# Acoustic and Haptic Feedback for Remote Drilling Operations

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impact innovation

# Project Team & Roles

**LULEÅ UNIVERSITY OF TECHNOLOGY**
Ö. Johansson, A. Nykänen,
A. Gustafson, S. Rajpurohit

a) Coordination
b) Sound, Vibration & HMI
c) Mining and Rock Mechanics

**EPIROC ROCK DRILLS AB:**
Robert Ström, Samuel Enbom,
Katarina Öquist

a) Machine technology
b) Drilling data and Maintenance,
c) Remote station development

**BJÖRKDALSGRUVAN AB:**
Fredrik Wallström
8 operators

a) Test site,
b) Operator access,
c) Field validation

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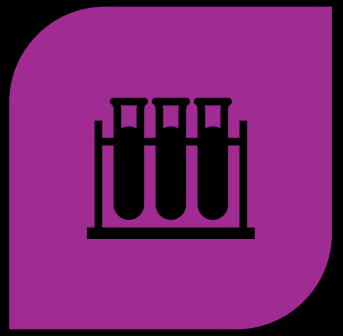
# Purpose

STRENGTHEN HUMAN–MACHINE INTERACTION IN REMOTE DRILLING

DEVELOP MULTIMODAL FEEDBACK (SOUND, VIBRATION, HAPTICS)

ENHANCE SAFETY, ERGONOMICS, PRODUCTIVITY, AND ENERGY EFFICIENCY



DELIVER VALIDATED PROTOTYPES, METHODS, AND GUIDELINES

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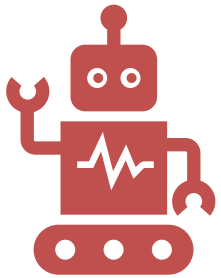
# Project Concept

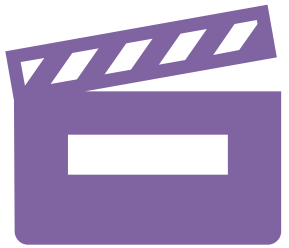


**Acoustic & Haptic Cues:**

Event and machine-based integrated into cabin or remote rigs

**Data sources:**

Drilling sound, vibration, pressure, force, machine data



**Feedback to operators:**

Real-time audio cues
seat/joystick vibrations
visual indicators

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# Work Packages

- WP1 Management & coordination
- WP2a Data collection: drilling sound, vibration, machine data, operator perception
- WP2b Participatory design sessions
- WP2c Prototype development & refinement
- WP2d Performance evaluation (simulator + field)
- WP3 Dissemination & communication

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# **Operator Interviews** - 19 Nov 2025
# **Field measurements and observations** 22-23 Mars 2026

## Reflections:

**8 operator interviewed**

**Measurements on 2 Simbas – vertical drilling**

- **Vibrations by 3-axis accelerometers:**
  a) Two accelerometers  on the boom
  b) One tri-axial on the seat
  c) One tri-axial on the panel
- **Sound recordings:**
  a) Outside cabin on front window
  d) Inside cabin on the hearing muffs
- **Data when drilling**
  a) Drill head hydraulic pressure variation
  b) Cam-bus machine and drill data

