Value Creation in the Digital Mine

Inspire and Shape

a digital world that reinvents safety and productivity

SAP Run Simple

A MESSAGE FROM ECKHARDT AND RUEDIGER

Times of big change are times to be bold and to forge a vision for a different kind of data-driven business. Successful leaders will not languish in legacy business processes, but step out of the shadows and make use of the newest technologies to drive Big Data, mobility, autonomy, geo sensing, analytics and even 3D printing.

Eckhardt Siess
Global Vice President , Mill Products and Mining Business Solutions, SAP SE

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Global Lead for Mining Business Solutions SAP SE

Transformation of the mining industry into a high tech industry

Almost everyone has this picture of a miner in his/her head: hard working men, with a pick over the shoulder and a dirty face in a dangerous work environment. It's time to rethink this picture. The mining industry is going through a huge transformation as it enters the digital age.

Low commodity prices that have dropped almost 50% below recent peaks, and the shortage of skilled workers is accelerating this transformation.[1] High capital spend and decreasing grades have led to an increasing productivity gap compared to other manufacturing industries like automotive, where productivity gains have been largely driven by automation. **Research shows a 3.5% drop in productivity per year in the last decade**.[2]

Despite these challenges, there are big opportunities. In fact, there's a huge ore body that's still unmined. Less than 1% of all data collected in mining companies is used.[3] Leading mining companies that are trailblazing the future understand this very well. With digital technology, they are tapping into that remaining 99% to **mine smarter, not harder.**

Successful leaders look beyond legacy business processes to make use of the newest technologies in **Big Data, the Internet of Things (IoT), mobility, autonomy, geo-sensing, analytics, and even 3D printing**. These technologies are not only game changers – they will become a necessity for survival with gains in operational efficiencies from automation and real-time planning, to total workforce management, and much more.

Every CEO we speak to sees digital technology as a key enabler in reinventing business processes and redefining work in their enterprises. In fact, **10 of the world's top mining companies see Big Data analytics as one of the game-changing technologies that will transform the industry in the next 5-10 years**.[4] We couldn't agree more.

The industry realized it needs to mine smarter, not harder, in order to:
- Make better real-time, data-driven decisions
- Make operations more automated, predictable, and agile
- Transform traditional labor workers into knowledge workers

It's time to act, innovate, and leverage digital connectivity to mine smarter, not harder.

We respectfully invite you to join this conversation. We have invested our best minds to provide you with what we believe is an inspiring point of view of where the industry is going and how our solutions can help in the digital transformation to the "digital mining enterprise." We are devoted to helping the world run better and improving peoples' lives. Safe, sustainable, and profitable mine operations are at the very center of this vision.

Thank you for your interest, and we look forward to your feedback.

Eckhardt Siess
Global VP, Mill Products and Mining Business Solutions

Ruediger Schroedter
Global Lead, Mining Business Solutions

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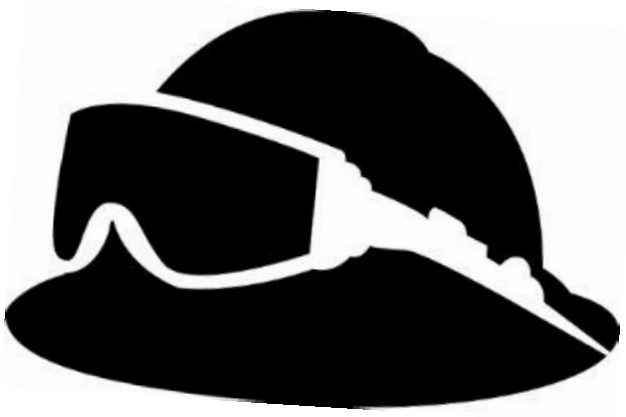


EXECUTIVE SUMMARY

Big picture: The digital economy is real and it's here to stay – What you need to know to be prepared

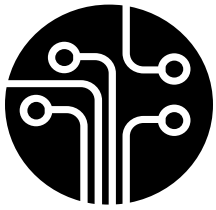
There are five key technology trends shaping the digital economy – hyper-connectivity, super computing, cloud computing, cybersecurity, and a smarter world focused on outcomes. Investing in IT solutions that support these goals is critical to keeping up with the rapidly changing industry.

How are mining companies using technology to drive efficiency?
Digital leaders in the mining industry are leveraging data streaming from smart devices and embedded software for smarter decision making. Spatial production monitoring systems incorporating inputs from mine planning, mineral resource management, ventilation, safety, rock engineering, and other sources with ERP integration can improve forecast accuracy significantly.

How will my employees benefit from the digital world?
Low worker productivity is often caused by technology challenges such as hard-to-use interfaces, lack of integrated systems, software that is too complex, and excessive time spent on compliance topics.

Once we invest in the right technologies, how do we drive adoption?
Employees don't want to read manuals or attend lengthy training session to learn how to use new systems. Instead, they want a solution that is intuitive, simple, and visual, similar to the consumer applications used in their personal lives. Implemented technology must included 3D graphics and be visually captivating in order for it to thoroughly be adopted.

What will it take to win in this newly digitized industry?
Companies that embrace the digital world and execute on their digital strategy are growing shareholder and stakeholder value. Value creation is significant, with +9% revenue creation, +26% impact to profitability, and +12% market valuation.[5]



Digital business models are disruptive. The rules have changed.

- The benchmark S&P/TSX Global Mining Index has fallen 65% since 2010[6].
- Mine productivity has declined by 28% in the last decade[7]
- On average, companies spend 3% of revenue on IT. Energy and natural resources companies lag far behind with an average of 1%[8]
- Ten of the world's top mining companies put Big Data analytics at the top of a list of what mining companies see as the game-changing technologies that will transform the industry in the next 5-10 years[9]

THREE IMPERATIVES FOR THE MINING INDUSTRY

The key to staying relevant in mining is to imagine new business models and constantly seek out and leverage new business and technology concepts.

- Be a leader in reinventing and digitizing the business
- Provide simple user interfaces connecting all relevant information in one place to push productivity
- Digitize collaboration with customers, suppliers, and the workforce

> Our industry is damned by the fact that our spending on innovation, research, and development is one-tenth that of the petroleum industry. If we don't start to bring innovation back...the major diversified companies will be subsidiaries of General Electric or some other conglomerate that has still got innovation in their vocabulary.[10]

EXECUTIVE SUMMARY

The future: Mining companies are becoming connected, digital enterprises

Transformation drivers

The mining industry is transforming at an increasing speed, driven by

- **Productivity:** High capital intensity continues to drive the need to increase productivity and the use of and search for new technologies in drilling, blasting, and hauling.
- **Automation:** From monitoring sensors and predicting machine behavior to driverless trucks and trains, automation will drive the digital mine. This will reduce costs and help minimize delays caused by labor shortages at the many sites in remote locations.
- **Technology innovation:** New technologies such as sensors and wireless devices will become more affordable, while existing technologies, such as gaming software, will find new use cases, including simulation and training.
- **Compliance:** Growing environment, health, and safety regulations demand sustainable, ecological, and safe mining operations.
- Environmental Factors.
  - **Water:** Stricter regulations about water usage are impacting finances and even the future viability of mines in many regions
  - **De-carbonization:** Renewable energy will replace fossil and nuclear fuels, helping to defer the ever-increasing variable cost of energy
- **Cybersecurity:** Protecting sensitive systems is more and more important as the real-time digital mining enterprise becomes an attractive target for cyber criminals.

The digital mining enterprise

Mining companies have been traditionally been driven by output volume. However, this is no longer sufficient, and many are aiming to design a system that better balances demand with production, focuses on profitability, and can also yield a more efficient operations and control system. This transformation requires real-time digital information and control in a digital mining enterprise.

New business models

Mining companies use the transformation drivers to reimagine business models, business processes, and job descriptions.

- **Making mining more predictable:** As the mining ecosystem is becoming digitally connected, mines and their internal departments, vendors, shippers, and customers collaborate digitally and exchange documents. Collecting data from equipment and combining it with demand and supply data from competitors can help mining companies more accurately predict production and sales and how these are impacted by the various factors. This will help to move to an agile and more demand-driven production model.
- **Collaboration** will strengthen relationships critical for sustaining high customer satisfaction and retention rates. Using digitized information, mining companies can provide additional services and models based on customers' individualized needs, such as new transportation methods or detailed tracking information. Mining companies can collaborate with one another to offer customers blended grades they would not be able to offer by themselves.
- **Robots and automation** allow mining in areas that were previously inaccessible, like Arctic and underwater mining. In traditional mines, it will make work safer and more productive.
- **Investments and divestures** of assets can be managed across a portfolio to mitigate short and long-term risk and improve profitability. Analyzing financial data on individual projects will allow mining companies to buy or sell projects as necessary to optimize revenue and maintain focus on core competencies.
- **Value chains** will change so that non-value-added tasks are moved more and more to contractors. Three-dimensional printing will reduce the bounded capital and allow faster and cheaper supply of parts.

