Vertical Geology Conference 2014

GEOSTRUCTURAL MAPPING AND KEY BLOC MODELING BY TERRESTRIAL LASER SCANNING AND DIGITAL IMAGING

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SOLID IMAGE CONTRIBUTIONS FOR OUTCROP INSPECTION

Pierre ASSALI

3D GEOSTRUCTURAL MODELING OF ROCK FACES IN RAILWAY ENVIRONMENT

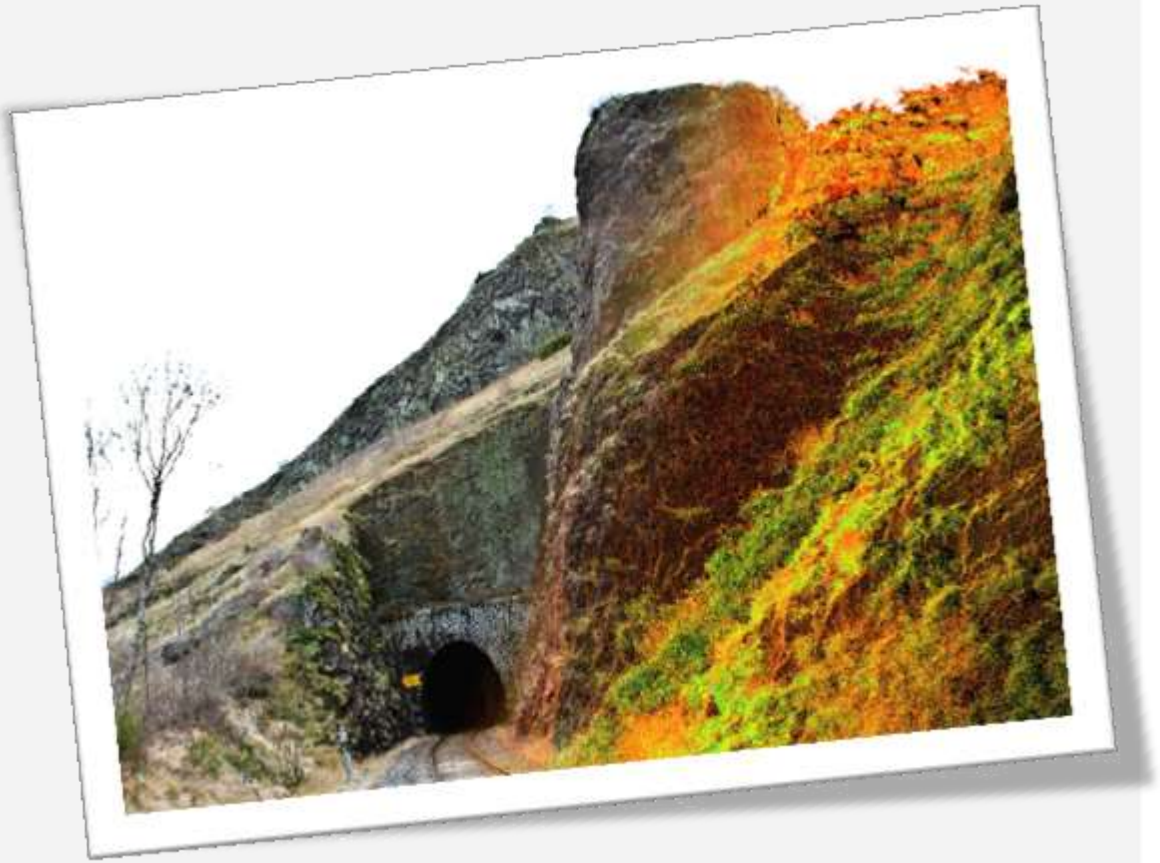
PhD Thesis

Pierre ASSALI | **Flavien VIGUIER** & **Nicolas POLLET** | **Pierre GRUSSENMEYER** | **Thierry VILLEMIN**

April 2011
–
March 2014

PRESENTATION OUTLINE

- CONTEXT & RAILWAY ENVIRONMENT
- DENSE 3D POINT CLOUDS
- SOLID IMAGE
  - Concept & structure
- DIGITAL SURVEY PROCEDURE FOR STRUCTURAL MAPPING
  - Discontinuity sampling
  - Key bloc modeling



