Institut Géographique National
Service de Géodésie et Nivellement
Division des Travaux Spéciaux
Thierry PERSON, Valérie MICHEL
Tél: 01.43.98.80.13 Fax : 01.43.98.84.50
thierry.person@ign.fr; valerie.michel@ign.fr

INSTITUT GEOGRAPHIQUE NATIONAL

Special Works Department

Various techniques and their evolution

Plan of the presentation

- **Standard topometry**
  - Description of the different process
  - Examples
- **Automated tools**
  - Standard tools with automated acquisition and processing
  - Examples
- **Evolutions**
  - New measurement techniques
  - Analysis tools

Standard topometry

- **Levelling**
  - **mainly direct precise levelling**
- **Planimetry**
  - **angles and distances measurements**
- **GPS**

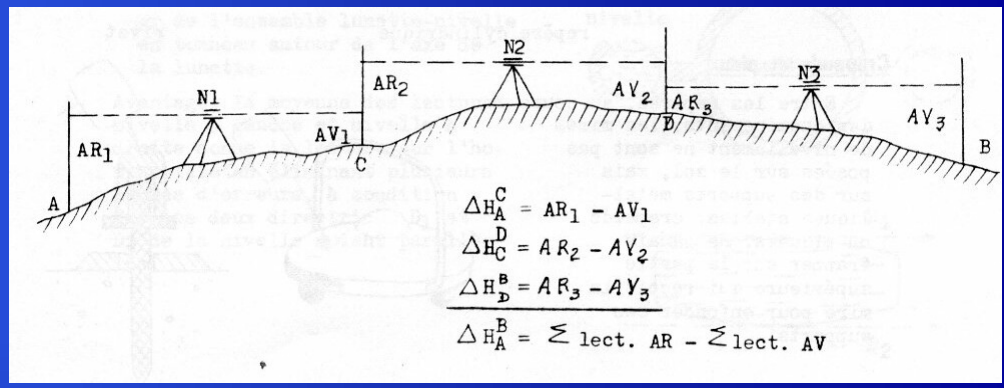
Levelling

- Altimetric informations
- Applications : soil movement (subsidence, settling, …) and their consequences
  - Underground storage areas, mines, structures (bridges, tunnels, …)
- Maily direct levelling

