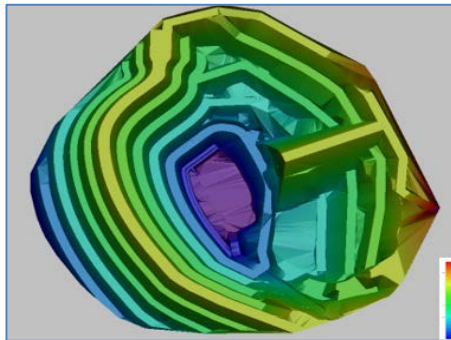
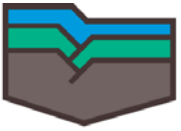


Roadmap to the Future Surface Mining Innovation

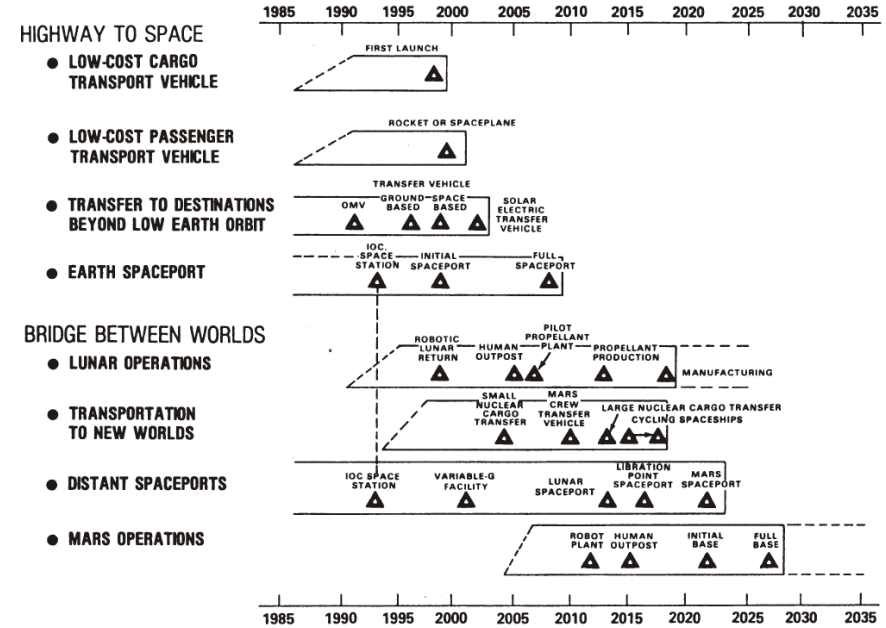




The Future...

