II CONGRESO INTERNACIONAL DE MINERÍA

THE UNIVERSITY OF QUEENSLAND
AUSTRALIA

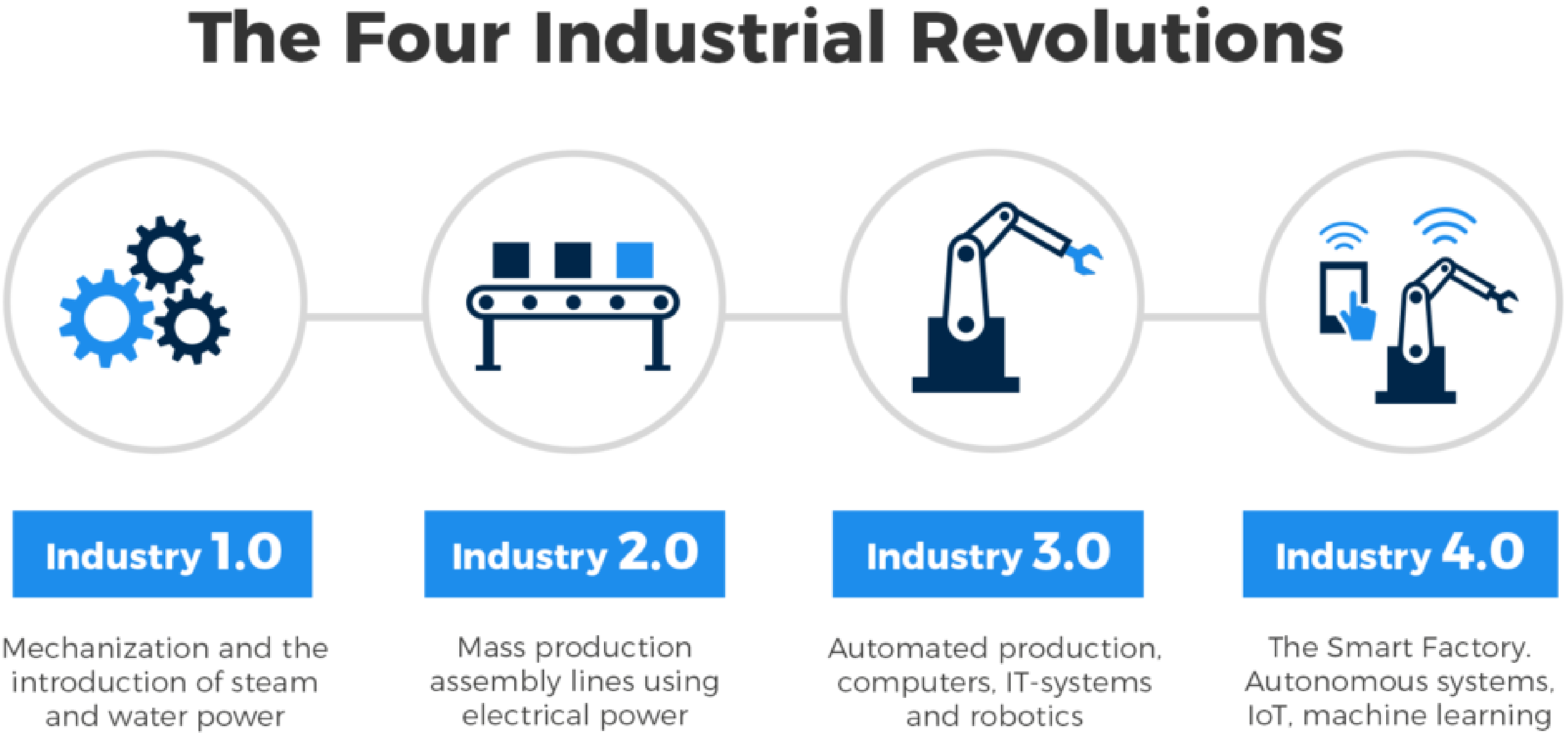
Industry 4.0 for increased mining safety and productivity

