

# ★ NGMINING ★

Research and learnings on applying 5G  
and edge computing for underground  
mining automation - NGMining project

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# Next Generation Mining

Business Finland  
funded Veturi co-  
innovation project  
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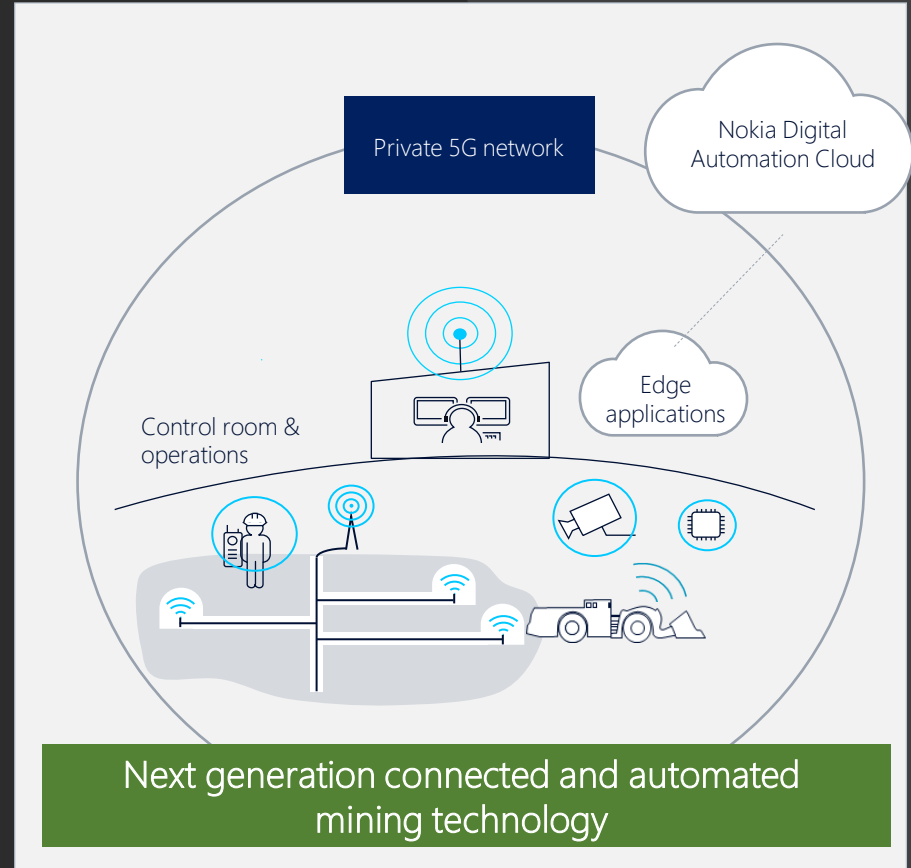
+ Advisory board  
members:



# Project mission

The target is to research, demonstrate and proof business potential for 5G connectivity, digital twin and edge computing enabled solutions for safe operation of autonomous machines in underground mines.

Demonstrations with 5G SA NDAC network in Sandvik's test mine



# Main themes for the project

## IoT and AI based situational awareness and control in mining

- Data (streams) management and exchange between stakeholders
- Algorithms, ML/DL components and prototype solutions for potential applications:
  - Safety of human-autonomous machines co-operation
  - Remote operation of mining machines/governance of autonomous fleets
  - Mining assets management

## ICT infrastructure for next generation mining technology

- 5G connected edge computing layer with capabilities to support the AI based situation awareness and control apps
  - Private wireless network evolution for mining environment
  - integration with other IT infra and applications in mining
  - 5G end device development
- IoT/IIoT and new sensing and control capabilities