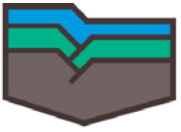


Figure 1: Low-Cost Access to the Inner Solar System



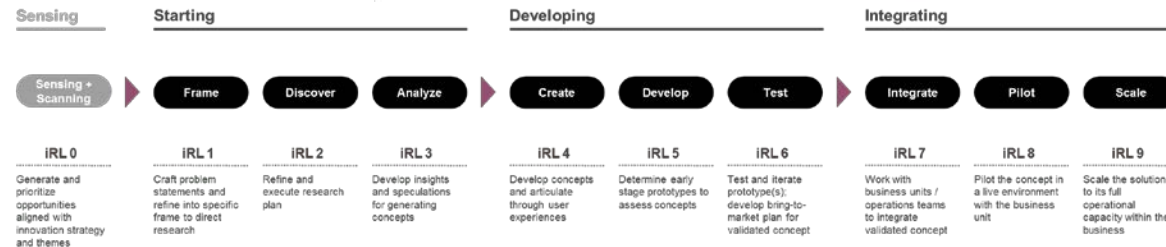
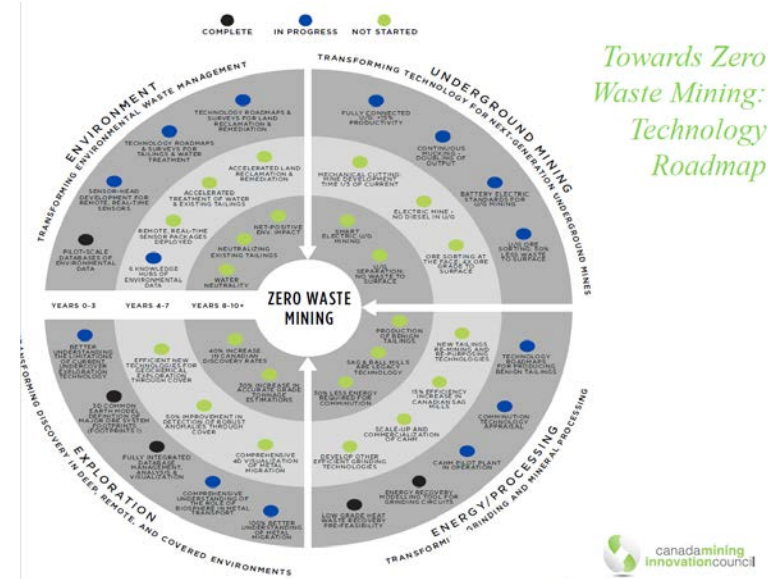
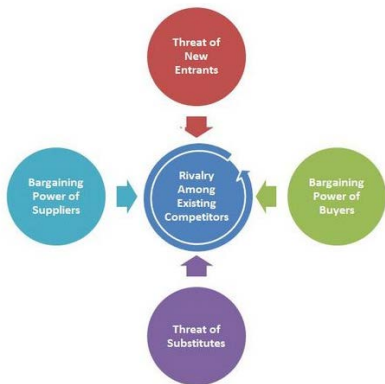
The Moon Shot...

National Congress on Space, Pioneering the Space Frontier, New York, Bantam Books, 1986.

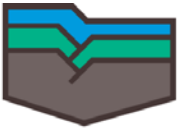


Roadmap to the Future...

- Simple definition: a plan for how to achieve something.
- Takes many familiar forms:



- *They are descriptive and prescriptive tools providing understanding and stimulating engagement*



The Surface Mining Workshop...(February 27 and 28, 2018)

Canada Mining Innovation Council (CMIC) requested Deloitte to facilitate a collaborative workshop with participants from different surface mining companies in Canada to create a roadmap that identifies grand challenges related to surface mining and plots a pathway to tackle these challenges

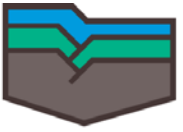
Participants...

Barrick
Imperial Oil
Kinross
McEwan Mining
Suncor
Syncrude
Teck

Mine RP
Krupp Canada
MMO
Global IO
University of Alberta
CMIC
Deloitte
GMSG

The workshop was made possible by a grant from Natural Resources Canada.





