Advances in the use of Ground Based Radar for Disaster Recovery Risk Management

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IDS AUSTRALASIA
an IDS Ingegneria Dei Sistemi company

FIG Working Week 2016

CHRISTCHURCH, NEW ZEALAND 2–6 MAY 2016

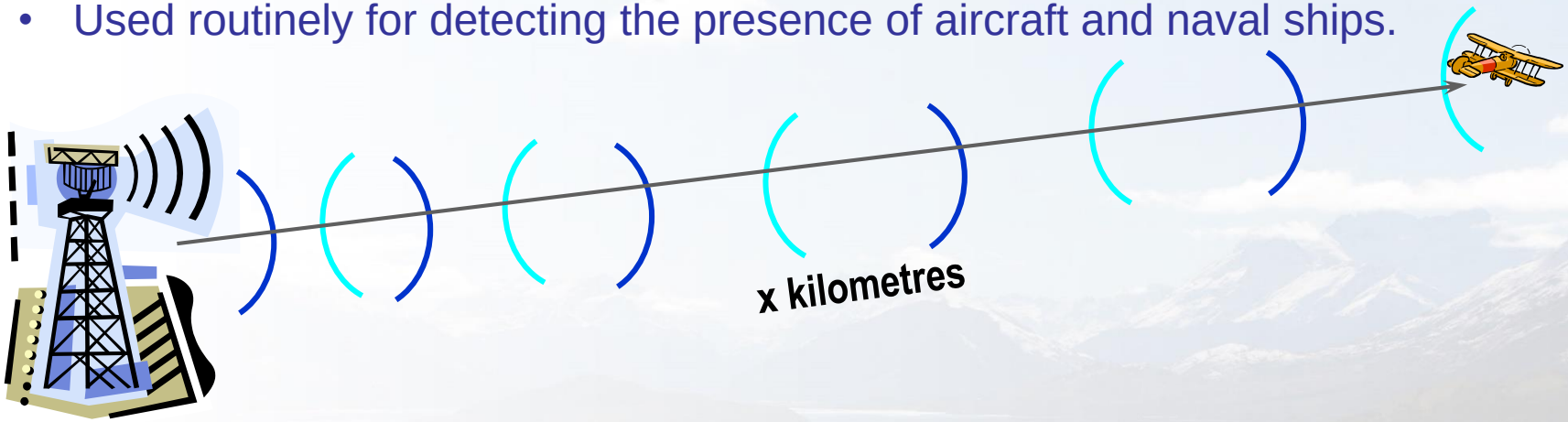
Recovery from disaster

Organised by FIG NZIS

Platinum Partners Trimble esri

Diamond Partner Land Information New Zealand Toitū te whenua

- RADAR – Radio Detection And Ranging
- Used routinely for detecting the presence of aircraft and naval ships.



- More recent uses of ground based radar:
- Ground-penetrating radar (GPR) for geological / civil infrastructure investigations
- Interferometry and Synthetic Aperture Radar (SAR) for remote monitoring of the movement of structures and landscapes.
- The use of ground based radar lends itself to many applications in disaster risk management.

IBIS

Image **B**y **I**nterferometry **S**urvey

Stepped Frequency - Continuous Wave (SF-CW)
Frequency Modulated – Continuous Wave (FM-CW)

IBIS F range

PRODUCTS

IBIS - FL

IBIS - FM

IBIS - FS

APPLICATIONS

LANDSLIDE & DAM MONITORING

SLOPE STABILITY IN MINING

STRUCTURAL MONITORING

IBIS-FS application overview

- IBIS-FS radar technology is used for vibration and displacement measurement
- The main advantages of the use of IBIS-FS is the high accuracy (0,01 mm) and the remote sensing nature of the system (up to 1 km range).

Sensor unit:
- Signal Transmitter and Receiver
- 200Hz sampling

Tripod and 3-D rotating head:
- Aluminium tripod:
  - lightweight: 4.3Kg;
- 3-D rotating head:

Processing unit:
- PC with management SW

Power supply unit:
- 2 batteries 12VDC 12Ah

Techniques behind the IBIS FS system

The IBIS FS product is based on two radar techniques:

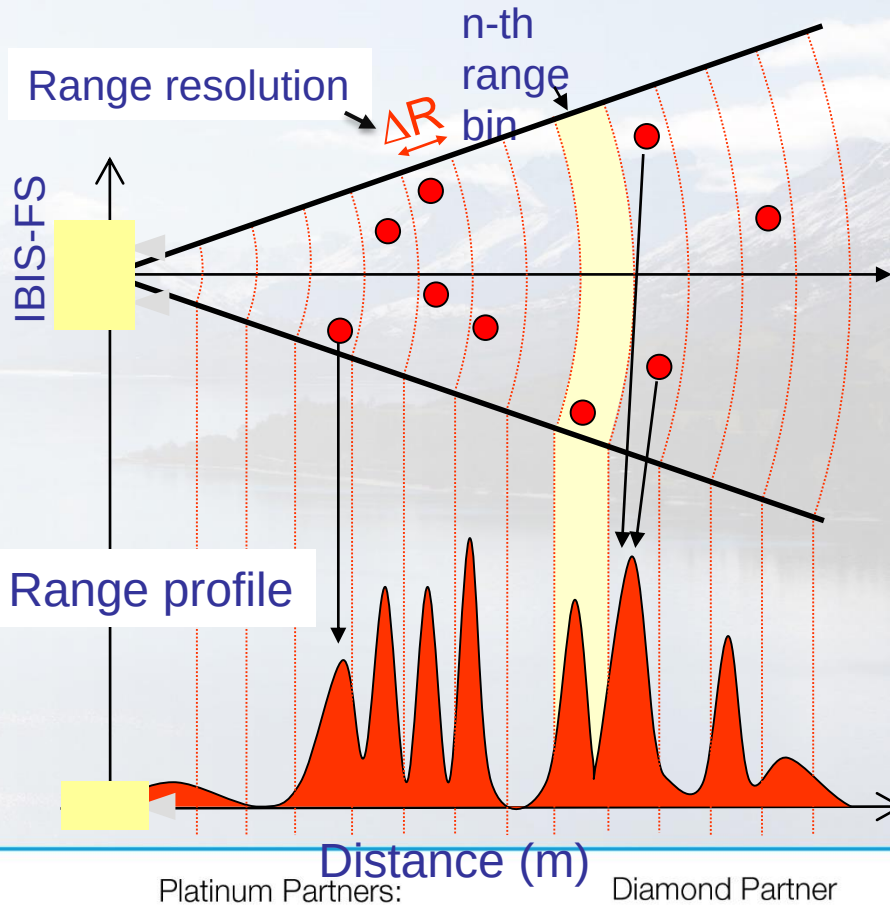
1. Stepped Frequency - Continuous Wave (SF-CW) is technique used to obtain a 1-Dimensional Range Profile with Range Resolution.

2. Interferometry technique, computes the displacement of each pixel by comparing the phase information of the radar signal collected between 2 acquisitions.

IBIS-FS Acquisition Mode

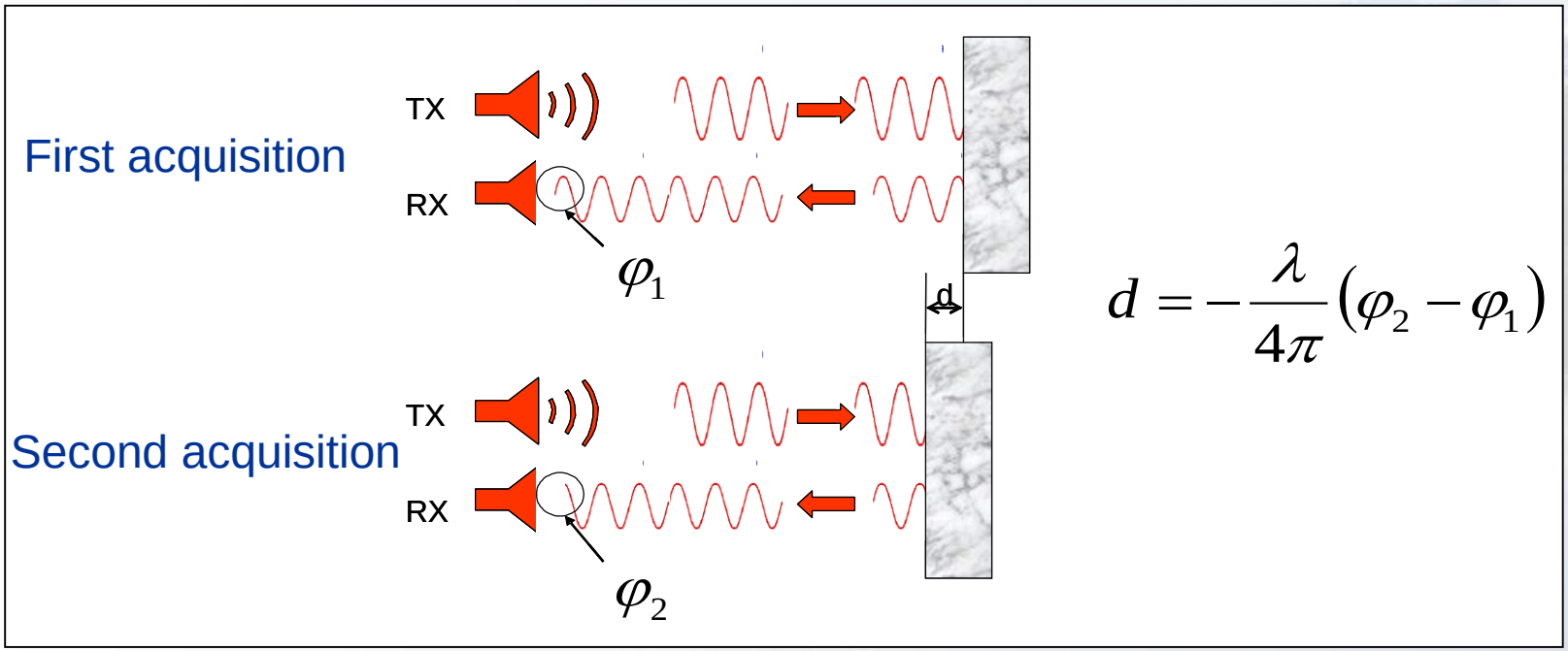
- Beamwidth variable between 20 and 100 degrees
- The measured scenario is divided into range bins, whose number depends on the range resolution (0.5 m minimum, constant with distance).

