COLLABORATION TOWARDS FUTURE MINING PERTH FORUM

Organized by GMSG and Austmine, with support from AusIMM

DAY 1: 23RD AUGUST, 2017

SESSION 1: INTRODUCTION TO GMSG

- Liaison organization to bring voice of mining industry to relevant organisations
- Created under Canadian Institute of Mining, but is independent
- History of GMSG: Started as surface mine operators user group. Discussions limited within operator group. Needed a multi-stakeholder organization to have broader conversations and develop building blocks.
- Outputs of GMSG are guidelines and building blocks for industry
- Guidelines are the way to articulate discussions and enable further broader discussions with partner groups, industry groups or government organisations
- Use guidelines as: key communication tool in groups, guideline for systems, synchronize internal company strategy with industry guidelines
- Everything in working groups is open – currently published on website
- Guidelines are facilitated through the working groups. Typical steps are:
    1. Discussions
    2. Guidelines drafted (multiple authors contributing specialized knowledge)
    3. Reviewed by working group
    4. Voted on by approval by working group
    5. Published

Industry Driver, Operator Led

Collaboration Driving Innovation

Questions:

1. Why are most GMSG members the larger companies?

GMSG are aware and will be reviewing how to increase small to mid-tier company participation. Some mid-tier companies are already using the guidelines actively in their business and providing feedback to the working groups.

2. We are a contractor already working with companies. How do we get involved with working groups?

GMSG publicize events on the website, but are looking to improve this plus hold more events in Australia. Will also soon publish a 12 month calendar of upcoming events. GMSG in-person events are:

i. Forums such as the Perth one
ii. Workshops (20 – 30 people) – active working group meetings
iii. Summits – more like a conference, linked to workshops

Each working group communicates through regular phone links, on-line collaboration tools plus in-person workshops. To join a working group contact Jennifer Curran at jcurran@globalminingstandards.org.

SESSION 2: AUTONOMOUS MINING

Autonomous Mining

Anthony Kirke (Group Manager Operations Planning, Fortescue Metals Group)

Operations at Solomon Minesite currently utilize 5 autonomous drills and 56 autonomous trucks – have moved 400mt autonomously. Will be moving to 100% autonomous in 2018. Using a range of different service providers.

Chichester Development (Cloudbreak and Christmas Creek) – 10 drills and 90 trucks to be automated in next 2 – 3 years.

FMG driver is cost reduction – focus on lowering cost of production and quick return on CAPEX investment. FMG are prioritizing technology that provides short-term cost reduction rather than longer term initiatives. Focus now on refinements of technology implementation.

Roll-out of autonomous mining:

- 20% of job is technical,
- 80% is people – need to retrain and redeploy affected personnel.
- Innovation = People + Process + Technology

Key business driver is a focus on culture.

Robust network is essential for autonomous minesite plus robust network monitoring software. Any outages directly impact on production and cost.

Predicting a 15% productivity increase in next 6 months – but mostly through improved personnel and mine process planning (e.g. better truck utilization, better road designs).

System works well for large operations; may not be cost effective for smaller mins.

Questions:

1. Examples of common issues in automated environment?

- Engineering developing design standards without understanding real issues in pit. Addressed through going into pit with pit technicians (driving behind trucks etc) to see actual issues. Essential that engineering plans don't compromise on issues that affect the truck performance (e.g. straight windrows important so trucks don't stop)
- Ensuring consistency between shifts. Constant review of organization and planning to create optimum working environment for autonomous trucks.

Autonomous Mining: New Global Drive to Standards

Andrew Scott (presented on behalf of Tim Skinner, who was unable to attend)

Tim is GMSG Vice Chair – International Standards. Working with ISO, Technical Committee 82 – Mining and TC127 – Heavy Equipment.

TC82 Autonomous Mining Subcommittee has developed revised scope of work - will be voted on 8th Sept 2017. Still available for industry comments but time is very limited. First meeting of working group planned for Q4, 2017. (NOTE: the Vote passed at ISO TC82 this September)

Questions:

1. *Timeframe for ISO?*

- Initial discussion in 2015
- SOW will be approved in Sept 2017
- Working group committee members have already been nominated and have the demonstrated range across industry groups.
- Timeframe then 1 – 2 years. That is mainly the time taken to get consensus on things – advantage of GMSG is that can get consensus before presenting to ISO for confirmation.
- Full timeframe is ~ 3 years. GMSG recognize the fast pace of change happening

---

Case Study: Autonomous Shuttle Bus Trial

Anne Still, General Manager, Public Policy, Royal Automobile Club of WA

RAC has been trialing a fully driverless, fully electric shuttle bus over the past year. After closed trials, it is now in the open stage on open roads in South Perth. The RAC Intellibus™ is a Level 4 automated vehicle (=high automation) and was imported from France.

Navigation is through:

- GPS
- Odometry (to determine position relative to its starting position)
- Stereovision cameras (to read traffic lights and other objects)
- 8 x LiDAR sensors (3D sensors on roof, plus 2D on front and back of vehicle

Currently many legislative barriers to using automated vehicles in Australia. RAC is working with state and federal governments to support the required change.

Questions:

1. Level 3 / 4 automated light vehicles ready for use in mine environment. How can these level 4 vehicles be rolled out for use before the predicted start time of 2025?

- Still many barriers to overcome before then. These include insurance issues plus accessing federal government funds to address other legislative issues

2. What kinds of incidents have been logged in the current trial?

- Basically all human related, not technology. Issues such as the vehicle stopping due to a bicycle cutting in front. The vehicle is also programmed not to cross the centre line of the road so will stop if a car is parked incorrectly (and will be recorded as an incident)

3. Required connectivity?

- In current trial, the connectivity only required for the GPS. No dedicated network required for it. There is redundancy in system, so can use the LiDAR if the GPS drops out. In more built up areas, then can rely more on the LiDAR systems

4. Comments on electrical vehicles

- Currently only ~200 electrical vehicles in Western Australia. RAC is lobbying the government to provide more incentives for their use (lower road taxes, ability to use bus lands, lower registration fees)
- RAC has been installing charging stations (available on highway south to Augusta).
- Believes once more options arise in terms of fleet car options and car dealerships come on board, then utilization will increase.

Autonomous Haulage: From Lessons Learned to the Next Steps – Functional Safety

Chirag Sathe (Principal Risk & Business Analysis, Strategy & Innovation, BHP Billiton)

BHP strategy is to analyze and evaluate the potential risks (through tools such as FTA and FMEA) and then identify the controls to reduce the risk. Need to demonstrate adequacy of controls (LPA- Layer of Protection Analysis, and ALARP).

Highest risk time for incidents is immediately after introducing new software/technology. Systems and training need to address this. Main causes of incidents in Autonomous Vehicles include software, lost communication, and road conditions (roads worn differently due to AV travelling on same track every time). Minor causes include ancillary interaction and object detection. Human errors account for > 50% of incidents (may be closer to 80%) – so essential to use good and well-trained people.

Questions:

1. How far away are we from using AI to drive AV's? To reduce human intervention

- Possibly with next 5 years. Means that truck doesn't need to automatically stop when something happens. Repeat assignments without operator.

2. Does BHP try to hack into own systems and networks (i.e. is cybersecurity an issue?)

- BHP does extensive system checks. Once the systems are more autonomous, then less communications required so lower the risk of security breaching.

3. Humans can currently assess risk and react. As AI improves, then should be able to make better risk assessment

- Yes – trucks will be able to continue to work even in communication stops
- Business rule management will be crucial (different rules for manned vs autonomous vehicles)
- Enable real-time reporting and updating of hazards (FMG currently do this)
- Currently have very high (conservative) safety limits in Autonomous Vehicles. Key is for systems to become more intelligent so can keep productivity high. (restrict downtime through smarter technology solutions)

SESSION 3: INTEROPERABILITY

Break Out Session: Interoperability

Definition – sharing and exchange of information so systems can work better. Includes transfer of control (can be controversial).

Please see Appendix 1 for Use Cases developed during the break out session.

Laying the Foundation for Digital Innovation

Gavin Wood (Chief Innovation and Digital Officer, Newcrest Mining)

After last downturn in gold price, IT spend within Newcrest dropped (including big drop in CAPEX). Big reorganization, new IT team selected with strong focus on culture, people and developing a vibrant work environment. Streamlined all systems and processes. Built the business foundations and then developed the IT strategy.

