Visual information management, integrated across the mining value chain

Paper

Abstract

From forward planning to operational control, mining businesses need information; preferably visual information so all stakeholders understand the realities of the business in the same way. Operational personnel specifically, can see their mine with their eyes closed. Others either do not carry the same picture or have no picture at all. Real time, spatial visualisation of fully integrated mining technical datasets is not only useful but is now a reality. This integrated world enables revolutionary new possibilities in information management, such as rapid creation of mine design options and linking technical and commercial datasets for routine modelling of business alternatives.

This paper will highlight recent innovations in all these areas with examples of proven concepts and operational practice.

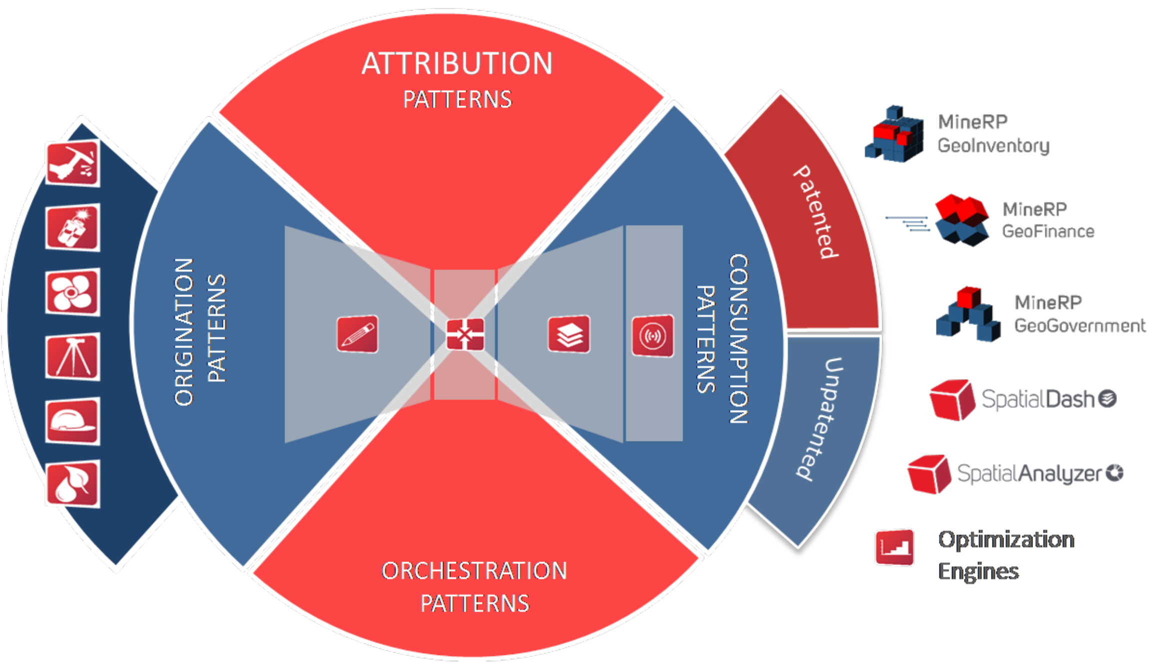
Mining Needs Information

If proof is required of the fact mining needs information we need only consider the complex and complicated world of reporting. A web based search [1] in 2013 identified 323 mining technical applications from 91 vendors, all creating data, and typically offering some form of reporting. The numbers continue to grow; this landscape is evolutionary in nature and not as yet systematized.

In addition to the initial creation of data (origination) about all the things related to mining disciplines, there is a continuous need to add further supporting information (attribution) as mining activities are executed. Information gleaned by one discipline will be needed by another in the value chain. It could simply be a routine transfer of information or require something more urgent to generate corrective action. These are forms of work flow (orchestration) which can be made faster, or indeed automated, in the digital world of information management. Finally, there is the need to provide sometimes daunting amounts of data for routine business and further analytical purposes (consumption).

The following diagram illustrates these information management patterns in the context of integrated mining business information. In particular, it is the consumption of data where the greatest business value is generated. Its full value foundation however, is integrated information across the mining enterprise.

Having integrated information is all very well but miners think in pictures. Check the walls of any production supervisor's office; they are lined with plans, cross sections and cut-away views of the operation in standard colours, and with useful annotations. Digitally, we are data rich but information poor. We need information, typically available in the form of a written report but preferably in the form of a picture. This progression can be summarised as follows; any business question will tell you what data is required to resolve it. That data is transformed into information and presented in the form of a report. A report is thus an answer to a business question but a report can be a picture.



Miners Think in Pictures

There are more than 20 [2] identifiable core and support professional disciplines with many more if we sub-divide geotechnical and engineering disciplines. They each have something to say about if, when, where or how an ore body should be mined. They all tend to live in their technical silo but all need to exchange information and collaborate with their peers and colleagues. This exchange can be accommodated if all the data is amalgamated in one database and available for both written and visual reporting. Such a database exists, using space as the index (MineRP SpatialDB), and complying with Open Geospatial Consortium (OGC) standards for the storage of spatial data.

