Beyond MES and ERP
The future of IT in mining & manufacturing operations

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Note: This paper has an accompanying PowerPoint presentation

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Abstract
In this paper Gavin Halse focuses on the challenges faced on the plant floor and the role of IT systems in the operations environment. Several examples and case studies of innovative operational systems in areas such as safety are presented. The key success factors of system implementation are highlighted together with the learning points from these projects.

Introduction
Business leaders in mining and manufacturing have to balance many conflicting priorities – for example raw material procurement, fixed cost reduction and improved service levels while securing and retaining the necessary skills to remain competitive. The CEO is also accountable to numerous stakeholders in the areas of governance, fulfilling board
and fiduciary duties, coping with increasing legislation and mitigating new business risks relating to global market volatility.

In this environment it is imperative that production plants operate predictably. Business leaders cannot focus on every detail of day to day operations and are therefore forced to delegate many responsibilities to operations personnel. However, notwithstanding this delegation, management remains unambiguously accountable for total business performance. IT based systems can play a vital role as tools to automate operational processes.

From a business perspective, ERP has now matured. Vendors have recognised that despite the strategic role of ERP in manufacturing, much of the actual working environment on plants is still reliant on information unrelated to ERP, such as safety, engineering, technology and process modelling. This reality demands a renewed vision for the future role of IT in manufacturing.

In plant environments the focus has until now been mainly on plant automation and manufacturing execution systems (MES). As systems matured, plant historians and other scada data analysis tools have become widely used by engineers and production staff to optimise plant operations. The software standards such as S88 and S95 to define and connect plant data with business data are based largely on the presumption that fully automated operations can be achieved through integration of plant with business systems. The concept of the “real time enterprise” was at one stage seen as the goal. In practice, the wisdom of tightly coupled and integrated systems has to be challenged and it is asserted that the real time enterprise is a myth: that information is in fact relevant in several time dimensions, from real-time process control to business lifecycle management over many years.
Time for new strategic thinking

It is almost 8 years after Y2k and we find the technology industry once again at a point where several major trends in IT and manufacturing systems are about to have a impact on the business use of IT systems into the future.

Business leaders are now, more than ever before faced with really difficult choices relating to technology strategy. These choices extend far beyond the unimaginative selection of a single vendor solution. Business leaders need to be able to relate their IT strategy to anticipated business drivers over the next 5-10 years. The decisions they take now will have a significant impact on the agility, efficiency and ultimately profitability of their individual mining and manufacturing companies going forward.

Forward thinking leaders in mining and manufacturing companies realize that IT can no longer be seen as a basic commodity akin to a telephone, to be obtained at minimum cost. They recognize that a “breakaway” business strategy requires IT as a core enabler, and they recognize that IT has the potential to be a key strategic ingredient for business growth and success.

This paper draws together several of the main themes in technology and business today to better inform strategic thinking. By its nature, the subject is broad, and several generalizations must be made. It is important to recognize that exceptions will exist, and that no one can reliably predict the future exactly. At the same time it is hoped that by making several educated guesses the future can become clearer.

The convergence of MES and ERP

Over the past few years we have seen several common elements emerge from the once separate areas of Manufacturing Execution Systems (MES) and Enterprise Resource Planning (ERP). This convergence is quite fundamental in nature and actually exposes the limitations of the TLAs (three letter acronyms) used to describe these different fields. The first real evidence that there are limitations is the relatively recent reinterpretation of
MES to refer to “Manufacturing Enterprise Systems” instead of “Manufacturing Execution Systems”. How convenient, the TLA stays intact! This is an acknowledgement that there are many overlaps and similarities between manufacturing execution systems and enterprise level business systems.

I would motivate that to distinguish too rigorously between MES and ERP would be to constrain your strategic thinking. Seeing IT systems as a whole, understanding the common technology and business elements is far more valuable than the traditional pyramid diagram that depicts business systems at the apex and the production plant at the bottom. I never quite understood the pyramid very well; seemingly the wider part at the base of the pyramid depicts increasing detail or complexity? However, this assumption is worth challenging, business systems are certainly complex too, so perhaps the pyramid would better be represented as an hourglass, with the complexities at the top and bottom and a relatively limited interface between the two areas.

