Enterprise interoperability of mining technical and commercial data-sets

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The mining industry traditionally has a silo-based approach to information management. More than 323 applications from 91 vendors indicate a large and growing body of software with a glut of data and file formats all concentrated on the mining space.

Using an open standard format for the amalgamation of all spatial data from mining's disparate disciplines opens up significant opportunities for cross-discipline information sharing and true enterprise information management.

Using existing toolsets for handling 'big data' (all the mining data) and optimization techniques long available in other industries and now applied to mining, MineRP is closing the gap between mining technical and financial management domains. This has impacts for all stakeholders – production, finance, shareholders, communities, and government alike.

This paper and presentation will highlight the progress achieved and emerging opportunities for sharing information based on data amalgamation.

Introduction

The mining industry's efforts at integratingd information management have long been encumbered by a mining technical application landscape of multiple data and file formats. This is further impaired by an inability on the part of commercial applications such as are commonly included under the umbrella of Enterprise Resource Planning (ERP) systems to match a mining operation's information requirements in both timeliness and level of granularity.

This paper highlights both successfully implemented progress and recently emerging opportunities for sharing information across the mining enterprise based on data amalgamation in a spatial context.

Traditional approach

Stakeholders are as diverse as their mining company origins and the dictates of their specific discipline. Most will have a technical silo-based view of the mining business, which is not necessarily wrong, but potentially incomplete (Global Mining Standards and Guidelines Group, 2015).

The mining technical application landscape is brimming with overlapping and duplicated functionality, constantly under creative development and redevelopment on the back of the continual progression in software and hardware capabilities.

One web search exercise (Schoeman, 2013) identified 323 different mining technical applications from geology to metallurgy, supplied by 91 different vendors. The numbers continue to grow. One consequence is an overabundance of underlying data and file formats. It is not unusual for an international mining company with multiple sites on multiple continents to find half or more of this assortment dispersed across their various operations. All these influences from different parts of the globe for different technical purposes, built up over three decades and more, unavoidably work against any sensible integration standard.

There is, however, a common denominator that emerges from the multidisciplinary data used across the mining value chain: its position in 3D space (Woodhall and Strydom, 2010). The evolution of this understanding is shown in Figure 1.

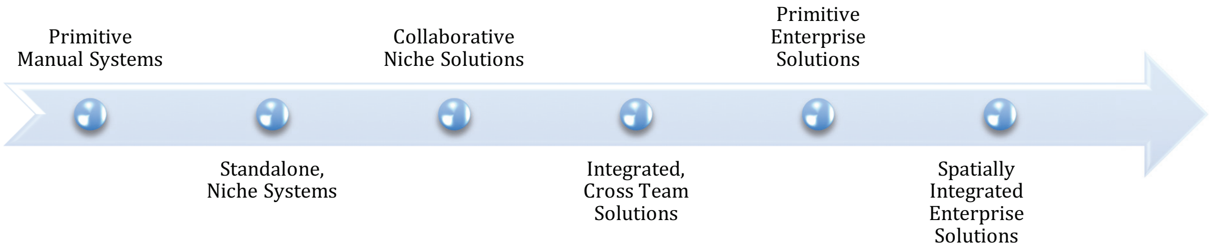

Figure 1 – Evolutionary development of mining technical solutions (Woodhall and Strydom, 2010)

Indexing space as the basis for managing inherently spatial mining data enables amalgamation of all mining technical data-sets from their raw form, whatever the source application. Such amalgamation avoids the chaos associated with attempting to interface or integrate across the multiplicity of existing data and file formats.

Exploiting this feature means 3D shapes such as geological features, planned mining activities, and surveyed excavations can be treated as named volumes in space. Everything else we know from interactions by diverse technical disciplines become attributes of the named volume; this includes not only the technical information itself but also the time and financial aspects vital to the mining business.

For example, a geologist will continuously update his knowledge base and periodically publish an authorized model for use by planners. The database maintains records of who made changes and when, based on the new data. Any updated planning options also have known inputs and unique plan identities, and any approved plan followed by execution has surveyed records of activities and orebody depletions. Ultimately, updated Resource and Reserve statements become both auditable and traceable.

Once all mining technical data has been amalgamated, it is possible to monitor, in real time, any and all interactions with the orebody and translate these interactions into stock, process, or financial transactions readily recognized by commercial ERP systems. This bridges the gap between mining technical systems (MTS) and financial information domains and thus lays the foundation for integrated information management across the mining enterprise, as illustrated in Figure 2.

