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for Higher Education

Good Practices of Industry 4.0 in the Mining and Raw Material Sector

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Source: https://www.youtube.com/watch?v=0cW_0Z-jbNw

PHYSICAL STABILITY MONITORING AND ASSESSMENT STANDARD FOR TAILINGS STORAGE FACILITIES

A PROPOSAL FROM CHILE

programa tranque

Monitoreo de avanzada para una minería responsable

Source: www.fch.cl/proyecto/sustentabilidad/tranque/

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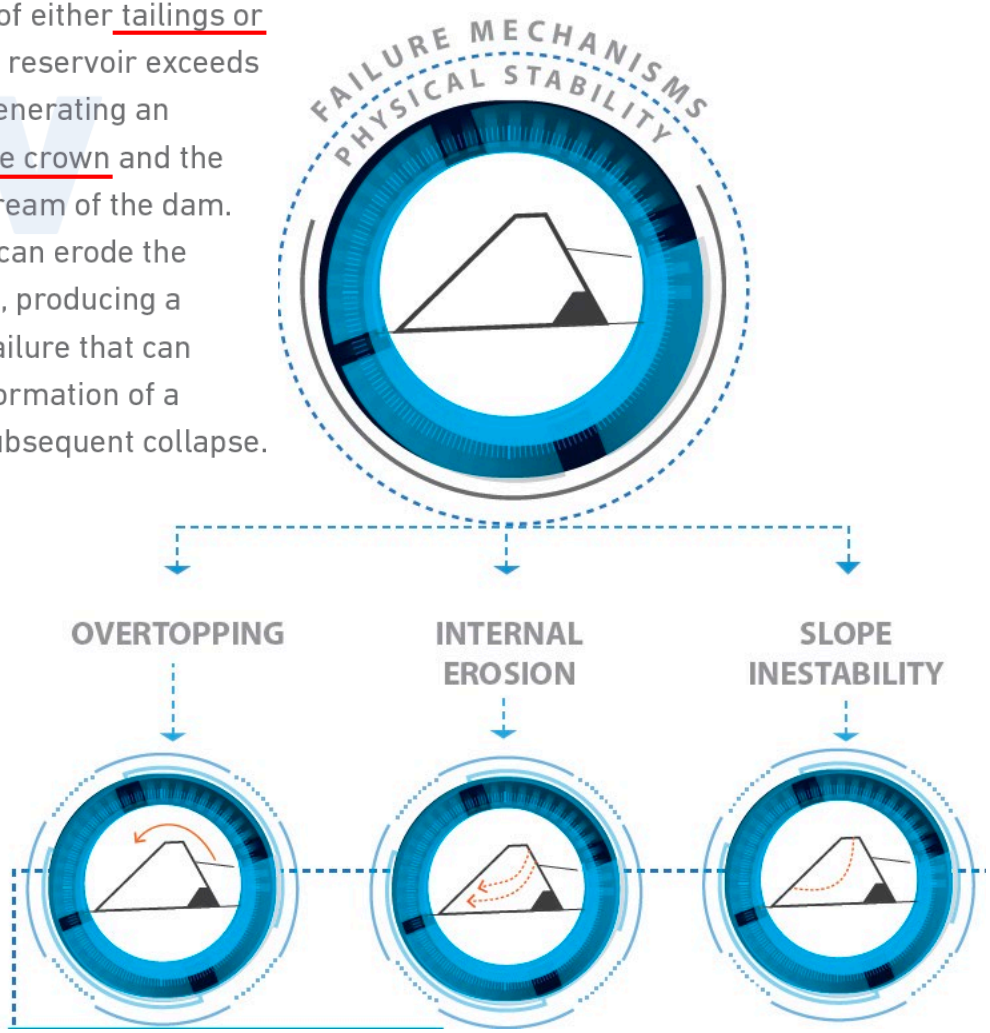
Internal erosion (also commonly known as piping) is the migration of material through the interior of the retaining dam or the foundation soil, leading to the formation of conduits that promote preferential flux paths for the circulation of water or tailings. The resulting cavities favor the progress of erosion, which can generate a local or global failure of the deposit or its foundation soil.

Overtopping occurs when the input volume of either tailings or water into the reservoir exceeds its capacity, generating an overflow of the crown and the slope downstream of the dam. The overflow can erode the retaining dam, producing a progressive failure that can result in the formation of a breach and subsequent collapse.



Slope instability corresponds to the sliding of a section of the dam slope along a failure surface, due to an imbalance between destabilizing forces and resistant ones. In general, the stability of slopes is mainly determined by the geometry of the dam (e.g., height and sloping angles), the physical and mechanical properties of the materials that conform the dam and the foundation soil.