Prof. Peter Knights

Discipline Leader Mining, School of Mechanical and Mining Engineering

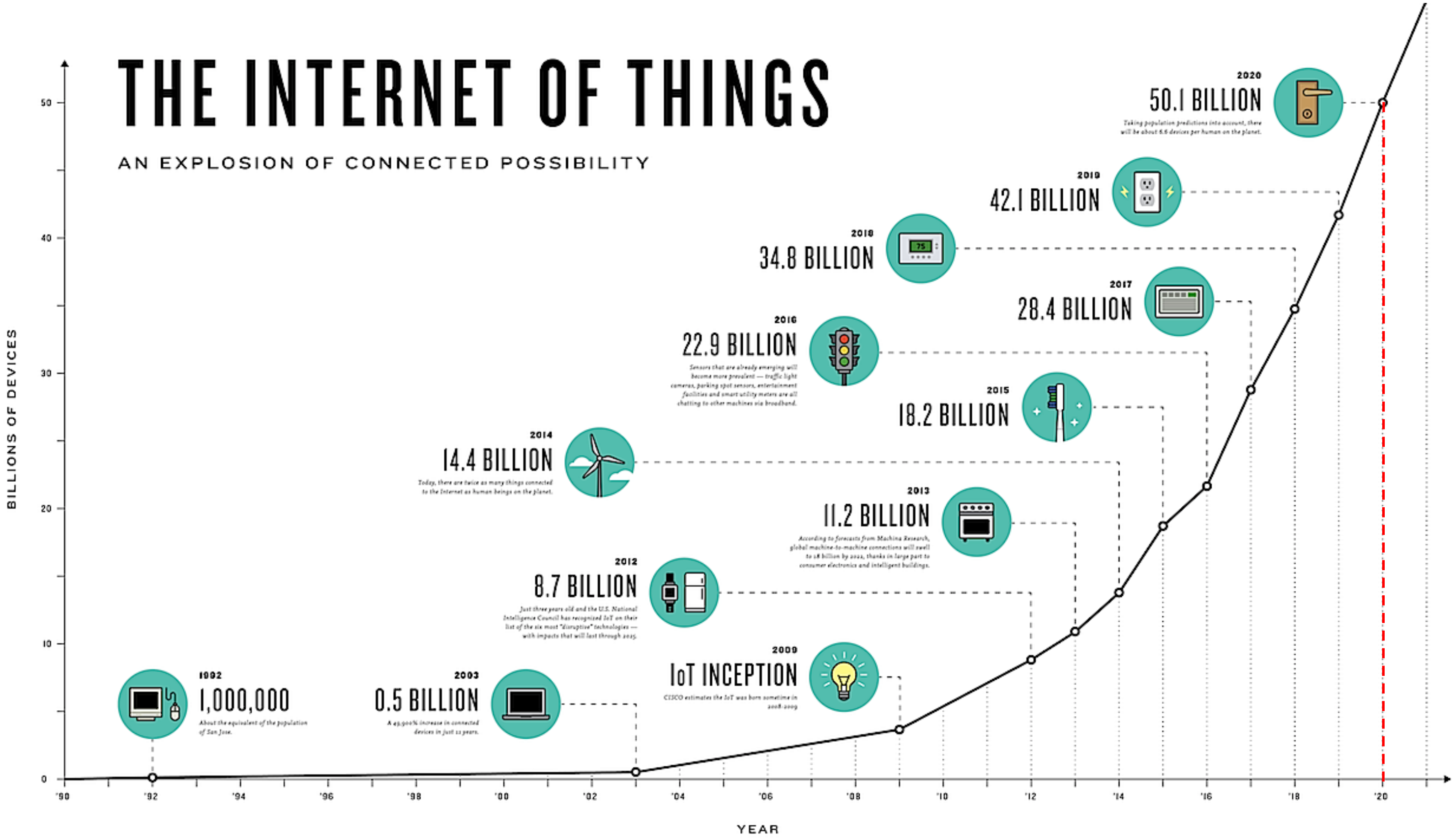
The University of Queensland, Brisbane, Australia

What is industry 4.0?



www.spectralengines.com/articles/industry-4-0-and-how-smart-sensors-make-the-difference

The global market for industry 4.0



www.spectralengines.com/articles/industry-4-0-and-how-smart-sensors-make-the-difference

Time line

2002-2013: Investment boom in mining driven largely by demand from China.

2014-2016: Lower commodity prices. End of the investment boom. Productivity drive and cost cutting sees record Australian coal and mineral production.

2016 - current: Accelerated investment in digital technologies (Industry 4.0).

Industry leaders; Rio Tinto, BHP, Fortescue Mining Group, NorthParkes mine, Resolute Gold

Current status in Australia

Rio Tinto: ~ 180 Automated Haulage Trucks in the Pilbara (Iron Ore)

Integrated Operating Centres in Perth. Developing RTViz operating system with University of Sydney. State-of-art autonomous Koodatorai mine under construction.

BHP: Around 30 AHTs (recently announced desire to ramp up to 500). Remote Operating Centres in Perth, Brisbane, Santiago (Chile). iMine test site in Arizona. State of art autonomous South Flank mine under construction. Have announced joint venture with Dassault (Geovia).

AngloAmerican Metallurgical Coal: 2 Autonomous blasthole drills, Dawson mine.

Two types of automation:

1. Equipment automation

2. Business process automation

- Both increase productivity - designed take “people out of the control loop”

- Both can enhance mine safety

- Project and implementation risks need to be carefully considered for technology investments

Equipment Automation – Australian Surface Mines

- Autonomous Haulage Trucks (220)
  - Iron Ore (Rio Tinto, BHP, Fortescue)

- Autonomous blasthole drills (~50)
  - Iron Ore and Coal (Rio Tinto, BHP, AngloAmerican)

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

Equipment Automation – Australian U/G Mines

- Autonomous LHDs
  - NorthParkes Mine (CMOC)
  - Cadia Mine (Newcrest Mining)
  - (Block caving operations)

- Autonomous Trucks
  - Syama Mine (Mali – Resolute Gold, Australia)

- Autonomous drills
  - Longhole (NorthParkes - development)
  - Jumbos (?)