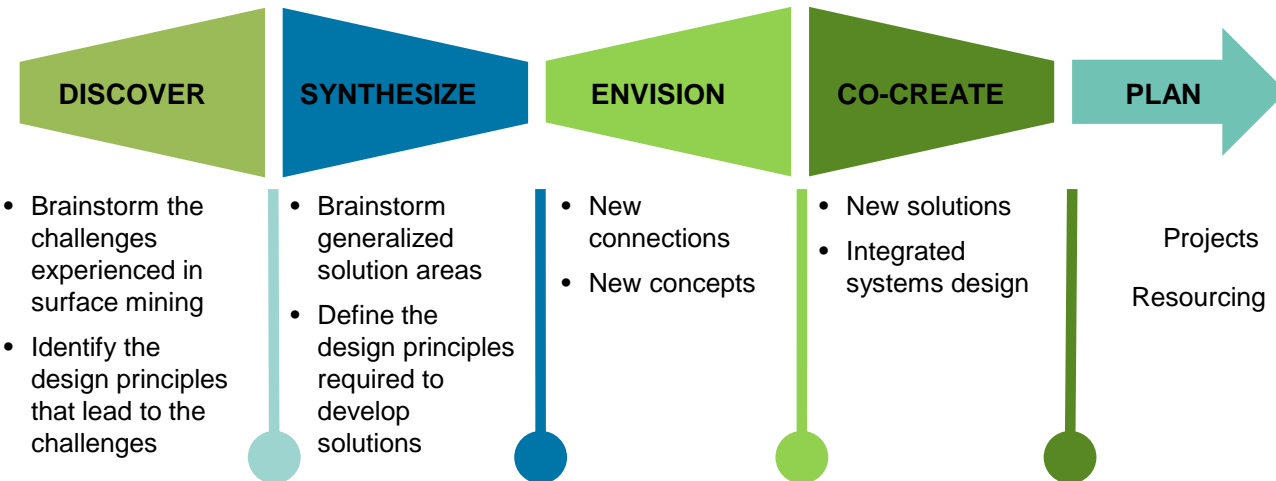
A Design Approach

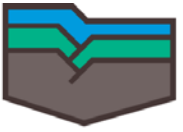
A two-day workshop was conducted with participants to identify the key challenges, to define the guiding principles and to develop new concepts and solutions for surface mining.

Objectives

- Identify the issues and establish existing design principles and constraints
- Establish areas of opportunity and new design principles
- Envision “what might be possible” and develop new concepts and solutions
- Create opportunities for future collaborative projects