The average capital intensity for a new copper mine in 2000 was $4,000-$5,000 per annual ton of production. Today, capital intensity is over $10,000 per ton on average for new copper mines.[11]

The variable cost of energy in the mining industry has more than doubled in the last 20 years from an average of 22% in 1995 to 50% in 2010.[12]

84% of mining CEOs are concerned about changes in regulations disrupting their business.[13]

Production of certain major commodities has expanded by 50% or more over the past decade.[14]

85% of organizations in the ENR sector believe that the ability to manage and analyze Big Data is critical for them to meet their strategic objectives.[15]

EXECUTIVE SUMMARY

Road map to Run Simple: Steps to digitizing your business

REIMAGINING

Do you have the right strategy? Start by reimagining your mining company with business outcomes and customers at the center.

REIMAGINE
BUSINESS MODELS

Competitive advantage is driven by expanding beyond traditional industry boundaries and transforming to a real-time and collaborative organization. We see three types of emerging business models:

- Making mining more predictable and agile
- Collaboration across mine sites, departments, and with suppliers and customers to work holistically when issues arise
- Increased automation with robot mining and smart equipment enables mining in even harsher environments and the development of new mining designs

REIMAGINE
BUSINESS PROCESSES

The need to improve productivity drives changes to business processes. Digital technology enables business process efficiency and innovation that inspire new business approaches and accelerate efficiency and safety gains from the pit to the port.

REIMAGINE
WORK

People remain a crucial aspect of a successful mine, with recruitment, retention, and productivity key focus areas. Many tasks will become automated, but people will be an even greater asset in ensuring the success of the mine as their roles change. Geo-sensing, automation, wearable technology, user interfaces, virtual reality, and 3D simulations are new technologies that will impact mining employees in the future, so they can focus on their work rather than on bridging process inefficiencies.

PLATFORM

Do you have the right platform? Leaders are investing in digital capabilities that are congruent with their strategy. The right technologies ensure agility and a rich environment for innovation.

SAP's **digital business framework** is based on the five key pillars of a digital plan and architecture:

1. **Supplier collaboration** across all spend categories (product, services, and T&E)
2. **Internet of Things and Big Data** to drive real-time insights and new business models
3. **Workforce engagement**, including employees and contractors
4. **Core business processes** (finance, supply chain, R&D, manufacturing, ...)
5. **Digital mine** to converge OT and IT and gain insights into all operations across the enterprise

Return on investment (ROI) drives this significant phase of the transition to digital. It's not about any one of the five pillars, but rather how they all interconnect to achieve business outcomes.

We apply **Design Thinking** as a our key approach to the reimagining phase. Design Thinking can be described as a discipline that uses the designer's sensibility and methods to match people's needs with what is technologically feasible and what a viable business strategy can convert into customer value and market opportunity.[16]

EXECUTIVE SUMMARY

Fundamental changes: Five technology trends changing everything

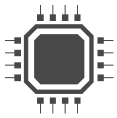
We are witnessing an unmatched era of true business innovation. Breakthrough technologies have matured and hit scale together, enabling five defining trends:

HYPERCONNECTIVITY

1 

Every business partner and every machine is connected and will allow better collaboration and data collection for miners as a basis for agile production and customer interaction.

SUPER COMPUTING

2 

The limits of 20th century computing power are gone. Networking and in-memory computing allow organizations to make use of the data already being collected from mining operational equipment and put this data to use for better prediction and analytics.

CLOUD COMPUTING

3 

Technology adoption and business innovation now move at lightening speed. Technology infrastructure is rented to eliminate barriers to entry. B2B transactions are moving to new cloud-based collaboration platforms, where mining companies can interact directly with suppliers, communities, and customers.

SMARTER WORLD

4 

Sensors, robotics, drones, 3D printing, and artificial intelligence are the new normal. This will allow for increased automation in areas which would not have been imagined by mining companies just a few years ago.6

CYBER SECURITY

5 

With the increased connectivity of equipment and autonomous vehicles, cybersecurity is becoming more and more important in preventing cyber criminals from attacking and disrupting mining production or gaining access to trade secrets.

REIMAGINING

THE DIGITAL ECONOMY OFFERS INFINITE NEW OPPORTUNITIES

In a connected world where every company is becoming a technology company and industry lines are blurring, smarter products and services will refocus commerce on business outcomes

DIGITAL INNOVATION IS REAL IN MINING

Mining companies reimagine their entire business to stay successful by becoming digital mining enterprises. This reimagining applies to business models and processes as well as the work itself.

REIMAGINE BUSINESS MODELS

With the challenges at hand and technology becoming available, mining companies have to adapt their business and operation models to stay competitive.

- **Make mining more predictable:** Consider external factors like demand, weather, competitors, and supplies and combine this with internal factors like predicted asset failure to become more agile and change to demand-driven production
- **Collaborate and use business networks** across the entire mine ecosystem to streamline data exchanges and decision making and become more agile
- **New approaches in mine developments**, including fully remotely operated mines, that better support the remote nature of some locations rather than just transferring the same approaches from less complex mine developments
- **Embracing new technology and driving automation** faster than in the past to make production more efficient. Precision mining is just one example to target the ore body better and reduce tons of waste moved

REIMAGINE BUSINESS PROCESSES

When analytics and transactions are combined in real time on the same platform, business processes will never look the same.

- **Smarter mine modelling,** where geomodeling includes real-time information for faster decision making and reserve calculation
- **Increase predictability** by connecting machines and transforming how assets are managed, operated, and maintained,.
- **Sustainable sourcing** and usage of energy and water, will be measured and analyzed real-time.
- **Adopt an agile supply chain** in real time based on demand signals or events and adjust to ever changing work and economic condition much quicker than today
- **Advanced analytics** of structured and unstructured data will significantly improve visibility into and use of social media. This is important to improve communication with external stakeholders. Sharing benchmarks in real time across the enterprise help to determine and implement best practices

REIMAGINE WORK

Employer of choice status goes beyond recruitment and retention to fundamentally revolutionizing the way people engage.

- **Digitize back-office processes** by eliminating manual steps in (e.g., invoice and payment processing)
- **Change work conditions** by moving more labor from mines to remote control centers and using self-learning and predictive operational systems
- **Share knowledge easier** as support-on-demand tools for the entire workforce become available in real time
- **Implement simplified user interfaces** and virtual reality to improve user experiences, including voice recognition, visualization, and gaming
- **Increase communication and information sharing** within the workforce and with outside communities through social and broadcasting networks
- **Manage a contingent workforce** to ensure contract workers receive the same training, meet the same qualifications, and hold the same certifications as employees. This ensures quality standardization across the workforce while allowing scheduling flexibility and maximizing profitability

REIMAGINE BUSINESS MODELS

Cost pressure, de-carbonization, regulations, financial markets, and digitization challenge established business models within the mining industry.

Current trends paint a picture of the future of the mining industry. New business models include:

- **Making mining more predictable:** Predicting asset failures and avoiding them is a first step. This then must be combined with external factors, such as weather and demand, to vastly improve production forecasting and decrease the costs associated with uncertainty. Sensing ore grades directly at the shuffle and hardness of the rocks to determine drilling speed will change how mines operate. They will become more agile and flexible so as to make adjustments according to demand. This necessitates a move from traditional mining practices toward a more modern manufacturing model with advanced forecasting models. Simulations and game technology will help organizations make better investments and operative decisions and prepare for demand swings
- **Collaboration:** This includes collaboration with customers to provide better information about shipment status in real time, handling of spot sales on electronic platforms, and also internal collaboration to improve mining processes, from planning to execution with vendors and contractors. Collaboration with other mining companies for blended products provides an opportunity to sell to a wider customer base that wouldn't be reached with the single grade offering. Business networks facilitate collaboration, sharing data and exchanging business transactions, and covering aspects from procurement, sales, workforce management, and equipment management
- **New approaches to mine development:** Aside from unchartered territories like underwater mining with robots, alternative approaches have to be considered for new mine developments in remote areas. Simply transferring concepts from less complex locations will not be sufficient. New approaches with holistic end-to-end methods need to be developed, for example, in site design and planning, and in energy use and management, including fuel, renewable energy, electrical vehicles, and hybrids. Mines operating fully remotely are no longer out of the question
- **Automation in operations**
  - Autonomous fleets and trains are becoming mainstream, but automation and robot mining will also allow mining in areas where it was not possible before, such as underwater or in very harsh environments. Mine workers' exposure to hazardous conditions will also be reduced, ultimately improving safety
  - Detecting waste before it gets moved by truck will lead to more efficient use of trucks
  - Use of drones can provide real-time updates on production progress, stockpile sizes, and composition, and deliver a level of accuracy in geospatial information that has not been seen before. This will also generate large amounts of data to be analyzed for trends and insights
  - Production may evolve into models seen in the oil and gas industry, where contractors take responsibility for the complete business process in the production
  - Energy-saving technologies in mine transportation and renewable energy will reduce the need for fuel and its expensive transport to remote locations
  - The definition of non-value added tasks will change. More tasks will be taken over by contractors, and mine operators will have to manage and synchronize these workers along their own employees

RIO TINTO'S CERRO VERDE MINE
Hauling rock around accounts for half of Cerro Verde mining costs, so it bought and programmed trucks and software to run a relatively small number of trucks more frequently. Monitoring software quickly spots problems in trucks and shovels, allowing them to be repaired before they have to be replaced, saving money. [6]

REIMAGINE BUSINESS PROCESSES

The rise of digital technology enables the digital mining enterprise by transforming business processes to make mining more efficient, innovative, and safer.