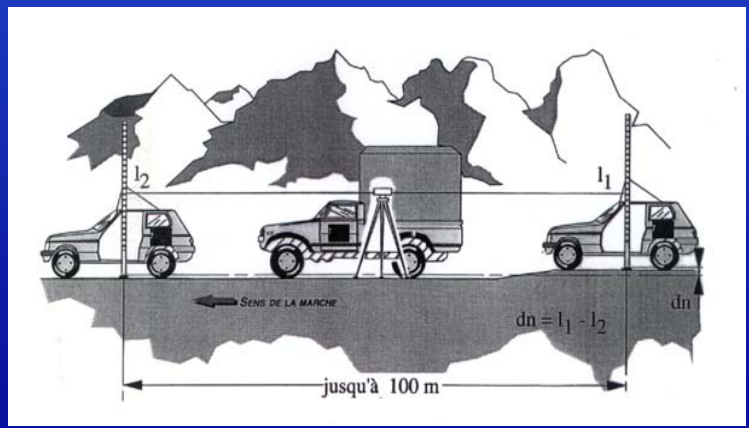
Direct Levelling

Survey 's rod

Electronic level



Levelling traverse

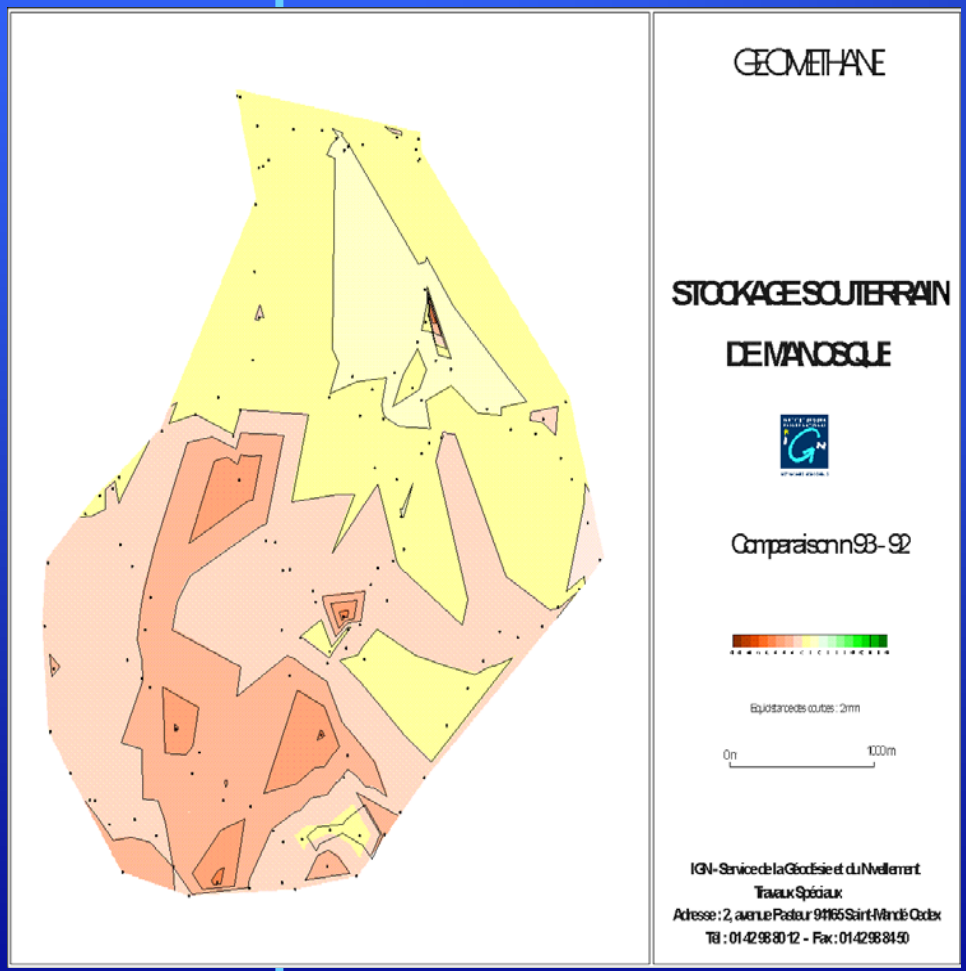


Motorized levelling

Direct levelling

- **Precision**
  - 0.02 à 0.04 mm par portée (20 à 40 m)
- **Rigorous procedure**
  - in order to detect mistakes and minimize errors
- **Least squares processing**
  - optimisation and accuracy indicators
- **Stability points**
  - behaviour of the whole studied area

