



**CODEVINTEC**

Tecnologie per le Scienze della Terra e del Mare

45° 27' 39.384" N  
9° 07' 30.145" E

# Metasensing FastGBSAR

## Interferometro radar da terra in modalità SAR e RAR



**FastGBSAR is a Ku-band ground-based interferometric radar system designed for**

- > **deformation monitoring**
- > **vibration measurement**
- > **stability assessment of natural slopes and man-made structures.**

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Mines  
Reservoir dam  
Land slide

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Railway bridge

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# FastGBSAR

## Fast Ground-Based Synthetic Aperture Radar



**MetaSensing has successfully deployed its innovative sensor to monitor**

- > **dams**
- > **bridges**
- > **landslides**
- > **open-pit mines**
- > **dikes (levees).**

### **Features**

- > Dual-operation mode (SAR and RAR)
- > Fast acquisition time for high temporal resolution (scan time less than 5 s)
- > Full polarimetry for selection of responding scatterers
- > System robustness for operations in harsh environmental conditions (high/low temperatures, inclement weather, dust, smoke, ashes etc.).





**MetaSensing's FastGBSAR is a ground based radar solution for monitoring instable natural elements and critical artificial structures.**

## SAR – Synthetic Aperture Radar

In SAR (Synthetic Aperture Radar) mode, the FastGBSAR is installed on a linear rail to produce two-dimensional (range and azimuth) images. It is suitable for deformation monitoring of man-made structures such as mines, dams, dikes, buildings and natural hazards, such as slopes, landslides.

The FastGBSAR is unique for two main reasons:

- > Short acquisition time: one image is produced in 4 seconds. The deformation monitoring is less sensitive to changes in the scenario (weather changes passing objects) and the images have higher quality.
- > Short acquisition interval: one image is acquired every 10 seconds. Issues due to phase unwrapping are minimized and faster changes and deformations are captured.

## RAR – Real Aperture Radar

In RAR mode the FastGBSAR is particularly suitable for static and dynamic structural monitoring of man-made structures such as bridges, towers, buildings, pillars, wind turbines, and similar structures. Being compact and portable, the system can operate in all weather conditions, producing range profiles with a sampling frequency up to 4 kHz.

Operating mode	SAR	RAR
Operating frequency	17.2 GHz (Ku band)	
Range resolution <sup>(1)</sup>	Up to 0.5 m	
Maximum range	4 km	
EIRP power	19 to 42 dBm	
Operating temperature range	-20° C to 60° C	
Environment	IP65	
Sensor weight	10 kg	
Accuracy <sup>(2)</sup>	± 0.1 mm	± 0.01 mm
Azimuth resolution <sup>(3)</sup>	Up to 4.8 mrad	-
Aquisition time	5 s	0.25 ms
Power consumption	<200 W	70 W
Rail weight	82 kg	-
Rail length (customizable)	2606 mm	-
Rail effective length <sup>(4)</sup>	1900 mm	-

(1) Range resolution depends on the frequency bandwidth allowed by local authorities, which is generally limited to 200 MHz, leading to a range resolution of 0.75 m.

(2) Measurement accuracy depends on target characteristics and distance from the sensor. Listed values are for a corner reflector at 1 km distance.

(3) In SAR Mode, azimuth resolution depends on rail effective length. Effective length is the length over which the sensor moves with constant velocity.

