10 Insights for Navigating the E&C Digital Revolution

Shaping Tomorrow

In Collaboration with the World Economic Forum

PREFACE

Over the last decade, the Engineering and Construction (E&C) industry has undergone a significant shift, embracing digital and emerging technological solutions, alongside innovative processes and products. In response to this transformative trend, industry experts, thought leaders, entrepreneurs, and innovators convened at an exclusive half-day Summit in New York City on November 28th, 2023, hosted by the Global Leaders in Construction Management (GLCM) group at Columbia University in collaboration with the World Economic Forum (WEF) to kickoff a deep dive examination around navigating the E&C Digital Revolution.

This report encapsulates the key findings and insights derived from the summit and the subsequent interviews and analyses, aimed at fostering a deeper understanding of the challenges and opportunities associated with digital transformation in the E&C sector. Through collaborative discussions and exchange of experiences and best practices, participants explored strategies to enhance the industry's technological adaptability to drive meaningful progress in the digital age.

The group identified common obstacles encountered during the digital transformation journey and explored effective management strategies and opportunities for industry alignment. Ultimately, the Summit aimed to produce actionable insights that could drive meaningful progress toward industry transformation.

One of the highlights of the summit was the alignment of key insights around three thematic pillars essential for successful Digital Transformation: People, Process, and Technology.

- People: Successful digital transformation in construction hinges on prioritizing human capital. Organizations must foster a culture of innovation, continuous learning, and collaboration by addressing skill gaps, mentoring, and upskilling. Leadership involvement and open communication are essential to empower employees and drive engagement, ensuring productivity and sustainable success in a competitive, evolving industry.
- Process: Digital transformation requires rethinking workflows and embedding digital tools into decision-making. This involves restructuring responsibilities, aligning objectives with technological solutions, and adopting a holistic approach to integrate new processes seamlessly. By reassessing traditional methods, companies can enhance efficiency, collaboration, and sustainability while staying competitive in an evolving landscape.
- Technology: Transforming construction through digital tools like AI & Digital Twins demands strategic focus on adoption and integration. Overcoming resistance, bridging skill gaps, and fostering innovation are critical. Investments in training, change management, and leadership alignment ensure organizations can fully leverage technology to boost efficiency, sustainability, and competitiveness.

As we navigate the complexities of digital transformation, stakeholders must collaborate and mobilize around practical action items. This report aims to serve as a roadmap for industry members, offering actionable recommendations to expedite the digital transformation journey and propel the E&C industry towards a more sustainable and prosperous future. Special acknowledgement was extended to all members of the steering and advisory committees, as well as the Summit team, for their invaluable contributions and support. The collaboration persisted, driving continued transformation within the industry to better serve clients and communities alike.

Thank you for joining us on this transformative journey towards navigating the E&C Digital Revolution.

