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FINAL MILESTONE REPORT

PROGRAMME	Longevity of Current Mines (LoCM)	**WORK PACKAGE**	LoCM21WP6.7: Electronic integrated planning and reporting systems
MILESTONE	WP6.7: Final, close-out report.		

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1 EXECUTIVE SUMMARY

This close out report for the LoCM WP6 research project, titled "*Electronic Integrated Planning and Reporting System*", forms part of the scoping of the SAMERDI Longevity of Current Mines (LoCM) research programme. This LoCM WP 6 research project has aimed to define the requirements and development capability gaps for the a pilot mining planning solution required by future mine managers and supervisors to adopt integrated planning and reporting processes within an underground and surface mining context. This research project followed an approach where the initial requirements were identified, firstly for the establishment of a pilot integrated Enterprise Resource Planning (ERP) platform, with the objective to provide an ecosystem for the implementation of short-horizon planning processes at a diamond mine in the Northern Cape.

2 AIM OF RESEARCH PROGRAMME

This LoCM WP 6 research project was aimed to define the requirements and development capability gaps for the development of a pilot mining planning solution required by mine managers and supervisors to perform integrated planning and reporting processes within an underground and surface mining context. The focus was on short-horizon operational planning capabilities, as strategic planning processes are already well-established. Currently short-horizon planning processes which focusses on the shift-level is usually slow, error-prone, manual processes.

Modern mines depend on fast, reliable access to mining data. Traditional mine technical planning systems are highly fragmented and unable to integrate seamlessly. The mining industry's effort at integrated information management have long been implemented as a landscape of multiple non-compatible data and file formats. This was further impaired by an inability on the part of commercial applications commonly included under the umbrella of Enterprise Resource Planning (ERP) systems.

Future mine planning systems shall have to implement unified ERP platforms to enable the seamless sharing of information across the mining enterprise, based on data amalgamation in a spatial context, in order to deliver a reliable singular database for integrated planning purposes.

3 METHODOLOGY USED

The establishment of an integrated Enterprise Resource Platform (ERP) would require the establishment of the requirements, the solution platform framework required as well as a pilot implantation at a mining site to verify the integrated capabilities to perform short term-planning processes. The methodology followed in this research project was:

3.1 Step 1: Explore the requirements and integrative nature of the mine planning process.

This stage explored the theoretical context of especially short-horizon operational planning in the mining context. Planning management has, in the past, mostly focussed on strategic and tactical level planning capabilities, with short-horizon, daily and shift level planning was mostly performed manually with defragmented data in spreadsheet format. Planning at this level was hence slow and error prone, providing the rationale to explore improved short-term planning practices.

3.2 Step 2: Definition of a conceptual solution framework.

On conclusion of the planning requirements definition stage, it is important to define a proven conceptual framework to guide the implementation of a future planning capability. This stage

explored possible solution frameworks for the implementation of an integrated ERP system to support short-horizon planning processes.

3.3 Step 3: Collaboration with OEM's in the implementation of a planning solution.

The availability of a solution framework enabled the collaboration with OEM suppliers for the implementation of an integrated ERP system, resulted in the creation of a single database capability mainly to support automated short-term planning practices for planning managers to automate planning as well as the updating of plans due to the availability of resources.

4 RESULTS

4.1 Requirements and integrative nature of the mine planning process

The international "Open Group" collaborated to explore the relationship of the various mining best practices and processes over the strategic, tactical and operational stages of mine operations. The primary feature of the "Open Group" is the sharing of best practices via forums, workgroups and industry. They have developed the "Exploration, Mining, Metals and Minerals Vertical (EMMMV)" model, depicted in Figure 1, which is such an initiative to support the mining industry. The members of the EMMMV are updating the reference framework continuously, hence collaborating to produce standard models for the mining business.