Remote Operating Centres

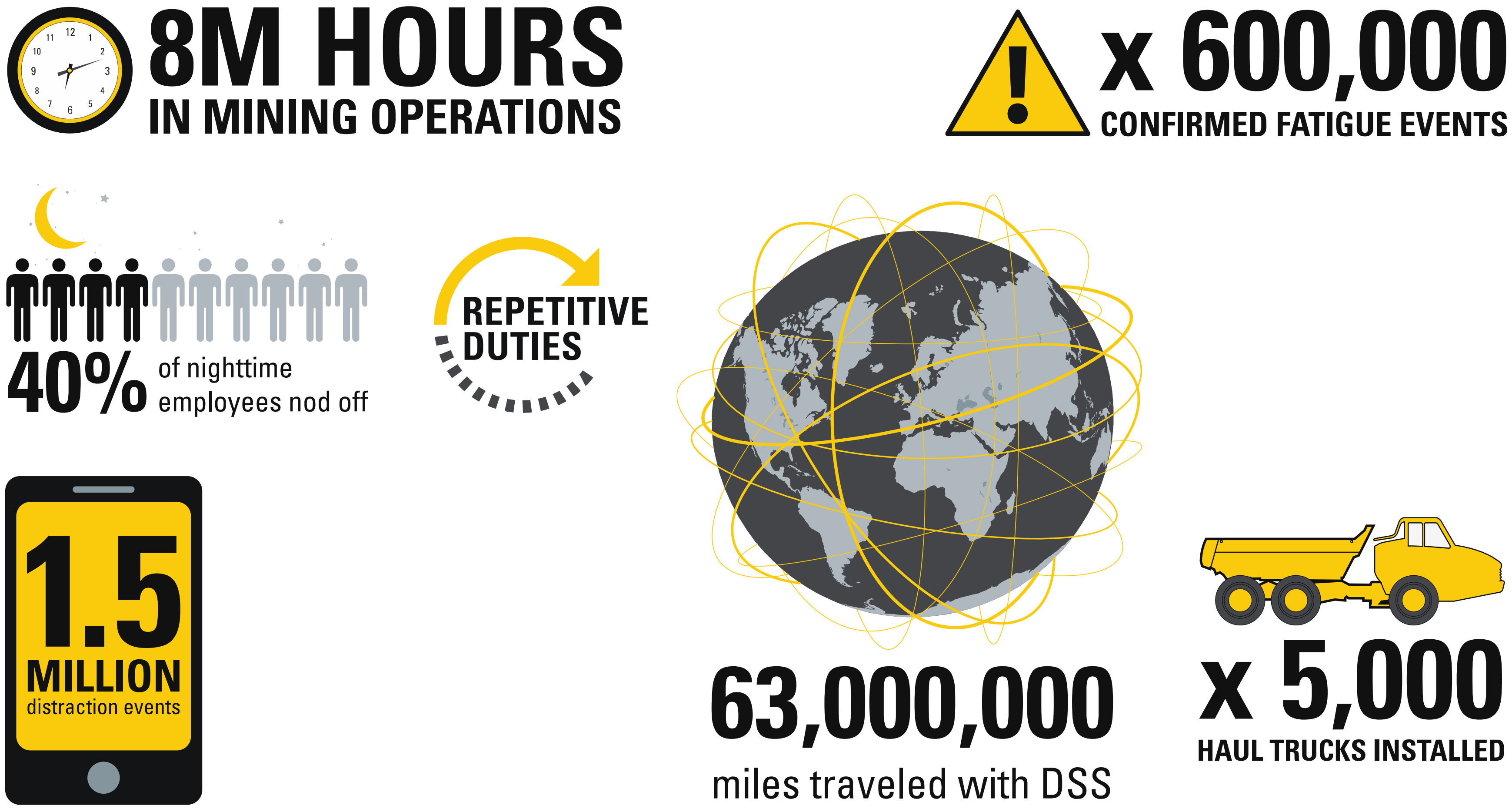
- Iron Ore Operations
  - Perth (Rio Tinto, BHP)
- Coal
  - Brisbane (BHP, AngloAmerican)
- Gold/Copper
  - Brisbane (Rio Tinto)
  - Orange NSW (Newcrest Mining)

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

Industry 4.0 includes “wearables”

Example: non-intrusive operator fatigue monitoring,
Measures brain wave (ECG) activity.

Eg. Caterpillar fatigue detection prevents accidents



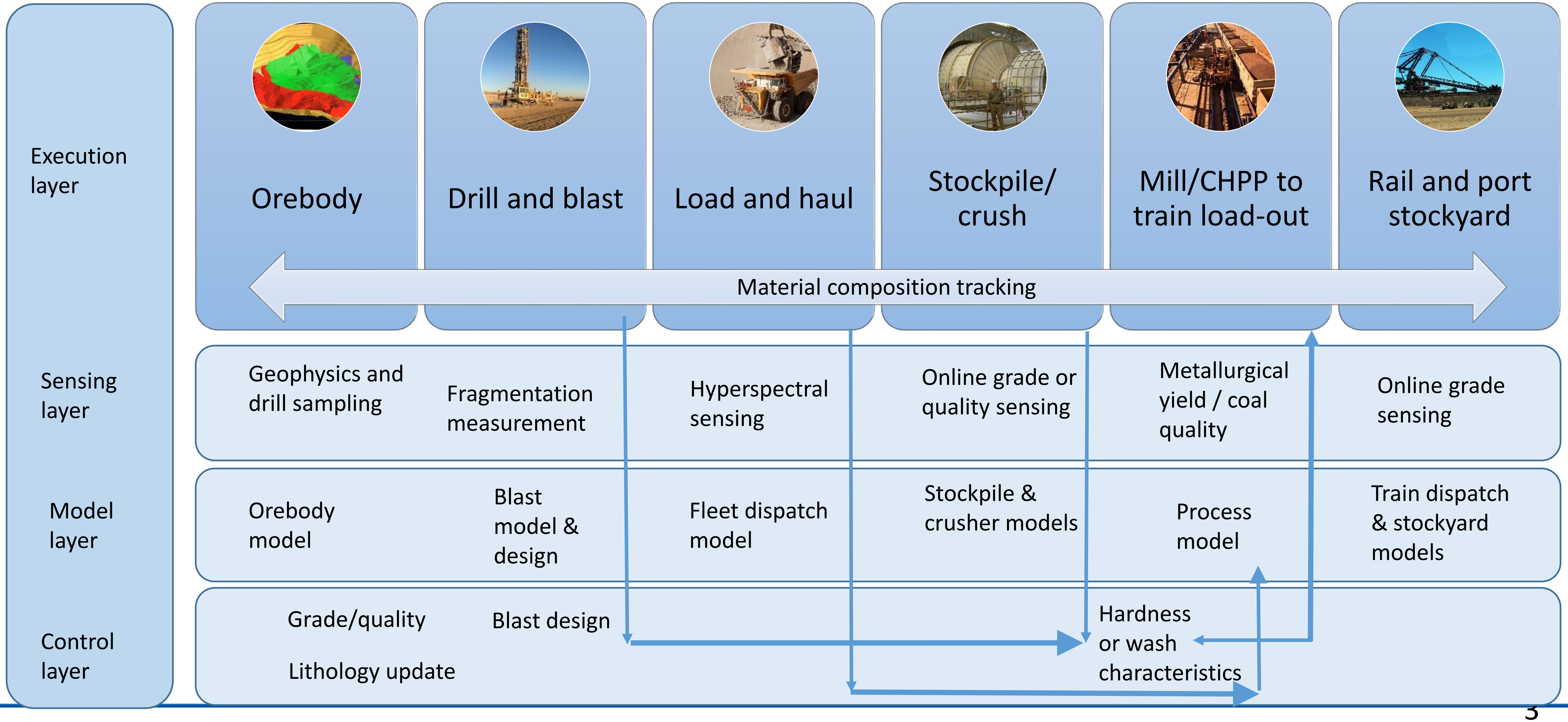
Source: Caterpillar – Data for Caterpillar Driver Safety System, 2018