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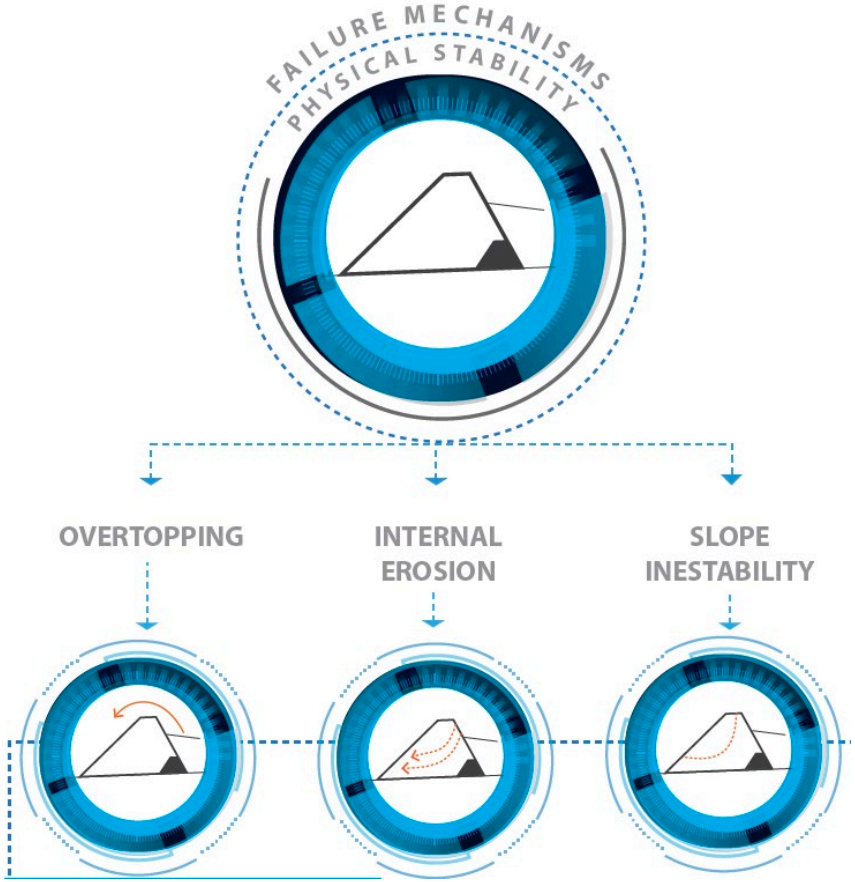
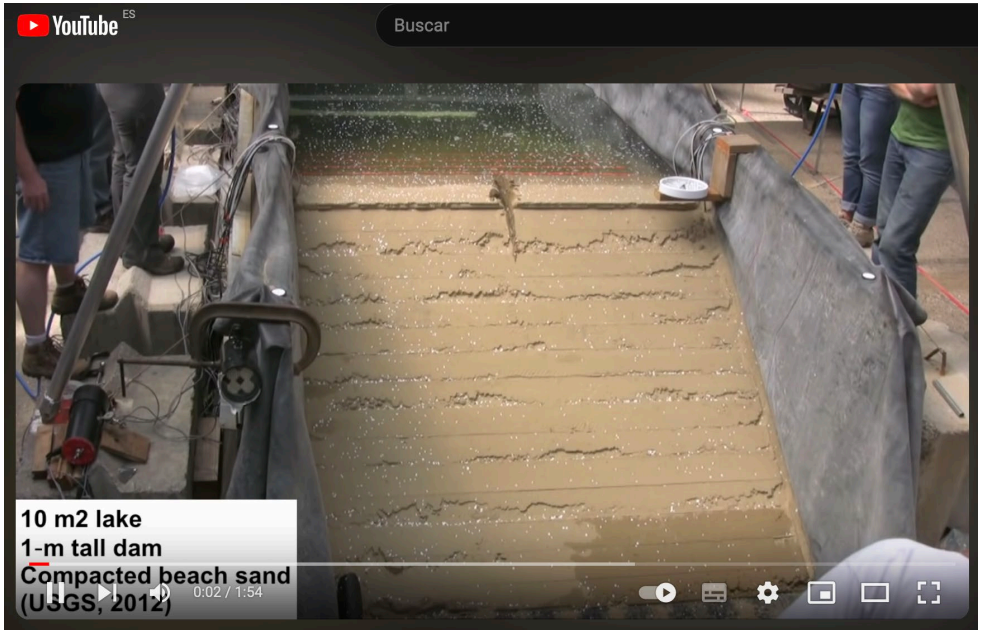
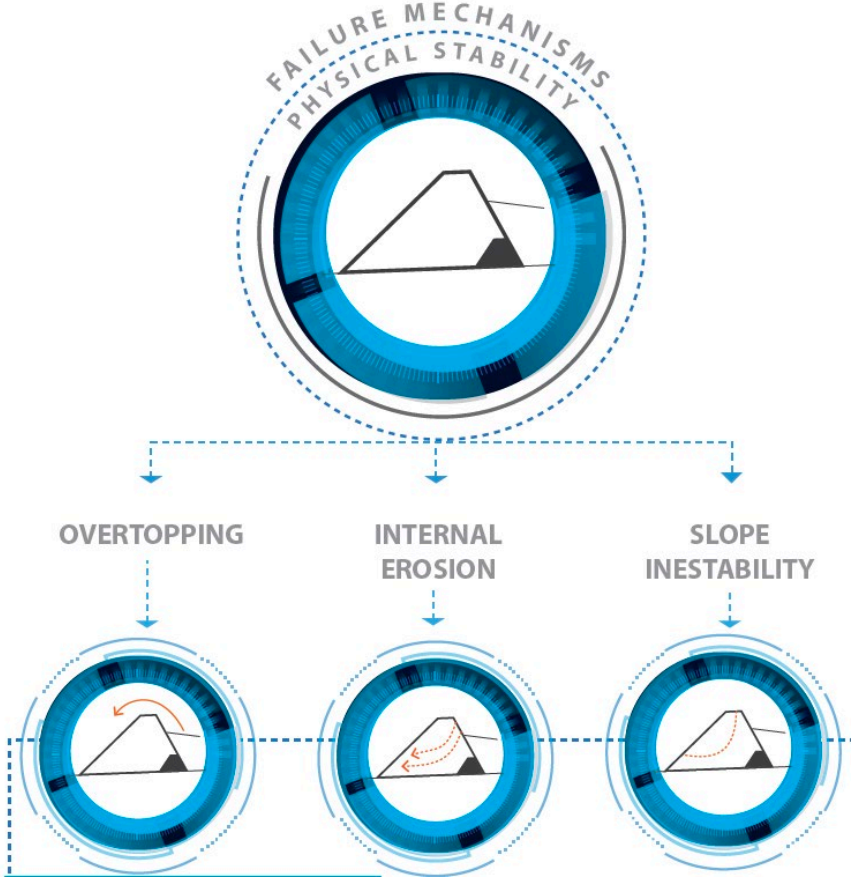
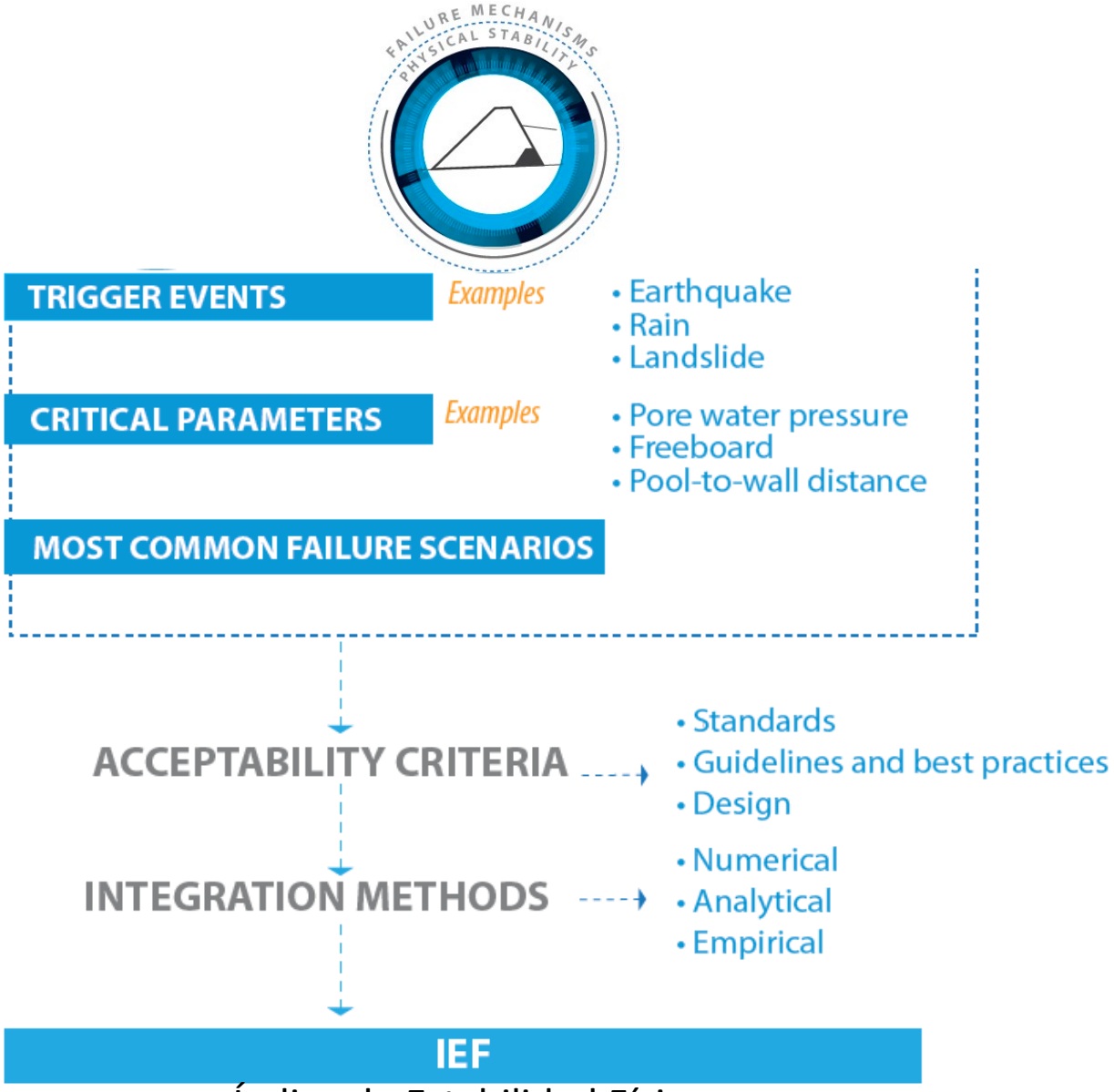




