



WIRELESS ELECTRONIC BLASTING

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- Design for a Safe System
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EVOLUTION OF INITIATING SYSTEMS



1830
SAFETY
FUSE



1910
ELECTRIC
DETONATORS



1980
NON-ELECTRIC
DETONATORS



2000
ELECTRONIC
BLASTING SYSTEMS



TODAY
WIRELESS
INNOVATION

Safety & Efficiency
& Reliability

INTRODUCTION

- A world of convenience with wireless communication taken for granted



WIRELESS COMMUNICATION

- Wireless communication in Mining application.
 - Between the firing control point and a remote blast box near the pattern.
 - A wireless connection between the firing control point and a transceiver at the collar
 - Wireless communication from firing transmitter through rock to a receiver in each hole.



WIRELESS BENEFITS

- Through the rock wireless brings a wider suite of benefits
 - Saves time and effort priming the holes
 - No surface component in blast area
 - Eliminates opportunity for damaged leg wire
 - Improves access and eliminates potential hazards (Mine Traffic, snap slap and shoot event)
 - Enables new automated mining techniques
 - Removes complexity at charging

WIRELESS BENEFITS

- It is self evident that wireless brings speed and convenience.

The value however is in safety and mining cost.....

- Eliminates physical connections
- Saves time and the restrictions of surface hook up at blast times
- Eliminates need to re-enter a blast area.

TODAY'S COMPLEXITY



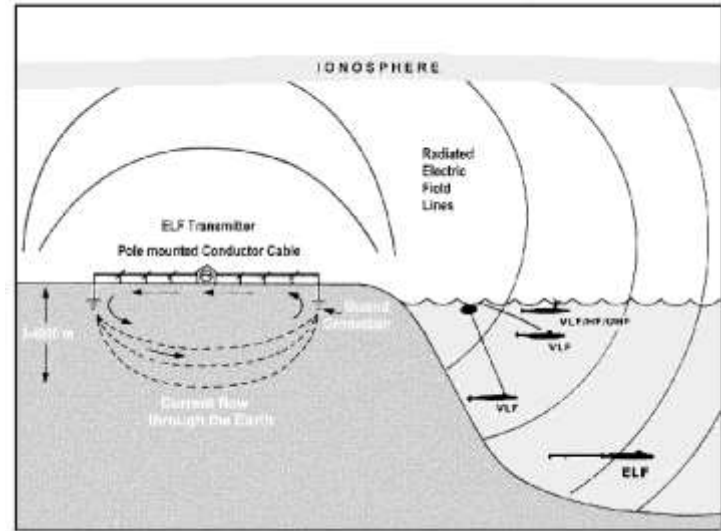
WIRELESS BLASTING



WIRELESS COMMUNICATION THROUGH ROCK

- How: Low frequency Magnetic Induction (MI) waves
- Current VLF comms widely used in underground PED *(personal emergency device)
- Large currents flowing through loop of conductor generate magnetic field.
- AC current generate oscillating fields in which we can carry data by modulating frequency or amplitude

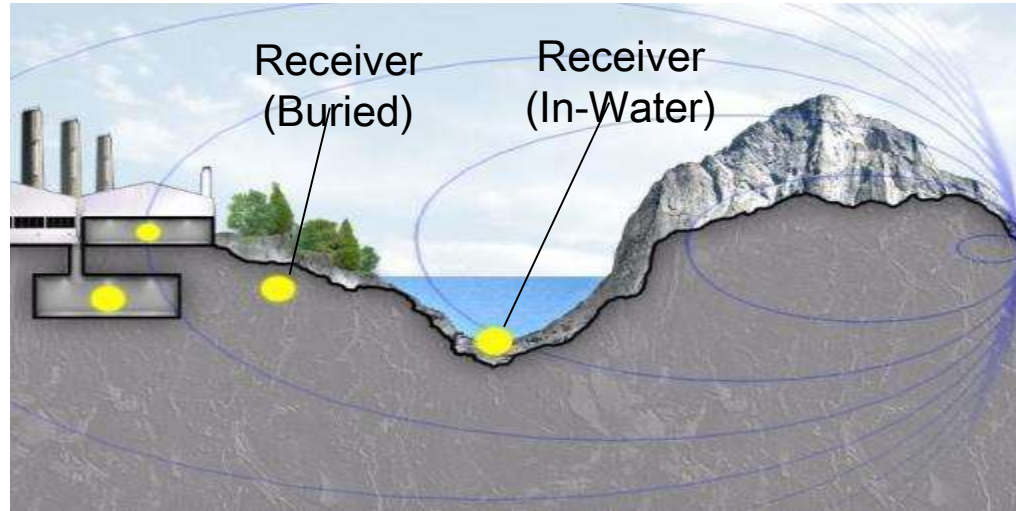
*Difficulty is sending precise data like a firing code



