



2017 Edition

Building a Sustainable World

How to survive and thrive in a digital construction economy



Run Simple

MIKE'S POINT OF VIEW



The industry is at an inflection point where digitization will fundamentally change the business models, construction methods, and the economics of the construction industry.

Michael Shomberg
Global Vice President
Engineering & Construction
Solutions
SAP SE

Dear Colleagues,

\$15 trillion – that's the projected size of the construction market by 2030, up from \$8 trillion today.¹ A recent study expects that 75% of the infrastructure that will exist in 2050 does not exist today, and expects that the design and expected outcomes will be transformative. We will have to double the current infrastructure and then double it again by 2050.²

This is a huge opportunity for the construction industry; however, projects are getting more complex and there are many inefficient and wasteful practices. Successful companies will grow by increasing market share, self-performing to a greater extent, expanding internationally, and even operating some of the assets they build. The **industrialization of construction** and the application of proven manufacturing technology and best practices will help companies drive reliable outcomes and improve margins by increasing productivity and eliminating waste and the impact of surprises with real-time information. Existing business models will collapse as "construction-ready" disruptive technologies like robotics, mobility, virtual design and construction, and 3D printing redefine design and construction processes. Construction will experience the dramatic productivity gains seen in other markets, while vastly compressing the 50-year evolutionary process that took place in the manufacturing industry.

At the same time, many firms will experience a dramatic shift in their workforce as skilled craftsmen reach retirement age. The new workers, though more familiar with technology, do not have the hands-on experience in skilled trades, resulting in a significant decrease in experience on many job sites. Construction companies will compete with each other as well as with other industries to secure and retain the best talent. Digital technologies will play a major role in attracting and retaining the brightest people capable of transforming the construction industry.

The industry changes provide unique opportunities for industry leaders. The move to digital is not optional and it will result in significant advantages for the innovators. We see four strategic priorities for digitization and the transforming industry:

- **Digitization of expertise and knowledge**
- **Digitization of the construction site**
- **Digitization of intercompany collaboration**
- **Digitization of commissioning and operations**

At SAP, we did not invent the digital economy, but we understand where it's going. We started a journey five years ago, building the agile platform and solutions needed for the digital economy. This took over \$30 billion in acquisitions and billions in R&D. The results speak for themselves – as we are the only company to provide the tools for end-to-end processes that help CEOs solve their diverse challenges. Our vision is to help construction companies build a more sustainable world and support the needs of future generations.

This document offers our perspective of the most significant trends, the industry direction, and how SAP can help in this journey. Now is the time to forge a bold vision for a different kind of data-driven construction business. Without this vision and the desire to act on it, organizations run the risk of falling behind rapidly moving competitors. Thank you for your interest, and we look forward to your feedback.

Michael Shomberg
SAP Global VP – Engineering & Construction Solutions

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MARKET OVERVIEW

Uncharted territory of growth, challenges, and disruption

Technology trends change everything

Digitization has reached every aspect of today's life, and it is here to stay. For engineering and construction companies, technologies like the Internet of Things (IoT), augmented reality, and cloud provide new and exciting opportunities. But at the same time, they open the playing field for companies from other industries with expertise in these technologies.

Access more information
on the latest technology
trends here:



Unprecedented growth

Worldwide, construction is already one of the largest industry sectors, accounting for more than 11% of global GDP and expected to grow to 13.2% by 2020.⁶ This growth is driven by a projected global population of nine billion by 2050³ and the expectation that two out of three people will live in cities by 2050.⁴ These growth statistics are staggering. However, there are several underlying challenges that can derail a company's ability to grow. The Associated General Contractors of America (AGC) found that 74% of the total respondents believe there is a crunch in skilled trades, and 53% said they were unable to hire construction professionals such as supervisors, estimators, and engineers.⁵

Underlying industry challenges

1. Poor productivity and profitability

The barriers to entry in construction are still low, leading to a large number of competitors and shrinking margins which constrain investments. Compounding this is stagnant construction labor productivity over the last 50 years compared to industrial businesses, which have increased over 100%.⁷ According to a Construction Owners Association of America (COAA) study, 63% of direct labor time on mega-construction projects is spent waiting for materials and equipment, traveling to the area, taking early breaks, and planning how to do the work. The lack of productivity is reflected on the bottom line, where typical margins for construction companies range from 2–8%.⁸ Poor profitability can inhibit a company's ability to invest in digital processes and technology.

2. Project performance

The opportunities in construction are growing, but so is project complexity, where one surprise can wipe out the profits for the whole company. Projects are getting larger, more technically sophisticated, and require greater efficiency. Unfortunately, according to an Accenture study, only 30% of large projects in the energy industry are delivered on budget, and only 15% of projects are completed on time.⁹ The 2015 KPMG Global Construction Survey suggests 53% of construction companies suffered one or more underperforming projects in the previous year.¹⁰

3. Shortage of skilled labor

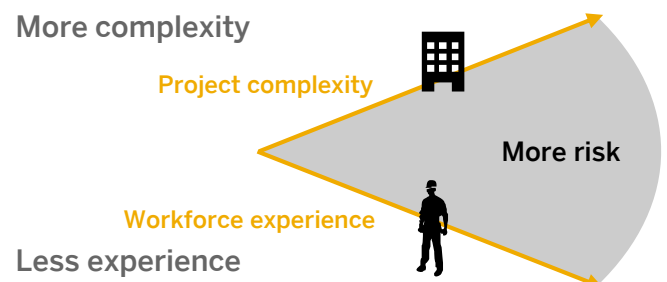
Adding to low productivity and higher risks, the construction industry is bracing for a dramatic reduction in workforce experience due to retiring baby boomers. During the recession, many skilled craftsmen left the industry and never came back. By 2020, millennials are expected to represent 50% of the global workforce.¹¹ Until 2010, the U.S. construction market was made up of two generations: the traditionalists and baby boomers. Now, the workforce has split into four generations: traditionalists, baby boomers, generation X, and millennials.

This present labor diversification is a challenge because of stark differences in work ethic, attitude, outlook, and behavior.¹² The combination of increasing project complexity and decreasing experience is a risk multiplier: risk to project deliveries, risk to quality, and risk to employee safety – these risks must be mitigated.

4. Lack of sustainability

Construction is the #1 global consumer of raw materials and generates 25–40% of the world's carbon emissions.¹³ This volume of natural resource utilization is not sustainable and could compromise the environment for the sake of growth.

More risk



MARKET OVERVIEW

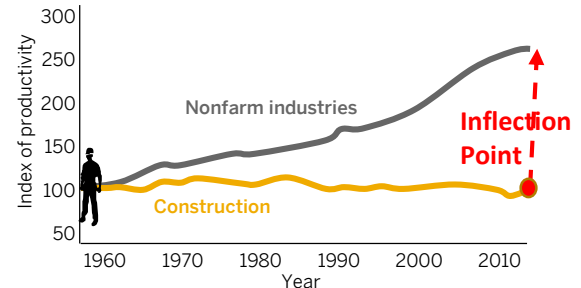
Embrace disruption with digital priorities

Embracing disruption

The construction industry is at an inflection point, analogous to the move from landline telephony to cellular technology. Digital technologies are rapidly becoming more capable of meeting construction's challenging and remote environments. Digitization will change most everything, including the competitors and the barriers to entry. The end result will be a more productive and profitable industry that builds more sustainable assets. The time to act is now.

