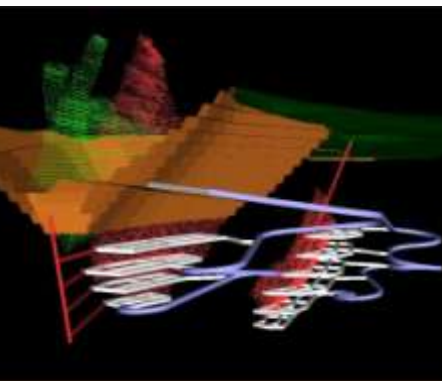


Zero entry mining in surface mining operations

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The age of automation



Photo source: Rio Tinto - Clayton, B. Group Executive Business Support and Operations, CITI presentation, 8 March 2012 available at www.riotinto.com

- Iron Ore companies, Rio Tinto, BHP, & FMG operate approx. 220 AHT (2 mines completely autonomous)
- Autonomous truck collects data from 180 sensing points
- Collects around 2.5 TeraBytes (2.5×10^{12}) of data per day

Next generation AHT



Photo source: equipmentworld.com 2016

- No operator cab
- Equal speed forward and reverse

Zero (human) entry mining



- Current mine automation efforts are not truly “manless” (i.e. it is necessary for surveyors, geologists, to enter mining zones, or for auxiliary equipment (graders, water carts) to interact with AHTs).
- Around the world, there are some complex orebodies that necessitate truly “manless” operations in certain mining zones. We have called this “Zero Entry Mining” because no human need ever enter the mining zone.

Economic benefit – extraction of deep reserves

www.earthworksaction.org/library/detail/photos_of_open_pit_mines



Objectives

To identify the gaps in current automation capability in order to achieve and to sustain zero-entry mining operations in surface mines.

To outline a development timeframe for developing solutions to these gaps.

Prior work – discrete systems

The interfaces between discrete systems present automation challenges, namely due to proximity detection, positioning and collision avoidance.



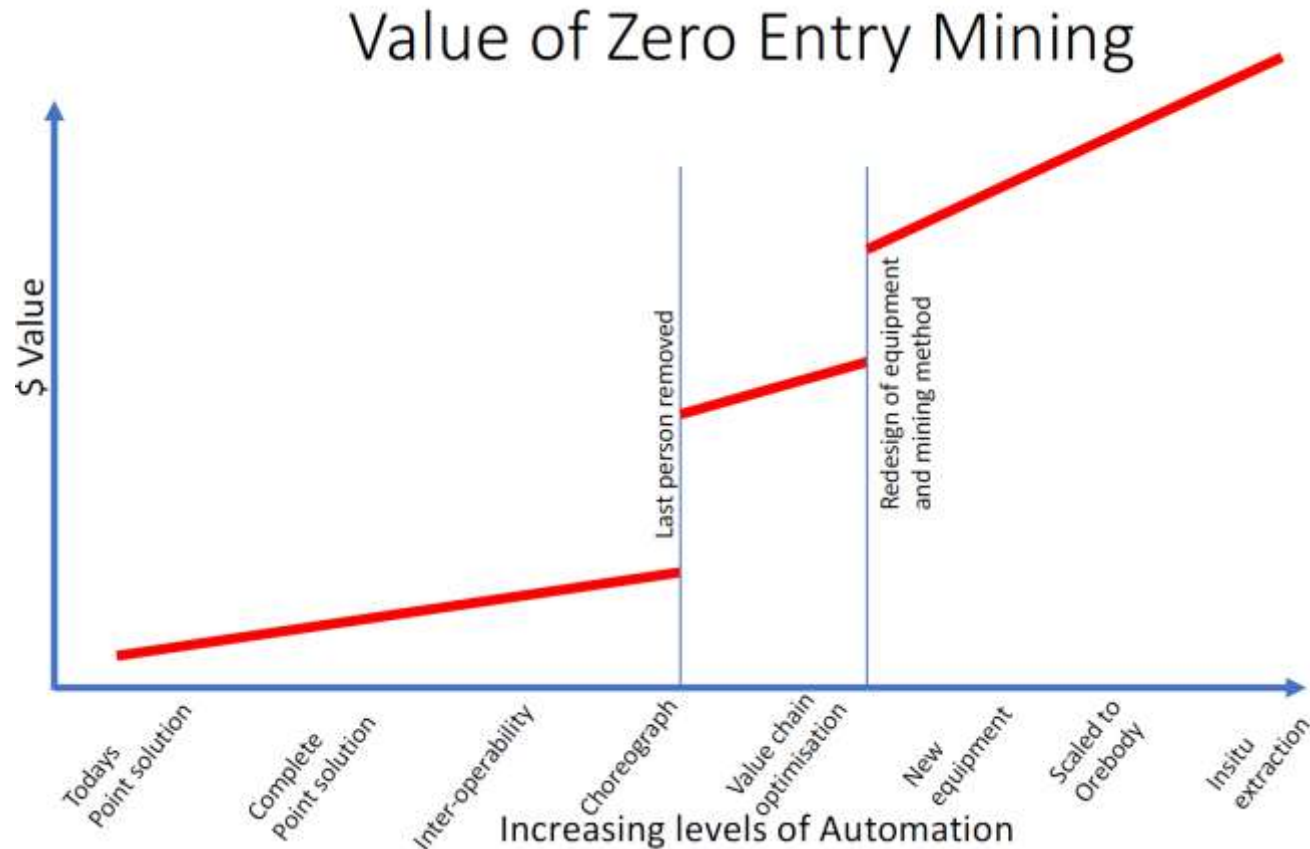
Continuous systems are easier to automate



