Constructing an Organizational Resilience Index for Decision Making

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Abstract: This paper examines the application of strategical and tactical management as foundations for creating a decision support tool designed to prevent and manage major accident risks. The discussion is based on results and experiences from the work of designing a decision support platform within the mining industry. The design activities are a part of the TERRAVISION project, an EU-funded initiative from 2024 to 2027. The research is carried out in close collaboration with three different mining companies in Spain and Greece – and stakeholders in their surrounding communities regarding identifying relevant knowledge needs. Within the context of risk, resilience is the ability of a system, organization, or community to anticipate, absorb, adapt to, and recover from disruptive events. While traditional risk management tools focus on predicting and preventing specific failures, resilience assumes that some disruptions may be inevitable and focuses on maintaining functionality during and after an event. The TERRAVISION knowledge management tool is being designed to improve decision processes related to emergency planning, at operational, tactical and strategic management levels in the mining companies. Furthermore, it will serve as a tool for local stakeholders residing near mining operations who are exposed to threats and hazards associated with the mining operation. As such, this tool acts as a boundary object that facilitates meaningful dialogue between industry operators and community stakeholders. The tool differs from conventional risk management tools in that it provides information about the organizations and local communities ability to manage to "bounce back" to normal situation with respect to business and community continuity. The tool will consist of a resilience index providing decision-makers with an overview of 1) the status of known hazards, 2) implemented measures to prevent known and unknown hazards from being triggered, 3) measures that have been introduced to reduce the consequences (consequence reducing barriers), and 4) measures to ensure normalization and business continuity. In addition, the tool will include indicators measuring the organizations and local communities' ability to learn after a potential incident with the aim of improving the ability to withstand and handle an incident.

Keywords: Knowledge management tools and platforms, Resilience, Strategic knowledge management, Mining industry, Innovation management, Communities of practice

1. Introduction

Europe is currently facing a range of emerging developmental challenges, including increased geopolitical instability, climate changes, shortage of energy and natural resources, and growing trade competition with China and United States (Draghi, 2024). Thus, raw materials are of high importance to the EU digital and green economy, formulating an essential basis of the European industry in the raw materials sector. On the other hand, mining operations may have negative impacts to the environmental performance during the mining life cycle. Mitigation measures are of significance to promote resilience to climate change effects and thereby contribute to enhance wellbeing of nearby communities.

Earth Observation based solutions have shown great potential in providing consistent information about mining related activities and supporting policy making and implementation. However, the heterogeneity and diversity of available data pose challenges with respect to integration for end-to-end applications. Further, relevant services based on Earth Observation data have not yet been integrated well with existing mining industry workflows and systems.

This paper is a part of the TERRAVISION project, an EU-funded project for the period 2024 – 2027. Three demonstrator cases are in Spain (Canteras and Tharsis mines) and one in Greece (TernaMag mine).

1.1 The TERRAVISION Earth Observation (EO) Mining Services Platform

TERRAVISION is designing and establishing an integrated platform to enhance the entire critical raw materials value chain towards implementing sustainable mining practices. The Platform will be demonstrated at both EU (Greece, Spain) and beyond coupled by validation campaigns at six mining sites. This paper is linked to the fourth of the following innovation pillars that support the Mining Services Platform; (i) the Data Ecosystem for Large scale EO mining services monitoring the entire raw materials life cycle; (ii) the Analysis Ready Data and Raw material spectral library, mapping of primary and secondary critical raw materials,(iii) the EO services for the mining industry developing and deploying services critical to supply chain but also enable a dynamic hazard mapping service for proactive management of risks to promote operational efficiency of mining sites; and (iv)

The Green & Resilience Accountability Component promoting critical raw materials supply chain resilience and sustainability, including the development and implementation of a resilience index.