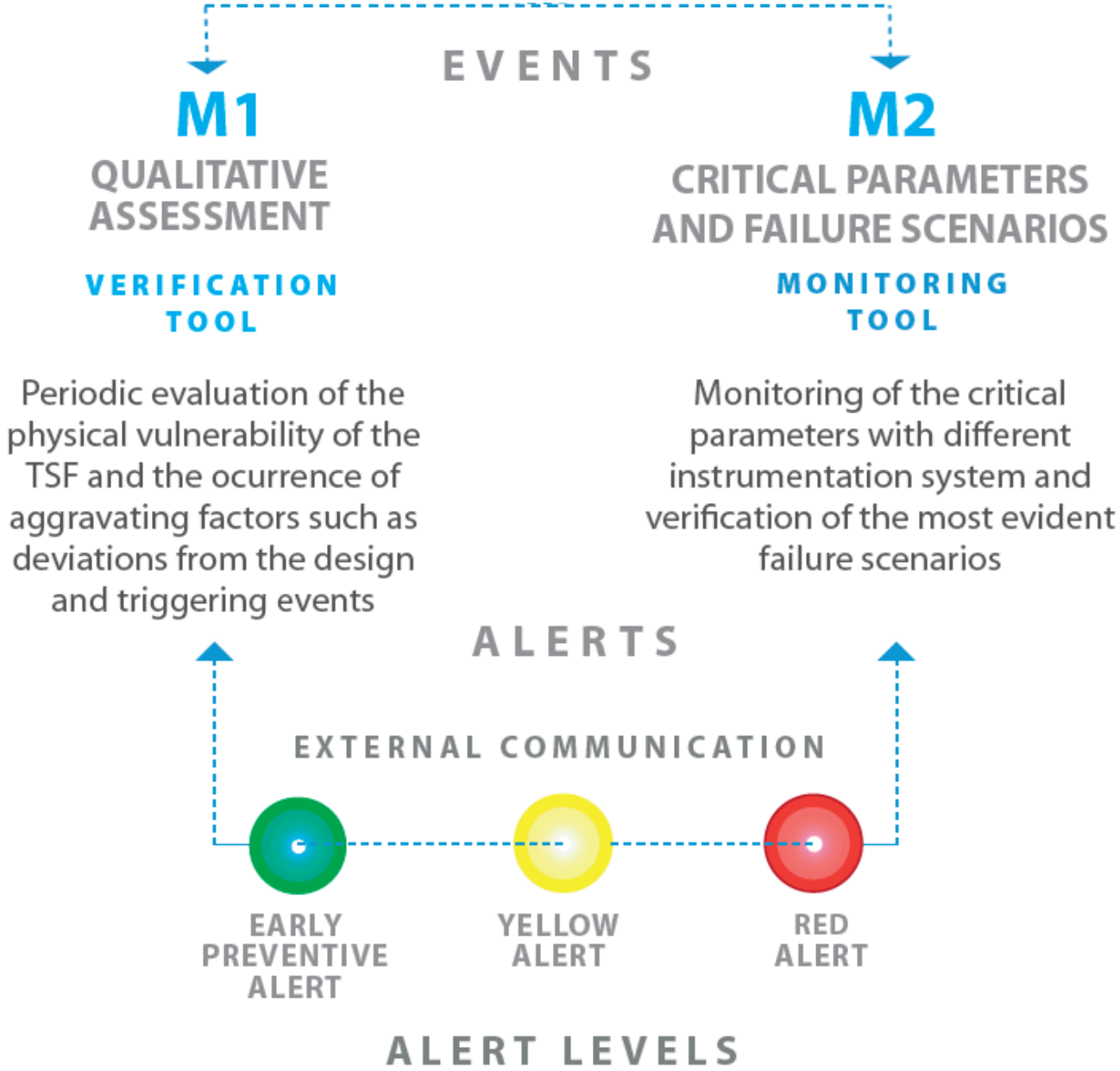
Source: https://www.youtube.com/watch?v=hmKLxoAPU1c



Source: https://www.youtube.com/watch?v=RcNqv0dm2lA



Índice de Estabilidad Física


EVENTS
M1
QUALITATIVE ASSESSMENT
VERIFICATION TOOL
Periodic evaluation of the physical vulnerability of the TSF and the ocurrence of aggravating factors such as deviations from the design and triggering events
M2
CRITICAL PARAMETERS AND FAILURE SCENARIOS
MONITORING TOOL
Monitoring of the critical parameters with different instrumentation system and verification of the most evident failure scenarios
ALERTS
EXTERNAL COMMUNICATION
EARLY PREVENTIVE ALERT
YELLOW ALERT
RED ALERT
ALERT LEVELS

Early preventive alert : This alert represents a normal functioning of the tailings facility, which is permanently monitoring the critical parameters.