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# The Sound of drilling

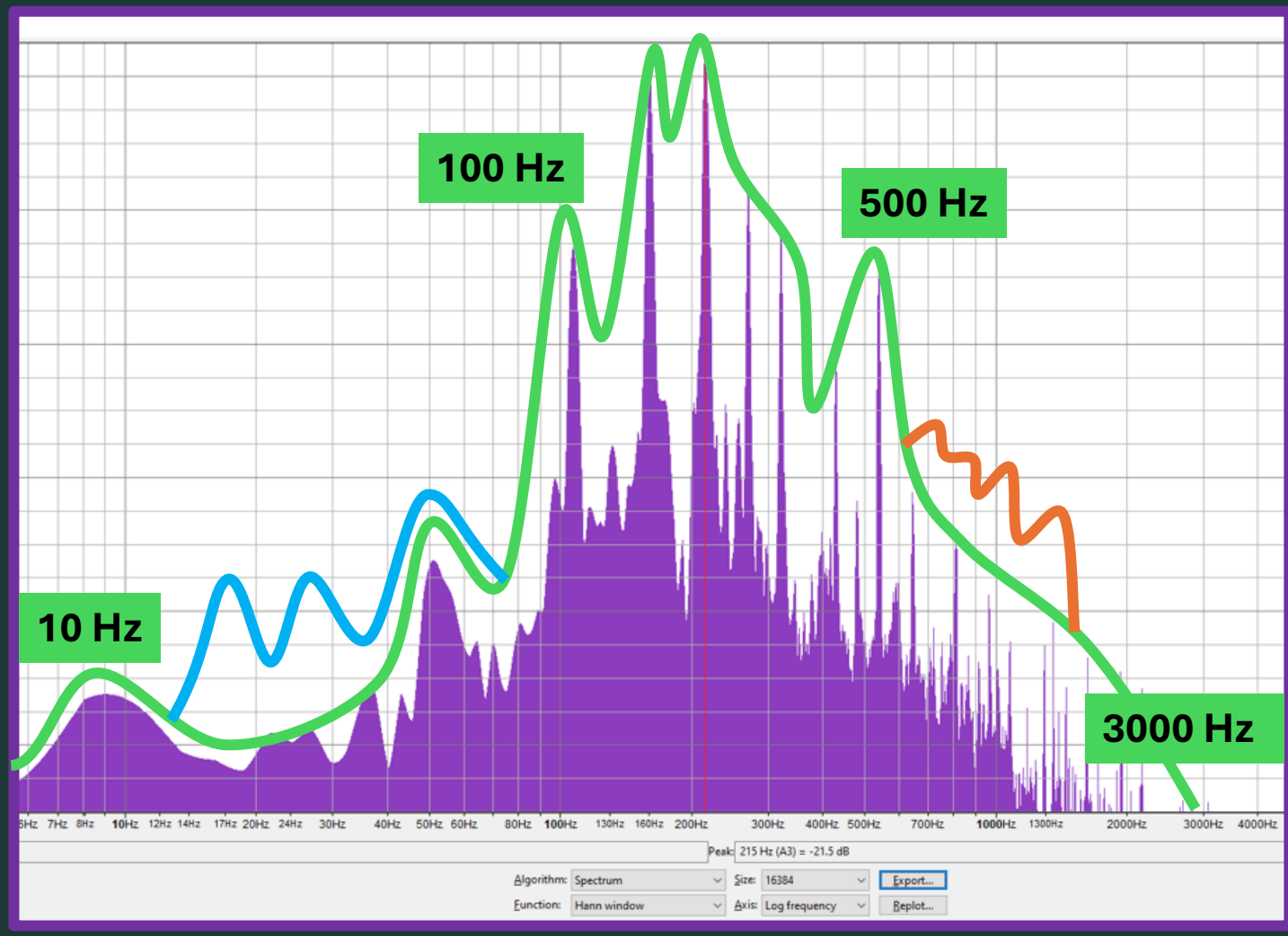
Ambient sound that resemble the sound of drill operation

Smooth harmonic sound with attenuated low and high and low frequencies

Captured in real time from a suitable position on the machine

## The Sound of Early Warning

## The Sound of Information

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# Methodology
# WP2b, 2c, 2d

- Agile, user-centered design sprints
- Iterative prototyping in high-fidelity simulators
- Participatory design with professional operators
- Validation through lab and mine-site testing

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# Goals

- Increased productivity (drilling meters/hour)
- Safer work environment
- Improved energy efficiency
- Reduced cognitive workload
- Inclusive, gender-aware operator interfaces
- New scientific knowledge on multimodal feedback