CONTEXT & RAILWAY ENVIRONMENT

- **2 300 km** of rock cuttings along the French railway network

- Natural hazards are the **second most frequent cause of traffic disruption**

2013 - Morlaix

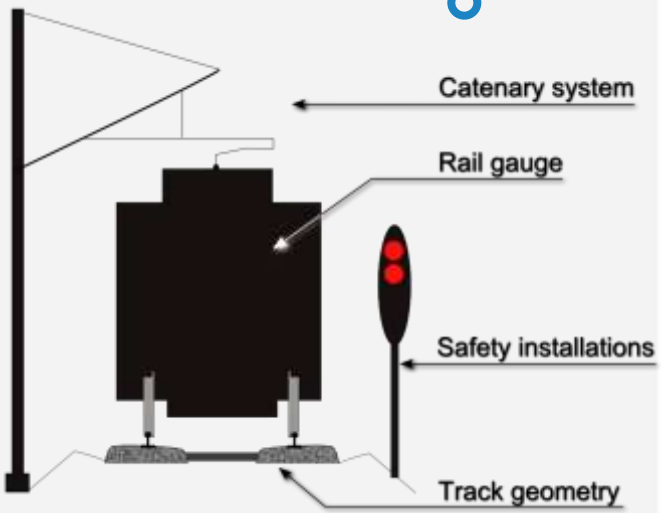
CONTEXT & RAILWAY ENVIRONMENT

Railway performances :
Reliability, Availability, Maintenability, Safety and Costs

Hazards ? Railway system

Rock fall risk

Barriers and reinforcement works

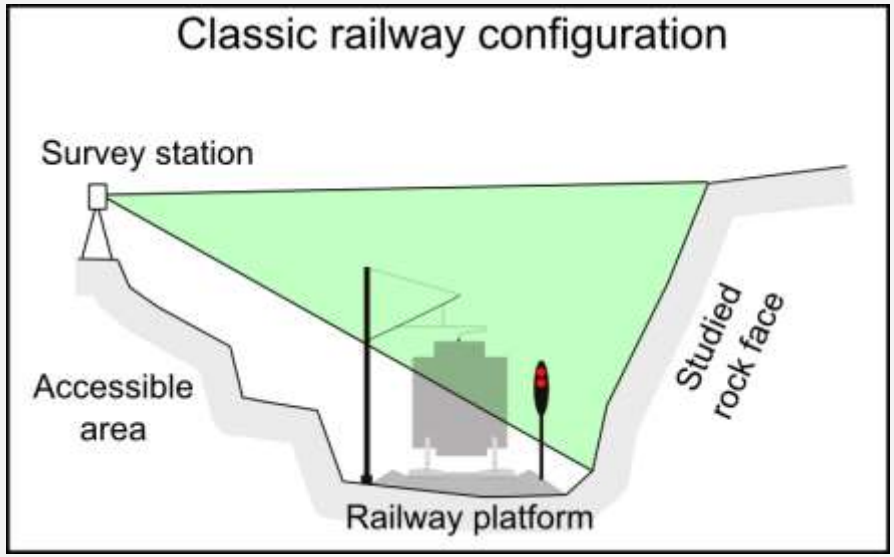


Optimizing survey data for risk management ?

DENSE 3D POINT CLOUDS…

… from :