The research is carried out in close collaboration with three different mining companies in Spain and Greece – and stakeholders in their surrounding communities regarding identifying relevant knowledge needs. This paper focuses on the development of the platform or dashboard supporting decision-making to prevent and manage major accident risks. Even though the platform covers several other aspects, this paper is limited to the creation and visualisation of a resilience index. The main object is to examine the application of strategical and tactical management as foundations for creating a decision support tool to handle potential damaging events, hazards and disturbances.

2. Resilience Characteristics

The resilience concept is used in different contexts, such as healthcare, aviation, chemical and petrochemical industry, nuclear power plants, and railways (Stene & Kongsvik, 2022). Within the context of risk, resilience is the ability of a system, organization, or community to anticipate, absorb, adapt to, and recover from disruptive events. While traditional risk management tools focus on predicting and preventing specific failures, resilience assumes that some disruptions may be inevitable and focuses on maintaining functionality during and after an event. The general definition of resilience adopted by the TERRAVISION project is:

> *Ability to maintain essential system functions prior, during and after changes and sustain required operations under both expected and unexpected conditions. (Hollnagel, 2019).*

2.1 The System of Interest

The system of interest in a particular study may differ from micro to macro levels. As such, the considerations and characteristics of interest may vary. In a TERRAVISION setting, relevant systems of interest are both organizations, critical infrastructures or a local community.

The TERRAVISION platform is being designed to improve decision processes related to emergency planning, at operational, tactical and strategic management levels in the mining companies. Furthermore, it will serve as a tool for local stakeholders residing near mining operations, and considering who are exposed to threats and hazards associated with the mining operation. As such, this dashboard tool acts as a boundary object that facilitates meaningful dialogue between industry operators (organisations) and community stakeholders.

2.2 Organisational Resilience – Knowledge Needs in Mining Companies

When focusing on an organisation or critical infrastructure these four resilience aspects are often emphasised:

- *Rebound* – Ability to bounce back from trauma to stable state (return to equilibrium)
- *Robustness* – Ability to withstand (known unknown)
- *Graceful extensibilit*y (Opposite of brittleness) – Ability to stretch beyond performance boundaries when surprise challenges the boundaries
- *Sustain adaptability* (Network architecture) – Ability to anticipate and adapt to future surprises as conditions evolve

Woods (2015) distinguishes resilience and robustness. While robustness refers to being able to deal well with *known unknowns*, resilience refers to being able to deal well with *unknown unknowns* and handle troubles that were not foreseeable. Definitions have recently emerged due to challenges regarding how systems may adapt to manage increased complexity, e.g. risk of brittleness and failure when events push the system up to and beyond its boundaries for handling changing disturbances and variations.

One main characteristic of resilient system performance is the *adaptive capacity* and the ability to adjust how it functions, including the ability to modify plans to situational changes (Woods, 2019).

2.3 Community Resilience – Knowledge Needs Within Local Communities

Climate change is a global challenge leading to natural hazards like hurricanes, floods and landslides. To reduce the consequences of both natural and man-made changes, local communities' ability to handle incidents is crucial. The *Community Resilience* (CR) perspective is highly contextual and generally refers to the ability of localised areas (usually geographically defined areas) to respond, cope and adapt to change through communal actions (Stene & Kongsvik, 2022). This includes the engagement at the *local level to build resilient capacity* –

both preparedness and responsiveness – by shared responsibilities by individuals, nongovernmental and private organizations, academia etc.

3. Constructing the Index

Several methodologies are used to systematically analyse and assess risks. The bowtie method is one of the methods that has become popular in high hazard industries like oil & gas, aviation and mining (de Ruijter & Guldenmund, 2016). One of their examples is illustrated in Figure 1.

