CRASTE-LF

Example of Use of GNSS and Laser scanning for Dams monitoring

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CRASTE-LF, Affiliated to the United Nations

CONTENTS

1. Activities of CRASTE-LF on GNSS

2. GNSS and Laser scanning : Application Example

1. Activities of CRASTE-LF related to GNSS

CRASTE-LF

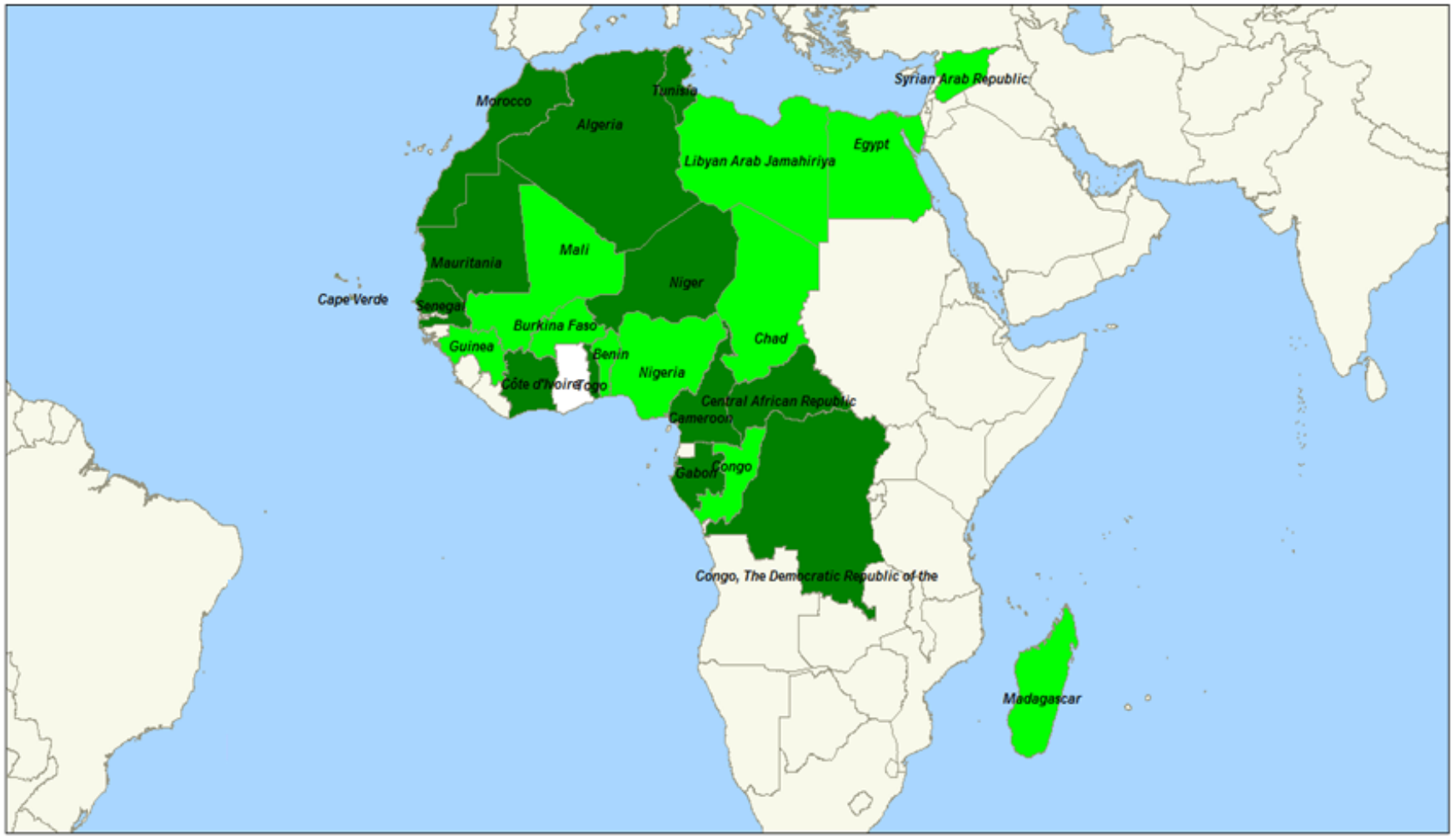
The CRASTE-LF has been established in Rabat on October 23, 1998. Initiative of the UN-OOSA.

Education and training on Space Science and Technology for sustainable development

13 Member States : Algeria, Cameroon, Cape Verde, Central African R., Ivory Coast, D. R. of Congo, Gabon, Morocco, Mauritania, Niger, Senegal, Togo and Tunisia.

