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The Data-Centric Owner SmartMarket Report

How Owners Are Driving Digital
Transformation in Design and Construction

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About Dodge Construction Network

Dodge Construction Network is a solutions technology company providing an unmatched offering of data, analytics, and industry-spanning relationships to generate the most powerful source of information, knowledge, insights, and connections in the commercial construction industry. The company powers long-standing and trusted industry solutions to timely connect and enable decision-makers across the entire commercial construction ecosystem. For more than a century, Dodge Construction Network has empowered construction professionals with the information they need to build successful, growing businesses.

To learn more, visit **www.construction.com**.

Introduction

Owners are the most influential engines of change in the construction industry, and their investments in technology and digital workflows have been increasing for the last decade. Now, the findings of this study reveal that many owners recognize that access to good project data is at the heart of their efforts to drive new levels of insight, productivity and quality in their capital planning, design, construction, operations and asset management processes. Their increasing need for project data that is not only timely, accurate and consistent, but usable across all these functions, is likely to be the most important driver of digital transformation in the construction industry in this decade.

This study provides a roadmap for other owners and a bellwether for future data and technology requirements for designers and contractors by benchmarking current owner engagement with data-centric approaches and digital technologies.

- **Data-Centric Approaches:** A detailed examination of owners' use of 42 approaches that put data at the center of how they manage their project teams, their organizations and their staff, reveals an ongoing commitment to using data and areas for improvement.
  - > This includes the critical use of data standards on their projects. Most industry stakeholders engaged with data and technology recognize the need for national standards, and owners have a unique ability to accelerate their adoption and drive the industry toward a new age of data-driven design and construction.

- **Technology:** An analysis of owners' engagement with seven digital technologies—from those widely utilized on their projects to those that are still emerging—reveals the technologies that they consider most essential and the specific project, process and technology benefits experienced due to their use, which have a major impact on owners' projects and organizations.

The findings clearly demonstrate that investment in becoming a truly data-centric organization allows owners to experience more benefits from their use of technology.

In addition to several well-established technologies that are used on projects, including project management software, BIM and GIS, the study also examines two emerging technologies, digital twins and tools that use artificial intelligence (AI). The rise of these solutions, already in use on at least some projects for roughly one quarter of owners, have the potential to help owners to fully integrate their organizations and create a virtuous loop of data from capital planning through to operations and asset management.

We thank the National Institute of Building Sciences for their vision and leadership in sponsoring this study and Autodesk, Esri and Trimble for their generous support of it.

**DONNA LAQUIDARA-CARR
PHD, LEED AP**
*Industry Insights Research Director,
Dodge Construction Network*

Donna Laquidara-Carr currently provides editorial direction, analysis and content to Dodge Construction Network's SmartMarket Reports. Prior to this position, she worked for nearly 20 years with DCN's Dodge division, where she gained detailed insight into the construction industry.

STEVE JONES
Senior Director, Industry Insights Research, Dodge Construction Network

Steve Jones leads Dodge Construction Network's Industry Insights Research division. He is active in numerous industry organizations and frequently speaks at industry events around the world. Before DCN, Jones was vice president with Primavera Systems (now part of Oracle), a global leader in project management software. Prior to that, he was principal and a Board of Directors member with Burt Hill, a major A/E firm (now merged with Stantec).

Message From the National Institute of Building Sciences

Congress created the National Institute of Building Sciences (NIBS) as an authoritative source of findings and recommendations and an independent non-profit dedicated to driving innovation in the built environment for the public interest. Innovation across all sectors—energy, tech, health, defense, and commercial enterprises—requires one shared foundation: the built environment. To lead, America must build smarter and stronger. NIBS ensures that Building Innovation becomes the foundation of American Innovation.

As a Premier Partner of *The Rise of the Data-Centric Owner* report by Dodge Construction Network, we are pleased that these findings provide evidence of a data-driven transformation in the construction industry— one that empowers building professionals, policymakers and owners to make informed, prioritized investment and risk decisions that enhance sustainability, efficiency and resilience. This study demonstrates the value of effective data use and technology adoption for Owners.