Gaz storage



- Installation before exploitation
- Measurements every 3 years

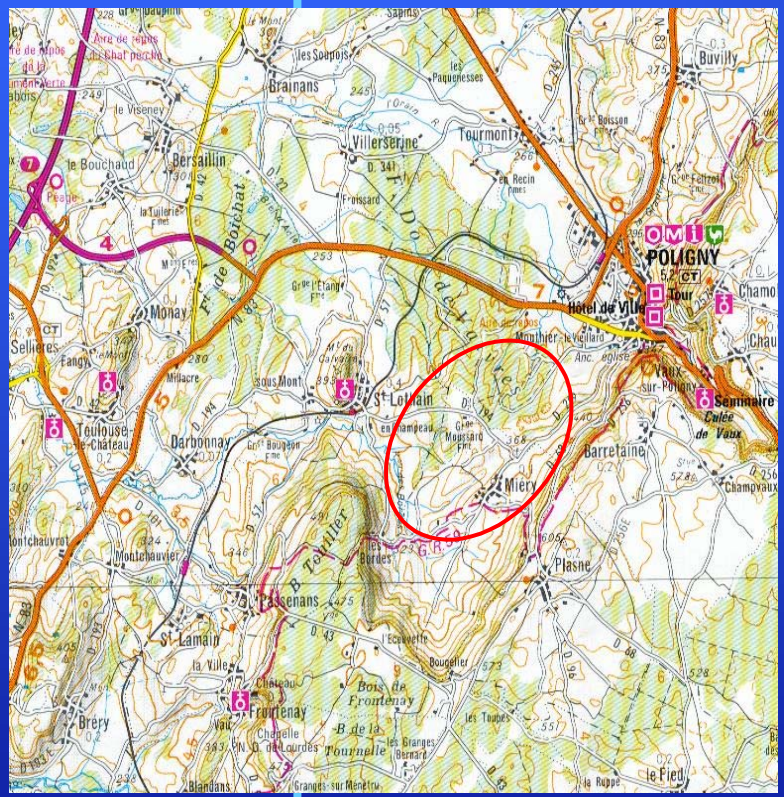
- Non motorized levelling
- 2 weeks with 3 surveyors