MI-SIGNAL PENETRATION

Not affected by vegetation, earth barriers, or burial

● Receivers



Not significantly affected by water

Transmitter

- Relatively inexpensive RX/TX, Low energy transmissions and less prone to interference
- Penetrates air, water, sediments and rock, bunkers, large urban structures and underground complexes. Across media boundaries. Current capabilities up to 1KM.
- Field strength not significantly attenuated in moderately conductive materials

SYSTEM COMPONENTS

- **WEB system Rx side:**
- Consumable receiver (DRX)
- Plugin detonator
- Booster



ASSEMBLY OF DETONATOR

Insert **Plugin** detonator via 4-pin terminal



Energized DRX (e-drx)



(2 of the terminals complete the battery circuit inside the unit)

ENCODING (PROGRAMMING TIMING AT LOW VOLTAGE – BUILT IN THE ELECTRONICS)

At the borehole at priming time, place unit in **Encoder** and program (Log)

Unit Receives from Encoder

- Delay time
- Group ID number (**GID**)



GID's are unique to a mine site

Communication between the Encoder and DRX is a isolated secure comms path.

ASSEMBLY – ENCODING - PRIMING



ACCESSORIES

Tether Lock Modular configuration



Tether lock at Booster end



Tether cord at the other End (Sub-antenna)

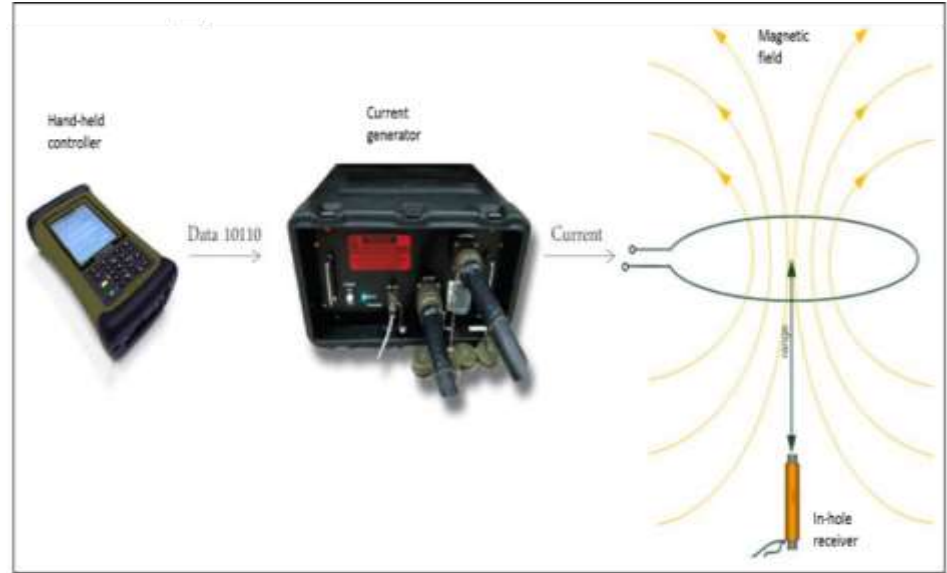


Spider Modular configuration



SYSTEM COMPONENTS

- **Transmission System:**
- Blast controller - hand held
- Transmitter
- Antenna
- Critical attribute of the signal detected in the borehole is the signal to noise ratio.
- Power lines & motors operating at 50-60 Hz.



SYSTEM COMPONENTS

- **System component comprises:**
- Handheld blast controller
- Transmitter (Signal generator)
- Power source (marine battery)
- Antennas (Quad & Ground Loop)



BLAST MANAGEMENT & FIRING

- **A Blast is a defined “Group” of Primers:**
 - A group of primers is allocated a unique single use encrypted ID
 - A series of GID's are allocated to a specific site
 - GID's are allocated with a unique Code Management Computer
 - USB Drive transfers blast data & authorisations between devices
 - Successive GID's can be fired



DESIGN FOR A SAFE SYSTEM

- Fully wireless blast bring 2 new and potentially hazardous situation:



- The in-hole device (DRX) contains its own power source !