Yellow alert : This alert corresponds to an abnormal condition of the tailings facility that requires an intensification of monitoring, inspection and control from both mining company and authority.

Red alert : This alert is associated with a critical physical condition of the tailings facility that requires the implementation of the emergency plan to evacuate the facility and the downstream communities.

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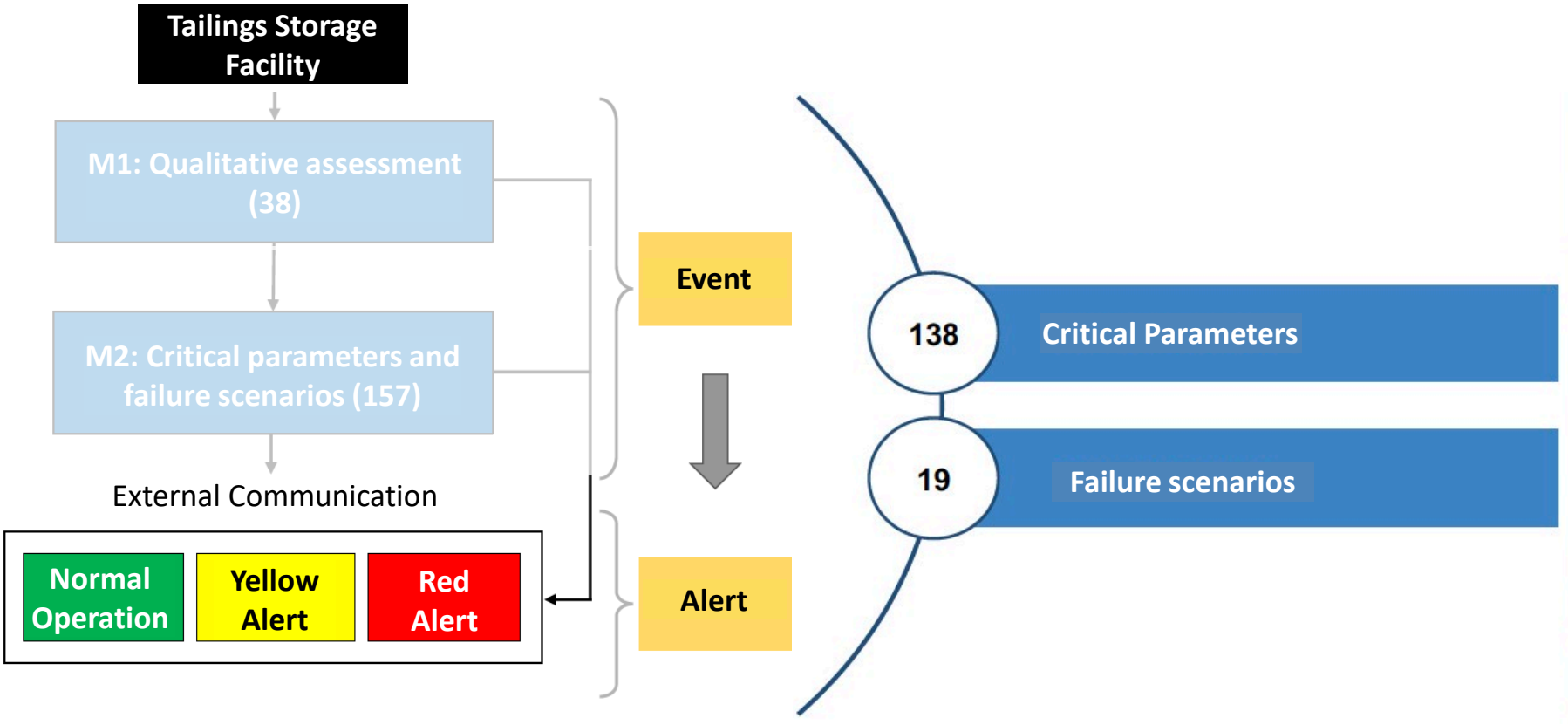
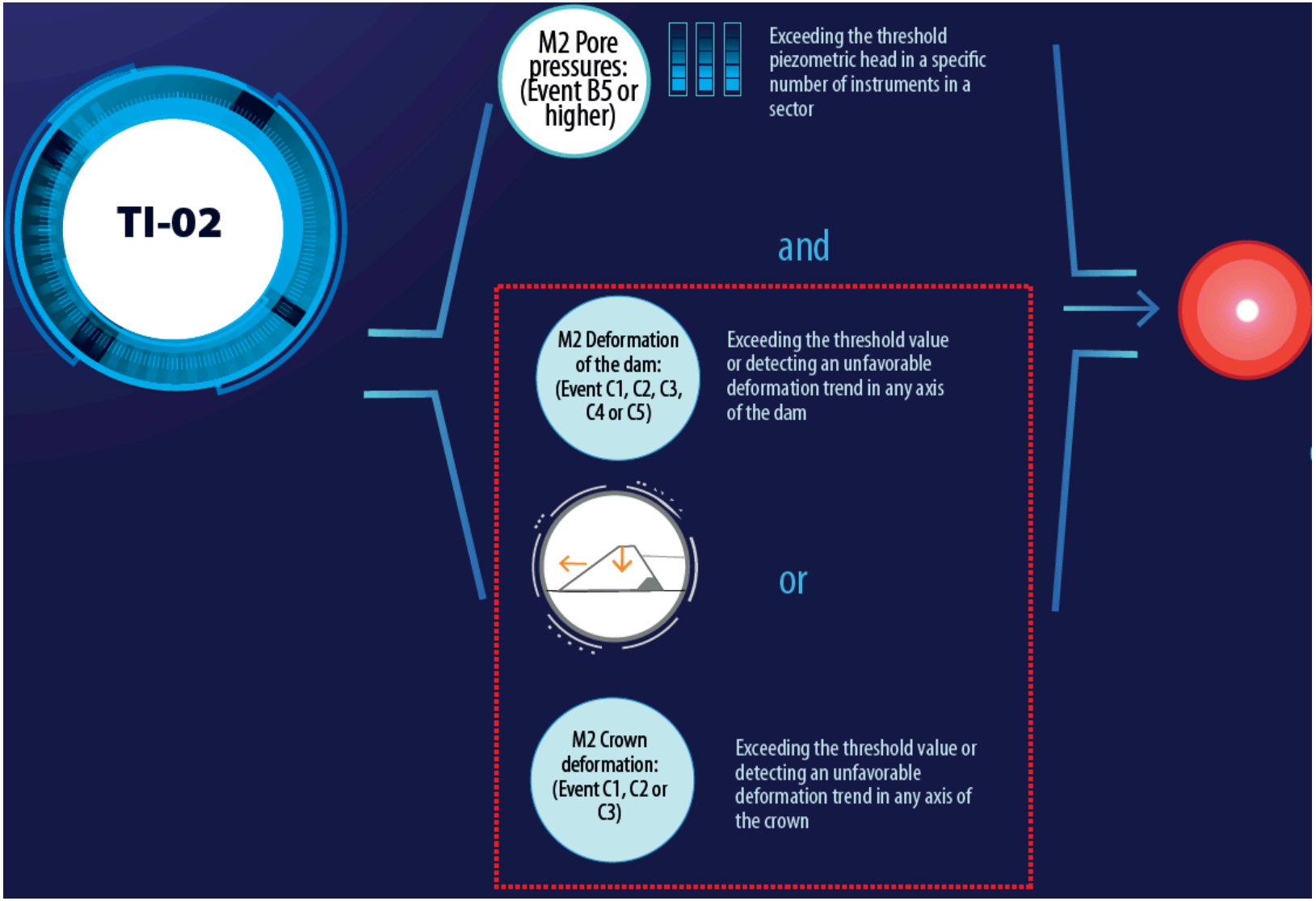
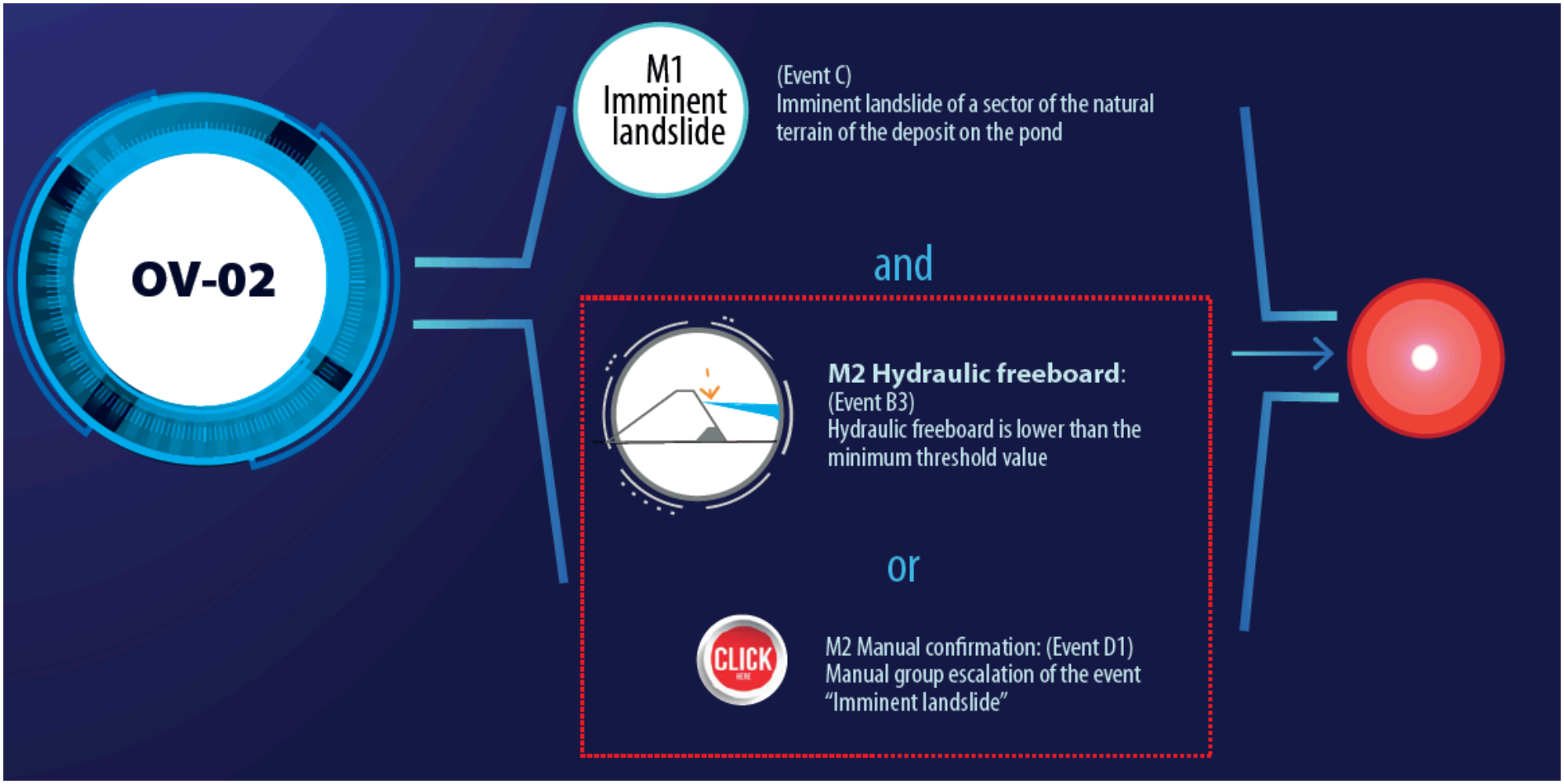