The visual reporting landscape has several requirements for 2D, 3D, online sharing and information reviewing. Visual reporting or more specifically spatial reporting then varies from simple interactive published views to full dataset interaction and query ability for an analyst:

SpatialPublisher

A lightweight browser hosted 3D viewer for a predefined and selected snapshot of the dataset at a specific date and time. The tool takes into consideration the users may want to access these snapshots from different devices and locations, and pre-processes the dataset and view so the receiving device only does minimal processing. Data sent across the network is minimal, allowing a user with very weak link, to view and interact with the datasets, both spatial data as well as attribute data.

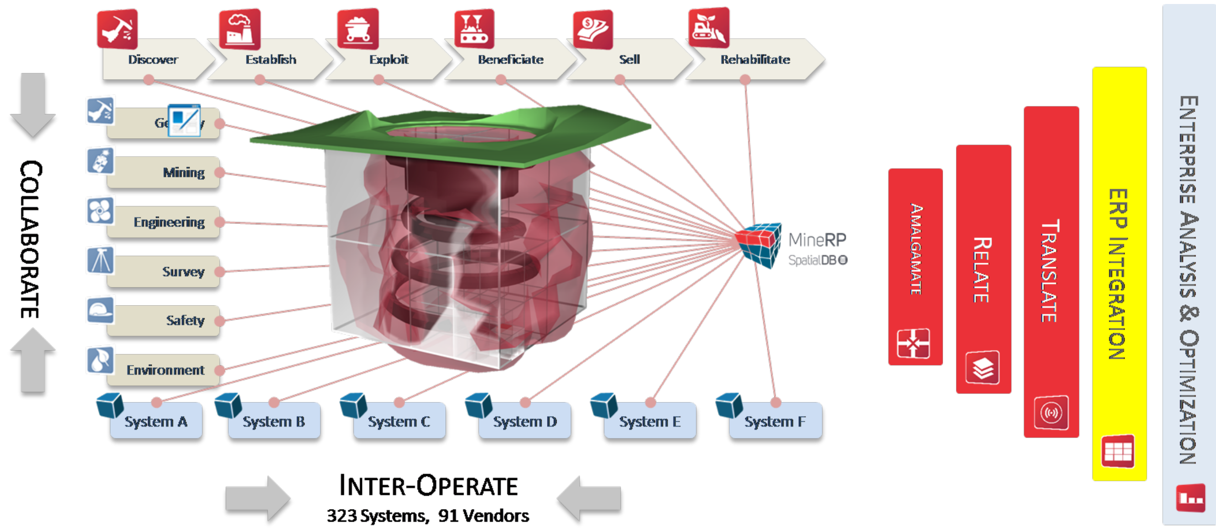
SpatialDash

A browser hosted Spatial Dashboard to display GIS like datasets and connected to other GIS data services, graphically displaying Key Performance Indicators. The Dashboard has basic drawing capabilities used to either place new geometry data points or as a spatial querying mechanism. The user has full interaction with the dataset in both Raster or Vector formats and full access to the published attribute dataset. The Dashboard not only hosts the spatial data, but also has comprehensive heat-mapping capability and a full set of graphs, filtering and sorting capability.

SpatialAnalyzer

A 3D spatial analysis desktop tool capable of dealing with large data volumes and doing 3D Boolean operations and analysis on the available datasets. With the 4th dimension of time, the analysis tools can slide through time and play the scene as it has developed over time. This sliding capability is also applicable to any of the other attributes associated with the geometries. A host of analytical capabilities exist, including exposing and utilizing the spatial operations available in SpatialDB.

With these spatial information management tools, the technical silo-based data sources are all made available for answering business questions in such a way that everyone gets the same picture, thereby understanding business problems in the same way. The environment is thus provided for more creative, participative, well-informed business decisions.



Framework for Integrated Mining Information Management

JJust as long lasting buildings need good architecture, so the digital world needs information architecture. One aspect of this is the structural design of shared information environments. Making sense of mining information requirements however, can only be done with mining domain knowledge. We can borrow from other industry experiences and many international standards and best practices but application must cater for the specifics of mining methods, terminology and value chain.

The table below is the foundation of a working model systematizing the mining data landscape. Having firstly separated out all the unique terminology of the CAD and data management worlds, we can focus on the mining world and its information requirements in detail. At the coarsest level of detail, all these requirements can be accommodated in just six categories, each with a formal definition, providing mutually exclusive containers for the information required across the value chain of the mining business.

Category	Definition
Natural Environment	All the information we gather before we change it by mining activities. Can include information from geological exploration activity and any other prior land use activity.
Built Environment	All the information on design and construction of the man-made buildings and structural facilities of use to the business of mining. All objects in this category are spatial objects.
Available Means	All the information about functional items and services at the disposal of those who build and operate the mine
Product	All the information about value added results of tasks throughout the mining value chain. Can include classifications of solid rock or broken material or goods as they move through the mining and metallurgical processes and delivery to customer. Products may be spatial, positional or general objects.
Stakeholders	All the information about people, their groupings and alliances associated with the mining venture
Documents	All the written, printed, or electronic matter providing information or evidence or that serves as an official record of planned and executed mining business activities.

In summary, Documents are all the things we can print out on paper and Objects are all the things we can make copies of with a 3D printer. People cannot be duplicated.

Proven Concepts in Operational Practice

Anglo American Platinum

Anglo American Platinum's Project Fast Forward [3] is focused on standardizing mining information to achieve the production of safe, profitable platinum. It provides an integrated set of modern planning tools and software platforms to make mine planning and management more efficient. Individual workplaces are managed proactively and transparently, meeting the need to grow beyond an existing fragmented approach.