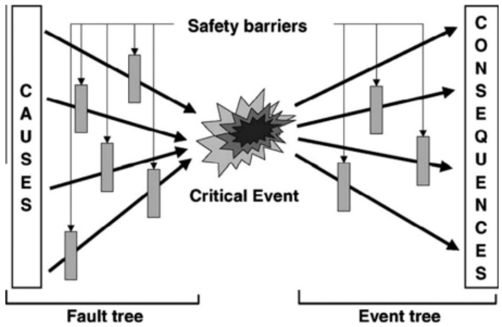


Figure 1: A generic example of a bowtie

An event is critical in the sense that it can lead to many negative events. All variants of the model extend out to both sides to include threats (or causes) on the left and consequences (or outcomes) to the right. *Barriers* can eliminate, prevent, recover or mitigate. Those at the left may be called *control or prevention barriers*, and the ones at the right as *recovery barriers*. Prevention barriers help preventing the top event from occurring. Recovery barriers minimize potential consequence from occurring. Implementation and maintenance of barriers are handled by the system's management in order e.g. to select optimal strategies to reduce risks of undesirable incidents.

3.1 Factors – Proactive and Reactive Barriers and Measures

Lately, a *resilience assessment methodology* is developed as a basis for investigating threats, incidents, and risks by identifying both preventive measures and reactive actions. Although Fjørtoft et al (2023) focus on autonomous shipping, the method is considered generic and valuable for developing solutions in other domains. Their framework was developed engaging project partners in workshops, and visualisations techniques aided in identifying relevant threats and top events. The purpose is to explore the critical role of resilience in a defined system. The authors describe a methodology with six steps, as illustrated in Figure 2.

Step 1 – Identification of impact categories (e.g. humans/people, environment, reputation, infrastructure and technology/equipment, services). To assess resilience and limit the scope, they suggest starting to consider operations to be evaluated, to describe different impact categories, and to decide what category to focus on.

Step 2 – Selection of top events: Identify potential critical events (related to identified impact categories) that may happen. One idea is to base the analysis on operational phases or sequences, e.g. within a transport chain from A to B.

Step 3 – Selection of threats sources: Use workshops to identify sources of threats that can trigger the top events in the bow-tie diagram. The methodology lists possible threats that might be relevant organized the sources in (A) Humans, organisations and operational threats, (B) Technological threats, and (C) External threats (often hard to prevent). While (A) and (B) are controllable through design, procedures etc., (C) involves uncontrollable threats, as weather.

Step 4 – Identification of preventive barriers and measures: Link the most critical sources of threats to possible preventive barriers and measures, forming the structure for developing preventive measures. The diagram serves as an effective tool for communication and facilitates productive discussions. The methodology has identified a set of possible preventive barriers that can be used or replaced with new barriers preventing top events from happening.

Step 5 – Identification of reactive barriers and measures and describe potential consequences if preventive barriers fail. The goal is to reduce consequences after an event has occurred. This includes to think about resilience activities to be launched, and thus situations that may be planned for.

Step 6 – Identify possible consequences including worst potential consequences of a top event. This should be aligned with step 1, the selected impact groups. It is important to prepare for worst cases.