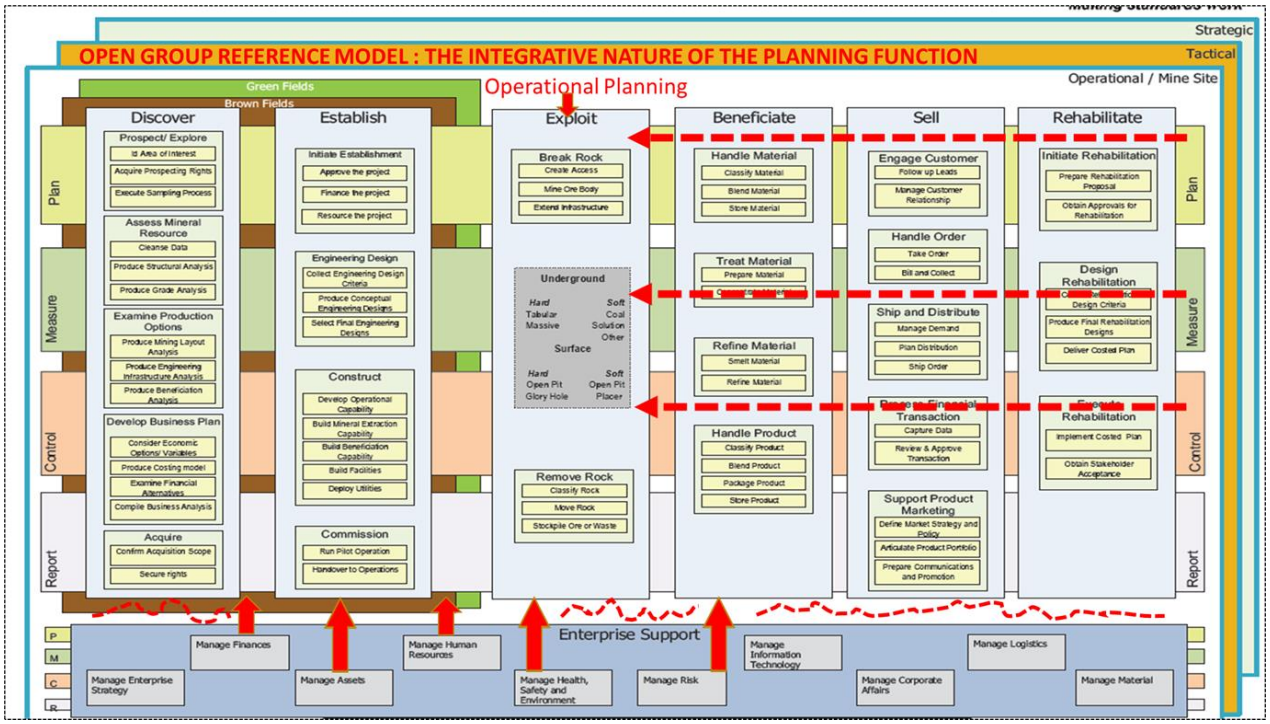

Figure 1: Open Group Reference model: The integrative importance of the planning function

This EMMMV model was used as input reference to define the context and processes required for a future integrated planning framework. The EMMMV model is vendor and technology agonistic and serves as a management reference enterprise model which spans over the value life-cycle of a typical mine, spanning from mine discovery, establishment to rehabilitation, as depicted in Figure 1.

The role and context of mine enterprise support functions are also depicted, with the vertical red arrows, identifying the most important support functions, mostly required during the operations planning stage of the mine. The current weak and defragmented nature of data integration over the enterprise functions, as depicted by the red dotted lines on Figure 1, was identified as a key drawback in the implementation of integrated planning capabilities. The many mine discipline-software systems used in mining, all generate their own data, which is often not compatible to integrate into one database to be useful for integrated planning processes, hence the requirement for an integrated ERP platform.

4.2 Definition of a conceptual solution framework

In exploring the Open Group EMMMV model during work-sessions with mine planning stakeholders it was identified that the four major mining enterprise planning pressing problems were:

a) Latency in decision making: caused mostly by fragmented data, broken company value chain and disconnected executives focussing on partial data views.

b) Disconnected technologies and financial mining planning systems: The current disconnects between mine technical and financial planning, leads to the current slow planning processes between disconnected mining management domains

c) Siloed scheduling and optimisation: lead mostly to fragmented schedules, and poorly optimised and disconnected from actual mine operations; and

d) Inefficient short interval control: leads to poor work management practices and lack of conditional awareness.

Future mining planning platforms should be data-source agnostic, leaving the mining company with the choice of integrated expert tools to suit their business processes. As a mature, integrated planning platform, a planning platform shall address governance and embed company specific process workflows. This shall include financial, safety, procurement and HR approval processes and version management for such as:

- Geological structure models
- Grade block models
- Survey and volumetric data
- Mine designs
- Integrated schedules across technical and non-technical domains

Mine planning management should have unfettered access to integrated data sets to swiftly develop and evaluate many alternate plans across all time horizons and all levels of planning. The ideal platforms shall uniquely allow planning teams to use rule-based tools attuned to their own mining method. These tools allow for the rapid generation of parametric, mine design options in a fraction of the time of traditional methods. Across the horizons of strategic, tactical, and operational planning, integrated mine planning should be unified with integrated business planning. This implies a level of integration between the Mine Technical Systems platform and ERP platforms that is adequate to the task of providing a “money (business)” version of the mine”.

To perform an integrated approach to mine planning, a minimum of eight (8) key operational functions have been identified. These operational functions and its required interaction with other value chain stages would be an imperative to support integrated planning. From this interaction requirement, the functional capabilities have been identified (F1 to F8 in Table 1) and earmarked to be incorporated in a future integrated planning solution.

Table 1: Functional capabilities required for a future integrated planning platform

Nr	Functional name	Description
F1	Geological (Technical) data	Integrated geological data management, geological modelling & resource estimations
F2	Mining planning data	Short/long term plans Integrated mine design, layout & optimization, risk assessment
F3	Engineering services data	Material handling, Maintenance, equipment movement, power supply, etc, Ventilation • Heat • Humidity • Dust and contaminants • Radiation • Industrial water
F4	Production (MRM system) data	Reporting, Activity scheduling (actuals + planned), labour used, bonusses paid, sq ms , tonnage
F5	Safety & environmental evaluation data	Mine safety and environmental management and legal compliance, look at big scale plan risks to mine area.
F6	Survey (Flexibility evaluation) data	Mine survey data and activities management Target from several mine sites/panels, if not reaching goals, plan e.g. 20% additional capacity to reach goals, hence do flexibility analysis
F7	Human Resources (HR) data	Availability, cost and scheduling of HR management related activities
F8	Financial data	Financial management, evaluation & impact of operational planning

Furthermore, the functional capabilities (F1 to F8) should be applied over the strategic-, tactical- and operational planning levels and time horizons. In particular, the required planning levels illustrated below (Figure 2), reflects envisioned discrete levels of work relevant to different planning horizons as well as prescribing the level of granularity or detail of a plan. The required planning levels shall be determined by the required planning requirements of the various management level requirements, e.g. Weekly and monthly planning requirements shall typically be reflected by the Operational Planning management levels.