- User's defined maximum range (up to 1 Km)



Interferometric capability

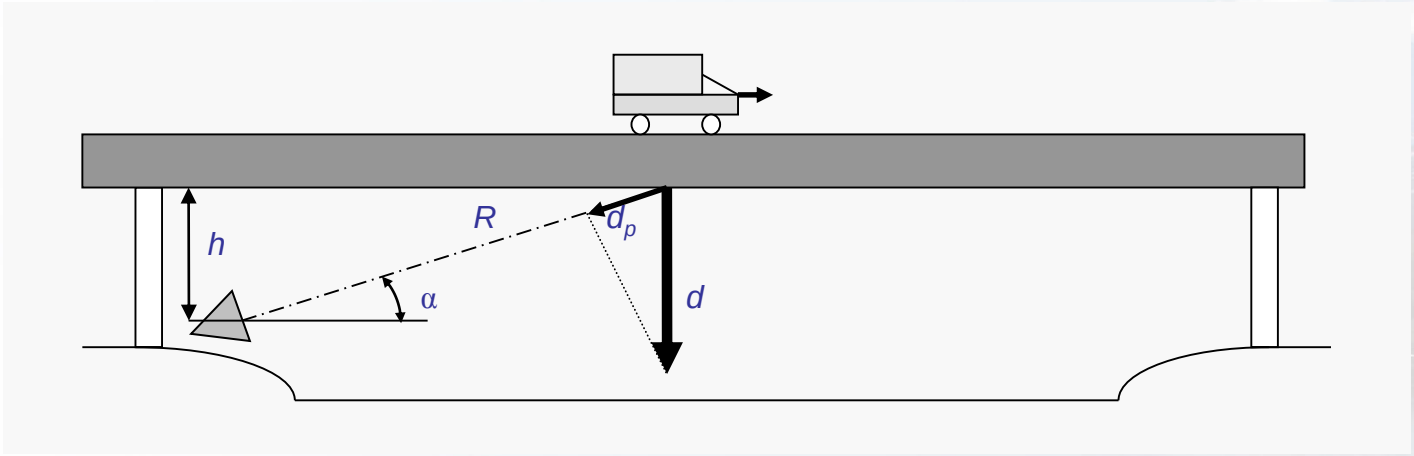
The **interferometric analysis** provides displacement information by comparing phase information of reflected waves between two separate acquisitions. Allows accuracy of less than 0.01mm to be achievable.



1-D Interferometric capability

The displacement is measured in the direction of the line of sight of the system.

To calculate the real displacement is needed to know the acquisition geometry



$$d = \frac{d_p}{\sin(\alpha)} \quad \Rightarrow \quad \sin(\alpha) = \frac{h}{R} \quad \Rightarrow \quad d = d_p \cdot \frac{R}{h}$$

*The distance **R** is measured by IBIS-S*

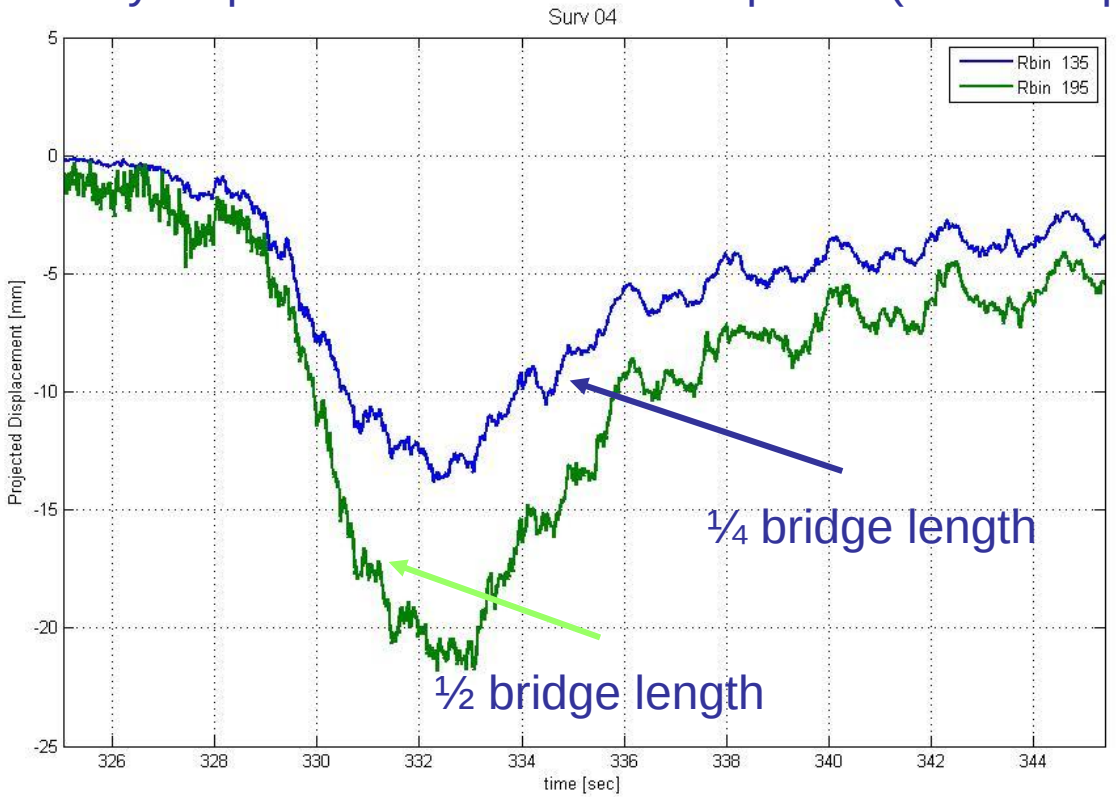
Dynamic Monitoring: Kuranda Scenic Railway

Kuranda train (Cairns, Australia)

Measurement set-up

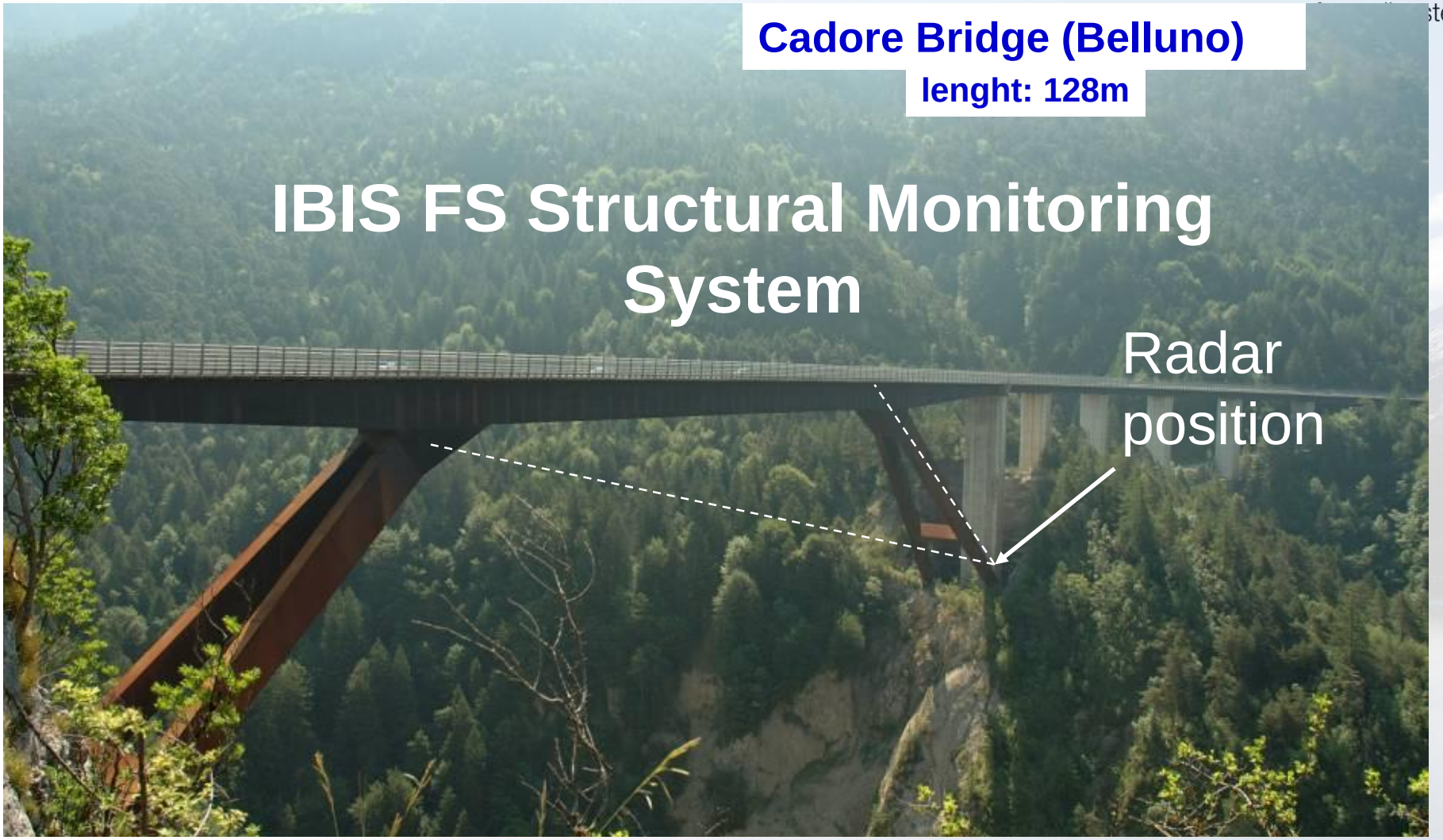
Dynamic Monitoring: Kuranda Scenic Railway