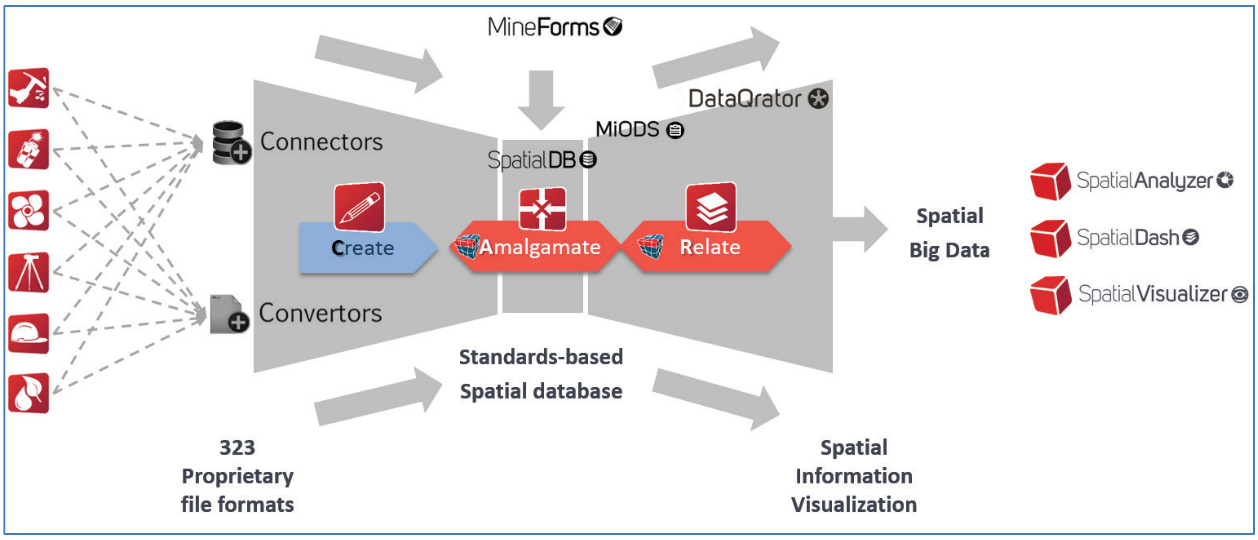

Figure 2 – Amalgamating information for integrated spatial information management

Open standards approach

The unprecedented, insatiable need for more (and more timely) information has further increased the need to standardize the terminology and conventions across the mining industry (Woodhall and Strydom, 2010).[3] This need can be sustainably addressed only through embracing standards both in terminology and approach to information management.

Open Geospatial Consortium (OGC)

The OGC is an international industry consortium of more than 500 companies, government agencies, and universities participating in a consensus process to develop publicly available interface standards (www.opengeospatial.org). Such standards mean complex spatial information and services can be made more accessible and useful to a diverse range of stakeholders.

Because most mining systems will create their own proprietary storage mechanism, systems will not be able to 'talk' to each other or seamlessly exchange data-sets. By applying and implementing the OGC standards, data-sets conform to a standard and can now relate to each other. Objects are spatially aware with regards to position and geographic location, about all things, above the surface of the earth, on the surface as well as underground. It is all about knowing where things are and how they relate so we have a better understanding of the mining world with a combined, integrated data-set.

Open data-sets create trust and have transparency so all organizations, from individual initiatives, small companies, larger companies, universities, and government agencies have an open, standard way of exchanging, sharing, integrating, and interoperating with data-sets and information. This allows for describing data objects, workplaces, activities, and information in a way that all can understand.

Implementation of OGC standards connects people to data, enabling data consumers to ask questions about their operations and areas of interest, giving a complete view of their operations and having the information and answers readily available on smartphones, tablets, and computers, regardless of the complexity of the data-sets or where the data comes from. OGC standards underpin display mechanisms for these different media where all data resides in a single, compliant spatial database.

Open Group

The Open Group (www.opengroup.org) is a vendor-neutral and technology-neutral consortium with members spanning all sectors of the IT community as well as academia and research. Services provided include strategy, management, innovation and research, standards, certification, and test development.

A primary feature of the Open Group is the sharing of best practices via forums, workgroups, and industry verticals. The Exploration, Mining, Metals and Minerals Vertical (EMMMV) is one such initiative. Its members are constructing a reference framework (see Figure 3), collaborating to produce standard models for the mining business of which the Exploration and Mining Business Process Reference Model was the first product (see Figure 4).