IT strategy included:

- Process Control
- Advanced Analytics
- Shared Intelligence (utilizing IBM Watson)
- Cloud Services (all data on the cloud)
- Workforce Safety and Productivity

Top performing group. > 95% projects delivered on time with high satisfaction levels from stakeholders. Strong focus on spending minimal CAPEX but with improved productivity.

Questions:

1. How long has this taken?

- 3 years. It was originally driven from top down, but now there is belief in its values including from bottom up.

2. Do the minesite personnel support the initiatives and how do you handle software "creep"?

- All software purchasing has to come through IT department. However they will review quickly and efficiently, so can generally meet site personnel objectives. So seem to have support

3. CAPEX vs OPEX.

- Move towards agile and project development environment has caused accounting issues in terms of deciding when CAPEX or OPEX. For example the Data Science platform utilizes off-the-shelf systems, so even if running from the cloud, can still capitalize as CAPEX.
- Minesites have own IT OPEX – still report to Gavin and all implementation on site is via the IT group

4. Acceptability and satisfaction of IT group being aligned with site objectives?

- Seems to be working; issue comes down to people and services. IT team generally align with relevant stakeholders on the minesite (rather than following management mandate)
- Data Science – started with IT pushing, but now been driven by users, and IT team being requested to come to minesites.

GMSG Interoperability Working Group: The Interoperability Collaboration Landscape

Heather Ednie (presented on behalf of Tim Skinner, who was unable to attend)

2 working groups – Autonomous Mining and Interoperability. Workshops held since Nov 2015 which have provided key topics for ongoing focus.

Critical success factors:

- 1st edition in 12 months
- Dedicated project manager about to be hired (~1 day/week)– required to coordinate volunteer working groups

DAY ONE WRAP-UP

Key highlights of the day:

1. Human interaction is essential for successful implementation of technology. Have to make the utilization of technology desirable. Transfer quickly from top down to bottom up….or middle out? (many key stakeholders are in the middle). *Desirability = Clarity of Purpose*

2. Service companies have to go into companies at every level (everyday users, direct supervisors, management).
   Everyone counts on the Journey

3. Move to automation exposes requirement for improved or new business practices (e.g. good road design is essential for good implementation of autonomous trucks)

4. Still some confusion between Interconnectivity and Interoperability. Start with Interconnectivity and move to Interoperability.

5. Learnings from business experiences are important

6. Request from delegate to see ideas generated on Interoperability from other Forum locations. Variations between regions?

DAY 2: 24TH AUGUST, 2017

SESSION 4: THE CONNECTED MINE: DATA, INFORMATION AND INTEGRATION

The OMF – Open Mining Format: Detailed Use Cases and OMG 0.9 Deswik-Leapfrog Integration Demo

Jayne Kato (Manager – Product Management, Deswik)

Presentation on status of Working Group (WG): Data Access and Usage – Data exchange for mine software. WG comprises mining companies and system/SW companies. ~ 2 years work to date.

Challenge: The mining industry needs a shared open format for 3D data to allow users to easily move clean and accurate 3D information between applications => OMF

"The tools need to support the user, not the other way around"

Data transfer between packages needs both data precision and data validity, so data model is valid in both packages. Aim is to support all 3D mining objects.

OMF v1: ready now; can be downloaded from GMSG website. Objects are deconvolved into geometries + Data

OMF v2:

- Test V1. For example, a demonstration between Deswik and Leapfrog – using OMF to move models easily in both directions between packages
- Engage users for better understanding (current phase)
- Iterate towards V2 based on above. (happening over next 12 months)

Python library generated for Leapfrog and C# library generated for Deswik – both now published on GMSG website.

User challenges presented and discussed in presentation; won't all be able to be addressed in OMF, but good to be aware.

CALL TO ACTION:

1. WG need to know where to focus – request submission of issues for inclusion in SOW for V2
2. Empower users to request features and encourage adoption by vendors

Questions:

1. Exchange of data between packages. OMF V1 is ACSII-based, so file sizes (e.g. LiDAR) will increase further?

- Andrew – format is compatible with streaming, so can be compressed – such issues have been considered already.

2. Checking validity of data models after transfer?

- OMF vs1 doesn't address this yet.

3. Will OMF make packages such as Gridmesh redundant?

- Yes

4. Will OMF be able to work with IREDES?

- OMF may not be able to address, as the IREDES is more prescriptive as not based on simple geometries

5. Can geotechnical information be included?

- Yes, the WG welcomes anyone with such data and input

6. Plans to include other data formats such as C++ and Binary file formats?

- Yes, binary file formats will be considered. No plans to include C++ at this stage. Use of C# and Python driven because Deswik and Aranzgeo are doing the work

7. Were other file formats from outside the mining industry considered?

- Andrew – discussions on this started ~ 2 years ago; all major software and mining companies were involved. Specifications sheet

drawn up; looked at existing open formats and future trends. Reached a decision point to proceed to developing V1 rather than keep researching existing formats. Other open source codes are possibly more applicable for the data rather than going back to fundamentals.

8. Did you look at going to voxels?

- Yes. Part of decision to start as ASCII based is so it can be visible to all. WG can now review development of other paths that users more familiar with

9. Any plans to have example files made available (e.g. case study of mine, roads etc.)?

- Andrew – yes that will be part of it, but is being developed within a parallel WG. Will include example of block model, pit shell, U/G. Same people working on both projects. Barrick has donated some data to this including different types of operating environments. Also currently trying to get data from closed mines.

10. Benefit to do integrated API real-time (rather than export and import?)

- Yes, definitely future way to go.

Andrew noted that most these questions were raised at the initial workshops, so encourages people to go to website and review the background discussions and SOW

Failure is not an Option: How Mining can Learn from a Century of Aviation Interoperability

Jeff Walsh (Principal Architecture Lead, Global Mining Vertical, Amazon Web Services)

Aviation has a long history of interoperability. Aviation safety is a 3 way relationship between owner/operator of plane, mechanic and pilot.

Pilots who are training on 1 type of plane, can then fly the same plane for any company throughout the world, plus similar plane types (due to interoperability in systems and training). Training is generally undertaken on simulators – most training is focused on abnormal or emergency situations. Mining can learn from this style of training.

Jeff recommends that mining industry prioritizes getting data formats sorted; rather than focus on new technology.

A few examples:

1. All planes tracked by radar – global standard since 1960's. New standards developed in 2006 which is being legislated around the world
2. TCAS system – aircraft automatically decides how to avoid collisions. Link and communicate to each other. System has been around for ~ 30 years
3. Common data formats for weather. Pilots can access and understand weather from anywhere. Then enables opportunities for development of technologies to utilize this standard information (e.g. Apps)
4. Many different suppliers of aviation equipment, but all have to conform to standard formats and are interoperable
5. Hardware also same size – have to fit standard space on instrument panels.
6. Approach charts – all standardized and the same layout globally

Standards bodies – 3 main ones (ICAO, ARING, RTCA) have been around for 80 – 100 years. GMSG can learn from them

Questions:

1. Difference between industries in regulation and compliance – did this drive interoperability

- Yes; government is less prescriptive in mining and mining is also more commercially sensitive. O&G has progressed in last 20 years to be more open and supporting interoperability

2. Argument in mining – too many standards and regulations stifle innovation

- Still get innovation in airspace – planes, equipment, systems. It is good that equipment manufacturers can develop equipment which is standard and interoperable so has a worldwide market

3. Some companies are spending lots of $$ on R&D. Won't this stifle innovation?

- Doesn't seem to in aviation; equipment is essentially plug'n'play. Airline manufacturers are competitive but still develop technology.

4. Issue in mine maintenance – every truck is different so have to check all prior to maintenance

- Legacy problem c.f. aviation

5. What will drive it in mining? (Global + safety => interoperability in aviation)

- Analogy is within a single mine site - making all equipment on the mine able to talk with each other. Start at this scale.

Austmine Co-Lab: Real Time Orebody Knowledge Working Group

Cameron Bowden (WA State Manager, Austmine)
John Kirkman (Managing Director, Enterprise Transformation Partners)
Chris Counsell (Principal Geology, FMG)

Dialogue started at Austmine 2015. 4 co-labs planned

Perth co-lab identified many issues - 1 stood out to generate real business use. "How to track material through Mining Process"

Partners: FMG decided to support as cheaper and faster development as a group than alone. Calculations were that the increase in throughput would give financial payback within a few months. ETP was doing own development but realized good synergies with Austmine co-lab.

