THE INTELLIGENT ENTERPRISE
FOR THE ENGINEERING, CONSTRUCTION, AND OPERATIONS INDUSTRY

Bringing intelligent manufacturing and a connected supply chain to engineering, construction, and operations to improve project schedule performance, reduce labor costs, and improve margins while delivering higher quality projects.
Dear Customers,

The global construction market is forecasted to grow 85% to US$17.5 trillion, accounting for almost 15% of world output by 2025.¹ A recent study expects that 75% of the infrastructure that will exist in 2050 does not exist today. We will have to double the current infrastructure and then double it again by 2050.²

Never before have construction companies faced so much change. Projects are continuing to increase in complexity as there is mounting pressure to design and construct in more efficient and sustainable ways, while workforce experience continues to decline rapidly and construction productivity remains stagnant. Today, leading companies are embracing technology to completely connect the construction project value chain in ways we haven’t seen before. Change is coming more quickly than many think.

I believe by 2025, the engineering, construction, and operations (EC&O) industry will bring manufacturing processes, such as cost and quality control, to the construction world, which will bring higher margins than historically possible. Intelligent processes and connected supply chains will deliver improved project schedule performance, and automation will reduce labor costs while improving quality. These improvements, combined with building-information-model-based collaboration, will result in well informed and highly satisfied customers.

To thrive, EC&O companies will focus on five strategic priorities:
- Digitalization of expertise and knowledge
- Connected construction
- Digitalization of intercompany collaboration
- Digitalization of commissioning and handover
- Digital supply chain

To execute on these strategic priorities and achieve the 2025 vision, companies need to change the way they operate. They must integrate and increase transparency of their own end-to-end processes and combine this with a real-world awareness that includes customers and partners. They can then learn from this information to make decisions and solve problems in intelligent ways.

By shifting routine tasks from humans to business systems enabled by machine learning and artificial intelligence, they will free up the capacity needed to define and pursue innovative and transformative business models.

With the SAP Intelligent Enterprise Framework, SAP provides the integrated suite of applications, the intelligent technologies, and the digital platform that companies need to realize the intelligent enterprise. We have the vision, the solutions, and the commitment to go with you all the way, from defining your transformation strategy and delivering the right solutions to running your digital backbone in the cloud.

Johnny Clemmons
Global Vice President
Industry Business Unit Head of Engineering, Construction, and Operations
SAP SE
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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%. According to a Construction Owners Association of America study, 63% of direct labor time on megaconstruction projects is spent waiting for materials and equipment, traveling to the area, and planning how to do the work. The lack of productivity is reflected in the bottom line, where typical margins for construction companies range from 2% to 8%. Poor profitability can inhibit a company’s ability to invest in digital processes and technology.

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. The 2017 KPMG Global Construction Survey indicates that 50% of construction companies admitted that adverse project performance significantly impacted their company in the past three years. 

Global “megathemes” such as the circular economy, future cities, sustainable energy, and global supply chain are affecting the EC&O industry but are also providing new opportunities for growth.
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 workers. Until 2010, the United States 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 attitude, outlook, and behavior.6 (See Figure 1.)

Further, the combination of increasing project complexity and decreasing experience is a risk multiplier: risk to project deliveries, quality, and employee safety – all of which must be mitigated. (See Figure 2.)

Lack of sustainability
Construction is the number-one global consumer of raw materials and generates 25% to 40% of the world’s carbon emissions.7 This volume of natural resource use is not sustainable and could compromise the environment for the sake of growth. 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. Digitalization 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.

Figure 1: Construction Companies Face an Inflection Point

Figure 2: Increased Risk for EC&O Projects

>11%
Of global GDP is accounted for by worldwide construction and is expected to grow to 13.2% by 2020.8

8.4 GT
Of resources, mostly water and biomass, are cycled. 1.4 GT are recycled.9

70%
Of the world population will live in cities by 2050.10

50%
Of the global workforce is expected to be represented by millennials by 2020.11

Only 30%
Of large projects in the energy sector are delivered within budget, and only 15% of projects are completed on time.12
By 2025, the EC&O industry will begin to reach manufacturing-inspired productivity and quality while reducing costs, driving margins higher than ever.