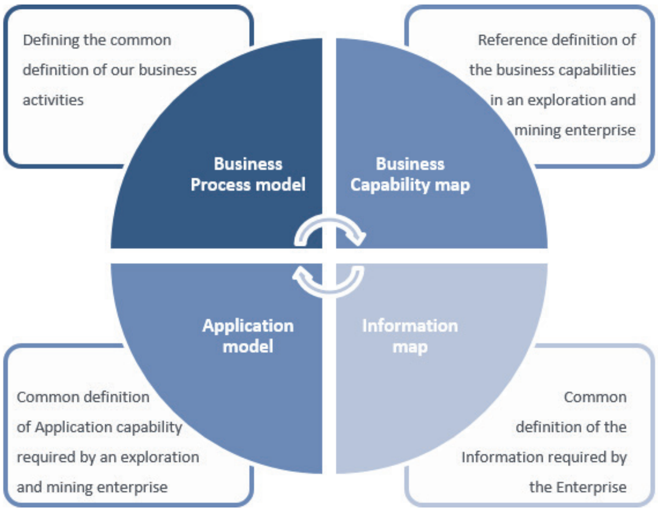

Figure 3 – Open Group EMMMV Forum Reference Framework

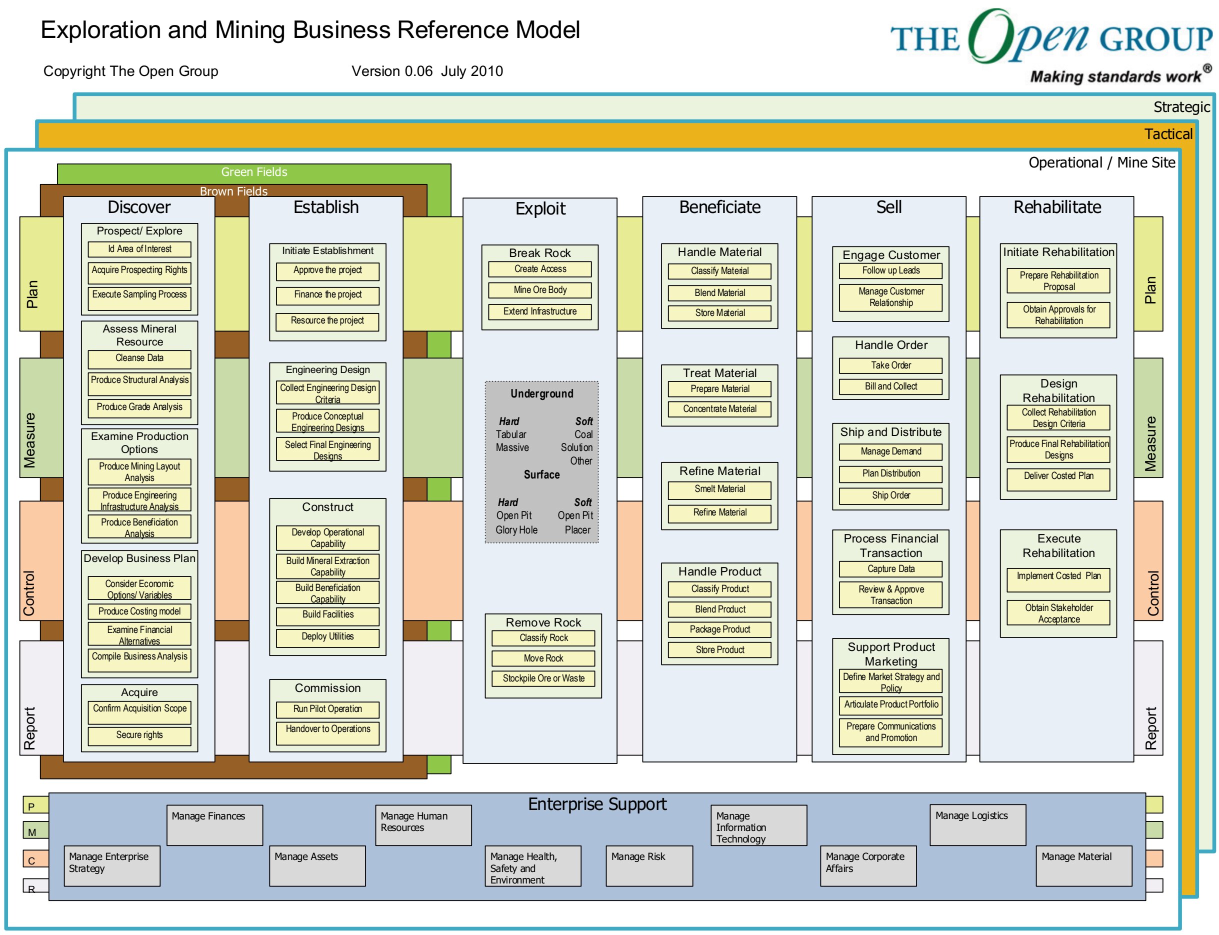

Figure 4– Open Group Exploration and Mining Business Reference Model

This process model displays legibly, on a single A4 page, generic terminology for the mining business across three levels of detail, *i.e*. Enterprise, Value Chain, and Process layers. The centre of the diagram is a reference to different mining methods. The implication for managing information below this generic level is that an intimate understanding of the specific mining method and its information requirements is required.