Currently in planning phase; project kickoff Oct 2017.

Questions:
Holy Grail: Block Models in Ground -> through mining -> through plant. What is the 1st step?

Base foundation to bring data together – data is in different formats. Starting tracking without dedicated software or hardware (i.e. moving voxels within the model).

Other technical issues – how to demonstrate physical movements

Options:

1. Tracking using lots of real-time sensors
2. Tracking using physics (i.e. prediction of ore movements)

Can then focus on software required, and different ways to collect data (sensors, geochemistry etc.)

GMSG Integrated Operations Working Group: Projects Update and Path Forward

Andrew Scott (presented on behalf of Tim Skinner, who was unable to attend)

3 projects launched for 2017 – 2018

1. Integrated Operations (IO) Research collaboration – survey existing industry knowledge. Presentation slides provide details of work program and key elements
2. IO Business Case Guidelines – possibly developing 3 subcommittees
3. Architecture Reference Framework

People present at the forum agreed that there was value to these projects. One feature that will feedback from these projects will be a better understanding of current skill-gaps in the industry.

Break Out Session on the Connect Mine. How to open up the flow of data and information throughout the mine life cycle.
What are the barriers and challenges to open flow of data across the mine value chain?
See Appendix 2.

Innovation Spotlight: Battery Electric Vehicles Underground

Heather Ednie (GMSG Managing Director)

GMSG – looking for Project Manager for new projects – preferably someone from Perth

Battery Electric Vehicles Underground project was run under Underground Mining Working Group. Guidelines published on GMSG website in May 2017

Timeline:

- May 2016: discussion started between GMSG and CMIC.
  - Many mines moving away from diesel in next few years
  - Focus – cost and safety. Both for vehicles and to address increased costs as Sudbury/Ontario mines going deeper (increased ventilation costs etc.)

- June 28th 2016: First meeting – outlined 5 key areas that had to be addressed. Formed 5 subcommittees with 100+ technical professional (50 companies) involved
  1. Mine design – what needs to be different for battery electric vehicles
  2. Batteries
  3. Chargers
  4. Safety
  5. Work

- Each group was peer-reviewed. Working groups included battery and charger suppliers – open discussion
- September 2016: more workshops globally and then each subcommittee continued to work
- December 2016: First draft. Underground mining group provided feedback; then presented to executive team for publishing
- May 2017: 1st edition published on GMSG website
- Sept 2017: meeting scheduled for steering committee for 2nd edition. Interest in getting standards for chargers also.

Questions:

1. Current issue is the lower energy of batteries compared with diesel.

- Issue was discussed in Working Group. Some solutions proposed – e.g. only haul downhill so trucks self-charge
- Standards structured so can be updated

2. Has there been any feedback from Kirkland Lake mine – operating 35 battery operated vehicles?

- There is a discussion document published online that outlines their pitfalls and solutions

3. OEMS approach? Are they looking to retrofit or a new design (like Elon Musk)?

- Over 20 OEM's. All taking a different approach – entire spectrum looking at modifying existing vehicles or entirely new design

Introducing MM-ISAC, Collaboration to Improve Security in Mining and Metals

Andrew Scott (Senior Director, Innovation, Barrick Gold)

http://www.mmisac.org/

GMSG's role in this initiative is to be aware and provide support.

Linked with ISAO (Information Sharing and Analysis Organization) and ISAC (Information Sharing and Analysis Centre. ISAC is an industry specific ISAO – 32 other groups that can collaborate if required.

Background: Recent cyber-attacks on Canadian mines; ransoms being paid. MM-ISAC looked at current state and future risks – such as whether more automation will increase exposure (full reliance on sensors, more networks

Core programs of MM-ISAC:

1. Information sharing - as soon as 1 company is hacked, then this information is distributed to all member companies
2. Incident response – learn from each other

Secondary programs:

3. Training – how to respond (only training) and practice threats
4. Operational Guideline Development
5. Research (2018) – secure deployment of new mining technologies

All companies will get hacked – essential to be prepared with systems and processes

Open to all companies engaged in mining or metals sectors. Must agree to Community Norms – must actively participate to provide bi-directional sharing of threat information

Started in 2017 – still looking for members. USD $25,000 / year

Questions:

1. Any pushbacks from mining companies on data sovereignty grounds?

- Yes some; MM-ISAC also provides some assistance to liaise with legal issues

2. Disclosure of board when company hacked?

- Have to report if a material change. Critical for the company to understand the impact first and ensure critical systems are protected
- Proactive – recognize what is critical including environmental risks (e.g. leaking from tank systems with tanks filled with contaminated material)

3. Is there a place for ethical hacking?

Case Study: Barrick Gold's Veladero iROC

Stef Pienaar (Integrated Operations Specialist, Global IO)

Veladero mine, Argentina (Barrick Gold and Shandong Gold). iROC installed in San Juan 350km from mine. First remote Mine Operating Centre developed in the country. Veladero is 4500m above sea level - ~40% productivity due to altitude

iROC enables:

- greater visibility and real-time information across the project
- enables cross-functional meetings

Other benefits anticipated:

- increased productivity
- happier and healthier workforce due to lower altitude
- access to more skilled workforce in San Juan

Workplace design considerations – collaboration, human factors, transparency, flexibility

March 2017 – temporary iROC centre commenced– mine, crusher, process and maintenance control
Dec 2017 – full iROC anticipated

Production impact after iROC when live:

- Loading queue time – decreased 26%
- Crushing queue time – decreased 32%
- Ore-bin queue time – decreased 41%
- Truck productivity – increased 13%

All product changes have resulted from improved situation awareness and regular performance-based collaboration.

Future – improvements in technical optimization

Anticipate 6 months payback on iROC (will be paid back before formal go-live date of December)

Questions:

1. How long to get truck productivity improvement?

- 3 – 4 months (March to July)

2. What level of training required in iROC?

- They leveraged knowledge from IO Global. Key is to understand what skills are actually required – bring new people in, retrain others
- Employed Centre Superintendent with range of new skills, not just mining (reported directly to the GM; same level of Mine Superintendent)
- Took supervisors to see other centres – then specific training and education

3.Communication link between site and centre

- Currently a microwave link – is affected by snow
- Fibre-optic line installed to Pascual-Lama project on Argentina-Chile border. Line stops ~ 12km from Veladero mine so reviewing how to extend this

Short Interval and Real Time Control: A New Joint Guideline. New GMSG project

Andrew Scott (presented on behalf of Tim Skinner, who was unable to attend)

New GMSG project – also with CMIC (Canadian Mining Innovation Council)

Innovation driven by collaboration – strong desire for increased control and automation in mining (pushing first into underground).

1. Produce guideline outlining current best practises for short interval and real time control
2. Provide a roadmap
3. Foster new technologies

Challenges:

- Expertise is global so difficult to coordinate
- Broad subject – need to be focused
- Rapidly evolving technical and business process changes (2nd edition of guidelines being planned from the outset of project

Questions:

1. When is 1st workshop?

- 21st September in Toronto. Business Sweden is organizing.
- Focus will be to set context, create framework and vision, getting companies to share existing knowledge and own user stories

2. One example of short interval and real time control?

- Biggest impact in an established large underground operation
  - understanding all tasks, all people and equipment resources (e.g. ventilation shafts).
  - As tasks executed, can monitor and assess delays and how to deal with them (e.g. drill breaks down and blocks shaft). Instant reassigning of resources
  - Often mines only review this at end of shifts and may take multiple shifts to correct and recover from
- Using a manual process achieved ~40% improvement in a mine in 2015.
- Rename project to be SHORTER interval – if have a weekly plan, then any time less than this is shorter interval

3. What is stopping people from implementing this if is a known problem?

- In some cases, trialled approaches didn't work, so project shelved. Generally related to individuals – is they leave then that knowledge may leave
- Dependency on people in leadership roles
- Need to review both how to put these processes/systems in place and then sustain them.

4. Installation of new sensors into Mine?

- Yes – potential to enable and support new technologies to assist. However often measurements are already existing but not used. Requires sharing of information

Information Overload: API Architectures for Driving Better Decision Making

Andrew Dent (Client Architect, MuleSoft)

MuleSoft is working in adjacent or enabling industries – utilities, financial services, building
API = Application Programming Interface

Disruption is impacting many industries; disruption to mining is a longer term agenda. Hasn't really happened yet compared with other industries (taxis, shopping etc.), so have time to plan.