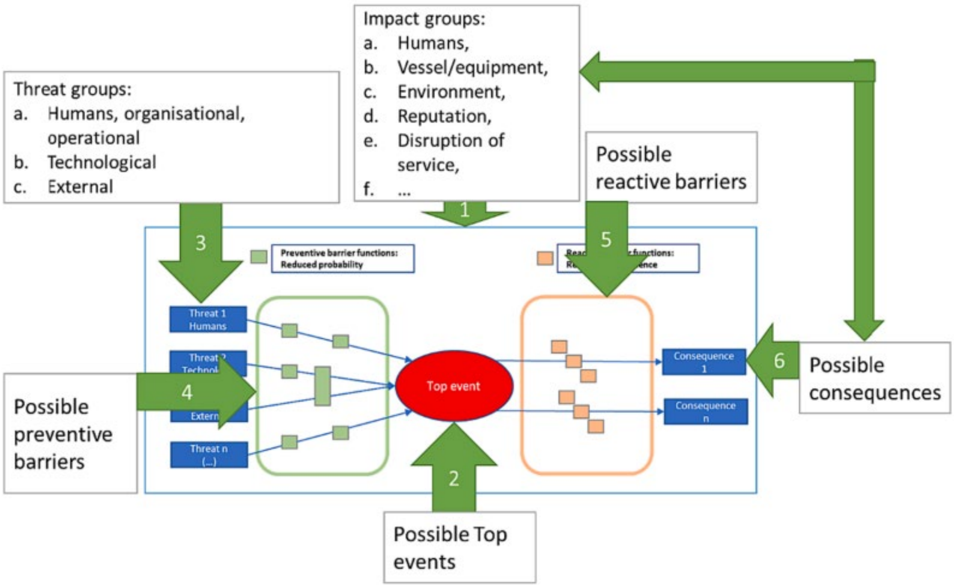


Figure 2: Steps in the AEGIS Resilience methodology

3.2 Resilience Indicators – Phases in Critical Infrastructure Functionality

Many definitions of the term indicator exist. Generally, an indicator describes how to measure a concern, for example: "An indicator is a measurable/operational variable that can be used to describe the condition of a broader phenomenon or aspect of reality." (Øien, 2001b). The term resilience indicators may include risk indicators, safety indicators, etc.

Generally, resilience curves are used to illustrate the evolution of system performance – such as a critical infrastructure – before, during, and after a disruption. The curve illustrates that a system function normally until an event occurs (e.g. extreme weather) that lead to loss of functionality.

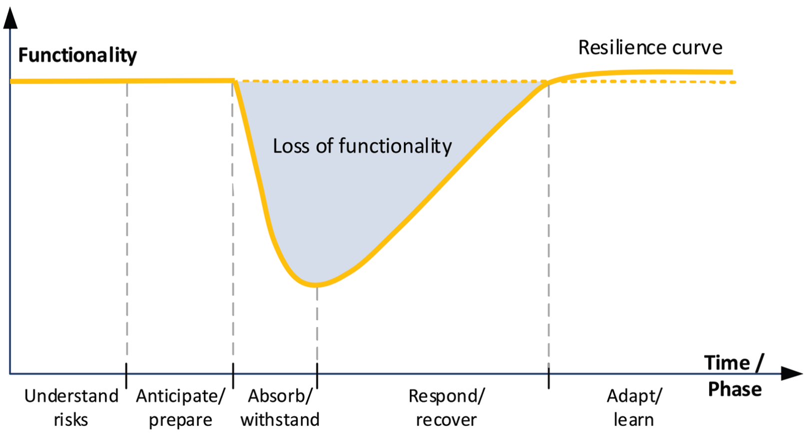


Figure 3: Resilience phases in the resilience curve/ cycle (Øien, Bodsberg & Jovanović, 2018)

The curves are often divided in five *phases* of a resilient cycle: (1) Understand risks, (2) Anticipate/prepare, (3) Absorb/withstand, (4) Respond/recover, and (5) Adapt/learn (see Figure 3.) Each of the phases are measured by *indicators* through the most important concerns affecting each of the phases, referring to factors, conditions, functions, actions, capacities, capabilities, etc. that is important to be resilient against severe threats. What is considered important, is allocated to one of the five phases in the resilience cycle.

Several methods are developed using *resilience indicators and measurement* related to critical infrastructures, like roads, bridges, inland waterways, energy networks and water supplies. One is *The SmartResilience RIL method* measuring the resilience level (RIL) of Smart Critical Infrastructure (Øien, Bodsberg & Jovanović, 2018). Another is *CIRAM* (Critical Infrastructure Resilience Assessment Method) aiming to reduce societal risks associated with climate changes on the built environment (Depina & Øien, 2021). The evaluation of resilience performance of a system is here based on critical and essential societal functions and related infrastructures. The development of societal resilience and performance goals are based on the expected effects of a threatening event on the societal functions and related infrastructures. The infrastructure supports many important society elements as residential, commercial and industrial areas, hospitals, ports and more. Based on these methods, we apply the following steps:

Step 1 – Choose area e.g. a municipality or region.