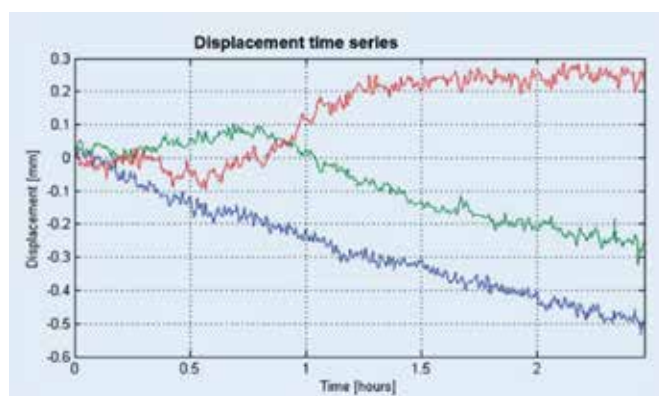
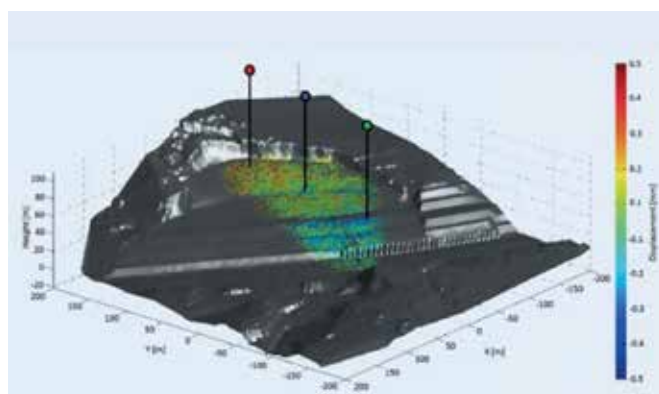
(4) Rail effective length is slightly dependent on sensor velocity. Listed value corresponds to minimum velocity of 0.1 m/s. Effective rail length at maximum velocity of 0.5 m/s is 1800 mm.



## FastGBSAR – SAR mode

### Monitoring a land slope

The FastGBSAR has been deployed on the side of a high-speed railway track in the Shanxi province in China, to monitor a land slope next to the railway. The measured displacement ranges from - 0.6 to 0.3 mm capturing the movement of the dry sand blown away from the wind caused by the passing train. The diagram reports the time series of the displacement for the three selected points.



Monitoring a land slope next to a high-speed railway track.

### Monitoring an open-pit mine

FastGBSAR has been intensively monitoring an open-pit mine in Czech Republic to produce accurate displacement maps of the area.



The maximum distance was set to 1500 m, with a range resolution of 0.5 m and azimuth resolution of 5.4 mrad. The displacement is close to zero in almost all the area except in one part where a deformation of about 100 mm appears, this is due to the excavation works.

Figure shows the displacement map measured by the FastGBSAR around the open-pit mine and projected on a Digital Elevation Model.

The movement of the excavator machine creates a movement away from the radar in the area behind it (red arrow) probably caused by the removal of material from the slope with relief of stress. A movements towards the radar (blue arrow) is also due to the accumulation of material.





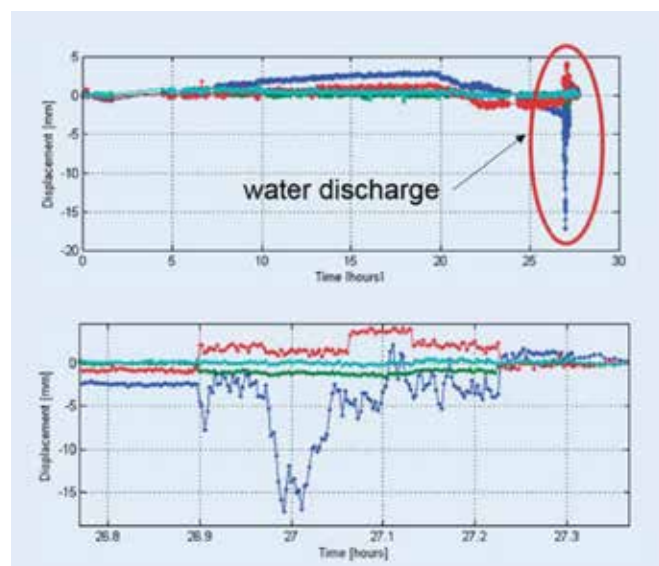
## Monitoring a water reservoir dam

FastGBSAR has been deployed to monitor the response behavior of the Three Gorges test dam in China with respect to four different intensities of water discharge.

The four steps of the water discharge are clearly visible from the red line corresponding to the gate of the dam.



Deployment site for the FastGBSAR, about 400 meters in front of the dam.



Time series of the displacement in four points of the dam before the water discharge (top) and during the water discharge (bottom).