The convergence of MES and ERP has been a reality for some years now and it can be anticipated that this trend will continue. Several factors are driving this convergence:

- Common network standards throughout (TCP-IP)
- Intelligent devices with IP addresses in plant networks
• Dominance of Microsoft based operating systems in both plant and business systems
• Patch deployment
• Common security models
• Common databases
• Common hardware and physical network topologies
• Adoption of internet based standards (http:) in business and plant systems
• Maturing supply chain systems, linking forecasting, planning and execution
• Maturing integration techniques such as service oriented architecture (SOA)
• Maturing standards such as S95
• Common skills sets – the rise of a generation of “Visual Developers” and moves towards integrating IT and engineering under common management structures
• Commercial factors driving vendor activity – ERP vendors building MES functionality and vice-versa

In order to help understand how the future might look, I will for simplicity’s sake combine MES + ERP and be guilty of introducing another three letter acronym, MBS (“Manufacturing Business Systems”). For the purposes of this paper I will now refer to
MBS as a future state where business and plant systems are fully integrated into a common system, and where the merged ERP and MES have lost their identities.

**The characteristics of Manufacturing Business Systems**

The term Manufacturing Business Systems (in this paper) refers to a state where plant and business systems are integrated to the point where the barriers between MES and ERP have been broken down and where the individual realms of systems are no longer considered separately.

So what are the likely characteristics of this future integrated environment, and what strategic practices should be put in place now to anticipate the likely future state?

The easiest way to break this question down is to consider three layers:

1. Infrastructure layer
2. Business Process / Productivity layer
3. Business Context layer

These concepts apply to the whole of the MBS arena. They are not new, but rely on existing concepts borrowed from the world of IT.

So how is this “new” conceptual way of looking at MBS helpful?

*The key in the integrated model is to recognize that people are an integral part of “automation”, and that it is unnecessary to constrain process automation to only the world of plant, equipment and process control.*
Infrastructure layer
As mentioned previously MBS systems share a common infrastructure, based on TCP-IP, http and SOA based integration. In addition, there is typically a common database platform for structured information, and a common information management system for unstructured information.

In the context of process control, the elements that constitute discrete, continuous and batch control can (for the purposes of this paper) be considered as belonging in the Infrastructure layer.

Business Process / Productivity layer
The business process layer refers to the processes that people, plant and equipment undergo in order to execute business functions. The key in the integrated model is to recognize that people are an integral part of “automation”, and that it is unnecessary to constrain process automation to only the world of plant, equipment and process control.
**Business Context layer**
This layer refers to the business environment. An easy way to differentiate this layer from the business process layer is to regard it as containing the links to the external environment where several factors exist that cannot be automated. In this layer, for example, we include collaboration with suppliers and customers, government, shareholders, employees, the business and financial markets.

**The infrastructure layer in more detail**
In a mining, manufacturing or process company, the infrastructure layer comprises all of the networks, computers, operating and software systems. In addition, the process control elements are included here. This layer forms the platform on top of which business process automation can take place. In the way we have defined this layer, it includes business system infrastructure and some of what were traditionally referred to as MES and plant systems infrastructure. The layer is characterized by a common network protocol, a service oriented software architecture and common communication protocols over http. The old boundaries between MES and ERP (business systems) are eliminated and a common approach is used in the design, management and maintenance of the entire infrastructure.

In practice this common infrastructure approach may require organizational changes where Process/Control Engineering and IT could potentially share a common manager.

In determining the practical steps necessary to achieve a common integrated infrastructure the business should embark on an optimization process. This process should address areas that will bring the most benefit to the business as a priority. An assessment of benefits should therefore be done across the board, to enable the effort to be focused initially on the quick wins.
While each business will have its own process, the optimization should essentially result in the following:

- A common network design
  - Simplification and reduction of proprietary networks in the process control layers
  - Managed routing of network traffic between physical plant systems and business users
  - The adoption of a common networking standard (TCP-IP) and the elimination of other protocols
- A common security and directory services design
- A common database reporting environment
- A common and searchable platform for unstructured information (documents, records, etc.)
- A common communication platform (e-mail, presence information, voice and video communications).