Step 2 – Select the relevant Critical Infrastructures (CI) for the area.

Step 3 – Select relevant threats for each CI, e.g. extreme weather conditions.

Step 4 – Consider each phase for each threat. What is considering is what is important to protect against or to handle each of the selected threats, and how these conditions can be measures by indicators (step 6).

Step 5 – Define the issues within each phase. What conditions are important to handle the threat? See examples in Table 1.

Step 6 – Constructing indicators for each issue. The development of indicators is based on operationalization in the form of metrics. This will be an iterative process, informed by both the availability of potentially relevant data and the identification of data gaps (i.e., data that ideally should be collected). Where appropriate, multiple metrics may be applied as indicators.

Step 7 – Determine normalized values for each indicator. Quantitative data relevant for constructing indicators will consist of different dimensions and utilize incompatible units of measurement, such as combining the system recovery time (hours) with the annual preparedness budget (monetary units), or material reserves (days) with employee training levels (percentages). To resolve this, the data must undergo a process of normalization (or translation), converting the distinct physical metrics into a dimensionless, common scale. The chosen solution is to use a 1–5 Likert scale, where 5 is best and 1 is worst. The translation rules should be based on expert and stakeholder judgments, relying on a comprehensive understanding of what certain original measurement values may represent in terms of, for example, reliability, availability, competence level, or capacity.

Step 8 – Aggregate the indicator values into indexes for each resilience phase. The indicator values (the Likert scale values) are aggregated into issue/condition values, which are subsequently aggregated into a single index value for each of the five resilience phases. The value of an issue/condition is determined by simple aggregation rules applied to its respective indicators. The calculation rules for each issue or condition may vary. These rules should be established based on expert judgment regarding the assumed relationships between the overarching issue/condition and its underlying indicators. Suitable calculation rules to determine the value of a specific issue may include, for example, (1) a weighted linear aggregation, based on the relative percentage contribution of each constitutive indicator, (2) the arithmetic mean of the aggregate scores, (3) the geometric mean, which is appropriate when lower indicator scores must be penalized more heavily than permitted by an arithmetic mean, (4) the arithmetic mean of the *n* lowest values, which isolates and highlights the system's most critical vulnerabilities, or (5) the minimum indicator value, whereby the final composite score is constrained strictly by the "weakest link" principle. The calculated values for the different issues/conditions are further aggregated into a single index value for each of the five resilience phases. This aggregation is based on the same calculation rules applied when aggregating indicator values into issue or condition values. Consequently, the indices for the five different resilience phases may utilize different calculation rules.

Step 9 – Perform the calculations. Aggregated scorer for each resilience phase based on empirical data from specific mines and mining areas.

Step 10 – Visualise status, trends, strengths and weaknesses, improvement needs etc. The visualization may utilize different illustrations such as bar charts, sequential profile lines, heat maps, "speedometers," "traffic lights," or spider diagrams. These results should subsequently inform decision-making processes, specifically regarding status tracking, progress monitoring, trend analysis, and targeted improvements.

Table 1: Examples of risk issues and indicators in each of the five resilient phases

Phases	Issues/ conditions	Indicators (examples)
Understand the risks (phase 1)	Knowledge of challenges and threats	Risk analysis; Documented historical events; Action plans
Anticipate/prepare (phase 2)	Involvement and responsibilities Regulations, laws and standards Surveillance and control of risks	Responsibility and coordination; Interdisciplinary expert group; Strategy, regulation and financial plans; Systems for surveillance (e.g. CCTV)
Absorb/withstand (phase 3)	Locations of buildings and infrastructures Redundance of transport modes, water supplies etc Requirements Maintenance Resources	Built-up areas in the geographical region/ municipality; Households in risk areas; Transport infrastructures in risk areas; Critical networks (communication, electricity, water etc) in risk areas; Access to more than one water supply; Maintenance workforce; Risk management resources (costs, jobs etc)
Respond/recover (phase 4)	Emergency plans and executions Access to electricity, water, roads, rail, web Resources to handle extreme conditions	Emergency plans related to water supply, electricity etc; Emergency and rescue plans and resources – In case of top events (e.g. fire, landslides); Population needed to be evacuated; Evacuation exercises and training; Resources (first responders, hospitals, organisations, inhabitants, neighbouring municipalities etc)
Adapt/learn (phase 5)	Learning after events	Learning arenas for debriefs, experience sharing, updating of risk documentation and management plans