## Monitoring a land slide

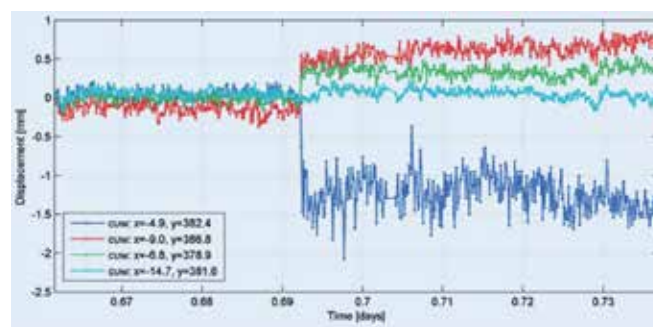
FastGBSAR was deployed to observe a land slide in Italy to monitor slope stability and falling rocks.

Figure shows the time series of the displacement for several points. The very high acquisitions rate (one image every 10 seconds) allowed a more efficient detection of falling rocks.

The falling rock event can be seen as a abrupt and instantaneous change in the displacement series.



Monitoring the Corniolo (FC) land slide.



Time series of the displacement monitored for four different points.



## FastGBSAR – RAR mode

### Monitoring of a highway bridge

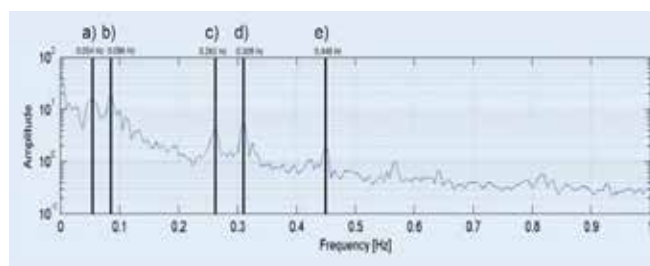
The simultaneous observation of many points along the bridge is particularly suitable for the determination of the mode shapes.

A mode shape is the vibration pattern of the structure executed at one particular frequency. It only varies according to material properties and is independent from the exciting force. Figure shows exemplary the mode shapes corresponding to the frequencies that are marked.

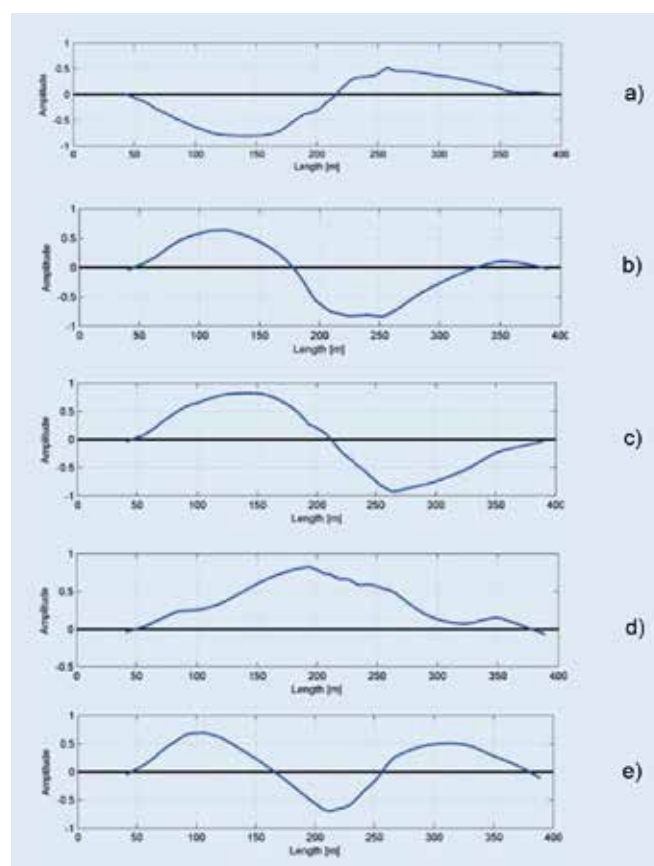
In order to distinguish between vertical, torsional and horizontal modes, measurements can be repeated from different viewing angles.