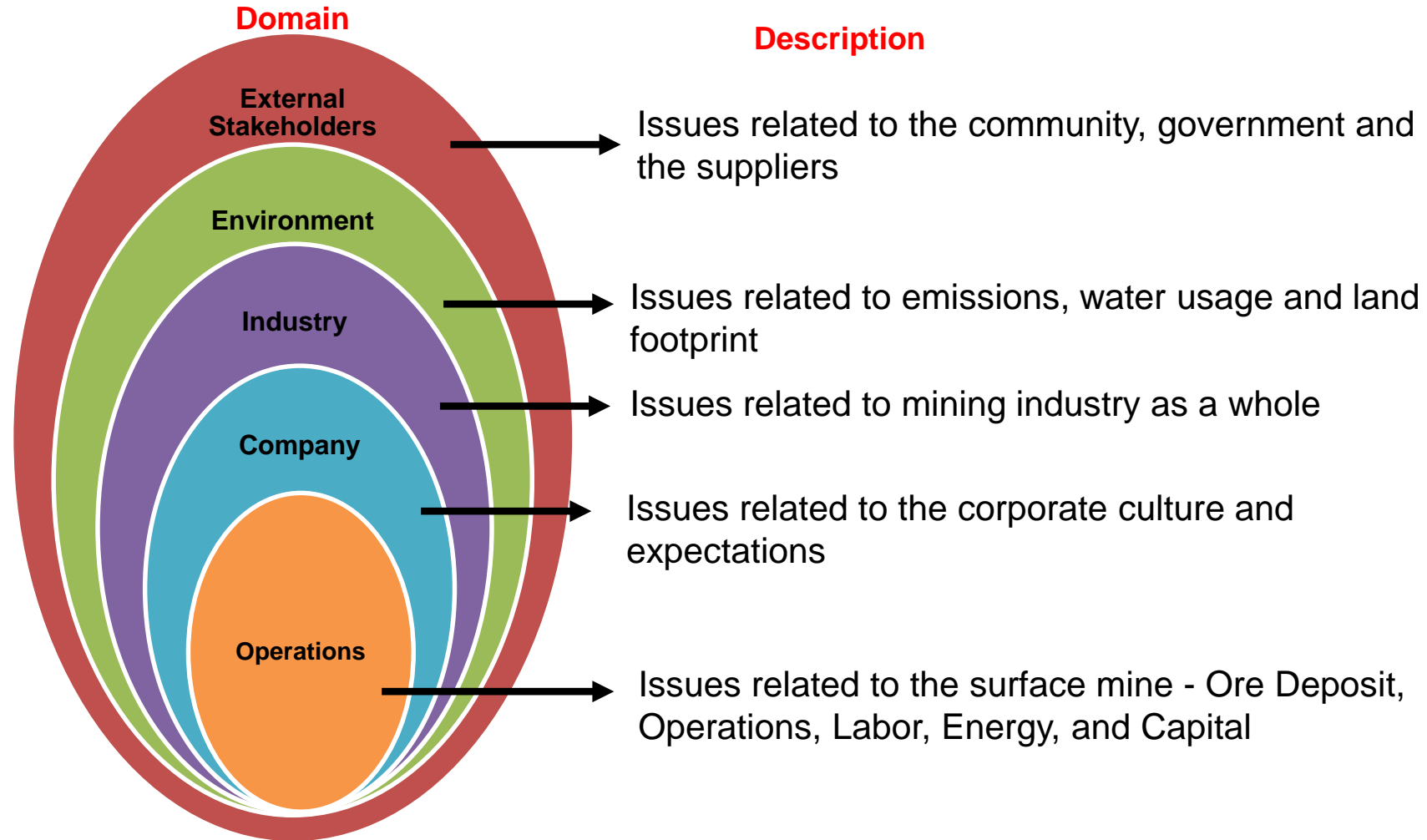
Process

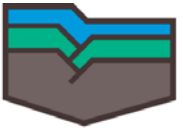




Key Challenges in Surface Mining

All the surface mining issues identified during the workshop have been categorized across the following domains





Current design principles used in surface mining today



1
Bigger is better –
Economies of
scale lowers cost

2
24/7/365 mine
operations
maximize asset
utilization and
production

3
Standardized
processes and
equipment at mines
and across mines
reduce cost

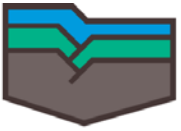
4
Mine life is
designed to
maximize return
on fixed
investments

5
Critical resources
like labor, energy
and water are
readily available

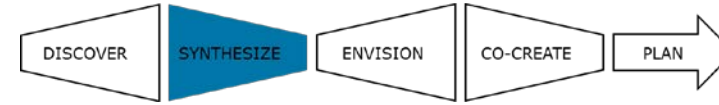
6
Waste movement
and processing has
to be minimized as
it erodes returns

7
License to operate
requires compliance
with minimum social
& environmental
regulations

8
Success across
each phase of the
LOM requires a
different focus



New design principles can overcome challenges



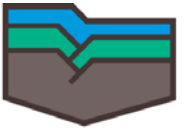
Current Design Principles

- 1 Bigger is better – Economies of scale lowers cost
- 2 364/24/7 mine operations maximize asset utilization and production
- 3 Standardized processes and equipment at mines and across mines reduce cost
- 4 Mine life is designed to maximize return on fixed investments
- 5 Critical resources like labor, energy and water are readily available
- 6 Waste movement and processing has to be minimized as it decreases returns
- 7 License to operate requires compliance with minimum social & environmental regulations
- 8 Success across each phase of the LOM requires a different focus



New Design Principles

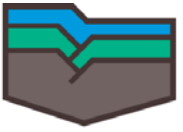
- 1 Modular, scalable & flexible design and equipment to increase options over LOM
- 2 Optimize mine plans & schedules to maximize value of mine to stakeholders
- 3 Customize processes and equipment to optimize value from ore body
- 4 Increase the amount of movable assets to create value from any life of mine
- 5 Minimizing the use of critical resources is a key criteria in mine design considerations
- 6 Invest to eliminate waste early in the value chain as and add value to what remains
- 7 Maximize the value to society & environment while achieving required returns
- 8 All decisions has to take into account the value of the integrated system over the LOM



New Principles must be adopted



- 1** Modular, scalable and flexible design and equipment to increase options over LOM
- 2** Optimize mine plans and schedules to maximize value of the mine to all stakeholders
- 3** Customize processes and equipment to optimize value from ore body
- 4** Increase the amount of movable assets to create value from any life of mine
- 5** Minimizing the use of critical resources is a key criteria in mine design considerations
- 6** Invest to eliminate waste as early in the value chain as possible and add value to what remains
- 7** Maximize the value to society and environment subject to achieving required returns
- 8** All decisions has to take into account the value of the integrated system over the LOM

