EO4RM

Earth Observation for the mining of Raw Materials

D2.2 Gap Analysis Report

V1.1 [FINAL VERSION]

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List of Abbreviations and Acronyms

EO	Earth Observation
EO4RM	Earth Observation for the mining of Raw Materials
RM	Raw Materials
SWOT	Strengths Weaknesses Opportunities Threats

1 Introduction

Following on from the delivery of the product portfolio (D2.1: Current EO Capabilities Report), a Gap Analysis was performed in order to define the gaps between EO capability and the geo-information requirements from the mining industry.

The EO products were compared to the RM sector's geo-information requirements, which were determined in the beginning of the EO4RM project (Task 1, D1.2). The overall aim was to define technology gaps between current RM needs/requirements and current EO capabilities.

Throughout the analysis, new satellite missions, technology developments, the possible development of new, adapted data products and changes in data policy have been taken into account.

All outcomes of the gap analysis will be consolidated during the 2nd EO4RM workshop, whereby priorities and potential of different technologies will be assessed (see the upcoming deliverable D2.3 Workshop 2 Report).

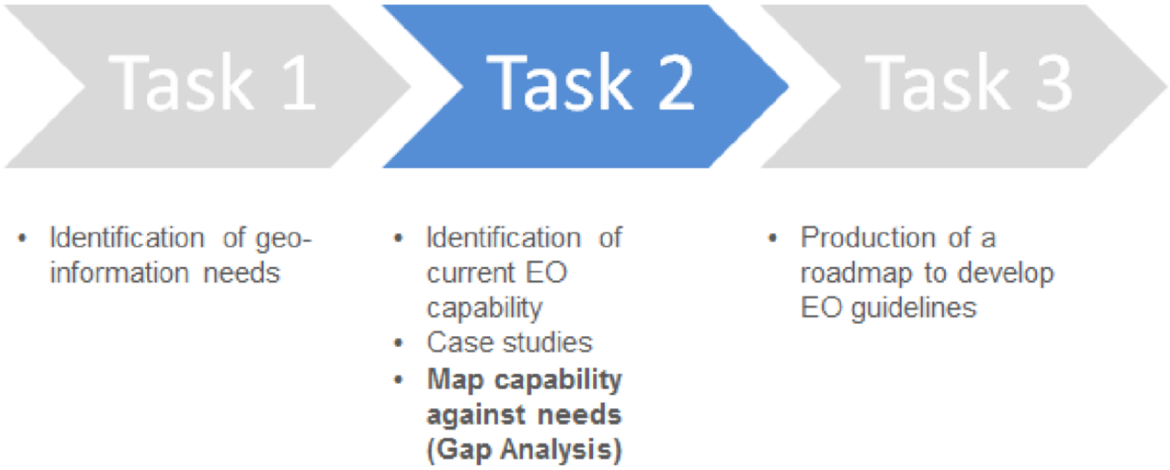

Figure 1: EO4RM project structure

2 Gap Analysis

The Gap Analysis was divided into two steps. First, a multi-criteria screening was developed to identify high potential products that would be subjected to a more detailed analysis. This detailed analysis formed the second step, where a strengths, weaknesses, opportunities and threats (SWOT) assessment was performed on the top 20 ranked products (see Figure 2).

The following chapter gives a brief introduction to the overall process.

Figure 2: Product screening and SWOT analysis approach

2.1 Multi-criteria evaluation screening

To identify the EO products that warrant being subject to a detailed gap analysis, a multi-criteria screening tool was developed. The aim of the screening tool was to identify the EO products with the greatest potential for further development or those with a need for action to encourage utilization by the mining sector.

The following three key questions guided the screening process:

1. What gaps exist between the information requirements and current EO capabilities now?
2. Can these gaps be addressed over the next 5 years?
3. What changes in data products or data policy are required?

The screening was performed based on three criteria:

- Utilisation - the current utilisation of EO products by the RM industry
- Demand - the demand for the EO product in the RM industry considering the quality level of the product
- Capability - the capability of the EO industry to provide the inquired EO product

Here again, the scoring of each criterion was guided by the following main questions:

Utilisation

1. To which extent is the mining industry using EO technology?
2. Is the sector using the most appropriate available products the EO industry can offer?

3. Is the sector using the EO products frequently or occasionally when capacity is available?

Demand

1. Do the challenges the mining industry faces suggest demand for better EO products?
2. Are drivers of demand changing the need for the EO product (especially those that might increase or decrease demand over the next 5 years)?

Capability

1. Does the EO industry have the capability to provide the EO product to the required standard/level (at the moment or in the next five years)
2. How mature or robust are the products?
3. Are the products able to be based on multiple sensors with good continuity?
4. Is there clear product specification and pricing?

Scoring Approach

To Score each product for each criterion an individual scoring system was developed.

Utilisation	
0 - negligible	No or very limited use
1 - Low utilization	Using freely available information sources
2 - Medium utilization	Using commercial services and products, but better specification products are available or they could utilise more of the product if better integration tools were available.
3 - High utilization	Using the best available products based on stereo or tri-stereo high resolution

Demand	
0 - No demand	No demand
1 - Low demand	Challenges can be addressed with reference to base images, Google Earth, and simple products. Limited, one-off demand for product. Limited change in demand forecast over 5 years as a result of RM industry drivers.
2 - Medium demand	Challenges, now or in future based on the industry drivers, require products based that are beyond sources such as Google Earth. Rigour is required in product generation.
3 - High demand	Challenges, now or in future based on the industry drivers, require a high quality product that is often fulfilled through aerial or ground-based survey.

Capability	
0 - No capability	No EO capability to meet RM demand
1 - Low capability	EO industry can only address the demand in a limited way. New sensors required.

2 - Medium capability	EO industry can often fulfil the demand, but there are some thematic content, accuracy, or delivery limitations to address the challenges and needs. In other cases, new sensors that are being developed should allow the development products that can address the demand (e.g. hyper-spectral)
3 - High capability	EO industry product is able to meet the current and anticipated needs of the mining sector. Initiatives such as standards, training, and integrations tools can still benefit the EO industry.

For the utilisation and demand scores, an online poll was developed and distributed amongst the IIB members. In this way, the knowledge of mining experts has been incorporated in the scoring process.

The capability score has been built up from individual scores describing parameters such as the resolution, frequency, content and cost, rated by experts from the respective EO field.

Gap identification

The results of the screening were automatically calculated based on the described scoring system. Finally, the difference and level of the scoring for each criteria resulted in the identification of the following gaps (see also Figure 3):

Guideline Gap

A Guideline Gap occurred if the capability of the EO sector to provide the product was higher than the demand. Thus, the RM sector has a need for guidance on the selected product regarding how it can be used to address their specific challenges. The gap is computed by subtracting the demand score from the capability score.

Utilisation Gap

A Utilisation Gap occurred if the demand for a product was equal to the capability of the EO sector to provide the product. However, utilization can lack even though it is assumed that the industry knows about the EO product. That implies the RM sector is choosing not to use the product for another reason e.g. cost or reliability. The gap is computed by subtracting the utilisation score from the demand score, in the case capability approximately equals demand.