Warm regards,

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The global construction industry has long been hampered by its minimal investment in research and development (R&D) and technology, typically allocating less than 1% of revenue compared to 3-5% in sectors like manufacturing or technology. This chronic underfunding has left productivity essentially stagnant since World War II, a stark contrast to other industries that have leveraged innovation to drive efficiency. Digital transformation, encompassing tools like AI, digital twins, and data-driven decision-making, represents the most significant opportunity to reverse this trend. By prioritizing investment in technology and aligning it with workforce upskilling and cultural change, construction can unlock substantial productivity gains and redefine its future in a rapidly evolving digital landscape.
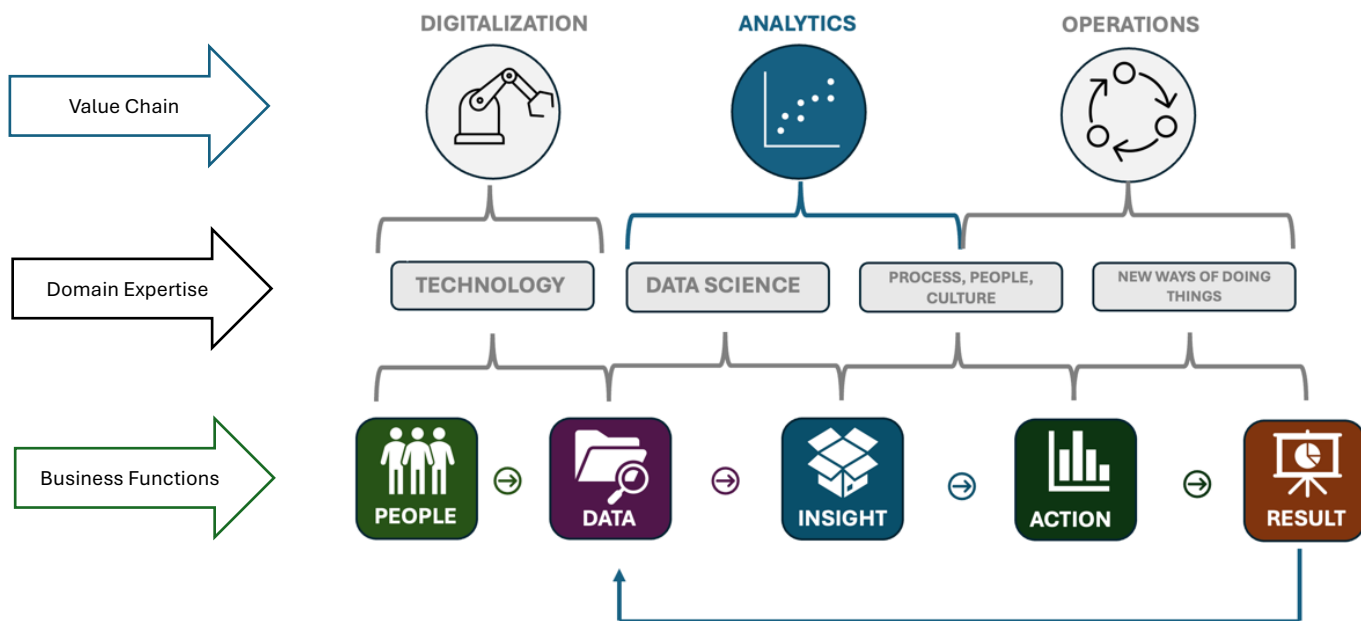

Illustration 1: Mapping the journey towards Digital Transformation

The digital transformation has catalyzed a paradigm shift across the construction industries, compelling organizations to reevaluate their operational frameworks and adopt transformative approaches to stay competitive. However, despite substantial investments projected to exceed $6.8 trillion by 2023, many companies struggle to realize tangible benefits or return on investment from their digital transformation initiatives. One of the primary pitfalls encountered by companies and public agencies in digital transformation initiatives is the misconception that investing in technology alone suffices to drive organizational change. The erroneous assumption that purchasing advanced tools or embracing trendy tech solutions inherently facilitates transformation overlooks critical factors such as organizational culture, processes, and talent alignment. It is crucial to highlight the significance of investing in workforce skills, specifically focusing on reskilling and upskilling efforts, to enhance technology adoption and bolster productivity gains. Analogous to persuading reluctant individuals to embrace new technology, convincing experienced employees or senior managers to deploy novel tech tools poses significant organizational challenges.

That mistake seems primed to repeat itself with the current race to deploy machine learning and artificial intelligence (AI). However, this need not be the case. To borrow the shopworn saying: *AI will not transform your business, but people who can use AI might*. A fundamental challenge in digital transformation lies in defining a clear vision and understanding its implications for organizational strategy. While each organization possesses unique characteristics shaped by industry, culture, and business model, the essence of transformation transcends the mere adoption of new technologies or data-centric approaches. True transformation entails becoming a data-driven organization, where key decisions and processes are informed by data-driven insights rather than human intuition. The transformative journey necessitates a fundamental shift in organizational behavior and operational methodologies. Successful digital transformation requires a holistic approach that encompasses technology, culture, talent, data, and strategic vision. By addressing these critical components and navigating inherent challenges, organizations can unlock the full potential of digital transformation and achieve sustainable growth and competitive advantage in an evolving digital landscape. Embracing the transformative journey is not merely about adopting new technologies; it is about redefining organizational paradigms and embracing a culture of continuous innovation and adaptation.