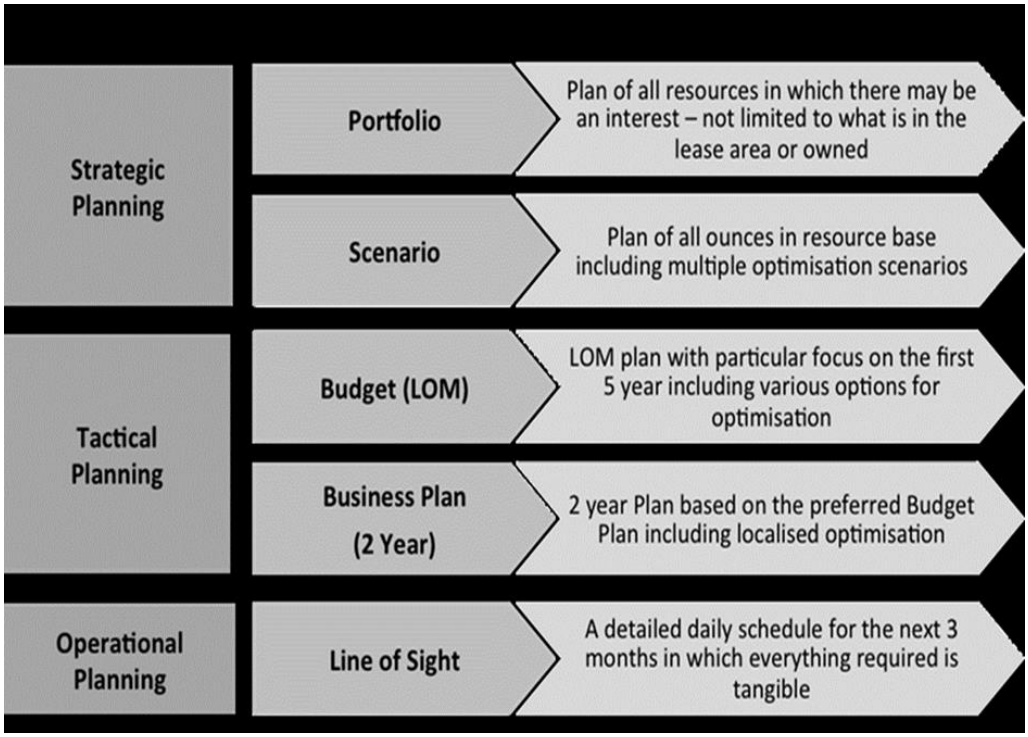

Figure 2: Planning levels and time horizons of mine planning capabilities

In conclusion, the various planning functional capabilities could be depicted in context as a set of minimum required functionalities to realise an integrated planning capability (Figure 3).

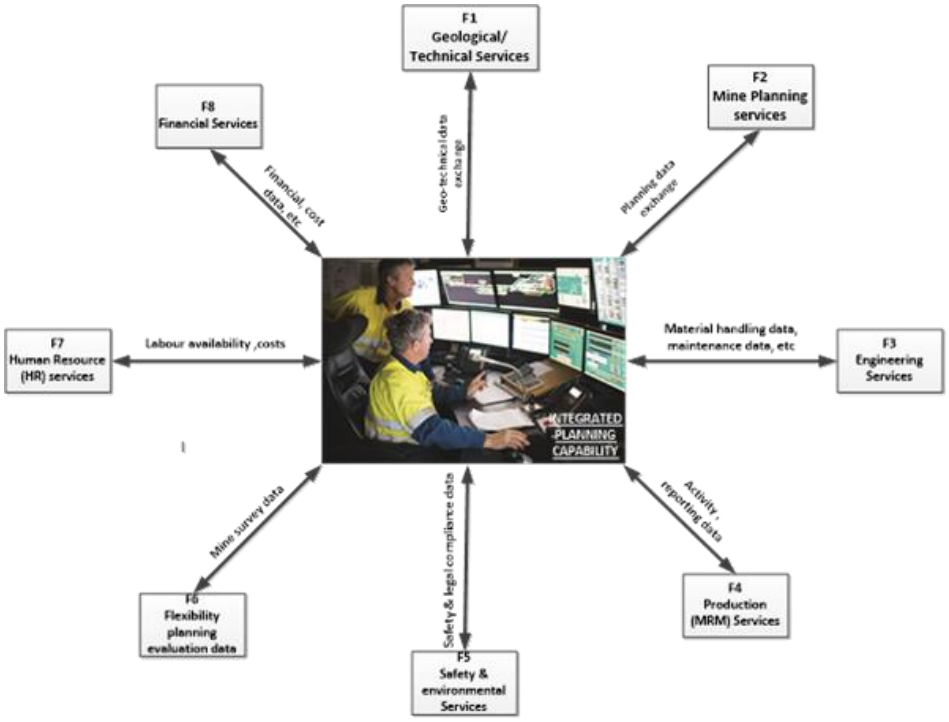

Figure 3: The minimum set of integrated functional capabilities required for an integrated planning capability.

4.3 *Collaboration with OEM suppliers in the implementation of a planning solution*

In order to facilitate the implementation and adoption of the integrated ERP platform, the collaboration of various suppliers (Table 2) during the research were essential.