> "The accuracy in production forecast increased significantly from a 30% variation to less than 3%, which creates a huge amount of credibility for the team"
>
> *- Frik Fourie, Head of Mining -*

Measurable outcomes include planning based on half level optimization, with the integration of MRM tools, for short- and long-term planning. Human resources terminology, rules and reporting have been standardized for more coordinated performance management, and crew performance is routinely measured with teams able to determine their bonuses. These outcomes are all founded on the timely delivery of reliable information.

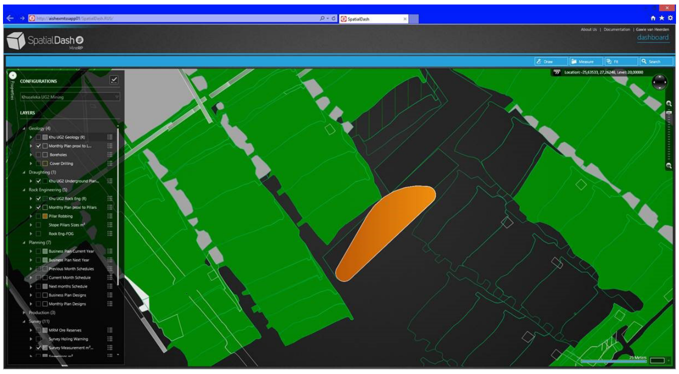


Figure 1 - Planning in Close Proximity to Pillars

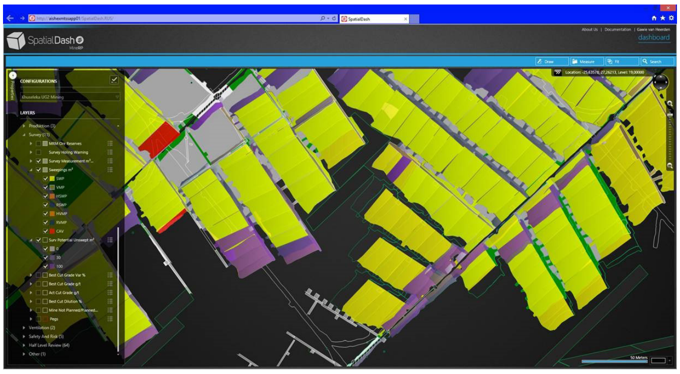


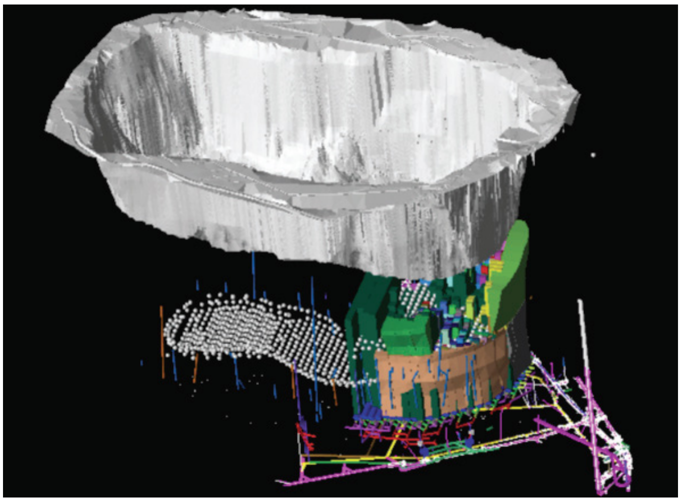
Figure 2 - Potential unswept m² indicated in variations of purple depending on volume (m²). Other sweepings completed indicated as per ledged

Petra Diamonds

Some of the challenges facing the current operations include routine production and project performance and managing capex but also interdependencies of mining and infrastructure. Additionally, there is a constant search for opportunities for profitability and cost control all within strict legal requirements.

A project was initiated [4] to create a structured and integrated 3D SpatialDB platform for the mine technical systems landscape to provide information from implemented solutions and manage the flow of information between systems and across disciplines.

The initial implementation of this spatial information management system covered 18 production and project KPIs from 11 source applications and reporting tools (including that most popular mining technical application, Microsoft Excel). The end result is a basis for decision-making with regard to the optimization of operations and improved information management.