R&D Gap

An R&D Gap occurs if the demand for a specific product is higher than the capability of the EO sector to provide the product to the expected/needed quality. The gap is computed by subtracting the capability score from the demand score.

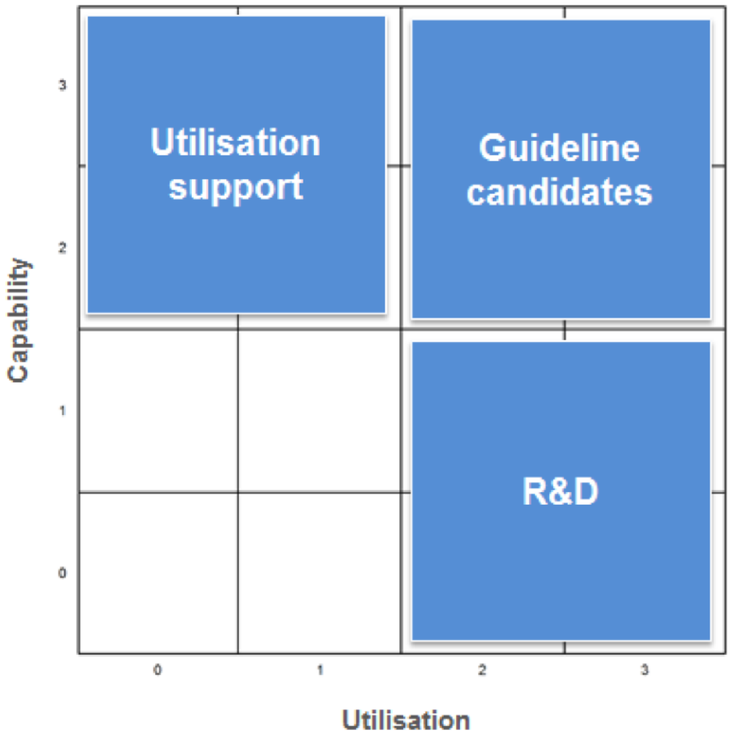

Figure 3: Product scoring matrix

Through the multi-criteria screening it was possible to rank products for inclusion in the detailed gap/SWOT analysis (please see Appendix A1 – Multi-criteria Screening Results).

2.2 SWOT Analysis

Based on the results from the multi-criteria evaluation screening, a strengths, weaknesses, opportunities and threats (SWOT) assessment was completed on the top 20 ranked products.

The consortium performed a detailed SWOT analysis on the following products:

Product Sheet	Total (potential)
Soil Structure and Chemistry	1,5
Surface Subsidence	1,4
Cultural Heritage	1,4
Air Quality TPM / Particulate Matter	1,35
Stockpile Monitoring	1,3
Monitoring of Infrastructure	1,15
Ground Water Monitoring	1,1
Lithology and Surficial Geology Mapping	1,1
Water Quality	1,1
Air Quality CH4	1,05
Land progressively rehabilitated	1
National Monuments	1
Topography / Elevation	0,95
Geophysical Assessment	0,9
Infrastructure Stability Monitoring	0,9
Air Quality CO2	0,8
Land disturbed by mining activities	0,75
Protected Areas	0,75
Orthophoto Map	0,7
Deep Crust Geological Mapping	0,65

Figure 4: The top-20 products, including their potential (the sum of their gap scores)

The product screening results as well as the detailed SWOTs can be found in the Appendices to this document.

Information requirements that cannot be met today (i.e. desired spatial and/or temporal resolution) are listed under **weaknesses** in Appendix A2. The prospect of these requirements being met within the next 5 years is elaborated under **opportunities** in Appendix A2.

3 Summary and Conclusions

Overall 20 products have been analysed. Besides some more detailed product-related outcomes which can be found in each SWOT sheet, a number of trends relating to the use of EO products were identified that apply to many of the products:

Strengths

- Reducing need for in situ personnel, making the working conditions better and safer
- Global coverage as part of the technological capabilities
- Unsafe, remote and rugged places are excellent for EO based services

Weaknesses

- Update frequency / revisit times of satellite imagery
- Dependency on satellite operators and data distributors down the supply chain
- Mining domain requirements don't always overlap with technical capabilities

Opportunities

- Better and more satellite data expected to become available in the future
- Demand and capabilities can match, with only utilisation being the prohibiting factor
- Increasing resources demand and scarcity leads to the need to extract more remote and close to urban areas, leading to more remote sensing based information needs.

Threats

- In situ or airborne substitutes often available
- Gaining user trust and implement it in currently accepted standards and methods
- Difficulties in validation of the solution, comparing it to available alternatives convincing customers to adopt the new solution

3.1 Opportunities in all mining phases

The specific opportunities for the application of EO data vary throughout the mining cycle. Figure 1 shows the potential in each phase of the cycle. Each of the top 20 products was assigned to one or more applicable phase (see also the individual product sheets in D2.1: Current EO Capabilities Report), after which an average was calculated for each phase (1= Exploration, 2 = Environmental Assessment & Permitting, 3 = Design, Construction & Operations, 4 = Mine Closure & Aftercare).

An interesting trend can be seen in Figure 1. In both exploration and closure phase, the biggest issues are the R&D and guideline gaps. In other words, either EO technology is not capable enough, other is no demand for it. However, in the permitting and operational phase, the opposite can be seen: the guideline and R&D gap is low, but there is a large utilisation gap. This means that in these phases there is a large demand for EO services that can technically be met, but is currently not done yet.

This indicates that there are large commercial opportunities for EO data services in the Environmental Assessment & Permitting, as well as the Design, Construction & Operations phase.