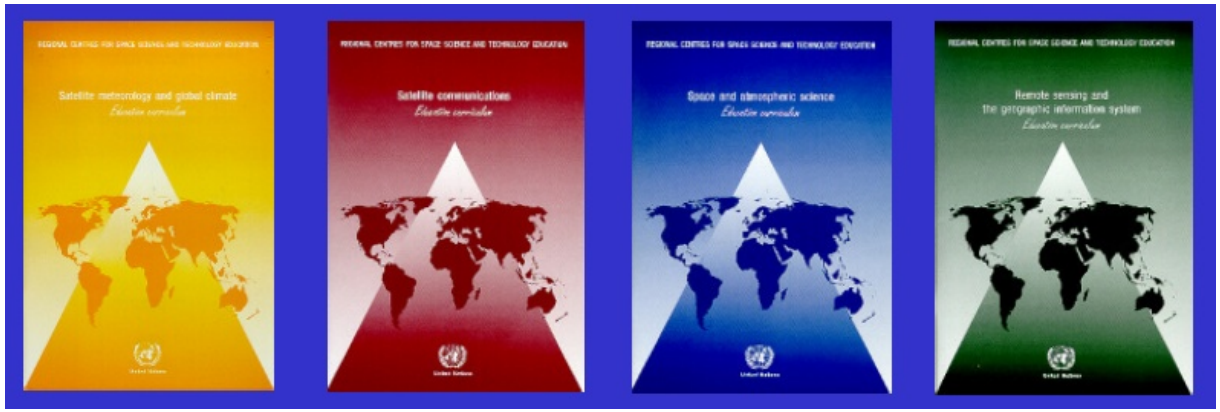
Building of CRASTE-LF

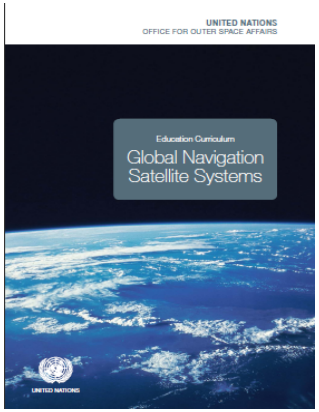
Origine of candidates (1998-2015) CRASTE-LF



CRASTE-LF
Education Programmes

- Remote Sensing and Geographic Information Systems,
- Satellite Communications,
- Satellite Meteorology and Global Climate,
- Space and Atmospheric Sciences
- *Global Navigation Satellite Systems*





Education Curricula established and Published by UN-OOSA

Training Course on GNSS

"Satellite Navigation and Location Based Services" , 28 September – 24 October 2009, with participation of 35 trainees from 19 Countries & from 32 different organizations and supervised by 10 experts.

Trainees supervised by METIS project team attending the demonstration at Mohamed V Airport, Casablanca , Morocco.

Regional Training Workshop

24 trainees from 07 countries

- Datums : Ellipsoid, Geoid.
- Coordinate Reference Systems
- Cartographic Projections
- Satellite Orbits.
- Navigation Signal.
- Errors and Precision.
- Positionning Techniques.
- Laboratories.

« Global Navigation and Based Services on Satellite Positioning »

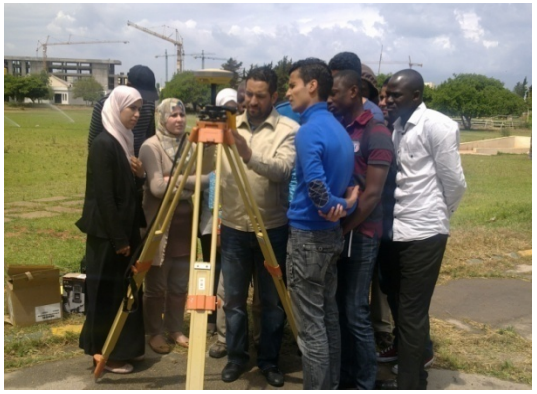
Lomé, Republic of Togo, 3 - 7 October 2011

Master on GNSS

Post Graduate training courses on GNSS, Nov. 2013 – Aug 2015
12 trainees from 6 member Countries & 8 different institutes

The participants have been supervised by Experts from 4 countries (Algeria, China, France and Morocco)

Training on Beidou : International Institute for GNSS Education, Beijing China.



Education Curriculum in GNSS (CRASTE-LF)

- The programme is based on the ***"Global Navigation Satellite Systems, Education Curriculum "***(December 2012)" prepared by the International Committee on Global Navigation Satellite Systems.

- This Master in GNSS is recommended to candidates graduated in electronic engineering, telecommunication Engineering, civil engineering, forestry, geomatics and geographic sciences, mathematical sciences and physical sciences.

