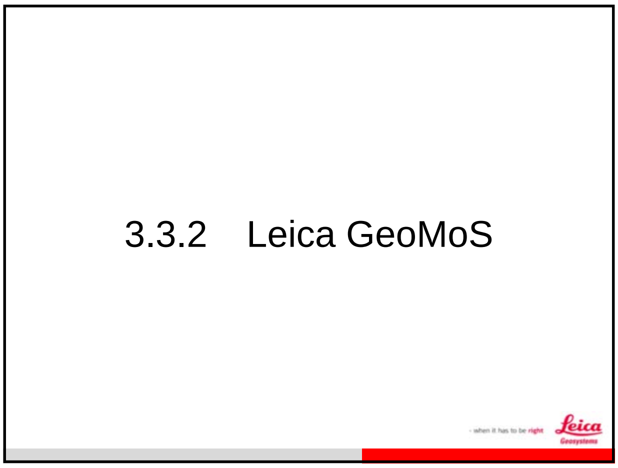
3.3.2 Leica GeoMoS
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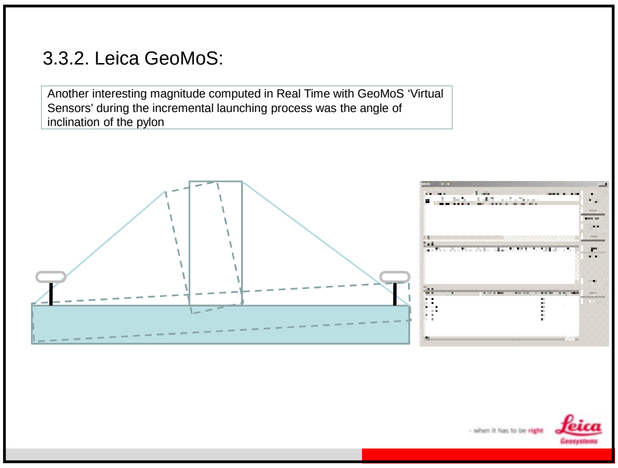
3.3.2. Leica GeoMoS:
Another interesting magnitude computed in Real Time with GeoMoS 'Virtual Sensors' during the incremental launching process was the angle of inclination of the pylon
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3.3.3 Leica Alignment Monitoring

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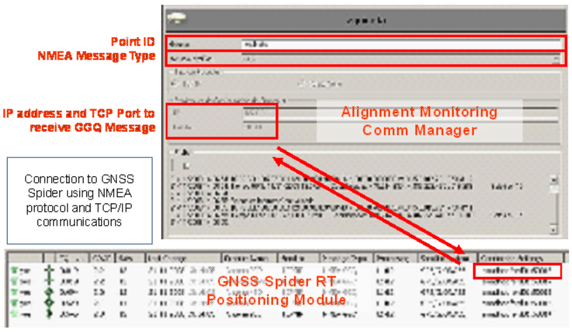
3.3.3. Leica Alignment Monitoring:



Connection to GNSS Spider using NMEA protocol and TCP/IP communications

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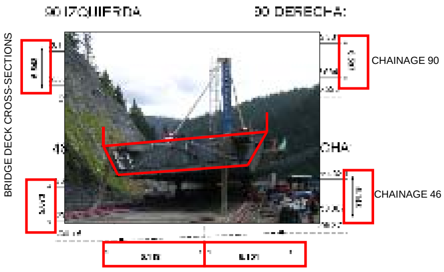
3.3.3. Leica Alignment Monitoring:

Offsets of the GNSS antennas have to be calculated with respect to the point of the deck structure from which we already know the theoretical trajectory.



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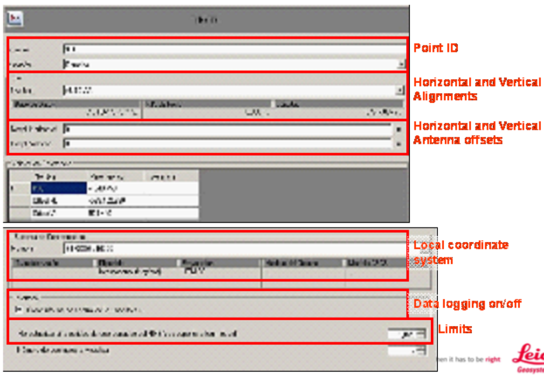
3.3.3. Leica Alignment Monitoring:



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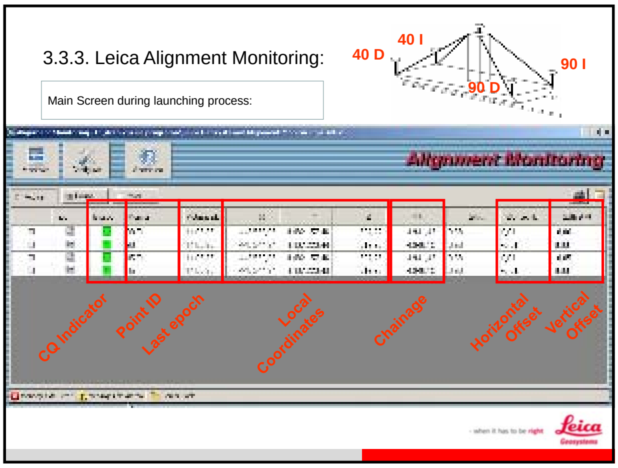
3.3.3. Leica Alignment Monitoring:
Main Screen during launching process:
40 I
40 D
90 I
90 D
Alignment Monitoring
CQ Indicator
Point ID
Last epoch
Local Coordinates
Chainage
Horizontal Offset
Vertical Offset
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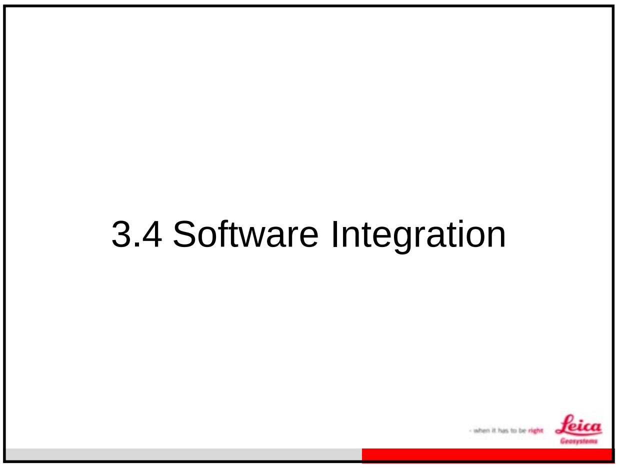
3.4 Software Integration
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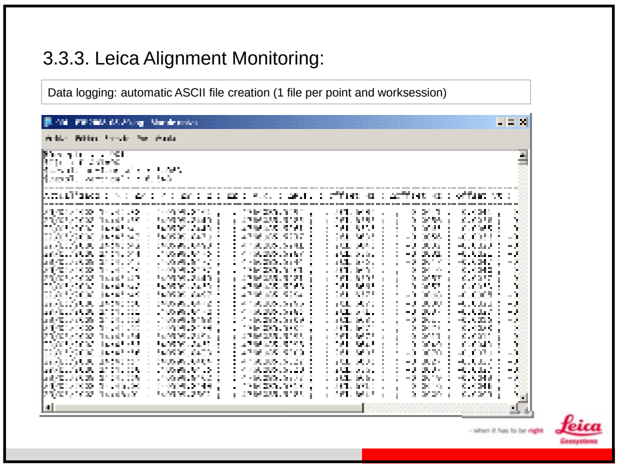
3.3.3. Leica Alignment Monitoring:
Data logging: automatic ASCII file creation (1 file per point and worksession)
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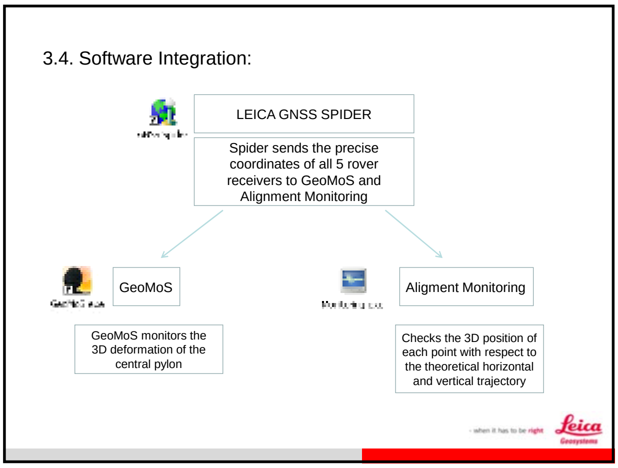
3.4. Software Integration:
LEICA GNSS SPIDER
Spider sends the precise coordinates of all 5 rover receivers to GeoMoS and Alignment Monitoring
GeoMoS
GeoMoS monitors the 3D deformation of the central pylon
Aligment Monitoring
Checks the 3D position of each point with respect to the theoretical horizontal and vertical trajectory
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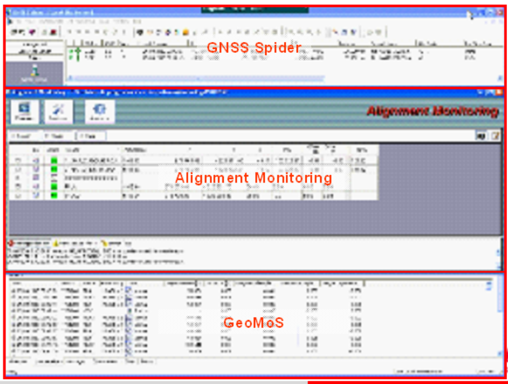
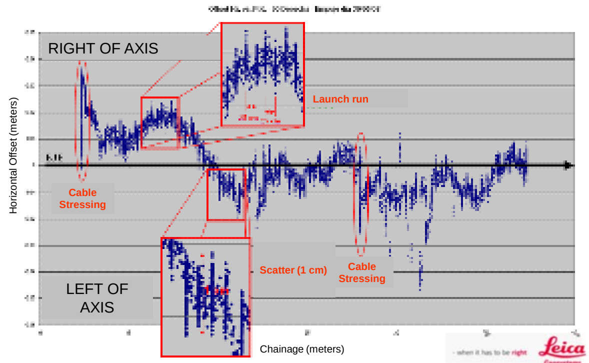
3.4. Software Integration:

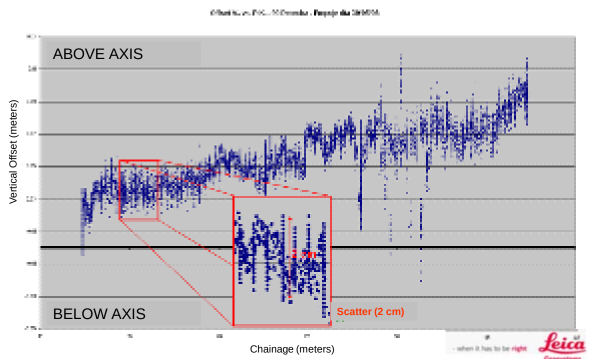


4. Results - Point 90D (front right): Horizontal Offsets



4. RESULTS

4. Results - Point 90D (front right): Vertical Offsets



5. FUTURE IMPROVEMENTS

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6. CONCLUSIONS

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5. Future improvements

5.1 Alignment Monitoring new features:

• CAD graphical output
• Support for Total Station measurements

5.2 Kalman filtering:

• Blunder prevention

5.3 Use of monitoring GNSS Receivers:

• Leica GMX901 & Leica GMX902GG

5.4 Use of Network RTK instead of Single Station RTK

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6. Conclusions:

- Monitoring and guidance system perfectly suitable for its use in any kind of moving structure.
- Need to include a graphical output.
- Other possible applications include:
  - Incrementally launched bridges
  - Barge guidance for pile's embedding
  - Jump forms
  - Cantilever bridges

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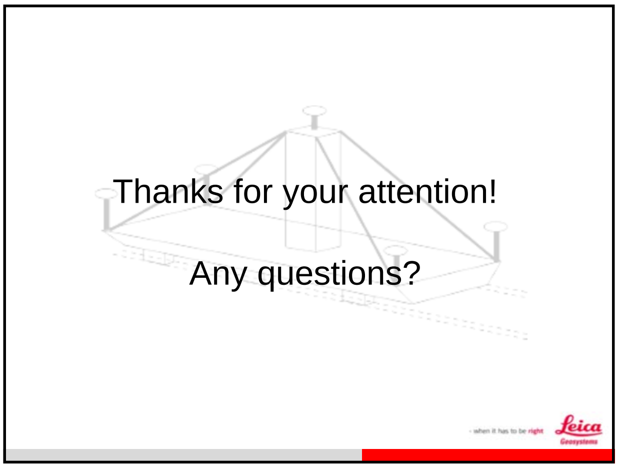
Thanks for your attention!
Any questions?