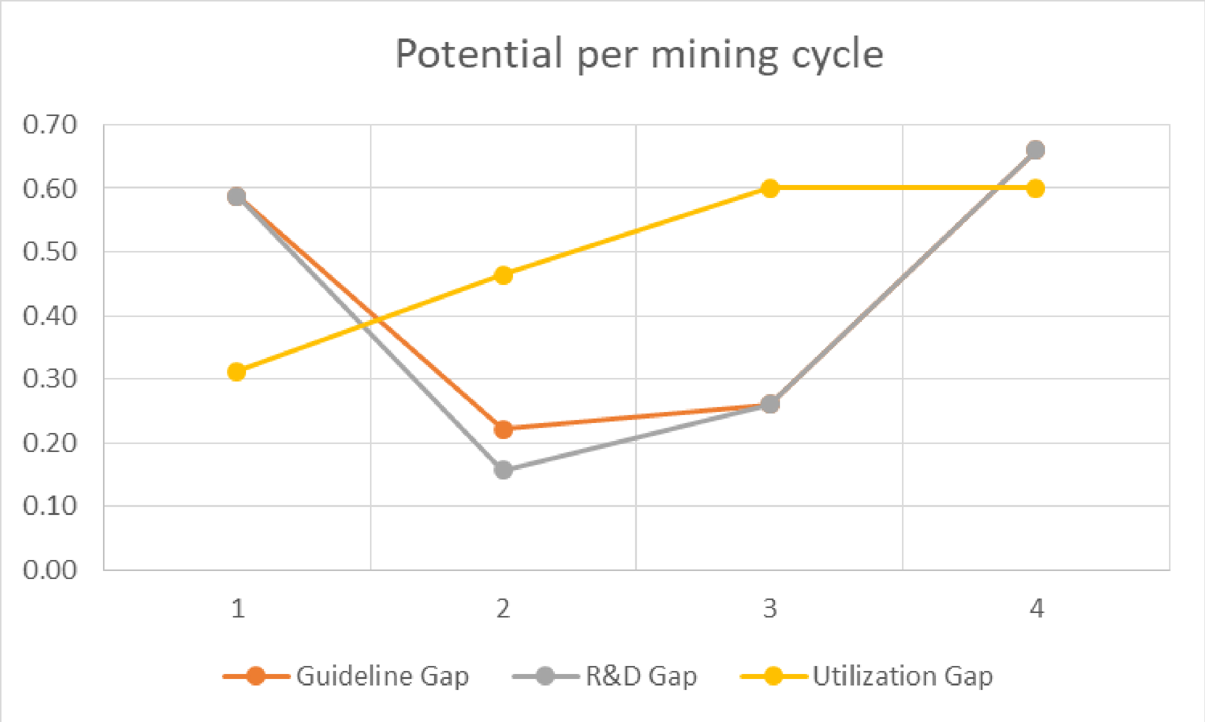

Figure 5: EO Opportunities in the different mining cycles

3.2 Conclusions

Looking at the strengths, it becomes clear that global coverage allows for providing information about unsafe or rugged and remote areas, as long as the frequency of satellite revisits aligns with the update frequency demand of users. In such scenarios there is a clear advantage compared to other technologies such as in situ or airborne measurement techniques. The global coverage also means that it is much easier to scale a service, potentially providing much more value than substitutes that are more location bound. As opposed to more traditional ways of working, it is clear that EO based services are a next step in automating work processes to make them become more efficient and safe.

If there is a need for more real-time information, other technologies can have an advantage over EO based techniques. This competition with alternative solutions is a weak spot and should be taken into account when assessing the viability of a proposed method. Furthermore there are some cases in which the specific requirements of the mining domain do not match the technological capabilities of the EO solutions. Finally there is a substantial dependency risk on satellite providers and distributors, which are relied upon to launch new satellites when old ones become obsolete, and to make available the information as needed. This is especially the case when there is a reliance on freely available imagery to make a profitable business case.

Technological development creates new opportunities through making more and better satellite based data and processing capabilities available. This means that some of the technologies are able to solve problems that they are not able to today, for example through an increase in resolution, revisit times, or the integration of additional data sources. Next to that, several SWOT analyses indicated that user demand and technological capabilities already match, and that implementation only depends on user adoption. If good validation methods are established and user trust is gained, these might be easy markets to penetrate. Finally there are global movements such as increasing demand and decreasing availability of raw materials that constitute trends in favour of remote sensing based services.

One of the threats that were often identified is that of viable alternatives in the form of in situ measurement devices or airborne substitutes such as drones. If these solutions form a better product/market fit to the problem at hand, they will most likely be a preferred alternative. Therefore a good understanding of strengths and weaknesses, coupled with domain knowledge about the mining industry is required to find the market for which EO services can create the most value. Another major threat is the difficulty in validation and proving to potential users the usefulness and reliability of remote sensing techniques. Without trust in technical capabilities, user adoption can be slow, and willingness to change in order to implement these techniques into existing official procedures and ways of doing might be low.

As becomes clear from the SWOT analysis and the Multi-criteria Evaluation Screening, only in a few cases it is a challenge to address the mining industry's needs with the current technological capabilities. In those cases, the satellite resolution, the image costs and the 'guaranteed' continuity in availability of suitable imagery in the future are generally the inhibiting factors. This can potentially be solved by the launch of additional and/or improved, satellites in the future. The current advent of CubeSats will most likely lower the image costs and increase the future image availability/continuity.

More often, however, the adoption of EO products in the mining industry depends on the specific context, and the subsequent product/market fit. The question then is rather whether a technological capability is the best suited, and most cost-effective solution to address a specific problem in comparison with other viable alternatives.

Appendices

Appendix A1 – Multi-criteria Screening Results

The results of the multi-criteria screening can be found in the separate document: Multi-criteria Evaluation Screening.xlsx.

Appendix A2 – SWOT Analyses

Satellite-derived soil structure and chemistry

	INTERNAL		
POSITIVE	**Strengths** ▪ Global coverage ▪ High revisit time of high resolution satellites (3-10 days.) ▪ Data redundancy with multiple EO sources available at different resolutions ▪ Wide availability of bands provide high spectral sensitivity ▪ Mapping of extensive areas (hundreds of km^2) ▪ Reduction in security and environmental risks compared to airborne/drone imagery ▪ Quicker acquisition and acquisition of larger areas compared to airborne/drone surveys ▪ Rapid updates at lower cost relative to airborne/drone imagery acquisition ▪ Rapid detection in case of environmental contamination/pollution ▪ The product can be generated for periods prior to the start of mining activities as long as EO sources are available (e.g., baseline conditions and earlier periods)	**Weaknesses** ▪ Global coverage of free-to-use EO products only available at 10-50 m resolution ▪ Revisit time cannot be less than 3-10 days (assuming cloud-free conditions) ▪ Minimum detectable changes in soil chemistry likely to be of 5-10 times the spectral bands resolutions ▪ Atmospheric contamination might be an issue for the production of the product ▪ Costs for seldom analysis of small areas could be too high ▪ High thematic detail requires special geological knowledge and/or in-situ information ▪ Field measurements and analyses of the main mineralogical components in the mining area are required for satellite-derived soil structure and chemistry mapping ▪ Snow cover (i.e., length of the snow season) is an issue for the production of the product	NEGATIVE
	Opportunities ▪ Facilitate exploration and development in remote and difficult to access areas ▪ Limit risks in areas with security concerns ▪ Important “base product” for integration into other products, services, or solutions ▪ Increased reporting obligation related to raising of environmental concerns (climate change, ecosystem services, etc.) lead to a higher demand for the product ▪ Future advances in remote sensing capabilities are likely to amplify the range of applications and improve the quality and availability of the product ▪ Swarms of Cube-satellites (i.e., small size satellites) will be able to provide very high-resolution imagery of any place on Earth multiple times a day (flexible tasking; rapid analyses)	**Threats** ▪ Risks for satellite platform failure ▪ Changes in data format over monitoring period ▪ Reliability of empirical model used for product generation ▪ Data availability (i.e., empirical model calibrated on specific wavelength bands) ▪ Product not being validated extensively using in-situ data and therefore not reliable	
	EXTERNAL		