- Terrestrial Laser-Scanning
- Dense Image Matching

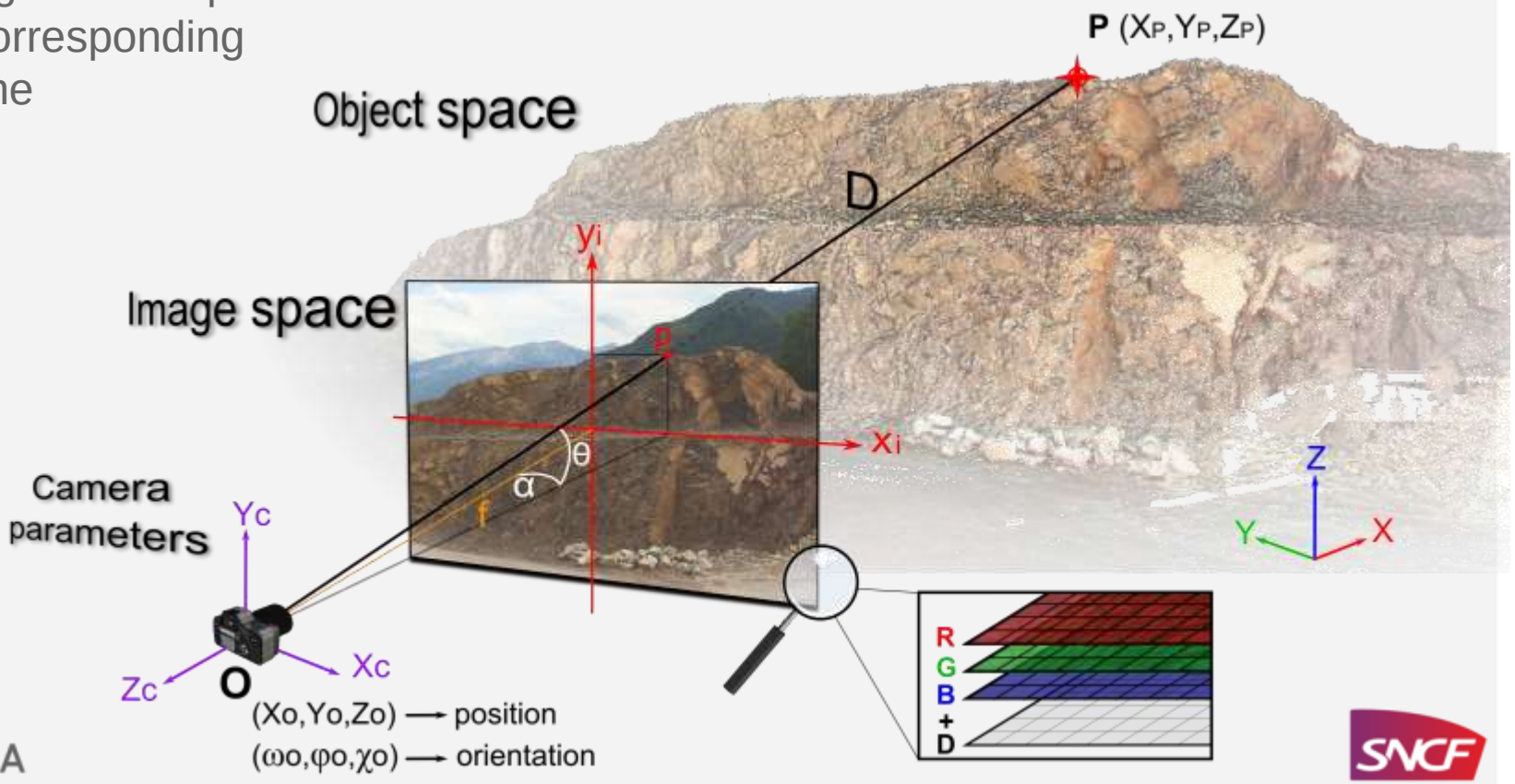


- New and massive data for the SNCF geologists
- How to handle and exploit it ?