It is part technology but mostly attitude.

e.g. Earth AI – AI for mineral exploration.
Gathering data (Automated collection of raw data, processing and database creation) -> neural networks -> selling as a service

Questions:
1. Can API's be reused? Find API's that other companies don't need?
- Consumer technology. API's are exposed, but enterprise market different and choose relevant partners.

Chain of Custody: Towards Use of Block Chain to Revolutionize the Mining Industry

Andrew Scott (Senior Director, Innovation, Barrick Gold)

Idea from leadership council –not yet a working group.

Chain-of-custody can help mitigate risk, as well as drive differentiation to unlock value. Primary drivers are regulatory compliance, transparency and ethical sourcing.

Block chain:
- Distributed ledgers (globally)
- Good for chain-of-custody – could it reduce time for permitting? (providing a trust platform)
- Also applicable throughout mining process. Impact and uses?

E.g. Uber-like automatic cargo hire process – hire the ship automatically and register the contract in a distributed ledger system. Potential to simplify cross-border payments and regulatory compliance.

Next steps:
1. Current scope proposal documents is with executive council for comment/approval
2. If sufficient interest, then form a working group

Questions:
1. Ethical sourcing? How will block-chain assist in scenario of payments/bribing to governments?
- Can't stop conflict, but block-chain can make is more visible

2. Two different issues: Trust is less of an issue within a mine; Outside – trust more of an issue
- This is a risk. Are we trying to force technology to fit the problem or finding a problem to fit the technology?

3. Tenements, JV agreements – sometimes difficult to track especially if in different business silos. Can lose tenements.
- Block-chain could provide mechanism for ownership independent from government control
- Developing a stable tenement system could be a significant factor in choosing exploration areas.

DAY TWO WRAP-UP

Key highlights of the Forum:

1. Aviation interoperability is impressive; applicability into mining?

2. Important to have a plan and communicate in a common language so have a common understanding. "Sticky tape and string first -> then technology"

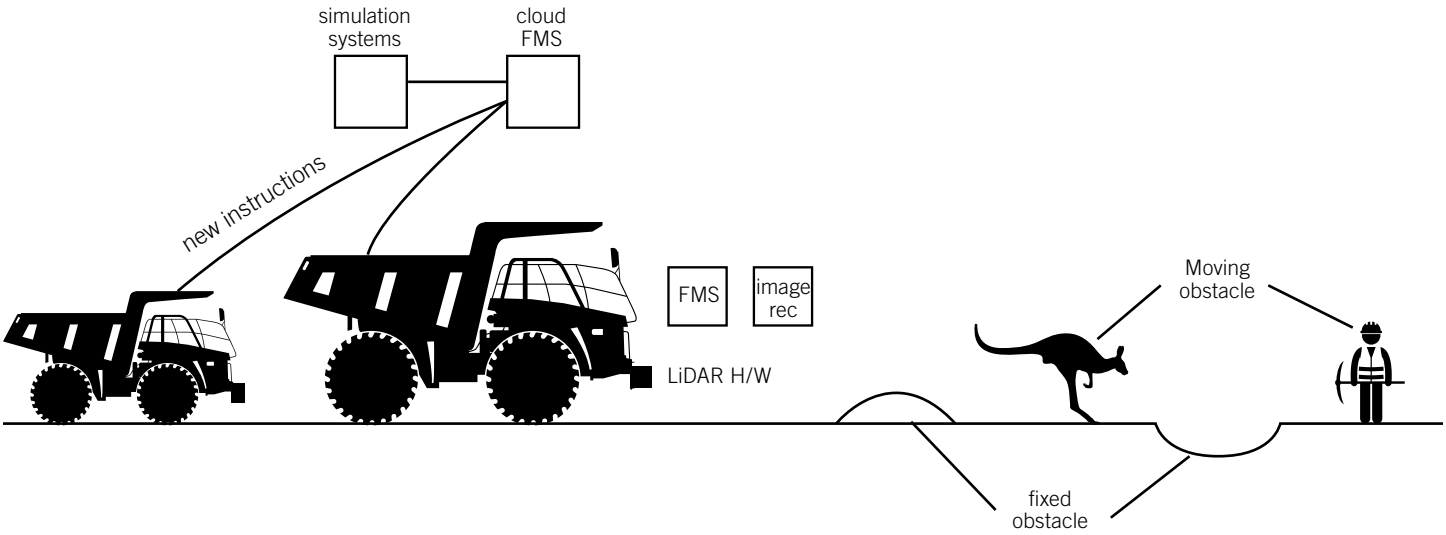
INTEROPERABILITY USE CASE / SCENARIO #1

Obstacle Avoidance

Contact: Andy Mulholland (DS)

An autonomous haul truck approaches a new obstacle and needs to react and avoid:

- LiDAR seamer (HW) scans and finds a new geospatial feature
- Image recognition software on vehicle identifies unknown feature e.g. pothole, rock, fallen berm etc
- Onboard RMS sends feature data/information to cloud simulation application (or a human)
- Simulation software determines new execution instructions
- Cloud FMS sends new instructions to entire fleet of trucks
- Truck continues with new route/driving strategy



VALUE/IMPACT:

1. Productivity increase – faster haulage cycle
2. Increased safety

INTEROPERABILITY USE CASE / SCENARIO #2

Mine Site Collaboration

Contact: Sonia Turner, Scope Systems (0434 303600)

Current issue: Silos of mine site roles and systems (planning) do not communicate efficiently. And if so, it is via Excel.

Bring together, from the mine plan, drill plan, contracts, KPI's via a fully integrated software platform all the plans and subsequently all the actuals of a mine site from geology, survey, engineering, management and GM to contractor.

VALUE/IMPACT:

1. True material movement and reconciliation
2. Increased productivity
3. Less data rework
4. Improved communication between the silos
5. One version of the truth – data integrity

INTEROPERABILITY USE CASE / SCENARIO #3

Data Sharing Across Corporate Boundaries

Grant Newham

- Data Sharing
- Problem Solving
- Good communication
- No I.P. infringement

VALUE/IMPACT:

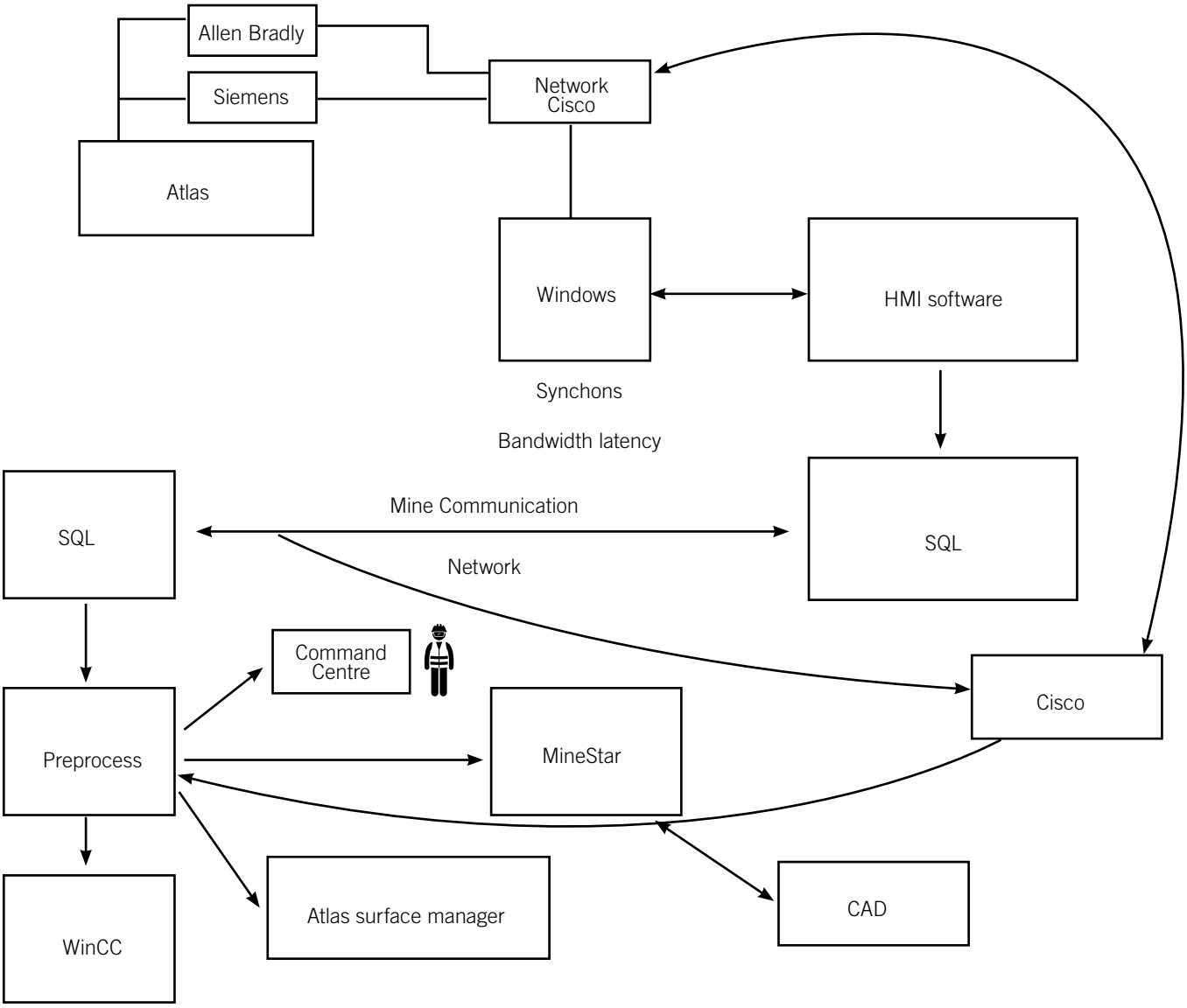
1. Faster / quicker implementation and improvements
2. Time saving
3. Zero harm
4. Reduced cost across industry
5. “Win win” scenario