Education Curriculum in GNSS (CRASTE-LF)

- The Master programme in GNSS is divided into four parts:

- **Lessons organized in 9 modules** consisting of 690 hours.
  - Lectures, tutorials, practical works and thematic seminars.
- **Laboratory experiments, practical activities and projects** related to the applications of GNSS consisting of 200 hours.
- **A GNSS project** realized in 12 weeks corresponding to 360 hours.
- **One year project** conducted by each candidate in his country on an issue related to the GNSS applications. The research project lead to the development of a thesis document presented in the CRASTE-LF centre.

Workshop on Space Weather & GNSS

Training Workshop on "Space Weather & GNSS Applications" , Feb 2015 with participation of 29 trainees from 13 Countries & 11 different institutes supervised by 8 experts.

Training on GLONASS

- The participation of Experts from Russia in GLONASS System is Highly recommended to support the CRASTE-LF centre : Training on Glonass, Practical works using Glonass receivers and softwares, development of applications.

- 13 contries will benefit from the training in order to promote the use of GLONASS in African countries and to encourage the interoperability with the GPS and other systems in this region.

2. GNSS AND LASER SCANNING : EXAMPLES OF APPLICATIONS

Monitoring of Dams in Morocco

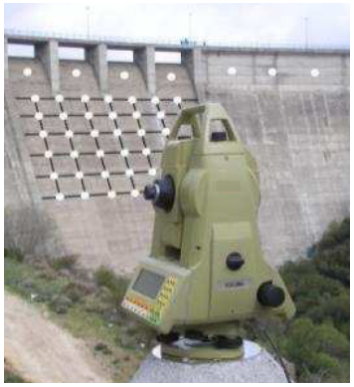
- Morocco undertakes important actions in order to protect and save hydraulic resources.
- These actions include the monitoring of dams.

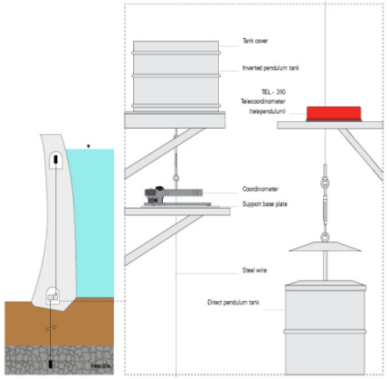
In morocco the dams are mainly used :

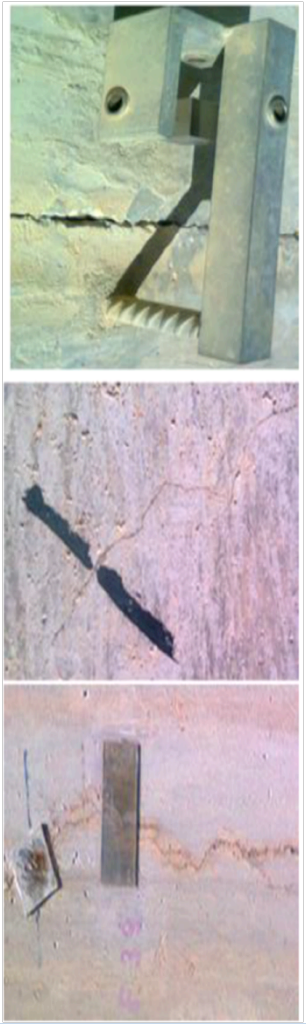
1. To provide water for various needs (human consumption, irrigation for agriculture, industrial use).
2. In Hydropower to generate electricity.
3. To manage or prevent water flow into specific land regions, to avoid floods.

Monitoring techniques

Dam failures are generally catastrophic if the structure is breached or significantly damaged.
Routine deformation monitoring is useful to anticipate any problems and permit remedial action to be taken before structural failure occurs.







Two types of measures to control and monitor the deformation of dams:

1. Geodetic or photogrammetric measurements:
   - provide the relative displacements as well as the absolute movement of objects relative to reference points considered as stable points.
2. Geotechnical and structural measures using extensometers, inclinometers and direct or inverted pendulums:
   - are typically used to determine the relative displacements within the structure of the dam

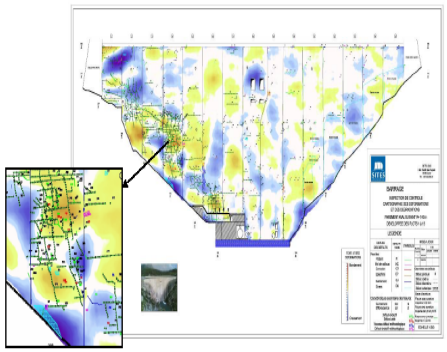
Geodetic monitoring

So far, geodetic monitoring is performed using the conventional method consisting of :

1. Spatial intersection with high precision theodolite instruments to monitor the dam in planimetry.
2. Geometric leveling instruments for the auscultation in altimetry.