To achieve this vision in the longer term you may want to phase out old legacy hardware and software that does not conform to the overall architectural plan, standardise on vendors who subscribe to the same fundamental infrastructure design, and make the organizational structure changes that deliberately break down organisational barriers between business and plant systems. Note that standardizing on vendors requires more imagination than simply choosing the big name vendor(s); within each vendor there will be strengths and weaknesses and there is merit in adopting a complementary vendor approach.

Notice that in this optimization process, the “boundaries” between ERP and MES are not considered – the intention is to put in place and enforce a conceptual design that has as its objective the standardization of the common infrastructure elements, on top of which a process automation layer is possible. With an integrated and common infrastructure now in place, business process optimization will simply operate across the old “MES/ERP” boundaries.
**Business productivity and process optimisation**

The Manufacturing Business Systems approach as defined in this paper helps to find common elements in what used to be known as MES and ERP, and ensures that common design elements are implemented across the hierarchical layers that artificially separate business and manufacturing systems.

The Infrastructure layer forms the foundation on which the Business Process layer is implemented. In the same way that an optimization process is relevant at the Infrastructure level, an optimization of the Business Process layer is recommended and quick wins can be identified and actioned in the short term.

The elements that make up the business productivity / process layer include:

1. Transaction Processing and workflows
2. Business Intelligence
3. Collaboration
4. Content Management
5. Search and Discovery
6. Communications

It is interesting that the above concepts are all from the world of IT. When these are mapped onto the S95 standard (from the world of ERP and MES), all of the S95 top level functions are relevant to the 6 areas above:

- Procurement, Material and Energy Control, Production Scheduling, Order Processing, Production Cost Accounting, Product Shipping Admin, Product Inventory Control, Quality Assurance, R&D, Maintenance Management.

When generic ERP is considered, the following areas are also covered by the business productivity / process layer:

- Human Capital Management, Product Lifecycle Management, Collaboration and Relationship Management, etc.
The important point here is to recognize that the business productivity infrastructure is entirely relevant to the traditional MES areas as described in S95, and also the areas covered in the ERP domain. While there are layers and boundaries between these systems, these are becoming increasingly blurred and it is clear that the three letter acronyms developed in the 1990’s are now falling short in their ability to describe the true nature of these systems.

**The human factor – an essential component of IT “architecture”**

So far we have been focusing on demonstrating that the traditional MES and ERP models can be distilled into an Infrastructure layer, a Business Process / productivity layer and a Business Context layer. By doing this we can see that there are similarities between MES and ERP that make the distinction between these 2 areas somewhat artificial. It is my prediction that whilst it will be a slow and painful process, “MES” and “ERP” will eventually die and be replaced with “Manufacturing Business Systems” (or a similar definition) which encompasses both areas.
What remains then is to consider the human being in the context of “IT architecture”. When looking at the business productivity infrastructure described above, it can be seen that the emphasis is not on plant automation, but rather on empowering people. It is this people centricity that is strategically vital to future-proof IT and manufacturing systems.

The reasons are simple and obvious: What can be automated should be automated, and your competitors will do this too. Things that happen in microseconds have to be automated. However what cannot be automated and therefore requires human reason and deduction should be recognized as a key resource for strategic and competitive advantage. The business productivity / process layer as described above should be designed to empower the humans in the business to make better decisions. This layer should not be constrained by the MES and ERP labels of the past. In practice people interact at all levels of the IT systems. The average process operator or shift superintendent is less concerned with whether or not he is interacting with MES or ERP than might be believed in some engineering circles. The hierarchies of old can certainly be flattened and simplified.
Example: Work Permit Creation
A good example of the interaction between technology and human deduction is in the
area of safety. This example relates to the issue of safe work permits in hazardous
environments. The combination of precise computer based knowledge and human
reasoning can be a highly effective approach when identifying risks relating to
abnormal work in hazardous areas. The computer will be able to provide information
on previous work in the area, design and other information on hazardous materials and
process; while the human will be able to identify abnormal circumstances, deviations
from past or predicted conditions, etc. A computer aided process to raise a safe work
permit can draw from scada information and process design information and then
combine this with human deduction through a question and answer approach to
produce a safe work permit. This permit is of a higher integrity than one prepared just
by a computer or just by a human. It assures management that the work permit is of
the highest integrity, and therefore ensures the safest possible working environment.
Such a process design would not have been possible by forcing the process into a
MES, ERP or even S95 paradigm.