Time history displacement of a selected points (first train passage)



Cadore Bridge (Belluno)

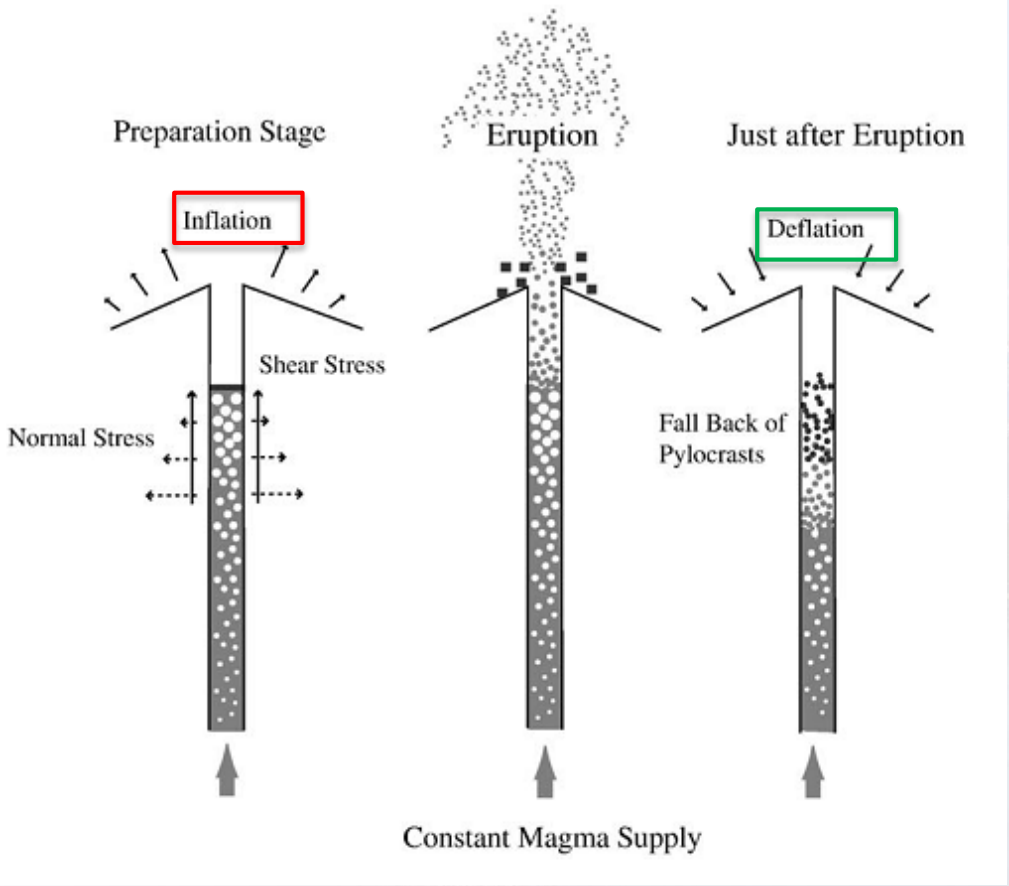
lenght: 128m



Early warning with IBIS RADAR (University of Florence and IDS)

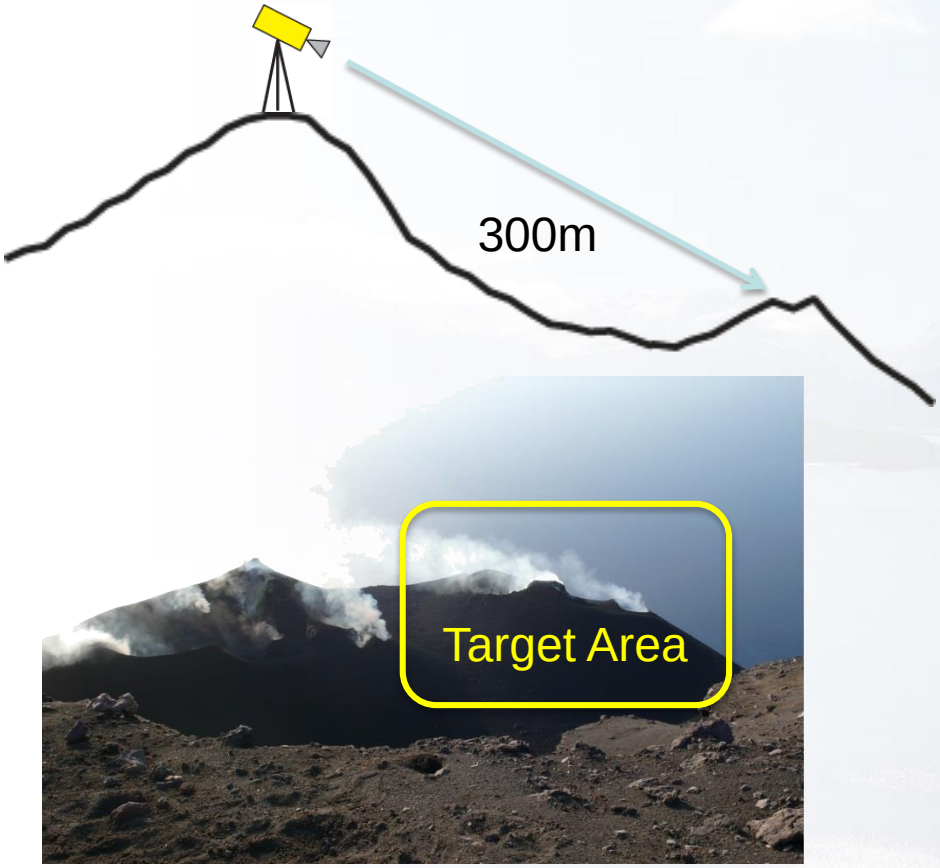
Stomboli, Italy

Ground deformation induced by magma rising in the conduit



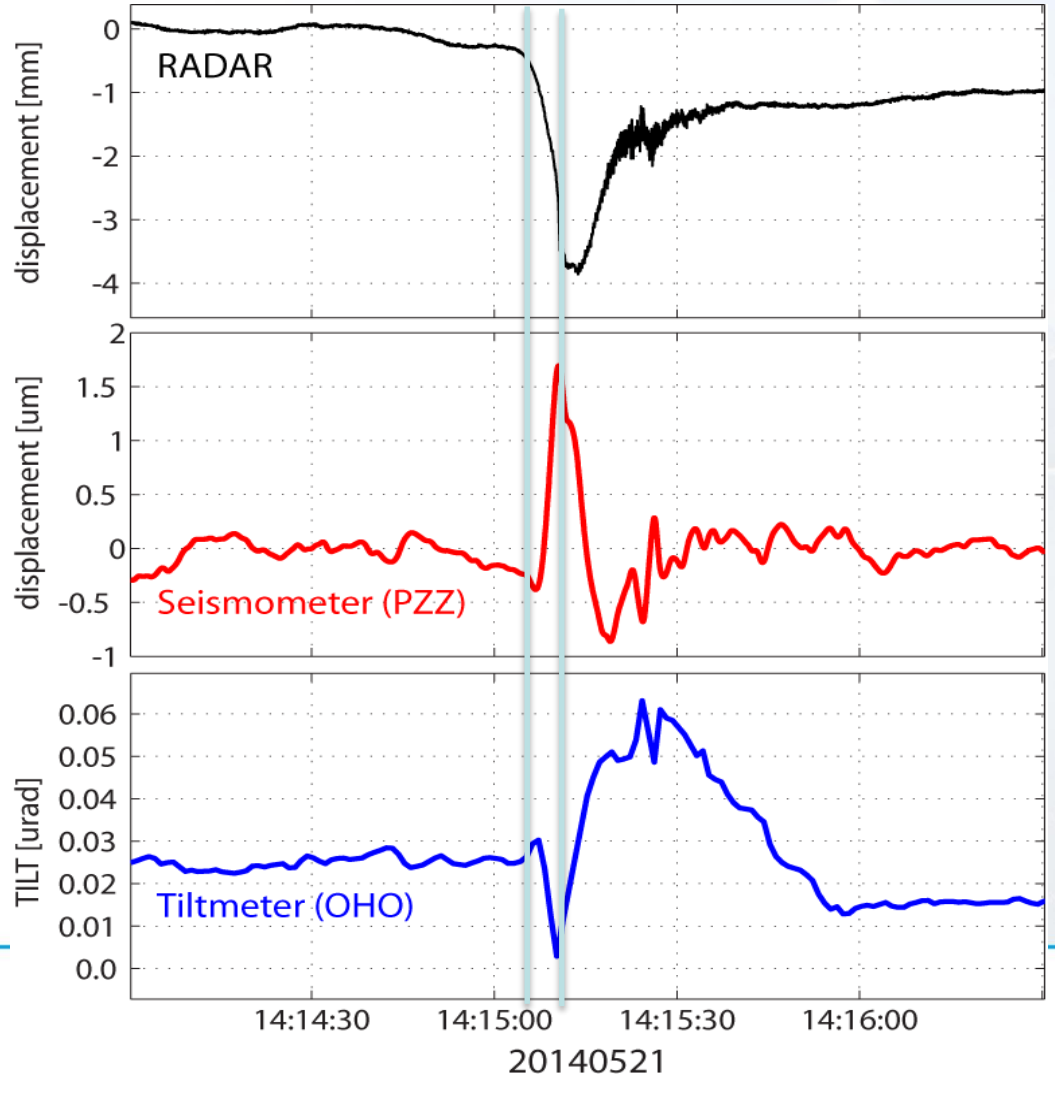
Ref. Nishimura, T., (2009), *J. Volcanol. Geotherm. Res. 187*, 178-192

RADAR & Volcanoes: test case Stromboli Volcano, Italy



Ref. Nishimura, T., (2009), *J. Volcanol. Geotherm. Res. 187*, 178-192

Signals correlation between radar, seismic and tiltmeter sensors



IBIS F range

PRODUCTS

IBIS - FL

IBIS - FM

IBIS - FS

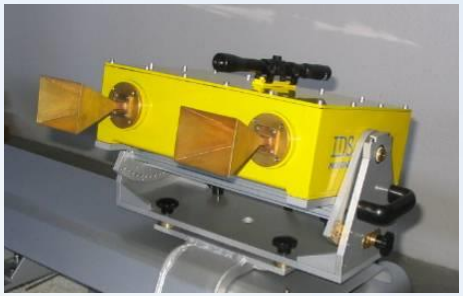
APPLICATIONS

LANDSLIDE & DAM MONITORING

SLOPE STABILITY IN MINING

STRUCTURE MOVEMENTS

Sensor unit:
- Signal Transmitter and Receiver



Linear Scanner :
- 2 m track
- Step-by-step motor

Processing unit:
- PC with management SW

Power supply unit:
- 2 batteries 12VDC 130

Techniques behind the IBIS-FL system

IBIS is based on 3 well-known radar techniques:

1. Stepped Frequency - Continuous Wave (SF-CW) is technique used to obtain a 1-Dimensional Range Profile with Range Resolution.