- Millimetric accuracy

- Processing with stability points

- Comparison point by point
- Graphic results with colored layer

Salt mine



Carte IGN TOP100 N° 37 - Echelle 1/100 000

- 3 basic traverses of 9.1km
- 39.2km traverse
- 530 points

- Non motorized levelling each year
- 2 weeks with 6 surveyors

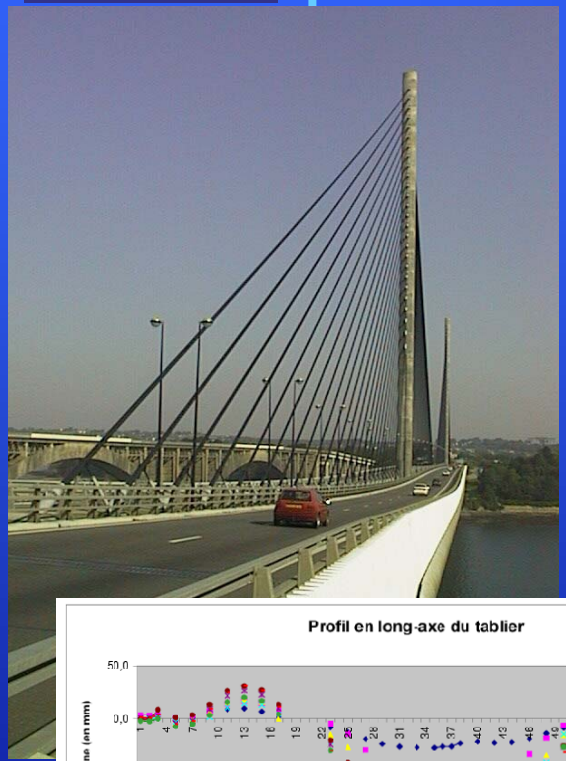
- Processing with stability points

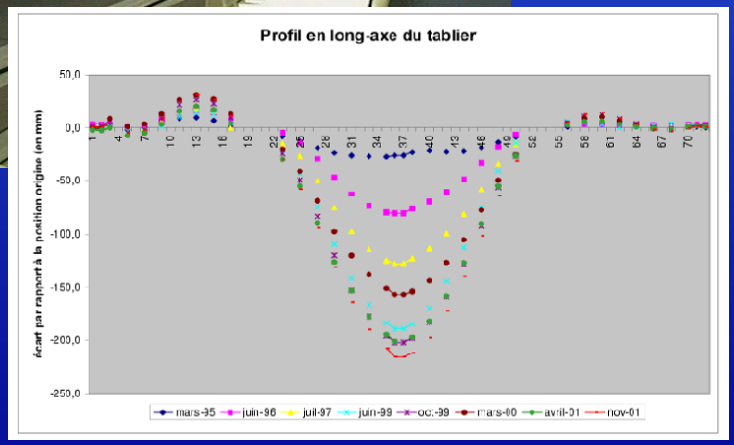
- Millimetric accuracy

- Important movements

- Comparaison point by point

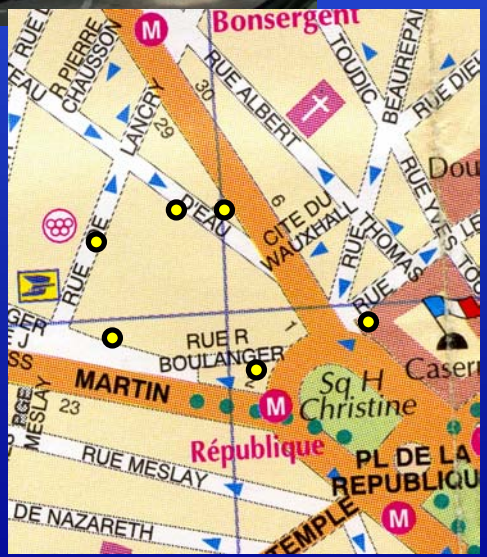
Pont d'Iroise

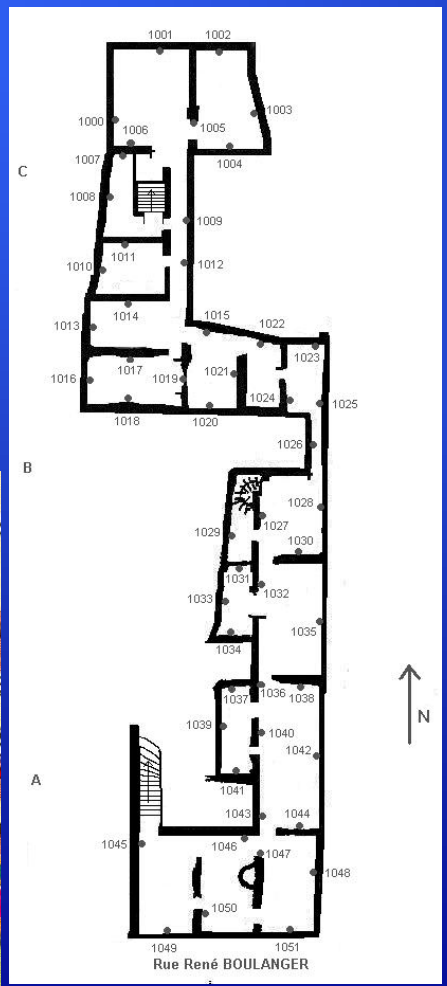




- Integration of topometric informations during the construction
- Measurement « state zero » before opening
- Levelling inside the deck
- Observations during the night : less traffic and thermal stability
- Processing with stabilities on each side
- Comparaison with the « state zero » and the long term model

36 rue René Boulanger





- Checking of the stability of the building
- Levelling in the cellars
- Markers on load-bearings
- Problems:
  - small luminosity
  - size
  - stairs down to the cellars
- Processing with stability outside the building

Planimetry

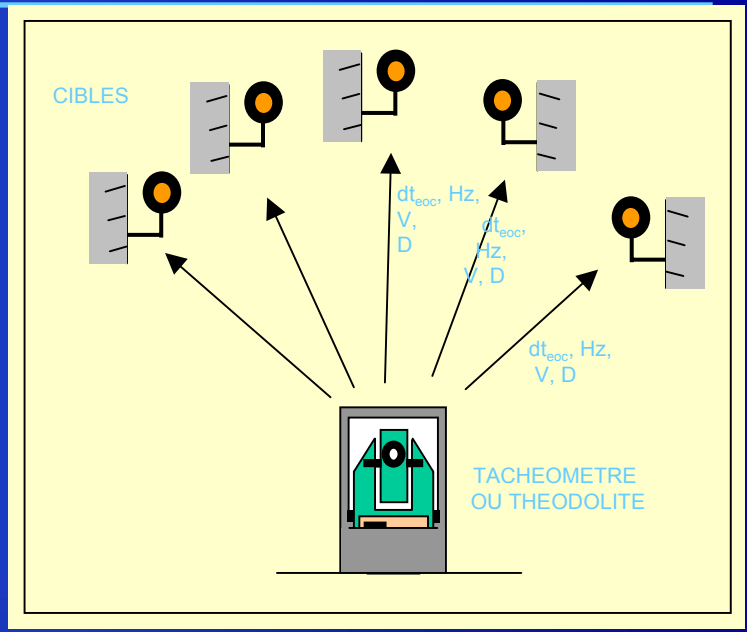
- Planimetric informations from angles and distances measurements