3.3 TERRAVISION Platform – Web Tool for Prognostic and Dashboard Visualisation

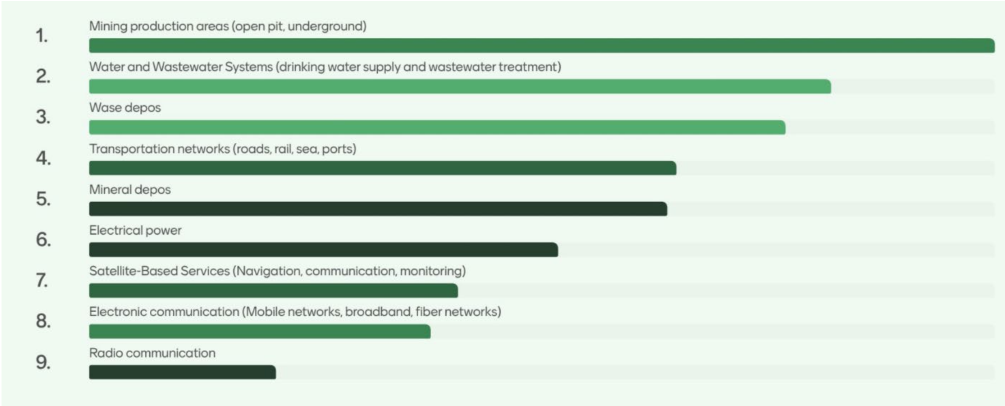
The web tool will play a crucial role in enabling users to monitor and analyse data generated by the services (see section 1.1) through intuitive and interactive visualisations. One element of the TERRAVISION platform will be a resilience index providing decision-makers with an overview of 1) the status of known hazards, 2) implemented measures to prevent known and unknown hazards from being triggered, 3) measures that have been introduced to reduce the consequences (consequence reducing barriers), and 4) measures to ensure normalization and business continuity. In addition, the tool will include indicators measuring the organizations and local communities' ability to learn after a potential incident with the aim of improving the ability to withstand and handle an incident.

3.4 Status of Work

Development of the platform is planned to be finished by the end of 2026. Currently a draft of the content and visualisations of the resilience index are under preparation, and after the summer the initial version will be tested and verified by the end-users (the three mining companies), before the final version is created.

So far, a literature review was used as a basis for the first stakeholder workshop in February 2026 in Seville, Spain. The purpose of the workshop was to establish a CoP (Community of Practitioners) to discuss and exchange knowledge on: (1) *Sustainability*: to map environmental indicators regarding their importance and data availability, and (2) *Resilience*: to facilitate the mining sector's preparedness to handle challenges and disruptions by: (a) Getting input on needs, hazards, barriers, local geographical conditions, regulations etc. and (b) To ensure relevance of the dashboard visualisations.

The resilience bow-tie method presented in section 3.1 was used to specify what to discuss and reflect upon, in addition to give feedback on an online questionnaire (using Mentimeter). The TERRAVISION project focuses on sustainability and socio-economic impact of mining activities (step 1). Based on step 2 they should indicate critical mining exploration and operation events (Mentimeter) both concerning critical infrastructures and critical social functioning. The infrastructures *seen as critical* are mining production areas, followed by water and wastewater:



Based on step 3 – 5, the participants should discuss and describe significant (1) Prevent and 2) Reactive barriers and measures related to the impact categories: (1) Human life (welfare, accidents, terror), (2) Environment (climate and nature) and (3) Business continuity (finance, maintain production).