Industry 4.0 – Integrated, intelligent mining

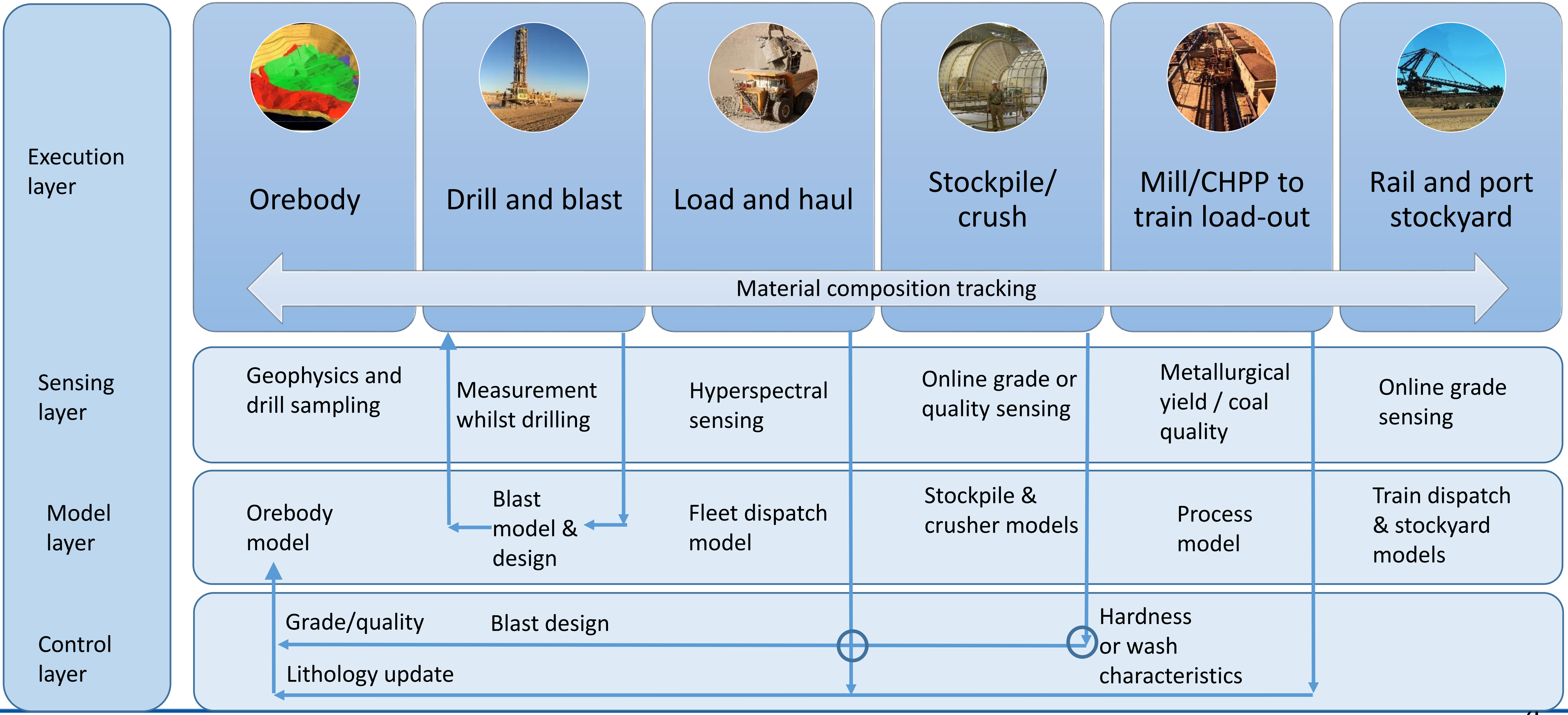
						
Execution layer	Orebody	Drill and blast	Load and haul	Stockpile/ crush	Mill/CHPP to train load-out	Rail and port stockyard
	Material composition tracking					
Sensing layer	Geophysics and drill sampling	Measurement whilst drilling	Hyperspectral sensing	Online grade or quality sensing	Metallurgical yield / coal quality	Online grade sensing
Model layer	Orebody model	Blast model & design	Fleet dispatch model	Stockpile & crusher models	Process model	Train dispatch & stockyard models
Control layer	Feed forward & Feedback control					