Digital transformation remains a formidable challenge for numerous organizations. Over 70 per cent struggle to derive any value from their digital transformation endeavors, with a significant 62 per cent attributing cultural barriers as the primary impediment to progress. *
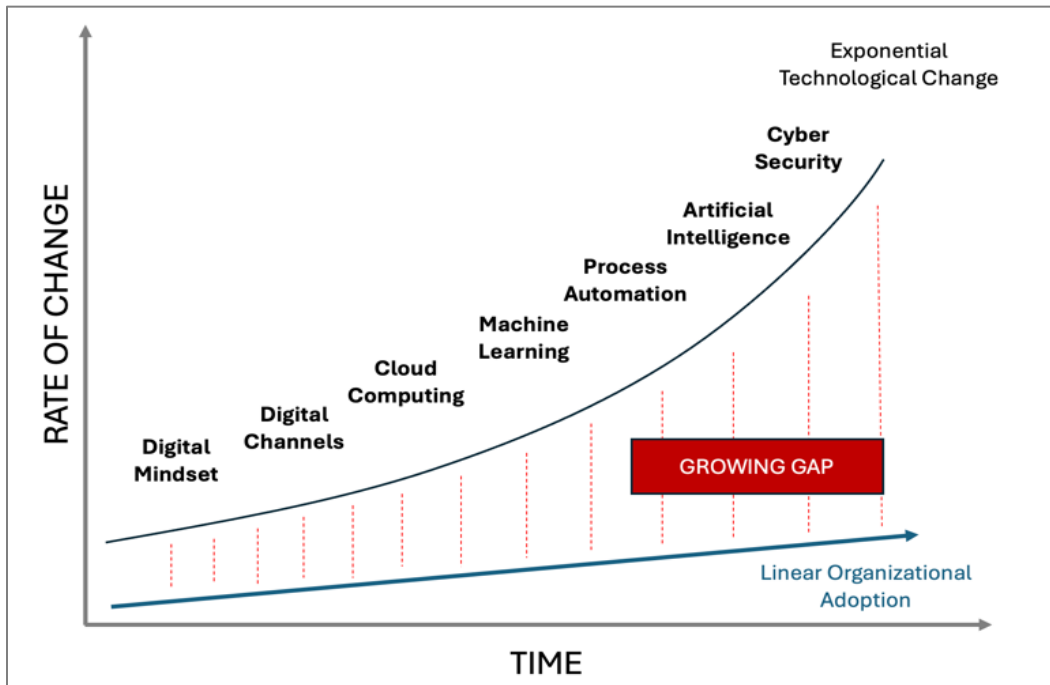

Illustration 2: Increase in Digital Skill Gap

The construction industry faces a growing digital skills gap as technology advances faster than human capabilities and knowledge can keep up. In today's knowledge economy, where information and expertise are paramount, the rapid evolution of powerful tools such as AI, digital twins, and advanced software outpaces the workforce's ability to adapt. This disparity highlights the urgent need for continuous learning, upskilling, and strategic training programs to ensure that professionals can effectively leverage emerging technologies, driving innovation and competitiveness within the industry. The construction workforce struggles to keep up with rapid technological advances like AI and digital twins due to the exponential pace of innovation outstripping human learning, cultural resistance to change, and limited training access in a fragmented industry. While academic programs are slow to adapt due to bureaucratic processes, corporate training often lags because of reactive, cost-driven approaches that prioritize short-term project demands over strategic upskilling. The private sector is best suited to lead change, leveraging agility and commercial incentives to deploy rapid training for competitive advantage, while academia plays a vital role in standardizing and validating best practices for long-term impact, with partnerships between both driving the most effective solutions.

TEN INSIGHTS INTO THE DIGITAL SHIFT

Illustration 3: Key Takeaways

The following section presents ten key insights gathered from summit participants through workshop discussions and follow-up interviews. These insights highlight practical considerations that companies and contracting agencies have faced in their efforts to integrate digital innovations within their organizations. Spanning both strategic and operational dimensions, some insights are supported by case examples shared by participating organizations. While these ten principles do not constitute a comprehensive roadmap for industry transformation, they serve as valuable guideposts for peers navigating the complexities of digital integration in the construction sector.

Insight #1: Effective technology adoption requires aligning investments with organizational goals.