Table 2: Collaboration with OEM suppliers to realise an ERP platform with planning capabilities

No	System description (OEM)	OEM Suppliers	Current usage
1	SCADA (Supervisory control and data acquisition) on ISA95 levels 1,2	Ampla	Control underground production systems , mostly with Programmable Logic Controllers (PLC's) mounted. Conveyor , ventaliation and material handling systems
2	Underground machine tracking	Epirock	
3	CADsMine	AST (Gijima)	3D modelling of the mine
4	Simplexity (HR System)	Various OEM agents	HR records processing and organisational structures management, interfaces directly with Pivit systems
5	Maxxess	Various OEM agents	Time and attendance system provideing
6	Electronic logbook system	Pivot Systems	Electtronic shiftboss logbook and level 1 and 2 planning inputs
7	Qmed	Various OEM agents	Process records of safety injuries, radiation exposure
8	LabX	Various OEM agents	Process occupational higiene filters maintenance, interfaces directly to Pivot systems
9	Pivot Mobile	Pivot Systems	Communicates all safety related data to mine personnel, such as ventilation status, occupational hygiene, occurances, interfaces with MineRP databse
10	MineRP ERP platform	MineRP	ERP integration platform for all levels of the ISA95 mine solution

The implementation of the ERP platform (Figure 4) entailed the integration of all the mining specific domain technology databases from Geology, Planning, Engineering, Volumetrics, Safety, environment and telemetry into a single database. The implication was that planning operations could be implemented by using a single database which is created with one view of the operational “truth”. Figure 5 illustrates the mapping of the ISA 95 Levels to the strategic, tactical and operational levels of a typical integrated ERP solution. ISA 95 levels 3 and 4 maps to the strategic- and tactical levels, while Levels 1 and 2 maps to the short horizon operational planning levels

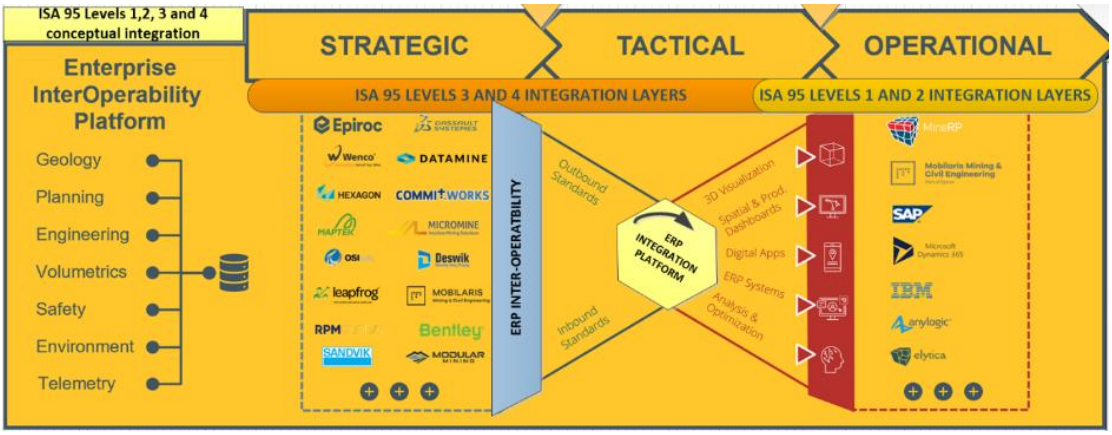

Figure 4: The current state of integration of mine ERP systems [Source: Adapted from Mike Woodall, MineRP]

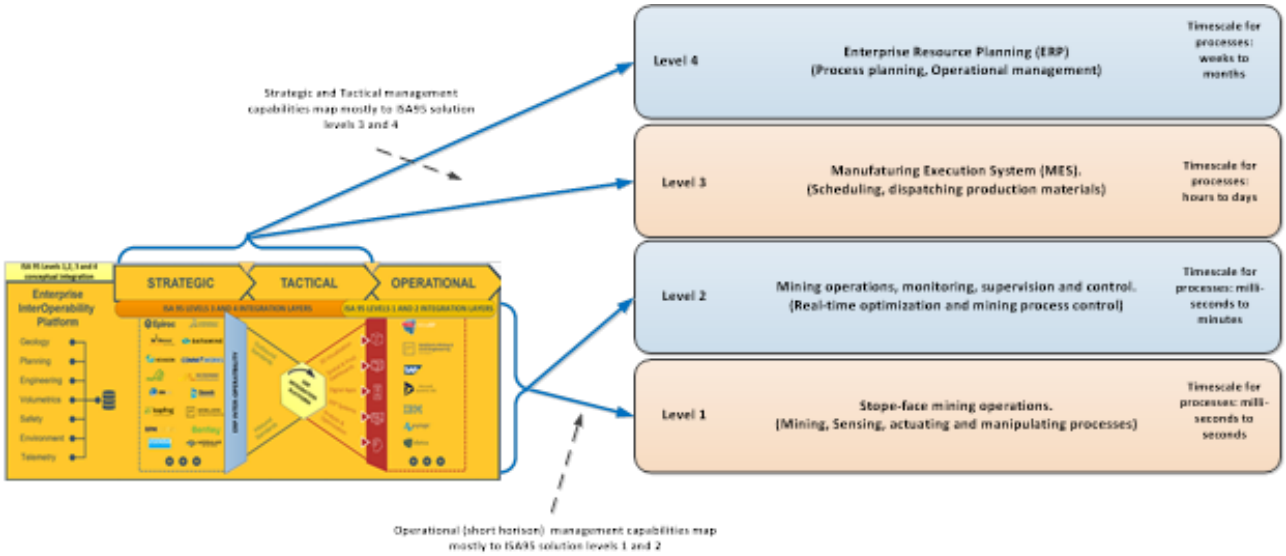

Figure 5: Mapping of ERP platform to ISA 95 solution framework [Adapted from MineRP]