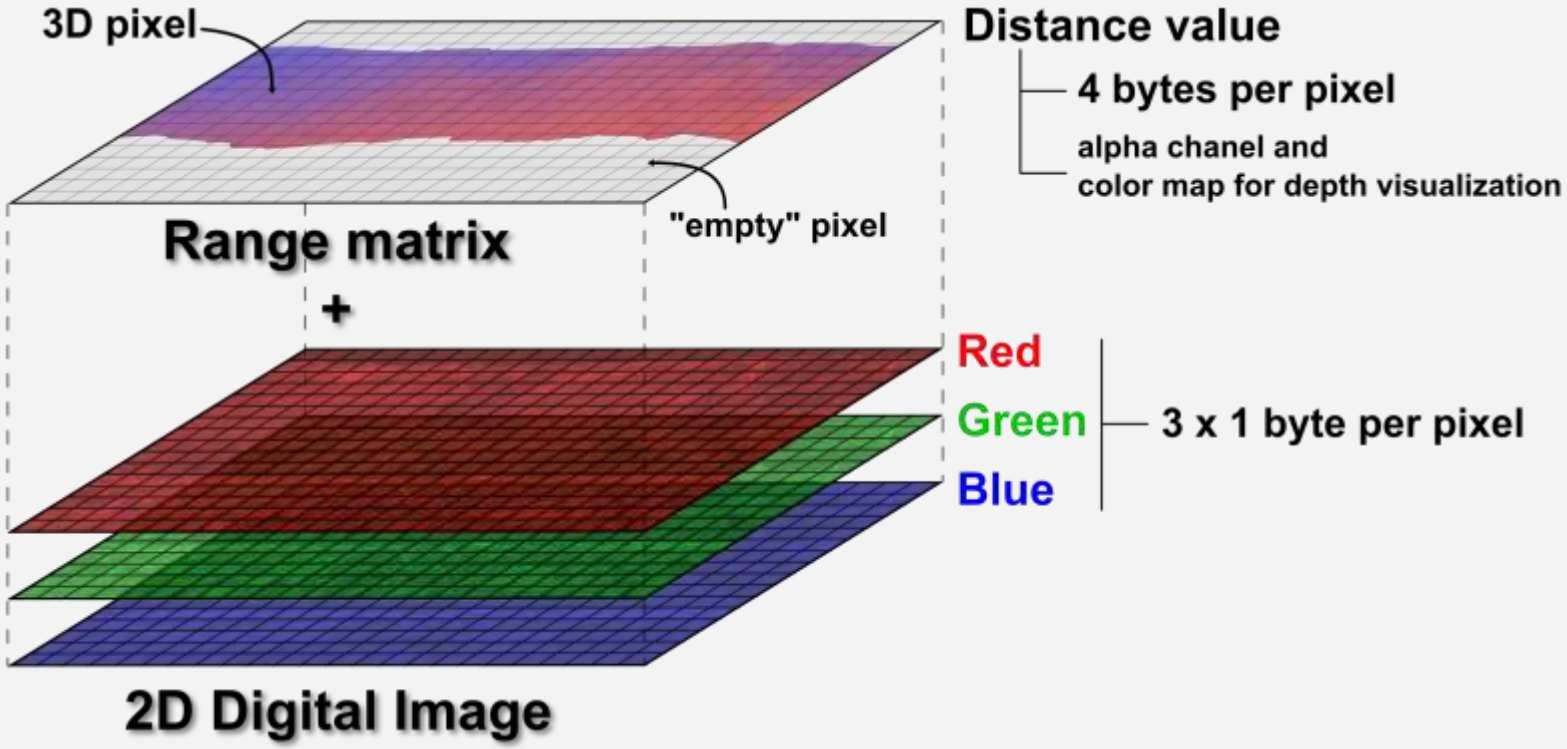
Solid image contributions

SOLID IMAGE : CONCEPT & STRUCTURE

- Enrichment of a classical 2D digital image with the corresponding 3D geometrical information [Bornaz and Dequal, 2003]
- Co-referencing the camera and the 3D model by surveying few control points
- Calibrated camera : focal length ? lens distortions ? …
- Projecting each 3D point onto the corresponding image plane



SOLID IMAGE : CONCEPT & STRUCTURE



Additional information

- → Range data (3D points)
- → Reflectivity values
- → Structural information (discontinuity set)
- → Temperature value
- → etc…