The ubiquitous application of AI, IoT, and BIM will create intelligent processes, enabling new levels of process automation in the industry. These intelligent processes and connected supply chains will deliver improved project schedule performance. For example, project schedules will be connected directly to reality-capture systems and will provide dynamic supply chain adjustment.

Together, these innovations will consolidate the massive amounts of structured data (engineering data and schedules) and unstructured data (contracts, submittals, and meeting minutes) generated in design and construction and make it seamlessly available for use in operations and maintenance. This will blur the lines between design, engineering, construction, and operations – enabling more vertical integration within the industry and driving completely new business models, thus defining a future for construction unlike the previous century.

The widespread use of augmented reality, cobots, and 3D printing will create an “augmented worker.” This reskilled and tech-enabled labor force will reduce labor costs while improving quality for prefabrication and on the project site. This will reverse the steady decline in productivity that construction has seen over the last six decades.
We have identified five strategic priorities necessary for EC&O companies to transform their business.

**Five Priorities for Success**

- Digitalization of Expertise and Knowledge
- Connected Construction
- Digitalization of Intercompany Collaboration
- Digitalization of Commissioning and Handover
- Digital Supply Chain
DIGITALIZATION OF EXPERTISE AND KNOWLEDGE

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

Capturing and using best practices can no longer be just a goal. It must be a reality. Otherwise, accidents, rework, and delays will become more commonplace.

Technology-savvy workers will not put up with manual, paper-based processes. 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 at the job site through mobile devices, for example.

The Vision
By 2025, entire categories of work will be eliminated through automation, and industry leaders will be using mobile and IoT technologies to automate productivity reporting and profitability analysis in near-real time.

High-performance analytics engines will turn data into intelligence, which will enable leaders to make better decisions faster, thereby improving productivity and profitability.

Interactive technology and robotics will help construction workers perform faster and more accurately. At the same time, digitalization will enable the emergence of an open-talent economy that brings together people and work in a borderless workplace.

The Journey
Construction companies will first start using mobile and IoT technologies to automate productivity reporting and profitability analysis in near-real time. This instant feedback will allow workers to understand how they are performing and enable competition through gamification. This will change how companies operate by allowing them to optimize their businesses in near-real time. Then, they will need to extend the business by improving project quality and productivity through the use of interactive technology. Office and field workers will be able to use voice recognition, visualization, and augmented reality to achieve better results.

Innovations such as computer-controlled blade elevation on grading equipment, 3D printing, and wall- and brick-laying robotics will enable EC&O to rapidly transform from a manual, low-productivity industry into an automated, high-productivity industry.
DIGITALIZATION OF EXPERTISE AND KNOWLEDGE
IMPROVING QUALITY AND SAFETY

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 such as 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 manufacturing.

At the same time, many firms will experience a dramatic shift in their workforce, as skilled craftspeople 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.

TRADITIONAL SCENARIO

Manual time sheets ➔ Disconnected progress report ➔ On-site coaching and job training ➔ Retiring skilled craftsman and inexperienced workers ➔ Low efficiency and high risk

NEW-WORLD SCENARIO

Eliminating work through automation ➔ Real-time reporting and analysis ➔ Interactive technology and robotics ➔ Better, faster decision-making based on real-time sensor data ➔ Improved efficiency and safety

TOP VALUE DRIVERS

10% Increase in project team productivity and end-to-end process efficiency
40% Lower worker acquisition time
>50% Potential savings in building time and costs

Source: SAP Performance Benchmarking
Historically, construction projects have been operated in largely independent silos.

Owners have a project need and hire a design firm. Engineering specifics are independently coordinated with the designer or architect. A general contractor is hired to execute the project. This contractor “bids and buys” the project from multiple entities, who in turn are also sourcing things themselves. Coordination and constructability often suffer.

Modern contracting is seeing a shift to vertically integrated contractors who own and operate the entire project supply chain (see Figure 3). With connected construction, companies are coordinating from design through construction and delivering projects of greater quality in less time for less cost. Technology is enabling this.

**The Vision**

By 2025, 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. Prefabricated, block-like connecting components produced with great precision will be 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. Project status will be continuously transmitted back to headquarters to ensure contractors are paid faster and based on progress.