Smarter mine modelling

Seismic and predictive geomodeling and analytics with data from sensors will allow for smarter mining. Real-time calculation of reserves will improve the accuracy and speed of communication to stakeholders to help make quick and informed decisions about whether to move forward with a development project.

Predictable operations

Real-time planning and scheduling, where real-time alerts and information from various stakeholders like production, maintenance, contractors, and the equipment itself reduce unexpected disruptions and allow for better execution. With precision mining, grades and digging speeds can be determined at the shovel and can influence planning in real time to continuously predict output for the shift and day. Real-time communication from vehicle to vehicle will synchronize them for better utilization.

Predictive maintenance completely reinvents the way asset health is monitored and maintenance and exchange of assets are planned. Sensors monitor all relevant plant assets and help predict the optimal time and sequence for maintenance/exchange of assets.

Increased collaboration with equipment manufacturers though the SAP Asset Intelligence Network allows seamless access and feedback back and forth, while keeping data accurate.

Sustainability

Renewable sources of energy will be build natively into the design of new mines and achieving water and power consumption reduction goals will be supported by accurate and real-time metering and analytics tools.

The new smart technologies transform and create new business processes.

Agile supply chain

Inventory optimization for spare parts and stock piles will reduce bound capital. Three-dimensional printing of spare parts has the potential to significantly reduce inventory, the associated capital, and idle time, as no wait time for deliveries is needed. Lower cost for shipping inventory to remote sites provides additional savings.

In the past, supply chain coordination could be done with telephones. Now, with more cost pressure, the availability of new technologies, and the need to offer more variety of shipping terms, collaboration and better planning of the supply chain become imperative. More demand-driven production will potentially reduce price fluctuation.

Procurement and asset management through business networks will automate many paper-based processes and run operations much smoother.

Advanced analytics and benchmarking

Real-time analytics and benchmarking can identify the true cost drivers and find correlations between factors in a way that has not been possible before, thereby improving decision making. Companies can more easily compare equipment and determine reliability factors. Analytics will present actionable data to operators to provide further decision support. Having one source of data across the enterprise enables improved collaboration between various departments.

Combining structured with unstructured data can provide new insights, from the impact of social sentiment on production and exploration, to factors impacting sales.

Anglo Gold Ashanti, a global gold mining company operating in 11 countries, is using precision-mining technology, to mine only high-grade ores. They're not wasting time digging for and transporting low-grade ore.[17]

Codelco equips underground workers with bionic jackets containing safety sensors, enabling tracking of physical location and monitoring environmental factors such as light, sound, and oxygen.[18]

REIMAGINE WORK

The fundamental transformation from a manual, labor-intensive industry to a digital mining enterprise profoundly changes what people do, how they learn, interact, and grow.

Remember the picture of the hard-working miner with a pick over his shoulder? This picture is becoming a thing of the past. Miners' work will be easier, safer, and much more technology-driven, but transitioning people's mindset into the new age is equally important.

Back-office business processes will be fully digitized; manual steps in procurement, inventory management, invoicing, and payment processing are replaced by smart digital processes that have access to real-time analytics to support rule-based decision making.

The work conditions will change. Business processes and labor will move from mine sites to (remote) control centers, ultimately making the work environment safer. Digitization of safety systems und deploying of wearable devices will make tracking and evacuation much faster. Operational processes will be supported or controlled by predictive and self-learning systems that interact with machines.

Enterprise knowledge becomes digital as business processes and decisions move to the machine. People who need the knowledge have digital access on demand and in real time, regardless of whether they are part of the core or the extended workforce.

New user interfaces will make much more use of images and pictures in place of words. Voice and gesture recognition will make using software easier and safer on mobile devices. Virtual reality and 3D imaging and modelling will be common and reflect the transition of people's roles from transaction workers to exception workers, who engage when the digital rulebook needs human creativity.

New people interactions will develop between the core, extended workforce, and with the public over social and broadcasting networks. Real-time digital information on the right devices is critical to advance the business agenda with each interaction between people.

Total workforce management systems are needed to ensure all workers meet consistent quality standards to streamline scheduling and easily track employees across locations, improving the health and safety of the entire team.

People continue to be key assets in the digital mining enterprise. Their roles will change, but their value within the network will grow.

PanAust provided easy-to-use interfaces using SAP Fiori, with near-zero training required for senior managers and non-English-speaking employees in Laos across purchasing, maintenance, and HR departments. SAP Fiori increased user acceptance and satisfaction, reduced training costs, and provides a powerful reporting and analytics platform.[19]

SAP HANA: THE GREAT SIMPLIFIER

At the heart of a digital business is the agility and flexibility to adjust course at any time. This involves two key concepts: simplification and innovation.

- **Simplification** is all about doing what we are already doing, but better, faster, and cheaper.
- **Innovation** is all about reimagining business models and customer value by leveraging the five technology trends

The diagram below depicts the possibilities of the transformation to the digital mine. The idea is very simple, but it took years to make it a reality: bringing together transactions and analytics on the same platform. Uniting structured data (e.g., finance) and unstructured data (text, video, voice) will change the way businesses plan, scale, and innovate.

In-memory computing is a concept brought to life by the breakthrough SAP HANA platform. While relatively young by commercial standards, SAP HANA's rapid adoption across multiple industries validates its massive potential for digital businesses.

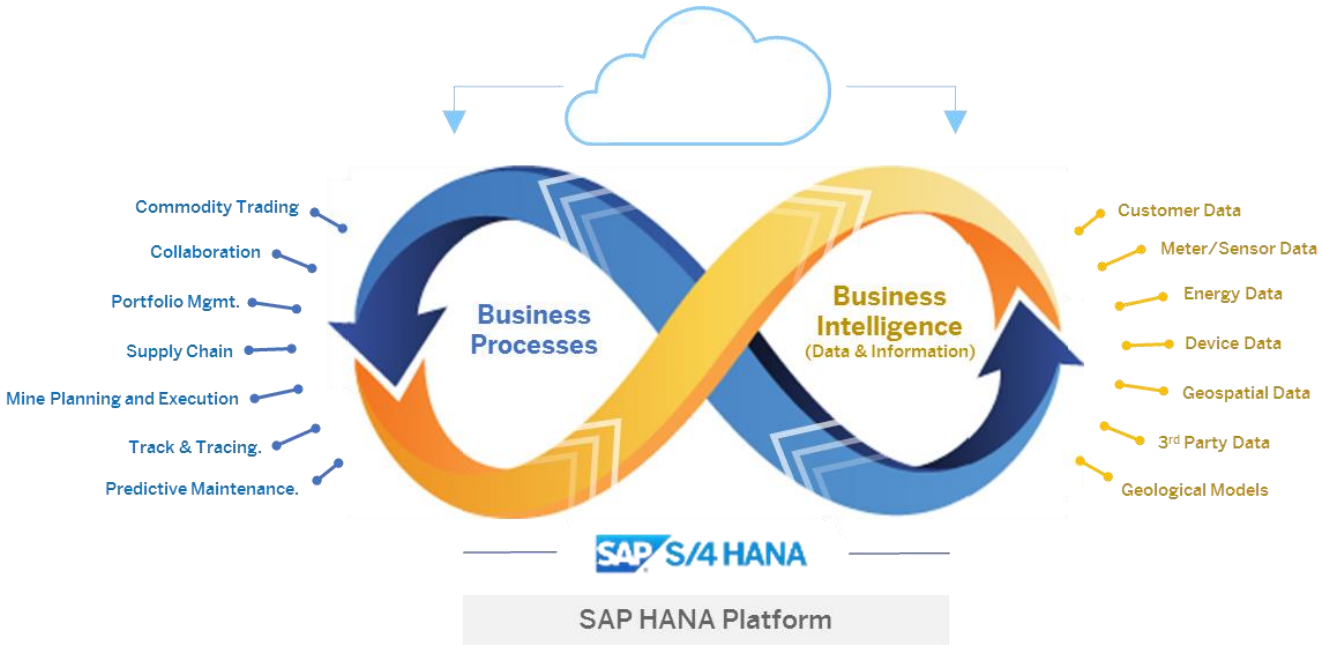
With in-memory computing, we can now finally:

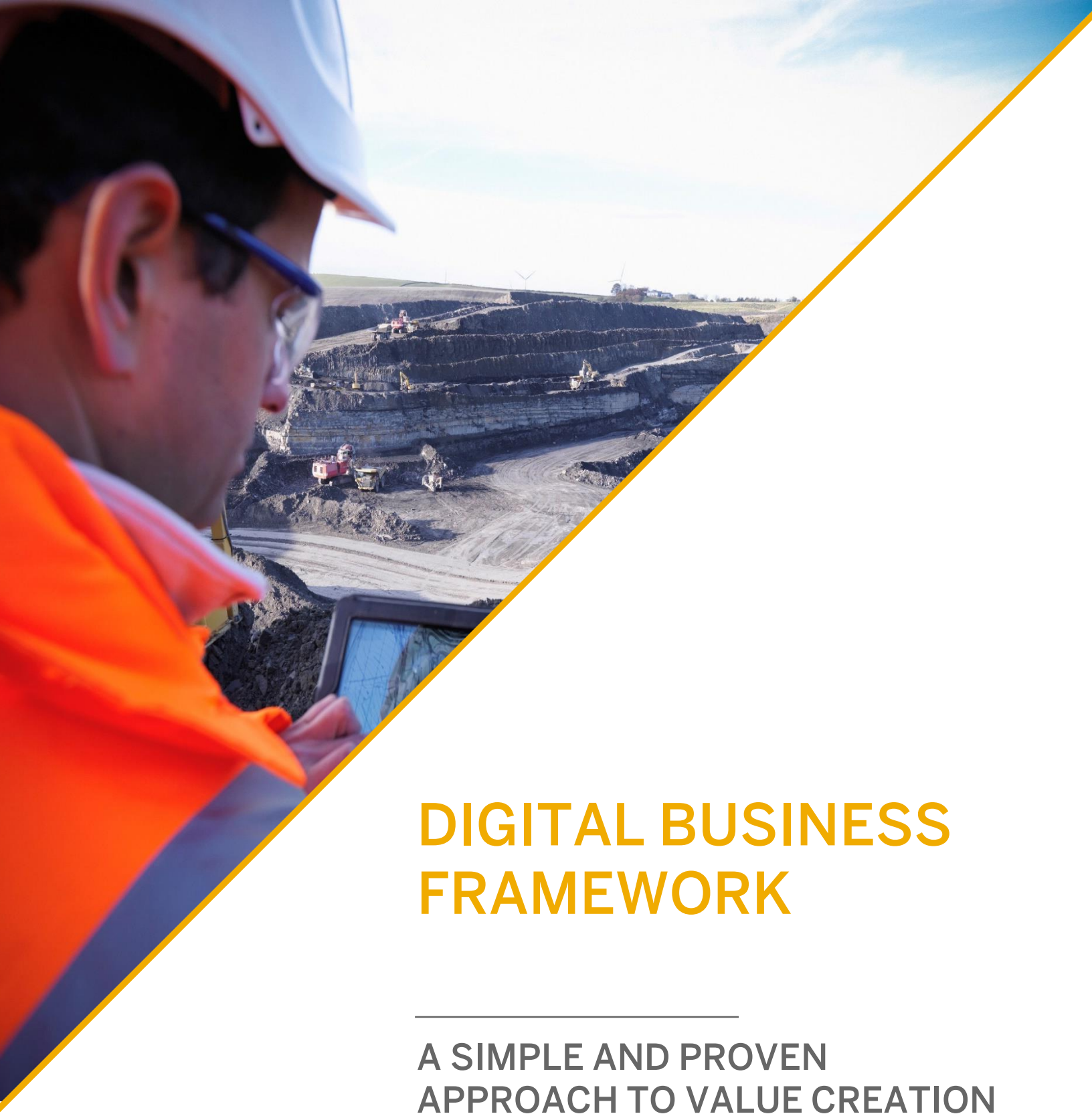
- **Leverage Big Data** from meters, sensors, weather, social, and geospatial sources. Bringing all data signals together leads to the perfect recommendation, which can be instantly acted upon in transactional systems via human and machine-to-machine interfaces
- **Extend the business process** to interoperate with business partners in near real time via advanced cloud-based business networks
- **Modernize business processes** from finance to supply chain, enterprise asset management and offer-to-cash, running them in rea time with no data replication and no batch programs

These capabilities open infinite new ways of optimizing business, driving business digitization, simplifying everything, reducing cost, and providing the agility required in fast-changing world.

SAP constructed an innovation road map designed to bring in-memory computing together with cloud computing and mobility.

SMARTER DECISIONS + SMARTER TRANSACTIONS = SMARTER BUSINESS





DIGITAL BUSINESS FRAMEWORK

A SIMPLE AND PROVEN APPROACH TO VALUE CREATION THROUGH DIGITIZATION

Every company, regardless of industry, requires a simple and pragmatic digital approach to execute on its digital vision and strategy.

DIGITAL BUSINESS FRAMEWORK

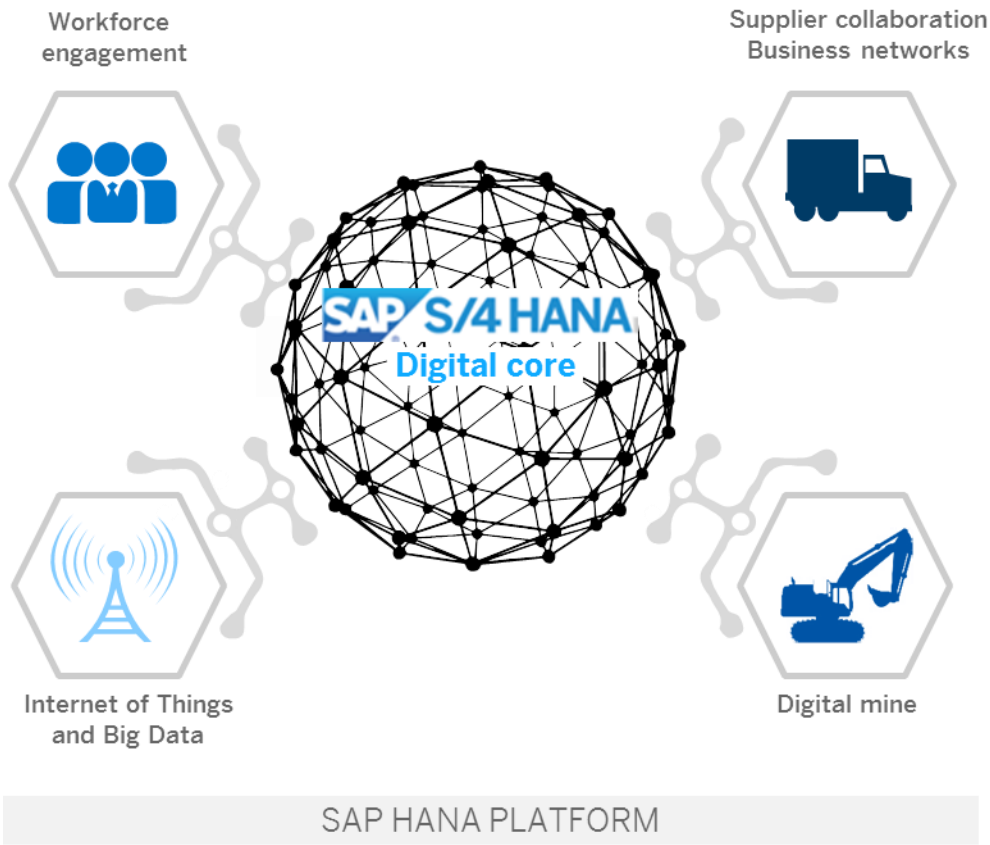
Every company needs to think about the five pillars of digitization

SAP understands the five pillars of digitization, and we also understand that continuously changing requirements pose big challenges for businesses. The method of reimagining work and business models and processes helps in developing the digitization road map.

We have built a framework to develop and execute on your digital enterprise strategy: the digital business framework.

Creating a digital strategy in mining based on this framework requires a focus on the following five pillars:

1. Outcome-based and smarter **operations management** across all mines and processing facilities
2. Smarter and engaged **workforce** across all employees and contractors
3. **Supplier** collaboration to accelerate growth and co-innovation
4. **Internet of Things and Big Data** to drive real-time insights and enable new business models
5. **A digital core** that connects business process and analytics in real-time to run smarter, faster and simpler



THE DIGITAL CORE FOR MINING COMPANIES

A new generation of ERP solution, running **in real time, integrating predictive, big data, and mobile,** will change how we work, how we run our businesses, and how information is consumed: the **future is here.**

Advanced in-memory computing marks the end of running the business in batch mode and eliminates complex workarounds for technical constraints. You can run simply and use the full power of the digital mine.

Real time

Real-time optimization of business-based changes will have massive implications on how we work, how we do business, and how we organize.

Power of prediction and simulation

Every employee can gain real business insights with the help of simulation and predictive tools to drive smarter decisions, improve productivity, and increase profitability.

Agility

The ability to rapidly enter new markets, acquire and onboard new companies, or reflect an organizational change in one-tenth of the time it takes with today's systems will yield the agility required in the digital economy.

Deployment choice and lower TCO

Accessing solutions to run the core has to be simple. Companies now have the choice to deploy in-house or in the cloud. In-memory computing also has a significant impact on TCO, and it will free up funds for innovation.