**Ensures No
Uncommanded
fire**

- In wired initiation system, only initiators connected to a physical wire can respond to a fire command !



**Ensures the
initiation
of the intended
blast**

LAB & FIELD TEST

- Formal verification and validation (V&V) methodology completed →
 - Formal fault injection program →
 - Test bench in virtual environment fired over 100,000 times without failure
 - Completed over 20,000 lab test including a fault injection protocol
- 

SIL 3 Certification



• Field Validations
(DUMMY's)



• Field Evaluations
(LIVE)

FIELD VALIDATION WITH DUMMY BOOSTERS

- Early field test with live detonator and dummy boosters
- Timing accuracy examined by monitoring shock tube flashes with high speed camera



FIELD TRIALS WITH LIVE EXPLOSIVES

Field Test	Summary
Quarries in Canada & Australia	8 blasts at 6 different quarries
Underground mines in Canada	3 blasts at 1 underground mine
Hole diameter	80 mm (3.5 inch) – 165 mm (6.5 inch)
Number of holes per blast	12 - 89
Antennas used	Quad loop x3, 40 m loop x8
Range from antenna to furthest hole	175 m (574 ft) – 875 m (2870 ft)
Total number of WEB primers used	1045

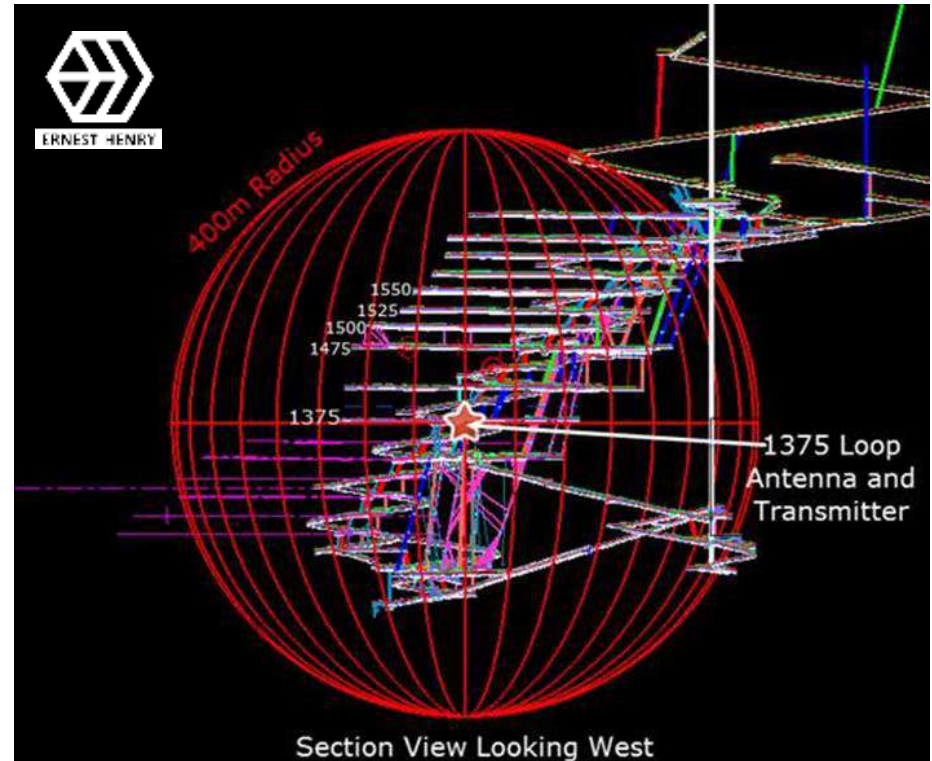


DRX next to a wet hole being loaded

FIELD TRIALS WITH LIVE EXPLOSIVES

Current Trial - Ernest Henry Mine

- Stage 1 **Proof of Concept**
 - Remove Operator from Drawpoint Brow
 - 30 Rings > 500 primers
 - Pre-charging out to 21 days
 - Process & Scalability
 - First Blast 1 November 2016
 - Production rings December - Jan
- Stage 2 **Mining Benefits**
 - Blast performance
 - Optimisation



WIRELESS SITE SURVEYS

1. Magnetic noise, ore characteristics, etc., in the real field environment does interfere with communications
2. System reliability is enabled by robust site survey



Blastometer for down hole survey



The Spectrum analyser showing a signal from the transmitter

LIMITATION OF ONE-WAY COMMUNICATION?