- Geodetic monitoring is an unavoidable method for monitoring the behavior of the dams.
- Periodic operations are launched twice a year that are executed by surveyors and controlled by DHA.
- The reports allow decision-makers to ensure the functioning of the dams and its security and stability.

GNSS and Laser Scanning



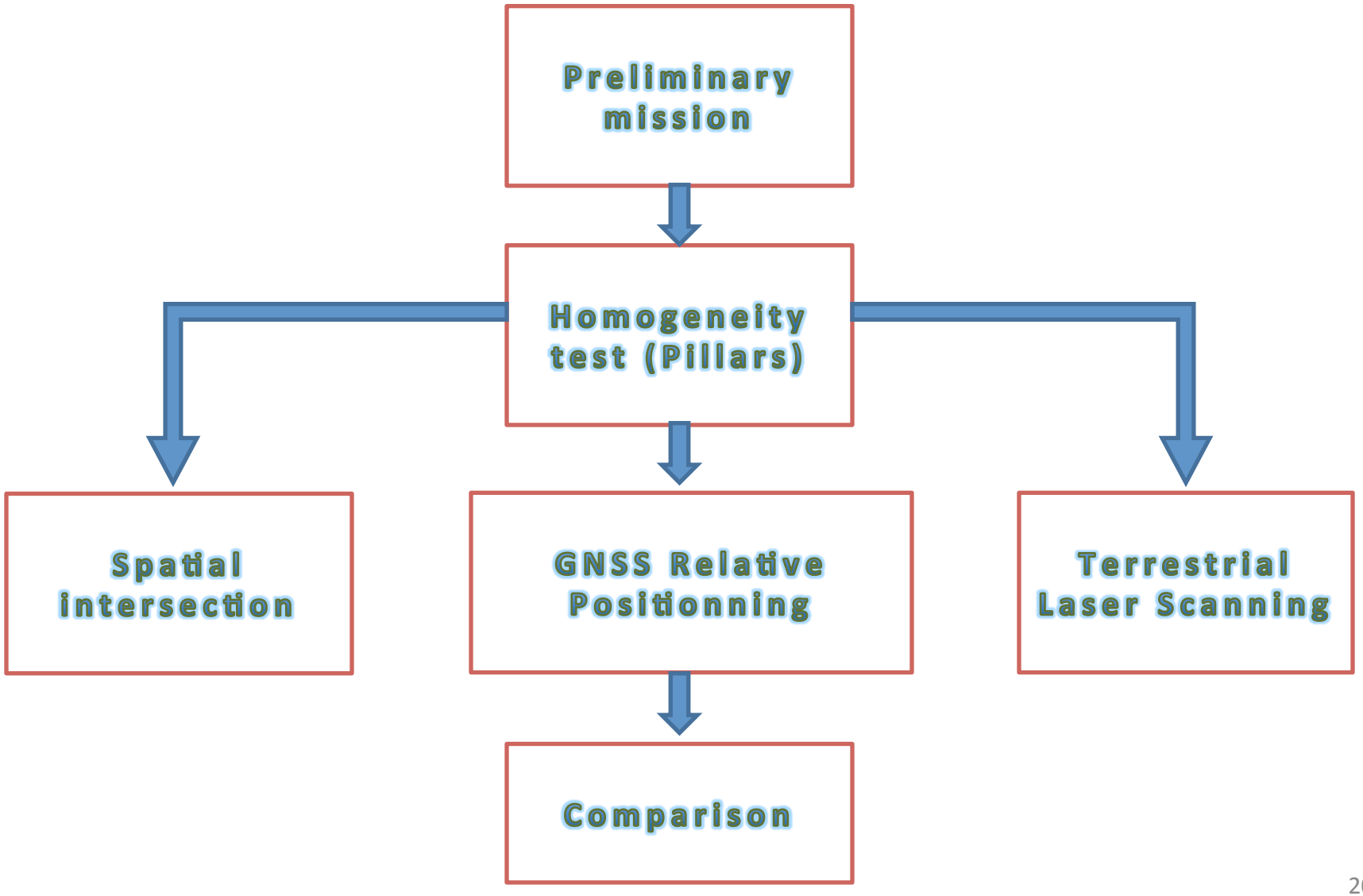
Laser scanning offers the advantage to acquire dense data quickly. The result shape almost perfectly the form of objects which allows a full three-dimensional reading. The problem is the level of precision and reliability that this technique can guarantee.

The Global Navigation Satellite systems are widely used in many areas of positioning but it is necessary to study this technique to see to what extent it can replace the conventional method in monitoring of dams.