Surface Subsidence

	INTERNAL	
POSITIVE	**Strengths** ▪ Global coverage ○ Worldwide availability of (free) Sentinel-1 data since 2015 ○ On some locations even a historical archive back to 1992 ○ Tasking/custom worldwide and in higher resolution ▪ Millimetre precision ▪ Abundance of measurements; the ability to see spatial deformation patterns, creating the potential to correlate those to underground mining activities ▪ Measuring both vertical and horizontal (east-west) movements ▪ Ability to establish a baseline measurement (looking back in time) ▪ No need for using in-situ personnel, making the process more safe and cost-efficient, without alarming potential stakeholders around the mining area.	**Weaknesses** ▪ A historical archive is for many locations only available with Sentinel-1. For some specific applications this might not be sufficient. ▪ The maximum measurement repeat frequency is once per 4 days. Therefore, processes occurring in a matter of seconds/hours cannot be measured. ▪ Locations with vegetation, water or loose sand are difficult to measure. ▪ Large changes in the surface (~millimeter) between two satellite acquisitions (~weeks) cannot be measured.
	Opportunities ▪ The EO capabilities of this product almost equal the demand, both of them being considered as high. ▪ However, the utilization of the product lags behind. If the reason for this can be discovered, there is a great potential for increasing the product's use in the mining industry. ▪ Many more relevant satellites will be launched in the coming years, promising a repeat measurement frequency of less than a day and sometimes even in the order of a couple of hours. This will allow the detection of faster deformations. ▪ An increasing need for resources and an increasing urbanization leads to more mining close to urban areas. Furthermore, there is a greater awareness of the impact on the environment, accompanied by stronger regulations, which increases the demand for monitoring. ▪ Innovations on algorithms might enable measurements on more difficult surfaces in the future.	**Threats** ▪ Potential for satellite platform failure, reducing the amount of available options. ▪ The mining industry not trusting EO data for this purpose or having difficulties interpreting/using it. ▪ Development of in-situ sensors that serve the purpose better than EO data	NEGATIVE
	EXTERNAL	

Cultural Heritage

	INTERNAL		
POSITIVE	**Strengths** ▪ Global coverage ○ Worldwide availability of (free) Sentinel-1 data since 2015 ▪ Millimetre precision detection of movements ▪ Abundance of measurements; the ability to see spatial deformation patterns, creating the potential to correlate those to the structural integrity of the national monument. ▪ Measuring both vertical and horizontal (east-west) movements ▪ Ability to establish a baseline measurement (looking back in time) ▪ Combination of identification and monitoring of (sometimes very remote) national monuments within the influence zone of the mine.	**Weaknesses** ▪ A historical archive is for many locations only available with Sentinel-1. For some specific applications this might not be sufficient. ▪ Locations with vegetation, water or loose sand are difficult to measure. National monuments in densely vegetated areas can be difficult to identify and monitor. ▪ High resolution imagery, if necessary for the specific application, can be acquired commercially (for example SPOT 6/7, or TerraSAR-X data). However, these data are expensive relative to (potentially small) number of monuments that have to be monitored. ▪ Large changes in the national monument (~decimeters) between two satellite acquisitions (~weeks) cannot be measured. ▪ For InSAR processing continuous reflectors are needed.	NEGATIVE
	Opportunities ▪ The EO capabilities of this product are higher than the demand and utilization. By performing the right marketing and by educating the market, there is a great potential for increasing the product's use in the mining industry. ▪ Many more relevant satellites will be launched in the coming years, promising a repeat measurement frequency of less than a day and sometimes even in the order of a couple of hours. This will allow the detection of faster deformations and the closer monitoring of the national monuments. ▪ There is an increasing awareness of the impact of the mining industry on the environment, which is accompanied by stronger regulations. This increases the demand for monitoring cultural heritage sites. ▪ Innovations on algorithms might enable measurements on more difficult surfaces in the future. ▪ Upcoming radar satellites with larger wavelengths will improve the identification and monitoring of national monuments in densely vegetated areas.	**Threats** ▪ Potential for satellite platform failure, reducing the amount of available options. ▪ The mining industry not trusting EO data for this purpose or having difficulties interpreting/using it. ▪ Development of in-situ techniques that serve the purpose better than EO data	
	EXTERNAL		

Air Quality TPM / Particulate Matter

INTERNAL

POSITIVE

NEGATIVE

Strengths

- Global coverage
- High revisit times (Sentinel offers 2-3 days observations under cloud-free conditions) resulting in high-frequency observations, with daily to sub-daily observations
- Data acquisition is low-cost and data is publicly available via the space agencies.
    - The free, full and open data policy adopted for the Copernicus programme makes access available to all users for the Sentinel data products, via a simple pre-registration
- Data availability is consistent over time and future missions are planned.
- Lower cost relative to airborne acquisition
- Quicker acquisition and acquisition of larger areas compared to airborne surveys.
- LiDAR and radar sensors (e.g. CALIPSO, CLOUDSAT), are effective for overcoming cloud limitations

Weaknesses

- Global coverage
    - Publicly available datasets are globally available, however at a lower spatial resolution than needed.
- The needed observed concentrations of TPM by satellites have often a higher background value than the concentrations that will be emitted by mining of raw materials.
- Ground validation is often necessary.
- Optical sensors are dependent on availability of clear sky; This means that mass concentrations of PM less than 2.5 micron in aerodynamic diameter (PM2.5) cannot be estimated from satellite observations under cloudy conditions or bright surfaces such as snow/ice.
- Spatial resolution of EO product is often much coarser than needed for the application.

Opportunities

- New satellites such as nano-satellites or commercial satellites provide opportunities to monitor more locally.
- Exploration and development focused in remote areas with challenging access, demanding remote sensing
- Resources found in areas with security concerns, needing remote observations
- The EO capabilities of this satellite product show higher temporal resolution than needed. This could open up opportunities for more continuous monitoring.
- EO products have the ability to monitor large areas automatically, whereas a poorly designed ground-based monitoring system will be inherently deficient until upgraded

Threats

- Potential for satellite platform failure
- Ground-based systems providing measurements of TPM concentrations have a smaller footprint and are more accurate and precise.

EXTERNAL

Stockpile Monitoring

	INTERNAL		

POSITIVE	**Strengths**
	▪ Global coverage
	  ○ Worldwide availability of (free) Sentinel-2 data since 2015
	  ○ Tasking/custom worldwide and in higher resolution
	▪ Derivation of volume and changes in volume of stockpiles.
	▪ Ability to distinguish between types of material by performing a hyperspectral analysis.
	▪ Visual interpretation or classification is possible to aid the process and to make the data more understandable for non-EO experts.
	▪ No need for using in-situ personnel, making the process more safe and cost-efficient.
		Weaknesses
		▪ A historical archive is not for all locations available with high resolution satellites. For some use-cases this might not be sufficient.
		▪ The maximum resolution available at the moment is only 0.5m. This does not allow for all types of applications.
		▪ If a high revisit rate in combination with high resolution imagery is needed, the costs of the product can be significant.
		▪ Differentiation between material types can only be done on larger deposits, as the resolution is generally not high enough.
			NEGATIVE

	Opportunities ▪ The EO capabilities of this product are significantly lower than the demand. With the right R&D, there is a great potential for increasing the product's use in the mining industry. One of the main challenges is the resolution, which depends on the available satellites. However, despite future developments, it is unlikely that the resolution will be as high as demanded by the mining industry in the near future. ▪ Many more relevant satellites will be launched in the coming years, promising high repeat frequencies and high resolution. This increase of availability will reduce the price of the product. ▪ Combining this product with drones could potentially lead to a product that is both cost-efficient and reaches the required resolution.	**Threats** ▪ Potential for satellite platform failure, reducing the amount of available options. ▪ Future satellite developments not fulfilling the resolution needs requested by the mining industry, causing this product not to become an industry standard. ▪ The mining industry not trusting EO data for this purpose or having difficulties interpreting/using it. ▪ Development of in-situ techniques that serve the purpose better than EO data	
	EXTERNAL		