INTEROPERABILITY USE CASE / SCENARIO #4

Drill Integration

Craig Spark

The ability of multiple systems to work together in a system to solve a problem or provide a solution.



VALUE/IMPACT:
Network = Interoperability

INTEROPERABILITY USE CASE / SCENARIO #5

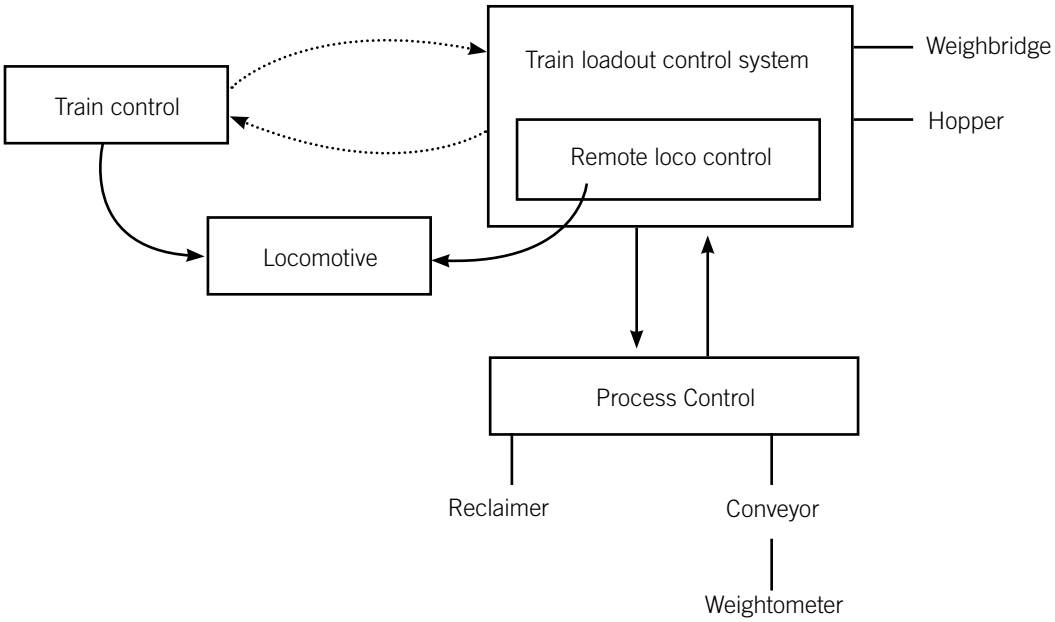
Train loadout control

Wayne White-Smith

Train Control System hands over control of train to SCADA / Remote Control

- Hopper level
- Reclaim rate
- Speed on conveyors
- Speed of train

Adjusted to maintain optimal weight of ore in railcars. On completion of train load, control is handed back to train control



VALUE/IMPACT:
Correctly loaded ore cars

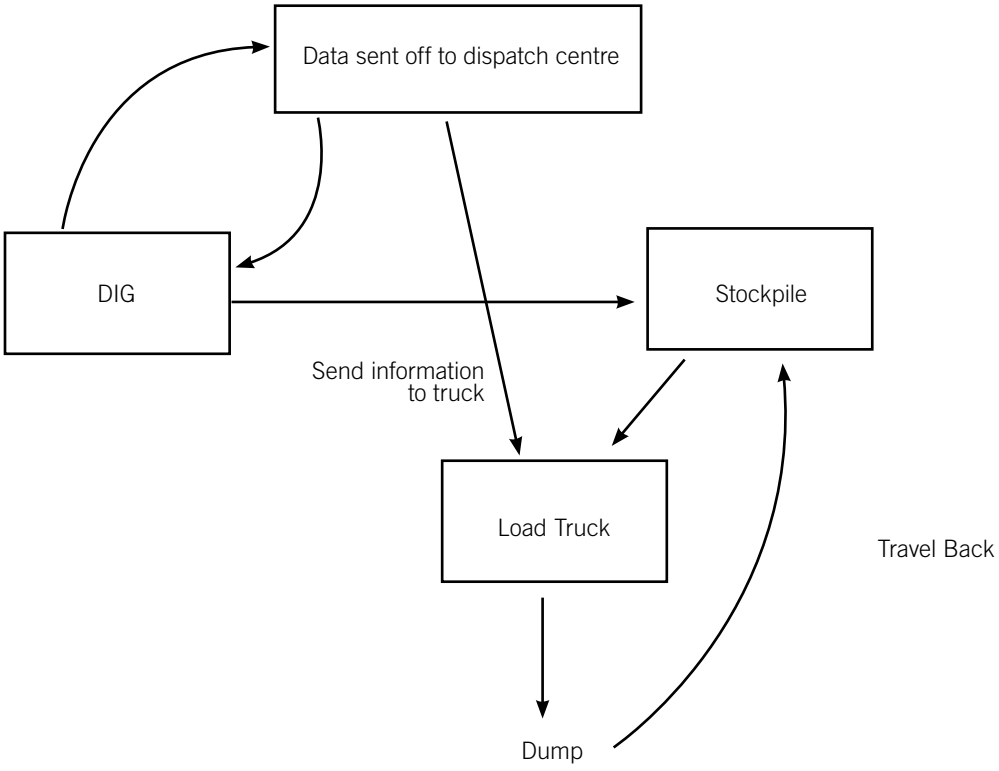
INTEROPERABILITY USE CASE / SCENARIO #6

Increasing Productivity with Knowledge of Stockpile Availability

Brian Toomey

Real-time information of stockpile is sent to the dispatch system. Production data from loader (in a standard format)

Dispatch system use that information to optimize the schedule of trucks; in order to minimize digger and truck wait time



VALUE/IMPACT:

1. Have the option of a mix fleet
2. Increase productivity and efficiency by decreasing idle time
3. Less fuel burn when machines are idle

INTEROPERABILITY USE CASE / SCENARIO #7

RAC – WA. Bus talking to V2V and V2 infrastructure

Jayne Kato

As a:	Autonomous Vehicle
I want to:	Communicate with infrastructure systems (traffic lights, SCATS, pedestrian crossing)
So that:	I can make optimized decisions about my environment

As a:	Autonomous Vehicle community
I want to:	Demonstrate reliability and safety through interoperability with infrastructure system
So that:	Prove value to community through safe and reliable operation