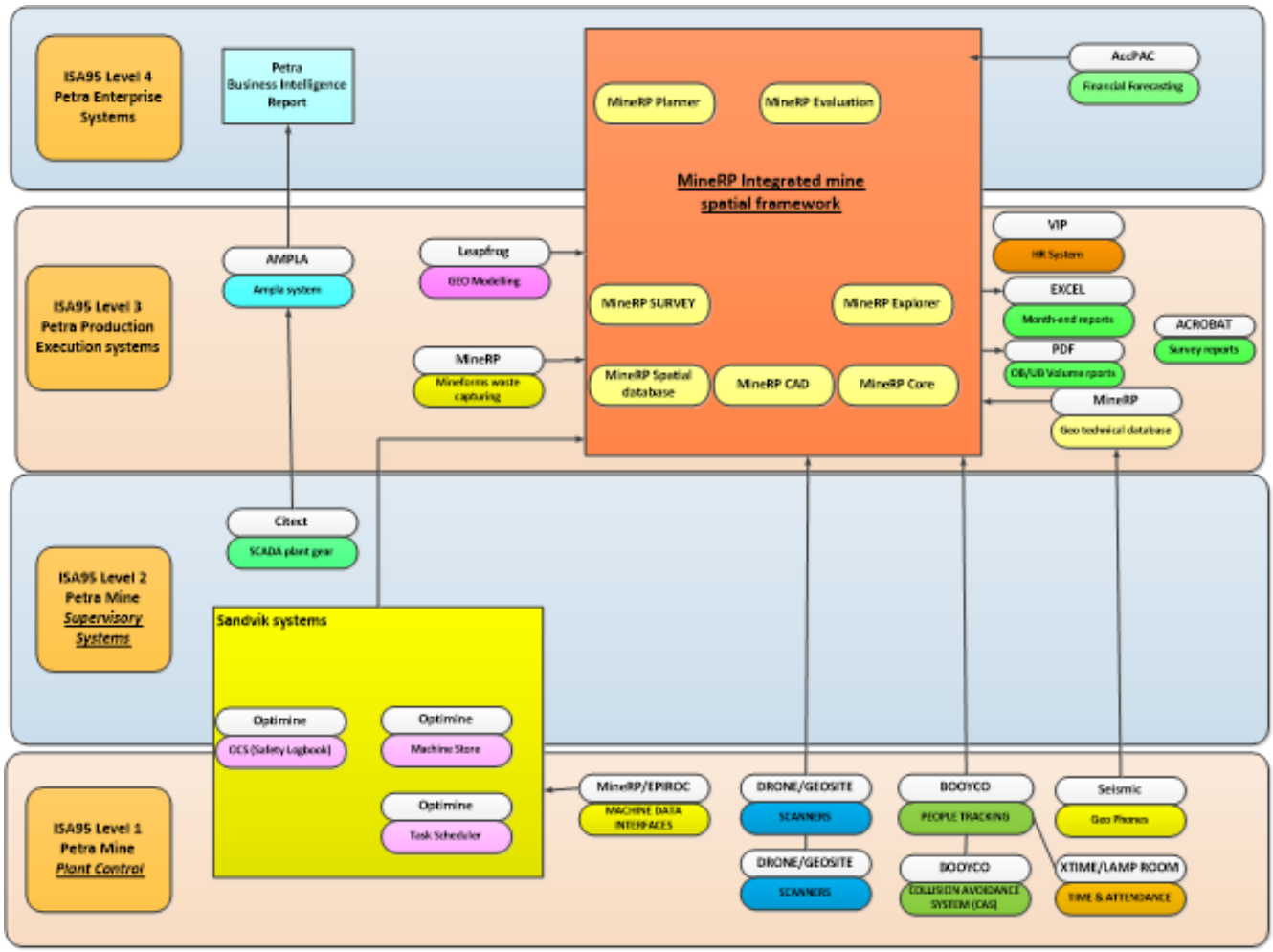

Figure 6: Final Petra integration operational solution

4.1 Introduction to the implementation mine

Petra Diamond Finch mine was approached due to their advanced development towards the integrated planning systems. The Petra Diamond Finch-Mine is situated near Lime Acres, in the Northern Cape, and has commenced with mining operations already in 1967. Petra (Finch) mine is currently one of the world's significant diamond mines and is currently South Africa's second largest diamond operation by production, after the De Beers' Venetia mine. Petra Diamond Finch mine was approached due to their advanced development towards integrated planning systems.

Figure 7: The Petra Finch mine situated in the Northern Cape [Source: Petra Diamonds]

The Finch-mine benefits from state-of-the-art mining infrastructure, including a modern processing plant which was upgraded shortly before Petra acquired the mine. The Petra (Finsch) mine has produced large, special diamonds in its mining history and has produced several +50 carat stones annually. In addition, the mine is known for high quality commercial diamonds of +5 carats and is rich in gem quality smaller diamonds. Mining operations are currently being conducted at a depth level of 700 meters and has a project Life-Of-Mine (LOM) estimated up to 2030. The overall production totalled 1.3 Mcts with a ROM grade of 46.7 cpht. The Finch-mine is configured around a typical kimberlite ore formation as illustrated in Figure 8. The mine initially started mining operations as an open-pit type operation, but has evolved into an underground operation, exploiting the deeper kimberlite ore body.

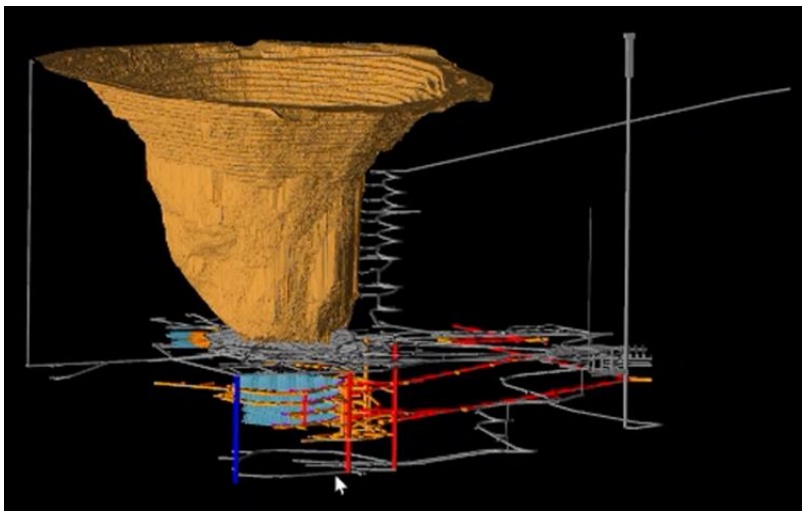

Figure 8: Finch mine typical kimberlite configuration [Source: Petra Mine]