400 m long Highway bridge under observation Google, 2014.



Frequency analysis of the time series. The marked frequencies are identified modes shown hereunder.



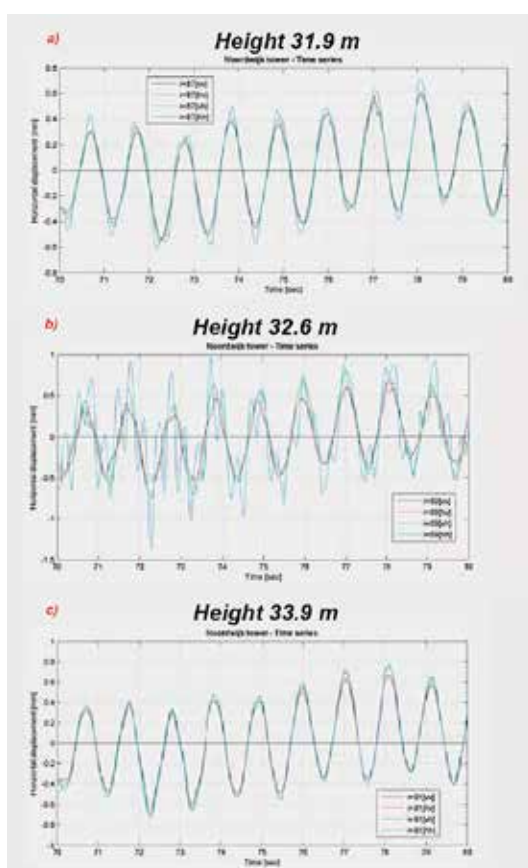
Mode shapes at  
a) 0.054 Hz, b) 0.086 Hz, c) 0.261 Hz, d) 0.309 Hz, e) 0.448 Hz.



## Monitoring of telecommunication tower

A 42 meter high telecommunication tower has been monitored in moderate-low wind conditions. The measurements were performed by the polarimetric FastGBSAR version, equipped with four antennas. The use of the four polarimetric channels gives sensitivity to different scattering mechanism.

Figure shows the oscillation of the tower plotted at three different heights for an observation time of 10 seconds. The sub-millimeter horizontal displacement value of the tower depends on the considered height.



Time series of horizontal displacement at different tower heights within the tower

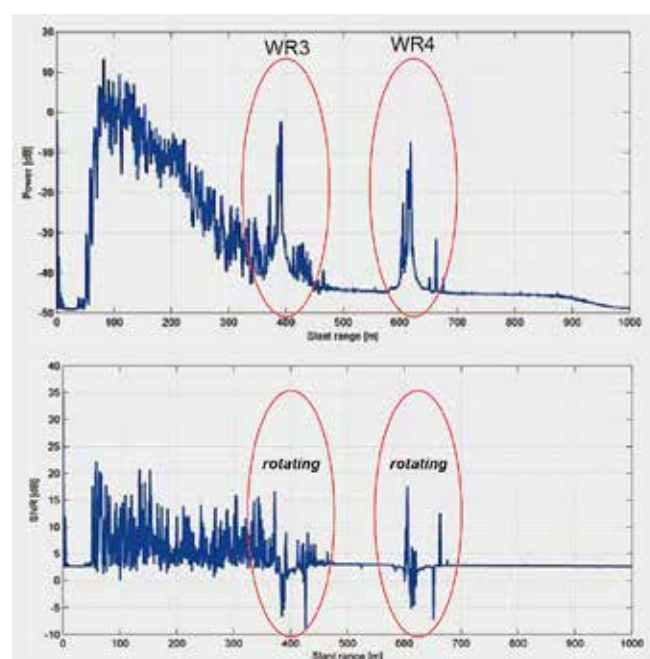
## Monitoring of wind turbines

The determination of vibrations and modal parameters of wind turbines can assist in the optimization of their design and performance.

To avoid structural failure, the knowledge of the eigenfrequencies of the tower and rotor blades is essential. In the following an example is shown of the simultaneous monitoring of two wind turbines at different distance.