Consumer-grade user experience

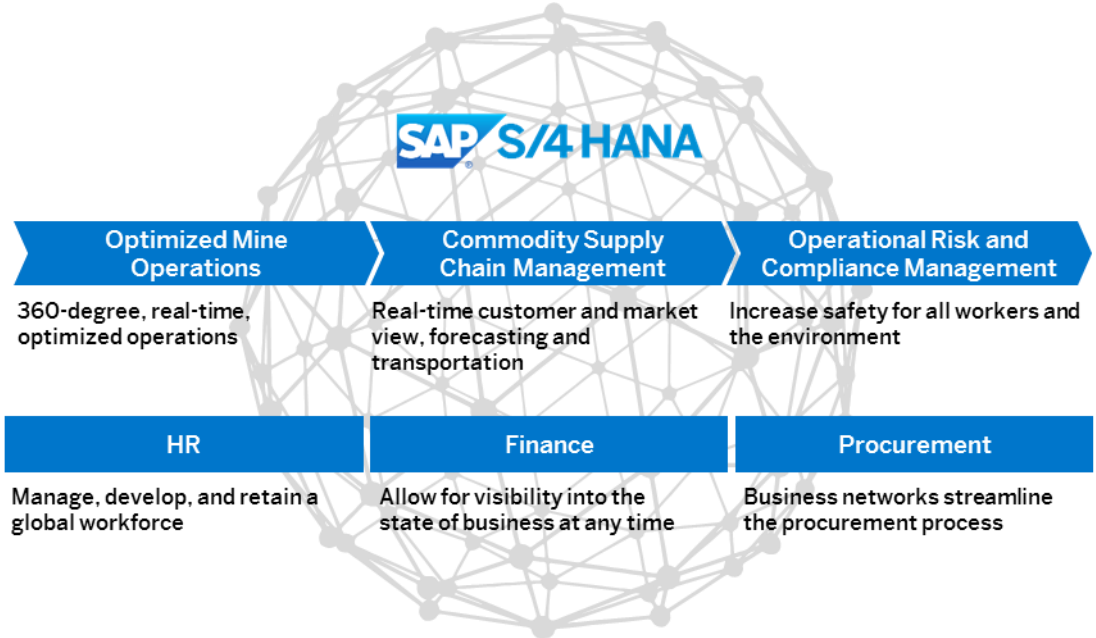
User experience is key to accepting digital change; it drives adoption, user engagement, and people productivity.

Simplify with SAP

SAP S/4HANA is the only end-to-end solution that covers all business processes across 25 industries and is running in-memory. It helps mines to run in real time for fundamentally better performance. For instance:

- Single, real-time view of plant and business performance with real-time analysis of asset performance
- Increase worker safety by receiving and analyzing real-time sensor data

In addition, the SAP HANA Cloud Platform can be the single enterprise data source for SAP S/4HANA and the rest of your solution landscape.



DIGITAL MINE

Digital technology has **changed the game**, but mining companies have to use it to their benefit to unlock productivity gains and achieve full visibility **anytime, anywhere, and on any device**.

Miners have to reimagine business processes in how they run their operations and take advantage of the digital economy, from sharing data securely and in real time to providing personalized and contextual insights for decision support and collaboration. Several trends are redefining the game:

Real-time decision support

With real-time and predictive planning and analytics, operators can act on data and share this information across departments and with external parties, thereby making assets and field workers more efficient..

Precision mining

Automation and precision mining technologies allow for a higher mine yield, rather than moving the waste. It drives predictability and profitability.

Asset networks

Let your suppliers connect to your critical mine assets to determine their health and make sure they run smoothly. Or receive this information directly based on your usage data updates on maintenance bulletins and synchronize data across all your operations.

20%
higher operating margins are achieved when enterprise mobility is embedded in all business processes[20]

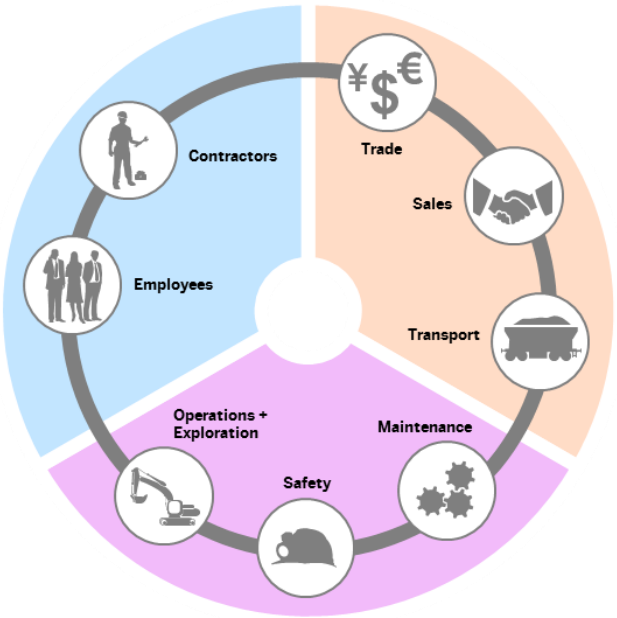
77%
of mining executives say mobile technologies are particularly helpful in achieving high productivity and capacity[21]

50%
of mining executives surveyed say they will invest in 3D visual display within the next five years[21]

Digitize your end-to-end mining processes with SAP

A single platform that brings together operational data, enterprise data, and analytics to ensure seamless digitization of the entire production process. SAP solutions powered by SAP HANA enable real-time integration and sophisticated predictive analytics, fully integrated to the core transactional system.

- Orchestrate business processes across sales, transportation, and operations
- Deliver personalized experiences in context with each interaction
- Create a single, harmonized experience for your operations managers, while reducing the burden on employees
- Full integration with your core business processes provides a unique mining-specific platform for real-time operations management and sales



WORKFORCE ENGAGEMENT

The world is getting **smarter** in the digital economy. But **complexity is overwhelming the workforce** in this pursuit.

Complexity is the enemy of workforce engagement. People are working as hard as ever but not necessarily accomplishing more. People need access to smart, consumer-grade technology to work faster, better, and more efficiently. Organizational complexity is driving costs up and slowing down progress. Three forces need to be addressed:

Changing of the guard

Over 50% of the workforce will be millennials by 2020.[22] Mining companies have to devise a workforce strategy to make work in this industry attractive for the digital generation, especially since a large portion of the current workforce will retire by 2025.

Contingent labor is on the rise

Companies are turning more and more to contractors and services providers to drive agility, lower fixed costs, and also fill skilled labor shortages. Mining companies can outsource work, but not the responsibility for safe and compliant operations. The contingent workforce must be digitally integrated into all business processes.

Complexity is on the rise

Regulations and complex new technologies are changing how work is done and the kind of knowledge workers have to acquire. Simplifying worker-machine interactions and user interfaces will increase safety and reduce complexity.

41%
increase in contingent workforce spending in the past five years[23]

30%
of executives say their companies give special attention to the particular wants and needs of millennials[24]

~40%
of the resource extraction industry's workforce in Canada is at least 50 years old, and one-third is expected to retire by 2022[25]

Simple, Global HR System

"We... came up with a road map for how to get multiple SAP HR systems into the cloud and get all our data into one place. SuccessFactors improves the culture and gives you more data around which to do analytics. And it allows us to go in and deploy easy-to-use solutions at a faster pace."[26]

Improve your total workforce productivity: Simplify with SAP

Digitize your workforce with SAP: SAP S/4HANA + SAP SuccessFactors solutions + SAP Fieldglass solutions + SAP Fiori provide the tools for total workforce engagement and advanced analytics.

- **Attracting the best people:** Recruit and onboard the best workforce, simplify their work, and ensure that regulatory and compliance requirements are met
- **Managing the total workforce lifecycle:** Manage the total workforce lifecycle from recruiting to onboarding, performance, compensation, and learning all in one place
- **Smarter apps with greater user experience:** Enable the workforce to easily access the right information across any device and through a dramatically simplified user experience simplified user experience

BUSINESS NETWORKS AND SUPPLIER COLLABORATION

B2B **transactional inefficiencies are costing $600 billion per year,** from sourcing and transacting to payment processing.

Collaboration across all spend categories will change the nature of how companies outsource, acquire products and services, and drive value creation across the entire value chain. Several trends are redefining the game:

Business connectivity at scale
When businesses small and large are connected in the millions, the transactional platform becomes the de facto standard for business networks. This is already a reality (examples: Ariba, Concur, Alibaba)

B2B collaboration by category
Acquiring products and services, or booking travel requires a set of open standards for business and technology terminology so organizations can collaborate. Those standards are now set and operational.

Consumer buying experience
Without a consumer-grade experience at work, users will work around the system, negating the value of negotiated contracts and driving maverick spending.

Network of networks
Companies are looking at end-to-end services like digital payment and invoice processing, asset management, travel booking, supplier certification, global business yellow-pages, etc. This is all possible as business networks like Ariba are aggregating the services into a one-stop shop.

#1
Respondents ranked automation and standardization of procurement processes to improve efficiencies #1 for mining procurement activities in 2015[27]

90%
of respondents say tracking and measuring savings achieved through procurement are top priorities for their businesses in the next 12 months. However, **only 60%** say said they currently have a measurement and reporting system in place to track savings[27]

27%
of mining procurement professionals are satisfied with their suppliers[27]

Simplify collaboration with your suppliers with SAP business networks

SAP S/4HANA gives you incredible capabilities to digitize processes across your business – and the connectivity to the business network allows you to extend those processes beyond the four walls of your business.