Case study : Rabat & Assfalou Morocco

El Aouni K. (2012) & Benkarroumi M., Rfifi M. (2014)

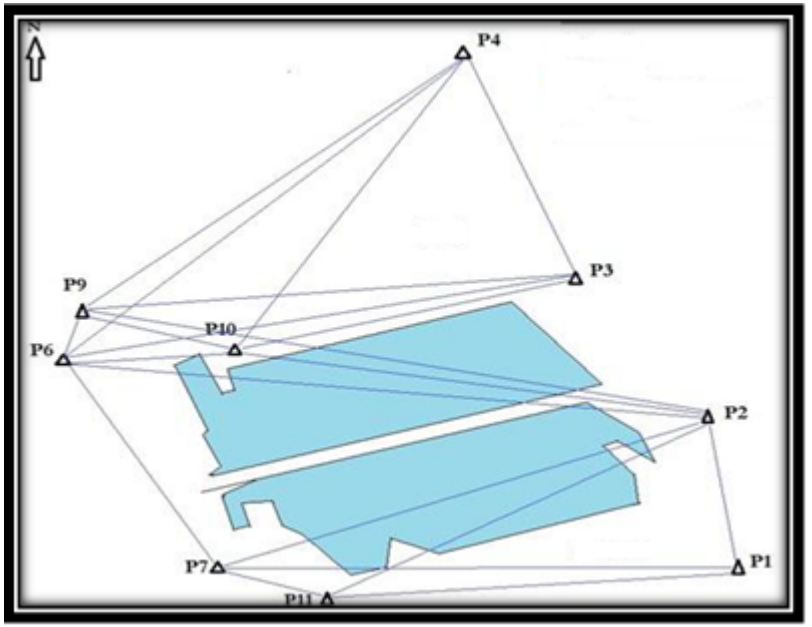
Methodology

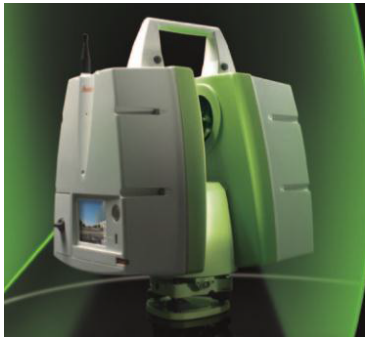


Targets

Experimentation 1

Equipments and base points





Spatial intersection

- Measurement of horizontal and vertical angles
- Angle accuracy : 0.5 ‘’
- 08 measurements per roundel
- Intersection of 18 roudels from 02 Pillars
- Least-squares adjustment
- Determination of positions in 3D

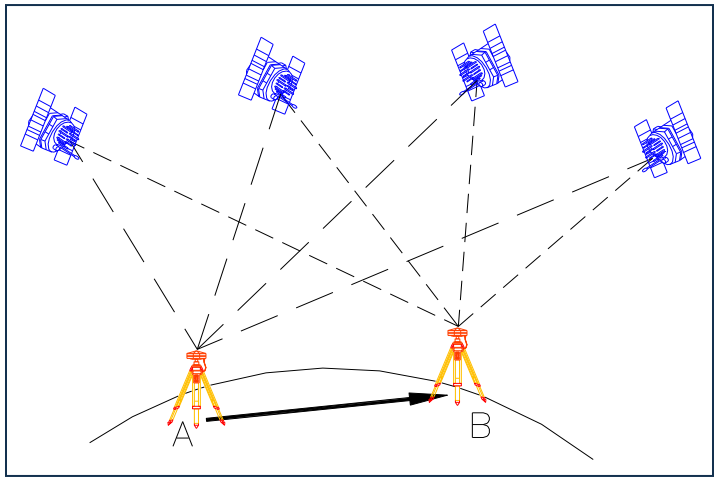
GNSS receivers

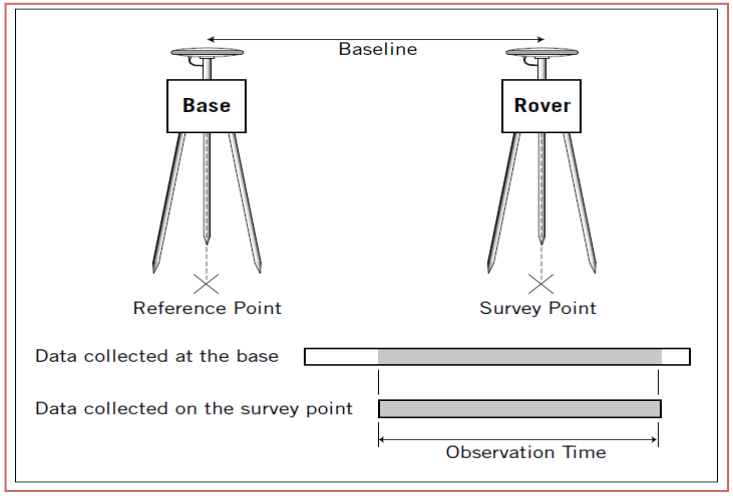
GNSS Characteristics

- 75 channels:
  - GPS L1 C/A L1/L2 P-code, L2C, L1/L2 full wavelength carrier
  - GLONASS L1 C/A L1/L2 P-code, L1/L2 full wavelength carrier
  - SBAS code & carrier
  - Low-signal acquisition and tracking engines for signal detection in difficult environments
- Fully independent code and phase measurements
- Advanced multipath mitigation
- Update rate: Up to 20 Hz position and raw data output