The analysis of the results was grouped according to the five resilience curve phases (see section 3.2). Examples of comments are shown in Table 2. Most of the discussion focused on preventive barriers related to impact of human life and environment, and where both phases (Understand risk; Anticipate/ prepare) were reflected on.

Table 2: Proactive and reactive barriers of top events in the mining industry

<table>
<tr><th>Impact categories</th><th>(1) Preventive barrier functions</th><th>(2) Reactive barrier functions</th></tr>
<tr><td rowspan="3">Human life (welfare, accidents, terror)</td><td>• Understand risks
• Investigations of causes
• Risk identification and barriers to react
• Describe specific barriers for specific accidents, e.g. don’t talk on the phone, hand on handrails walking in stairway
• Accident:
• Historical records
• Terror
• Occurrences in other industries like oil
• Military experiences on measures</td><td>• Absorb/ withstand
• Follow procedures, get practice from time to time
•</td></tr>
<tr><td rowspan="2">• Anticipate/prepare
• Culture
• Build a safety culture
• Unions are important – they may have opinion about priorities, build trust and collaboration
• Human error due to working conditions
• Learning from mistakes
• Plans and regulations
• Improve safety procedures
• Create policy
• Guideline development
• Competence
• Training and education
• Monitoring</td><td>• Respond/recover
• Emergency plans
• Execute reaction exercises very often, for example fire, explosion etc
• Evacuation, hospitals plan
• Resources
• Health care</td></tr>
<tr><td>• Adapt/ learn
• Learning from investigation
• Military ops
• Protect area
• Compensate victims
• Healing facilities</td></tr>
</table>

Impact categories	(1) Preventive barrier functions	(2) Reactive barrier functions
Environment (climate and nature)	• Understand risks • Climate and natural pollution: • Document waste production in volume and storage • Risks • Landslide events: Document hazard zones of relevance with potential landslide or prone danger • Extreme weather events: Rest time notification system, Alerts • Knowledge system • Lack of a detailed environmental analysis	• Absorb/ withstand • Landslide events: • Real-time alerts for danger events • Depending on the size, huge implementation, operational flexibility • Extreme weather events: • Safety zones for evacuation • Climate and natural pollution: • Cleanse or try to limit the extent of disaster • Resources • Awareness • Emergency cell to rescue services • Result of prior-to-mining
	• Anticipate/prepare • Competence • Education • Training and education • Soft barriers – training people • Monitoring • Landslides – monitoring to prevent consequences to people and infrastructure • EIA/ monitoring • Radar for monitoring moving cities, traffic lights • Logistics • Monitoring • Shelters • Alerts • Surveillance and control of risks • Backfill to prevent subsidence in underground mine • Regulations, standards • Taxes • Climate – taxes, education • Technical recommendation	• Respond/recover • Resources • Emerging health and rescue service • Logistics • Relocate people • Healing facilities • Plans, regulations • Stakeholder closet plans • Sanctions • Insurance policies • Adapt/ learn • Fulfil all required documents/ requirements/ reports
Business continuity (finance, maintain production)”	• Understand risks • Finance: Loss of human life/ accident, Environmental accident, overspending • Production rate risks: Close follow current market, logistics data	• Absorb/ withstand • Operational flexibility
	• Anticipate/prepare • Strategy, regulations, plans • Future tasks • Mining plan and reserves • Trade regulations - Prepare for production in future shares, get money every year, cash flow continue • Mining plan • Cash flows – future • Surveillance and control • Monitoring stock market • Diversity portfolio • Predictive cash flow	• Respond/recover • Resources • Operational excellence • Having proper measures for each scenario • Plan, regulations • Regulate • Adapt operational costs