The digitization and industrialization of construction has begun and is accelerating rapidly. Knowledge and technology developed by the other industrialized industries will enable construction to leapfrog to the latest, proven methods.

CONSTRUCTION COMPANIES FACE AN INFLECTION POINT



Strategic priorities for construction

In these times, construction companies need four strategic priorities to drive digitization:



1. **Digitization of expertise and knowledge** will enable organizations to access best practices and highly skilled workers at the point of need through technology and training, thus maintaining high quality and improving safety.



2. **Digitization of the construction site** establishes the modern 'construction-manufacturing site' with prefabrication in factory-like settings and real-time feedback for optimization of resources and equipment.



3. **Digitization of intercompany collaboration** connects the project team to share the latest information while delivering at the lowest possible costs.

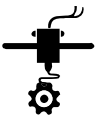


4. **Digitization of commissioning and operations** improves the transition from the construction phase to the operational phase with seamless transfer of data and models while harmonizing the information with as-built conditions.

Reimagining digital disruption

Do you have the right strategy? Only the bold and the nimble will invest and realize these strategic priorities, resulting in unprecedented levels of verticalization of the supply chain through partnerships and consolidation. The unprecedented growth presents enormous opportunities, but also considerable challenges. Leading construction companies are changing their core business models and outdated methods of construction. These leaders are realizing greatly improved margins, quality, and safety. Digitization of core business models, processes, and work is forcing all construction companies to reevaluate where they invest, how they compete, and if they are prepared.

The potential is huge:



3d printing and robotics

Several companies are evaluating the use of 3D printing, such as for pouring concrete using robotics and 3D designs, enabling greater precision, 30–60% less building materials, and 50–80% faster delivery.¹⁵



Portable and modular buildings

Portakabin, a UK-based construction company building portable and modular buildings, was able to construct 50% faster than conventional building (using 3D building information modeling (BIM) technology and a factory-like setting to build), obtain a higher level of precision, and deliver on time and within budget.¹⁶



Internet of Things

CCC, a large Middle Eastern contractor, faced weak demand in 2008 and had two choices: become more efficient or go out of business. Now it uses the Internet of Things to monitor and improve the utilization of its assets, saving approximately \$15 million per year.¹⁷



Prefabrication and assembly

A Chinese-based contractor built a 57-story building in just 19 days: 90% of the parts were premanufactured, greatly reducing waste and time. The building is able to withstand a 9.0 magnitude earthquake and is five times more energy efficient.¹⁸

REIMAGINE EVERYTHING

Key business models



REIMAGINE BUSINESS MODELS

Reimagined business models fundamentally change how contractors perform, how they work together, and how they retain their workforce.

Extensive verticalization and new contract models

- Much like the industrial construction market, where a few large engineering procurement and construction (EPCs) firms have emerged in each geography, commercial and civil construction will see more joint ventures and consolidation to provide end-to-end solutions. This evolution has already started in civil construction, where leaders have increased their percentage of self-performed activities through verticalization and are starting to dominate in each geography.
- Much of the poor productivity in the construction industry can be traced to the design-bid-build delivery method that dominates the industry. This arrangement creates a three-way adversarial relationship between the owner-architect-contractor that inhibits information flow as all parties are protecting themselves against the all too common litigation in the industry.
 - Integrated project delivery (IPD) contracts will bring a focus to what is best for the project to drive true partnerships versus pitting companies against one another.
 - With IPD contracts, participants are evaluated based on the outcome of the project, rather than just their particular piece. This allows contractors to deliver more value while reducing overall project risk and, also importantly, the owner's perception of construction risk.
- Integrated **project delivery** contracts have the potential to deliver faster with less claims because **collaboration** is incentivized. The implications for supply chain simplification and cost reduction are significant, with a single entity controlling all aspects of the project from design to prefabrication and construction.

Asset or facility-as-a-service

- Contractors have traditionally delivered their end product to an owner to operate and maintain. To improve margins in this low-margin industry, some contractors are financing and **operating** what they construct. This allows construction companies to deliver facilities-as-a-service and assets-as-a-service.
- Early examples of this model are public-private partnership projects. It has become increasingly common for transportation departments to employ public-private methodologies to construct new roads or bridges, where the contractor provides the financing and construction of the asset, performs maintenance on it for 20 to 30 years, and receives payment over time, often through the collection of tolls. We expect this shared model to grow beyond its roots in the cash-strapped public sector into commercial, industrial, and residential construction.
- Armed with new technologies from BIM to the Internet of Things (IoT) to predictive analytics, contractors will be well-positioned to translate construction information to operational insights, thereby increasing their profit margins and guaranteeing long-term revenue streams.



Fluor is not just building the Tappan Zee Bridge; it will also operate the bridge for the next 30 years.¹⁹

REIMAGINE EVERYTHING

Core methodologies



REIMAGINE BUSINESS PROCESSES

Companies understand that, along with business models, antiquated business processes must be transformed.

Digitization of the construction site

Lean methodologies

Concepts such as just-in-time (JIT) delivery and prefabrication are transforming the construction industry. From supply chain to workforce planning, there are tremendous opportunities to streamline business processes in construction.

- The lean processes, perfected in the industrial industry, have provided a framework for optimization and reduced waste.
- The complex, remote, and one-off nature of construction projects overwhelmed the technology, so that practitioners operated in silos using minimal technology, relying mainly on craftsmen to improvise.
- Today's business networks enable seamless communication of information on a global scale, helping lean practitioners to truly make reliable promises.
- The broader use of lean principles and methods could reduce completion times by 30% and cut costs by 15%.²⁰

Green methods

Sustainable, 'green' construction is rapidly becoming standard practice, but only for the nimble.

- Standards like Leadership in Energy and Environmental Design (LEED) are driving sustainability projects. But to achieve and document the performance levels required in LEED facilities, contractors must remain nimble.
- New products such as low-volatile organic compound (VOC) coatings may require special installation procedures in order to perform, so contractors can't rely on tried and true methods. They must access and use current, accurate information to ensure quality.

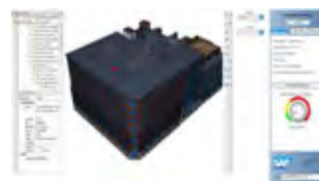
Visual collaboration: Construction, commissioning, and operations

Huge amounts of structured data (CAD models, engineering data, and schedules) and unstructured data (contracts, submittals, and meeting minutes) are generated and need to be effectively leveraged throughout the facility lifecycle.