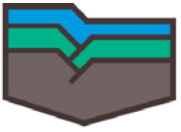


Solutions become enablers of new design principles

Various solutions become enablers of the proposed new design principles to address the challenges of surface mining in a meaningful way

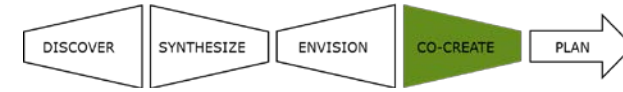


- 1 Improve ore body knowledge
- 2 Integrated mine design, planning and scheduling
- 3 Selective Mining
- 4 Alternative hauling technologies
- 5 Modular mining
- 6 Integrated operations with intelligent work environment
- 7 Automation
- 8 Electrification & re-newable resources
- 9 Transact more efficiently
- 10 Improve Water Treatment & Management

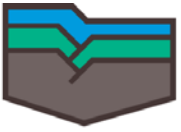


Solutions become enablers of new design principles

A number of different solutions are required to enable the new guiding principles to successfully address key surface mining challenges

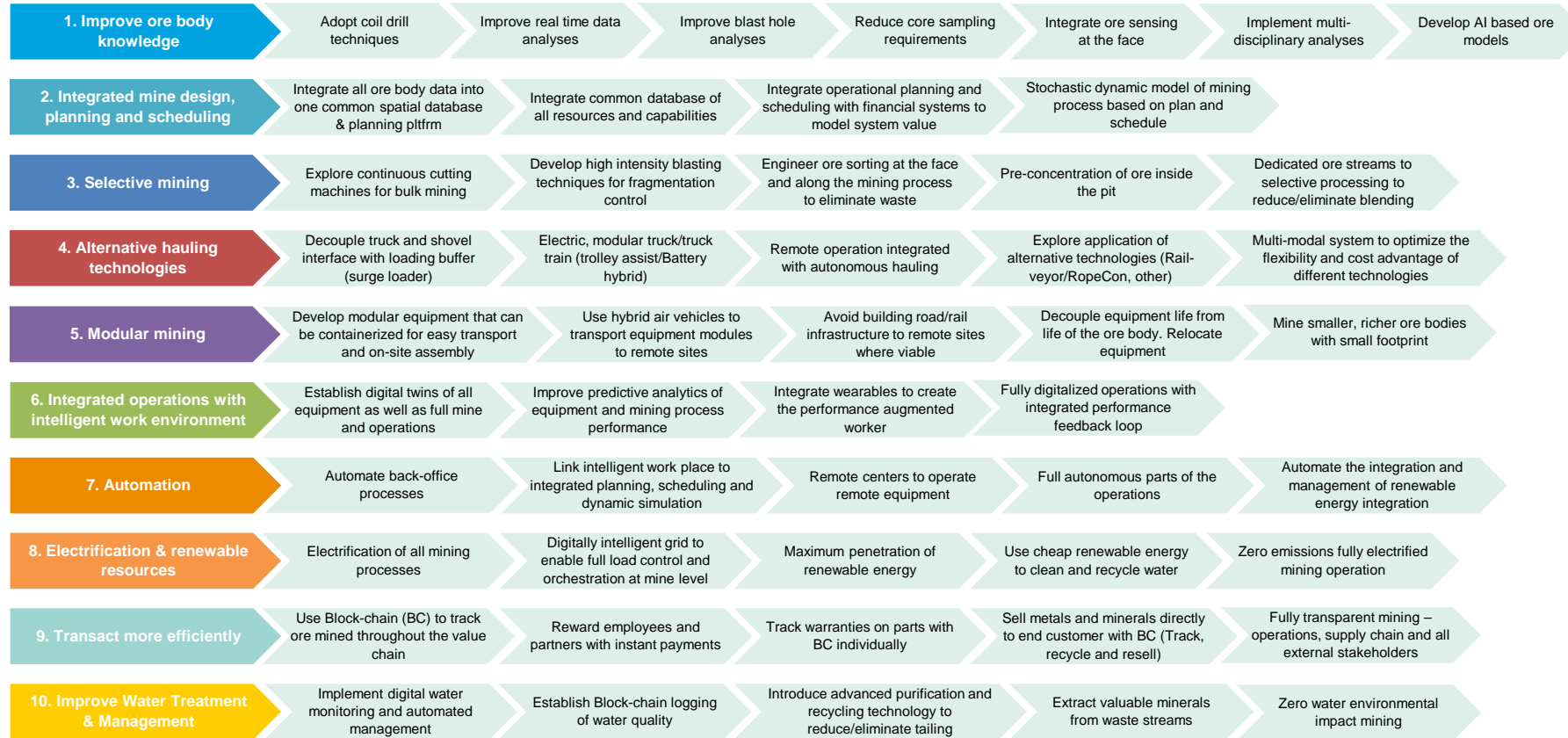


New Design Principles	Solutions									
	1. Improve ore body characterization	2. Integrated mine design, planning and scheduling	3. Selective Mining	4. Alternative hauling technologies	5. Modular mining	6. Integrated operations & Intelligent workplace	7. Automation	8. Electrification & renewable resources	9. Transact more efficiently	10. Improve Water Treatment & Management
Modular, scalable and flexible design and equipment to increase options over LOM	X	X		X	X	X				
Optimize mine plans and schedules to maximize value of the mine to all stakeholders	X	X	X	X	X	X	X	X	X	
Customize processes and equipment to optimize value from ore body	X	X	X	X		X	X			
Increase the amount of movable assets to create value from any life of mine	X	X		X	X	X	X	X	X	X
Minimizing the use of critical resources is a key criteria in mine design considerations	X	X		X	X	X	X	X		x
Invest to eliminate waste as early in the value chain as possible and add value to what remains	X	X	X	X		X	X		X	
Maximize value to society and the environment subject to achieving required returns		X					X	X	X	X
All decisions has to take into account the value of the integrated system over the LOM	X	X							X	x

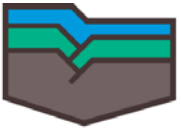


CMIC surface mining roadmap – V1

ALBERTA CHAMBER OF RESOURCES



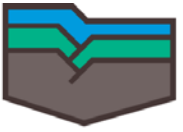