2. Interferometry technique, computes the displacement of each pixels by comparing the phase information of the radar signal collected between 2 acquisitions.

3. Synthetic Aperture Radar (SAR)

3. IBIS-FL: Synthetic Aperture Radar (SAR)

SAR technique enables the system to provide high cross range resolution exploiting the movement of the physical antenna along a linear scanner

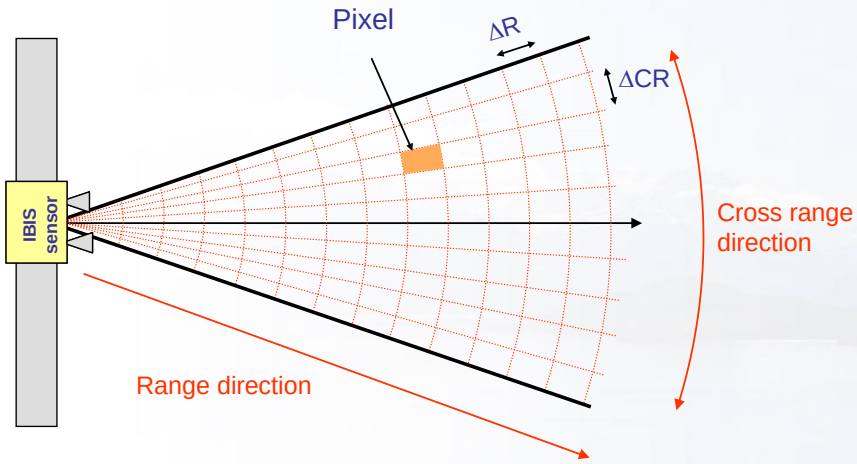
Using 2 m rail
IBIS-L system obtains
4.38mrad (=0.25deg)
angle resolution

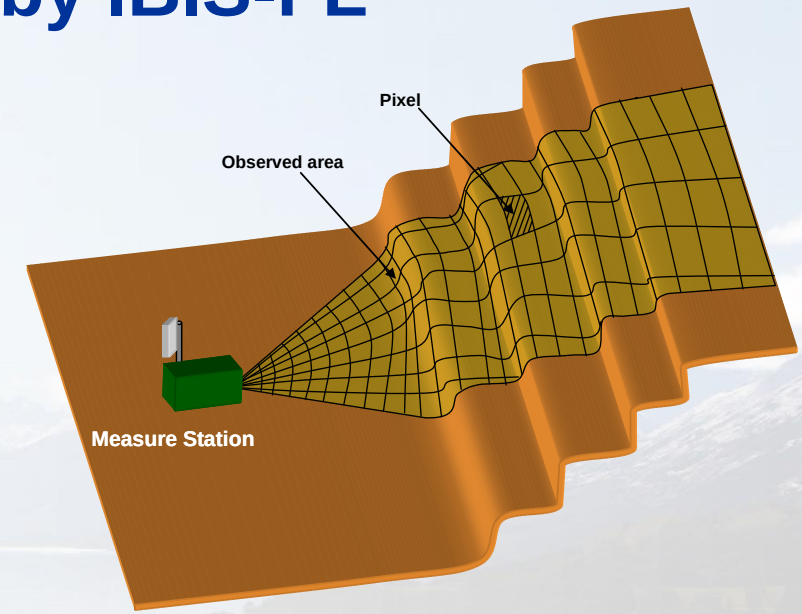
The SAR process allows the IBIS-FL and FM systems to synthesize a 2m antenna.

System range is 4km.

Area covered by IBIS-FL

Spatial resolution



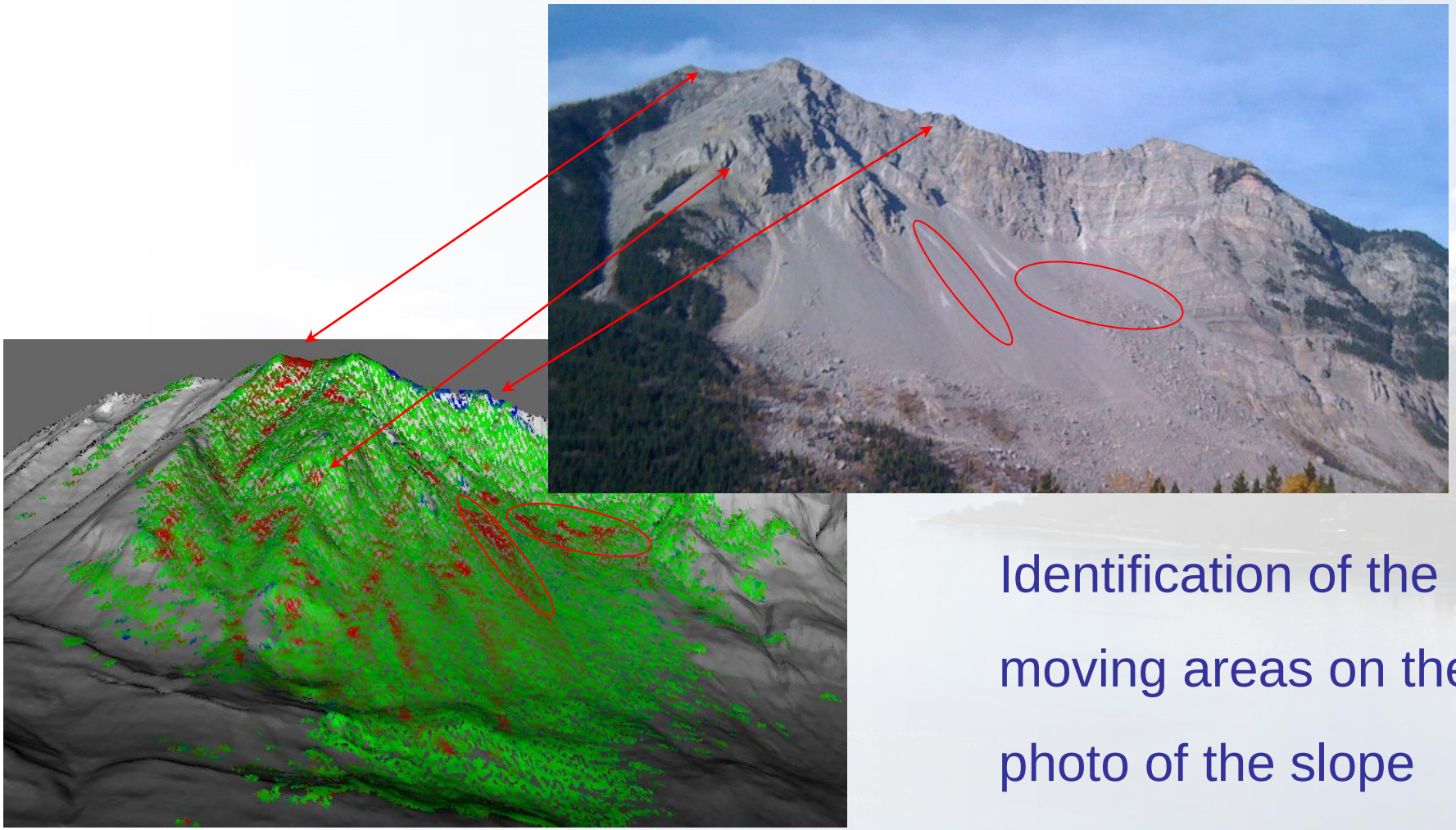


Spatial resolution:

- Pixel size varies with distance
- (1km = 0.5m x 4.3m)

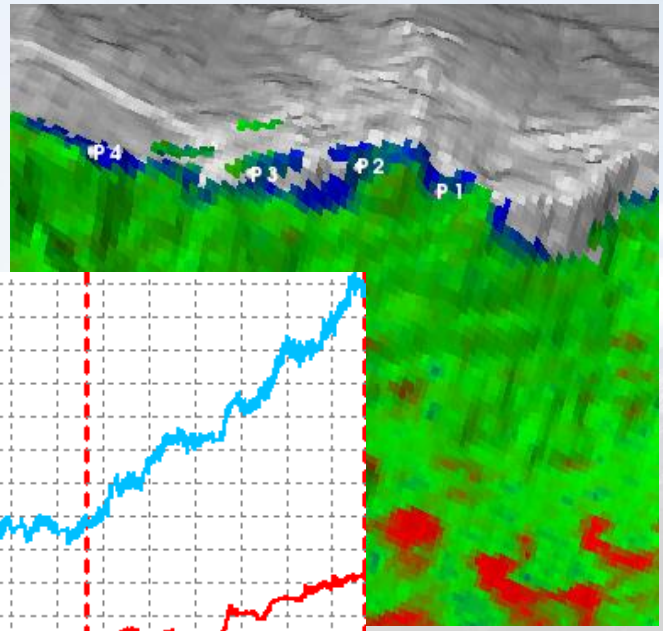
IBIS-FL instalation site at Frank Slide, Canada