The Finch mine management has committed, already three years back, to a strategic objective, which is to improve management processes by means of the implementation of an integrated mine digitisation strategy. This strategy aimed to improve on the integration of management processes to enhance productivity and overall commercial effectiveness. A key aspect of this strategy was to improve the short-horizon integrated production planning capability of the mine, as short-horizon planning processes were often error prone and considered to be too complex to do accurately. The availability of planning data was often delayed which led to slow and in-correct planning practices. The integrated approach led to the availability of a single operations database of near real-time data, sourced from spatially distributed domain sources, which empowered the Petra management to implement improved and accurate short-horizon planning practices.

5 RESEARCH FINDINGS

5.1 Research Finding 1: Implemented a full forecast-plan-do-review cycle.

The Petra mine has successfully implemented of a full "*forecast-plan-do-review*" integrated planning cycle, which is applicable over the various planning horizons, stretching in scope from the annual- down to the shift level time frames (Figure 9).

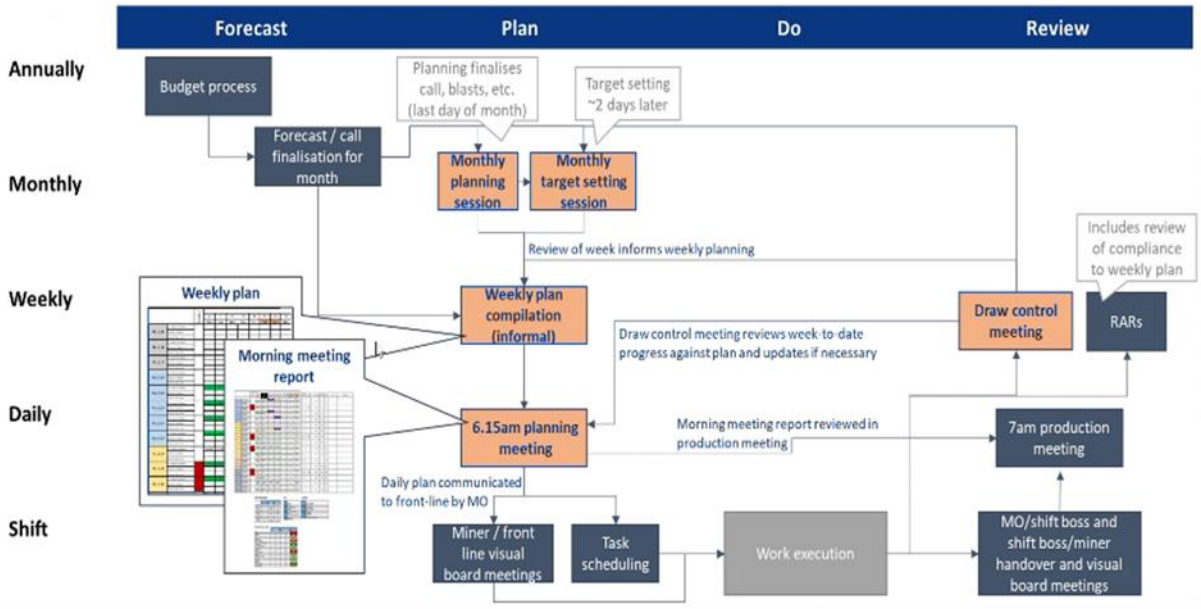

Figure 9: A full planning cycle implemented

The short horizon (daily and shift) planning cycles are completely integrated on the MineRP ERP platform and source all required planning data from the central ERP data base. All the required data sets are collated from the various knowledge domains and transferred into a single database, which reflects the only official planning state of the mine. Short horizon on the daily and shift levels could be generated automatically and be re-planned on short notice, should resources become un-available during a shift. Task scheduling is communicated in electronic format to relevant personnel and can even be "pushed' to mobile devices used by underground miners.

This short horizon planning cycle was implemented successfully at the Finch mine and could serve as a proven example which could be adapted for various mining operation types in the industry.

5.1.1 Research finding 2: Value of integrated ERP platform to Petra mine

The adoption of an integrated ERP planning system into the operational eco-system of the Petra mine, created emerging value-chain attributes which is indicative to future digitised integrated mine operations. The emerging value attributes observed at Petra are depicted in Figure 10.