Utilizing this standard model as the basis for understanding the mining business also provides, among other things, direction for software development initiatives and examining in further detail subjects such as the process of mine planning and the information flow requirements for production reconciliation and analysis.

Further collaboration is taking place with other parties interested in establishing mining industry information management standards on the basis that without a commonly accepted framework providing a generic description of the mining business, every new initiative starts afresh with issues of explaining objectives and solutions to mining industry challenges (Global Mining Standards and Guidelines Group, 2015).

Global Mining Standards and Guidelines Group (GMSG)

The GMSG (www.globalminingstandards.org) facilitates global mining collaboration on solutions to common industry problems, needs and technology through standards, guidelines, and best practices. GMSG does this by operating on the five principles of inclusivity, collaboration, innovation, optimization, and technology.

The vision of the GMSG is to become a global organization for the mining community to develop, maintain, endorse, collaborate, educate, and communicate mining industry standards and guidelines which will be supported and used by mining stakeholders to improve the safety, operational, environmental, and financial performance of the mining industry.

There are several initiatives covering diverse areas of interest to members from mining communities and companies around the globe. Figure 5 illustrates some of this diversity.

Figure 5 – Global Mining Standards and Guidelines Group – examples of areas of interest

GMSG has formed a new working group to collaborate with The Open Group's Exploration, Mining, Metals and Minerals (EMMM) forum. The objective of the working group is to assess the EMMM industry standards as context models for the industry. The desired outcome will be a user's guideline outlining its use and application (Global Mining Standards and Guidelines Group. 2015).

ISA-95

ANSI/ISA-95, or ISA-95 as it is more commonly referred to (http://isa-95.com), is an international standard from the International Society of Automation for developing automated interfaces between enterprise and control systems. This standard has been developed for global manufacturers. It was developed to be applied in all industries, and in all sorts of processes, like batch, continuous, and repetitive processes.

The objectives of ISA-95 are to provide consistent terminology that is a foundation for supplier and manufacturer communications, provide consistent information models, and to provide consistent operations models serving as a foundation for clarifying application functionality and information usage.

Figure 6 illustrates how this standard applies to the world of mining with an example of integrated information management across different applications and systems demonstrating how they relate to both the ISA-95 standard and to each other.