Construction firms must ensure that the adoption of new technologies aligns closely with their overall strategic vision and objectives. This alignment ensures that technological investments are not made in isolation but rather integrated into the broader framework of the organization's mission and goals. By aligning technology adoption with strategic objectives, construction firms can prioritize investments that directly contribute to achieving desired outcomes, whether it's improving operational efficiency, enhancing customer satisfaction, or gaining a competitive edge in the market all business goals in the 21C are ultimately technology strategies. Moreover, strategic alignment helps in fostering coherence and synergy across different departments and functions, preventing disparate technology implementations that may undermine overall organizational effectiveness. Ultimately, a clear alignment between technology and strategic objectives ensures that resources are allocated judiciously and that technology initiatives drive tangible value for the organization.

- For instance, the Illinois Tollway faced a $14 billion capital improvement program but lacked a suitable software tool to manage the influx of funds and projects. They adopted e-Builder, a construction management software, to successfully manage 1,200 firms across 500 construction projects. This level of complexity and communication requires a cloud database solution. Similarly, the Pittsburgh Water and Sewer Authority is using e-Builder to manage its $100 million capital budget. This investment in technology aligns with their goal of effectively overseeing and tracking capital projects and expenditures, ensuring accountability and transparency in the use of public funds.

Insight #2: Adherence to regulations is crucial for technology integration in construction.

Integrating technology into construction operations requires a comprehensive understanding of and adherence to various regulatory requirements. From building codes to safety regulations and data privacy laws, construction firms must ensure that their technology initiatives comply with all relevant regulations to mitigate legal and financial risks effectively. Failure to comply with regulations can lead to costly penalties, project delays, and reputational damage. Therefore, construction firms must conduct thorough assessments to understand how technology implementations impact regulatory compliance and take proactive measures to address any potential gaps or risks. Additionally, staying abreast of evolving regulatory landscapes and adapting technology strategies accordingly is crucial for maintaining compliance amidst changing regulatory environments. By prioritizing regulatory compliance in technology adoption efforts, construction firms can minimize risks and build a foundation for sustainable growth and success.

- The Associated Builders and Contractors (ABC) 2023 Tech Report emphasizes the need for construction firms to prioritize cybersecurity and data privacy when implementing new technologies. With the increasing use of digital tools and data-driven analytics, companies must comply with regulations like the General Data Protection Regulation (GDPR) and industry-specific data privacy laws to protect sensitive information and avoid costly penalties for non-compliance.

- Similarly, a study by Sepasgozar et al. (2016) highlights the importance of adhering to building codes and regulations when adopting Building Information Modeling (BIM) technologies. BIM models must comply with local building codes, zoning regulations, and accessibility standards to ensure that the designed structures meet all requirements, preventing costly rework or legal issues during construction.

Insight #3: Prioritizing green practices reduces environmental impact and meets regulatory demands.

In today's construction industry, digital transformation is driving a shift towards sustainability. By integrating green building practices and renewable energy solutions into their technology adoption efforts, firms can reduce environmental impact, meet client expectations, and comply with regulations. Technologies like BIM, IoT sensors, and AI enable real-time monitoring and data-driven decision-making to optimize resource usage and enhance energy efficiency throughout the project lifecycle reducing OPEX for project owners. Embracing sustainable digital solutions not only meets societal expectations for corporate responsibility but also positions firms to seize opportunities in the green construction market, enhancing their reputation and driving business growth.

- For example, Skanska, a leading construction and development firm, has made sustainability a core part of its business strategy. They have implemented Building Information Modeling (BIM) and other digital technologies to optimize resource usage, reduce waste, and enhance energy efficiency throughout the project lifecycle. Skanska's commitment to sustainable practices has enabled it to meet stringent environmental regulations and attract clients who prioritize green building initiatives.

- Similarly, Balfour Beatty, a multinational infrastructure group, has adopted a range of sustainable practices, including the use of renewable materials, energy-efficient equipment, and data-driven decision-making powered by IoT sensors and analytics. These initiatives have helped the company reduce its carbon footprint, comply with environmental regulations, and position itself as a leader in sustainable construction."

Insight #4: Investing in talent enables effective technology utilization and fosters innovation.

Investment in talent development, upskilling programs, and fostering diversity initiatives is pivotal for enabling employees to leverage emerging technologies adeptly and fostering a culture of innovation within the organization. In the rapidly evolving landscape of construction technology, the success of technology adoption initiatives hinges on the capabilities and adaptability of the workforce. Construction firms must invest in continuous learning and development opportunities to equip employees with the skills and knowledge needed to effectively utilize new technologies. This includes providing training on software applications, equipment operation, and emerging industry trends, as well as offering mentorship programs and career advancement pathways. Additionally, fostering diversity and inclusion within the workforce not only promotes a culture of innovation and creativity but also ensures that technology solutions are developed with diverse perspectives and

experiences in mind. By prioritizing workforce development, construction firms can build a talented and resilient workforce capable of driving technological innovation and staying ahead in a competitive market. Additionally, loudly and actively investing in employee development is a recruiting and retention strategy. It's an attractive benefit to current employees and candidates.