**The Journey**

Construction companies will first improve and optimize win rate and manage risk with a single view of historical data for superior bidding. This will allow them to track project progress, cost, and margin with greater accuracy, in real-time, and on any device, with the help of business analytics and machine learning. As a next step, they will need to adapt innovative constructing models, such as prefabrication and modularization, either on-site or off-site, to provide increased productivity, decreased costs, and improved quality. 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.

**Figure 3: From Siloed Construction to Vertical Integration**
TRADITIONAL SCENARIO

- Disconnected departments and limited access to the business network prohibit responsive planning.
- When plans are not consistently created and shared, information cannot flow quickly. R&D, sourcing, sales, manufacturing, and planning are not aligned – wasting time and money.
- When companies rely on a few external partners and communicate manually with suppliers, visibility is limited – making collaboration difficult, delays inevitable, and the risk of error high.

NEW-WORLD SCENARIO

- Our cloud-based solution focuses on the digital construction experience for companies to work together in the design, plan, and build phases of construction and capital projects.
- Share one plan with all critical resources and partners to achieve visibility, agility, and responsiveness.
- Accelerate time to market with collaboration between R&D and sourcing.
- Achieve insight into future demand for premanufacturing and procurement, optimizing inventory.
- Align sales and project execution, and improve customer satisfaction.
- Transform linear supply chains into digital supply networks.
- Enable simultaneous collaboration with all relevant stakeholders.
- Place your company at the center.

TOP VALUE DRIVERS

Optimize
Operating performance conditions

Improve
Diagnostics

Enhance
Decision-making
DIGITALIZATION OF INTERCOMPANY COLLABORATION

New standards, regulations, and 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.

The Vision
By 2025, construction companies will be able to share the latest information through model-based collaboration while delivering at the lowest possible costs. Project teams will be able to eliminate wasted worker-hours spent waiting with enhanced, model-based scheduling.

Owners, contractors, architects, and other members of the construction team will work on contracts designed to improve information sharing. Armed with new technologies from BIM to the 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.

Project collaboration systems will be available to everyone on the project for up-to-date structured (2D and 3D renderings, job cost, and the like) and unstructured (documents, procedures, manuals, and so on) information.

The Journey
Construction companies will focus on mitigating risk with simplified processes for bidding and estimation to secure more business. Then, to improve and optimize visibility on cost, schedule, scope, and so on, they will provide a collaborative network of design information that includes the owner, contractors, and suppliers. To do this, they will be using a digital twin to synchronize the virtual, physical, conditional, and commercial definitions of assets and products in real time to accelerate innovation, optimize operating performance conditions, predict service requirements, improve diagnostics, and enhance decision-making. (See Figure 4.)

Finally, with the network of digital twins, they will be able to undergo an end-to-end digital transformation from design to construction through operations, maintenance, and service to end of life, which will facilitate:
- Sharing of digital twin data across all departments
- Engagement with suppliers, customers, and service providers throughout the lifecycle
- New product and service business models

Figure 4: Digital Twins to Accelerate Innovation in EC&O

Portakabin Limited, a United Kingdom–based construction company building portable and modular buildings, was able to construct 50% faster than conventional building using 3D BIM technology and a factory-like setting to obtain a higher level of precision and deliver on time and within budget.
DIGITALIZATION OF COMMISSIONING AND HANOVER

Construction companies must digitalize 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. Hence, construction companies need to build a platform for innovation and business process optimization, connecting the workforce, field equipment, supply chain of contractors and suppliers, and owners and operators.

The Vision
By 2025, the handover of critical information from the construction phase to the operational phase will occur seamlessly and without having to reenter the information into asset systems. BIM data will be linked to the ERP system 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.

The Journey
Construction companies will start their journey by using intelligent forecasting and advanced analytics to get a global view of all operations across all areas of the enterprise (see Figure 5), which will optimize their control over project status and profitability, resource utilization, global cash management, and risk management. They will then be able to digitally transition asset and equipment information from project to operational systems to improve information accuracy, lower costs, and expedite retention payments from customers.