We see increasing evidence, as the study supports, that owners treat data as a strategic asset and rely on standard practices and digital tools such as BIM, GIS and Digital Twins to enhance lifecycle integration, management and long-term asset performance. Of course, as the study also found, there are challenges. Owners must address key barriers, such as limited resources, legacy systems and inconsistent data, by investing in scalable data management, modern tools and stronger collaboration with project partners.

NIBS will continue to convene across the built environment to build what matters, bridge gaps and overcome challenges to advance the study's recommendations. NIBS will continue our mission to transform cutting-edge research into real-world building solutions, and we will continue to advance standards such as the National CAD Standard (NCS), the National BIM Standard (NBIMS), and ANSI/ASHRAE/NIBS Standard 224 BIM for Owners, along with buildingSMART and ISO standards. We urge all owners and practitioners to examine the study, implement its key findings and join us in propelling digital transformation forward!

Embracing a data-centric approach can significantly boost industry growth and optimize returns on investments across all the classes of physical assets. We thank Dodge Construction Network, Autodesk, ESRI, and Trimble for their partnership in advancing a more innovative and connected built environment.

GEORGE K. GUSZCZA, D.ENG, CPEM, CCM
President & CEO, National Institute of Building Sciences

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President & CEO, National Institute of Building Sciences

George K. Guszcza, D.Eng, CPEM, CCM, is the President and CEO of the National Institute of Building Sciences.

Prior to joining NIBS, Dr. Guszcza served as the Chief Transformation Officer of Michael Baker International, an Engineering News Record (ENR) Top 50 Design Firm. He also served as an adjunct professor at The George Washington University and as a strategic advisor to the Middle East Institute's Board of Directors.

He brings over 25 years of experience in the built environment spanning the public, private, and non-profit sectors in the US, UK, Europe, Middle East, and Africa. Dr. Guszcza has previously held executive roles as the COO (CRO) of the Neal Richards Group and the EVP for Finance and Administration (CFO/CIO) of Adams and Associates, a 2,400 person ESOP operating across 19 locations in the US. As the founder/CEO of the Aedifos Group, a multinational start-up, he and his team led the restart of the Nelson Mandela Children's Hospital project on behalf of Project HOPE and the W.K. Kellogg Foundation. In 2003, as an active duty US Army Medical Service Corp officer and the National Director of Healthcare Facilities for Iraq under the Coalition Provisional Authority and Iraq Ministry of Health, Dr. Guszcza led a staff of 3000 architects and engineers to restart 240 hospitals, 10 specialty centers, and 1200 clinics across the country.

Dr. Guszcza earned a Bachelor of Science in Sociology from the United States Military Academy at West Point, a Master of Science in Major Program Management from the University of Oxford's Said Business School, and a Doctor of Engineering in Engineering Management from The George Washington University. He has served as the Chair of George Mason University's Civil Engineering Institute Board of Directors, Treasurer of the Society of American Military Engineers Northern Virginia Post Board of Directors, and on the WiRED International Board.

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Executive Summary

The Rise of the Data-Centric Owner

Owners are in the midst of their process of becoming more data-centric, with wide use of at least some data-centric approaches. To gain more from their data, though, most owners need to utilize many more of these approaches.

The study examines 42 specific ways that organizations can improve the quality of the data on their projects and assets, and increase its use and value across their organizations and across all stages of an asset lifecycle. It also reveals the frequency at which 18 of those are measured and tracked for improvement.

The chart below summarizes owner usage of 27 of the data-centric approaches into seven major categories. These 27 were selected because they were asked in a consistent manner that permits this type of analysis.

- The vast majority of owners—between 71% and 86%—use at least one approach, practice or policy in each category. This demonstrates their commitment to improving data in their organization.

- However, use of individual approaches within each category trends lower. Per category, only 31% to 51% of owners use any one of the individual approaches. This captures the current state of owners' evolution toward becoming data-centric organizations.