Source: <https://mining.komatsu/product-details/flexible-conveyor-train>

- Continuous systems lend themselves to automation precisely because they negate the necessity for such interface systems.
- Future autonomous mining systems might look quite different from today's discrete systems

The value of zero entry mining



When automation enables both zero entry and re-imagined mining methods, significant new value is unlocked.



- Analyze the sequence of tasks that need to be undertaken in a typical surface mining operation in order to delineate and extract a block of ore.
- Consider available automation solutions in order to identify autonomy capability gaps.

Automation gaps identified

1. Surveying (pre-dig and post-dig)
2. Geological mapping, sampling and lay out of dig-lines
3. Geotechnical assessment of wall stability and (if necessary) installation of wall controls
4. Blasthole (and wall control) drilling
5. Explosives loading, charging and tie-up
6. Secondary breakage (hydraulic hammer)
7. Excavation
8. Haulage
9. Services (communications, pumps, power, lighting, camera and sensor) installation
10. Equipment maintenance, re-fueling and consumable replacement, including recovery of broken down equipment
11. Haul route and bench maintenance (Motor graders and wheel dozers)

Surveying – pre dig



Source: Maptek i-site drive <https://www.maptek.com/products/scanners/drive.html>

Modern GPS dig control systems installed onboard diggers can replace the need to stake out ground. Dig zones can be updated and downloaded via the mine intranet system to the diggers.

Surveying – post dig



Source: <https://www.questuav.com/drones/q200-survey-drone/>

Drones are now regularly flown in some large surface operations.

Geology – automated sampling



Source: <https://www.britannica.com>

Automated sampling – has been done for MARS explorer expeditions!

Geotechnical wall control



Source: <https://archive.sltrib.com/article.php?id=3752451&itype=CMSID>

Automated monitoring of slope stability, plus automated remediation

Blasting services

Automated priming,
loading of blastholes.

Automated tie-in of
pattern?

Could dual frequency WIFI
be feasible?



Source: www.orica.com

Secondary breakage



Automated hydraulic breakers exist in underground mines (eg Codelco Andina).
Need to provide a mobile platform

Automated digging



- Currently no system on the market that will manage unsupervised loading of shovels, FELs or hydraulic excavators.
- Simultaneous location and mapping (SLAM) capability required to excavate a muckpile,
- Also require mission planning algorithms to optimally guide extraction of a full bench.

Interoperability



Source: <http://www.austmine.com.au/News/category/press-releases/interoperability-the-key-to-the-future-of-mining>

- Physical, functional and data compatibility
- There is a lack of an agreed set of standards across the industry.
- The Global Mining Guidelines (GMG) group has established a number of working parties.

Road and bench maintenance



Source: <https://www.forconstructionpros.com/equipment/earthmoving/graders-scrapers/product/20998756/caterpillar-cat-caterpillar-24-motor-grader-for-construction-and-maintenance-of-mine-roads>

Automated motor graders and wheel dozers required in a zero-entry mine.