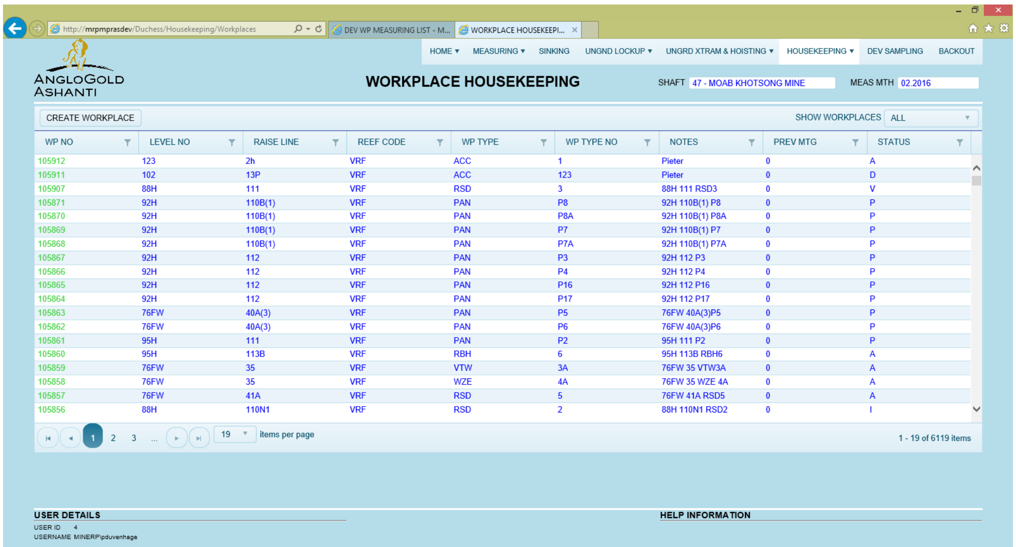


The benefits of the approach are focused on better management of mineral resources, and analysis of production performances with augmented decision making on Sites and by Group management. Such a proactive approach, drawing data from different mining disciplines and business processes would be far too complex and time consuming without the SpatialDB platform. A similar proactive approach to hazards management is based on trending data/early alerts, reducing delays in reporting of key business

AngloGold Ashanti

AngloGold's business critical Mining Production Actuals System (MPRAS) currently running on a mainframe is due to be decommissioned in Q1 2017 after three decades of service. A small group of users have access to this centrally driven system and interfaces, receiving data from and feeding various external databases including a corporate data warehouse.

It will be replaced as an intranet web application on a more cost effective and easily maintained Microsoft platform, running in parallel to a MineRP-in-1 deployment to upgrade existing mining technical systems. Thus data source and processing will change but strictly in accordance with AngloGold specific business rules for required information. The picture below is a screen shot example of the type of information and standards applied in the process of upgrading accessibility and usability of a business critical dataset.



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105907	88H	111	VRF	RSD	3	88H 111 RSD3	0	V
105871	92H	110B(1)	VRF	PAN	P8	92H 110B(1) P8	0	P
105870	92H	110B(1)	VRF	PAN	P8A	92H 110B(1) P8A	0	P
105869	92H	110B(1)	VRF	PAN	P7	92H 110B(1) P7	0	P
105868	92H	110B(1)	VRF	PAN	P7A	92H 110B(1) P7A	0	P
105867	92H	112	VRF	PAN	P3	92H 112 P3	0	P
105866	92H	112	VRF	PAN	P4	92H 112 P4	0	P
105865	92H	112	VRF	PAN	P16	92H 112 P16	0	P
105864	92H	112	VRF	PAN	P17	92H 112 P17	0	P
105863	76FW	40A(3)	VRF	PAN	P5	76FW 40A(3)P5	0	P
105862	76FW	40A(3)	VRF	PAN	P6	76FW 40A(3)P6	0	P
105861	95H	111	VRF	PAN	P2	95H 111 P2	0	P
105860	95H	113B	VRF	RBH	6	95H 113B RBH6	0	A
105859	76FW	35	VRF	VTW	3A	76FW 35 VTW3A	0	A
105858	76FW	35	VRF	WZE	4A	76FW 35 WZE 4A	0	A
105857	76FW	41A	VRF	RSD	5	76FW 41A RSD5	0	A
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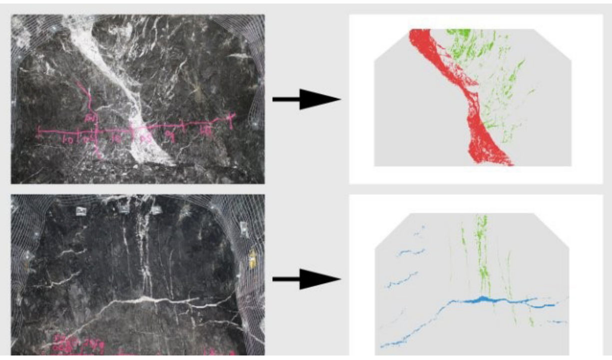
Figure 4 - Example screen shot of the type of information and standards applied in the process of updating accessibility and usability of a business critical dataset

GlassTerra

The GlassTerra [5] platform has been built from the ground up to handle petabyte scale geospatial data. It works seamlessly with the 100+ mining industry specific proprietary formats, with browser based visualisation and interaction to and from a cloud storage platform. In late 2015, GlassTerra successfully teamed up with Unearthed to run an online competition for Goldfields in Australia. The goal of the competition was to find a way of turning photographs of the face in a drive into a grade estimate.

In another use of the platform [6], the New South Wales Government Geological Models, whilst always open to the public, have been put up in parallel with the GlassTerra platform. Downloads from the traditional site have not dropped but this new mechanism has further accessed a customer base which previously ignored the publicly available information. The State's mineral potential is thus promoted in a highly visual and interactive way to potential investors and miners.

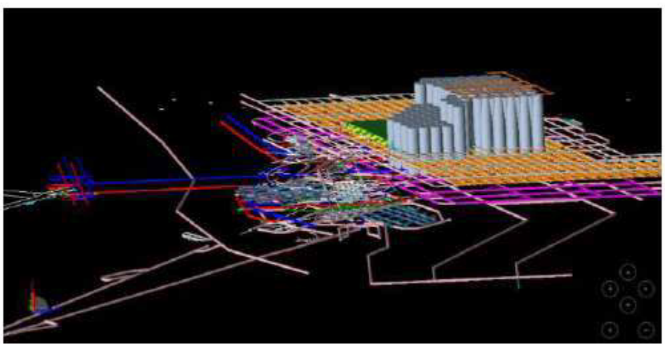
This project is part of GlassTerra's vision to provide anyone in the mining industry with easy access to geospatial data, in any location, at any data size.