- **Solution already at scale** and covers all spend categories (direct and indirect material, labor and services, travel and expenses)
- **Business networks operate on a global basis,** meet data security standards, and operate with near zero downtime
- **Extensive offering by leveraging services** from many partners such as supply chain, financing, payment, supplier certification, etc.

INTERNET OF THINGS AND BIG DATA

The most **dramatic change** in the digital economy will be driven by hyperconnectivity and big data science. These will **transform nearly every business model.**

Utilities are finally understanding the full potential of the interlock between physical and digital assets and the Internet of Things. We are witnessing new use cases across utilities with breathtaking results. Below are some key trends:

Data-driven business models

The transformation in the mining industry is enabled by Big Data technology and the computing power to process massive amounts of data in real time.
Sensor and meter technology is not only collecting those big amounts of data, but it will also transform business processes and how organization use that data along the complete value chain in mining and processing.

Technology-driven supplier engagement and engineering

Equipment suppliers and their services and engineering groups are spending more and more on Big Data and sensor technologies, as their functions are the most transformed by these new technologies. Mining companies will be able to collaborate with them directly.

New alliances

Seamless collaborations around new business models involving partnerships that may not have made sense few years back are now possible. Examples include partnerships between transportation providers and satellite/weather companies, between Cisco and Caterpillar, and many others.

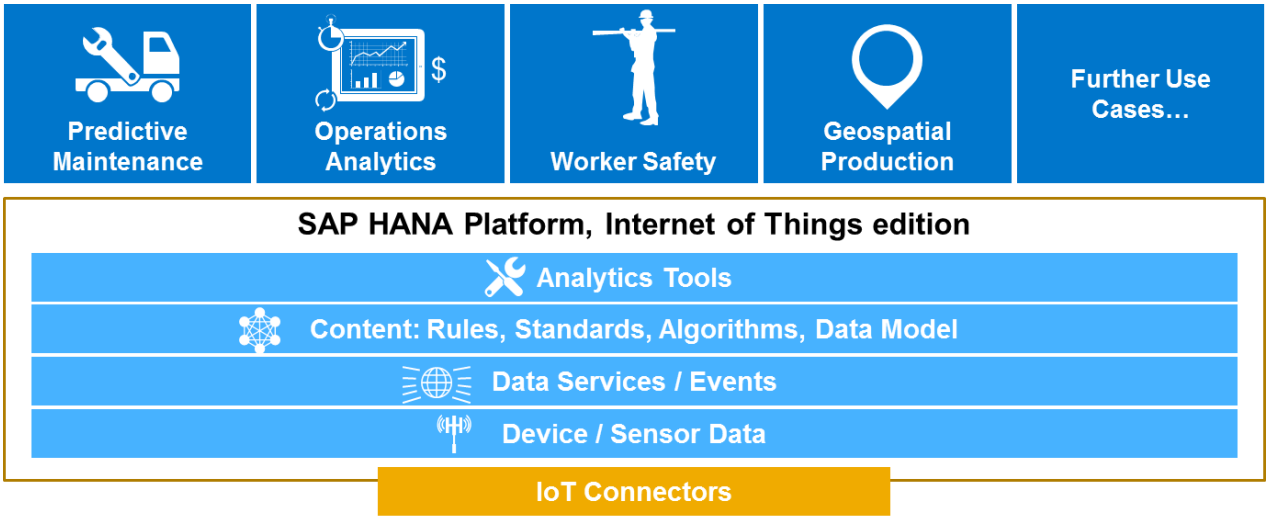
3 billion
Internet users and an expected 30-50 billion connected devices by 2020[28] [29]

80%
of all companies are planning IoT investments[30]

Remote Control Center
Roy Hill has a central control center 1,300 kilometers from the mine. With a live view of its remote mines, operational managers monitor, analyze, and predict factors such as production output, equipment status, operations, and other conditions. [31]

Connect, transform, and reimagine with SAP

With SAP HANA platform, Internet of Things (IoT) edition, organizations can now take embedded device data, analyze this data into information in real time, and apply the information across the value chain to drive business insights and create new business models. The Internet of Things platform provides the connectivity to OT systems either directly or via partners like OSISoft. The data is stored and processed in the platform, which provides basic functions like data services, predictive analytics, and others. Based on this platform, SAP, partners, and customers develop applications that enable mining use cases, such as predictive maintenance or connected logistics.



SAP HANA PLATFORM – A NEW COMPUTING PARADIGM

SAP HANA is the ultimate simplifier and the platform for innovation and digital business

Dream, develop, and deliver with SAP HANA Cloud Platform

SAP HANA Cloud Platform gives mining companies the mobile, collaboration, integration, and analytics capabilities you need to dream big, develop fast, and deliver everywhere, with the following capabilities:

Application extensions

Extend your current cloud and on-premise solutions for additional customization, enhanced business flows, and more.

Real-time analytics

Engage mine operations, optimize business processes, and gain new insights with real-time analytics apps, powered by SAP HANA.

New cloud apps

Quickly build innovative consumer-grade and industry apps for today's always-on, mobile, social, and data-driven world.

Extended storage capabilities

Holistically manage all structured, unstructured, and infinite data streams with flexible combinations of data stream processing, in-memory technology, disk-based columnar storage, and Hadoop-based storage solutions.

Data footprint reduction

Significantly reduce memory footprint and TCO. In ERP systems, we have seen ~6x reduction by SAP HANA's dictionary compression. Removing aggregates and actual and historical data separation further reduces the footprint up to ~10x.

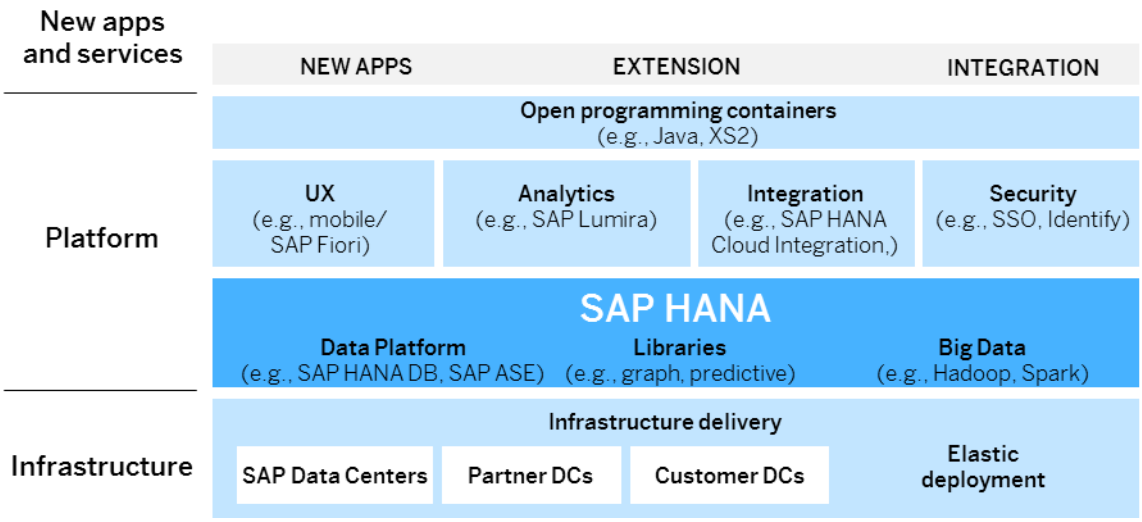
ArcelorMittal

ArcelorMittal is leveraging SAP HANA to differentiate itself from competitors.

"I am very convinced about SAP HANA as our common platform for any kind of data – SAP, non-SAP, reporting – and becoming our one point of truth, not only for reporting, but also for predictive analysis and proactive review of data."[32]

The SAP HANA platform is...