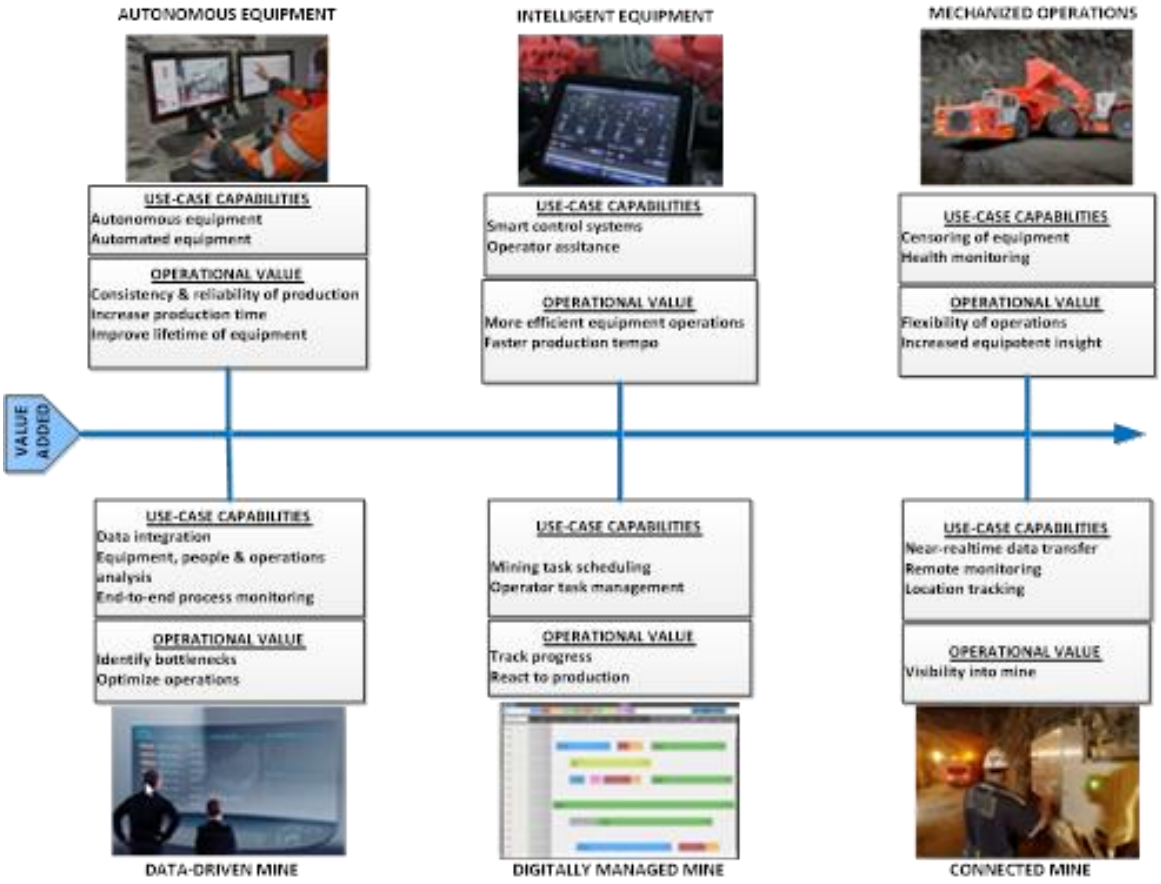

Figure 10: Emerging value attributes expected of future digitised mine operations

5.1.2 Research Outcome 1: Typical short-horizon planning schedule

The integrated ERP platform allows for the automated generation of short-horizon shift schedules as depicted in Figure 11.

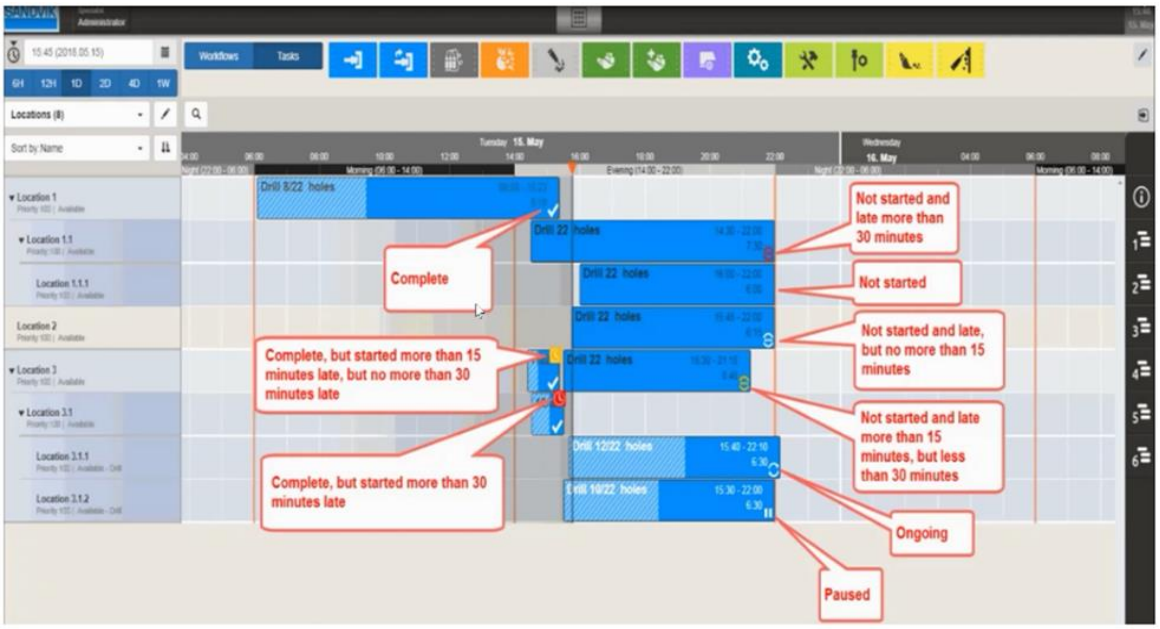

Figure 11: Example of short-horizon shift-level planning schedule

The schedules could be generated in an automated mode, as well as updated based on the availability of changing resource levels. The shift level schedules allocate tasks to workplaces, can show progress and other execution issues that would management interventions.

5.1.3 Digitisation strategy

During the past four years, Petra Finch mine has adopted and commenced with implementation of a digitisation strategy as depicted in Figure 12 below. The digitisation strategy was executed in a phased approach, mostly focussing on the following aspects:

- Creation of the solution concept.
- Amalgamation and defining the relation of all mine operational processes.
- Translate all processes into formal business processes, of which planning was part of and lastly executed, and
- Execute and control implemented processes.