VALUE/IMPACT:
Bring along regulators to change regulation => promote investment

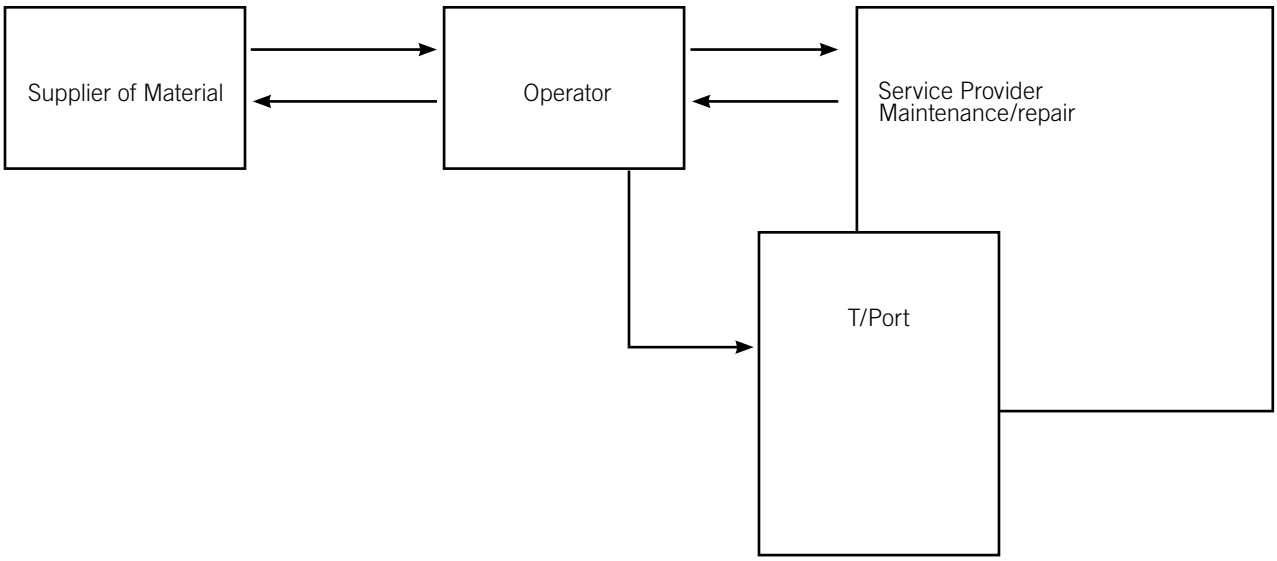
INTEROPERABILITY USE CASE / SCENARIO #8

Across Organization Boundaries Integration

Bonnie Ryan - GSI

Enabling end to end life cycle tracking of materials

Traceability / product authenticity



VALUE/IMPACT:

1. Open data standards for interoperability
2. Reduced cost of integration
3. Improve data quality
4. Accelerates development
5. Cheaper and quicker

INTEROPERABILITY USE CASE / SCENARIO #9

Simulation based short-term mine planning

Marc Rheinlander

Integrate live feeds from equipment and geoscience acquisition – into a 3D terrain and geology simulation to enable high fidelity simulation of the short-term mine plan and iterate through potential scenarios.

Real time geology, hydrology

Real time positioning and state of equipment

Real time weather information

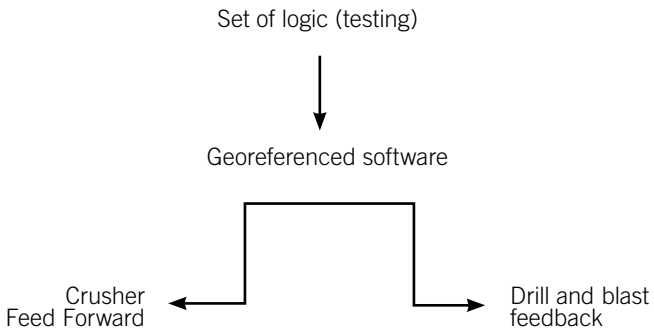
VALUE/IMPACT:
Optimise the short term plan with a view to maximize safety and minimize cost

INTEROPERABILITY USE CASE / SCENARIO #10

Excavator Talking to Crusher. Big Rocks and Tune the Plant

Dig rate; fragmentation, rock breakers
Detection :

- Strut pressure
- Vibration sensor
- Vision
- LiDAR



VALUE/IMPACT:
Less downtime; increased productivity; decreased cost

INTEROPERABILITY USE CASE / SCENARIO #11

Sensor Data for Use on Different OEM Equipment

Damien Roberts

- Using a range of sensor hardware to measure the immediate physical environment
- Data from the sensors are processed/analysed and used with other systems
- Data from the sensors can provide some level of autonomy so output needs to be integrated with machines from multiple OEMS
- Integrating across multiple sub-systems from different manufacturers
- Interoperability between data processed on-board mining equipment and the mine-site FMS
- LiDAR

VALUE/IMPACT:

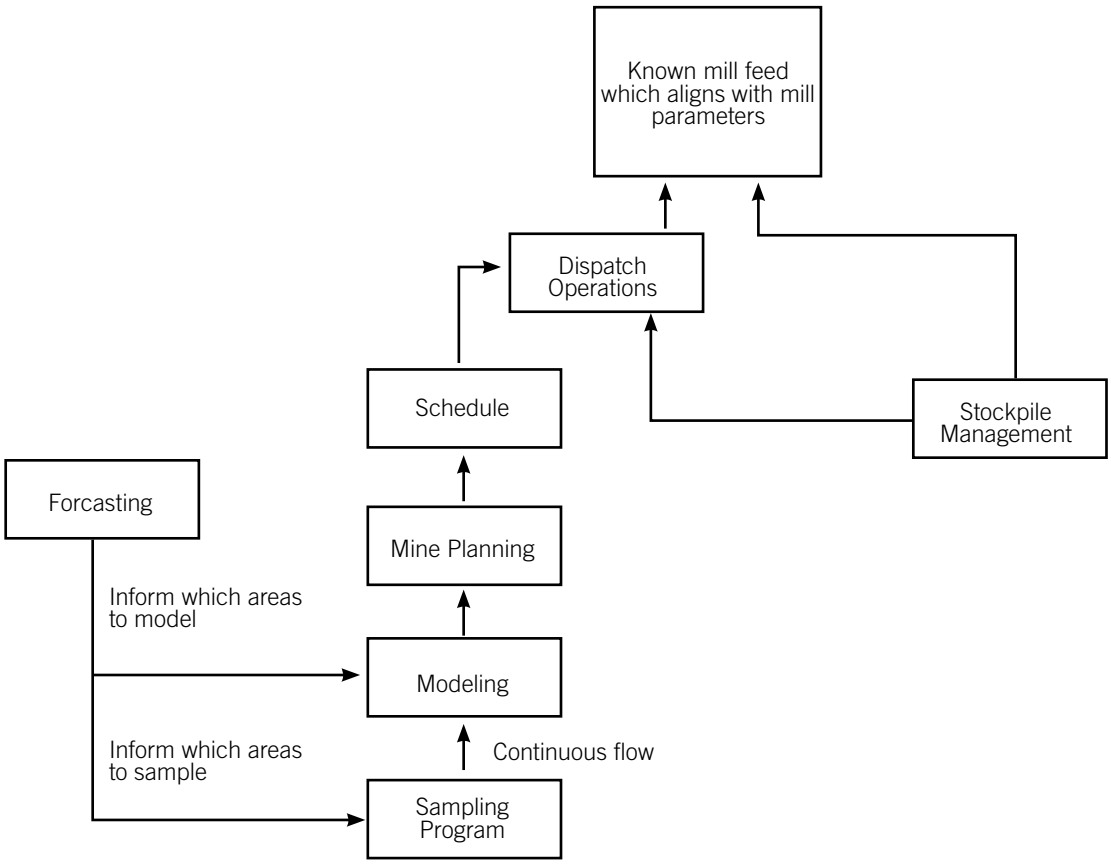
1. Take data from a wide variety of sensors to increase knowledge of the mining environment. This will allow data analytics to extract new knowledge
2. Flexibility in purchasing mining equipment
3. A more centralized and cohesive solution in terms of monitoring / management

INTEROPERABILITY USE CASE / SCENARIO #12

Application of Rapid Resource Knowledge

Steve Mundel

Objective – reduce variability, and create certainty with what is being delivered by the mine



- Small decisions that get the extra 1 – 2% out
- Allow decision to be made with the most recent knowledge

VALUE/IMPACT:

1. Reduced variability in mill feed
2. Greater certainty for decision making
3. Making full use of the resource knowledge / understanding
4. Breaking down silos of blinkered decisions which have downstream effects
5. Reduced reconciliation requirement w.r.t net balance
6. Improve recovery / mill performance

INTEROPERABILITY USE CASE / SCENARIO #13

Material Heads Up

David Prance (Trimble)

Objective: Making material quality / type or stratigraphy data available in a real-time scenario to downstream processes (e.g. Crushing, milling, plant)

Outcome: Allows downstream processes to act rather than react to changes in material make-up or quality

VALUE/IMPACT:
More efficient use of downstream process consumables (e.g. power/mill/etc)

INTEROPERABILITY USE CASE / SCENARIO #14

Integrated Work Plan for Supervisors/Crew

Paul Moynogh

Integrate all work sources into a single plan such that all work on-site is “planned work”.