Relative Precise Positionning

- Post-Processed Static
- Two frequencies (GPS, GLONASS)
- 01 hour observation / session
- 02 reference points, 18 survey points (Roundels).
- Recording Interval : 1 s
- 04 Receivers used : 02 Bases & 02 Rovers





Terrestrial Laser Scanning

- Measurement Accuracy :
  - Angle : 10''
  - Distance : 3 mm
- Range : 300 m
- Field of view :
  - Horizontal : 360°
  - Vertical : 270°
- Scan Rate : Up to 50.000 pts/sec
- Scan of 18 roudels from 02 Pillars

Intersection Results

N° Roundel	σ X (m)	σ Y (m)	σ H (m)
200/201	0.001	0.001	0.003
202/203	0.001	0.001	0.003
204/205	0.001	0.001	0.003
206/207	0.001	0.001	0.003
208/209	0.001	0.001	0.003
210/211	0.001	0.001	0.003
212/213	0.001	0.001	0.003
214/215	0.001	0.001	0.003
216/217	0.001	0.001	0.003
218/219	0.001	0.001	0.003
220/220	0.001	0.001	0.003
236/237	0.001	0.001	0.003
238/239	0.001	0.001	0.003
240/241	0.001	0.001	0.003
242/243	0.001	0.001	0.003
244/245	0.001	0.001	0.003
246/247	0.001	0.001	0.003
248/249	0.001	0.001	0.003

GNSS Results

N° Roundel	σ X (m)	σ Y (m)	σ H (m)
200/201	0.003	0.003	0.004
202/203	0.003	0.002	0.004
204/205	0.002	0.002	0.004
206/207	0.003	0.002	0.004
208/209	0.002	0.002	0.004
210/211	0.004	0.003	0.006
212/213	0.002	0.002	0.004
214/215	0.002	0.002	0.005
216/217	0.002	0.002	0.004
218/219	0.002	0.002	0.004
220/220	0.002	0.002	0.004
236/237	0.005	0.005	0.005
238/239	0.006	0.004	0.013
240/241	0.002	0.002	0.004
242/243	0.002	0.002	0.004
244/245	0.006	0.005	0.011
246/247	0.004	0.003	0.007
248/249	0.006	0.005	0.007

TLS Results

N° Roundel	σ X (m)	σ Y (m)	σ H (m)
200/201	0.008	0.004	0.013
202/203	0.007	0.005	0.013
204/205	0.008	0.002	0.010
206/207	0.005	0.002	0.006
208/209	0.004	0.003	0.003
210/211	0.003	0.002	0.005
212/213	0.003	0.002	0.005
214/215	0.004	0.002	0.005
216/217	0.003	0.002	0.003
218/219	0.002	0.002	0.003
220/220	0.002	0.005	0.003
236/237	0.003	0.002	0.005
238/239	0.003	0.002	0.005
240/241	0.006	0.002	0.010
242/243	0.003	0.002	0.005
244/245	0.003	0.003	0.005
246/247	0.002	0.005	0.005
248/249	0.002	0.008	0.003

Comparison with reference survey

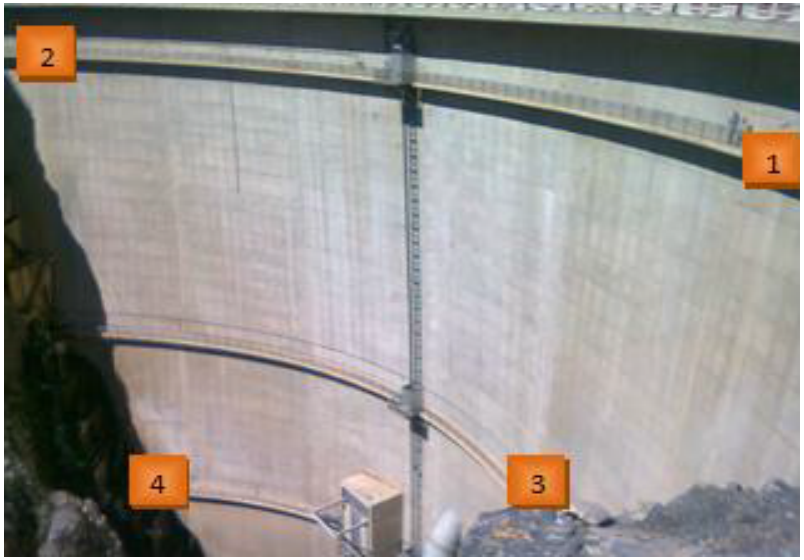
Results :