II CONGRESO INTERNACIONAL DE MINERÍA

Opportunity 1: Feed foward (eg. plant optimisation)



Opportunity 2: Feedback (eg. rapid resource reconciliation)



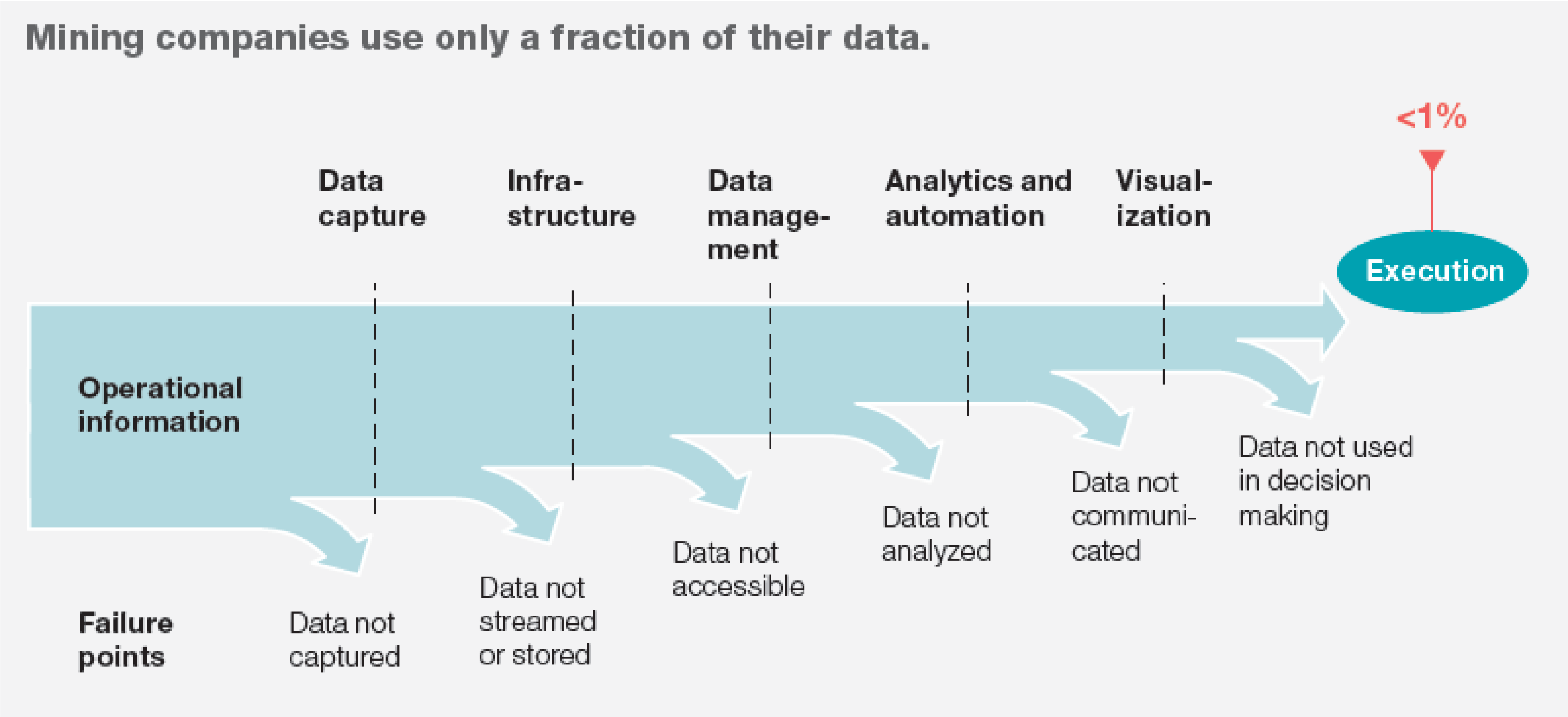
The age of data

An autonomous truck collects data from 180 sensing points

Collects around 2.5 TeraBytes (2.5 x 10^{12}) of data per day

Photo source: Jensen, S. www.oemoffhighway.com/electronics/smart-systems/automated-systems/article/12243110/autonomous-mining-equipment

What happens to this data?



McKinsey & Company “How digital innovation can improve mining productivity”, 2015

The value case

The value at stake for the mining industry is sizable.

McKinsey Global Institute estimates[1]