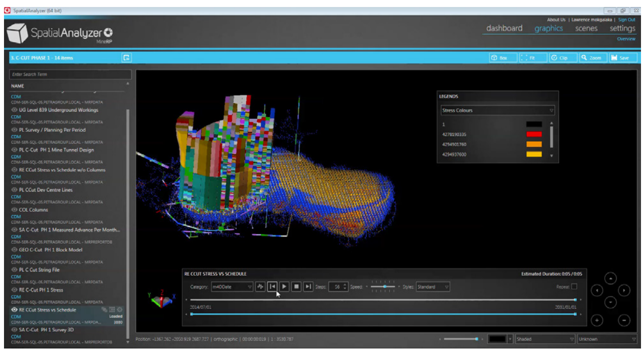


Codelco's El Teniente

At the Minexcellence 2016 conference, this paper [7] makes the point that an integrated mine system must be capable of displaying and reporting valuable information so it can be used to easily understand, manage and take action on the key parameters being reported. One such requirement is the viewing of scheduled mine developments, enabling quick validation of the construction program and analysis of specific periods of time as required.

The screenshots below are a 3D, multi-source compilation of the entire project and a stress analysis resulting from the planned mining schedule.





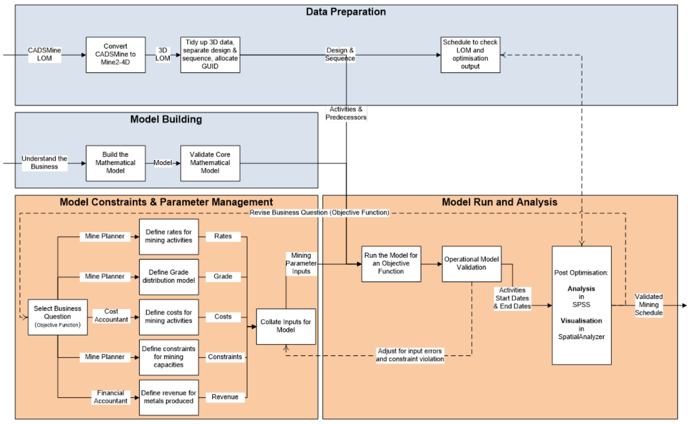
The point is made in the paper that photogrammetry of underground development is a key technology successfully being used in Teniente mine and vital for the use of other mining applications oriented to improving integrated mine planning.

The Revolution has begun

This digital world of integrated spatial data has opened up revolutionary new possibilities in mining information management and business decision making. Access to data means tools long available to other industries can be brought to bear for analysis and optimization. New initiatives have taken root for rapid creation of mine design options and linking technical and commercial datasets for routine modelling of business alternatives. That same linkage enables integrated control of operations and a new business agility, all in 3D.

Analysis and Optimisation

Depending on who you speak to, the word 'optimisation' is used in many different ways [8], all seeking improvements to the bottom line of the business. Such attempts are often reduced to 'picking the best option in the time available' due to the typical time constraints for decision-making.



Various analytical processes from routine reconciliations to mathematically provable optimisations have always been hindered by lack of access to data. Having overcome these limitations, previously tedious, time consuming or impossible to analyse mining problems can be tackled with confidence. The right tools have long been available to other industries. The right mathematicians, harnessing mining domain knowledge and given unobstructed access to integrated data are able to structure mining scheduling problems for effective use of available tools and computing power. With the ability to visualize the resultant schedule in 3D animation, mining logic discrepancies are immediately visible [9] to the mining professional and will identify any input datasets requiring adjustment. The diagram above illustrates the combination of mining and mathematical procedures for the execution of successful optimization exercises.

MineRP Planner

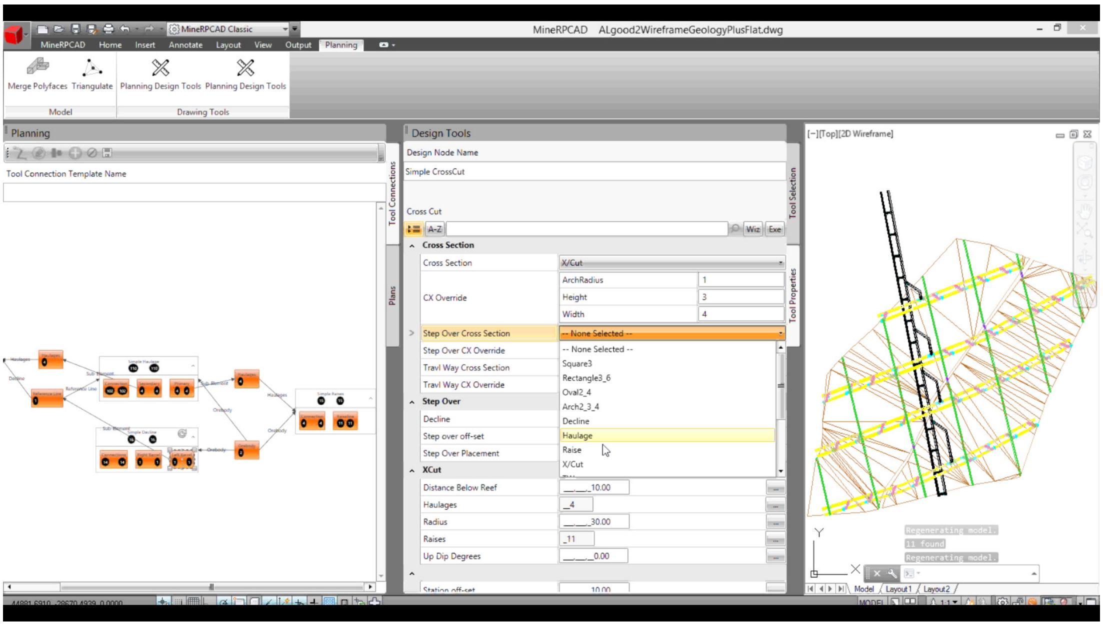
Template Aided Design capabilities with tools specific to each mining method and orebody type allow for the fast generation of mine design alternatives for evaluation, scheduling and final selection at any level of planning detail.