DATA-CENTRIC ENGAGEMENT INDEX

Another way of understanding the ongoing transformation of how owners are improving their data management and utilization is by categorizing them by how engaged they are with the 37 data-centric approaches and 18 metrics for measuring and tracking their application (see charts at right on page 6).

Their distribution across the three categories again suggests that becoming data-centric is an ongoing process in the owner community. Most are nearly evenly split between limited and moderate engagement. However, nearly one quarter of owners have a high level of engagement, which demonstrates that a significant number are leading the way and will be expecting the rest of the design and construction industry to support their efforts to use project data more effectively across their organizations. Those who can comply should enjoy a competitive advantage.

Owner Engagement With Seven Categories of Data-Centric Approaches

Category	Use at Least One Approach/Practice/Policy	Average Share Using Them
Organizational Policies and Investments	86%	48%
Approaches That Support Use of Data for Project Management	80%	31%
People-Related Approaches That Support Better Data Management	79%	51%
Data-Related Approaches That Support Collaboration	79%	51%
Approaches That Help Leverage Data Throughout Their Organization	72%	39%
Digitized Operational Tasks	71%	45%
Data-Centric Procurement and Contract Approaches	71%	36%

Use at Least One Approach/Practice/Policy **Average Share Using Them**

Executive Summary

Owners' Use of Digital Technologies

Most owner organizations either use or require several digital technologies on their projects, and, in many cases, directly license and use these tools in their organizations.

The study included seven digital technologies, which are used to various degrees by owners on projects.

- **Established Technologies Frequently Used by Owners Themselves:** Use of CAD, project management software, GIS and asset management software are all well-established on owners' projects, and the owners themselves most frequently own a license for and utilize these tools themselves.

- **Technologies Widely Used on Projects but Less Frequently Used by Owners:** More than half of owners require that their project teams use BIM and reality capture tools, but far fewer actually use these technologies themselves.

- **Emerging Technologies:** AI/Machine learning tools and digital twins are more rarely used on projects currently, but the use of these tools is likely to grow.
  - > AI/machine learning has the highest share of owners who plan to adopt it in the next two years.
  - > Over half of the owners using digital twins consider them essential for their role.

Data-Centric Engagement

40%	37%	23%
Limited (Less Than 25% of the Total Opportunity for Engagement)	Moderate (25% to 49% of the Total Opportunity for Engagement)	High (50% or More of the Total Opportunity for Engagement)

Technology Engagement
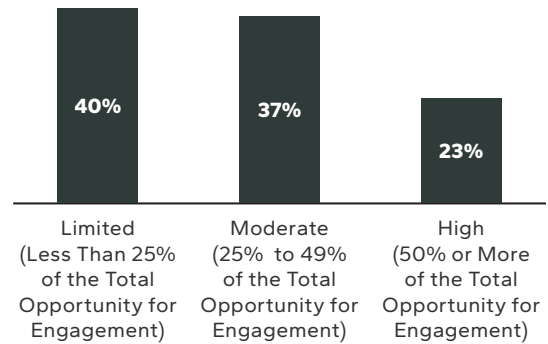
37%	50%	13%
Low (Less Than 25% of the Total Opportunity for Engagement)	Moderate (25% to 49% of the Total Opportunity for Engagement)	High (50% or More of the Total Opportunity for Engagement)
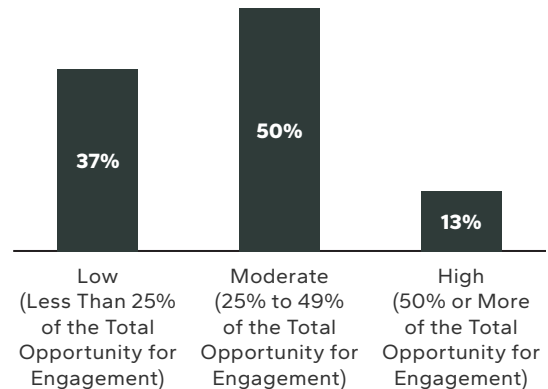
Owner Engagement With Digital Technology on Their Projects