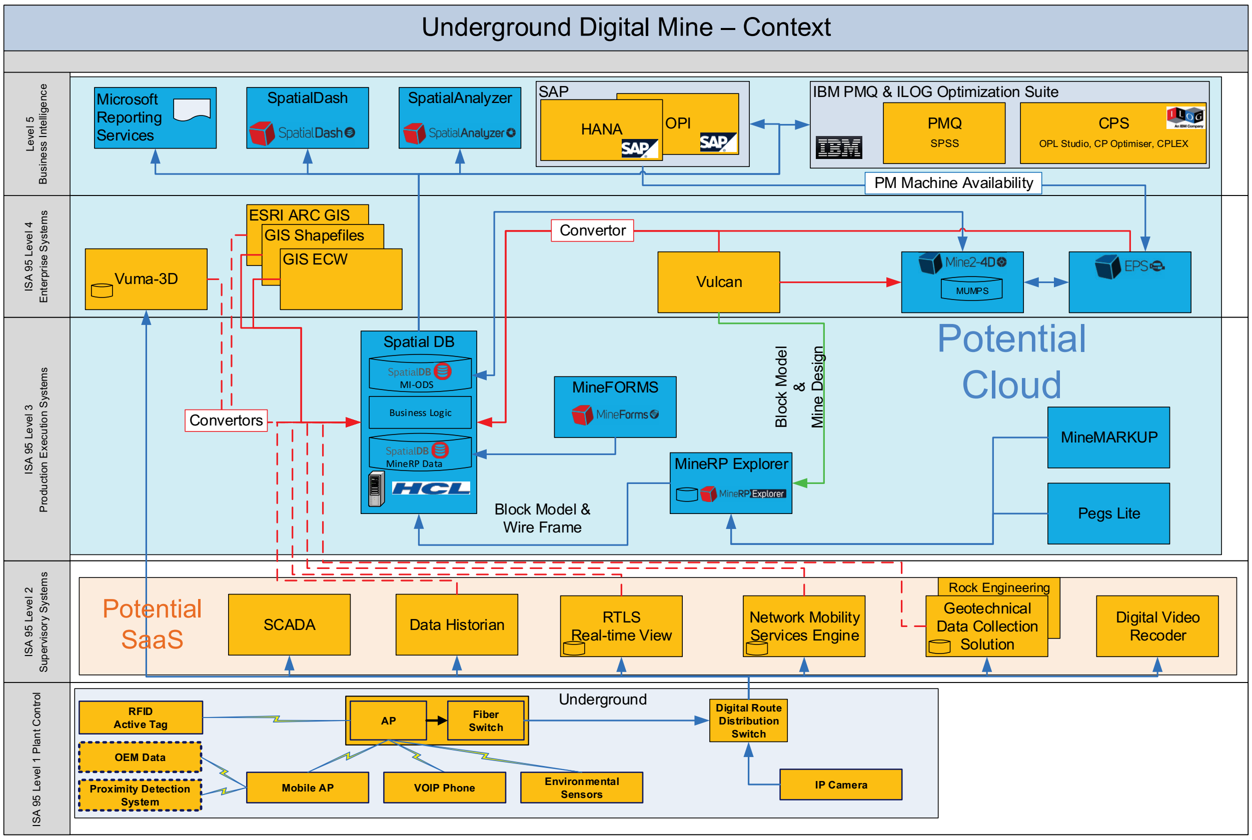

Figure 6 – ISA 95 context for underground digital mine

Big data and analytics in mining

According to Wikipedia, big data is a broad term for data-sets so large or complex that traditional data processing applications are inadequate. What is considered big data varies depending on the capabilities of the users and their tools, and expanding capabilities make big data a moving target. A very useful definition for big data in mining is 'all the data'. Compared to Google (apparently way past 100 billion searches per month), mining does not have too much data. We have more than we can conveniently handle sometimes, especially considering all the permutations of available data we deal with when analysing and reporting information across the enterprise. Even so, we certainly don't make the best use of the data we have. We are however, running out of excuses because the tools exist to make much better use of all our data.

The term 'big data' also often refers simply to the use of predictive analytics or other advanced methods to extract value from data, leading to more confident decision-making. In this respect it is useful to consider the analytical hierarchy displayed in Figure 7.

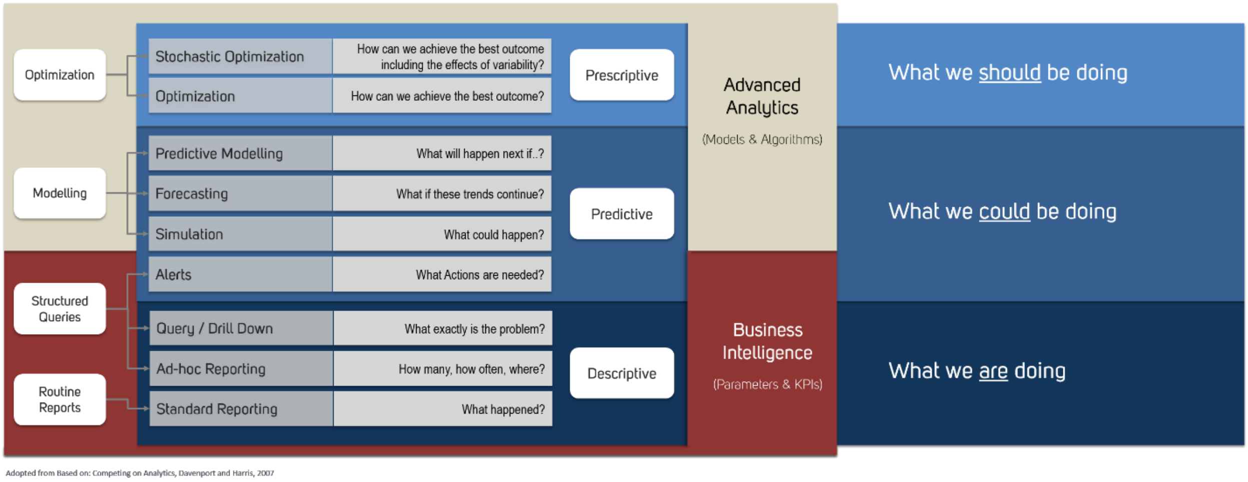

Figure 7 – Analytical hierarchy

Managing information in an integrated way across the enterprise can leverage industrial-strength scheduling and optimization platforms as well as simulation and analytics solutions in line with practices and techniques used successfully in other industrial domains. This will allow mining companies to respond more quickly to changing market circumstances and sustainably improve productivity. For example, building a modern aircraft requires scheduling of several million activities over a period of a few years. On a shift-by-shift basis, these activities can be rescheduled, based on the previous shift's performance and end state.