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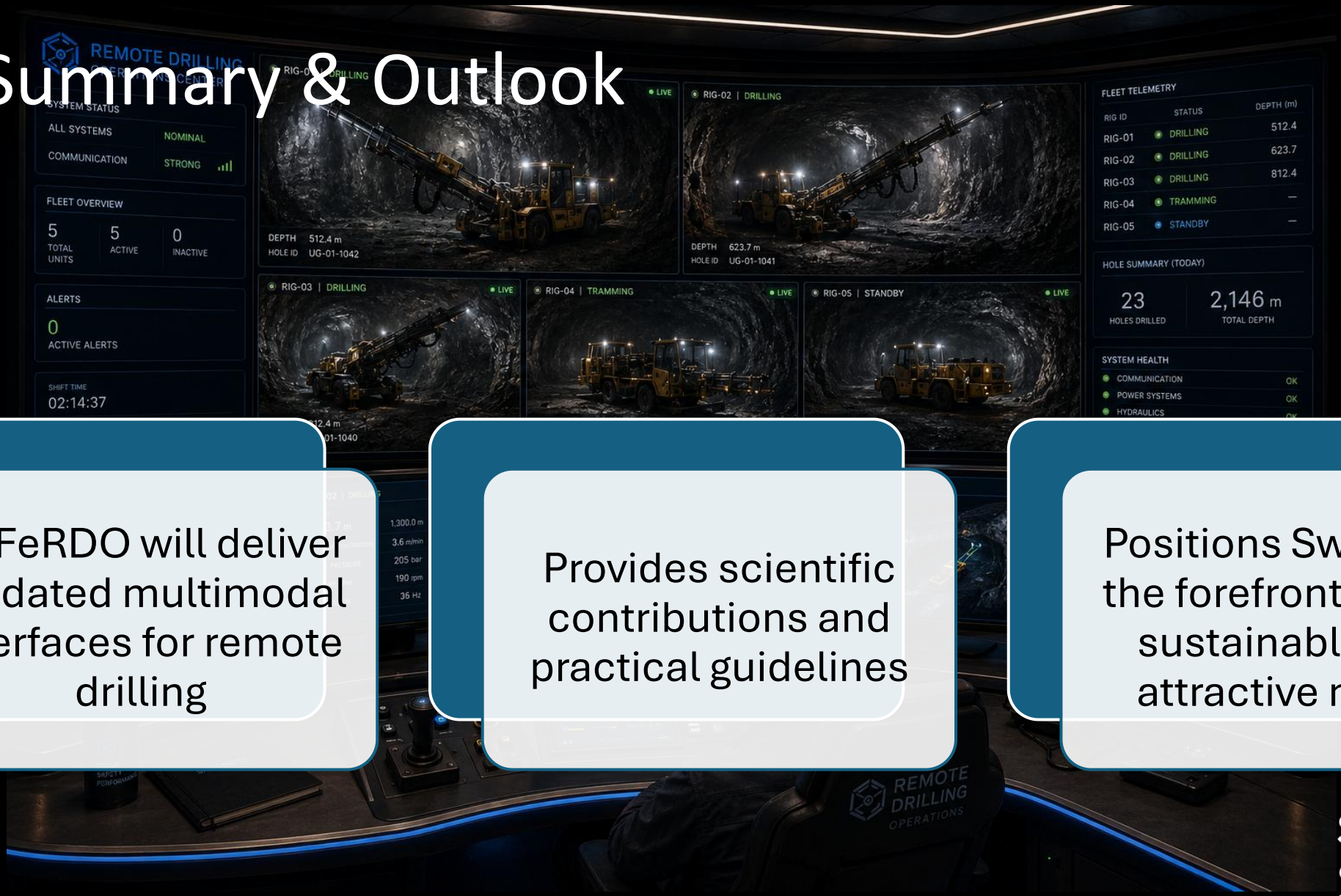
# Summary & Outlook




AHFeRDO will deliver validated multimodal interfaces for remote drilling

Provides scientific contributions and practical guidelines

Positions Sweden at the forefront of safe, sustainable, and attractive mining

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