STRUCTURAL MAPPING AND DIGITAL SURVEY

Case study

11 images : Canon EOS 5D Mark II + 105 mm

TLS Point Cloud : Leica HDS7000

14 ground control points for the co-referencing

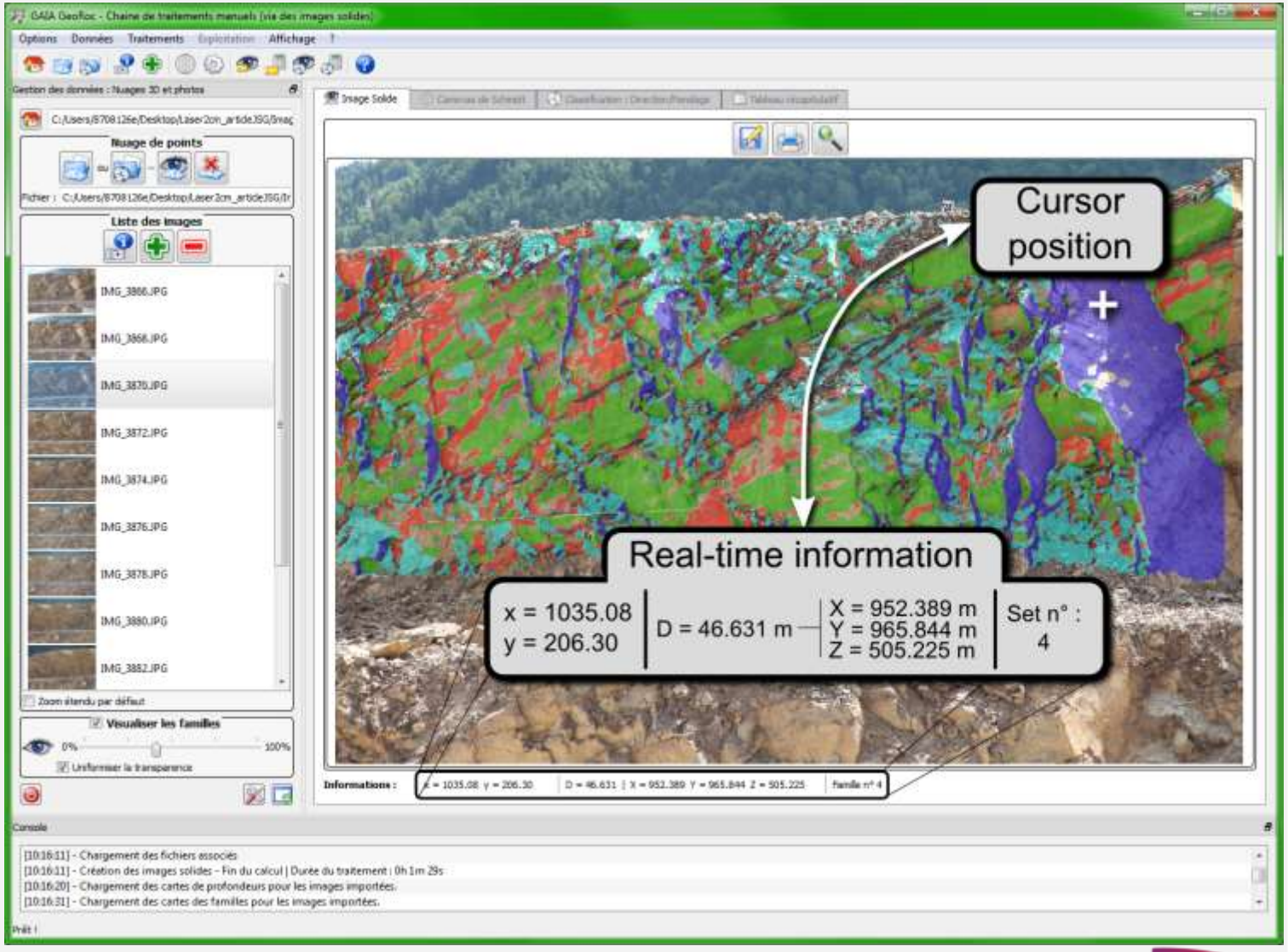
11 Solid Images

STRUCTURAL MAPPING AND DIGITAL SURVEY

Graphical user interface

Real-time information directly on the image

Multiple layers helping with the structural interpretation



STRUCTURAL MAPPING AND DIGITAL SURVEY

Converting 2D pixels selections into useful information for rock engineering

3D INSPECTION TOOLS

3D distances

Discontinuity survey and geometrical characterization

Orientation viewing