Finally, construction companies will be able to enable a collaborative, end-to-end digital transformation from design to construction through operations, maintenance, and service to end of life, which facilitates the sharing of digital twin data across all departments, as well as the engagement with suppliers, customers, and service providers throughout the lifecycle.

Figure 5: Bringing Together Project and Asset Data for a Global View of Operations

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.25
DIGITALIZATION OF COMMISSIONING AND HANDOVER
SIMPLIFYING THE USER EXPERIENCE

TRADITIONAL SCENARIO

- Multiple screens and transactions are needed to create and maintain project data.
- Staffing and subcontracting are separated from the project and reporting and built per application area, not across the project as a whole.

NEW-WORLD SCENARIO

- Obtain an intuitive user experience on any device, with a consolidated source of truth for all project-related information presented at the lowest level of granularity.
- Allow a single point of entry for project-related execution, so project managers can react more quickly and more accurately to all project-related tasks.

TOP VALUE DRIVERS

95% Faster quote-to-order process when quotes are configured by configure, price, quote

46% Fewer customer complaints when real-time order, billing, and invoicing are available

Source: SAP Performance Benchmarking
Construction companies are modernizing the design, build, and delivery process, and this requires a new connected supply chain of contractors, material suppliers, and owners and operators.

**The Vision**

By 2025, supply chain networks in EC&O companies will be completely modular and flexible to allow the seamless execution of different project delivery strategies. Project schedules connected directly to drone-based reality capture systems will provide real-time demand signals and allow for dynamic adjustment of supplier shipments.

Increased automation in prefabrication and on the project site with the use of cobots, 3D printing, augmented reality, and machine learning will increase efficiency even more. Through IoT technologies, supply chains and construction operations will be completely transparent and managed on a global level.

**The Journey**

Construction companies will start their journey by using intelligent planning and advanced analytics to connect their projects to a global view of suppliers (see Figure 6), which will synchronize the delivery of materials and resources to improve schedule predictability, cost controls, and on-time completion and handover.

They will then be able to use collaborative BIM to improve the fit of prefabricated components. As a result, they will be able to improve project productivity through improved supply chain transparency and shop-floor-to-top-floor connectivity. Finally, construction companies will be able to utilize machine learning to combine demand sensing and supply chain limitation information to optimize project planning and scheduling.

**Figure 6: Driving Efficiency with Accelerated Design, Plan, and Build Phases**
Of all global change vectors, technological advancements have the most profound impact on dictating how industries and businesses transform themselves to respond to their customer needs and to the volatile environments in which they operate.

Intelligent technologies promise to bring great benefits, such as productivity and efficiency gains, enabling innovative new business models and superior customer service. Below are key technologies that are major drivers of the industry trends we have identified.

**3D Printing and Robotics**
Several companies are evaluating the use of robotics and 3D printing for things such as pouring concrete to enable greater precision, reduce building materials by 30% to 60%, and speed delivery by 50% to 80%.13

**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 (IoT) to monitor and improve the use of its assets, saving approximately $15 million per year.14

**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 obtain a higher level of precision and deliver on time and within budget.15

**Prefabrication and Assembly**
A China-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.16

**Augmented Reality**
Construction companies have been using smart wearables to collaborate with their front-line workers while delivering real-time, hands-free data and applications. By doing this, they are able to gain immediate access to expert help to reduce errors and improve the quality of work; provide real-time data feeds and alerts to create a safer workplace; and monitor tasks, checklists, and instructions, dramatically improving productivity.

**Statistics**
- **60%** Of human tasks will be automated by 2025.17
- **25%** Of Dubai’s buildings will be 3D printed by 2025.18
- **91%** Of off-site construction is prefabrication, followed by modular construction at 78%.19
Companies will become intelligent enterprises on three distinct tracks as they evolve their strategic priorities to match their company’s vision. They will:

1. **Optimize** what they already do by implementing a stable and scalable digital core to make processes more transparent and integrated.

2. **Extend** their current processes by connecting them to the real world using IoT technologies.

3. **Transform** their business using a constant stream of data enabling new service-driven business models. (See Figure 7.)