- New standards, new regulations, and new products make today's projects more complex and riskier than ever.
- Project collaboration networks enable participants to access and publish the latest content from anywhere.
- This goes far beyond document management to the integration of structured and unstructured data to provide a more complete view of your project (scope, schedule, cost, and beyond), thereby visualizing all components to improve quality, safety, and profitability.
- A minimal increase in upfront costs of about 2% to support optimized design will lead to an average lifecycle savings of 20% on total costs.²⁰

Predicting the future and changing it for the better

- Predictive software and machine connectivity will transform project safety: sensing danger, notifying workers, and stopping equipment before incidents occur
- Mockup miniaturization using BIM and 3D printing will eliminate the need for full-scale mockups, saving time and money while improving project quality
- Laser scanners will confirm field dimensions to within 1/100 of an inch and communicate with suppliers, ensuring prefabricated components connect without fail



Hatch, a leading Canadian engineering services provider, intends to leave behind advanced sensors and measurement tools at the conclusion of its engineering projects in order to sense, analyze, and provide better advice to its customers in maintaining the engineering asset.²¹

REIMAGINE EVERYTHING

Automation and information-driven work



REIMAGINE WORK

Reimagined business models and processes need an adaptive workforce with new skills.

Digitization of knowledge and expertise

Eliminating work through automation

- Entire categories of work will be eliminated through automation. An early example of this is automation of invoicing and payment processing, which speeds the payment process while eliminating errors. Advances in computing power, connectivity, and sensor technology are opening doors to eliminate ever-more complex tasks, such as quantity take-offs, scheduling, and forecasting. Improved accuracy and lower costs of the automated processes provide a competitive advantage for early adopters.

Real-time reporting and analysis

- Leaders are leveraging mobile and IoT technologies to automate productivity reporting and profitability analysis in near-real time. This instant feedback allows workers to understand how they are performing and enables competition through gamification. This is changing how companies operate by allowing them to optimize their businesses in near-real time.

Better, faster decision making through intercompany collaboration

- The real-time enterprise created by the technologies described above requires leaders who make decisions in real time. To do this, they need access to intelligence in near-real time. Today, high performance analytic engines can turn data into intelligence, which will enable leaders to make better decisions faster, thereby improving productivity and profitability.

Interactive technology and robotics

- Visionary companies are improving quality and productivity through the use of interactive technology. Office and field workers use voice recognition, visualization, and augmented reality to achieve better results. Technicians' hands can be freed up using voice recognition to capture information or find schematics, which they then interact with through augmented reality. These tools help them work faster and more accurately.

- First-generation construction robotics are already having significant impact on construction quality and speed. Computers control blade elevation on grading equipment, and small robots perform precision physical tasks from wall layout to laying brick. We are now also seeing second-generation robotics such as 3D printers capable of printing an entire home in 20 hours. These innovations will enable the construction industry to rapidly transform from a manual, low-productivity industry into an automated, high-productivity industry.

Open talent economy

Digitization will enable the emergence of an open talent economy that brings together people and work in a borderless workplace.

- Contractors will be able to scale operations rapidly by sourcing talent from trade workers to management through the talent network. Acting as a virtual union hall, the talent network will maintain training and certification records to validate the qualifications of the candidates. Resourcing processes will need to reflect this paradigm change, allowing resource managers to tap into not only the company's on-payroll talent, but also identify best-of-breed contractors, alumni, freelancers, and open source talent, map them against demand, contact them, and engage them anywhere in the world, anytime.
- Once a project team is assigned, digital collaboration tools and networks provide a borderless workplace for effective virtual collaboration – within the team as well as with partners and clients.
- Ultimately, this will enable vertical integration as organizations can quickly bring together the talent they need to execute any type of project.



Kiewit is connecting to the field to get near-real-time status and eliminate downtime waiting for materials or equipment.²²

DIGITIZATION OF CONSTRUCTION

Do you have the right strategy?

The move to digital will provide significant advantages for the innovators. We see the following key areas being impacted by digitization and industry transformation.

Expertise and knowledge

As a new generation enters the workforce and more experienced craftsmen retire, there will be an urgent need to make up for the resulting experience gap.

- Capturing and utilizing best practices can no longer be just a goal; it must be a reality, or accidents, rework, and delays will become more commonplace.
- The knowledge and experience that helps determine the amount of consumables or small tools required for a job will have to be translated into a format that can be easily accessed (e.g., tablets) at the job site.
- Technology-savvy millennials will not put up with manual, paper-based processes.

Construction sites

Many activities traditionally performed piecemeal on-site will be consolidated and moved to efficient factory-like settings with safety and equipment availability greatly improved.

- The use of modern, lean techniques, including a major role for robotics, will improve quality, greatly reduce waste, and improve costs and schedules.
- Pre-fabricated Lego-like components produced with great precision and transferred to the job site where skilled-enough labor will be directed by 3D models and wearable technology to quickly and accurately assemble the components.
- The construction site will be transformed by sensors gathering up-to-date information to improve safety, capture progress, and eliminate unnecessary downtime due to lack of materials or equipment issues.
- Project status will be continuously transmitted back to headquarters to ensure contractors are paid faster and based on progress.

Intercompany collaboration

Owners, contractors, architects, and other members of the construction team will work on contracts designed to improve information sharing. They will be compensated based on the project's success, rather than individual accomplishments.

- Project-as-the-tenant collaboration systems will be available to everyone on the project for up-to-date structured (2D and 3D renderings, job cost, and so on) and unstructured (documents, procedures, manuals, and so on) information.
- Case studies show change orders can be virtually eliminated, RFIs become documentation of decisions already reached in the field, and general trust and respect is common place.

This shared stakeholder collaboration will be paramount for greater success.

Commissioning and operations

The handover of critical information from the construction phase to the operational phase will occur seamlessly and without having to re-enter the information into asset systems.

- BIM data is linked to the enterprise resource planning (ERP) and project management information, providing a visual component throughout the process. This will help minimize errors and costly rework.
- Information captured in the design phase will have a common thread that will be used to populate the information in the asset management systems.
- Equipment installed during the construction will have information on warranty and maintenance stored in an open network that operators will be able to access well after the construction phase is completed.



SAP's DIGITAL BUSINESS FRAMEWORK

TECHNOLOGY PLATFORM

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

DIGITAL BUSINESS FRAMEWORK

Building a digital business framework for growth and flexibility

Construction companies must digitize to grow revenue and margins with the ever-increasing complexity of construction projects. Productivity measures have just not measured up to the gains of other industries and have left construction productivity stagnant for more than 50 years. Construction companies need to build a platform for innovation and business process optimization, connecting the workforce, field equipment, the supply chain of contractors and suppliers, and the owners and operators.

It all starts with a digital core which is the backbone for innovation and business process optimization. The digital core consists of a financial, analytical project management foundation provided by the SAP S/4HANA® Enterprise Management solution, which provides a real-time 'single trusted version of the truth' for all financial and operational aspects of the company. The challenge is while many companies have invested in financial and analytical solutions, the solutions are typically not well integrated with the project management systems, resulting in manual reconciliation and delayed status reports. At SAP, we think there is a better way: a more efficient way. SAP integrates financial management applications on the same database as the progress and project management systems, resulting in real-time controls and a single version of the truth. It also opens up new possibilities, as this information can be integrated to the design information to provide a visual aspect to all construction operations.