- Applications: soil movements, building, structures, sensitive aeas monitoring, etc …

Planimétrie

Tacheometer

Target



Measurement figure

- **Precisions : 5 à 8 dmgr, 1mm+1ppm**
- **Necessity of known stable points or reference points**
- **Basic network**
- **Least squares processing**

« Moving building »

Rue Raynouard

- **Planimetric observations outside the building : front monitoring**
- **Successive operations following the work progress**
- **As a general rule : observation of the consequences of a vertical move**

Pont de Cumières

- Network outside the bridge
- Redondancy for a least squares processing :
  - monitoring targets overdetermined
  - basic network overdetermined
- 4 pillars, 2 fixed

GPS techniques

- Putting up main order network
- Specific monitoring
- Area stability

Port 2000 project

- **Setting up a main network**
  - **20 points all along the sea wall**
- **Supply a homogeneous datum for all the project's actors**
- **Differential GPS observations**
- **a posteriori processing**

Pont de Saint-Nazaire

- 24 h observations and 1 s acquisition frequency
- Checking the geometry
  - verticality of the pylons
  - length of the deck
- Detection of the pylons moves
- Centimetric precision

Viaduc de Verrières

Monitoring the lauching of the desk

- **RTK GPS**
- **3 receivers used**
- **Checking against a priori estimations**
- **Advantages :**
  - **meteo**
  - **night**
  - **real time**

…..MILLAU

- RTK GPS during the successive launchings
- All automatized
- 300m high

Robotic tools

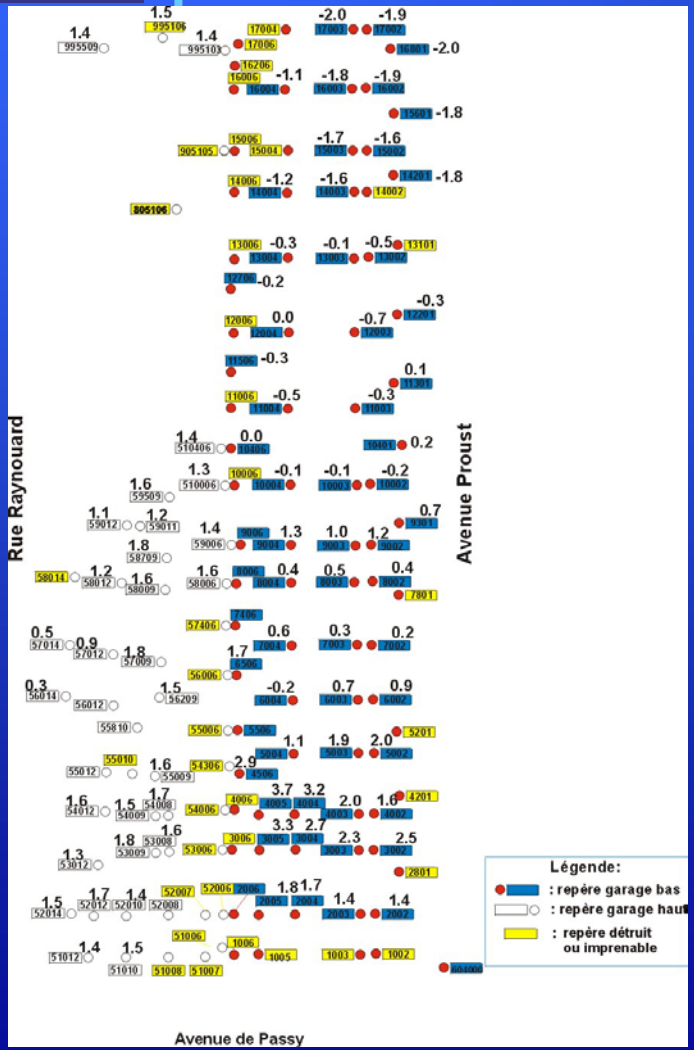
Acquisitions and processing permanent and automatised