**Figure 7: Redefining the Way EC&O Companies Operate**

The industry enables the strategic priorities that address the major themes shaping the industry through the application of intelligent technologies and next-generation practices. By reviewing examples of these technologies and practices, we are able to understand the impact they can have and the business value they can bring.
SAP’S FRAMEWORK FOR THE INTELLIGENT ENTERPRISE

The Intelligent Enterprise framework is a suite of intelligent business applications that use intelligent technologies and can be extended on a digital platform. This enables next-generation business processes to deliver breakthrough business value on our customers’ journey to becoming intelligent enterprises.

**Figure 7: The Intelligent Enterprise Framework**
HOW TO PLAN
YOUR PATH TO THE
INTELLIGENT ENTERPRISE

In the digital economy, intelligent technologies and integrated business processes are now driving digital transformation.

To do this effectively requires an end-to-end plan for becoming an intelligent enterprise. (See Figure 7) This includes creating an intelligent enterprise road map and implementation plan with proven best practices and deployment options that optimize for continuous innovation with a focus on intelligent outcomes.

The End-to-End Journey to Becoming an Intelligent Enterprise

Plan
well to manage expectations

Simplify and innovate
• Reimagined business models, business processes, and work
• SAP Intelligent Enterprise Framework methodology as a guide for digital transformation
• Value-based innovation road maps

Build and launch
with proven best practices

Standardize and innovate
• Model-company approach to accelerate adoption with model-industry solutions
• Design thinking and rapid, tangible prototypes
• Coengineered industry innovations delivered with agility

Run
all deployment models

Run with one global support
• One global, consistent experience
• End-to-end support – on premise, cloud, or hybrid

Optimize
for continuous innovation

Optimize to realize value
Continuously captured and realized benefits of digital transformation

To move forward with speed and agility, it helps to focus on live digital 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, a model-company approach is aimed at simplifying and increasing the speed of the digital transformation journey.

Model companies represent the ideal form of standardization for a specific line of business or industry. They are built on preconfigured SAP solutions and based on best practices supported by SAP, along with the business content that encompasses our experience and expertise relevant for the industry. They provide a comprehensive baseline and come with the accelerators to jump-start digital transformation projects.
COMPREHENSIVE SAP ECOSYSTEM
ORCHESTRATING THE WORLD TO DELIVER VALUE FASTER

Our comprehensive EC&O ecosystem offers integration into:

- Open architecture with choice of hardware and software
- Complementary and innovative third-party solutions
- Broad reach through partners to serve your business of any size anywhere in the world
- Forum for influence and knowledge
- Large skill sets

Our partner ecosystem includes, among others:
SAP supports EC&O companies in becoming intelligent enterprises – providing integrated business applications that use intelligent technologies and can be extended on SAP Cloud Platform to deliver breakthrough business value.

10-Year Innovation Vision
SAP delivers fully intelligent business solutions and networks that span across company boundaries and promote purpose-driven businesses. These solutions will be the most empathic symbiosis between machine intelligence and human ingenuity.

- Self-running enterprise systems
- Self-organizing business ecosystems
- New markets and business models

Comprehensive Industry Coverage
SAP enables comprehensive coverage of the complete EC&O value chain across the enterprise. With its clear industry road map, SAP is the partner of choice for the EC&O industry.

- More than 3,000 EC&O companies in 107 countries are innovating with SAP solutions
- There were more than 25,000 days of industry-specific development last year
- All lines of business are supported on a single platform

Proven Services Offering
By bringing together world-class innovators, industry and emerging technology expertise, proven use cases, and design thinking methods, we help EC&O companies develop innovations that deliver impact at scale.

- Proven methodologies to drive innovation, from reimagining customer experiences to enhancing operations
- Innovation that is fueled through a managed innovation ecosystem from SAP
- Ability to build your own innovation capability and culture

SAP supports EC&O companies in becoming intelligent enterprises – providing integrated business applications that use intelligent technologies and can be extended on SAP Cloud Platform to deliver breakthrough business value.

Learn more
- SAP.com for EC&O
- SAP Leonardo
- SAP Digital Business Services
- SAP Design Thinking
Outlined below is external research that was used as supporting material for this paper.


Note: All sources cited as “SAP” or “SAP Performance Benchmarking” are based on our research with customers through our benchmarking program and other direct interactions with customers.