If one looks at the six components that constitute the Business Process / productivity
layer, it is clear that they are all concerned with human productivity, and far less so with
operating plant efficiencies, etc.

It is my belief that a balanced future proof IT strategy has to be concerned with this
human decision making aspect and an optimization of the Business Process / productivity
layer is as important as the infrastructure optimization. The two go hand in hand;
automate what can be automated and free up human decision making for the really
difficult problems – then empower the decision makers with good, accurate and timely
information for making these decisions.

Finally, it should be recognised that automation is only relevant when time horizons are
short (from microseconds to at most several hours / batches). It is generally unwise and
impractical to automate long term processes, too much can change in the interim. When
longer term business decisions are required, sophisticated scada systems that capture the
history of every recipe execution are almost useless; here the information needed relates
to long term business planning – where the information is typically unstructured and
imprecise.

**What about integration? – SOA**

The convergence of MES and ERP implies integration of software components at all
levels. Service oriented architecture (SOA) can achieve this integration, whilst also
providing the business with several degrees of freedom to be agile and to adapt to a
changing environment.

- A SOA based strategy can lead to significantly higher levels of business agility
  and flexibility, allowing you to reconfigure business processes quickly and
effectively between plants, suppliers, customers and other third party outsourced
  providers.
- A SOA based strategy can allow existing software assets to be “sweated” for
  many years to come, by ring-fencing the legacy application and exposing the
  interfaces only. Business processes can then be orchestrated around existing
  applications with standard middleware products.
- A SOA based strategy can integrate disparate systems in a federal system where
  no single standards are in place across the enterprise and therefore allows more
  rapid integration of acquisitions into the enterprise.
- A SOA based strategy can result in the IT Department becoming more business
  relevant, responsive and agile.
- A SOA based strategy can lead to significant IT cost reductions in applications
development and systems integration.
- A SOA based strategy can leverage the existing investments in basic
  infrastructure by using standard web based protocols.
- SOA is a way of breaking down complex business processes such that the
  components to be re-assembled in ways that reflect the changing dynamics of
  your business. SOA allows parts of a business process to be executed on your
behalf by third parties. SOA therefore leads to increased “virtualization” of business and the strategy can be an enabler of outsourcing to third parties.

- To succeed, SOA needs to be embedded in the way you think when designing, selecting and implementing technology solutions for complex business processes.

All the major ERP and MES vendors have adopted a SOA based approach in their own software design. This is not entirely unselfish; SOA architecture is in many cases the only mechanism larger vendors can integrate their own, often disparate internal systems. It provides vendors with a mechanism of wrapping legacy applications in web service interfaces which allow integration over standard web based protocols.

What is critical however is that SOA integration is not possible without strong industry standards defining the “language” by which software components talk to each other. Without a common language, the ability of one software module to talk to another is next to useless, and in any case this ability for programs to “talk” to each other has arguably existed in one form or another since the mid 1980’s! It is the language that makes the communication meaningful.

From a strategic perspective it is therefore important to keep track of standards that facilitate communication between software elements in a manufacturing or mining context. These standards include, of course S95, but there are several other industry standards that also need to be monitored.

**The third layer – Business Context**

The title of this paper is “Beyond MES and ERP” and the intention is to stimulate a newer strategic thinking on the role of IT in mining and manufacturing, beyond the hierarchical “pyramids” of old. So far we have concentrated on defining an architecture that cuts through the MES and ERP boundaries; this architecture is simply three levels – Infrastructure, Business Productivity / Process Optimisation and Business Context. We have spent little time on business context and will introduce some of the main elements
now, before drawing some conclusions on the future of IT systems in mining, manufacturing and process companies.

In general, a mining or manufacturing company will either succeed as a large global player of commodities with lowest production cost per ton; or as a regional player with a highly differentiated service based niche product. Those companies that are neither large nor niche are about to be sold/acquired or will be increasing their product / service differentiators.

Companies that want to be global players will have to grow rapidly into new territories. This process is characterized by acquisitions and some disposals; followed by standardizing business processes into the newly acquired businesses to avoid replicating fixed costs. Long term technology strategy is in general standardized across the enterprise and the business stays competitive by centralizing certain corporate functions and services. Access to the end customer is not always very important, because products are distributed and sold as commodities by third parties based on price; and the lowest cost producer wins, eventually.