Having an integrated understanding of the mining domain and its information requirements is the start of gaining benefit from these technologies and practices. Together with mining domain knowledge, tools can be leveraged to introduce optionality in mine design at the planning phase and flexibility and optimization in scheduling at the execution phase. Taking advantage of these capabilities requires integrated processes and the elimination of silo-based methodologies to information management so the mining business operates as a whole rather than via disconnected parts.

Pulling all this together – how do you manage all the data? Figure 8 illustrates how this is done. A quick scrutiny of the Open Group Model will identify more than 20 separate disciplines, each of which uses its own set of applications yet requires integrated information for decision-making. A standard format for spatial data enables integrated information management and its availability as 3D visualizations.

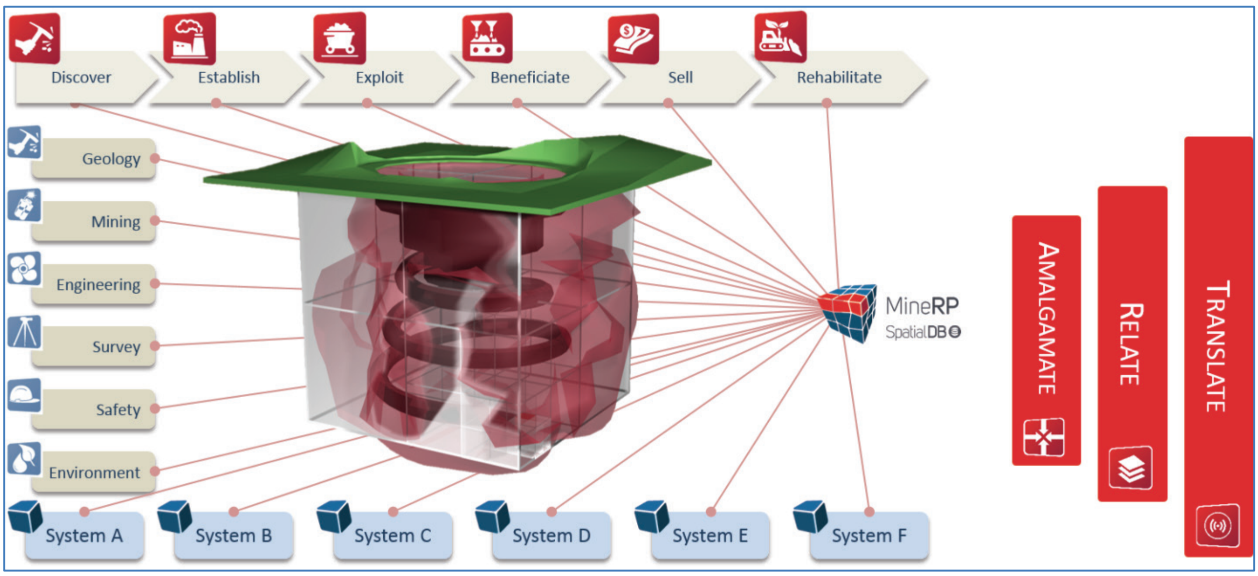

Figure 8 – Information for all the disciplines across the value chain

Using this approach, everybody concerned can understand the mining issues the same way and multi-disciplinary information can therefore drive enhanced decision-making.

Mining business optimization approaches

One example of the use of the analytical hierarchy diagram is to unpack varied usage of the word 'optimization'. It is used to mean different things across this hierarchy, but all its uses have one thing in common; a desire to seek improvements impacting the bottom line of the mining business.

There are a small handful of true optimization techniques and toolsets applied to mining, each tending to focus on different mining methods, portions of the mine planning and execution control processes or pieces of the value chain. Several of these use the same mathematical optimisation engine in the background but they all have one significant hurdle to overcome: they all require significant effort in up-front data collection and preparation, irrespective of the mining business objective such as a focus on kilograms of product, tonnage, NPV, capex, operating cost, balanced portfolio *etc*.

The effort is worthwhile because optimization tools and techniques are needed to address issues and business questions throughout the entire value chain, for any and all mining methods and commodities across different planning horizons, planning scope, levels of complexity, and ambiguity.

In an attempt to find the best mining schedule given the mining business objective, these optimization and analytical toolsets have improved significantly over recent years. Collaboration is also proving highly effective in producing toolsets more readily usable at both an operational and corporate level as a routine part of the planning cycle. MineRP, IBM, and North West University, Potchefstroom recently joined forces in successfully demonstrating new capabilities in analyzing mining data and optimizing the mining business.