Tailings Storage Facility
M1: Qualitative assessment (38)
M2: Critical parameters and failure scenarios (157)
External Communication
Normal Operation
Yellow Alert
Red Alert
Event
Alert
138
Critical Parameters
19
Failure scenarios

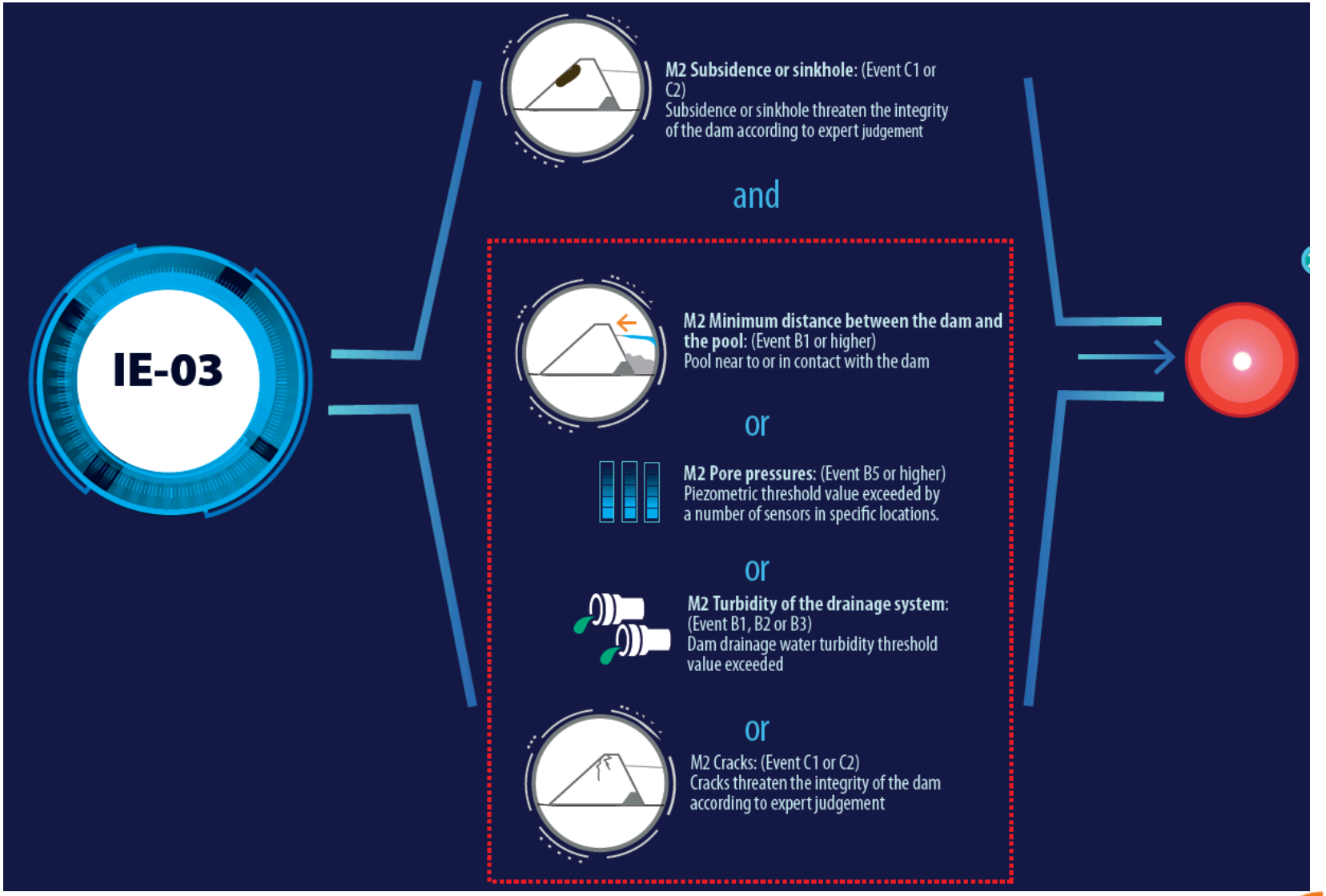
Example Failure Scenario T-02:
"Instability due to increased pore pressure with evidence of deformation"



Example Failure Scenario Re-02:
“Overtopping by wave due to sliding”



Example Failure EI-03:
“Internal erosion resulting from the appearance of subsidence in the dam”



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The real challenge of this type of innovation is not technical but social

How and **when** to communicate to the public?

AUTHORITIES:
ONEMI VS SERNAGEOMIN

ONLY RED ALERTS OR FREE ACCESS TO ALL THE INFORMATION AT THE ONLINE PLATFORM

If it is not mandatory to communicate to the population (LACK OF REGULATION), should a mining company do it proactively?

Teleremote drilling system at Magdalena (Sandfire Matsa, SW Spain)

Sandfire matsa

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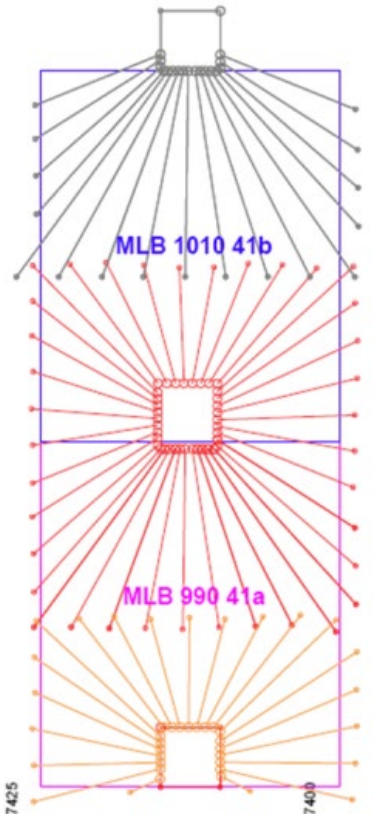
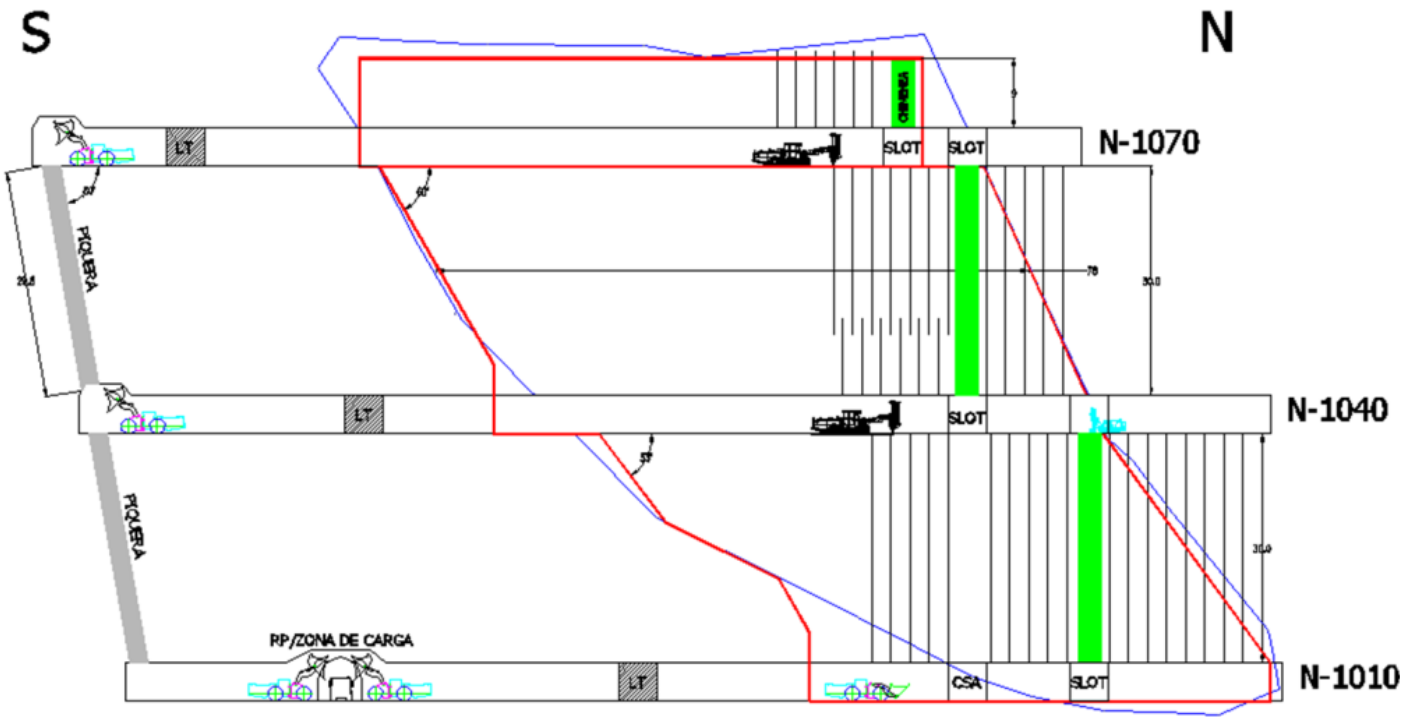
- 360º Drilling