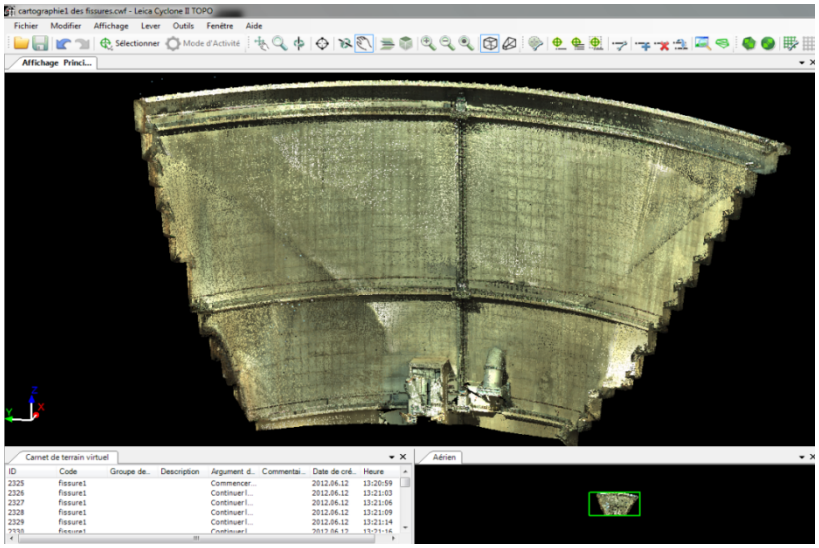
- Spatial Intersection : 1 mm
- GNSS : 5 mm
- TLS : 1 cm

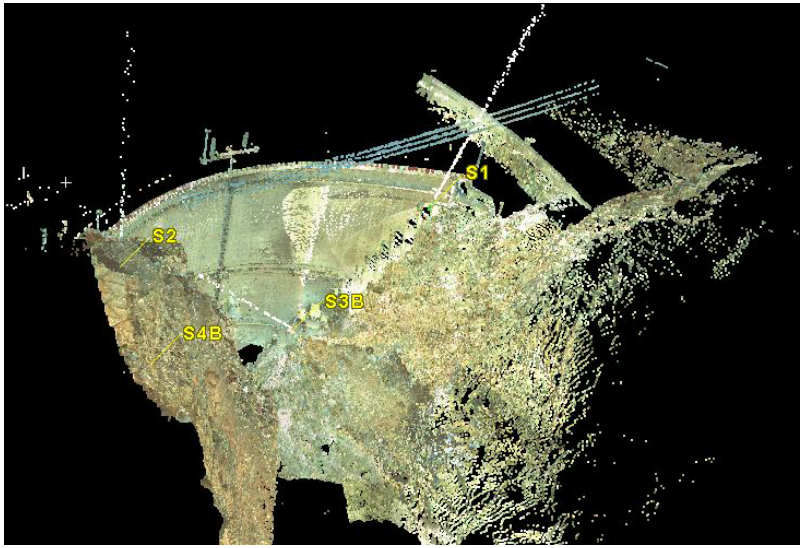
Conclusion :

- GNSS recommanded for monitoring.
- Use of GLONASS and GPS is a necessity to improve the geometry of positionning.
- TLS could be used with some arrangement : If Pillars are close to the structure (<60 m)