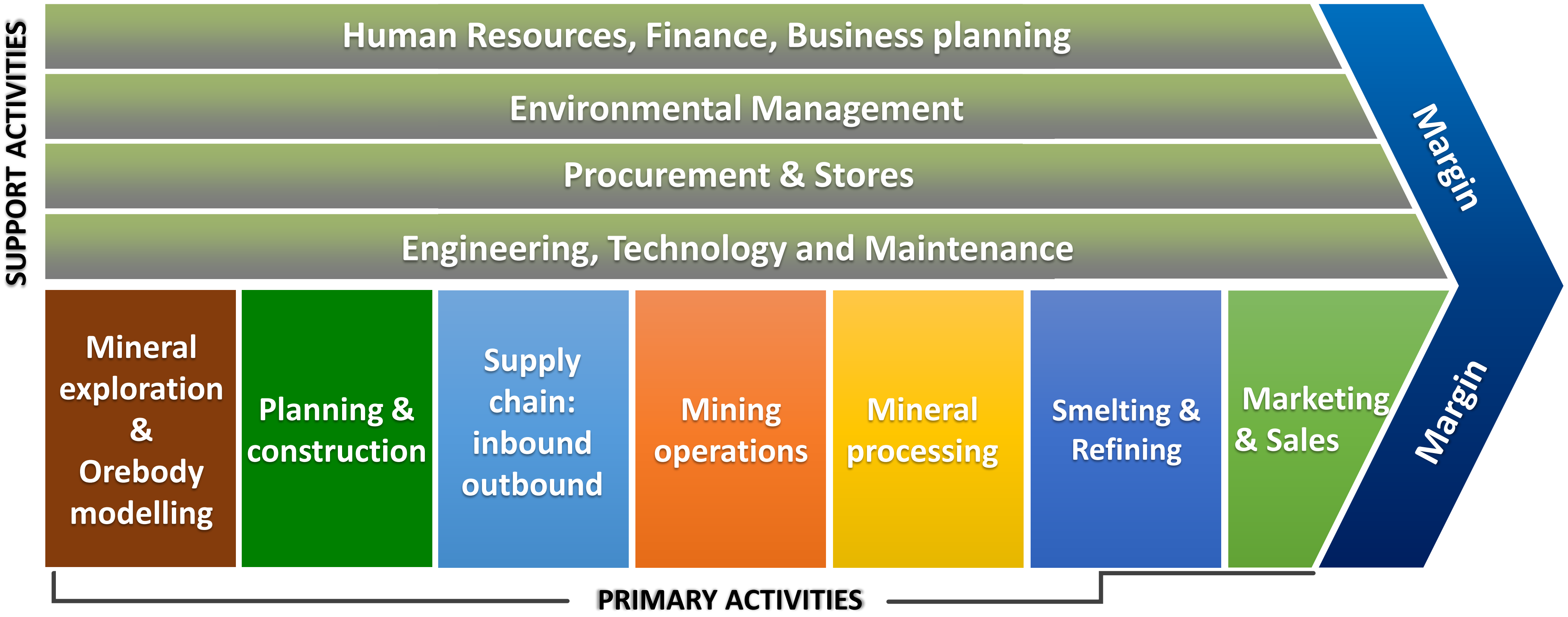
Focus of the paper

Applications	Description	Potential economic impact of sized[2] applications in 2025, $ billion, annually
Operations management	• Deeper understanding of the resource base • Optimization of material and equipment flow • Increase in mechanization through automation • Monitoring of real-time performance vs plan	250
Equipment maintenance	• Improved anticipation of failures • Reduced unscheduled breakdowns • Longer equipment life	100
Health and safety	• Minimized exposure to dangerous conditions	10
Equipment supply	• Improved purchasing analytics • Internet of Things–enabled R&D into cost-efficient equipment design	5
Human productivity	• Augmented reality (built on better human-machine interaction) • Task-based activity monitoring	5
Total		370

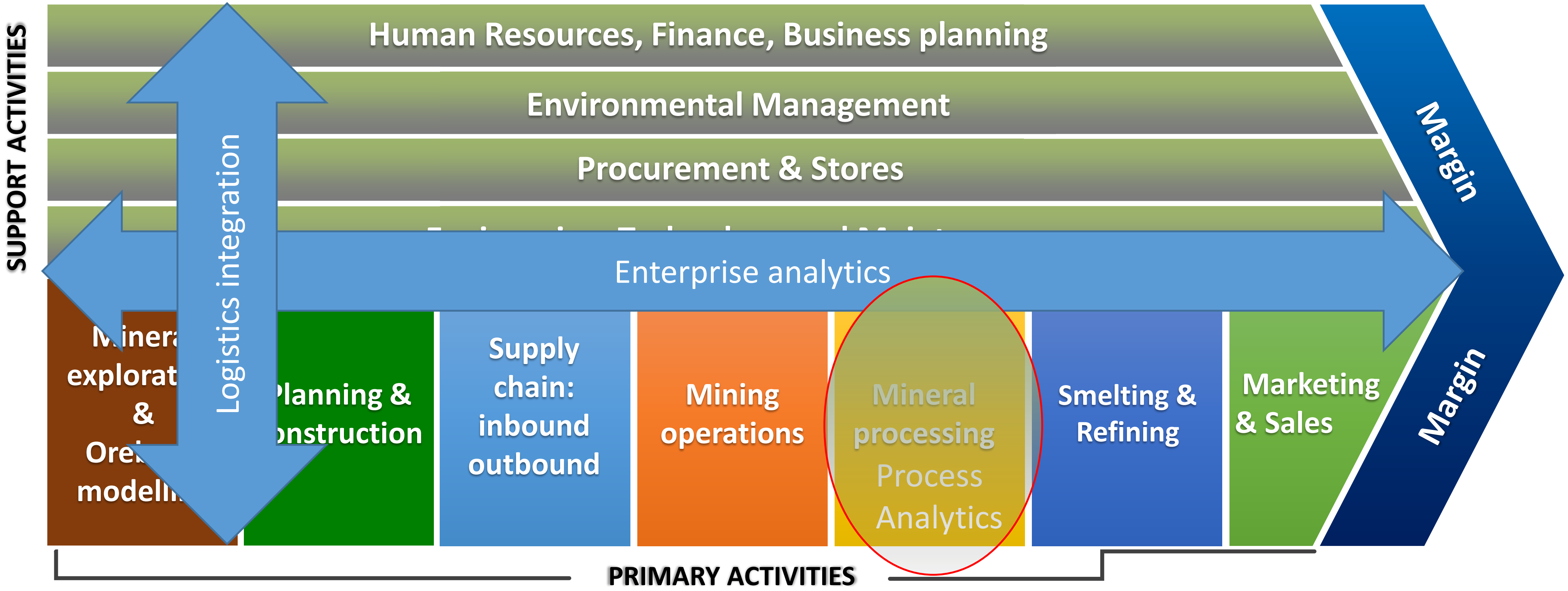
[1]Estimates based on high-adoption-rates case (80% in operations management and 100% in equipment maintenance).
[2]Sized applications are those applications for which the economic value has been analyzed.