FastGBSAR installation for monitoring wind turbines.

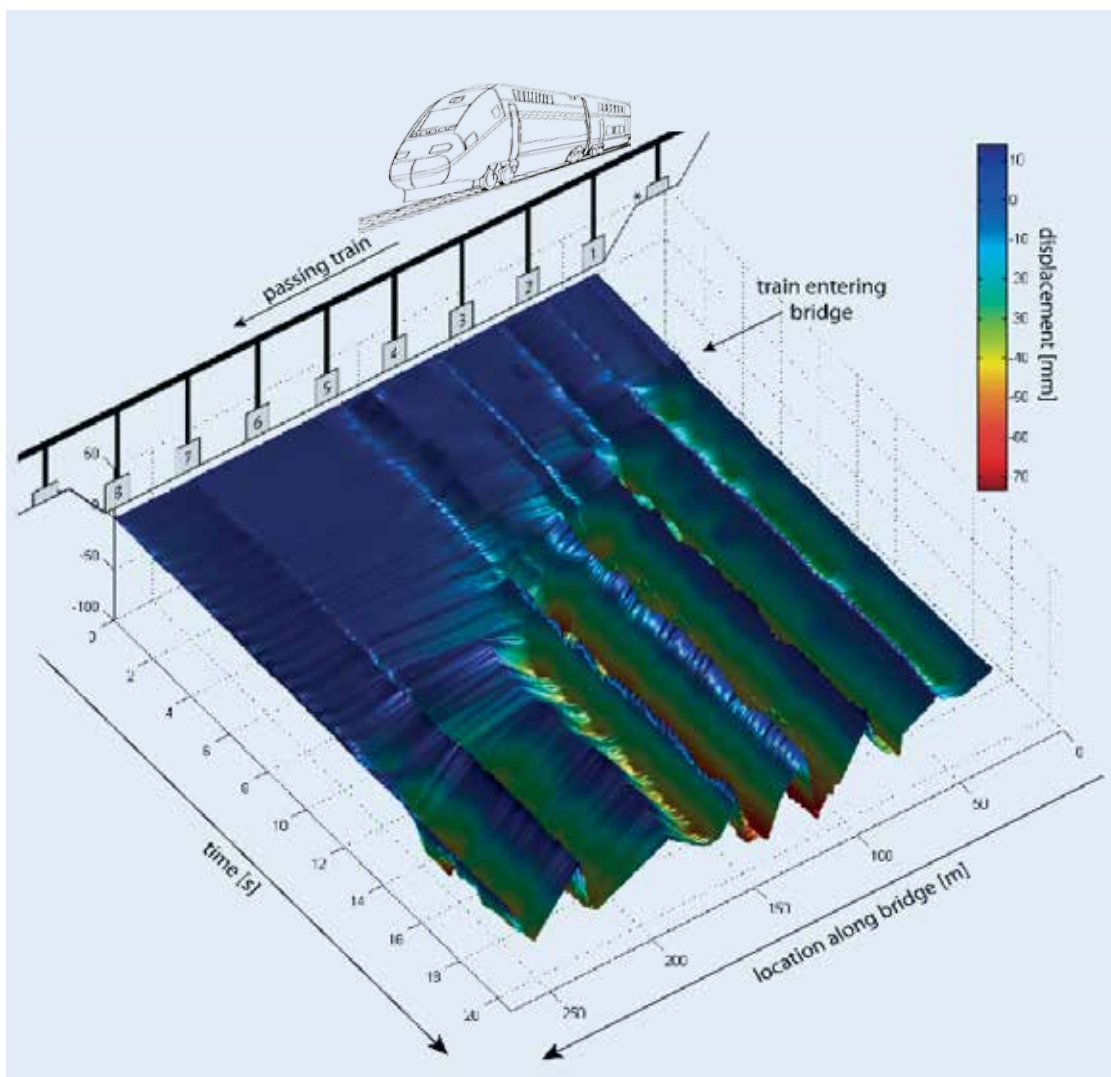


Backscattered power and Signal to Noise Ratio (SNR) along the wind turbine. In correspondence of the rotor, **the SNR is low due to the moving rotor blades.**



## Monitoring of a railway bridge

The fixed installation of the sensor on a tripod, allows simultaneous measurement of multiple spans along the bridge and gives the complete picture over time of the behavior of the entire bridge during the passing of a train.