Removing the rule-based workload for the mine design process fundamentally improves design time and sets the scene for enterprise planning across the mining value chain. In beta testing, using a relatively complex geological model, a competent mine planner generated 9 designs in 31 minutes!

Within this initiative, three levels of planning can be identified:

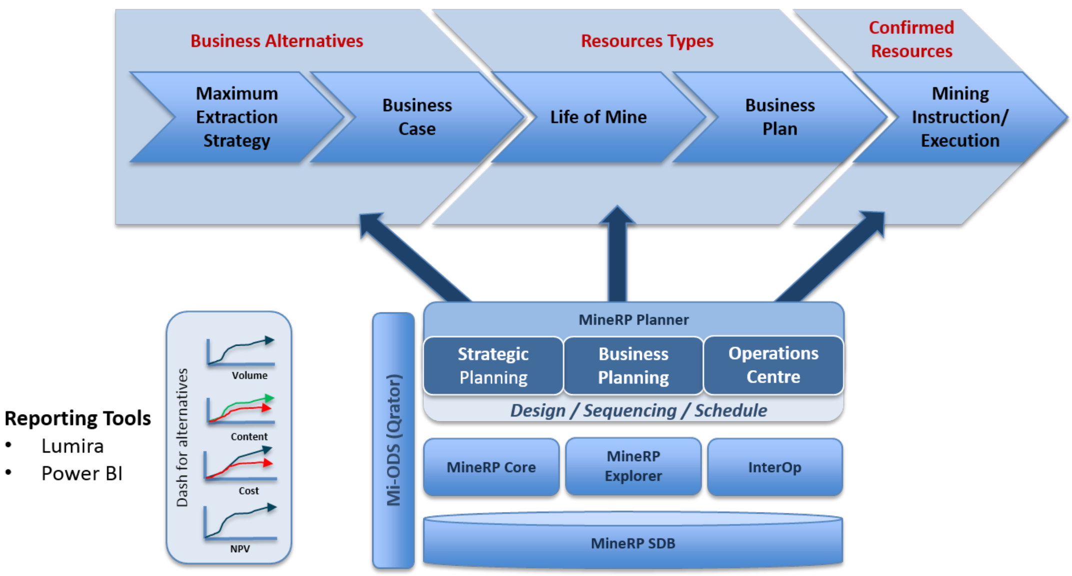
- Strategic Planning: where an extraction strategy is yet to be determined and the necessary resources are modelled only by type e.g. will I move rock via truck or train?
- Business Planning: where resources and other capacities are levelled to their budgeted constraints, resulting in target setting for operations e.g. how many trucks of what type?
- Operational Planning: where resources are directly allocated to tasks and the relevant time frame is determined by the longest resource lead time e.g. which truck and driver allocated to which task in this shift?

At the coarser levels of detail, the mine planner is interested in alternatives for comparative purposes. At the finer levels of detail the mine planner sets the basis for operational control.



There are significant consequences flowing from the ability to do such rapid planning:

- Firstly, the ability to create rapid mine design alternatives provides mines with a reliable means of testing appropriate long and short term responses to changing market and physical conditions at every level of planning detail
- Secondly, having created a long term plan in this way, it can be seamlessly augmented with medium and short-term detail, without losing the context of the original strategic plan nor having to re-create the plan in order to add more detail.



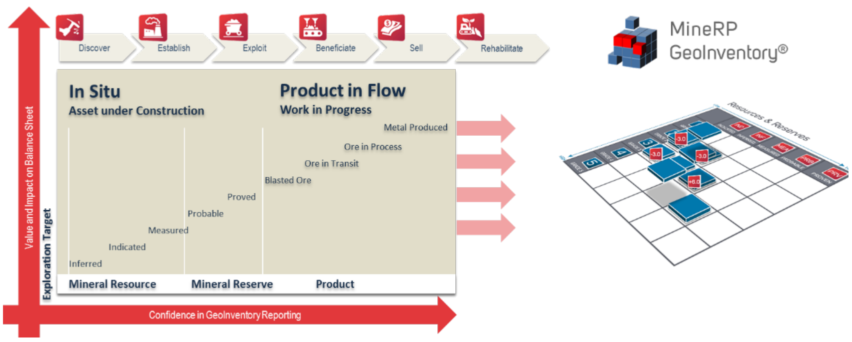
GeoInventory

Mining companies are very often vast organizations, with information required from many, varied data sources. This reality creates the demand to integrate mining technical and commercial datasets. While commercial Enterprise Resource Planning (ERP) solutions have largely succeeded in the integration of the supporting business functions, such integration is much harder to achieve in the mining technical disciplines, where fragmented specialist systems are still the norm.