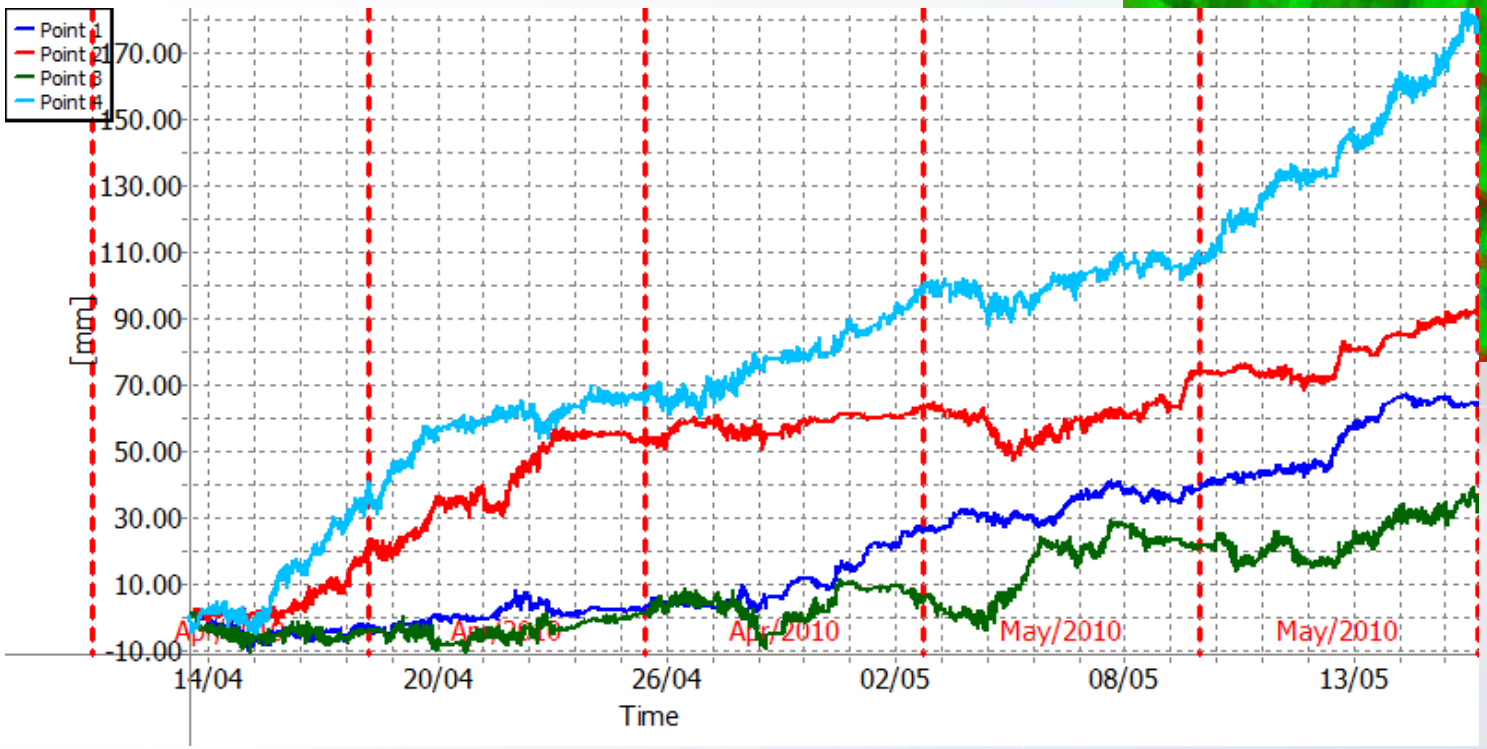
IBIS –FL is used for monitoring the famous Frank Slide on Turtle Mountain that in 1903 killed 90 peoples. The landslide is still active.



Identification of the moving areas on the photo of the slope

14/04/2010-17/05/2010 dataset





FM-CW SIRIO OBSTACLE DETECTION SYSTEM

Innovative technology for high risk zones

PROBLEM: COLLISION BETWEEN TRAIN AND AN OBSTACLE ON TRACK

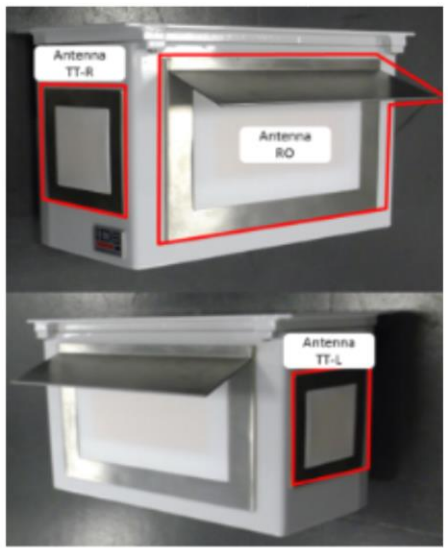

2012 Italy
Level Crossing Accident


2012 England
Level Crossing Accident


2010 China
landslide


2010 Italy
landslide

SYSTEM COMPOSITION



1. Radar Sensor

- Obstacle Detection

2. Video Sensor

- Triggered by radar alarm

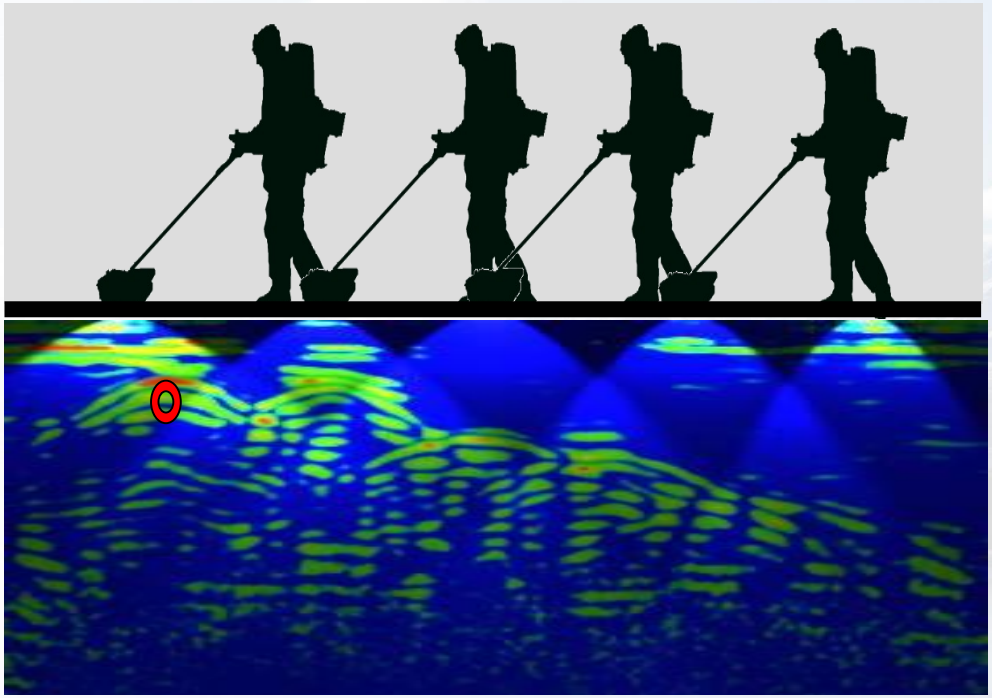
3. NCU-Node Control Unit

- Power supply
- Interface with Signalling System

4.Remote Control Unit

- GUI Interface for operator

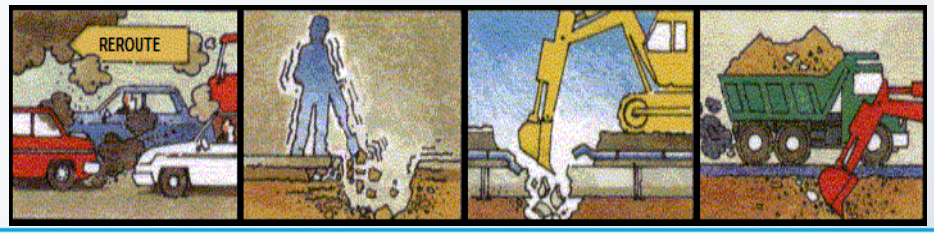
GPR



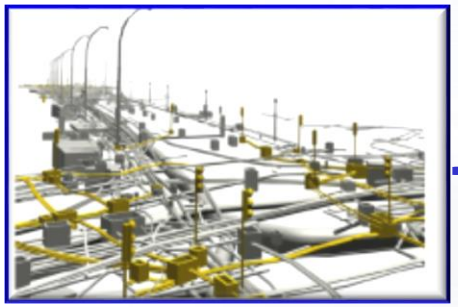
Contrasting EM properties show as features and these can be mapped

WHY GPR technology?

- Varying depth and resolution possible, highest resolution geophysical technique
- GPR can **detect all material types** and is a **MUST** method in urban environments
- GPR **optimizes** excavations - reduces cost and risk.