- **Digital levels**
- **Tacheometers**
- **GPS**

Robotic digital levels

- Motorisation of the horizontal move and the focal
- Control from the office
- Relative altimetric information very precise
- Automatised processing
- Limited to 30 m
- Calibrated focal
- Light level

Immeuble rue Raynouard



- 2 digital levels working all time during 5 months
- Bar-code staff fixed
- Control, acquisition and processing of the observations from our office in Saint-Mandé

Motorised theodolite

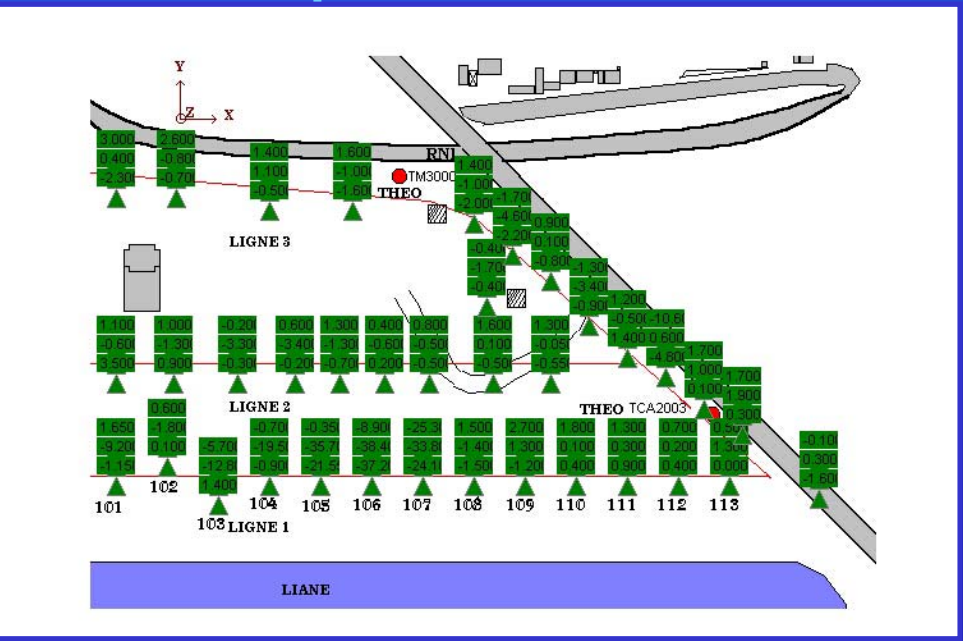
- Vertial and horizontal motorisation
- Totally autonomous
  - target detection
  - Hz,V,D measurements
- Needs a learning step and after a piloting system
- Tridimensionnal information given automatically
- Decreasing accuracy while growing distances