GET replacement



Source: <http://s7d2.scene7.com/is/content/Caterpillar/CM20180308-56068-63011>

As with lubrication and filter replacement, it may be necessary to replace wear parts such ground engaging tools (for example, dipper teeth and adapters) in the field.

Recovery systems



Source: <https://www.tinkercad.com/things/kD2ucNuYsl9-swissport-airport-tug>

Some equipment failures will occur in-pit - a remote controlled recovery rig will be required to tow, or transport, equipment out of the zero-entry zone.

Pumps, power, lighting



Source: <http://watermanagementaustralia.com.au/index.php/bore-water-treatment/mine-dewatering-bores/>

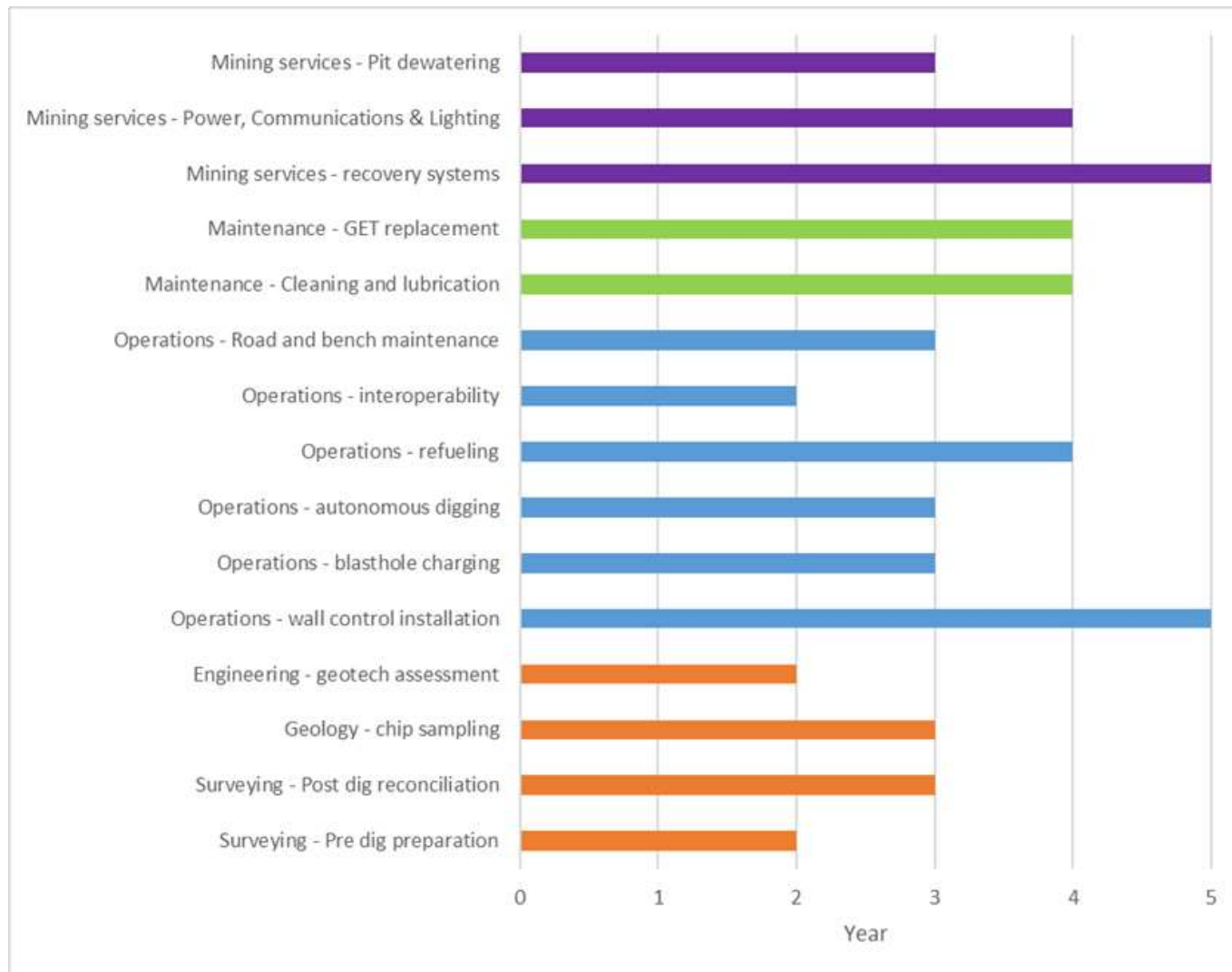
Continuous provision of services such as lighting, power and pit dewatering are a routine consideration of any mining operation.