- Swinerton, a leading construction company has shifted their hiring mindset towards long-term career growth to attract ambitious talent. With over 80 professionals dedicated to recruitment and development, they offer various workforce initiatives like apprenticeships and leadership programs. This investment in talent fosters innovation, enabling effective technology utilization and ensuring a skilled workforce for future challenges.

Insight #5: **Strategic alliances drive innovation and expand market access for construction firms.**

Forging strategic alliances with technology providers, suppliers, and industry stakeholders accelerates innovation, expands market reach, and facilitates the delivery of comprehensive solutions to clients within the construction sector. In an increasingly interconnected and complex business environment, collaboration has emerged as a cornerstone of success for construction firms looking to leverage technology effectively. By collaborating with external partners, such as technology vendors, research institutions, and other construction companies, firms can access complementary expertise, resources, and networks that enhance their innovation capabilities. Strategic partnerships also enable construction firms to pool resources, share risks, and jointly develop and commercialize innovative solutions that address industry challenges and market demands. Moreover, collaboration fosters a culture of knowledge sharing and cross-pollination of ideas, driving continuous improvement and collective innovation across the construction ecosystem. By embracing collaborative opportunities in technology adoption, construction firms can amplify their impact, drive growth, and remain competitive in an ever-evolving market. Firms must urgently reevaluate their intellectual property strategies, as many so-called 'trade secrets' are standard practices already shared informally by former employees. Adopting a tech-inspired approach—where ideas are abundant, but execution is paramount—recognizes that having an idea does not equate to successful implementation.

- The partnership between SitScape and AECOM is an example of a strategic alliance to leverage tech solutions in the construction sector. SitScape's innovative software, integrated into AECOM's Management Services, streamlines operations and enhances project efficiency. By leveraging SitScape's Digital Enterprise Enablement Platform (DEEP) software, AECOM gains advanced analytics, machine learning, and visualization capabilities, empowering data-driven decision-making.

- Turner Construction Company leverages Versatile's CraneView technology to optimize efficiency and productivity on job sites further. Versatile's CraneView technology captures and analyzes thousands of data points collected throughout the workday via a proprietary crane hook-mounted sensor array and provides Turner with actionable insights on jobsite performance through their online and mobile dashboard. These insights support Turner in the planning and sequencing of construction activities and positively impact scheduling and safety.

Insight #6: **Addressing cultural and skill-related resistance is essential for successful technology adoption.**

The successful adoption of technology in construction firms depends on effectively managing cultural resistance, addressing concerns related to job displacement, and bridging skill gaps through transparent communication and change management strategies. Resistance to change is a common challenge encountered in technology adoption initiatives, particularly in industries like construction that have deeply entrenched practices and traditions. To overcome resistance, construction firms must proactively engage stakeholders at all levels, communicate the rationale behind technology initiatives, and solicit feedback to address concerns and misconceptions. Transparent communication helps build trust and buy-in, while change management strategies, such as piloting new technologies, providing training and support, and celebrating successes, can help ease the transition and build momentum for change. Additionally, addressing fears of job displacement by emphasizing the role of technology as an enabler of productivity and job enrichment can alleviate concerns and foster a more positive attitude towards technological innovation. By effectively managing resistance, construction firms can create an environment conducive to successful technology adoption and drive sustainable change within the organization.

- Thornton Tomasetti's CORE Studio exemplifies cultivating a culture of innovation to overcome cultural and skill-related resistance to technology adoption in construction. Since 2014, this R&D hub has driven collaboration through annual AEC Tech hackathons and workshops, developing tools like Konstru and T2D2 that enhance

workflows on projects like Hudson Yards. By fostering hands-on learning, open idea-sharing, and employee-driven experimentation, CORE Studio counters skepticism and bridges skill gaps, proving that an agile, inclusive approach accelerates successful integration of advanced technologies like AI and digital twins.