Boulogne

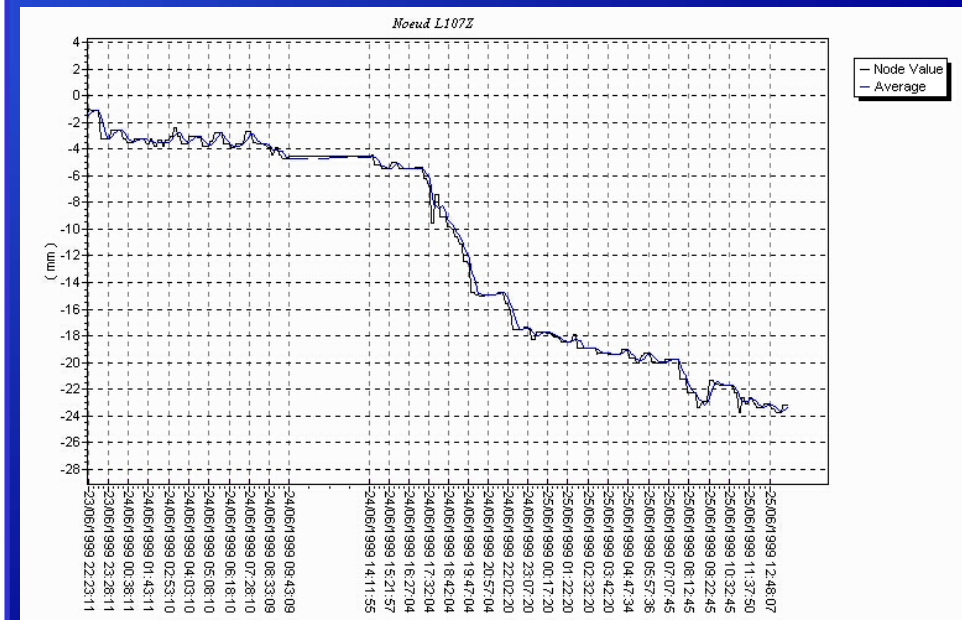
2 independant theodolite

Automatic alarm pannel 24h/24h

Very fast moves detection



Global site



Point deplacement

« Veilleur »

VEILLEUR

- Alarm management tool multi sensors (each or associated)
- Alarm configuration :
  - absolute moves
  - relative moves
  - period
  - system stability
- Fax, bip, pager, email, SMS outgoing

Joeuf et Homécourt

- Mining areas
- 40 prisms
- 2 theodolites during 6 months with:
  - 1 PC
  - 2 phone lines

- Up to 1km
- No moves

- Problem : fog

GPS monitoring

- Large dimensions areas
- GPS precision better than anything else
- Configuration and alarms parameters easy to modify