Monitoring of Infrastructure

	INTERNAL		

POSITIVE	**Strengths**
	▪ Global coverage
	  ○ Worldwide availability of (free) Sentinel-1 data since 2015
	  ○ On some locations even a historical archive back to 1992
	  ○ Tasking/custom worldwide and in higher resolution
	▪ Millimetre precision detection of movements
	▪ Abundance of measurements; the ability to see spatial deformation patterns, creating the potential to correlate those to the structural integrity of the infrastructure surrounding the mining area. This allows for better management of the infrastructure and preventing unforeseen interruptions in production.
	▪ Measuring both vertical and horizontal (east-west) movements
	▪ Ability to establish a baseline measurement (looking back in time)
	▪ No need for using in-situ personnel, making the process more safe and cost-efficient.
	▪ Possibility of remote visual interpretation of the damages with high resolution optical imagery.
		Weaknesses
		▪ A historical archive is for many locations only available with the Sentinel satellites. For some specific applications those might not be sufficient.
		▪ The maximum measurement repeat frequency is once per 4 days. Therefore, processes occurring in a matter of seconds/hours cannot be measured.
		▪ Locations with vegetation, water or loose sand are difficult to measure.
			NEGATIVE

	Opportunities ▪ The EO capabilities of this product are similar to the demand and both are considered as high. ▪ However, the utilization of the product is lagging behind. If the cause of this can be discovered, there is potential for increasing this product's use. ▪ Many more relevant satellites will be launched in the coming years, promising a repeat measurement frequency of less than a day and sometimes even in the order of a couple of hours. This will allow the detection of faster deformations. ▪ An increasing need for resources and an increasing urbanization leads to more mining close to urban areas. Furthermore, there is a greater awareness of the impact on the environment, accompanied by stronger regulations, which increases the demand for monitoring.	**Threats** ▪ Potential for satellite platform failure, reducing the amount of available options. ▪ The mining industry not trusting EO data for this purpose or having difficulties interpreting/using it. ▪ Development of in-situ techniques that serve the purpose better than EO data	
	EXTERNAL		

Ground Water Monitoring

	INTERNAL		
POSITIVE	**Strengths** ▪ Global coverage o Worldwide availability of GRACE mission and Sentinel-1 data o Historical archive of data ▪ High revisit time of commercial very high and high resolution satellites ▪ Data acquisition is low-cost and data is (partly) publicly available ▪ High resolution data (radar data) ▪ Radar satellite can monitor ground subsidence which is related to land subsidence and ground water extraction/depletion	**Weaknesses** Data available in medium to low resolution (GRACE mission) The frequency is constrained by satellite revisit and acquisition, but also processing requirements ▪ Inability to make direct observation of the groundwater storage ▪ Additional in-situ data such as chemical analysis needed to understand the quality of the groundwater ▪ Monitoring the rate of depletion and recharge of groundwater is difficult	NEGATIVE
	Opportunities ▪ Increased resolution of new GRACE-FO mission (100km), potential to support finer scale applications ▪ High revisit times of freely available high resolution Sentinel-1 data of under five days	**Threats** ▪ Potential for satellite platform failure ▪ The mining industry not trusting EO data for this purpose or having difficulties interpreting/using it. ▪ Overselling EO products, meeting expectations, not appreciating the value	
	EXTERNAL		

Lithology and Surficial Geology Mapping

INTERNAL

POSITIVE

Strengths

- Global coverage
  - Worldwide availability of (free) Sentinel-2A data since 2015, free Landsat 8 data available since 2013
  - On some locations historical archive back to 1999 (ASTER)
- For exploration lithology mapping is usually necessary at a regional (~1000 km2) to local (~10 km2) scale, this is available.
- The traditional way of mapping geology and mineral resources is a costly and time-consuming undertaking. Satellites can support this challenge.

NEGATIVE

Weaknesses

- Lithological mapping is best-suited for arid to semi-arid regions. Temperate and tropical regions with deep weathering and dense canopy are more challenging and accuracy of analysis and interpretation is lower.
- Areas with dense vegetation are more difficult to observe. However, in these regions vegetation can assist in the interpretation of the lithology.
- For optical imagery, atmospheric effects need to be removed to increase accuracy of interpretation and assist interpretation of underlying lithology.
- For exploration purposes concentrations of metals are needed in the range of: ore (4-30%), copper ore (2%) and gold (0.05%). This might not be achievable directly using earth observation-based lithology mapping solely.
- For geochemical mapping a combination of lithology mapping and soil chemistry is needed. Lithology can give information about the potential elements, but information about the soil chemistry is needed to get information about the exact mineral composition of the metal elements
- For ore body definition a resolution down to 15x15 m is needed. High resolution data is costly.
- A quality control measure includes professional judgement and by comparison with any published geological mapping/reports or ground truth data (geological mapping and collection of field spectra, borehole logs).

Opportunities

- The EO capabilities of this product are similar to the demand and both are considered as high.
- However, the utilization of the product is lagging behind. If the cause of this can be discovered, there is potential for increasing this product's use.
- More relevant satellites will be launched in the coming years (EnMAP), promising a continuation of observations
- In areas which are difficult to reach or are unsafe, satellite observations can be a solution
- Airborne geophysics data can be effectively incorporated. When more detailed studies are done, the processing of EO data to a reliable product will be more accurate.

Threats

- Potential for satellite platform failure, reducing the amount of available options.
- A lack of experts in processing. Other techniques that become cheaper than processing of EO data
- Development of in-situ/airborne techniques that serve the purpose better than EO data

EXTERNAL

Water Quality

	INTERNAL		

POSITIVE	**Strengths**
	▪ Global coverage
	  ○ Worldwide availability of free GRACE mission and Sentinel-1 data
	  ○ Historical archive of data
	▪ High visit rate of satellites (Sentinel) allow for a continuous update
	▪ Data acquisition is low-cost and data is publicly available via the space agencies
	▪ Range of spatial resolutions available
	▪ Range of extents possible (from 1 to thousands of km^2)
	▪ Data redundancy with multiple EO sources available
	▪ Continuity of optical products
	▪ Quality assessment and monitoring is possible through assessing various indicators with continuous updates
	▪ Web-based solutions guarantee easy access to the information and make it possible to receive information on any device at any location
		Weaknesses
		▪ The frequency is constrained by satellite revisit and acquisition, but also processing requirements
		▪ Relatively coarse spatial resolution which typically restricts monitoring to larger lakes and coastal regions
		▪ Sun glint and haze in satellite imagery might make them useless
		▪ For change analysis the acquisition date can be crucial
		▪ Additional in-situ data such as chemical analysis may be needed for further indicators of water quality
			NEGATIVE