- Prioritise tasks
- Standardise:
  - location
  - Equipment ID’s
  - Volumes
  - People
  - Skills
  - Time/shifts
- Logic / coordinate
- Responsive to the changing workplace -> self-learning / correcting
- Feedback -> management system (PDCA) -> machine learning

VALUE/IMPACT:

1. Improve productivity and safety
2. Less waste
3. Less variation
4. Auditable -> control data
5. Continuous learning

INTEROPERABILITY USE CASE / SCENARIO #15

Autonomy for Everyone

Anthony Kirk

- Lower cost, broad application of autonomy
  - Open standards
  - Move to independent supervisor systems
  - Third party developed truck / loader software
- Data standard – bring back to standard database

VALUE/IMPACT:

INTEROPERABILITY USE CASE / SCENARIO #16

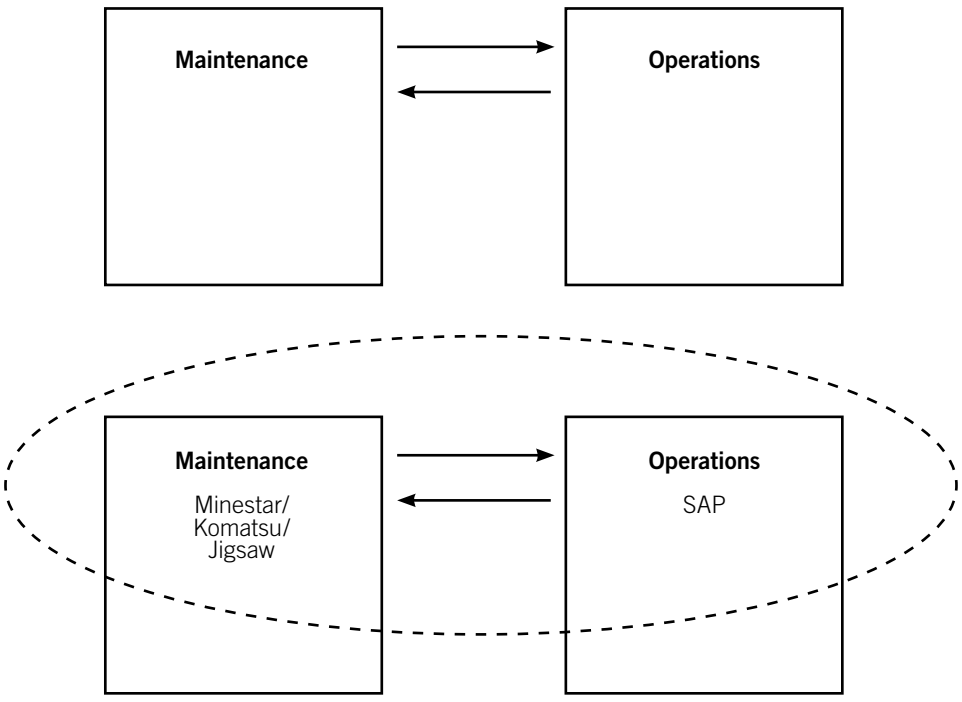
Integration of Short-term Maintenance with Operations

Mark Austin

- Planned maintenance aligning with production shifts
- NEED MAINTENANCE TO TALK TO OPERATIONS
- Need a standardized method of transferring information

PROBLEMS:

1. Short-term planning does not integrate with long term planning
2. Operations does not know what maintenance is doing and vice versa
3. Solutions between operations and maintenance are generally proprietary



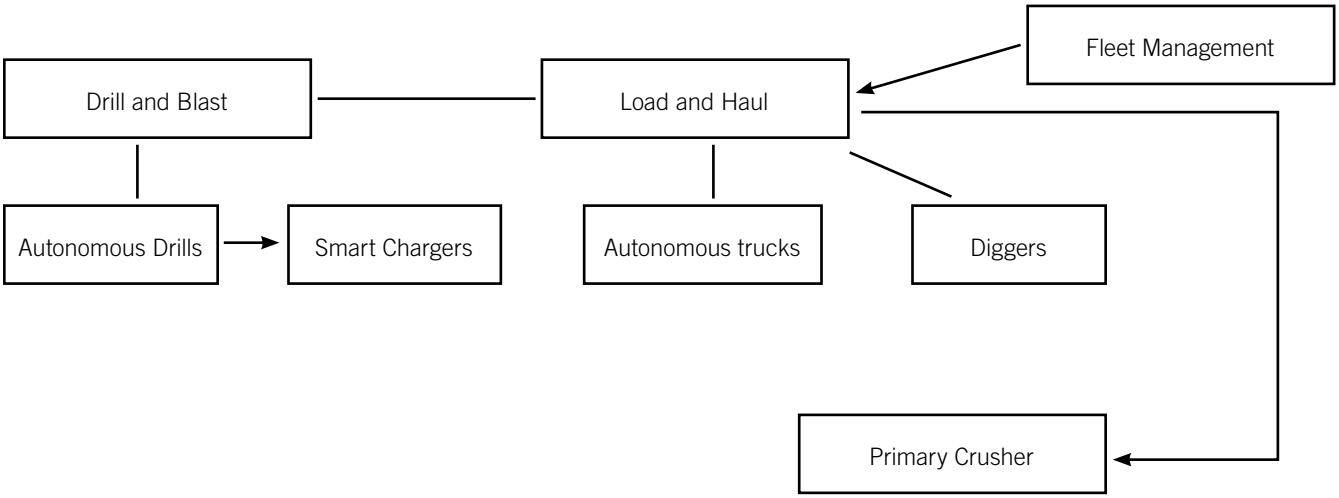
VALUE/IMPACT:

1. Increased safety
2. Better decision making
3. Improved productivity
4. Lower costs

INTEROPERABILITY USE CASE / SCENARIO #17

Autonomous Journey

Steve (Minetek), Caris (Rio), Mark (Donhad)



Autonomous drills:
- Over drilling elimination
- Cost reduction
- More predictable / less variability
- Reduce drill down-time
- More operating hours
- Ore body information / rock competence
- Improve next process
- Improve drill rostering

Smart chargers (Blast):
- Integrate drill knowledge
- Software
- Reduce explosive consumption
- Cost reduction (explosives)
- More predictable
- Fragmentation improvement

Autonomous trucks:
- Cost reduction
- Productivity
- Improvements
- More predictable
- Optimisation of haul routes / mine planning process

Load and Haul:
- Productivity of digger
- Dilution control
- Management of truck
- Fleet management
- Pay load of rucks
- Pay load management

Primary crusher:
- Predictable
- Through put improvement
- Fragmentation
- Cost reductions

VALUE/IMPACT:

Mine planning:
1. Reduce operational cost for drill and blast
2. Reduce operational cost for load and haul
3. Increase productivity of primary crusher
4. Potential elimination of stops in the process

ABSOLUTELY NOT

> Human / development silos
> Old systems and technology don't make it easy
> No infrastructure/framework in place
> Data volumes
> Volume of data being transferred between remote sites
> Opens up your org to additional risk
> Data spill/cyber hacking
> Hardware/software communications
> Connections across the mine
> Cellular connectivity
> Lack of tech savvy
> Data time stamps/languages
> Departmental ownership of systems
> Better job of making data smaller
> Lack of leadership/"the why"/purpose/align people
> Multiple disparate systems
> Intentional disconnect
> Culture "I don't want to share my data"
> Humans (behaviour that stops flow when making decisions)
> Comms infrastructure
> Culture/emotional aspect (just the way it's always been)
> Silo & business units with differing KPIs requiring different data sources
> Every mine is different with different processes/methods/strategy, even within same company
> Too hard to change from old systems and tech
> Integrated systems
> Personal vs management knowledge of different systems
> Language/literacy/skill levels (training)
> Not safe to ask questions (how can we learn to get big picture)
> Human personalites & ambition (making ones' mark)
> Different priorities (likes/disklikes/ways of completing things)