Technical evolutions

About measurements

- **GPS trajectography**

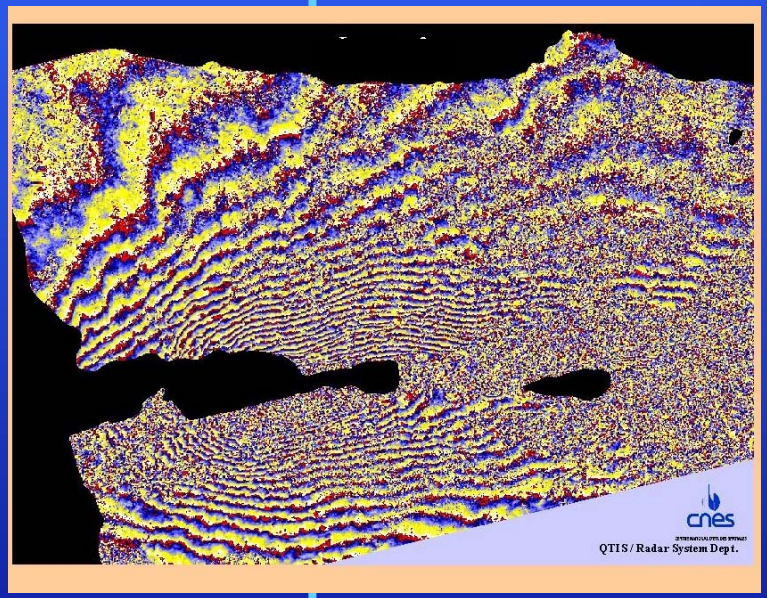
- **TAMS**
- **Radar**

- **Photogrammetry**
- **Laser**

GPS trajectography

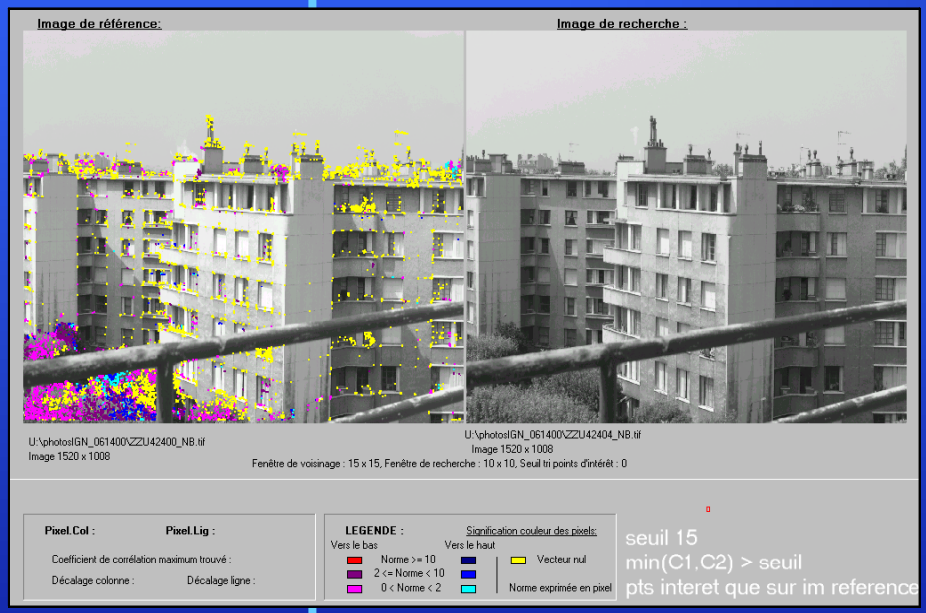
- Tool for subsidence detection
- At the moment : 1 cm accuracy
  - 1 measurement per second
  - speed : 36 km/h
    - ⇒ 1 point every 10m
- Difficulties : masqs (trees, urban areas)
- Road surveys

Radar interferometry



- Satellite on board radar
- Successive radar acquisitions processed by interferometrie
- Each fringe = 28 mm of a vertical move
- Final accuracy : subcentimetric
- Information for a large area
- Not very sensitive on meteo conditions
- Sensitive on vegetation

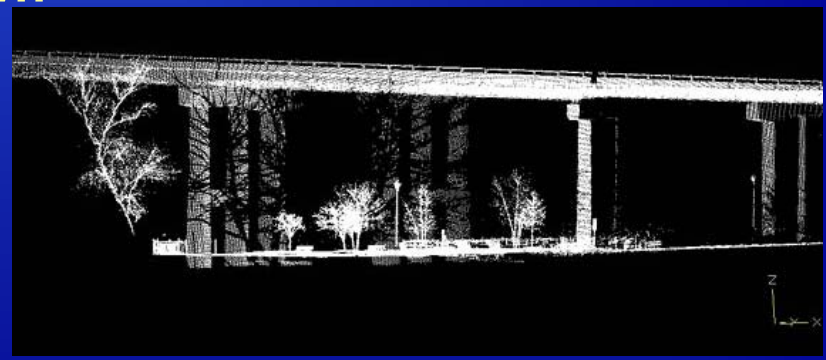
Photogrammetry



- Association digital image / topometry
- Automatised processing, monoscopy or stereoscopy
- Alarm configuration using these results
- Association theodolite/digital camera

Laser Scanner

- Thousands of points per second
- 3D scanning
- HZ V D
- Accuracy not really known
- Problem : what about refraction ?



Others projects

- **Software developments**

⇒ **Associate different informations and process them all together**

⇒ **Analysis tools**

⇒ **Visualisation tools**

Associating pontual sensors and topometry

- Ponctual geotechnical sensors : piezzometers, inclinometers, etc …
- Generally very precise informations
- Topometry : geometric reference basis
- How to associate these different informations?

GIS

- Geographic information system
- Management of localised informations
- Treatements and association of different kinds of informations
- Analysis including constraints or deformation models
- 3 or 4 dimensions GIS