	Opportunities ▪ Increased reporting obligation related to environmental issue (climate change, ecosystem services, environmental impact etc.) lead to a higher demand for water quality information ▪ The free, full and open data policy adopted for the Copernicus programme access available to all users for the Sentinel data products, via a simple pre-registration ▪ Increasing sensor capabilities facilitate a denser analysis ▪ Establishment of remote sensing as a reliable and cost-effective technique for water quality monitoring	**Threats** ▪ Potential for satellite platform failure ▪ The mining industry not trusting EO data for this purpose or having difficulties interpreting/using it. ▪ Overselling EO products, meeting expectations, not appreciating the value	
	EXTERNAL		

Air Quality CH4

	INTERNAL	

POSITIVE	**Strengths**
	▪ Global coverage
	▪ High revisit times resulting in high-frequency observations, with daily observations
	▪ Data acquisition is low-cost and data is publicly available via the space agencies.
	  ○ The free, full and open data policy adopted for the Copernicus programme makes access available to all users for the Sentinel data products, via a simple pre-registration
	▪ Data availability is consistent over time and future missions are planned.
	▪ Lower cost relative to airborne acquisition
	▪ Quicker acquisition and acquisition of larger areas compared to airborne surveys.
		Weaknesses
		▪ Global coverage
		  ○ Publicly available datasets are globally available, however at a coarser spatial resolution than needed. Spatial resolution of methane retrievals from satellite-based EO are currently relatively coarse – native resolution of sensors is around 10 km (GOSAT) to 30 km (SCIAMACHY) or more. Models may average the data to a regular 1° longitude × 1° latitude grid
		▪ The needed observed concentrations of CH4 by satellites have often a higher background value than the concentrations that will be emitted by mining of raw materials. Estimation error magnitude is similar to the variability in the greenhouse gas mixing ratio being measured
		  ○ The novel LiDAR system on the MERLIN satellite will be dedicated to CH4 monitoring and will provide data with 50 km resolution. Both systems will measure CH4 abundance with an accuracy of about 1-2%.
		▪ Ground validation is often necessary.
		▪ Spatial resolution of EO product is often much coarser than needed for the application.

NEGATIVE	**Opportunities** ▪ New satellites such as nano-satellites or commercial satellites provide opportunities to monitor more locally. ▪ More relevant satellites will be launched in the coming years (Merlin), promising a continuation of observations ▪ The EO demand is higher than the utilization. Developments in this field will open up opportunities. ▪ Exploration and development focused in remote areas with challenging access, demanding remote sensing ▪ Resources found in areas with security concerns, needing remote observations ▪ The EO capabilities of this satellite product show higher temporal resolution than needed. This could open up opportunities for more continuous monitoring.	**Threats** ▪ Potential for satellite platform failure ▪ Ground-based systems providing measurements of CH4 concentrations have a smaller footprint and are more accurate / precise.
	EXTERNAL	

Land progressively rehabilitated

	INTERNAL		
POSITIVE	**Strengths** ▪ Global coverage ▪ High revisit time of high resolution satellites (3-10 days.) ▪ Data redundancy with multiple EO sources available at different resolutions ▪ Reduction in security and environmental risks compared to airborne/drone imagery ▪ Quicker acquisition and acquisition of larger areas compared to airborne/drone surveys ▪ Rapid updates at a lower cost relative to airborne/drone imagery acquisition ▪ Automatic extraction of land covers evolution from imagery products ▪ Ability to map the return of land cover to baseline conditions over a long period of time (several years) ▪ Baseline information on the flora (seasonal and yearly variations due to climate) can be easily captured by historical satellite data compared to a single baseline field campaign ▪ Ability to compare baseline with current conditions and help in the logistic planning of future rehabilitation steps	**Weaknesses** ▪ Global coverage of free-to-use EO products only available at 10 m resolution ▪ Revisit time cannot be less than 3-10 days (assuming cloud-free conditions) ▪ Snow cover (i.e., length of the snow season) and frequent cloud cover might be an issue for the production of the product ▪ Precise land-use classification requires special knowledge on rehabilitation activities and/or in-situ information ▪ EO observations do not directly measure biomass (i.e., the volume of the vegetation). Additional EO products and processing steps are required to estimate accurately the biomass.	NEGATIVE
	Opportunities ▪ Facilitate exploration and development in remote and difficult to access areas ▪ Limit risks in areas with security concerns ▪ Increased reporting obligation related to raising of environmental concerns (climate change, ecosystem services, etc.) lead to a higher demand for the product ▪ Assessment of the effectivity of certain rehabilitation steps in returning land cover to baseline conditions ▪ Free-to-use data from Sentinel-1 (radar) and -2 spacecrafts (visible and IR channels) can be used to estimate biomass ▪ Swarms of Cube-satellites (i.e., small size satellites) will be able to provide very high-resolution imagery of any place on Earth multiple times a day (flexible tasking; rapid analyses)	**Threats** ▪ Risks for satellite platform failure ▪ Changes in data format over monitoring period ▪ Reliability of the training dataset (land cover detection algorithm) used for product generation ▪ Biomass/land cover estimates not being validated extensively using in-situ data and therefore not reliable	
	EXTERNAL		

National Monuments

	INTERNAL	INTERNAL	

POSITIVE	**Strengths**
	▪ Global coverage
	  ○ Worldwide availability of (free) Sentinel-1 data since 2015
	  ○ On some locations even a historical archive back to 1992
	  ○ Tasking/custom worldwide and in higher resolution
	▪ Millimetre precision detection of movements
	▪ Abundance of measurements; the ability to see spatial deformation patterns, creating the potential to correlate those to the structural integrity of the national monument.
	▪ Measuring both vertical and horizontal (east-west) movements
	▪ Ability to establish a baseline measurement (looking back in time)
	▪ Combination of identification and monitoring of (sometimes very remote) national monuments within the influence zone of the mine.
		Weaknesses
		▪ A historical archive is for many locations only available with Sentinel-1. For some specific applications this might not be sufficient.
		▪ Locations with vegetation, water or loose sand are difficult to measure. National monuments in densely vegetated areas can be difficult to identify and monitor.
		▪ High resolution imagery, if necessary for the specific application, can be expensive to acquire relative to (potentially small) number of monuments that have to be monitored.
		▪ Large changes in the national monument (~decimeters) between two satellite acquisitions (~weeks) cannot be measured.
			NEGATIVE

POSITIVE	**Opportunities** ▪ The EO capabilities of this product are higher than the demand and utilization. By performing the right marketing and by educating the market, there is a great potential for increasing the product's use in the mining industry. ▪ Many more relevant satellites will be launched in the coming years, promising a repeat measurement frequency of less than a day and sometimes even in the order of a couple of hours. This will allow the detection of faster deformations and the closer monitoring of the national monuments. ▪ There is an increasing awareness of the impact of the mining industry on the environment, which is accompanied by stronger regulations. This increases the demand for monitoring national monuments. ▪ Innovations on algorithms might enable measurements on more difficult surfaces in the future. ▪ Upcoming radar satellites with larger wavelengths will improve the identification and monitoring of national monuments in densely vegetated areas.	**Threats** ▪ Potential for satellite platform failure, reducing the amount of available options. ▪ The mining industry not trusting EO data for this purpose or having difficulties interpreting/using it. ▪ Development of in-situ techniques that serve the purpose better than EO data	NEGATIVE
	EXTERNAL	EXTERNAL	