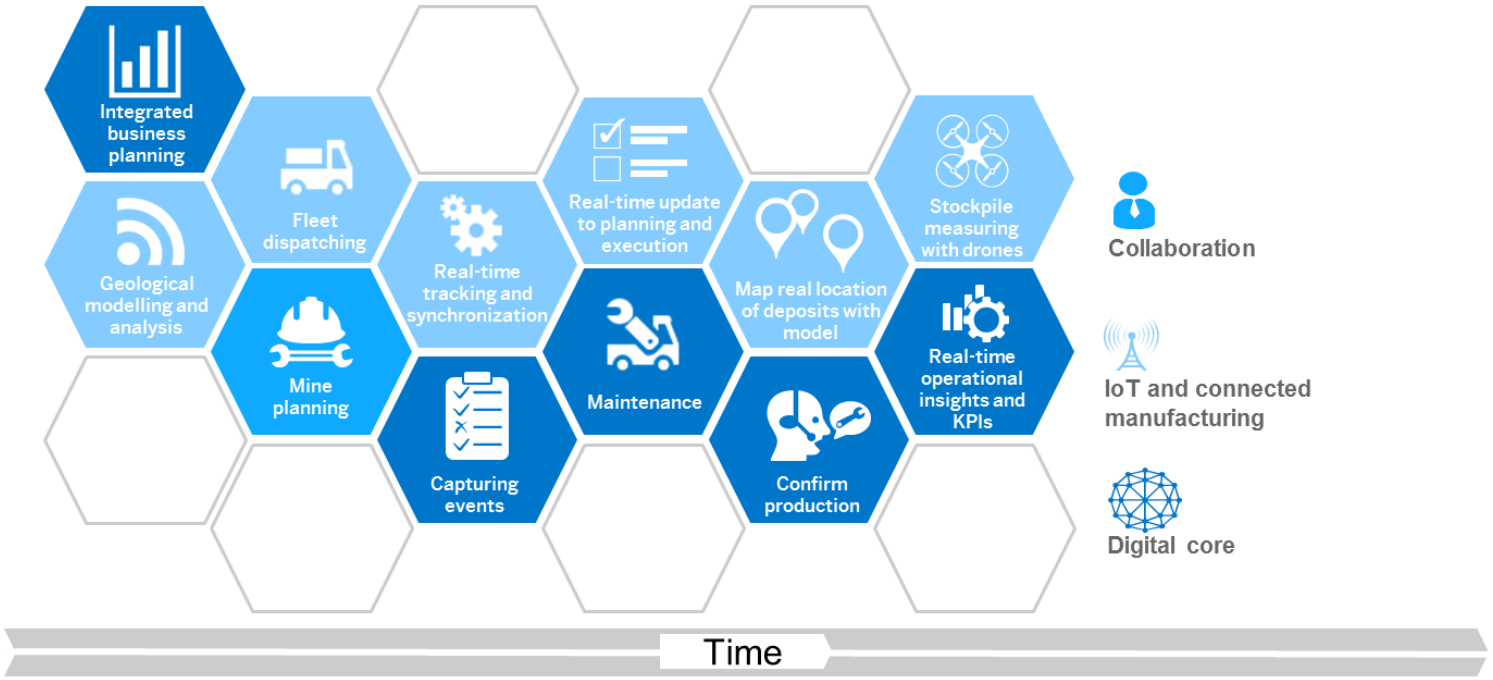
Real-time, in-memory platform • 10x data footprint reduction for ERP • Extended storage, including Hadoop • Open architecture • Developer-friendly • Embeds mobile and analytics • Secure • Cloud-ready



HOW DOES IT ALL COME TOGETHER? – EXAMPLE

Real-time mine planning, execution, and analytics in the future

While the five digital business pillars deliver significant value as a stand-alone capability, the ultimate goal is to design the next generation of business processes that will span across all the digital pillars. Mine planning, execution, and analytics will become real time and have to be aligned with the corporate strategy.



The process flow shown on this page portrays how leaders in the mining business can better integrate their OT and IT technologies to increase productivity. OT is the operational technology that manages mining-specific requirements (geological modelling, fleets, etc.), while IT represents the business systems that allow management of the business processes (finance, procurement, HR/payroll, maintenance, etc.). These two technology platforms are typically owned and operated by two different parts of the business. In the new digital mining era, value will come from the interoperability of these environments.

The scenario above shows how sensors (placed on equipment like shuffles, trucks, drones) and Big Data coming from the OT world will be leveraged by the IT world to drive next-generation best practices in mine management.

The real-time nature of ore grade sensing, geospatial information, and equipment synchronizing will change how people work, how automation increases productivity and reduces operational costs, and how our business partners are integrated in real time.

The benefits of this scenario are significant:

- Higher return on assets by using optimal maintenance strategies
- Safer operations due to the ability to monitor current situations and send immediate alerts
- Fewer unplanned outages because of a preventive-predictive maintenance approach
- Increased productivity and user acceptance, and reduced training costs from simple user interfaces
- Increased data accuracy through exact measurements rather than estimates; immediate data availability

HOW TO START

THE JOURNEY TO THE DIGITAL MINE BEGINS WITH A CAPABILITY ANALYSIS THAT RESULTS IN THE TRANSFORMATION AGENDA

THE JOURNEY TO THE DIGITAL MINE

The journey to define future business models capitalizing on the digital mine involves all disciplines of a modern mining company and requires a systematic approach to identify and capture business opportunities.

THE COLLABORATIVE VALUE AND INNOVATION FRAMEWORK

Mining companies embarking on the transformation journey to the digital business typically start to reimagine their business with a focus on business outcomes and customers. Answering the key questions, "What will change to operate mines?" and, "How will we make money?" will provide direction for reimagining your business processes and operational model.

For innovation today, a new level of collaboration is required. As a result, we have developed a framework that will be a continuous and holistic partnership model designed to drive true collaboration and engagement. Outlined below are the five steps of SAP Collaborative Value and Innovation Framework:

1. Strategy alignment: Understand company and SAP strategic direction and identify initiatives
2. Opportunity assessment: Opportunity deep-dive based on strategic initiatives and prioritization based on value
3. Solution road map and ROI: Document end-state solution, and business case including benefits, TCO, ROI, and strategic road map
4. Value realization: Deliver transformation on time, on budget, and on value
5. Governance: Maximize investments and accelerate value creation with governance based on executive engagement, value delivery, and continuous innovation

WHY SAP?

SAP ENABLES THE DIGITAL MINE WITH THE DIGITAL CORE, BUSINESS NETWORKS, SUPPLY CHAINS, AND THE INTERNET OF THINGS

SAP IS COMMITTED TO INNOVATION

Vision	Help the world run better and improve people's lives
Mission	Help our customers run at their best
Strategy	Become the cloud company powered by SAP HANA

- **75K employees** representing 120 nationalities
- **295K customers**
- SAP operates in **191 countries**

- Solutions for **25 industries and 12 LoBs**
- **98% of top valued brands** are our customers
- **74% of the world's transactions** managed on SAP

- **80 million** business cloud users
- **1.9 million connected** businesses
- **$800 billion+** in B2B commerce
- **99%+ of mobile devices** connected with SAP messaging

- 2011 **SAP HANA** launched
- 2012 **SAP Cloud** launched
- 2014 **SAP business networks** are the largest marketplace in the world
- 2015 **SAP HANA Cloud Platform**
- 2015 **SAP S/4HANA:** Most modern ERP system

- Mining solutions for commodities, transportation, and OT integration
- **67% of diversified metals and mining companies** in the Forbes Global 2000 are SAP customers – 700+ in total

MONITOR TRUCK SHIPMENTS AT PORT OF HAMBURG

Brought together port and road traffic conditions, truck availability, and incoming/ outgoing shipment schedules to **reduce idle truck/ship time**. The solution allowed the port to **increase container handling capacity by 178%** within the same land area.[33]

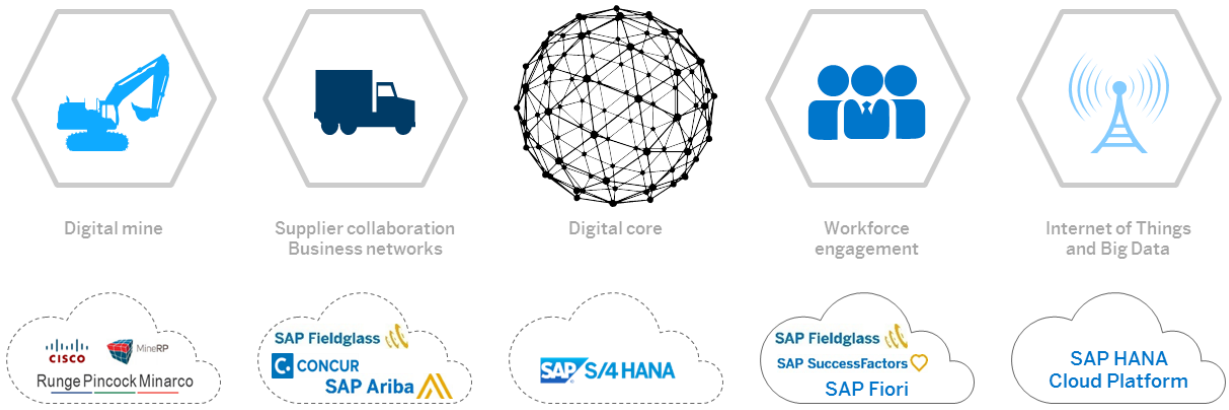
FIRE AND RESCUE

New South Wales now has a comprehensive view of fire and disaster risk to **protect 7 million residents.** 30+ years of experience available **in real time in SAP HANA** ensures the right people are addressing emergencies at the right time.[34]