World-class core ERP and procurement

The SAP core ERP platform is proven across various industries and disciplines. It provides synchronization of key functions such as finance and procurement operations. This is where the actual costs are stored for all projects.

Prefabrication and modularization

With the digital core, SAP provides extensive material management and production planning capabilities required for efficient factory-like results. Prefabrication and modularization, either on-site or off-site, of many work processes is providing increased productivity, decreased costs, and improved quality with a less experienced workforce.

Project applications

SAP provides the first fully integrated project controls and cost management system, where the project management and financial management information is on the same database, eliminating the manual, monthly reconciliation process and allowing accurate, real-time forecasts, eliminating preventable surprises.

Open integrations

The SAP digital core has certified interfaces with industry tools, such as scheduling and estimating systems, while maintaining control and a single version of the costs. This seamless integration with SAP allows contractors, owners, and other partners to leverage existing tools to accelerate time to value.

Visualization engine

The SAP® 3D Visual Enterprise application can harmonize over 120 different 2D and 3D design authoring tools and synchronizes the information with information from SAP to provide a unique, comprehensive view of the as-built information with operational information from SAP. This combines both construction design information and equipment (for example, HVAC, elevators, and so on) together into a true as-built model required for operations.

Mobile access

Through SAP Cloud Platform, users can integrate information from the field without restricting their choice of mobile devices or operating system. The result is accurate and timely project status information.



Powerful analytics

Based upon a new in-memory platform, companies can now get real-time and in-depth analytics on their company without the bother of expensive data warehouses with dated information.

Unified dashboard and reporting

Customers can use the flexible SAP BusinessObjects Business™ Intelligence Reporting package to create virtually any report easily, while using SAP Fiori® user experience (UX) for a next-generation UX and SAP Lumira® software to enable end-user data exploration. The customer can also choose the construction digital boardroom, which brings together real-time information in a consolidated view across the entire business.

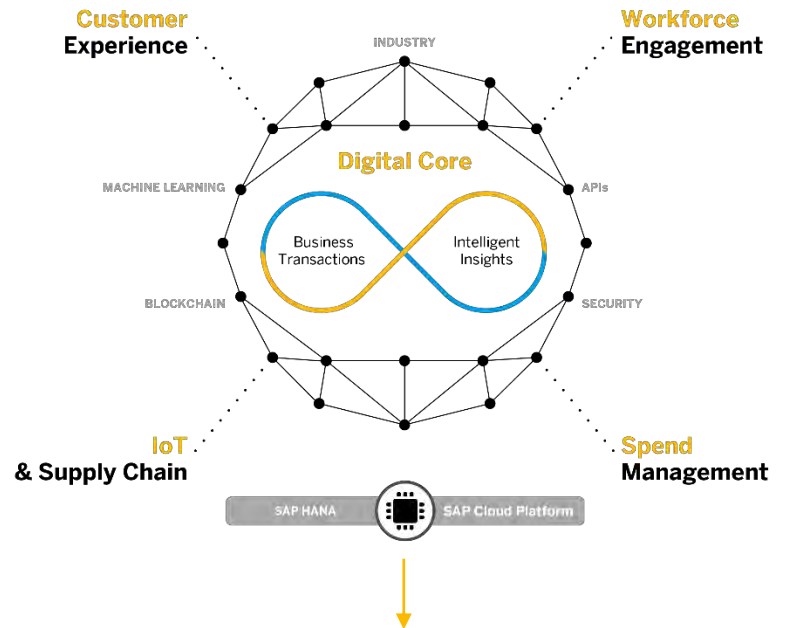
SAP PORTFOLIO FOR DIGITAL BUSINESS FRAMEWORK

Building five pillars of digitization

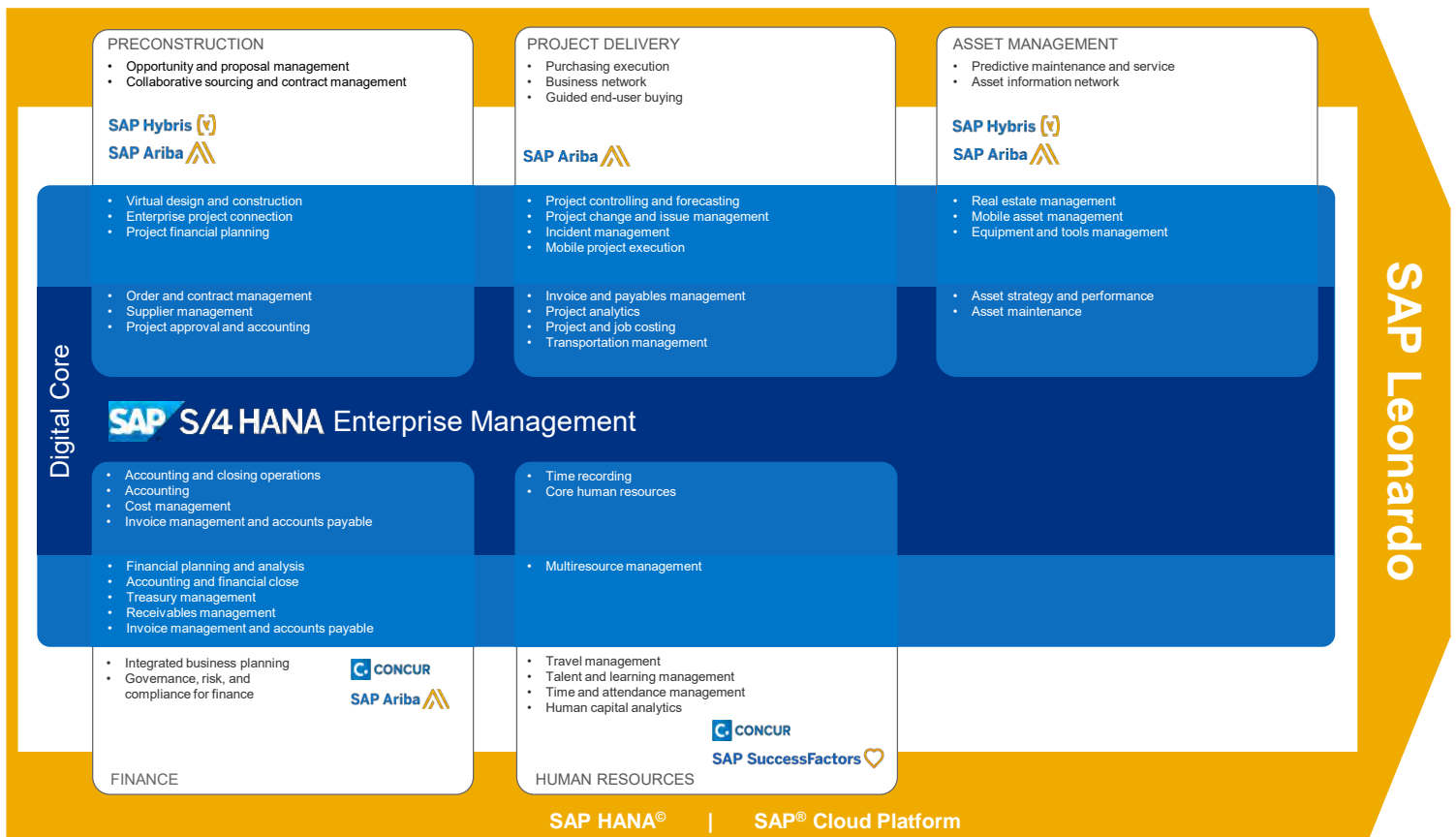
SAP has defined five pillars of digitization to address the continuously changing requirements of today's construction environment. We developed the digital business framework to help real estate companies develop and execute on their enterprise strategy. The digital core is the platform for innovation and business process optimization. The heart of the business for managing financials and projects performance, the digital core connects the workforce, the construction sites and assets, supply networks, and stakeholders.