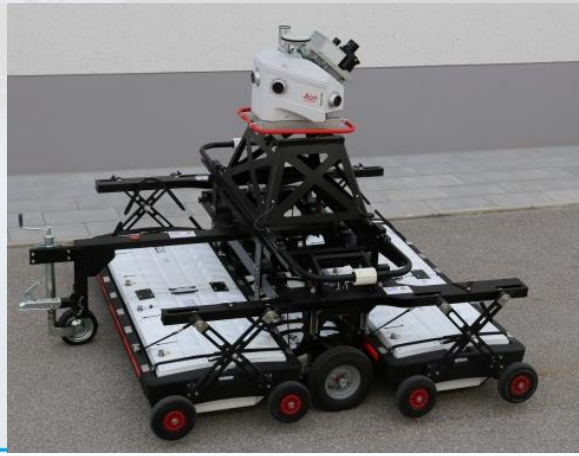


SPECIALIZED SOLUTIONS FOR UTILITIES

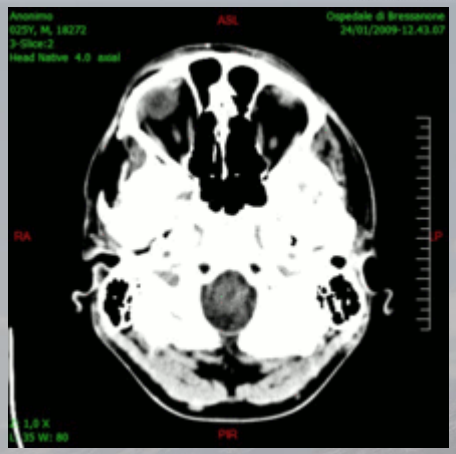


UTILITY DETECTION AND MAPPING

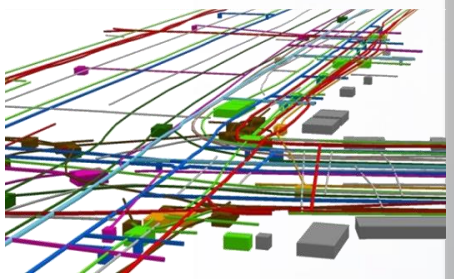
- **Real Time Detection** → **OPERA DUO**
- **Detection and Mapping** → **RIS MF Hi-Mod**
- **Product for extensive utilities mapping** → **Pegasus Stream**

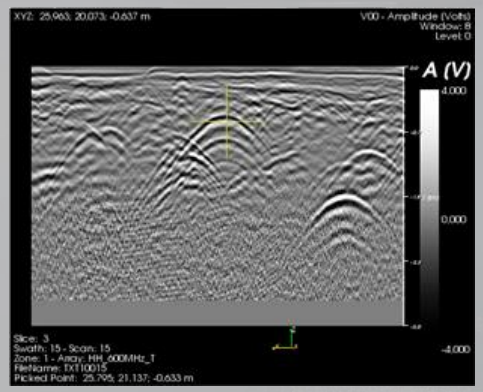


Radiography



CAT (Tomography)





B-Scan

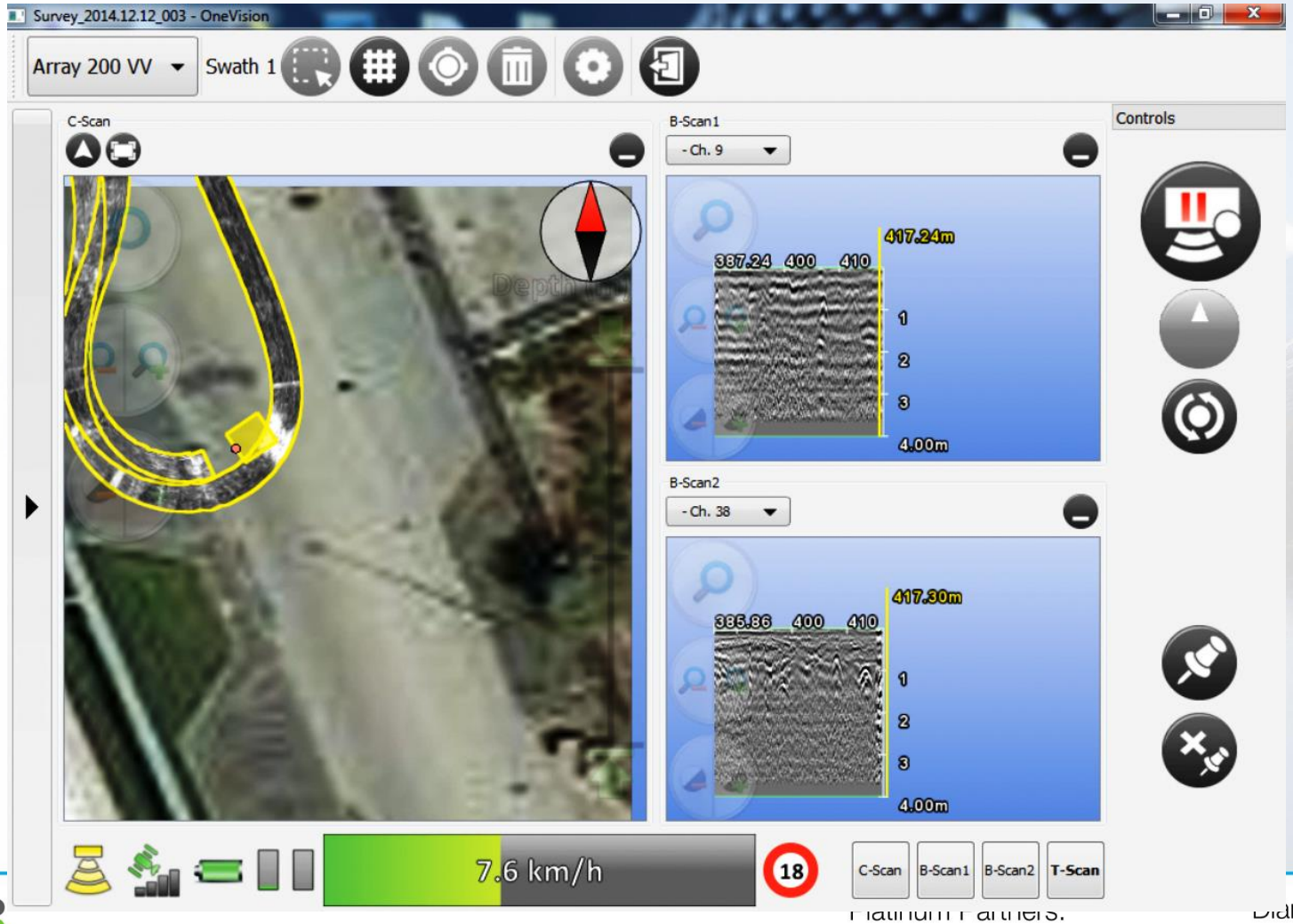
C-Scan (Tomography)

One Vision - Real time tomography (1of7)

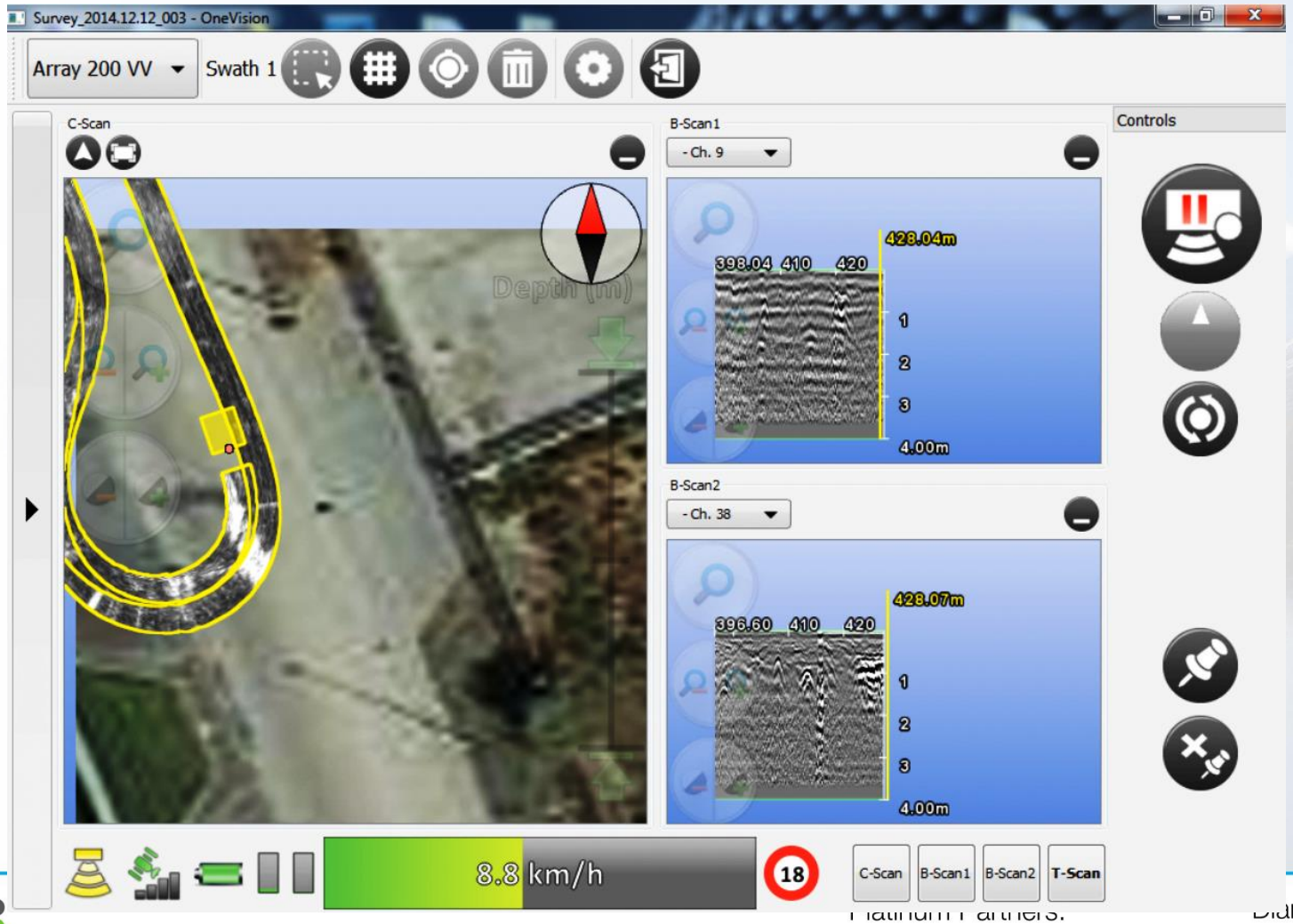
One Vision - Real time tomography (2of7)

One Vision - Real time tomography (3of7)

One Vision - Real time tomography (4of7)