Source: McKinsey Global Institute

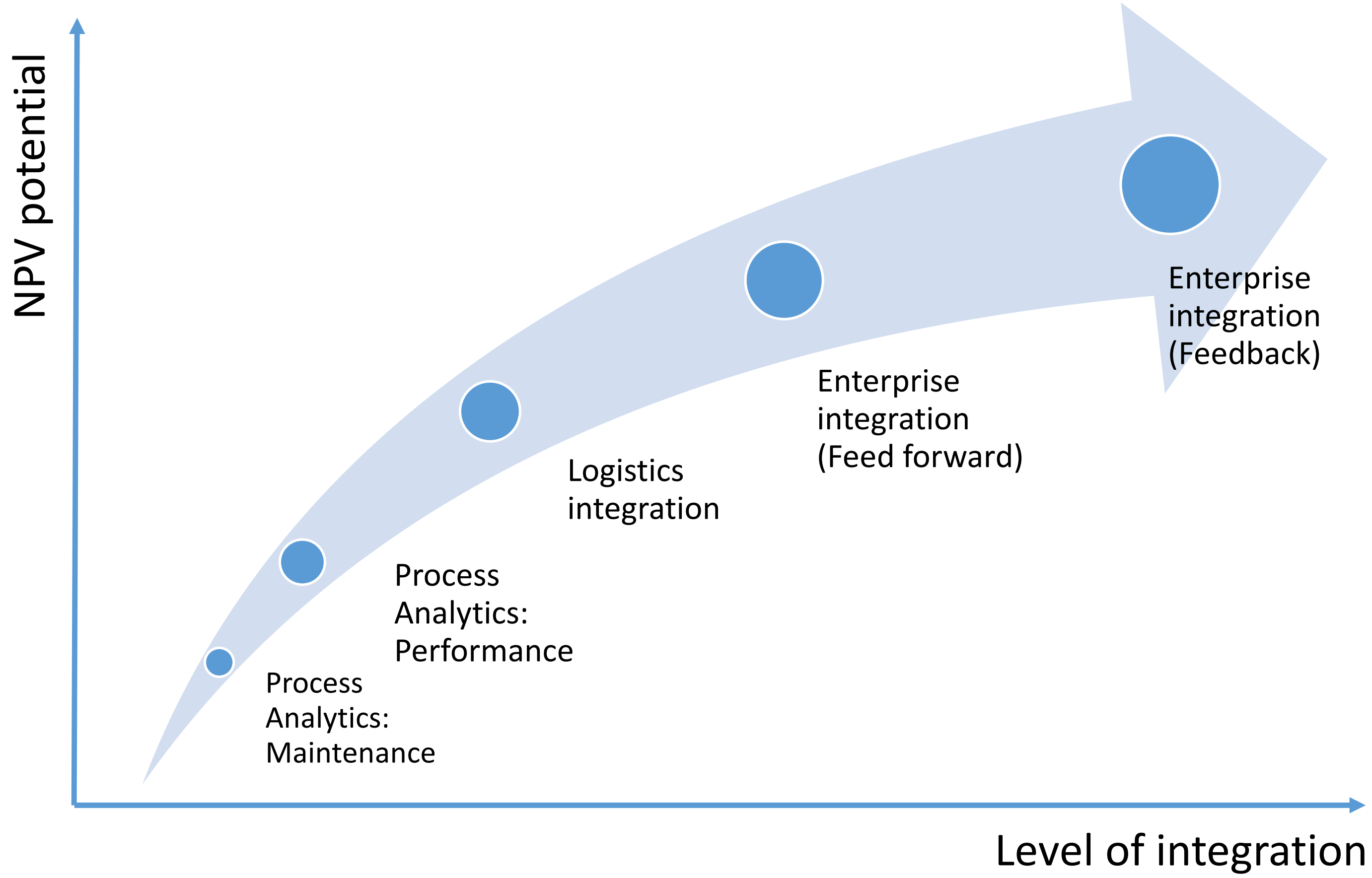
Porter's value chain for mining



What happens to this data?