Topography / Elevation

	INTERNAL		

POSITIVE	**Strengths**
	▪ Global coverage
	  ○ consistent data availability over time
	  ○ Historical archive available
	▪ Multiple EO sources available
	▪ Basemap that can be used directly or support tasks in all stages of the mining life cycle.
	▪ The product is a core service that can easily be combined with additional spatial data such as land ownership, cadastre data, building footprints
	▪ Large-scale processing is easy possible.
		Weaknesses
		Elevation as product is often only available for 1 moment in time.
		  ○ For monitoring specific expertise is necessary
		High latitudes coverage is restricted for free SRTM data.
		When generating DEM from stereo pairs, good quality imagery needs to be available with 2 or more images showing the same area from different directions. This can be a time consuming process
		The frequency is constrained by satellite revisit and acquisition, but also processing requirements
		Data sources are commercially licensed and must be purchased through the operator/vendor
		In dense vegetation where bare earth models are needed (for example in Seismic Planning) EO derived products cannot provide a solution and as such LiDAR is the most commonly used dataset
			NEGATIVE

	Opportunities ▪ Increasing sensor capabilities with higher resolution and higher revisit rates ▪ The revisit times of satellites are higher than the needs by mining industry. When processing expertise becomes more common this will lead to a potential increase in use.	**Threats** ▪ Potential for satellite platform failure ▪ Other techniques become easier/cheaper available (for example LiDAR imagery)	
	EXTERNAL		

Geophysical Assessment

	INTERNAL		

POSITIVE	**Strengths**
	▪ Global coverage
	  ○ Worldwide availability of (free) Sentinel-1 data since 2015
	  ○ On some locations even a historical archive back to 1992
	  ○ Tasking/custom worldwide and in higher resolution
	▪ Millimeter precision
	▪ Abundance of measurements; the ability to see spatial deformation patterns, creating the potential to correlate those to the stability of the ground.
	▪ Measuring both vertical and horizontal (east-west) movements
	▪ Ability to establish a baseline measurement (looking back in time)
	▪ No need for using in-situ personnel, making the process more safe and cost-efficient.
		Weaknesses
		▪ A historical archive is for many locations only available with Sentinel-1. For some specific cases this might not be sufficient.
		▪ The maximum measurement repeat frequency is once per 4 days. Therefore, processes occurring in a matter of seconds/hours cannot be measured.
		▪ Locations with vegetation, water or loose sand are difficult to measure.
		▪ Large changes in the surface (~decimeters) between two satellite acquisitions (~weeks) cannot be measured.
		▪ It can sometimes be a challenge to correlate specific surface movements with underground processes.
			NEGATIVE

	Opportunities ▪ The EO capabilities of this product almost equal the demand, both of them being considered as high. ▪ However, the utilization of the product lags behind. If the reason for this can be discovered, there is a great potential for increasing the product's use in the mining industry. ▪ Many more relevant satellites will be launched in the coming years, promising a repeat measurement frequency of less than a day and sometimes even in the order of a couple of hours. This will allow the detection of faster deformations. ▪ An increasing need for resources and an increasing urbanization leads to more mining close to urban areas. Furthermore, there is a greater awareness of the impact on the environment, accompanied by stronger regulations, which increases the demand for monitoring. ▪ Innovations on algorithms might enable measurements on more difficult surfaces in the future.	**Threats** ▪ Potential for satellite platform failure, reducing the amount of available images. ▪ The mining industry not trusting EO data for this purpose or having difficulties interpreting/using it. ▪ Development of in-situ sensors that serve the purpose better than EO data	
	EXTERNAL		

Infrastructure Stability Monitoring

	INTERNAL		
POSITIVE	**Strengths** ▪ Global coverage o Worldwide availability of (free) Sentinel-1 data since 2015 o On some locations even a historical archive back to 1992 o Tasking/custom worldwide and in higher resolution ▪ Millimetre precision ▪ Abundance of measurements; the ability to see spatial deformation patterns, creating the potential to correlate those to the structural integrity of key mining infrastructure. This allows for intervening before a potential accident and more precise planning of long-term maintenance. ▪ Measuring both vertical and horizontal (east-west) movements ▪ Ability to establish a baseline measurement (looking back in time) ▪ No need for using in-situ personnel, making the process more safe and cost-efficient, without alarming potential stakeholders around the mining area.	**Weaknesses** ▪ A historical archive is for many locations only available with Sentinel-1. For some specific applications this might not be sufficient. ▪ The maximum measurement repeat frequency is once per 4 days. Therefore, processes occurring in a matter of seconds/hours cannot be measured. ▪ Locations with vegetation, water or loose sand are difficult to measure. ▪ Large changes in the infrastructure (~decimeters) between two satellite acquisitions (~weeks) cannot be measured.	NEGATIVE
	Opportunities ▪ The EO capabilities of this product are lower than the demand. With the right R&D, there is a great potential for increasing the product's use in the mining industry. ▪ Many more relevant satellites will be launched in the coming years, promising a repeat measurement frequency of less than a day and sometimes even in the order of a couple of hours. This will allow the detection of faster deformations. ▪ An increasing need for resources and an increasing urbanization leads to more mining close to urban areas. Furthermore, there is a greater awareness of the impact on the environment, accompanied by stronger regulations, which increases the demand for monitoring. ▪ Innovations on algorithms might enable measurements on more difficult surfaces in the future.	**Threats** ▪ Potential for satellite platform failure, reducing the amount of available options. ▪ The mining industry not trusting EO data for this purpose or having difficulties interpreting/using it. ▪ Development of in-situ techniques that serve the purpose better than EO data	
	EXTERNAL		

Air Quality CO2

INTERNAL

POSITIVE

Strengths

- Global coverage
- High revisit times resulting in high-frequency observations, with daily, 3-daily or 16-daily observations
- Data acquisition is low-cost and data is publicly available via the space agencies.
  - The free, full and open data policy adopted for the Copernicus programme makes access available to all users for the Sentinel data products, via a simple pre-registration
- Data availability is consistent over time and future missions are planned.
- Lower cost relative to airborne acquisition
- Quicker acquisition and acquisition of larger areas compared to airborne surveys.

NEGATIVE

Weaknesses

- Spatial resolution
  - Spatial resolution of carbon dioxide retrievals from public satellite-based EO are relatively coarse (coarser than needed for the mining application) – native resolution of sensors on existing missions is approximately 4 km2 (OCO-2) to 75 km2 (GOSAT). Regional chemical transport models, used to assimilate the measurements of these missions have typical spatial resolutions ranging from 12 x 12 km2 to 3 x 3 km2.
  - Commercial satellites (GHGSAT) can get to a higher spatial resolution but can be costly.

The needed observed concentrations of CO2 by satellites have often a higher background value than the concentrations that will be emitted by mining of raw materials. Estimation error magnitude is similar to the variability in the greenhouse gas mixing ratio being measured

- Ground validation is often necessary.