There is a need to develop a remotely controlled multi-purpose services vehicle to enable these tasks.

Development schedule

Initiative	w/o zero entry	with zero entry	Year
Surveying - Pre dig preparation		Y	2
Surveying - Post dig reconciliation	Y		3
Geology - chip sampling		Y	3
Engineering - geotech assessment		Y	2
Operations - wall control installation	Case specific		5
Operations - blasthole charging	Case specific		3
Operations - autonomous digging	Y		3
Operations - refueling	Y		4
Operations - interoperability	Y		2
Operations - Road and bench maintenance	Y (graders)		3
Maintenance - Cleaning and lubrication		Y	4
Maintenance - GET replacement	Y (OH&S)		4
Mining services - recovery systems		Y	5
Mining services - Power, Communications & Lighting		Y	4
Mining services - Pit dewatering		Y	3

Development timeframe



Conclusions

There is a strong business case to apply zero-entry mining in large surface mines that are exploiting orebodies which are open at depth

The study identified a list of fourteen initiatives associated with mine geology, surveying and engineering, operations, maintenance and mine services.

Operations initiatives (such as interoperability) take priority, as these have an immediate applicability in current surface mining operations (the exception to this is Ground Engagement Tools (GET) replacement robotization where there is a clear OH&S benefit).

Surveying, Engineering and Mine service initiatives have lower development priority - the mining industry must not neglect the development of these applications!

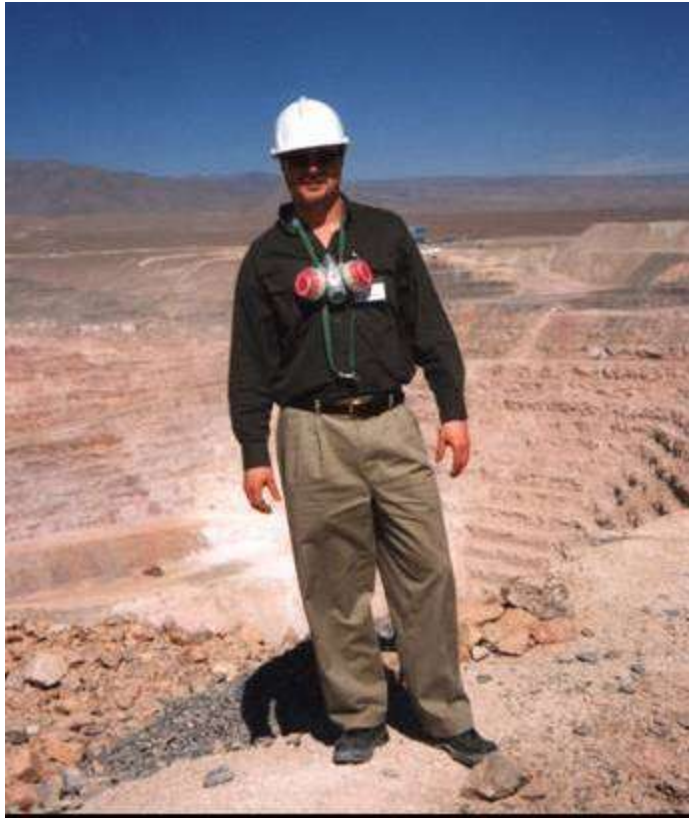
There is a need to develop an automated (or remote controlled) multi-functional platform capable of performing geological grab sampling, and move lighting and communication platforms, electrical transformers and cables.

References

Knights, P. & Yeates, G. “The Business Case for Zero-Entry Mining”, IEEE-ICIT Automation in Mining Conference, 13-15 Feb, Melbourne, 2019.

Williams, I & McAree, R “Situational awareness for automated operation of electric mining shovels”, CRCMining Australian Mining Technology Conference, Twin Waters Resort, 16-18 Sept, 2008

Thank you



- Questions?
- Need more details?
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