Amalgamating and integrating big volumes of fragmented, siloed mining technical datasets into a spatially-referenced, standards-based mining technical database leverages the ability to process big volumes of data in an efficient manner. We can now continuously translate the effect of mining activities on the state and status of the mineral asset, into standard stock management transactions for processing in standard inventory management systems.

The resulting Mineral Asset Inventory provides mining companies with a range of business-critical optimization opportunities including real-time, reliable resource and reserve reporting in compliance with regulatory codes, as and when required.

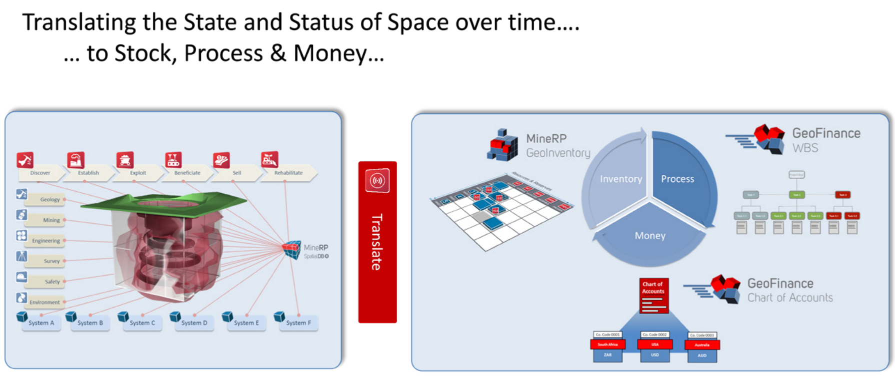
The diagram illustrates the impact of mining activities on the classification of resource and reserve and subsequent interpretation as material inventory based on measures of confidence and value.



GeoFinance

Executives ask questions spanning both technical and commercial domains, yet these domains are not adequately integrated. The major reason for the lack of integration is the misalignment in the granularity at which mining activities are managed in these domains. This has dramatic implications for the accuracy with which mines are able to manage enterprise schedules, cost, production forecasts and many other business critical elements.

Building on the GeoInventory approach, the vastly different process and data domains of 'science of mining' and the 'business of mining' are aligned by allowing mining tasks to define a work breakdown structure (WBS) at a level of detail suited to operational control. This is then reflected in the cost code structure and chart of accounts thereby bridging the gap between mining technical and commercial datasets.



GeoFinance enables granular alignment between the levels at which costs and revenue are managed, delivering reliable area and activity-based costing as well as resource management, mine planning and scheduling decisions based on financial, market and economic business constraints.

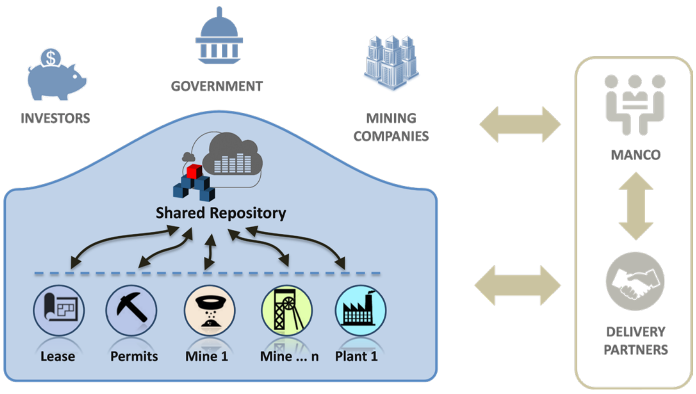
GeoGovernance

Many nations wish to leverage mining to develop other sustainable industries and human capital for long-term national development by establishing a control system to align all stakeholders with the overall objective and related laws, policies and guidelines.

A proposed solution is available for automation of Governance processes and creating a trusted source of information underpinning the management of mineral resources as an asset, from exploration to rehabilitation.

A spatial knowledge base is used to amalgamate mining information from multiple mining systems to enable inter-operation between stakeholders and within Government. Integrated process automation and workflow capabilities enable ad-hoc queries and manage structured processes, such as applications to prospect and the filing of governance reports.

The solution empowers a Government to become pro-active managers of national development and a responsive economy able to adapt rapidly to changes in demand and commodity prices.