Opportunities

- New satellites such as nano-satellites or commercial satellites provide opportunities to monitor more locally or merge the observations.
- More relevant satellites will be launched in the coming years (SCARBO, MicoCarb, ASCENDS), promising a continuation of observations
  - Spatial resolution of carbon dioxide retrievals from public satellite-based EO are relatively coarse – native resolution of sensors on existing missions is approximately 4 km2 (OCO-2) to 75 km2 (GOSAT). Regional chemical transport models, used to assimilate the measurements of these missions have typical spatial resolutions ranging from 12 x 12 km2 to 3 x 3 km2.
- The EO demand is higher than the utilization. Developments in this field will open up opportunities.
- Exploration and development focused in remote areas with challenging access, demanding remote sensing
- Resources found in areas with security concerns, needing remote observations
- The EO capabilities of this satellite product show higher temporal resolution than needed. This could open up opportunities for more continuous monitoring.

Threats

- Potential for satellite platform failure
- Ground-based systems providing measurements of CO2 concentrations have a smaller footprint and are more accurate / precise.

EXTERNAL

Land disturbed by mining activities

	INTERNAL		
POSITIVE	**Strengths** ▪ Global coverage ▪ High revisit time of high resolution satellites (3-10 days.) ▪ Data redundancy with multiple EO sources available at different resolutions ▪ Reduction in security, influence on ongoing mining activities and environmental risks compared to airborne/drone imagery ▪ Quicker acquisition and acquisition of larger areas compared to airborne/drone surveys (allow for the study of area possibly disturbed ▪ Rapid updates at a lower cost relative to airborne/drone imagery acquisition ▪ Automatic extraction of land covers evolution ▪ Ability to separate events caused by natural phenomena from events caused by mining activities	**Weaknesses** ▪ Global coverage of free-to-use EO products only available at 10 m resolution ▪ Revisit time cannot be less than 3-10 days (assuming cloud-free conditions). In period of intense mining activities, a capture of all the conducted mining activities (since the last image acquisition) might not be possible ▪ Snow (i.e., length of the snow season) and frequent cloud cover might be an issue ▪ Precise land-use classification and training of the land cover classifier require special knowledge on mining activities ▪ Detailed classification (sub- to meter scale) requires very high resolution data which needs to be commercially acquired	NEGATIVE
	Opportunities ▪ Facilitate exploration and development in remote and difficult to access areas ▪ Limit risks in areas with security concerns ▪ Increased reporting obligation related to raising of environmental concerns (climate change, ecosystem services, etc.) lead to a higher demand for the product ▪ Ability to compare baseline with current conditions helps in the planning and management of future mining activities ▪ Swarms of Cube-satellites (i.e., small size satellites) will be able to provide very high-resolution imagery of any place on Earth multiple times a day (flexible tasking; rapid analyses)	**Threats** ▪ Risks for satellite platform failure ▪ Changes in data format over monitoring period ▪ Reliability of the training dataset (land cover detection algorithm) used for product generation	
	EXTERNAL		

Protected Areas

	INTERNAL	
POSITIVE	**Strengths** ▪ Global coverage ▪ High revisit time of high resolution satellites (3-10 days.) ▪ Data redundancy with multiple EO sources available at different resolutions ▪ Reduction in security and environmental risks compared to airborne/drone imagery ▪ Quicker acquisition and acquisition of larger areas compared to airborne/drone surveys ▪ Rapid updates at a lower cost relative to airborne/drone imagery acquisition ▪ Biomass estimates (e.g., the volume or percent coverage of the vegetation) from EO products for large areas can help in the identification of sensitive areas ▪ Ability to detect new potential areas to be protected based on the detailed EO-based baseline product	**Weaknesses** ▪ Global coverage of free-to-use EO products only available at 10 m resolution. ▪ The detection and localization of cultural heritages/protected sites of meter-size scale may require the use of higher resolution products (e.g., commercial products) ▪ Product's accuracy is dependent on local knowledge of the flora, fauna and history of the area ▪ EO observations do not directly measure biomass. Additional EO products and processing steps are required to estimate accurately the biomass. ▪ The use of EO products to map flora and fauna characteristics (such as key, sensitive areas for animals, which should be protected or animal biomass) are very difficult to achieve
	Opportunities ▪ Facilitate exploration and development in remote and difficult to access areas ▪ Limit risks in areas with security concerns ▪ Increased reporting obligation related to raising of environmental concerns (climate change, ecosystem services, etc.) lead to a higher demand for the product ▪ Detailed baseline information on the flora (yearly variations due to climate) can be easily captured by historical satellite data compared to a single baseline field campaign ▪ Automatic extraction of land cover types at high resolution will most likely improve significantly the existing land cover products (such as free-to-use land cover products based on national-scale surveys)	**Threats** ▪ Overseeing potential areas to be protected due to image resolution close to the detection limit ▪ Risks for satellite platform failure ▪ Changes in data format over monitoring period
	EXTERNAL	NEGATIVE

Orthophoto Map

	INTERNAL		

POSITIVE	**Strengths**
	▪ Global coverage
	  ○ consistent data availability over time
	  ○ historical archive available
	▪ Multiple EO sources available
	▪ Very high resolution data provide the spatial resolution required to get a detailed basemap for further tasks
	▪ High revisit rate of satellites (Sentinel) allow for a continuous update
	▪ Range of extents possible (from 1 to thousands of km^2)
	▪ Continuity of optical products
	▪ Detailed basemap that may support various tasks in logistics planning and operations
	▪ The product is a core service that can easily be combined with additional spatial data such as land ownership, cadastre data, building footprints
		Weaknesses
		The frequency is constrained by satellite revisit and acquisition, but also processing requirements
		Data sources are commercially licensed and must be purchased through the operator/vendor
			NEGATIVE

	Opportunities ▪ Increasing sensor capabilities with higher resolution and higher revisit rates	**Threats** ▪ Potential for satellite platform failure	
	EXTERNAL		

Deep Crust Geological Mapping

	INTERNAL		

POSITIVE	**Strengths**
	▪ Global coverage
	  ○ Worldwide availability of GRACE and GRACE-FO data
	  ○ Historical archive: Continuous data availability since 2002
	▪ Range of extents possible (from 1 to thousands of km^2)
	▪ Continuity of optical products
	▪ Monitoring is possible as the revisit rate is 30 days; however, annual update is required by mining industry
		Weaknesses
		Relatively coarse spatial resolution (GRACE mission: 300km; GRACE-FO: 100km), the high resolution requirements of 30m cannot be fulfilled with current EO capabilities
		The frequency is constrained by satellite revisit and acquisition, but also processing requirements
		▪ Inability to make direct observation of the mineral being present – additional in-situ data may be needed for more in-depth analysis; however, the gravitational field is used by the mining industry to construct an image of the structures in a region and this information can be used to establish the likelihood of mineral being present
		▪ Surface penetration (depth of 4,000 m) cannot be fulfilled unless at very low resolution.
			NEGATIVE

	Opportunities ▪ Increased resolution of new GRACE-FO mission (100km), potential to support finer scale applications. However, requirements of the mining industry are still not met. An even higher resolution is a challenge as well as an opportunity for EO industry. Nevertheless, it will not be likely that the requirements will be met in the near future.	**Threats** ▪ Potential for satellite platform failure ▪ The mining industry not trusting EO data for this purpose or having difficulties interpreting/using it. ▪ EO capabilities of this product are significantly lower than the demand. Requirements will supposedly not be met in the near future.	
	EXTERNAL		