Impact categories	(1) Preventive barrier functions	(2) Reactive barrier functions
	• Stockpiling • Coordination and responsibility • Operational excellent: reduce costs, methodology when costs are too high • Maintain production: Lack of situational awareness • Monitoring • Robust geological resources model • Robust geological reserve model	• Adapt/ learn • Optimise costs • Production rate risks: Optimize, update market and production rate policies • Carefully analyse the risks affecting normal business (low ore, demanding operation conditions, market changes, …) • Selling the mine

3.5 Planned Progress

The results so far have given some results indicating platform content regarding resilience indicators. However, to be useful to the end-users, each of the mining companies must specify relevant threats for their organisation, critical infrastructures and impact on the local community concerning specific environmental and socio-economic effects. Further, a resilience index should be determined, calculated and visualised (see step 6 – 10 in section 3.2).

Hence, we are planning to use several methods in the coming work, e.g. Teams meetings with each of the involved mining sites, interviews of end-users, questionnaires with citizens in the nearby communities, and physical workshops at the three mining sites in Spain and Greece.

4. Discussion

The TERRAVISION platform will be applicable for both strategical and tactical mining management as foundations for creating a decision support tool designed to prevent and manage major accident risks.

Like resilience, strategic knowledge management perspectives take a proactive management approach for handling both normal operations and unexpected events, emphasising the identification of potential futures alternatives (Stene & Ramstad, 2025). Central in both approaches is the concept of “known and unknowns”, referring to how organisations can prepare for and respond to future changes, events, and disruptions. Thus, both approaches may support planning and decision-making regarding future uncertainty and absence of knowledge.

The tool differs from conventional risk management tools in that it provides information about the organizations and local communities ability to manage to “bounce back” to normal situation with respect to business and community continuity.

The bow-tie and resilience curve methodology are complementary considerations. The two approaches may complement each other with knowledge from different perspectives. The bow-tie method is generally used to illustrate risks with accompanying causes and consequences. Focus is to ensure at least one barrier or measure related to each risk arrow (chain of event). One advantage is that the method is easy to understand and illustrates the problem. The attention is on expected barriers and control needed to prevent and limit undesirable incidents. The considerations may give input to loss of critical functions.

The resilience curve with accompanying indicators may give additional information on significant aspects needed to maintain critical function. This may derive additional barriers and measures. Assessment of resilience may “stress test” the business against selected extreme events. Considerations of risks (like the bow-tie) are included in the first five steps in identifying resilience indicators. In addition, resilience indicator methods may complement risk assessments by selecting extreme events, which is generally not included in risk analysis.

Risk analysis cover only what is known and have a potential probability – i.e. expected events – while resilience perspectives also intend to handle any event – both known and unknown – whether they are expected and unexpected. Characteristics as vulnerability and uncertainty are considered. Resilient characteristics to cope with the unknown may include adaption, flexibility, and improvision.

5. Concluding Remarks

The TERRAVISION project includes to establish and to deploy an integrated platform to enhance the entire critical raw materials value chain – from exploration to production and closure – towards implementing sustainable mining practices. One element of this platform is to develop visualisations with prognostic features and to develop and implement resilience indices. This shall provide the mining sector and the stakeholders with key information about response capabilities about response capabilities to perturbations and shocks.

So far, a first general approach for resilience monitoring applicable to all European companies has been developed. Further development will give examples on how to specify resilience indicators to a particular mine, exemplified by involving end-users at each of the three involved mining companies in Spain and Greece by establishing so-called "Communities of Practice" at each site. This includes to identify available historical data before the mining activities, available data gathered by the TERRAVISION services using both satellite, drone and in-situ monitoring.

The last step will be to design the dashboard visualisations based on available data, to validate the developed services by involving end-users, and to finalise both the resilience content input and the visualisation of the resilience indicators and a resilience index.

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Ethics and AI Declaration: Ethical clearance for the research referred to in this paper was not needed. However, the informants are anonymized due to responding as part of a group, and not as individuals. No relevant AI tools are used to develop this paper.

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