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INFRASTRUCTURE STABILITY MONITORING

Tailings dam collapse in Kolontár, Hungary

PRODUCT DESCRIPTION

Category

☐ Topographic information	☒ Surface deformation
☐ Impact assessment	☐ Precision ortho-images
☒ Change detection / continuous monitoring	☐ Terrain information
☐ Land cover / use	☐ Water quantity & quality
☐ Near surface geology	

Uses

Monitoring the stability/deformations of (critical) assets and infrastructure

Challenges addressed

Development and Operations – Structural Stability

Closure and Aftercare – Structural Stability

Geo-information needs

DO-13: Pit slopes stability

DO-14: Tailings Storage Facilities stability

DO-15: Waste Rock Dumps stability

CA-11: Demonstrate long term structural stability of key infrastructure – WRD’s / TSF’s

Description

This product provides information on the stability/deformations of infrastructure and assets, based on the satellite-based InSAR (Interferometric Synthetic Aperture Radar) technique. It provides mm-precise measurements over large areas on a weekly-monthly basis and can serve as scanning tool for the whole mine and its direct environment. Depending on the satellite, up to 100,000 measurements per km^2 can be obtained.

Typical mining applications of this product are monitoring the stability of tailings storage facilities, waste rock dumps, pit slopes, transport roads, buildings and the environment of the mine, both during and after operation. The advantages are that critical infrastructure can be monitored on a regular basis, in a fully automated manner and without human intervention, and that a complete view can be obtained of the deformations in the mining area and its direct environment. Furthermore, by using satellites, a uniform data format and quality can be obtained over all mines in the portfolio.

This technique is based on radar images from various radar satellites. The products from these satellites differ in terms of number of measurements per km^2, measurement frequency, price (free vs. paid imagery) and availability. In most locations worldwide, there is imagery available dating back to 2015 and for some locations even back to 1992. Therefore, it is easy to obtain a baseline of the deformations in the mine and thereby context of what is or has been happening. By using multiple satellites, vertical as well as horizontal (in the east-west direction) movements can be tracked.

Depending on the specific application, triggers can be implemented to warn the infrastructure owner if the structure is at risk of failing. This allows for both intervening before a potential accident and a more precise planning of long-term maintenance.

Known restrictions / limitations

The highest measurement frequency that current satellites can obtain is once per couple of days, which could be too low for certain applications. If the deformations leading up to a failure can occur in the timespan of minutes/hours rather than days, it is better to use another system for intervention purposes.

The satellite’s ability to measure is dependent on the reflectivity characteristics of the surface. For some specific locations/cases, the satellite might not be able to obtain the requested measurements.

Lifecycle stage and demand

Exploration	Environmental Assessment & Permitting	Design, Construction & Operations	Mine Closure & Aftercare
	■	■■■■	■■■■■

Environmental Assessment & Permitting:

- Establishing a baseline measurement of movements already occurring on infrastructure present in the area before the mine was built and taken into operation.

Design, Construction & Operations:

- Design: Establishing a baseline measurement of movements already occurring in the area where the mine will be built. Potential to adjust the design of the mine infrastructure based on that information.
- Construction: Monitoring the movements of infrastructure present in the environment of the mine during the building process. This gives the possibility to adjust the building process and to assess potential claims based on thorough measurements.
- Operations: Monitoring the stability of critical mine infrastructure (tailings storage facilities, waste rock dumps, pit slopes, etc.) during operation. Using triggers to intervene or to plan long-term maintenance activities.

Mine Closure & Aftercare:

- Monitoring the stability of critical mine infrastructure (tailings storage facilities, waste rock dumps, pit slopes, etc.) after closure. Using triggers to plan long-term maintenance activities, without having to go to the (remote) mine location.

Geographic coverage

Global coverage

EARSC Thematic Domain

Domain	Built Environment
Sub-domain	Infrastructure
Product description	Asset Infrastructure Monitoring

PRODUCT SPECIFICATIONS

Input data sources

Sampling of available products:

Satellite	***Sentinel-1***	***TerraSAR-X***	***RadarSat-2***	***COSMO-SkyMed***

Status	In operation	In operation	In operation	In operation
Operator	ESA	Airbus Defence & Space	MDA	e-Geos
Data availability	Public	Commercial, on demand	Commercial, on demand	Commercial, on demand
Resolution (m)	20x4	3x3 or 1x1	25x7 or 5x5 or 3x3	3x3 or 1x1
Coverage	Global	Global	Global	Global
Frequency (days)	6-12	11	24	4-16
Launch year	2014	2007	2007	2007
Website	link	link	link	link

Minimum Mapping Unit (MMU)

The satellite can detect very small features (~decimeters), provided that objects and/or surfaces of interest reflect well enough. Generally, solid, stable, angular objects are the best reflectors.

Accuracy / constraints

Thematic accuracy:

The technique works best on solid, stable, angular objects like infrastructure, buildings, solid rock, etc. Water cannot be measured and vegetated surfaces are more difficult to measure.

Spatial accuracy:

Dependent on the satellite resolution. The measurement can be located on sub-pixel level, typically in the order of 1-5 meters.

Measurement accuracy:

The deformation/movement of the infrastructure can be determined with a precision of around 1 mm/yr.

Accuracy assessment approach & quality control measures

The quality is assessed by automated, thoroughly tested, quality control algorithms, delivering validated results. The quality of the product and the approach taken are described in an automatically-generated report, ensuring high quality and reproducibility.

Frequency / timeliness

Observation frequency:

Depending on the satellite, varying from once per 4 days to once per 24 days.

Timeliness of delivery:

Depending on the satellite provider, the service provider and the type of application, within 1-5 working days.

Availability

- Global coverage with free imagery, lower resolution, including archive since 2015 and in some locations since 1992.
- Global coverage on demand with paid imagery, higher resolution. Archive imagery available in some locations.

Delivery / output format

- Data via API (Application Programming Interface), as GIS file format (geopackage, shapefile, .kml, .csv, etc.) or in a webviewer.
- Triggers via API or email.
- Automated reporting in pdf.

Use case

Rotterdam – The Netherlands *(Source: Sensar)*

Monitoring the A15 highway in the Netherlands for Strukton. Strukton has a contract with the Dutch government to maintain the highway for the coming 20 years. By using InSAR they are able to monitor the stability of the highway and the structures around it more easily, reliably, and cost-effectively. A comparison with conventional measurement techniques showed similar results, but using InSAR allows them to get a picture of the complete area they are responsible for, without having to send (expensive) personnel into the field.