- Designed with One Way Communication
 - Cost
 - Signal Power Requirements
 - Band Width & protocol's

- Majority of faults in “wired” initiating systems:
 - Damaged lead wires
 - Problems with connectors
 - Current leakage from known or unknown sources
 - “Out of the box failures”, identified at logging.

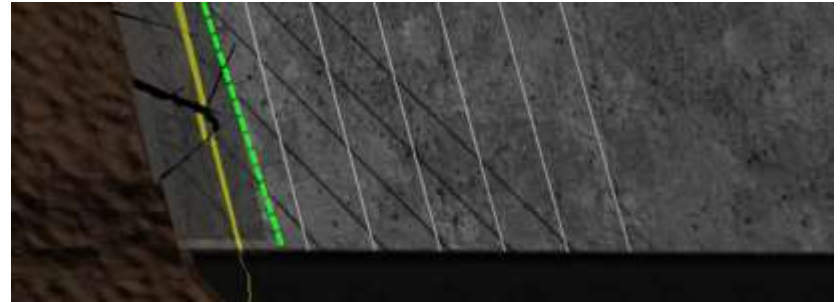
- Thus, two way comms useful where the physical connections are the main risk

MINING APPLICATIONS

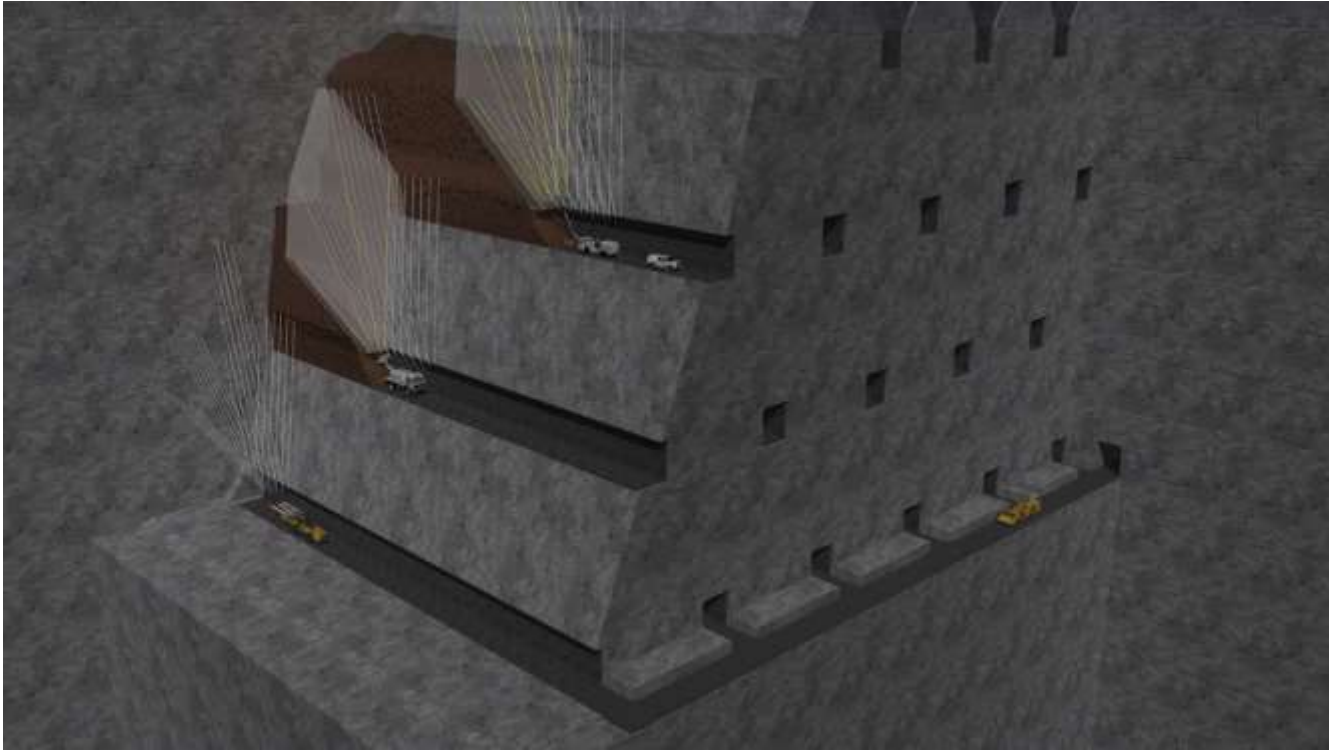
- **Wireless is not a direct substitute for conventional systems – it will need to deliver Value to justify use.**
- **Applications**
 - Sub Level Cave Mining
 - Drawbell/Pre Undercut Blasting & Preconditioning
 - Stranded Ore
 - Starter Detonator
 - Automation of Charging
- Wireless will be only be offered as a service – to ensure safe and reliable use of the blasting technology, and ensure successful launch.