Specific orientation highlighting

Intersection/Propagation of fracture planes

Block modeling

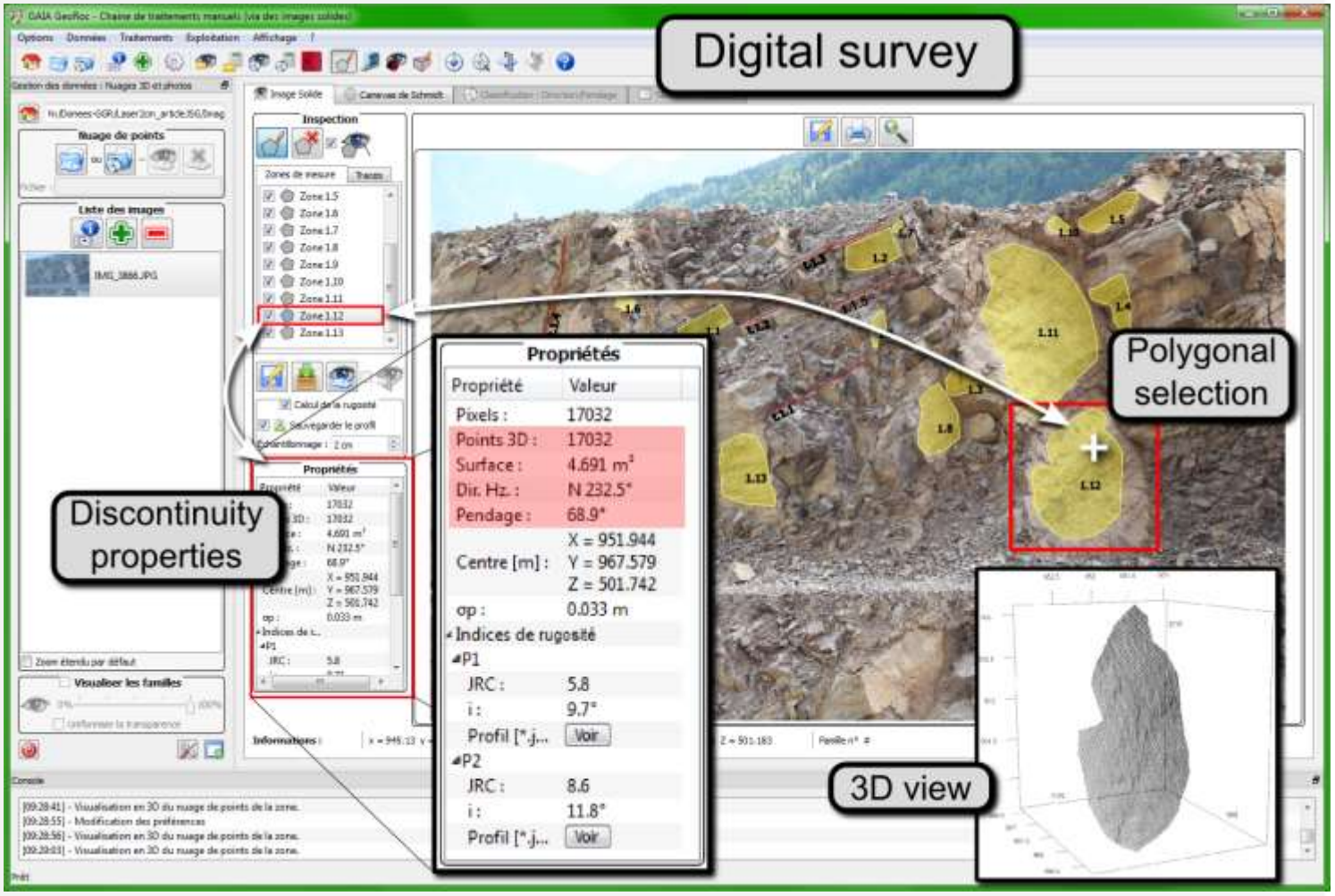
Support the geologist in its expertise

STRUCTURAL MAPPING AND DIGITAL SURVEY

Converting 2D pixels selections into useful information for rock engineering

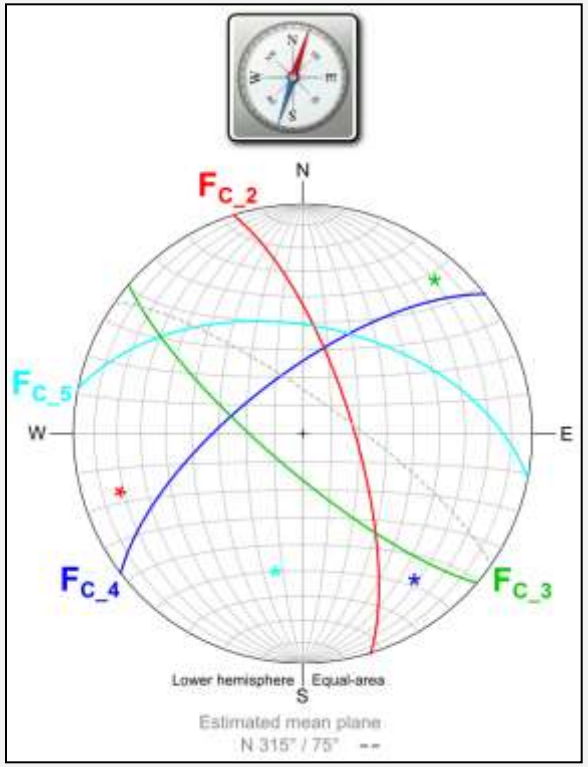
Discontinuity sampling :

- **Length/Surface**
- **Orientation and stereoplot**
- Standard deviation from the mean plane
- Roughness profiles



STRUCTURAL MAPPING AND DIGITAL SURVEY

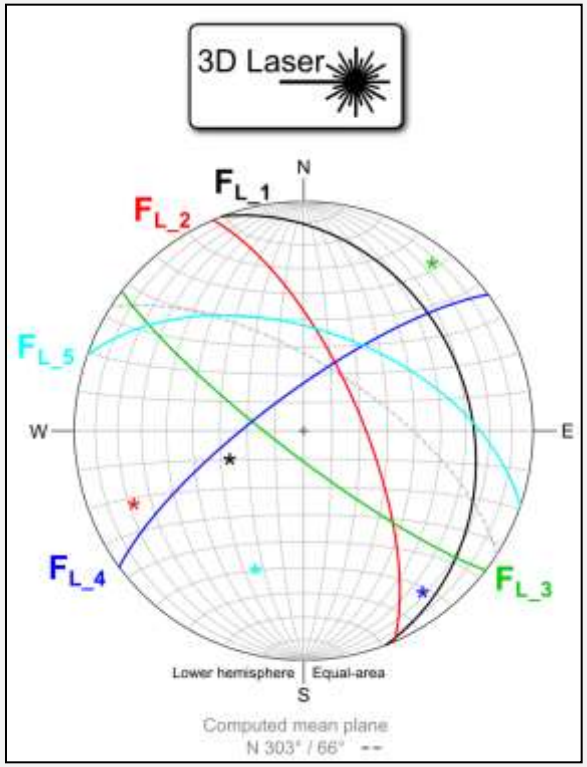
Check and validation for the discontinuity orientation