Regional service based companies embark on a strategy to differentiate their products through offerings that are as close as possible to the customer’s needs. Here agility and the ability to communicate into the customers’ systems are essential to maintaining relationships in which service delivery is rated more highly than price. As an example, to retain customers, these companies adapt tactics such as vendor managed inventory, whereby automated replenishment of chemicals is initiated from the customer’s inventory management system.

Both categories of company are faced with increasing regulatory compliance issues. For example, corporate governance (e.g. King), Sarbanes Oxley and Safety, Health & Environment legislation (e.g. OHS Act) place significant constraints on business systems and there is a clearly defined need for properly implemented technologies to facilitate transparency and compliance.
Companies in both categories are also faced with the desire to outsource certain business processes - for example in the areas of HR, Finance, Legal, IT, Logistics, Warehousing, Plant Maintenance, etc. Each of these outsourcing functions requires significant levels of integration and communication between the business systems of the mining / manufacturing company and the outsourced provider.

The technology world

IT companies are in many respects subject to the same challenges as mining and manufacturing – they are part of the same ecosystem and subject to common pressures in volatile financial markets and times of uncertainty.

A few large players have emerged (both in business and plant systems) and these will continue to dominate the technology landscape for some time to come. These large companies are complemented by a sometimes rich ecosystem of smaller, niche software vendors and IT companies. It is not true that these companies are all vulnerable – several best of breed companies have outlived their big brothers in ERP and MES and will continue to do so.

Technology complexity is rising, forcing vendors to invest more in maintaining software applications – hence the move to annuity based software pricing or increased maintenance. It is arguable, but appears that most of this increased maintenance revenue is to maintain the status quo – major functionality enhancements in the world of Manufacturing Business Systems are few and far between – the focus is on interoperability and standards based integration.

There is a gradual shift away from pure business process automation and plant automation towards empowering users of software to make better decisions. Unstructured information, resident in documents, e-mail messages, etc. is now seen as a major element of business knowledge and needs to be managed properly. As companies mature their basic business processes, the emphasis will move towards “people centric” computing.
Conclusions

The conclusions below are based on a comparison between traditional MES and ERP systems and several trends in IT – to derive a simplified model that removes artificial boundaries between these “layers”. They are at best an educated guess; however they should form a set of assumptions to direct strategic planning:

1. ERP and MES will converge and both die a natural death. A single concept will emerge which I will call “Manufacturing Business Systems”.
2. MBS will in future comprise three layers that cut through what were once MES and ERP: a basic infrastructure, a business process / productivity optimization layer and a business context layer.
3. The human element is essential to the business process / productivity optimization layer and IT systems will be designed first and foremost to empower better human decisions; the rest will be automated.
4. Strategic IT in mining, manufacturing and process should focus on automating what should be automated, and then paying particular attention to the middle layer (business process / productivity) because this is where human decisions are made and significant competitive potential lies.
5. SOA will continue to gain acceptance as a viable integration approach, driven by the business requirements of mining and manufacturing companies, but also by the need of mega-vendors to integrate their own acquired software products with each other.
6. There will be a continued emphasis on industry standards for interoperability between software modules, but progress will be slow and in the short term will probably only have a superficial impact on integration.
About the author

Experienced for 22 years as a Chemical Engineer (BSc Chem Eng cum laude, UCT), Gavin Halse founded ApplyIT (Pty) Ltd, a South African company specialising in niche solutions relating to operational safety, health, and environment within the manufacturing and mining sectors. Prior to forming ApplyIT, Gavin has held traditional roles as a Process Engineer (previously involved in a number of Synthetic Fuels projects in South Africa) and in IT (since 1999 he has held the position of CIO and IT Consultant for AECI, a speciality chemicals group in the South African region). He has been involved in initiatives in a number of process industry sectors including Chemicals, Petrochemicals, Biotechnology, Mining and Paper; and has led a variety of projects in many different company sizes from a few hundred to many thousand employees. Gavin has been a speaker at several conferences in South Africa and in Europe on the topic of IT in manufacturing.

As Managing Director of ApplyIT Gavin’s responsibilities include leading business development and partner strategy, and to continue to build and support new technology based solutions relating to safety and plant operations with relevance to a global market.

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