MAYBE

> Common data storage (lack of)
> Software vendors
> Clearly articulated statement of the problem/opportunity
> Proprietary "ownership" of legacy systems/
> Multiple vendors/systems
> Standards/backhaul/communication costs
> Security protocols
> Ensuring the integrity of the data
> Data security (eg geologist and engineer sometimes can't see the same data)
> Connectivity & infrastructure to exchange data
> IP protection and ownership
> Unaligned/inconclusive KPI's
> Integration is expensive
> Old school view on "Competitive Advantage"
> Lack of platform thinking
> IT/OT disconnect
> NS vs DS, NQ vs site

SHOULD

> Lack of R & D tools to promote collaboration (bring together different groups)
> Mining co activities are geographically dispersed using unconnected groups
> Connected groups to finance, legal, regional offices and sites
> Vested interests
> Different efficiency requirements
> Poor communication
> Zero innovation culture
> Not willing to sacrifice functionality for conformity
> Fear of unknown
> Security of process control systems
> Bottom up design rather top down system of working/systems
> No standard format
> Data management
> Lack of automated processes
> IP ownership
> Proprietary systems
> Remove barrier to vendors (CAT/KOMATSU)
> Owning IP that stalls integration to an autonomy suite
> Different schemas
> Data formats
> Conservative defensive mindsets (I win, you lose)
> Who pays?
> No buy in from customer or supplier
> Need to be able to ask better questions (not answers)
> Bust silos and cross pollinate
> Vendor disparity or disconnect
> Limit of data volumes which are most relevant to your problems
> Interoperability - not just file formats but how it moves
> "New world" systems that hit industry stalwarts
> Lack of custody of ore body knowledge (phased project changing teams)
> Incompatibility of inputs/outputs
> Establishment of data standards (and compliance to these)
> Consenus on data standards
> So much choice of platforms & tech on the market, it has fragmented it
> Change paranoia (people)
> Specialized systems per function with no common interface
> Proprietary rather than open software interfaces & other data inputs (equip)
> People specialized in silo
> Lack of leadership (management)
> Who owns data inside company? Who can sign off?
> Technology interoperability to remove silent info and allow holistic approach
> Consenus on problems to solve
> Infrastructure and constraints
> Too much data (storage, comms systems)
> People fear losing their information power (won't share)
> 1st to be 2nd philosophy
> Communication systems

ATTENDEE LIST

Bookers Membership Name	Attendee	Job Title
ABB Enterprise Software	Jonathan Maher	Sales Manager Mining Systems
	Ralf Eckart	Manager Mining and Minerals
acQuire Technology Solutions	Stephen Mundell	Director
	Mark Rheinlander	Research Consultant
Airobotics	Nitzan Beck	Marketing Manager
Amazon Web Services	Jeff Walsh	
AMC Consultants	Damian Peachey	Equipment Selection Engineer
API Management	Roger Nottage	Study Manager
	William Wu	Mining Engineer
	Robert Beeck	General Manager
ARANZ Geo Aus Limited (Leapfrog 3D)	Karl Howley	Regional Director - Asia Pacific
Atlas Copco Australia Pty Ltd	Adrian Boeing	Automation Manager
AusIMM	Chris Davis	Director
Austmine	Christine Gibbs Stewart	CEO
	Helen Warner	Conference and Events Manager
	Martin Collard	Business Adviser
	Cameron Bowden	WA State Manager
Banlaw	Andrew Page	Regional Manager - WA - SA
Barrick Gold	Andrew Scott	Senior Director, Mining Information Technology
BHP Billiton	Chirag Sathe	Principal Risk & Business AnalysisÂ Technology
Calibre Global	Chris Inie	
Commit.Works (Fewzion)	Mark Austin	Global Sales Director
	Paul Moynagh	CEO
Dassault Systemes	Tony Nykiel	
	Andy Mulholland	GEOVIA Portfolio Management Director
Deswik	Jayne Kato	Senior Consultant
DHI Water and Environment	Cornelius Strydom	Managing Director
Donhad	Mark Butterfield	Manager
	Noor Crookshanks	Director - Sales & Marketing
Draeger Safety Pacific Pty Ltd	Satiesh Muniandy	
Enterprise Transformation Partners (ET Partners)	John Kirkman	CEO
	Simon Chalmers	Senior Consultant
Esco Holdings	Warren Sands	IT Client Services Manager
Esri Australia	Craig McDonnell	Senior Consultant
Flanders Electrics	David Besing	
	CraigSpark	Field Engineering Manager
	Tyler Parke	Software Engineer

Fortescue Metals Group	Anthony Kirke	Group Manager - Operations Planning
	Christopher Counsell	Manager Geology
Freo Group	Grant Newham	
GCS (Global Communication Services)	Grant Huxtable	Branch Manager
Glenn Wylde	Glenn Wylde	
Global Integrated Operations (Global IO)	Stef Pienaar	Business Development Director
GMSG (Global Mining Standards and Guidelines Group)	Heather Ednie	Managing Director
	Tim Skinner	President
	Anne Still	General Manager, Public Policy Advocacy and Member
	Elizabeth Stroud	Director
	Helen Anderson	Communications
GS1	Bonnie Ryan	
IBM Australia	Michael Alberghini	Client Technical Advisor - Natural Resources
Imdex (Reflex Instruments)	Michelle Carey	Integrated Solutions Manager
	Dave Lawie	Chief Technologist and Chief Geoscientist
Intertek Genalysis	Frazer Fallens	Business Development Manager - WA
Joy Global Surface	Renier Koekemoer	Product Specialist - Rock Drills
METS Ignited Australia	Peter Clarke	General Manager
Micromine	Julian Lim	Pitram Technical Product Manager
Mine Vision Systems Australia (MVS)	Damien Roberts	Managing Director
	Paul Lucey	CEO
Minerals Research Institute of Western Australia (MRIWA)	Anil Subramanya	Research Portfolio Manager
Minetec	Steven Rodgers	Business Development & Bid Support Executive
	Alan Fenelon	VP & GM Business Development
Mining Technicians Group Australia - MTGA	Toan Vu	
Mitacom	Chris Doran	Director
MuleSoft	Andrew Dent	Enterprise Architecture/Product Design
Newcrest Mining	Gavin Wood	Chief Information and Digital Officer
Orbiz	Peter Walker	Director & Performance Specialist
OSIsoft Australia Pty Ltd	Peter Carter	Industry Principal - Metals & Mining
PETRA Data Science Pty Ltd	Alex Atkins	Chief Operating Officer
R-Group International	David Martin	Business Development Manager
Remote Control Technologies (RCT)	Brian Toomey	Research Development Manager
	Tim Tran	Analyst
	Brendon Cullen	Automation and Control Product Manager
Resolution Systems Pty Ltd	Kim Eales	Mining Specialist
Rio Tinto	Cristobal Jeria	
	Peter Day	Principal Mining system
	John Mulcahy	Manager Innovation and Operational Systems

Roy Hill Holdings Pty Ltd	John Myles	
Schneider Electric	GregJohnson	
	Anthony Wong	Global Mining, Mineral Processing & Metals (MMM) Segment Business Leader
Scope Systems	Sonia Turner	Client Executive
Sentient Computing	Scott Dumaresq	Business Development
Sitech	Brad Dalton	Business Development Manager
Steve Craig	Steve Craig	
Tamryn Barker	Sophie Hancock	Skills Catalyst
Telstra	Drew Kenney	Regional Manager WA / SA / NT
TikForce	Grant Thomas	Group Sales Manager
Tim Graham	Tim Graham	
Trimble Mining	David Prance	Director of Business Development
	Maurice Behn	Manager Product Development and Operations
Unearthed Solutions	Holly Bridgwater	Industry Lead - Crowdsourcing
Visagio	Wilson Casado	
Wayne White-Smith	Wayne White-Smith	
Zitron Australia	Steve Broadhurst	Sales Manager - Mining
	Javier Fernandez Lopez	Managing Director