Experimentation 2



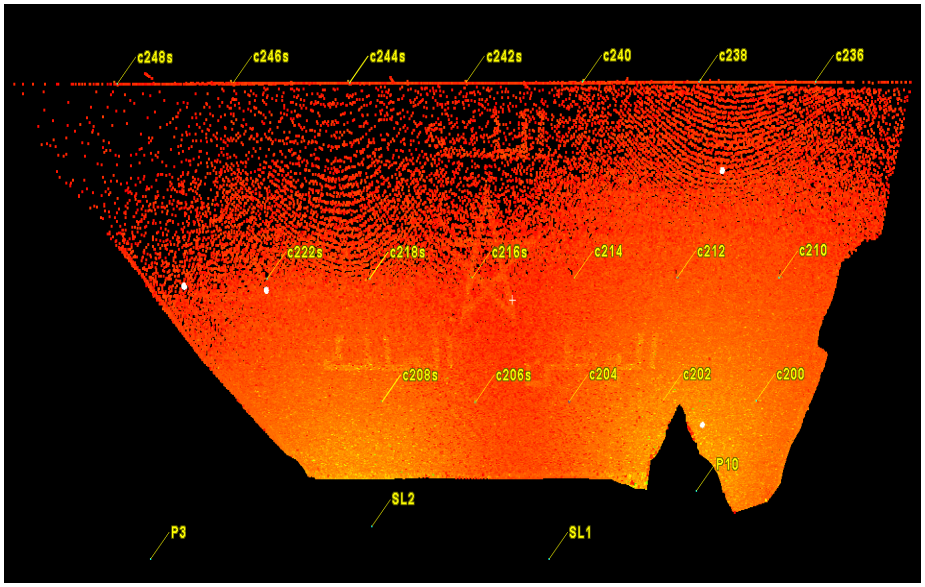


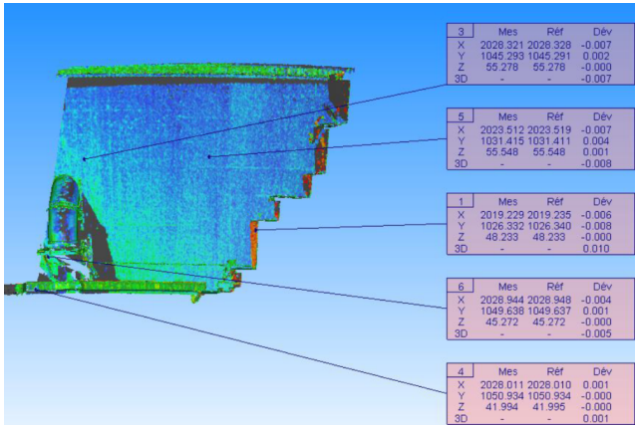


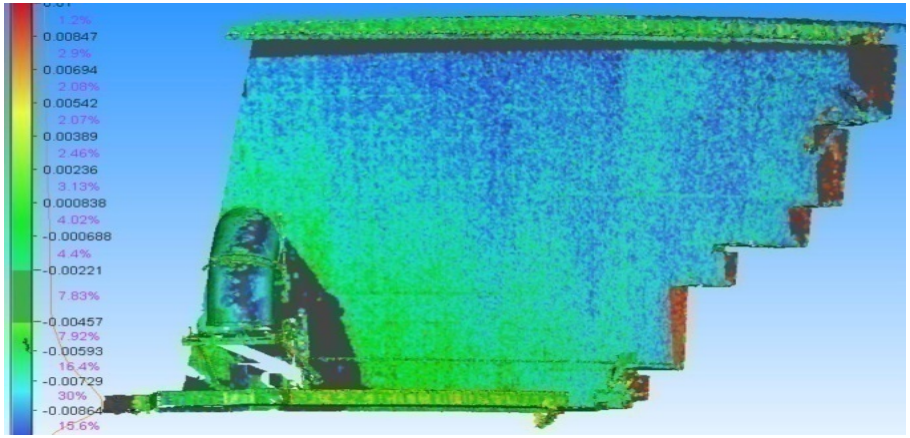
Results

- Angular Intersection : 1 to 3 mm
- GNSS : between 5 mm and 1 cm
- TLS : > 1 cm
- Monitoring of the hall structure by TLS :
  - detection and monitoring of cracks
  - surfaces comparison between two dates
- Conduct experimentation using Permanent GNSS Stations.

TLS Products







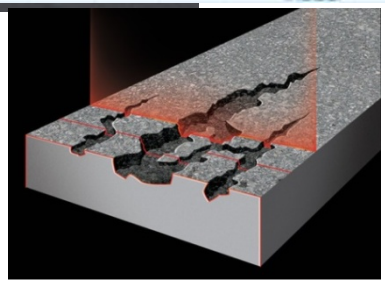
Ongoing Experimentations

Monitoring the silting of dams using GNSS, Laser scanning and Inertial sensors

- Multibeam Echosounder
- TLS
- MMS
- GNSS RTK
- Data aquisition in two periods
- Periodic Change detection : Bottom and shores of the dam

F., Boucht & F., Nouri (2015)

Monitoring the quality of the pavement for urban roads



- Equipments : GNSS & LS & IMU
- GNSS : RTK
- Methodology : determination of optimum parameters
- Comparison between design and scanned models to detect Pavement degradation

M., Benmira & B., Condé (2015)

Conclusion

- Promote GNSS use (interoperability between GLONASS and other GNSS).
- Precision and Rapidity of use of new technology are big advantages.
- Use of GLONASS and GPS improve the geometry of positionning.
- GNSS and TLS can be Used together. Their integration will improve Monitoring Operations but :
  - ➢ Design of Pillars, Roundels and Targets must be adapted
  - ➢ Methodology required by DAH has to be modified

- THANK YOU FOR YOUR ATTENTION