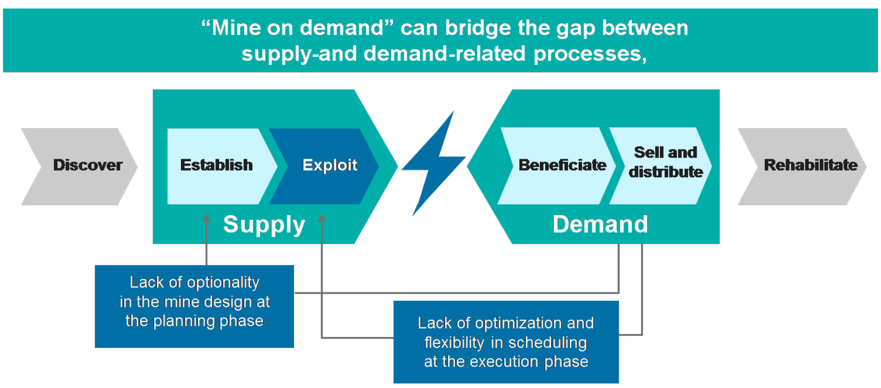


IBM's Mine on Demand

The "Mine on Demand" [10] methodology for optimal agility and productivity is a combination of end-to-end integrated business processes and advanced technologies that can eliminate the silos across organizations. Together, these processes and technologies enable mining companies to more rapidly respond and adapt to shifts in market demands and prices whilst also optimizing their financial performance

These outcomes are achieved through optionality in mine design including how the ore reserve will be exploited and optimization and flexibility in scheduling allowing linkages between market demand and mining operations. Ultimately, the goal of "Mine on Demand" is to bridge the gap between supply- and demand-related processes, big data, analytics and integrated enterprise systems, combined with effective business processes.

The "on demand" principle has been implemented in other industries and can be implemented effectively in mining. Providing the optionality in the design and scheduling phases of mine planning can result in improved productivity and the flexibility to respond in a timelier manner to changing market and operational conditions.



Bringing Information to the Virtual Age

With the rise of Virtual Reality as a viable technology it has been a challenge for companies across the software and hardware development spectrum to determine the best way to leverage this technology in their field. It has been difficult to find practical applications of this abstraction of the real world, with the novelty factor quickly wearing off.

A sustainable solution for mining will not only give the user a novel view of their environment but also make critical data available in an interactive manner. With the amalgamation of all the various mining spatial data into a single database, the information now becomes easily accessible for the development of Augmented Reality solutions, mixing or blending virtual reality and real life.

In the example to the right, a plan view of a mine design is used as a reference layer and using a smartphone, we can now view the mine in 3D in relation to the mine design. This allows a user to interact with the design in a way never before possible.

In the same way mobile applications operate on many different mobile devices, Virtual and Augmented Reality solutions need to become platform agnostic. Spatially amalgamated mining information can now be exported natively into a development engine allowing for the seamless and quick creation of Virtual and Augmented Content.

By focusing on the information at hand, and letting the users select what they need to see, we can leave the question on how they wish to see it up to them, regardless of the device they chooses to use.

Conclusion

Mining stakeholders of all types now have access to highly visual, integrated 3D information from data sources across the mining value chain. This availability means everyone gets their perspective on the business but can also share the same picture, thereby understanding business problems in the same way.

The digital world of linked technical and commercial datasets revolutionises mining information management from routine modelling of business alternatives to operational planning and control. It also creates the opportunity to apply tools long available to other industries for analysis, simulation and optimization of the mining business.

The technologies are available and working for a new business agility based on more creative, participative and well-informed business decisions.

References

1. Real IRM. A Mapping of Current Vendor Solutions to the EMMM Business Capability Model. April 2013
2. Open Group Exploration Mining Metals and Minerals Forum. Exploration and Mining Business Process Reference Model. v1.01, February 2013
3. Anglo American Platinum Limited. Project Fast Forward, Integrated Production Information Review 2015
4. Mokgalaka, L., Langenhoven, J. & du Toit, R., Progress update on Petra Diamonds' MTS 3D SpatialDB Integration and Reporting Project. Southern African Institute of Mining and Metallurgy. Diamonds Still Sparkling 2016 Conference, 14–17 March 2016, Gaborone International Convention Centre, Gaborone, Botswana
5. GlassTerra website and blog: www.glassterra.com
6. Geological Survey New South Waleswebsite: https://gsnsw.glassterra.com/
7. Carbonell, P. G., Díaz, C. & Faúndez, E., Mine Planning Information from Photogrammetry Sources in El Teniente Mine. Sustainable Minerals Institute. Minexcellence 2016, 30 March-1 April 2016, Santiago, Chile
8. Southern African Institute of Mining and Metallurgy Journal, Journal Comment, March 2016
9. Woodhall, M. & Strydom, E., Enterprise Interoperability of Mining Technical and Commercial Datasets. The Southern African Institute of Mining and Metallurgy. Mine Planning and Equipment Selection 2015, 9-11 November 2015, Johannesburg, South Africa
10. IBM Global Business Services. Thought Leadership White Paper, Mine on Demand. September, 2015

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English born, Australian bred, South African resident mining engineer. After graduating from the University of Sydney in 1973, worked around Australia for a year and came to South Africa in 1975 (for two years to take a look). Worked on production and projects for Gold Fields, JCI and AngloGold Ashanti until 1998 when he joined GMSI, now known as MineRP. Mine Planning was always a passion, keeping pace with the IT tools of the day and now works in the world of 3D graphics, helping miners and IT personnel alike to understand and visualize the realities of mining.

Empie Strydom, *VP Marketing, MineRP*

Empie's background is in software development in the mining and logistics industries. He joined MineRP in 2001 where he was initially involved in the development of Enterprise Risk Management Solutions before heading up sales and later marketing in 2006. Working as a member of the Strategic Value Creation team, Empie is responsible for go-to-market strategies for the company's spatial enterprise resource management solutions.

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