## FastGBSAR – Ranger Software

### The new software for real-time processing



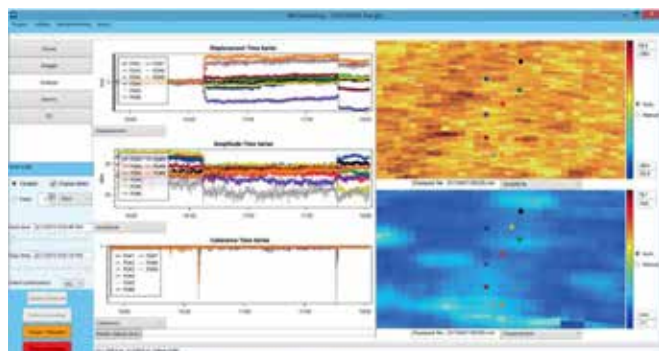
FastGBSAR in open-pit mine

The FastGBSAR Ranger software is the new software for the real-time processing and visualization of the SAR mode FastGBSAR data, developed specifically for the mining environment and for monitoring critical structures and slope stability.

Thanks to its user friendly interface the user can obtain a complete picture of critical areas at first glance.

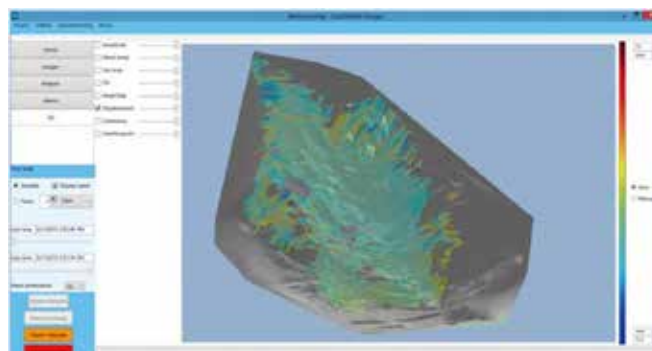
Data analysis is simple and fast, allowing for time series analysis, estimated time of failure calculation, quality parameter inspection and alarm display.

The software includes planar and 3D view for easy data visualization on a Digital Terrain Model.



Analysis tab with multiple parameters time series and synchronized planar view

Multiple parameters time series can be displayed by selecting several pixels on the maps. In just a few seconds all time series plots and all maps are automatically updated as new data are available. Figure shows an example of analysis in a case of a rock fall.



3D tab with a displacement map over a DTM of the observed area

With the 3D view of the Ranger software the FastGBSAR displacement maps can be displayed on a Digital Terrain Model (DTM) of the area. Several maps can be superimposed thanks to the use of layers and transparency.



## Key Features

- > Appealing graphical user interface
- > Simultaneous visualization of displacement maps, quality parameters and time series
- > Straightforward processing of the FastGBSAR radar data
- > Processing results available in a few seconds
- > Data download and storage handling
- > Real time processing and back analysis
- > Time of failure estimation
- > Planar and 3D view
- > Alert system for situational awareness

## Visualization

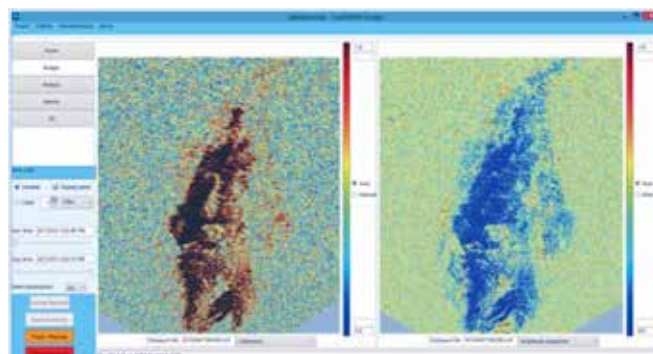
The user can easily navigate through different tabs of the graphical interface, each one equipped with specific tools for data visualization. All plots are synchronized and can be explored by zooming and panning. Simply passing the mouse over the map will show the pixels geographical coordinates and value.