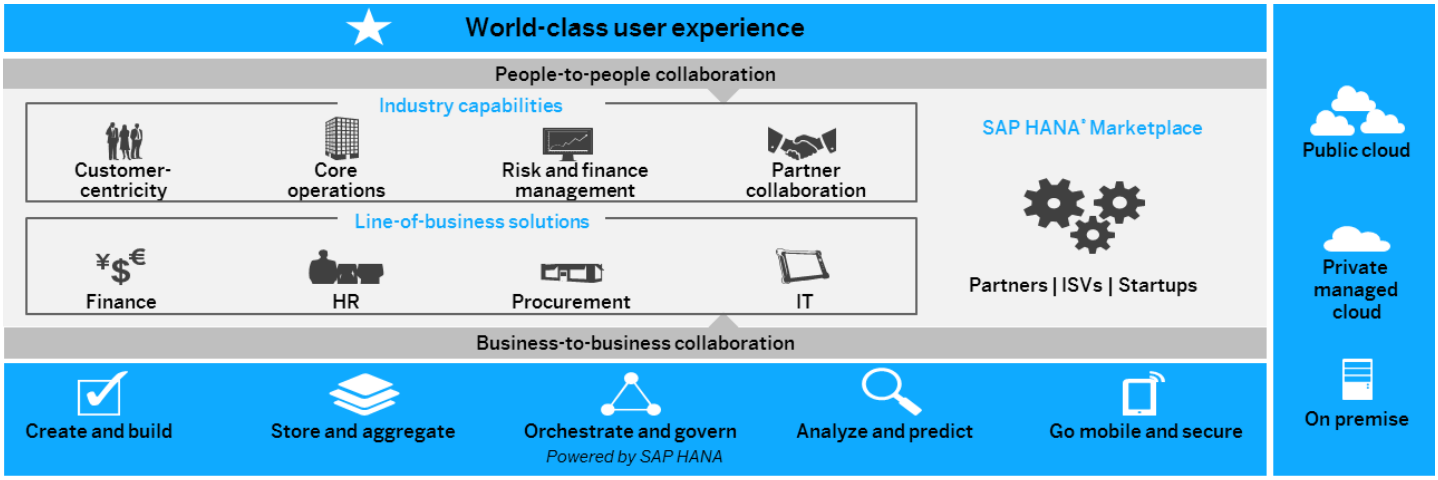
EARLY FLOOD DETECTION IN INDIA

With SAP HANA and SAP Predictive Analytics, water levels can be **monitored in real time to alert the population** about the floods and ultimately save lives.[35]

CREATE COMPETITIVE ADVANTAGE THROUGH INNOVATION



SAP will bring simplification, innovation, and acceleration required to support the development of your digital business strategy. These capabilities will be leveraged throughout SAP's collaborative value and innovation framework.



SIMPLIFY

Simplify transaction processing, account management, and customer service, while enhancing mining operations.

- Deliver improved productivity through better control of costs and efficient management of spend
- Proper planning and estimation of projects combined with accurate and timely delivery of cost, time, and quantity information
- Eliminate risk with near real-time warnings of issues and potential problems

INNOVATE

Use SAP HANA Enterprise Cloud to enable mines, suppliers, and customers to connect and collaborate.

- Connect mobile users to enterprise data on customers, assets, and operations
- Process and optimize data on customers and assets across all operating units and legal entities with SAP HANA in the cloud
- Adopt and apply analytics solutions through the cloud to enhance visibility into demand and operations

ACCELERATE

Predict and respond to opportunities and risks with predictive analytics solutions powered by SAP HANA.

- Address unplanned asset outages more quickly
- Adjust production in a more agile manner
- Reach workers faster for critical alerts

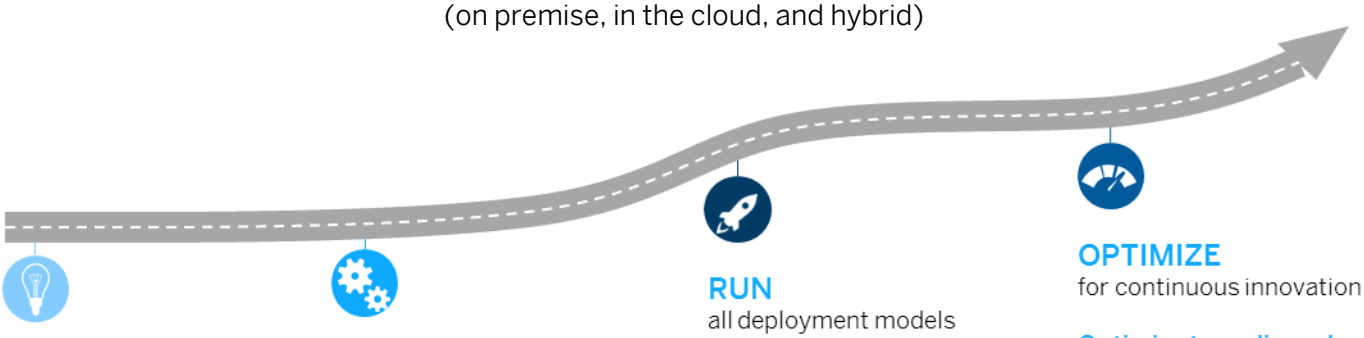
SAP GLOBAL SERVICES AND SUPPORT TO DRIVE YOUR SUCCESS

In the digital economy, simplification and business innovation matter more than ever. SAP has a broad range of services to cover the end-to-end digital transformation journey, ranging from advising on a digital innovation road map and plan, to implementing with proven best practices, to the ability to run across all deployment models, and ultimately optimize for continuous innovation across your digital journey. SAP provides both choice and value within our services, allowing you to tailor the proper approach based on your needs.

Turn to the 30,000 consultants and support professionals who can bring your digital strategy to life. Global Service & Support (GSS) provides a consistent experience – on premise, cloud, or hybrid. GSS provides the expertise, assets, and the proven methodologies required to accelerate business innovation, reduce TCO, and run a stable platform (on premise or in the cloud).

SAP Activate is a new, simplified consumption experience introduced for SAP S/4HANA and cloud adoption. It provides a combination of SAP Best Practices, methodology, and guided configuration. In addition, we provide leadership in learning to drive quick time to value realization and a solid engagement foundation with SAP MaxAttention, SAP ActiveEmbedded and SAP Value Partnership across the end-to-end customer lifecycle.

Global Service & Support provides the expertise, assets, and proven methodologies required to accelerate business innovation, reduce TCO, and run a stable platform (on premise, in the cloud, and hybrid)



ADVISE

Simplify and innovate

- Digital innovation road map and plan
- Co-innovation by industry

IMPLEMENT

with proven best practices

Implement with SAP Activate

- Simplified consumption experience for SAP S/4HANA
- SAP Best Practices, methodology, and guided configuration

RUN

all deployment models

Run with one global support

- One global, consistent experience
- End-to-end support –on premise, cloud, hybrid

OPTIMIZE

for continuous innovation

Optimize to realize value

Continuously capture and realize benefits of digital transformation

Learn | Extend / Innovate | Engagement Foundation | Support

SAP COMPREHENSIVE ECOSYSTEM

Orchestrating the world to deliver faster value

Our comprehensive ecosystem for mining offers integration into:

- A wide range of business services (OEM suppliers, banks, key vendors)
- Special technology services for mining with focus on IT/OT convergence, geospatial integration, asset health management, etc.
- Open architecture: choice of hardware and software
- Complementary and innovative third-party solutions
- Reach – partners to serve your business of any size, anywhere in the world
- Forum for influence and knowledge
- A large pool of industry experts with broad and deep skill sets

Our partner ecosystem includes, among others:

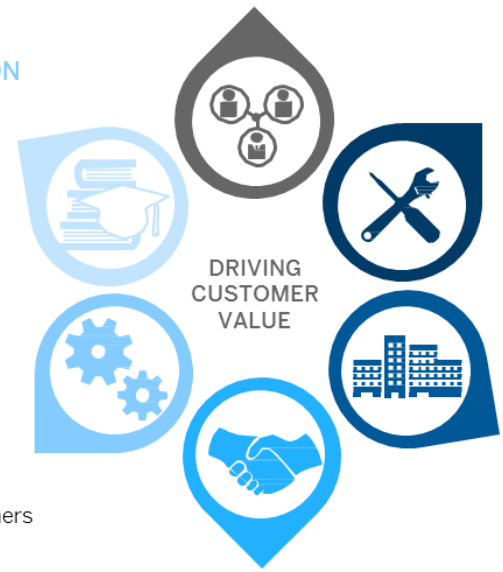
accenture, Illumiti, Deloitte., pwc, EOH, BearingPoint., NEORIS, Vesta, barnstone, ROLTA, cisco, esri, WIPRO, IBM, MineRP, Capgemini, RTS, ERM, utopia, OPENTEXT, TATA CONSULTANCY SERVICES, Runge Pincock Minarco, OSIsoft., VIST Group

BUSINESS NETWORK

- 1.8 million suppliers
- 200 major travel partners (air, hotel, car)
- 50K service and contingent labor providers

INFLUENCE FORUMS & EDUCATION

- 32 user groups across all regions
- 40+ industry councils
- SAP community >24 million unique visitors per year
- 1,800 SAP University Alliances



IMPLEMENTATION SERVICES

- 338 mill & mining partner companies
- 3,200 service partners
- Delivering mining-specific solutions

INNOVATION

- 1,900+ OEM solution partners to extend SAP solute
- 2,000 startups developing SAP HANA apps

PLATFORM & INFRASTRUCTURE

- 564 cloud partner in mill & mining
- 1,500+ platform partners

CHANNEL & SME

- 937 channel partners in mill & Mining
- 4,800 overall channel partners

ADDITIONAL RESOURCES

Outlined below is additional external research that was used as supporting material for this white paper.

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Note: All sources sited as "SAP" or "SAP benchmarking" are based on our research with customers through our benchmarking program and/or other direct interactions with customers

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