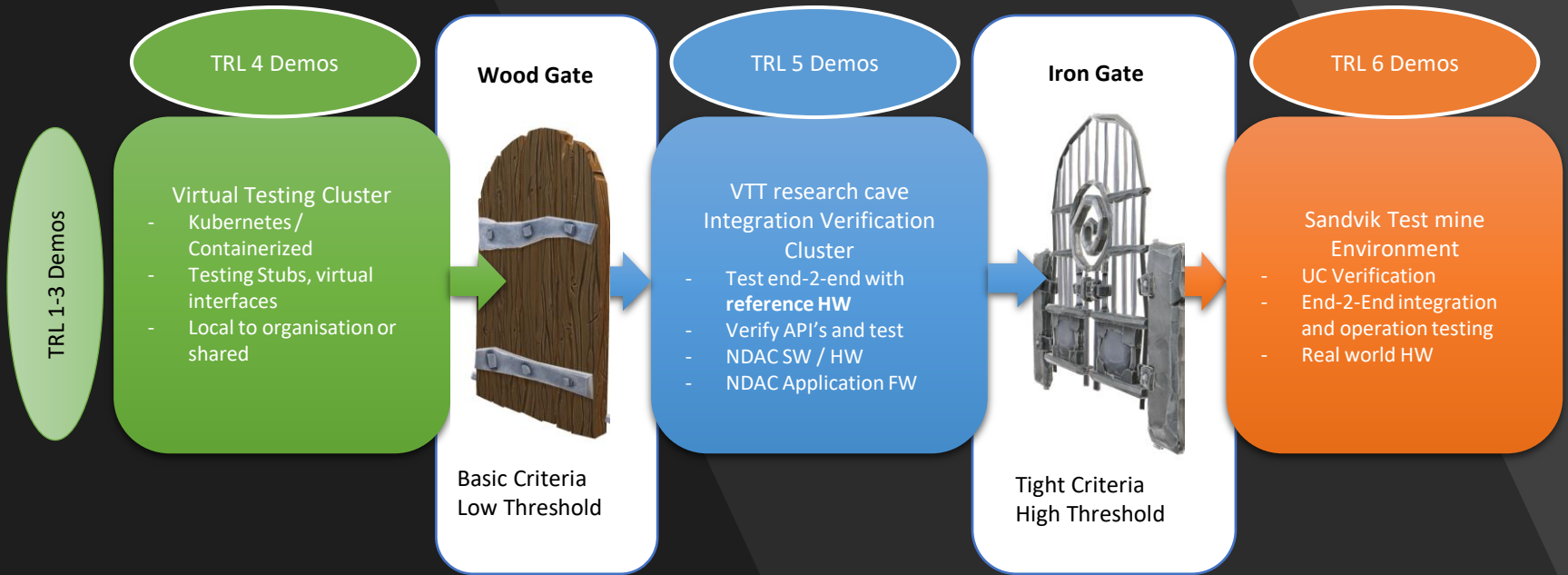
# Epic goals

Epic 1: Enable dynamic safety zones and alerting in mining operations, where people and autonomous working machinery move around and work together at the mining site.

Epic 2: Enable near real-time shared situational awareness for actors involved in mining operations planning, monitoring and control.

Epic 3: Build, operate, maintain and continuously evolve a reliable edge computing and communications infrastructure to serve the needs of changing highly automated and remotely controlled mining operations.

# Demonstrations - gate model





# Key new concepts studied

- **5G SA, edge computing and AI enabled next generation mining technologies and solutions**
  - Supporting autonomous remotely controlled mining machinery and operations
- **Digital Twin of the mining site enabling shared situation-awareness in mining operations**
  - Real-time interoperable information exchange among people and autonomous machines working at a mining site and control center.
- **5G SA enabled functional safety concepts including dynamic and probabilistic safety-zones**
  - Enabling safe co-working of people and autonomous machines without static safety zones and fenced areas
- **Virtual RF models in networks planning, validation and monitoring**
  - Enabling design, pre-validation and monitoring of network performance for autonomous mining operations
- **Multi-connectivity and seamless positioning**
  - Enabling real-time communication and positioning of people and vehicles at mining sites.



# Key Results Summary

TRL > 6

TRL 5-6

TRL < 5



Process, requirements and reference architecture for co-innovation of multi-stakeholder digital solutions in underground mining.

Study on autonomous mobile machines in mines using 5G enabled operational safety principles ([report](#))

New virtual, dynamic and probabilistic safety zone concepts and algorithms.

Dynamic and virtual safety zones - based safety warning system prototype.

Real-time data management and system-of-systems interoperability via Digital Twin of a mining site.

Workshop series on Mine Information Modelling (MIM) concept and data model.

Study and prototype on situation-adaptive cognitive robotics for improving autonomy of AMRs in non-deterministic environments.

Underground radio channel measurements in 3.5, 5.5, 26.5 & 38.5 GHz as enablers for underground wireless networks planning.

Study and laboratory tests on radio performance enhancements with agile beam forming radio architecture platform.

Study, prototypes and evaluation of multi-connectivity and seamless positioning technologies for autonomous underground mining vehicles.

360-degree video streaming prototype from moving underground vehicles.

Joint prototypes evaluating various communication, positioning, data management and virtual dynamic safety zones enablers via the project Epics in real underground environments.



# Key Requirements identified for site Edge ICT

- **Reliability, availability and resilience of the edge ICT infra**
  - Design and pre-validation before operational use
  - Continuous monitoring & maintenance
- **Optimizing uplink throughput and minimizing the delay is critical for teleoperation**
  - Continuous video and sensors data streaming from autonomous vehicles
- **Minimizing jitter and delay is critical for functional safety applications**
- **Positioning services and support for edge applications for digitalization of mining**



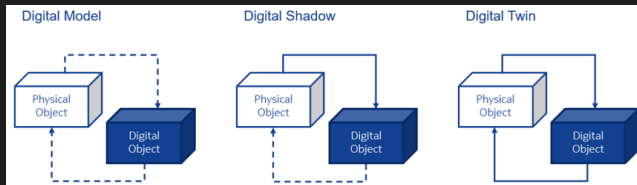
Underground  
trials for  
feasibility  
evaluation of  
enabling  
technologies



# Key learnings from the underground trials



- Network performance verification measurements should be made before operational use for mining automation and safety applications.
  - Jitter and delays in the non-line-of-sight and handover areas are critical for functional safety applications.
  - Uplink throughput and delay are critical for video transmission used in remote control, especially in the non-line-of-sight and handover areas.
- 5G SA technology supports mission-critical safety communication with at least 192 ms watchdog timer with simultaneous data traffic.
- Network traffic prioritization is needed for ensuring small and constant delays with the time-critical safety messages (e.g., end-to-end network slicing).
- 360° video streaming from moving vehicles underground over 5G SA network is feasible with compression techniques (e.g., Nokia RXRM tested).
- Digital Twin of mining site can enable near real-time information exchange across the site systems and actors to support operative planning, monitoring and control.
- Radio signal attenuation in mine tunnels needs to be considered in network planning to achieve reliable communications





# Future R&D

- Solutions for wireless networks and edge computing infrastructure planning, pre-testing, monitoring and maintenance at underground mining sites
- Field devices and operational technology integration and interoperability via Digital Twin of a mining site (including M2M communication and control)
- Dynamic and probabilistic safety zones solutions and safety warning systems
- Finding 'low hanging fruits' on edge applications for commercialization and scaling in digitalization of mining
- Cognitive distributed situation-aware robotics supported by multi-zone edge computing.
- Edge computing and AI in supporting decarbonization of mining via improving energy efficiency and optimizing use of energy from renewable sources.