Users bring this framework to life through collaboration and interactive efforts



Risks associated with implementation

The six major risks associated with implementation of a digital mine roadmap are described below with the associated management strategy.

#	Risk	Profile	Mitigation Plan
1	Inaction due to risk aversion and resistance to change	High	<ul style="list-style-type: none"> • Create dedicate innovation teams to de-risk innovation projects in an environment that minimizes production risk. • Create projects that present a benefit to all parties involved to diminish resistance to change within the industry.
2	Limited funding for innovation	High	<ul style="list-style-type: none"> • Develop strategic innovation ambitions that are grounded in the business strategy. • Dedicate funds to innovation to ensure that overall innovation ambitions are met.
3	Poor communications and stakeholder engagement	High	<ul style="list-style-type: none"> • Define the accountability for innovation within each organization.
4	Managing ownership of IP	Medium	<ul style="list-style-type: none"> • Develop an IP management framework.
5	Missing key enablers and technologies within “windows” of opportunity	Medium	<ul style="list-style-type: none"> • Create a collaboration framework for mining companies to share resources and expertise.
6	Lack of industry support on key initiatives	Medium	<ul style="list-style-type: none"> • Identify common issues across the industry to develop an understanding of the focus for key initiatives. • Define measurable success factors for initiatives to foster increased engagement and desire to collaborate.



Next Steps

- Align on the content for the surface mining roadmap – common vision
- Decide on the best collaborative structure to explore the solution theme
- Develop agile solution development
- Determine resource requirements for successful development projects and piloting efforts
- Identify where projects and pilots will be conducted and who would lead it
- Developed detailed plan (timing, specific solutions, resources etc.) for each proposed solution.
- Managing the tension between long-term vision and short-term demand.

Accelerating the pace of innovation
Efficiently developing the right technology