The starting point for such a mining business optimisation exercise is a business question in context of a mine design and sequence of activities. The required input data is the list of monthly work activities *e.g*. development, ledging, stoping *etc*., each with a predecessor activity and its known attributes *e.g*. metres, square metres, tons, cost *etc*. plus any mining constraints such as hoisting, tramming, rock engineering, ventilation *etc*. A mathematical model captures these realities and an optimization search engine is set an Objective Function (the business question) such as maximize NPV or kilograms produced over the life of the mine. The output is in the form of mathematically effective schedules and production profiles.

Because all the mining activities are known volumes in space, any resultant schedule can be animated in 3D for immediate examination of mining logic, enabling the choice of best schedule in response to the business question. This best long-term plan this is then persisted back to operations so that 'the long term informs the short term'.

Even in a highly constrained, flat tabular, operational shaft production build-up environment such an exercise delivered a 3.7% improvement in NPV and dramatically displayed the folly of chasing early production at the expense of creating reserves to support future production levels.

Another exercise was focused on the relative merits of retaining surface decline hoisting capability in the presence of a vertical shaft option and alternative tramming routes. Inputs are much the same, the difference is the business question.

In addition to appropriate use of mine planning, visualization, analytical, and optimization tools, the significant breakthroughs in technique arise from organizing spatial input data around mining activities with attributes and visualizing the optimized mining schedule in 3D space for speedy visual validation and analysis of mining logic.

This collaborative approach differentiates itself from other optimization approaches by utilizing:

- Spatially amalgamated input
- Access to actual values for grade, costs *etc*. rather than just averages
- Ability to spatially inspect and visually confirm the feasibility of a mining schedule
- Ability to consider both technical and commercial constraints
- Ability to implement/persist a selected optimisation option into shorter term planning.

Figure 9 illustrates some of the constituents of data management required for a typical mining business optimization process.

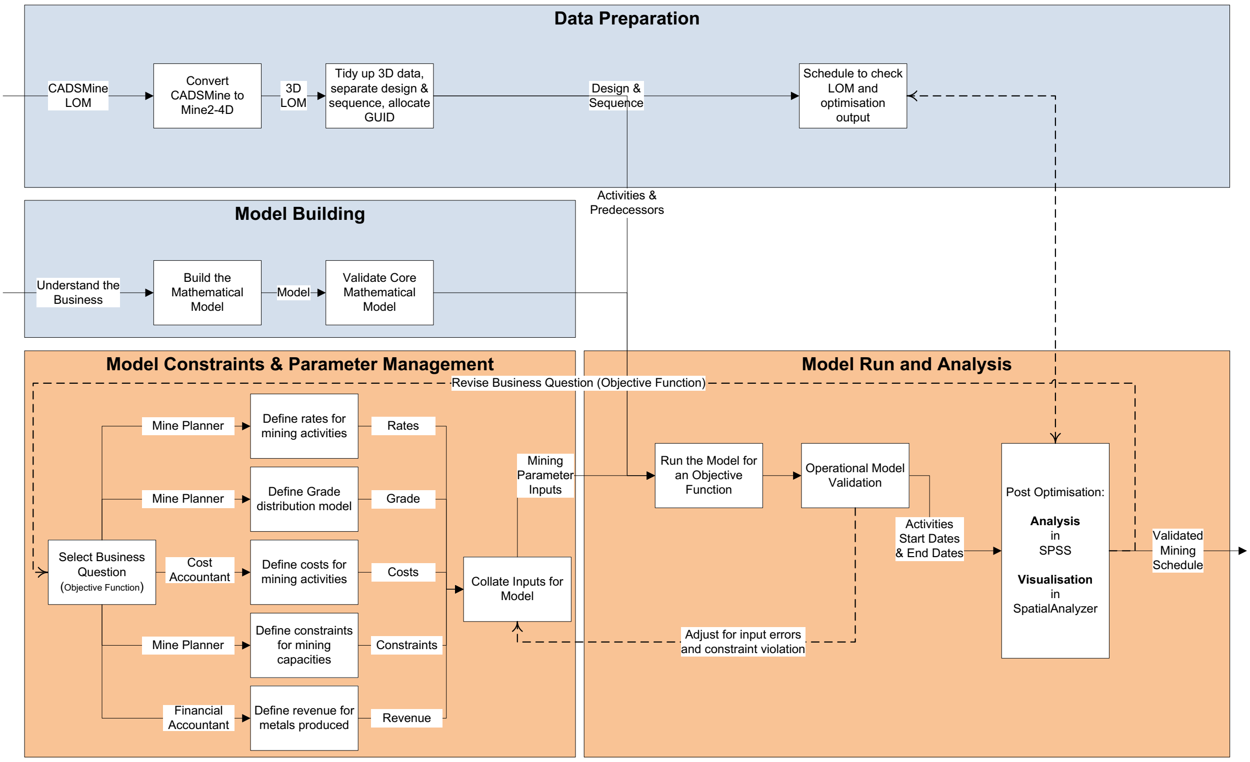

Figure 9 – Typical data requirements and process for optimizing the mining business