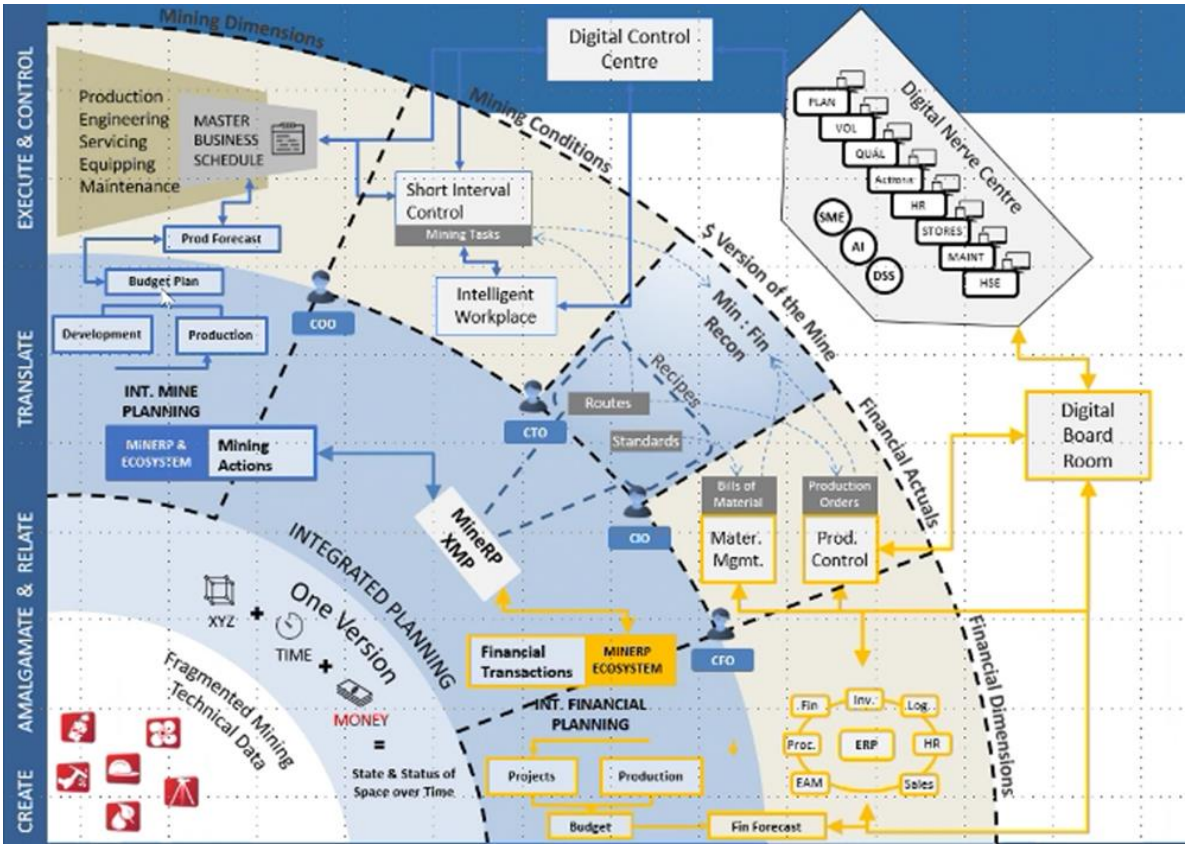

Figure 12: The Petra Finch mine digitisation strategy

The overall digitisation process (Figure 12) focussed mostly on the integration of the mining operational dimensions, integrated with the financial dimensions of the business. The MineRP [ERP] system was adopted to serve as backbone integration platform, integrating all four levels of the ISA 95 solution architecture, ensuring only one version of the mine operational "truth" is managed. An operations room was also established to ensure management processes are visualised in near-real-time, ensuring managers can make accurate in-time decisions.

6 CONCLUSIONS

The digitisation strategy implemented at the Petra Finch diamond mine has established a suitable and integrated ecosystem within which a short horizon operational and tactical planning system could be implemented. The integration of various OEM platforms at the ISA 95 levels 1 and 2 with the ERP system at levels 3 and 4 provided a single operational data base capability from which planning processes could be executed at all ISA95 levels in near-real time. Even more importantly, short horizon level planning at the shift level could be revised on short notice as availability of resources change. The challenge of error-prone short horizon shift planning has been solved.

7 RECOMMENDATIONS

This research project suggests that planning at the strategic, tactical and operational levels can be done accurately in near-real time and communicated via mobile devices to relevant members within the mining operation. This capability now opens the opportunity for future research at the MMP test-mine to further enhance mine operational processes, provided an ERP platform capability is established for research purposes.

It is hence recommended that a follow-up research program is initiated to establish an ERP system at the test-mine to serve as a research platform to integrate future connected mine TMM and LHD vehicle systems to optimise mine operational effectiveness.

8 WAY FORWARD

The establishment of a competent multidisciplinary research team that could perform research in an integrated and holistic systems thinking way, focussing on the test mine ERP system, to "spin-out" value to the mining community as they become available. Demonstration of integrated planning and operational technologies to industry would accelerate adoption as the maturity level would be suitable for industry to accept.

9 LESSONS LEARNED

South-African research institutions, in collaboration with local OEM suppliers do have the locally developed capabilities to develop and implement digitisation strategies to enhance planning capabilities for local mining companies. Future local digitised mines could become examples in mining efficiency to international role-players on how to convert traditional mining processes into integrated optimised systems. The adoption of digitised ERP platforms could become a gamechanger to local mines to become internationally competitive.