Compass-clinometer survey

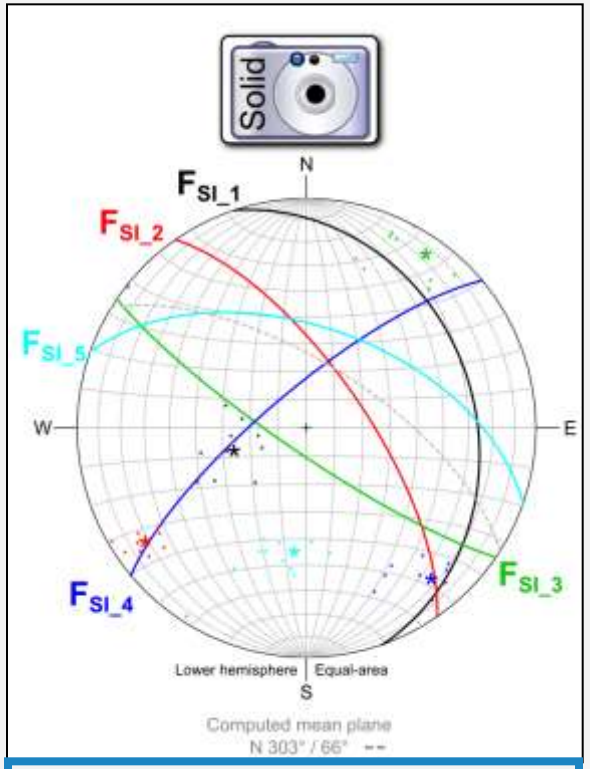
⟶ weak statistical sample

⟶ 1 set is missing



3D point cloud survey

⟶ Automated and non-controlled operation



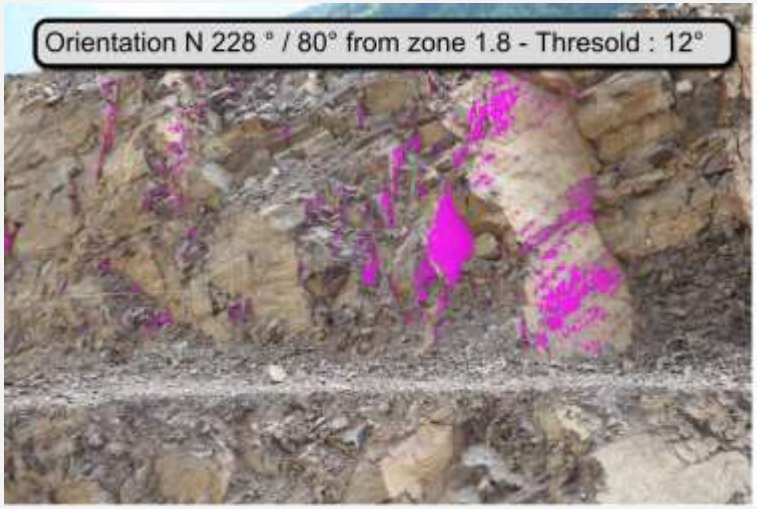
Solid Image survey

⟶ Controlled

⟶ Quick, easy and precise

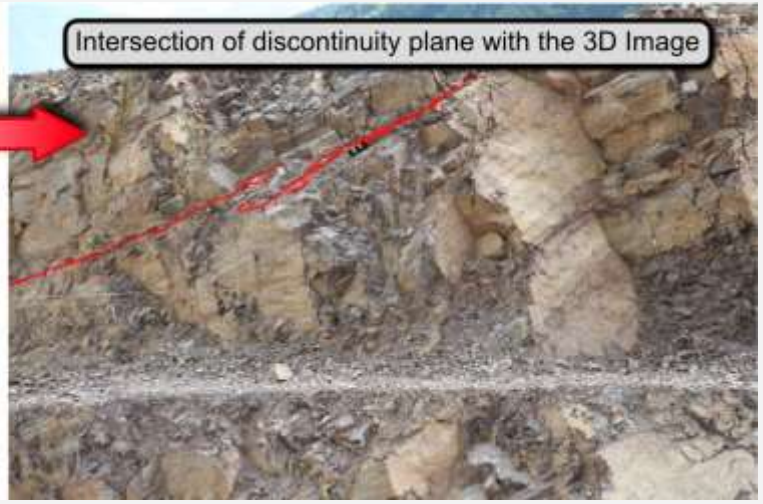
STRUCTURAL MAPPING AND DIGITAL SURVEY

Tools for structural investigations



Highlighting specific orientations with a given threshold

Fracture propagation or intersection with the 3D image

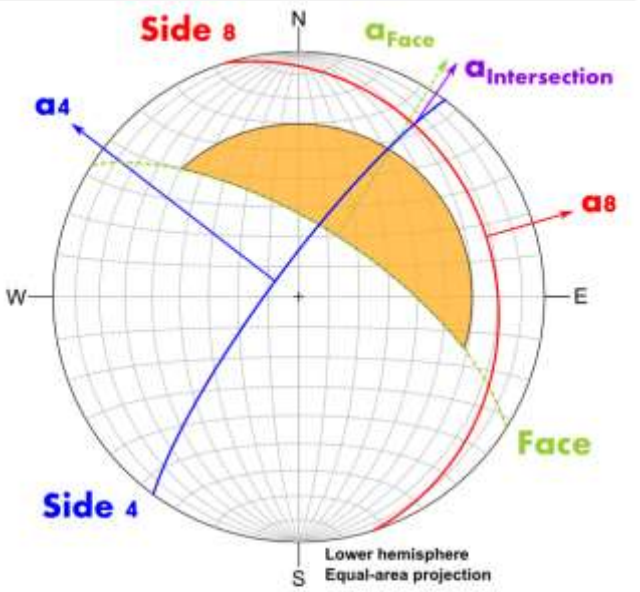


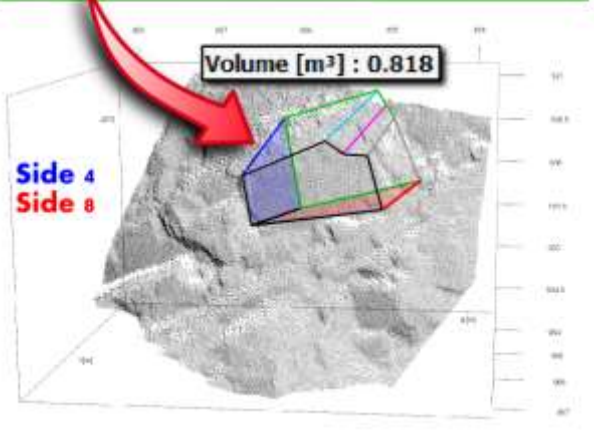
STRUCTURAL MAPPING AND DIGITAL SURVEY

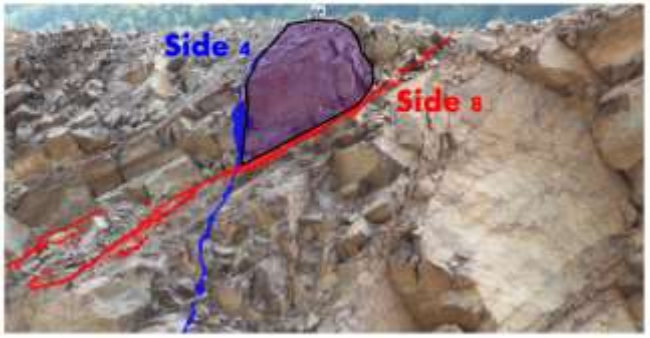
Key block modeling

Virtual delineation of the studied block

- Defining the number of sides
- Computing the 3D coordinates for every vertex
  - intersection of 3 planes
  - selection on the image
- 3D preview helping the process







Volume & kinematic analysis

CONCLUSION

The presented tools are gathered into a standalone software :

GAIA-GEOROC

developed primarily for geologists in charge of rock fall risk management along the French railway network.

CONCLUSION

- **GEOMETRIC CHARACTERISATION of a rock face using dense 3D POINT CLOUDS**

- **BENEFITS**

SAFETY	**for field and office staff, thanks to remote sensing technologies and the 3D data**
RELIABILITY	**Complete and reliable geometrical model of the studied outcrop (structural analysis ↗)**
COSTS	**Saving estimated between 10-20% compared to classical methodology**

- **PERSPECTIVES :**

  Integration of these geometric parameters into other solutions for modeling the mechanical behavior of a global rock solid mass (Discrete element method) in 3D…

MANY THANKS
FOR YOUR ATTENTION

Pierre ASSALI