The digital business framework will help companies create:

1. A smarter and technology-enabled **workforce** across employees and contractors
2. **Supplier collaboration** to reduce costs and eliminate downtime waiting for materials
3. Outcome-based **owner engagement** to improve satisfaction and speed change approvals
4. Increased utilization of **assets leveraging the Internet of Things** to drive real-time insights
5. Real-time business transactions and analytics connected to a **digital core**, so everything is smarter, faster, and simpler



Learn more about SAP solutions today and discover planned innovations by accessing the SAP road map for engineering and construction here:



Digitally **reimagine** your business models through **new business capabilities** along a value map.



Digitalization of expertise and knowledge



Digitalization of the construction site



Digitalization of intercompany collaboration












Digitalization of commissioning and operations

Typical benefits from SAP S/4HANA*

Engineering, construction, and operations (EC&O) companies are increasing margins and reducing surprises by industrializing their processes with:

- Proven, industrial, and lean processes; real-time monitoring and feedback; and industry best practices to achieve operational excellence
- Real-time forecasting, monitoring, and optimization of complex projects

	Preconstruction	Project delivery	Asset management	Finance	Human resources
	Reimagine processes to acquire, train, and retain a skilled workforce				
	<ul style="list-style-type: none"> Attract, retain, and train skilled labor Support workforce planning 	<ul style="list-style-type: none"> Increase visibility into resource demand and supply through simpler search capabilities based on skill sets 			<ul style="list-style-type: none"> Extend total workforce management across internal and skilled labor
	Reimagine processes to enhance the construction manufacturing site with prefabrication				
		<ul style="list-style-type: none"> Track project progress, cost, and margin with greater accuracy, in real time, and on any device 	<ul style="list-style-type: none"> Deliver a digital twin of as-built assets to allow employees to access visual maintenance guides on their mobile devices 	<ul style="list-style-type: none"> Help ensure overall solution profitability and mitigate risk with real-time project financial performance 	<ul style="list-style-type: none"> Collect accurate time information from the field Track safety and certifications accurately
	Reimagine business models to increase collaboration and decrease risk				
	<ul style="list-style-type: none"> Increase win rates and mitigate risk with simplified processes for bidding and estimation Provide a collaborative network of design information that includes the owner, contractors, and suppliers 	<ul style="list-style-type: none"> Access a single, consolidated view of all project-related information Share structured and unstructured data with owners, contractors, and suppliers 	<ul style="list-style-type: none"> Transition information seamlessly from construction systems to the owner's operational landscape 	<ul style="list-style-type: none"> Tune scalable quote-to-cash processes to digital acquisition, selling, and consumption requirements 	<ul style="list-style-type: none"> Standardize contracts
	Reimagine business models to design, build, operate, and maintain assets				
	<ul style="list-style-type: none"> Harmonize design authoring models into a complete as-built framework Enable accurate model-based quantity takeoffs 	<ul style="list-style-type: none"> Create digital twins of data for contractors and suppliers Apply a visual component to every role and report 	<ul style="list-style-type: none"> Commission facilities faster with accurate equipment information from construction systems 	<ul style="list-style-type: none"> Transition from manual to digital processes and from project to operational systems to help increase information accuracy and lower costs 	
	<ul style="list-style-type: none"> Planning and forecasting: -35% Sourcing costs: -3%–9% Customer satisfaction: +10%–20% 	<ul style="list-style-type: none"> Total project costs: -2%–3% Project delivered on or below budget: +1.9x Rework costs: -10% Dispute or claims incidents: -10% 	<ul style="list-style-type: none"> Speed of commissioning: +25%–50% Unplanned maintenance of equipment: -18% 	<ul style="list-style-type: none"> Audit cost: -5%–10% Rate of compliance with regulatory reporting requirements: 100% Costs of compliance and risk management: -48% 	<ul style="list-style-type: none"> Rework time: -10%–21% Accident frequency: -53% Revenue per professional employee: +20%

		Preconstruction	Project Delivery	Asset management	Finance	Human resources	
SAP S/4HANA	Suite	<ul style="list-style-type: none">• Opportunity and proposal management• Collaborative sourcing and contract management <p>SAP Hybris </p> <p>SAP Ariba </p>	<ul style="list-style-type: none">• Purchasing execution• Business network• Guided end-user buying <p>SAP Ariba </p>	<ul style="list-style-type: none">• Predictive maintenance and service• Asset information network <p>SAP Hybris </p> <p>SAP Ariba </p>	<ul style="list-style-type: none">• Integrated business planning• Governance, risk, and compliance for finance <p>CONCUR </p> <p>SAP Ariba </p>	<ul style="list-style-type: none">• Travel management• Talent and learning management• Time and attendance management• Human capital analytics <p>CONCUR </p> <p>SAP SuccessFactors </p>	SAP Leonardo
	Products	<ul style="list-style-type: none">• Virtual design and construction• Enterprise project connection• Project financial planning	<ul style="list-style-type: none">• Project controlling and forecasting• Project change and issue management• Incident management• Mobile project execution	<ul style="list-style-type: none">• Real estate management• Mobile asset management• Equipment and tools management	<ul style="list-style-type: none">• Financial planning and analysis• Accounting and financial close• Treasury management• Receivables management• Invoice management and accounts payable	<ul style="list-style-type: none">• Multiresource management	
	Enterprise Management	<ul style="list-style-type: none">• Order and contract management• Supplier management• Project approval and accounting	<ul style="list-style-type: none">• Invoice and payables management• Project analytics• Project and job costing• Transportation management	<ul style="list-style-type: none">• Asset strategy and performance• Asset maintenance	<ul style="list-style-type: none">• Accounting and closing operations• Accounting• Cost management• Invoice management and accounts payable	<ul style="list-style-type: none">• Time recording• Core human resources	
SAP HANA® SAP Cloud Platform							

*Benefits are based on early adopters of SAP S/4HANA or conservative outside-in benefits of moving from a traditional enterprise resource planning solution to enhanced SAP S/4HANA and line-of-business or cloud capabilities.

