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PIT SLOPE STABILITY

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 surface movements during mining operations.

Challenges addressed

Development and Operations – Ground Stability/Geotechnical

Closure and Aftercare – Affected Stakeholders

Geo-information needs

DO-19: Underground operations – surface subsidence

Description

This product provides information on the pit slope stability during mining operations, 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 complete area above the mine and the 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 of ground and slope motion. The advantages are that large areas can be monitored on a regular basis, in a fully automated manner and without human intervention, providing a spatially dense view of the effects of mining operations. Furthermore, by using satellites, a uniform data format and quality can be obtained over all mines in the portfolio.

InSAR is based on radar images, as acquired by various radar satellites. The products from these satellites differ in terms of number of measurements per km^2, measurement frequency, price (free vs. commercial 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 for deformation of the pit slopes within the mining area 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.

Triggers can be implemented to warn the mine operator if ground motion is reaching pre-defined thresholds set by the regulator or when the above ground infrastructure is at risk. This allows for intervening before a potential accident happens and a more precise planning of backfilling/ground support strategies.

Known restrictions / limitations

The satellite's ability to accurately measure surface motion is dependent on the reflectivity characteristics of the surface which is generally the case for pit slopes.

Lifecycle stage and demand

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

Design, Construction & Operations:

- Construction & Operations: Monitoring pit slope stability in operational mines.

Mine Closure & Aftercare:

- Monitoring the pit slope stability after mine closure

Geographic coverage

Global coverage

EARSC Thematic Domain

Domain	Land
Sub-domain	Geology
Product description	Monitor mineral extraction

PRODUCT SPECIFICATIONS

Input data sources

Sampling of available products:

Satellite	***Sentinel-1***	***TerraSAR-X***	***RadarSat-2***	***COSMO-SkyMed***	***ICEYE-X2***

Status	In operation	In operation	In operation	In operation	In operation
Operator	ESA	Airbus Defence & Space	MDA	e-Geos	ICEYE
Data availability	Public	Commercial, on demand	Commercial, on demand	Commercial, on demand	Commercial, on demand
Resolution (m)	20x4	3x3 or 1x1	25x7 or 5x5 or 3x3	3x3 or 1x1	< 1
Coverage	Global	Global	Global	Global	Global
Frequency (days)	6-12	11	24	4-16	< 1
Launch year	2014	2007	2007	2007	2019
Website	link	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, angular objects like solid rock, etc.

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 pit slope 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 daily to 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

This product is part of the project's service demonstration. Use case will be added soon.