Insight #7: **Careful budgeting and ROI demonstration are vital for securing technology funding.**

Meticulous budget planning, strategic prioritization of technology investments, and demonstrating return on investment (ROI) are critical for overcoming financial constraints and securing funding for technology initiatives in construction projects. Technology adoption often demands significant upfront investment in hardware, software, training, and infrastructure, which can strain resources if not carefully managed. Construction firms should develop clear business cases that outline costs, benefits, and risks to justify funding and gain stakeholder support. Prioritizing investments based on their potential to deliver tangible value and align with strategic goals ensures efficient resource allocation. However, while ROI is essential, firms must balance rigorous evaluation with fostering a culture of innovation. Overly bureaucratic processes can stifle workforce-driven innovation proposals, which are vital for long-term growth. Nurturing these ideas without smothering them in red tape is key. Ongoing monitoring of ROI metrics allows firms to assess technology impacts, optimize resource allocation, and maximize value over time. By blending financial discipline with an open approach to innovation, construction firms can minimize risks, maximize returns, and drive sustainable growth.

- Trimble, along with Associated General Contractors of America organized a Webinar on Construction Technology Budgeting, demonstrating their emphasis on the importance of budgeting for technology in the construction industry. By bringing together a panel of experts and customers, including engineers, contractors, and owners, Trimble aims to provide insights into the return on investment (ROI) of construction technology and strategies for effective budget planning.

Insight #8: **Effective governance and security measures are necessary for managing technology-generated data.**

To effectively manage the vast volume of data generated through technology integration in construction processes, implementation of robust data governance practices, stringent data security measures, and compliance with regulations is critical. With the proliferation of digital technologies in construction, the amount of data generated has grown exponentially, encompassing project plans, schedules, budgets, sensor data, and more. Effective data management is essential for ensuring data integrity, accessibility, and security throughout the project lifecycle. This involves establishing clear data governance frameworks, defining data ownership and accountability, and implementing standardized data management protocols and procedures. Furthermore, construction firms must invest in robust cybersecurity measures to protect sensitive data from unauthorized access, breaches, and cyber threats. Compliance with data privacy regulations, such as GDPR and CCPA, also requires construction firms to implement appropriate data protection measures and ensure transparency and accountability in data processing activities. By prioritizing robust data management practices, construction firms can harness the full potential of technology-generated data, derive actionable insights, and drive informed decision-making, ultimately enhancing project outcomes and driving business success. Two examples of vendor-neutral data governance frameworks include DGI Data Governance Framework, and DAMA-DMBOK, which can be adopted by construction firms incorporating new technologies or services.

Insight #9: **Fostering a culture of learning supports innovation and technological advancement.**

Fostering a culture of continuous learning through training, development programs, and cross-functional collaboration nurtures innovation, keeps employees competitive, and supports ongoing technological advancements within construction firms. In a rapidly evolving technological landscape, the ability to adapt and learn new skills is essential for staying competitive and driving innovation in the construction industry. Construction firms must prioritize learning and development initiatives that empower employees to acquire new skills, stay abreast of emerging technologies, and adapt to changing job requirements. This includes offering formal structured training programs, workshops, certifications, and opportunities for hands-on learning and experimentation that track development. Encouraging cross-functional collaboration and knowledge sharing also fosters a culture of innovation, where ideas are exchanged freely, and diverse perspectives contribute to creative problem-solving. By fostering a continuous learning culture, construction firms can build a dynamic and resilient workforce capable of driving technological innovation and achieving sustainable growth in the long term.

Insight #10: Starting small and scaling gradually mitigates risks in technology adoption.

Adopting an iterative approach by starting with pilot programs, testing technologies, and gradually scaling based on real-world outcomes enables construction firms to mitigate risks associated with large investments and make informed decisions about technology adoption. Given the complexity and uncertainty inherent in technology adoption, construction firms can reduce risks and maximize returns by adopting an iterative approach to implementation. This involves starting small with pilot projects or proof-of-concepts to validate assumptions, test feasibility, and assess potential impacts before scaling up. By gathering real-world data and feedback, construction firms can identify and address issues early on, refine their technology strategies, and make evidence-based decisions about further investment and deployment. Moreover, an iterative approach fosters a culture of experimentation and learning, where failures are viewed as opportunities for improvement rather than setbacks. This iterative process of exploration and adaptation enables construction firms to navigate technological challenges effectively and leverage emerging opportunities for innovation and growth.