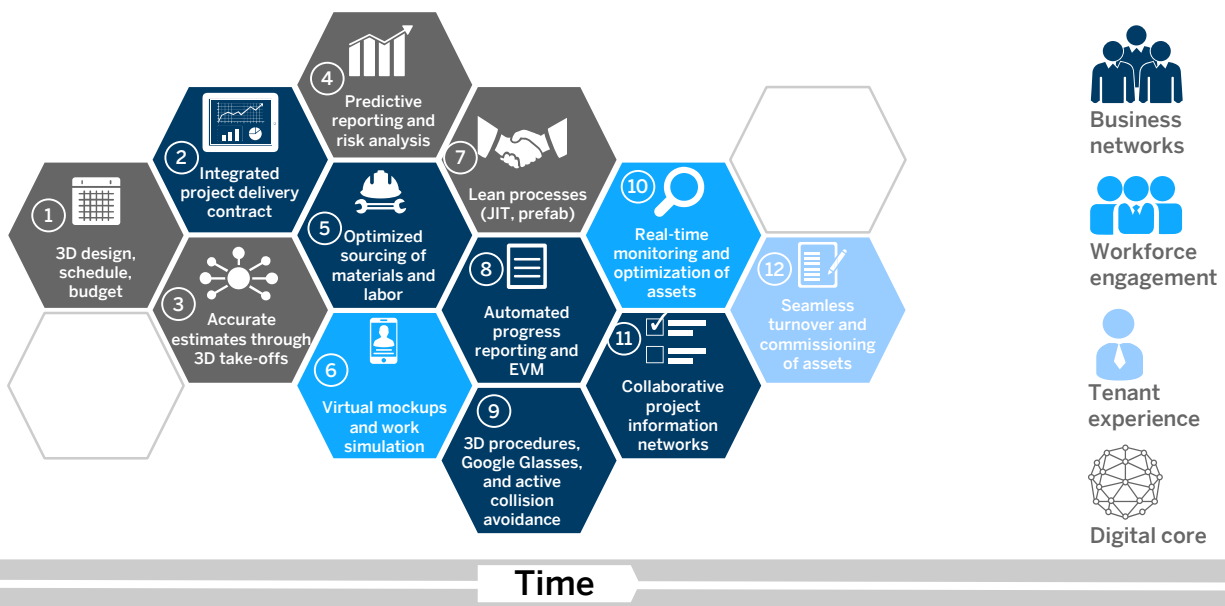
HOW DOES IT ALL COME TOGETHER? – EXAMPLE

Watch the video
around connected
construction.



Each of the five digital business pillars delivers individual business value, but next-generation business processes often span multiple pillars. This is the case with facility lifecycle management, which uses the building information models as an information conduit to collect, harmonize, and enrich data throughout the facility lifecycle.

DIGITAL BUSINESS SCENARIO: FACILITY LIFECYCLE MANAGEMENT



Scenario description

In the reimagined process, project planning is captured in the digital core and communicated to stakeholders through business networks. Stakeholder feedback enables accurate estimates and proactive risk identification and analysis back in the core. Business networks then optimize sourcing of materials and workforce allocation. Virtual mockups are used to ensure the workforce clearly understands the plan and the work environment. The core ensures just-in-time delivery of resources and prefabricated components. Business networks allow automated progress reporting and deliver work instructions and safety information directly to workers through enhanced reality devices. Real-time monitoring enables a continuous feedback loop that keeps the project on track. As-built information is collected through the business network and augmented with commissioning data, facilitating a seamless handover to the customer.

Facility lifecycle management

This is a digital process for effective project delivery and efficient, seamless transition to operations. It provides an optimized, visual context to information delivered to the right person at the right time to improve productivity, reduce errors, and eliminate injuries. This gives users a competitive advantage by leveraging visualizations to deliver real value.

- **10%** fewer engineering changes²⁷
- **45%** less rework²⁷
- **79%** lower accident frequency²⁷

Although digitization has enabled this power, only a small group of firms has harnessed it in their work.

Globalization, shifts in workforce composition, and changing demographics are affecting the way companies approach project execution and facility management. Firms will need to reimagine their business models and adjust their processes accordingly to stay competitive in the era of digital empowerment.



FROM YOUR CURRENT STATE TO DIGITAL

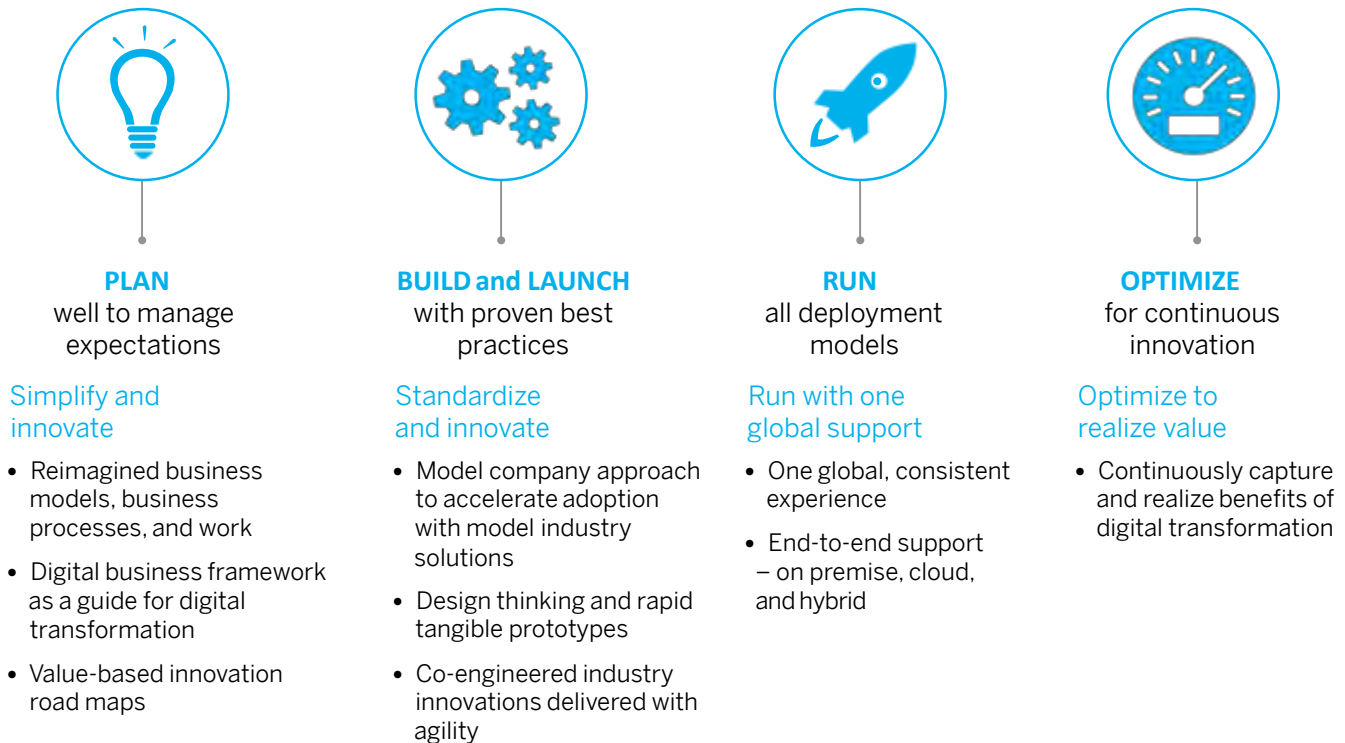
THE JOURNEY TO BECOMING A
DIGITAL MANUFACTURER BEGINS
WITH PLANNING A DIGITAL
TRANSFORMATION ROAD MAP