MINING APPLICATIONS - SLC

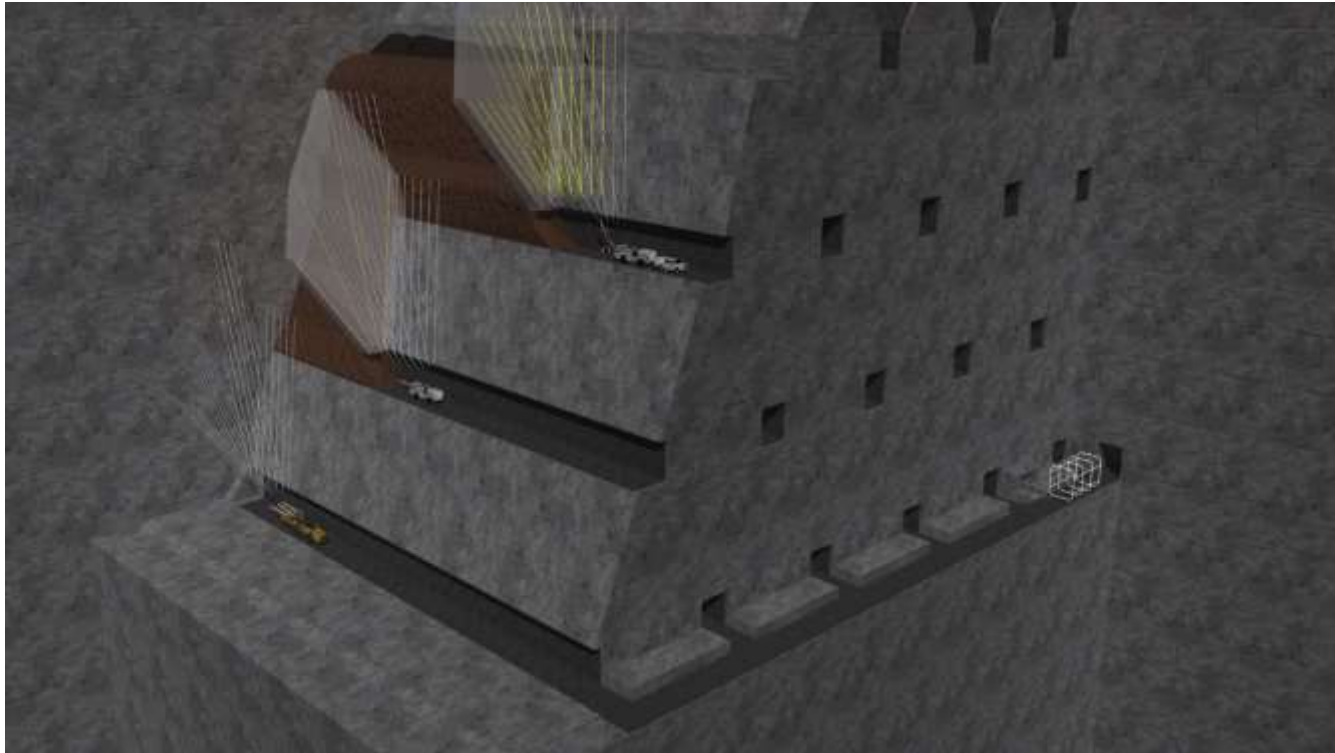
- **Wireless blasting example in Sub-level caving:**
 - Remove people from drawpoint brow – No hook-up
 - Significantly reduce exposure people to hazardous areas
 - Improve drawpoint availability
 - Reduced re-drills due to lost brows and dislocation
 - Improved ore flow - avoid misfires
 - Improved recovery



TRADITIONAL SUB-LEVEL CAVING



WIRELESS SUB-LEVEL CAVING



WIRELESS BLASTING - CHANGING THE WAY WE BLAST



QUESTIONS