Technology	Use or Require Project Teams to Use	Own License/Use Themselves
CAD	86%	70%
Project Management Software	80%	65%
GIS	72%	57%
Asset Management Software	70%	63%
BIM	62%	39%
Reality Capture	51%	31%
AI/Machine Learning	28%	23%
Digital Twins	18%	14%

■ Use or Require Project Teams to Use ■ Own License/Use Themselves
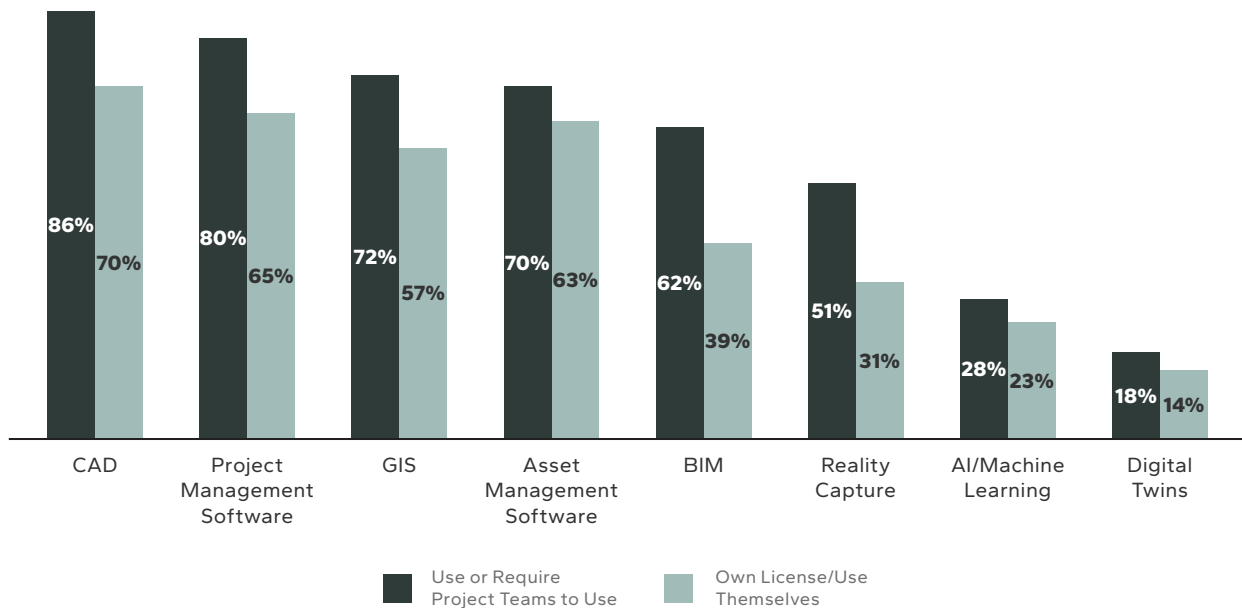
Executive Summary

Benefits Owners Experience From Their Use of Digital Technologies

Owners using digital technologies experience significant benefits to their projects and organizations. The more deeply engaged data-centric their organizations are, the more likely they are to experience these benefits.

Overall, between two thirds and three quarters of owners using the seven digital technologies see major improvements to their projects and their organizations.

- That share increases to between 80% and 86% of owners from highly data-centric organizations. The investment in data-centric approaches allows these owners to experience even more value from the digital technologies they use.

- Using more technologies also increases project and process benefits, but not to the degree that good data management does, and it also does not impact the degree to which other divisions in their organizations can benefit from the project data captured by these tools.

The analysis on pages 48 to 58 provides a detailed examination of which technologies most frequently result in each benefit measured in the study.

Obstacles to Wider Use of Data-Centric Approaches and Digital Technologies

The findings in this study can help owners demonstrate the return on investment to justify getting more resources for their use of data and technology.

The challenge of getting sufficient resources is the top obstacle, both to increased investment in data-gathering and analysis and to being able to experience more benefits from the digital technologies they use.

Obtaining resources is always a challenge at any organization, but the ability to demonstrate a clear return on investment can help overcome that hurdle. This study provides evidence that owners can expect a high level of return from making targeted investments in technology and especially in effective data-centric strategies and approaches.