- Mining Method: **Long Hole Stoping**.
- **Mine galleries backfilling** using Paste (mixture of tailings and cement)



- Perforación y Desescombro con Teleremote.

http://www.interempresas.net/Mineria/Articulos/160847-Control-tele-remoto-de-palas-LHD-en-Mina-Magdalena-(Almonaster-Huelva).html
http://www.interempresas.net/Mineria/Articulos/169141-Implantacion-puesta-marcha-sistema-Teleremote-equipos-perforacion-Mina-Magdalena.html

DRILLING SYSTEM EVOLUTION

Manual drilling

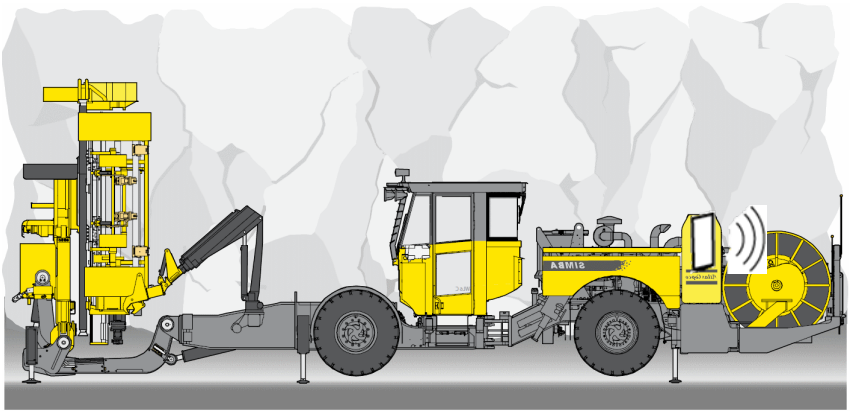
Automatic drilling

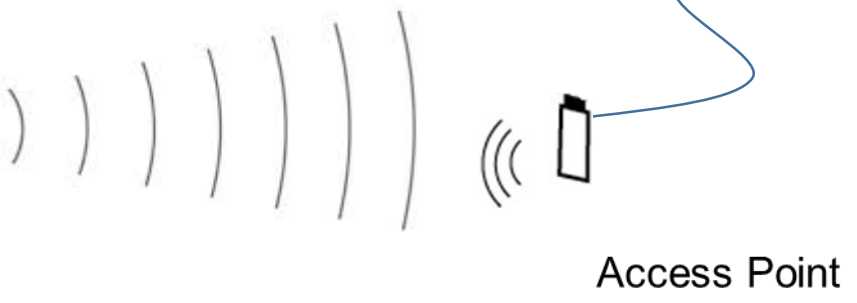
Remote Drilling

Teleremote Drilling

TELEREMOTE DRILLING SYSTEM

The drilling rigs at Mina Magdalena are **Simbas M6-C** from Atlas Copco equipped to be operated remotely from the surface, for this the rigs have ABC Total technology and the Teleremote System.

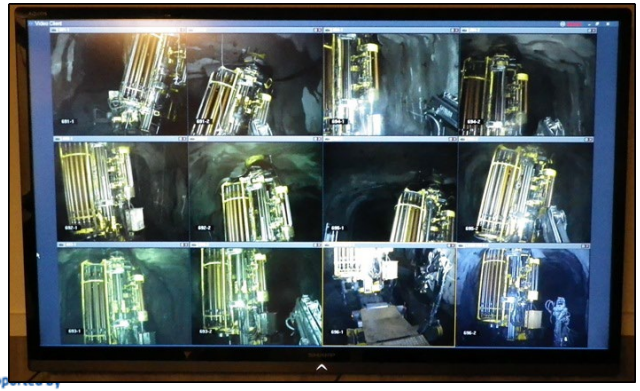


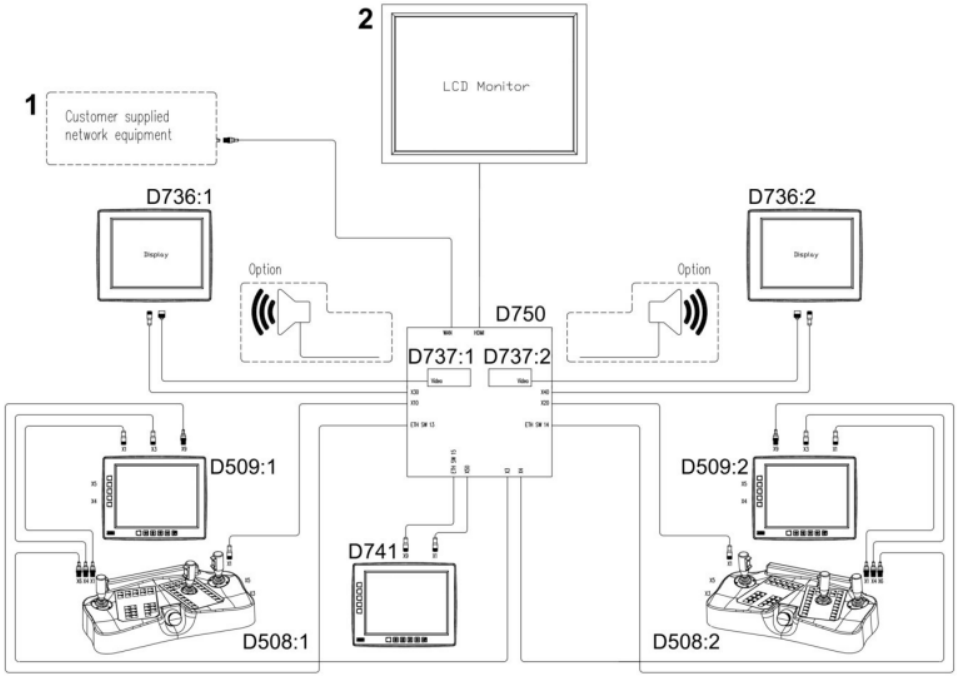


TELEREMOTE CONTROL ROOM

The management of the equipment from the surface is carried out from the control room located on the surface, it has two video screens, a 50” LCD screen, two command stations, and an Atlas Copco ACMS server.