TRANSFORMING FROM YOUR CURRENT STATE TO DIGITAL

The keys to success

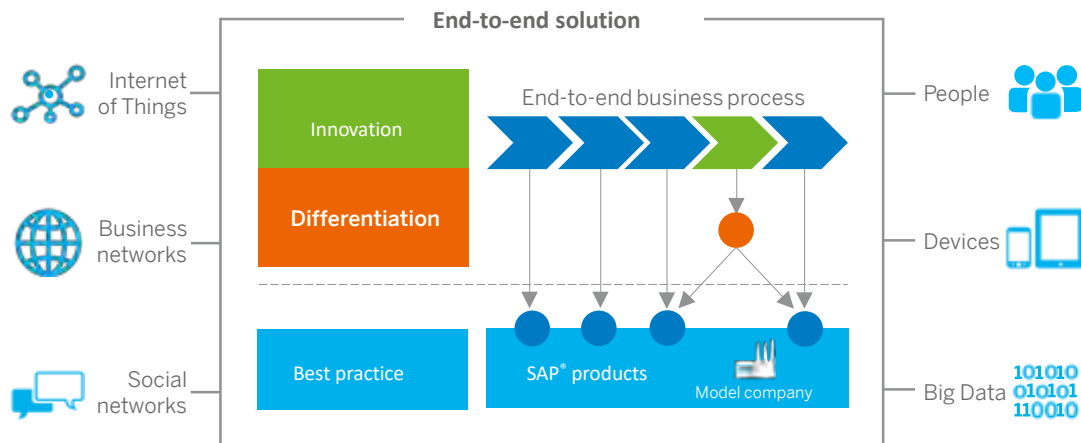
In the digital economy, simplification and business innovation matter more than ever. To do this effectively, it's important to cover the end-to-end digital transformation journey, ranging from planning a digital innovation road map and implementation plan with proven best practices to the ability to run all deployment options and ultimately optimize for continuous innovation with a focus on outcomes.

The end-to-end digital transformation journey



And to move forward with speed and agility, it helps to focus on live digital data, instead of Big Data, and combine solution know-how and industry-specific process expertise with data analytics so that the right digital reference architecture is defined and delivered. In that context, we believe that a model company approach is very relevant to enable you to transition from your current state to digital. Model companies represent the ideal form of standardization for a specific line of business or industry. They are built on existing SAP solutions using best-practice content, rapid prototyping solution packages, and additional content from customer projects. They provide a comprehensive baseline for rapid, customer-specific prototypes, cloud demos, and quick-start implementations.

Model company approach



SAP DIGITAL BUSINESS SERVICES

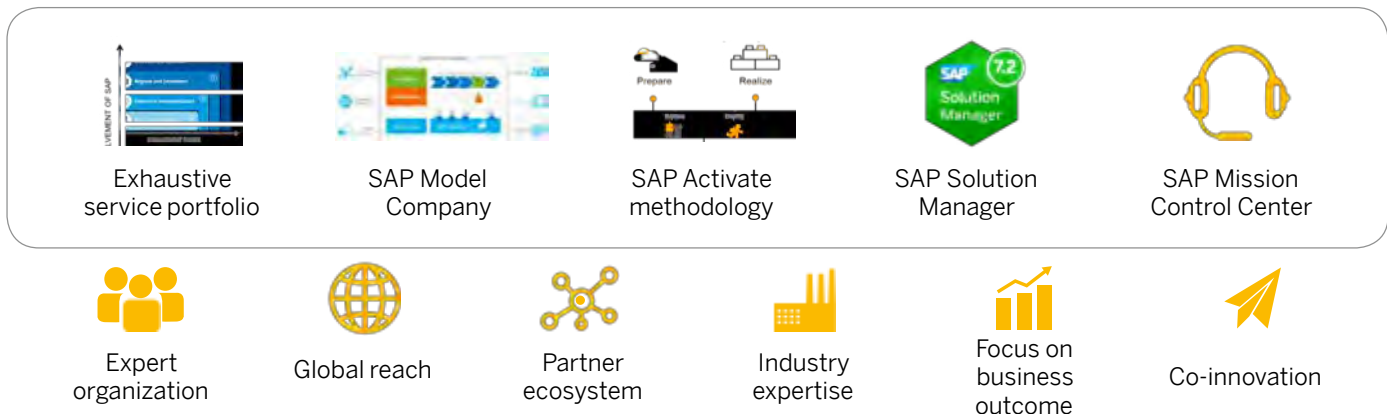
Enabling your success in digital transformation

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 implementation plan with proven best practices to the ability to run all deployment options and ultimately optimize for continuous innovation. We provide both choice and value within our service offerings, allowing you to tailor the proper approach based on your specific company expectations and industry requirements.

- 25,000 professionals in 70 countries
- Serving customers in 130 countries
- Outcomes delivered as one team in one contract
- Projects connected in real time to global network of support functions through SAP Mission Control Center
- SAP MaxAttention™ and SAP ActiveEmbedded services to safeguard investment
- Consistent experience – on premise, cloud, or hybrid
- Standardized adoption of processes and tools
- Streamlined onboarding and ramp-up of stakeholders

From proposing a comprehensive digitization proposal to realizing and running it, SAP delivers on the digital transformation promise to its customers, on time, on budget, and on value.

SAP value delivery relies on unique differentiating assets:



SAP Digital Business Services deliver digital innovation with simplification and accelerated implementation, which is key to adoption and value realization. Continuous improvement is supported through ongoing assessment of real-life data insights and joint governance with customers.