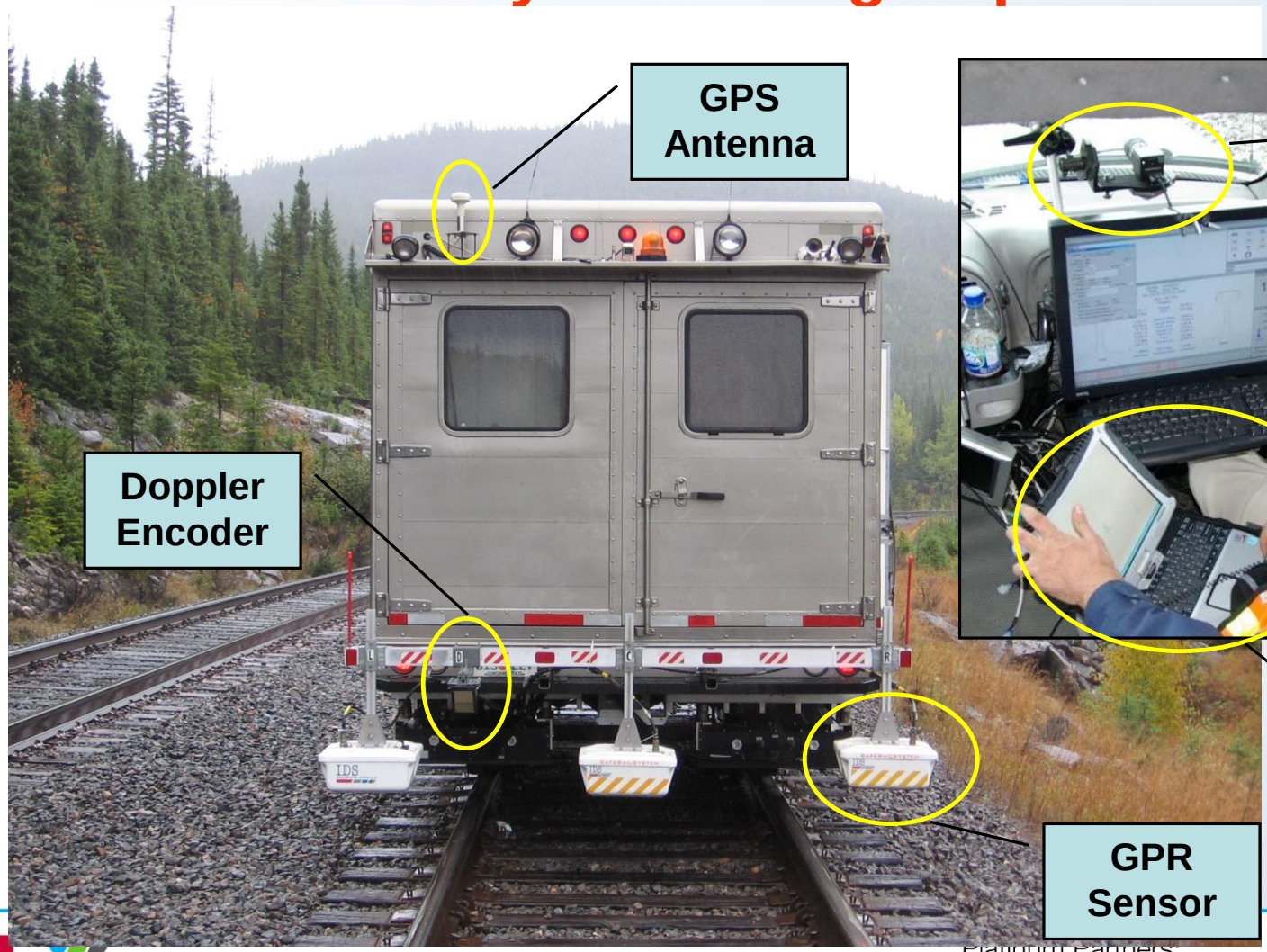
One Vision - Real time tomography (5of7)



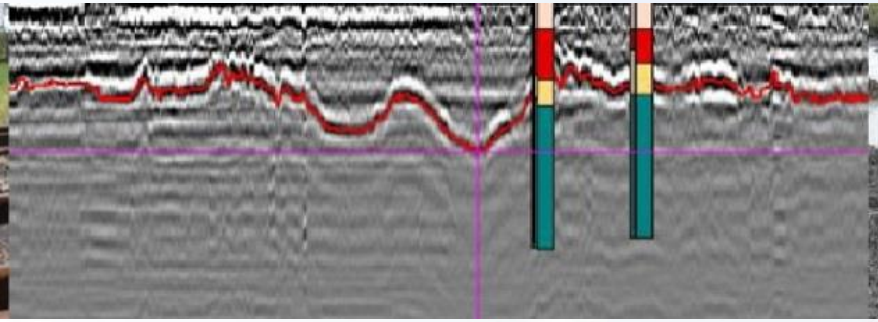
One Vision - Real time tomography (6of7)

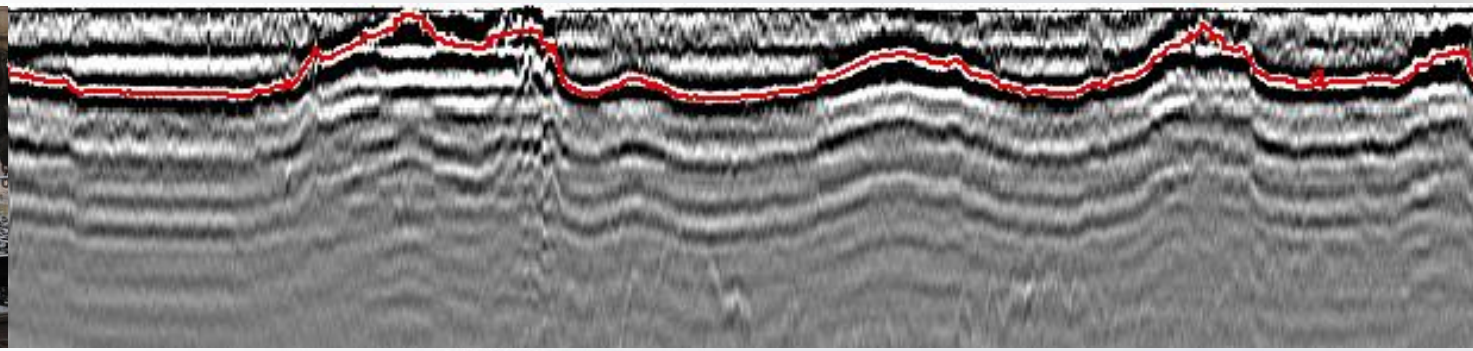
One Vision - Real time tomography (7of7)

SafeRailSystem – High Speed GPR

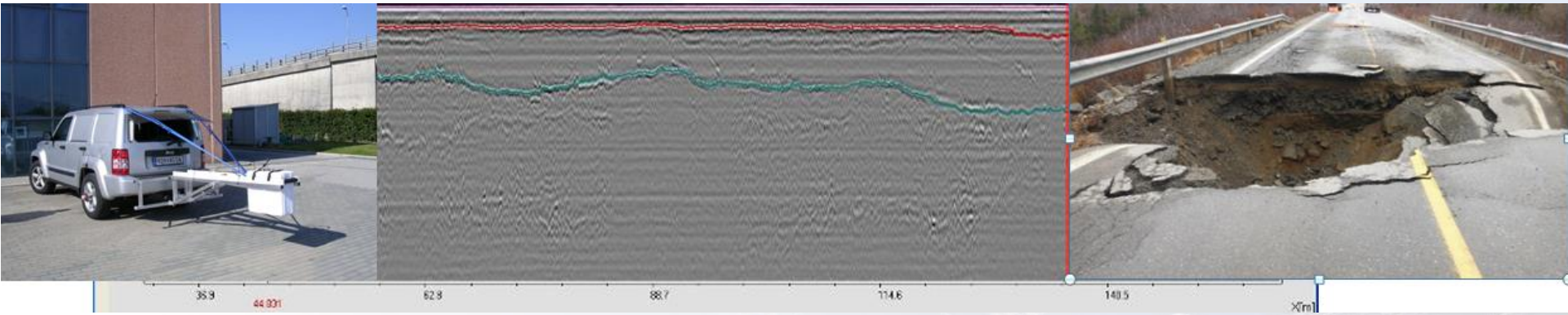


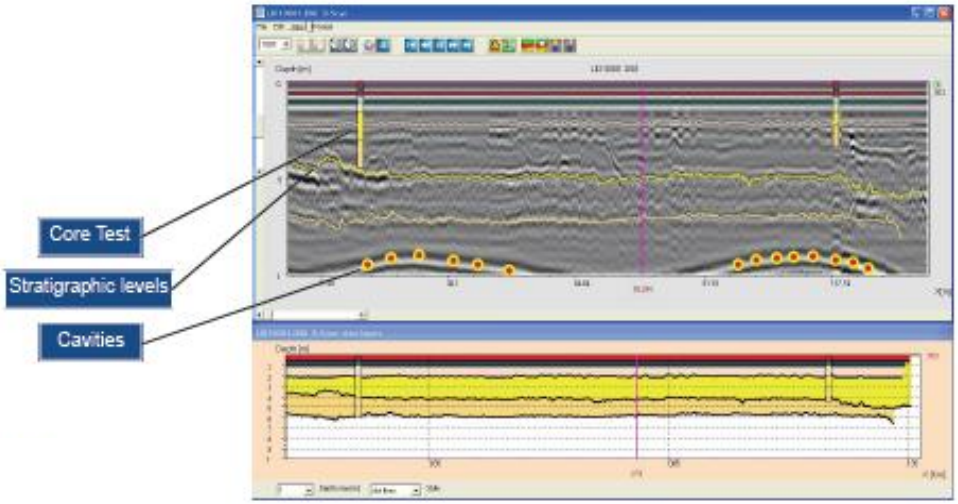
SafeRailSystem – High Speed GPR

Hi-Pave – High Speed GPR





Imaging of:

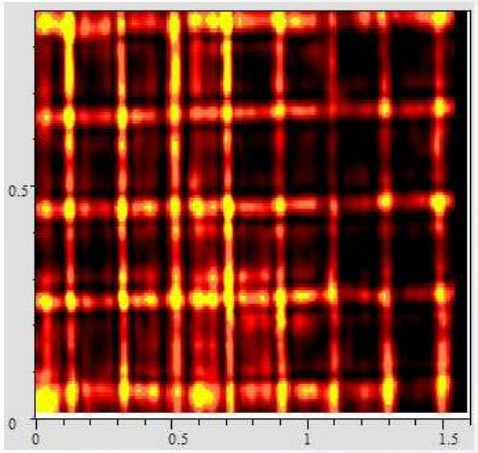
- **Debonding**
- **Cavities**
- **Moisture ingress**

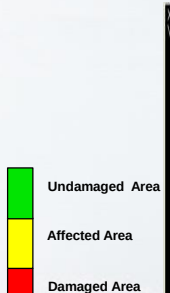
Civil and Structure Engineering

RIS Hi-BrigHT:

Array for bridge deck survey

Depth: 0.10m





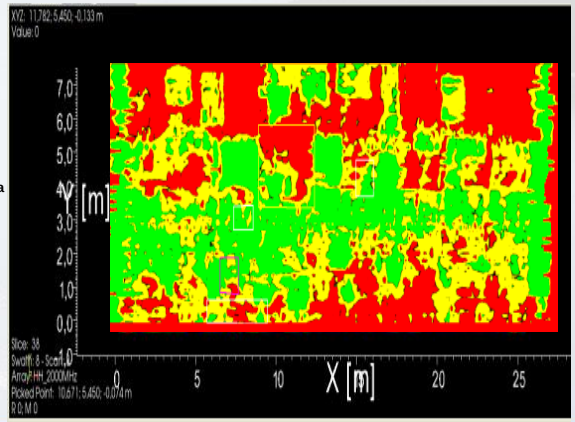


Image rebar and internal structures

Bridge deck maps

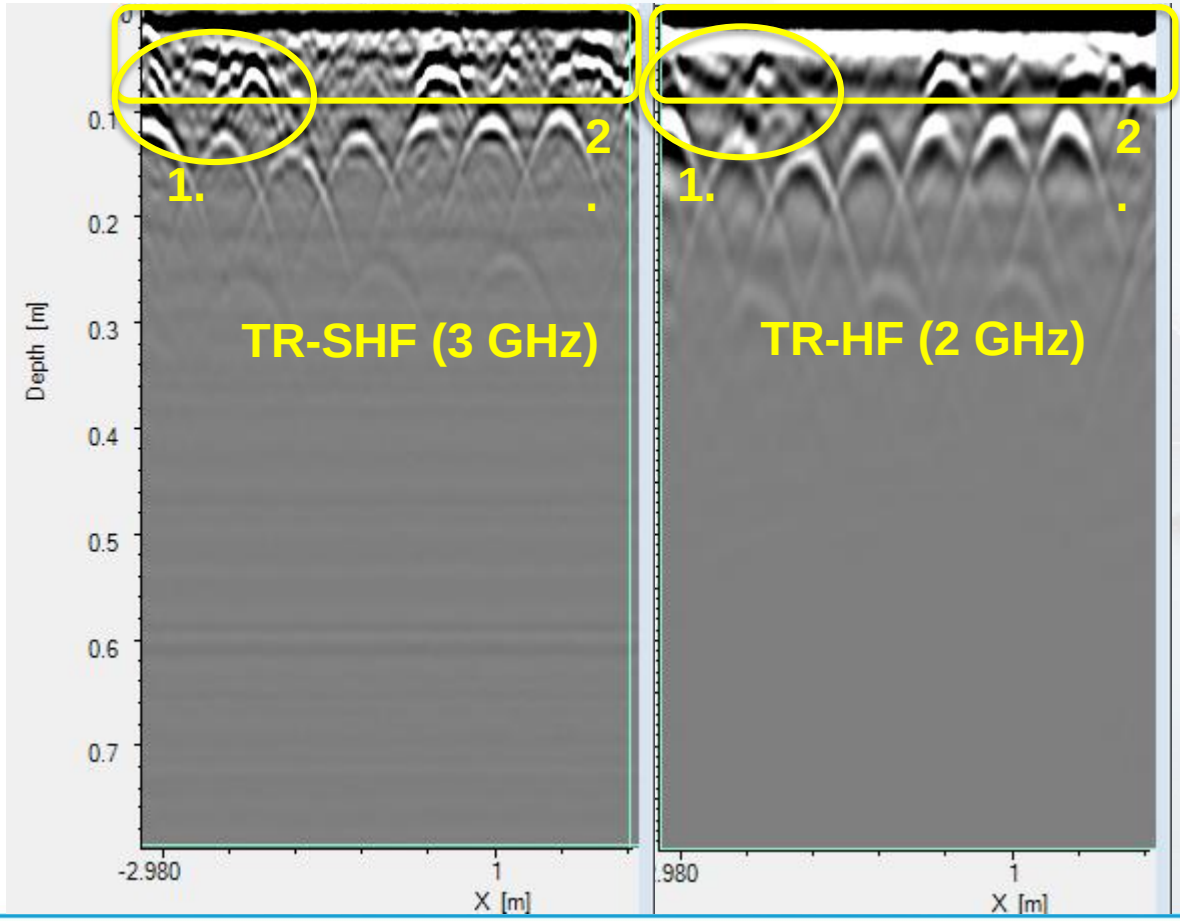
- **Moisture**
- **Rebar corrosion**
- **Concrete cover**

TR-SHF Super High Frequency antenna: 3 GHz

"See things no one else can see"

Super High-Resolution antenna for concrete inspection

Comparison TR-SHF vs. TR-HF (1of2)

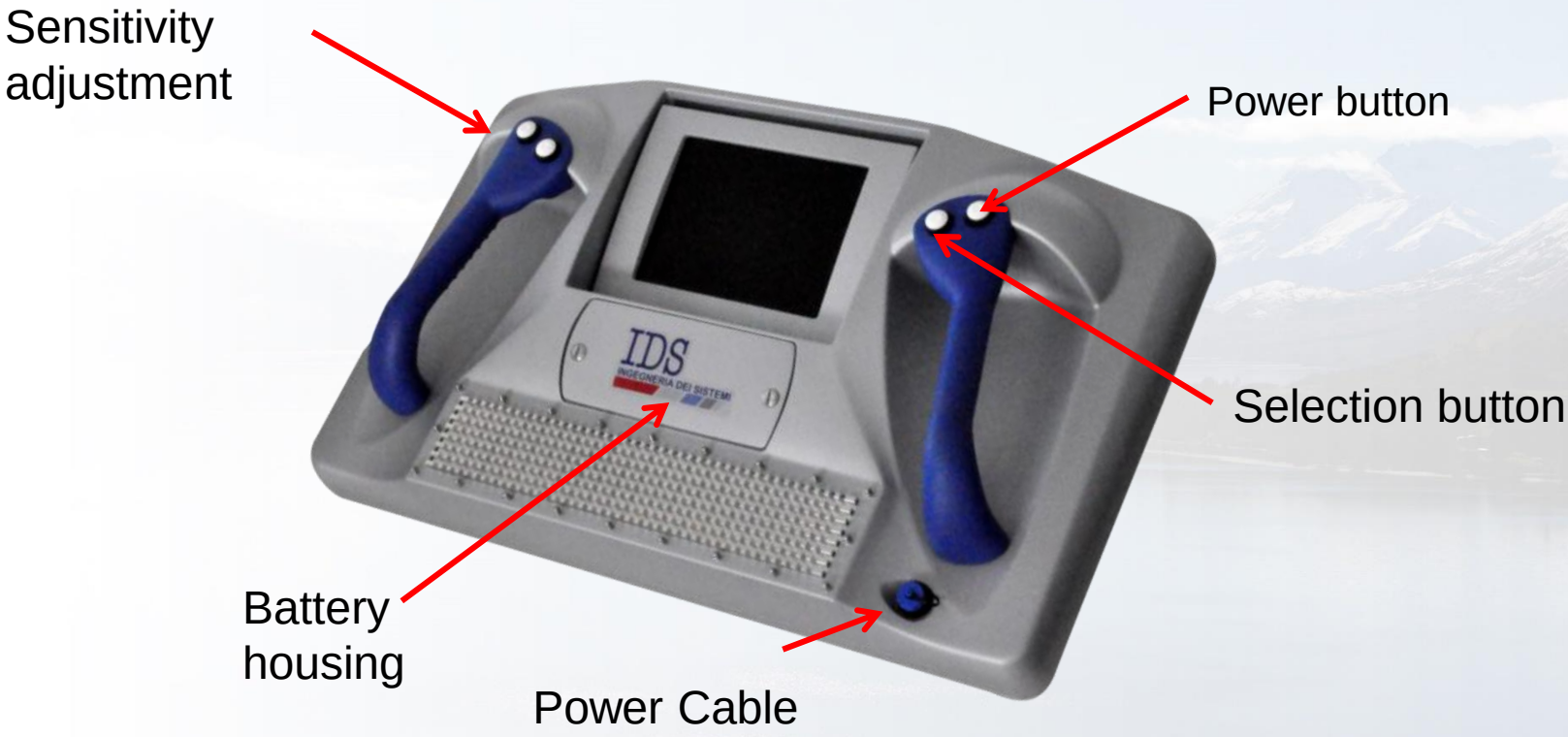


Super High-Resolution permits to:

1. **distinguish close rebar;**
2. **Resolve fine defects (Voids, cracks)**

Through Wall Radar

Carbon & Glass fibre materials, total weight 4,5 Kg, dimensions 60x32x12 cm



Through Wall Radar

multi-target tracking and detection of stationary personnel through breathing

- Buried persons under debris
- Location of people in smoke-filled or dim environments

Through Wall Radar

Observed Scene		Radar Detection
Target	Movement	Range [m]
Moving person	Walking	15
	Crawling	10
Moving still person	Chest, Head, Arms, Legs	8
Still person not moving	Speech, Breathing	0,2-4
	Heartbeat (holding breath)	0,5–2

Through Wall Radar

Display mode: 2D plain view, 1.5D (range with time history)

Display type: Colour, tilt-able, ultra bright

Thank You!

Please come and see us at the **Accurate Instruments** stand in the exhibition hall.

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