- > **Home** system log and information
- > **Images** simultaneous data quality parameter and coherency visualization
- > **Analysis** displacement maps, multiple time series analysis, time of failure estimation
- > **Alarms** alarms visualization and information
- > **3D** visualization of the displacement maps and quality parameters on the 3D model of the surface

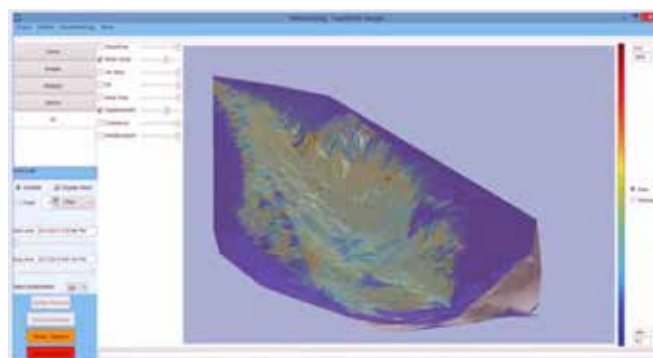
## Alarms

The FastGBSAR Ranger encompasses an early warning system for safe operation in the monitored surface:

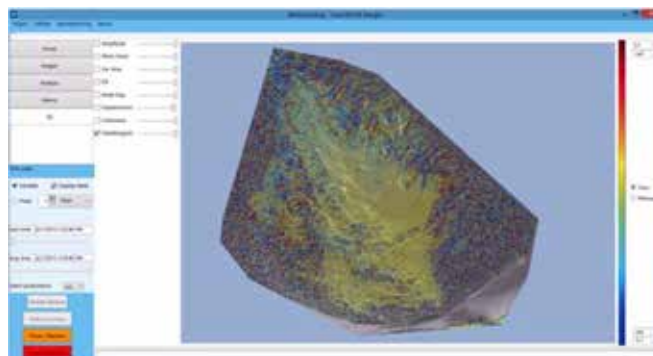
- > Visual alarm messages and e-mail alerts
- > Alarm raising based on maximum displacement and loss of coherency
- > Critical areas display
- > Continuous update
- > Statistics



Images tab with multiple quality parameters on a planar view



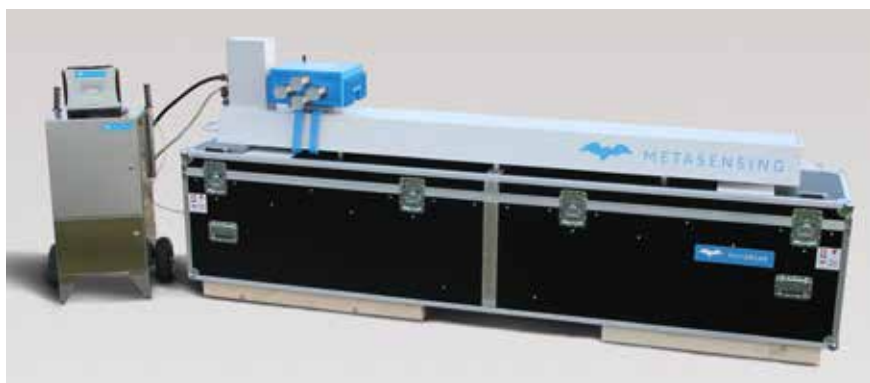
3D view of displacement over DEM



3D view of interferogram over DEM



FastGBSAR in RAR Mode (sensor on tripod).



Fully Polarimetric version of the FastGBSAR in SAR Mode (sensor on rail).



FastGBSAR Polarimetric version (front view)



## FastGBSAR – SAR mode



Land slope



Water reservoir dam



Open-pit mine



Land slide

## FastGBSAR – RAR mode



Telecom tower



Wind turbines



Bridge monitoring