A **single operator** could operate **up to 6 machines** simultaneously in automatic drilling.

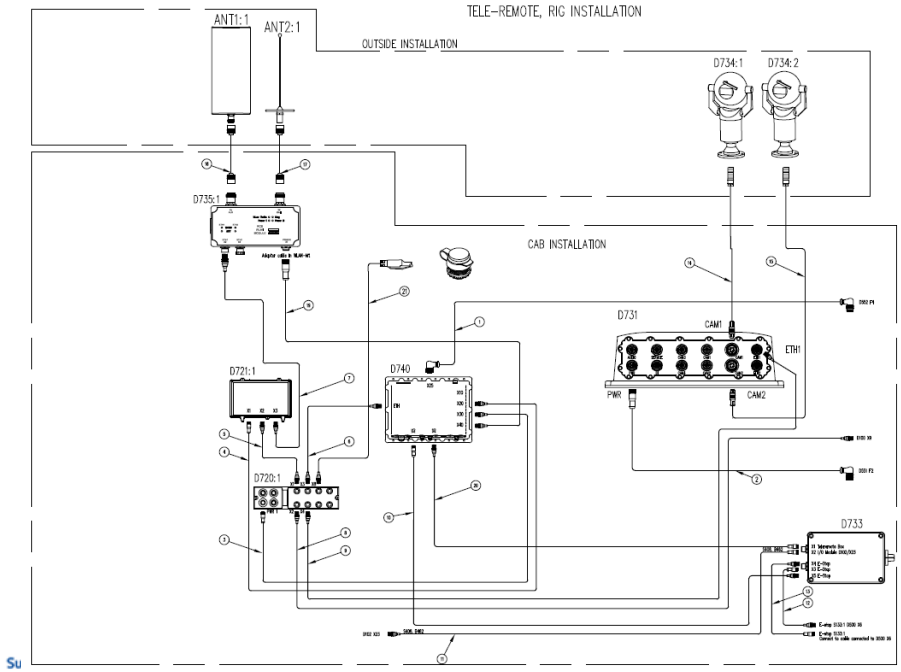




EQUIPMENT

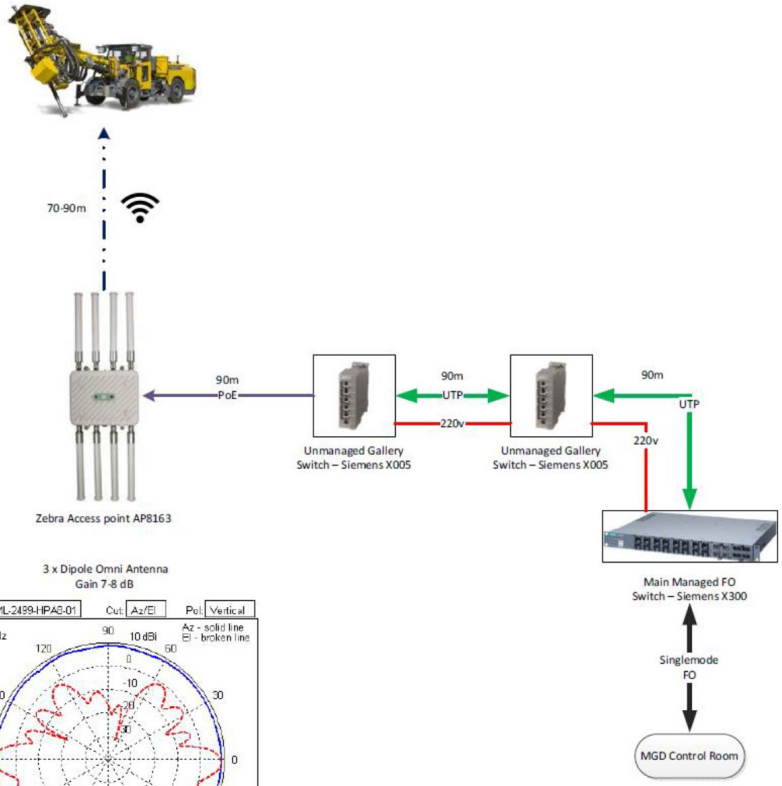
In the external and highest area of the cabin:

- Two Bosch cameras (Mod MIC 550 28X color), with the ability to record in 360º.
- Video encoder (VideoJet X40).
- Security modules.
- Switch to switch the machine from local to remote operation.
- A router.
- 2 antennas, one of them directional and the other radial, (80-90m and 30-40m respectively).



COMMUNICATION

The **connection** between the control room and simba is made **through Wi-Fi** points inside the mine connected to the ring single-mode fiber optic network at 1GBps.



Data transmission between the Simba and the fiber network is carried out via Wi-Fi to an AP (Access Point).

From the AP to the surface, the signal travels through the fiber network, it has connection boxes placed every 90 m (supply power and direct data traffic from the rack to the surface).

The Simba requires a minimum bandwidth of 10 Mb/s so that the data bus needed by the security system and the image quality from the control room are adequate.

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SAFETY BENEFITS

Safety benefits for operation:

- Reduce the exposure time of personnel inside the mine to risks such as possible ground instabilities.
- There is no exposure of personnel to re-drilling of failed holes.
- It avoids exposure of workers to environments with high content of dust and toxic gases

Questions

Select the three main failure mechanisms of a tailings dam:

- 1) Overtopping, Internal Erosion, and Slope Instability.
- 2) There is no exposure of personnel to re-drilling of failed holes.
- 3) It avoids exposure of workers to environments with high content of dust and toxic gases

Earthquakes, heavy rains and landslides can be considered events triggering a physical failure of a tailings dam:

- 1) Yes
- 2) No

Qualitative Assessment (Module 1) and Critical parameters and failure scenarios (Module 2) ae used in combination to generate the alerts within the Tranque Program:

- 1) Yes
- 2) No

Questions

The biggest benefit of implementing a teleoperate drilling system is:

- 1) Safety
- 2) Economy
- 3) Environment

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