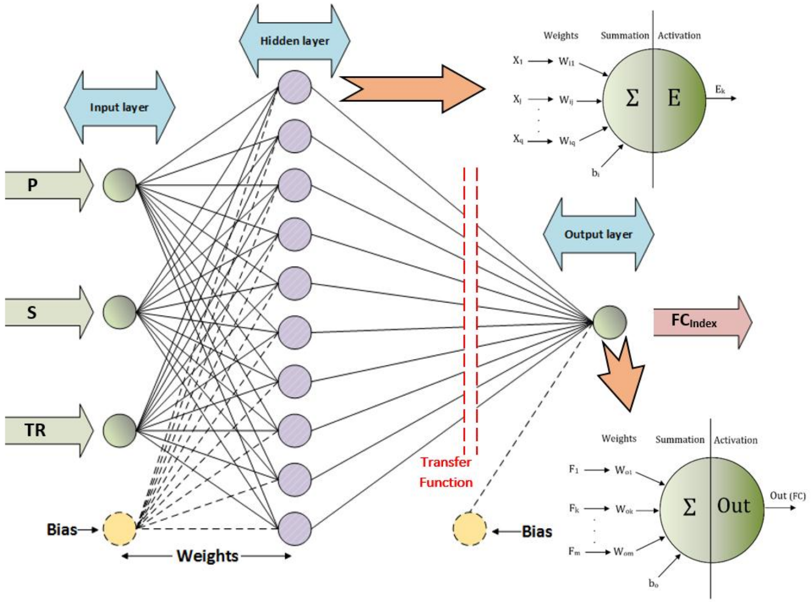


Maturity scale

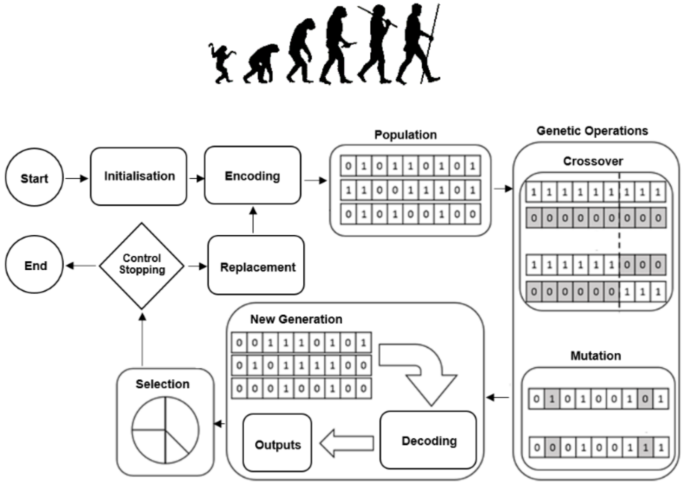


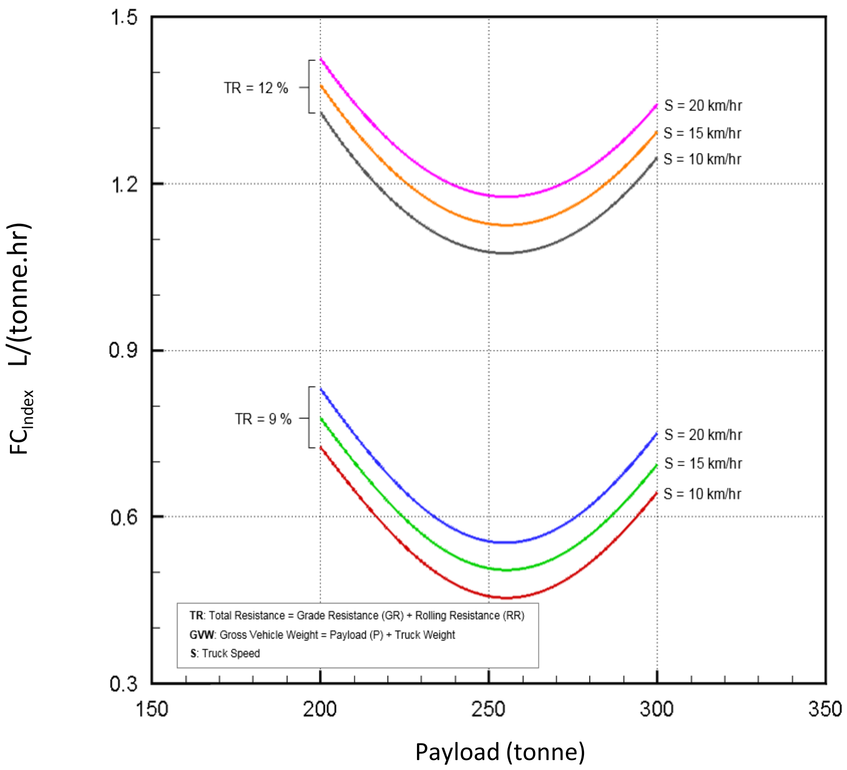
Rewards	Reliable processes	Efficient processes	Less working capital	Reduced capital	Enhanced resource
Motivation	Avoid breakdowns	Avoid rate queue losses	Avoid delays	Eliminate rehandling	Enhance value

Artifical intelligence – eg. optimising fuel consumption



+ Optimise Set Points: Genetic Algorithm





Example: CAT 793D Specific Fuel Consumption (Soofastaei, 2017)

THE UNIVERSITY OF QUEENSLAND AUSTRALIA

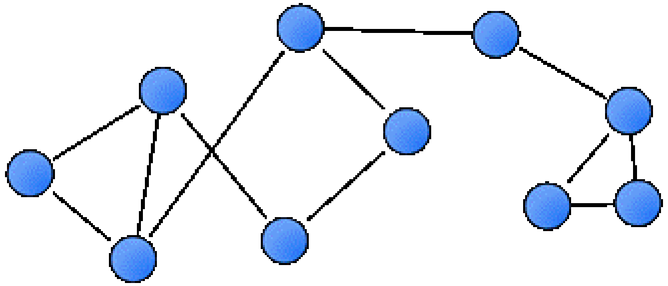
II CONGRESO INTERNACIONAL DE MINERÍA

Why do we need this…

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

…when we have these?

The future is portable!



Embrace the skill set of the **millennial** generation

Networks for decisions (the power of groups!)

The new iROC: **Portable** everywhere.

Conclusions

Over the next 5 years we will see great changes in digital connectivity and intelligence via Industry 4.0 technologies being adapted and developed for mining.

Humans will also be “instrumented” via wearable technology.

This will enhance safety, financial, environmental and social performance of the mining industry (eg. Energy/water efficiencies, regulatory transparency)

II CONGRESO INTERNACIONAL DE MINERÍA

Gracias!

Prof. Peter Knights
School of Mechanical and Mining Engineering
The University of Queensland
p.knights@uq.edu.au