Closing the gap between mining technical and financial information domains

Most commercial enterprise resource planning solutions express their measurable parameters such as expenditure, resource requirements, and other operational metrics against cost and profit centres of their own making. Mining technical solutions are more concerned with identifying the exact physical location of a given resource in the process from location through extraction to the eventual beneficiation and sale of product. In order to ensure optimal planning and execution, mining technical systems have to communicate with one another using spatial location as the common reference (Woodhall and Strydom, 2010).

At the risk of oversimplifying the complexities involved in mining, the foundation of control in any business lies in end-to-end control over the following three rudiments:

- Inventory: the 'product' of the business. In mining, this relates to the physical inventory of the commodity mined and is controlled in the MTS domain
- Process: the activities comprising the enacted business model. In mining, the core activities related to mineral extraction are controlled in the MTS domain
- Money: control over revenue and cost elements comprising the transactional planning and information flow within the business. In mining this is controlled within the ERP domain based in the execution of mining activities.

By standardizing the spatial format of mining technical data and translating it into transactional data understood by commercial ERP solutions, the gap can be closed between mining technical and financial information domains. Based on required mining activities, the miner can now dictate the useful level of information granularity to the accountant. Managing information at equivalent granularity across the technical and financial domains means performance metrics from both can be continuously accessed. This way, budgeting and control can finally be managed at a level of detail to suit the miner's needs and at the same time suited to any accounting approach be it role-, area-, or activity-based.

With all mining technical data firmly in hand and the ability to match costing and revenue data at the same level of granularity we are in a position to continuously monitor the effect of mining activities on the mining business as they occur and as they effect changes in the state and status of the real mineral asset, the orebody. This is accomplished with an integrated, spatially referenced mining database and translation of the effect of mining activities into standard stock management transactions for processing in standard inventory management systems.

Providing a standard resource and reserve statement on demand from a mining company's ERP system has already been demonstrated and has opened the way for further cross-domain integration. The Mineral Asset Inventory provides real-time, reliable resource and reserve classification and analysis and forms the basis for meaningful financial and other business input into production planning options and subsequently continuous operational and financial control of the mining business.

In summary, we have the ability to match planned mining activities with equivalent granularity cost control, uniting the worlds of the miner and accountant.

Stakeholder impact

Including the broader range of stakeholders requires even more information and creativity in its format and delivery.

Production personnel have timely access to relevant KPI information not only in number format but in pictures. Mining personnel hold pictures of their operation in their heads. Check any production office – the walls are lined with maps, charts, and scale drawings. Managing information spatially means they can ask multi-disciplinary questions and get a picture of their mine as the answer.

Finance personnel have timely access to budget and costing information at a level of granularity relevant to mining activities. Budgeting processes across multiple discipline silos become seamless and cost control takes place as mining activities take place. The financial manager now also sees and understands production issues the same way as his colleagues.

Shareholders gain confidence in reported information (*e.g.* reporting code compliance of resources and reserves, capex spend, triple bottom line *etc.*) backed by web-based visual displays placing information in context. This is further supported by traceability and auditability from report back to source data.

Mining communities now also understand visually, the same way management does, issues affecting them from both mining technical and financial perspectives *e.g.* status of social investments, employment distribution, environmental impacts *etc*. Timely visual information over the web overcomes both time lag and distribution issues.

The government has its own value chain of opportunity for information management. As custodians of the nation's mineral wealth they maintain visibility of issues such as multi-departmental authorizations, ongoing safe and healthy exploitation of mineral wealth, fiscal revenue streams *etc*. The responsible departments get up-to-date, visually integrated information.

Conclusion

The tools and techniques exist for enterprise interoperability of mining technical and commercial data-sets. The existing and deeply entrenched use of mining technical applications across the value chain does not lend itself to integration at that level. Leveraging a common reference to 3D space and making use of a range of IT industry open standards permits the amalgamation of all spatially relevant data for integrated information management and timely decision-making across the mining enterprise.

This integrated data and information management environment creates opportunities to apply analytical techniques long available in other industries and through the use of relevant and matched data granularity, closes the gap between mining technical and financial information domains. The capability further facilitates a common understanding of the issues of mining across diverse stakeholder groupings for more informed decision-making.

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After graduating from University of Sydney in 1973, worked around Australia for a year and came to South Africa in April 1975 (for two years to take a look)

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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 visualise the realities of mining.

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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.