- Los Angeles' decision to pilot digital twin technology in the Bunker Hill neighborhood showcases a cautious strategy to mitigate risks and maximize benefits. This focused pilot allowed the city to validate capabilities, gather insights, and refine processes gradually. Successful outcomes will inform city-wide implementation, unlocking the technology's potential for achieving decarbonization goals.
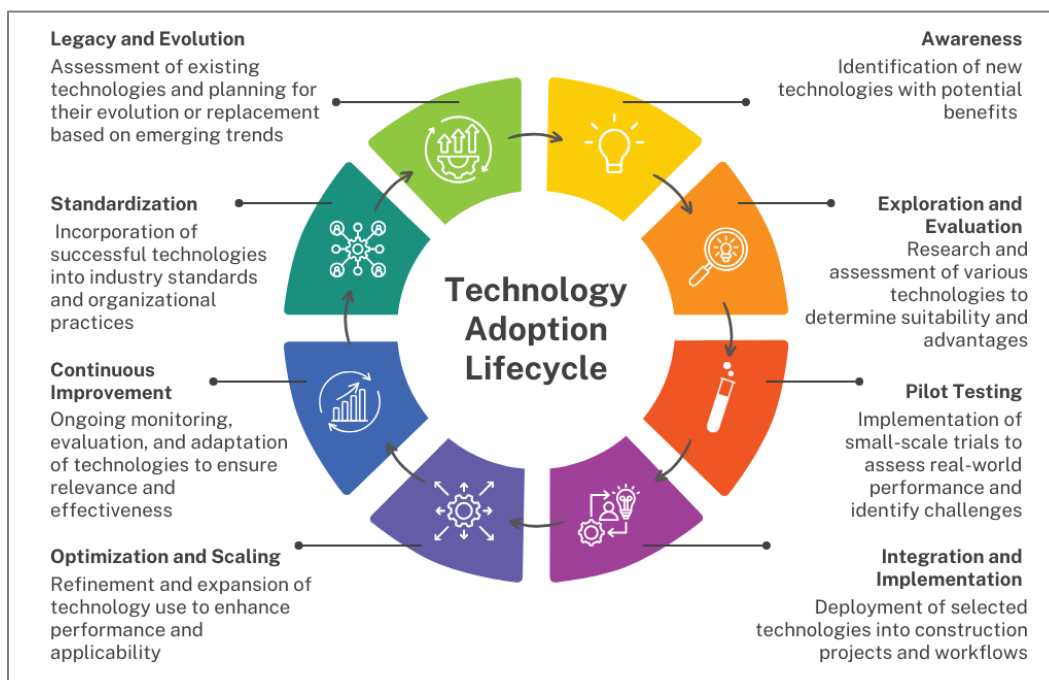

Legacy and Evolution
Assessment of existing technologies and planning for their evolution or replacement based on emerging trends

Awareness
Identification of new technologies with potential benefits

Standardization
Incorporation of successful technologies into industry standards and organizational practices

Exploration and Evaluation
Research and assessment of various technologies to determine suitability and advantages

Technology Adoption Lifecycle

Continuous Improvement
Ongoing monitoring, evaluation, and adaptation of technologies to ensure relevance and effectiveness

Pilot Testing
Implementation of small-scale trials to assess real-world performance and identify challenges

Optimization and Scaling
Refinement and expansion of technology use to enhance performance and applicability

Integration and Implementation
Deployment of selected technologies into construction projects and workflows

Illustration 4: Technology Adoption

CONCLUSION

While the construction industry faces challenges in embracing digital transformation, there is tremendous opportunity for growth, innovation, and success. By focusing on the three pillars of people, process, and technology, E&C firms can navigate these challenges effectively and drive positive change. Empowering employees through continuous learning and development initiatives fosters a culture of innovation and adaptability. Streamlining processes and aligning them with organizational goals ensures efficiency and effectiveness in implementing new technologies. Leveraging cutting-edge technologies such as digital twins, AI, and IoT enables construction firms to optimize operations, enhance decision-making, and stay ahead of the curve in a rapidly evolving digital landscape. Together, these pillars form the foundation for sustainable growth and success in the digital age of construction.

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