SAP value delivery focuses on the following deliverables:



SAP COMPREHENSIVE ECOSYSTEM

Orchestrating the world to deliver faster value

Our comprehensive ecosystem for EC&O offers:

- A wide range of business services (OEM suppliers, key vendors)
- Special technology services for EC&O with focus on IT and OT convergence, geospatial integration, estimating, CAD integration, and so on
- Open architecture: Choice of hardware and software
- Complementary and innovative third-party solutions
- Reach of 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 skillsets

Our partner ecosystem includes, among others:



BUSINESS NETWORK

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

INFLUENCE FORUMS AND EDUCATION

- 32 user groups across all regions
- EC&O-specific industry councils
- SAP community >24 million unique visitors per year
- 2,650 SAP University Alliances

INNOVATION

- >1,900 OEM solution partners to extend SAP® solutions
- 3,200 startups developing SAP HANA® apps

CHANNEL AND SME

- >870 EC&O channel partners
- 4,800 overall channel partners

IMPLEMENTATION SERVICES

- >280 EC&O partner companies
- 3,200 service partners delivering EC&O-specific solutions

PLATFORM AND INFRASTRUCTURE

- >470 EC&O partner companies
- 1,400 cloud partners
- >1,500 platform partners



SAP IS COMMITTED TO INNOVATION

Vision
Mission
Strategy

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



- **82K employees** representing 120 nationalities
- **335K customers**
- SAP operates in **190 countries**



- Solutions for **25 industries and 12 LoBs**
- **98% of most valued brands** are our customers
- **76% of the world's transactions** managed on SAP



- **120 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** comprise the largest marketplace in the world
- 2015 **SAP HANA Cloud**
- 2015 **SAP S/4HANA**: Most-modern ERP system



- Member of **Industry 4.0 board** and the **Internet of Things Consortium**
- **80%** of the construction companies in the Forbes Global 2000 are SAP customers

ADDITIONAL RESOURCES

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

1. "Global Construction 2030: A Global Forecast for the Construction Industry to 2030," PwC, www.pwc.com/gx/en/industries/engineering-construction/publications/global-construction-2025.html
2. "75% of the Infrastructure That Will Exist in 2050 Doesn't Exist Today," Aurora Almendral, Next City, Oct. 22, 2014, <https://nextcity.org/daily/entry/75-of-the-infrastructure-that-will-exist-in-2050-doesnt-exist-today>
3. "World Population Projected to Reach 9.7 Billion by 2050," United Nations Department of Economics and Social Affairs, July, 2015, <http://www.un.org/en/development/desa/news/population/2015-report.html>
4. "World Urbanization Prospects," United Nations, Department of Economic and Social Affairs, 2014, page 5, <http://esa.un.org/unpd/wup/Publications/Files/WUP2014-Highlights.pdf>
5. "Global Construction Labor Skill Shortages," Construction Business Owner, March 2015, <http://www.constructionbusinessowner.com/management/workforce-management/march-2015-global-construction-labor-skill-shortages>
6. "Global Construction Growth to Outpace GDP This Decade," PwC, March 3, 2014, <http://in.reuters.com/article/idINIndia-55293920110303>
7. "Reengineering Management of Construction Projects," *International Journal of Business and Social Science*, Vol. 4, No. 7, page 3, July 2013, http://ijbssnet.com/journals/Vol_4_No_7_July_2013/1.pdf, original data and chart found in Teicholz, P. (2013), "Labor – Productivity Declines in the Construction Industry: Causes and Remedies (Another Look)," AECbytes Viewpoint #67, March 2013, http://www.aecbytes.com/viewpoint/2013/issue_67.html
8. "Construction Services Industry Profitability" chart, Net Margin lines, CSI Market, http://csimarket.com/Industry/industry_Profitability_Ratios.php?ind=205
9. "How to Boost Capital Project Performance," Omar Abbosh, James Arnott, Michael Grady, Accenture, page 2, <https://www.accenture.com/hu-en/insight-outlook-how-to-boost-capital-project-performance.aspx>
10. "Climbing the Curve, Global Construction Survey 2015," page 7, KPMG, https://www.kpmg.com/BR/PT/Estudos_Analise/artigospublicacoes/Documents/Build-Construction/global-construction-survey-2015.pdf
11. "Millennials at Work, Reshaping the Workplace," 2011, PwC, https://www.pwc.com/en_M1/m1/services/consulting/documents/millennials-at-work.pdf
12. "Global Construction Labor Skill Shortages," Construction Business Owner, March 2015, <http://www.constructionbusinessowner.com/management/workforce-management/march-2015-global-construction-labor-skill-shortages>
13. "Shaping the Future of Construction – A Landscape in Transformation," World Economic Forum, Jan 2016, http://www3.weforum.org/docs/WEF_Shaping_the_Future_of_Construction.pdf
14. "Small Business Facts," Chapter 5, Course Hero, <https://www.coursehero.com/file/6829910/Chapter-5/>
15. "WinSun China Builds World's First 3D Printed Villa and Tallest 3D Printed Apartment Building," www.3ders.org, January 2015, <http://www.3ders.org/articles/20150118-winsun-builds-world-first-3d-printed-villa-and-tallest-3d-printed-building-in-china.html>
16. "Product Development, Innovation and the Product Life Cycle," Portakabin Business Case Studies, Page 2, gray box, <http://businesscasestudies.co.uk/portakabin/product-development-innovation-and-the-product-life-cycle/introduction.html#axzz41nHot4Bb>
17. "The Internet of Things Is Giving the Construction Industry a New Strategy," June 4, 2015, <http://www.ibmbigdatahub.com/blog/internet-things-giving-construction-industry-new-strategy>
18. "Chairman Zhang's Flatpack Skyscrapers," BBC News, June 11, 2015, <http://www.bbc.com/news/resources/idx-3cca82c0-af80-4c3a-8a79-84fda5015115>
19. "Fluor Team Selected for Tappan Zee Bridge Replacement in New York," Fluor 2016 Annual Report, <http://investor.fluor.com/phoenix.zhtml?c=124955&p=newsarticle&id=1767956>
20. Shaping the Future of Construction – A Landscape in Transformation: An Introduction, World Economic Forum, January 2016, page 6, http://www3.weforum.org/docs/WEF_Shaping_the_Future_of_Construction.pdf
21. "Analysis of Factors That Influence the Sensor Location Problem for Freeway Corridors," Hatch company Web site, <https://www.hatch.com/About-Us/Publications/Technical-Papers/2015/01/Analysis-Of-Factors-That-Influence-The-Sensor-Location-Problem-For-Freeway-Corridors>
22. "Kiewit Procurement," overview, Page 7 and 10, Kiewit.com, https://www.kiewit.com/files/6814/2259/1263/Procurement_Brochure.pdf
23. "2015 TCS Global Trend Study on IoT," Press Release TCS, July 22, 2015, http://www.tcs.com/news_events/press_releases/Pages/Internet-of-Things-TCS-Global-Trend-Study-2015.aspx
24. "Workforce 2020: Building a Strategic Workforce for the Future," Oxford Economics, 2014, <http://www.oxfordeconomics.com/workforce2020>
25. SAP Fiori UX: It Is Not a Matter of If, but When and How," Gartner, <https://www.gartner.com/doc/3016622/sap-fiori-ux-it-matter>
26. SAP Customer Success Story, From Insight to Action - Real-time Enterprise, Page 10 http://www.sapevents.edgesuite.net/SAP_Forum/sap-mining-metals-forum/pdfs/MM_Forum_C1.pdf
27. SAP Estimates*

*Note: All sources cited 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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