Experienced at Least One Benefit That Had a Major Impact on Their Projects/Organizations From Use of Digital Technologies

	All Owners	Owners With High Technology Engagement	Owners With High Data-Centric Engagement
Project Benefits (Reliable Cost and Schedule Estimates, Improved Quality, Safety and Sustainability, Performance Expectations Exceeded)	74%	79%	86%
Process Benefits (Tracking Progress, Increased Transparency, Improved Collaboration and Ability to Convey Goals and Provide Input)	67%	72%	80%
Digital Benefits (Use Project Digital Deliverables for Planning, Operations, Asset Management)	64%	64%	83%

Recommendations

For Owners

1. **Commit to being a data-centric organization.** This report includes 42 different ways that owners can improve their ability to manage and share data. While several are recommended below, the most important recommendation for owners is to recognize that for an organization to thrive in the current age, it needs to be as rigorous in its data management as it is in its project or asset management.

2. **Data standards need to be part of a data-centric approach.** Only 11% of owners require the use of data standards from their project teams on all their projects. Using an established industry standard, rather than an internal one, is critical to help the project team meet the data requirements with minimal additional cost.

3. **Invest in processes for managing data, not just technology infrastructure.** 64% of owners invest in technology infrastructure, but only 30% invest in a process to manage new technology adoption. Less than 40% invest in processes for data quality control, change management, a documented approach to information security, or use a BIM execution plan or data governance plan on the majority of their projects. Processes are essential to good data management.

4. **Invest in the human side of data management.** As previously mentioned, change management is not typically part of an owner's data strategy, but ultimately, staff buy-in and ability to use digital tools effectively is essential for a successful data management strategy. Training is a critical part of this, but 45% of owners currently do not provide regular data training and even more (66%) do not provide training on digital project management.

5. **Include the project team's data as part of your overall approach.** Currently, owners have more organizational strategies in place for internal data workflows and exchanges, but organizations that plan to use data internally rely on the data they receive from their project teams. Giving your project teams clear guidelines and standards to follow, and collaborating with them on data strategies from the time they are brought on board increases the likelihood that project data can be used to inform all asset-related functions at the owner's organization.

6. **Recognize that being data-centric is an ongoing process.** Use the various pieces of information in this report as a road map and recognize that processes to review data standards and requirements to keep up with changes in technology will always be necessary. Track how data-centric policies and approaches are performing and get feedback for continual improvement.

For Designers and Contractors

1. **Build your data management skills to help meet client demands.** As owners become more data-centric, they will need better data from their supply chain. Invest in internal expertise on data management processes and standards and use the information in this study to consider how you can be a good data partner to your clients.

2. **Consider how your data requirements for consultants and subcontractors need to align with your data deliverables to owners.** Even if owners infrequently interact with subcontractors, their data is very important as owners seek to use project data in operations, asset management and capital planning.

3. **Make sure you establish the owner's data needs and requirements at the start of a project.** Knowing not just what data they need but how they intend to use it can make you a better partner. This includes understanding what type of analysis from your use of digital technologies will serve them best.

4. **Use the findings of this report to better understand the trends of how the owners on your projects deal with data.** Private, commercial owners, local governments, institutions and state/federal government agencies are all becoming data-centric in different ways. The analysis in this report clearly differentiates the practices of each.

5. **Be prepared to demonstrate your company's digital acumen when negotiating for work with owners.** Including your digital capabilities as part of what you can deliver to an owner can provide a competitive advantage now and may be increasingly important in winning work in the future.

Data Introduction

This study provides critical benchmarks about how owners are transforming themselves into data-centric organizations and increasing the value they gain from their increasing investments in digital technology.

First, it examines owner engagement with 37 different approaches that can help improve data management at their organizations.

It explores how many of them have instituted organizational policies and investments, including training, and engaged in approaches that allow data to support project management and increased collaboration.

It looks at the specific data requirements and standards that they implement on projects with their designers and contractors, and the approaches they have instituted to leverage the use of data across their organizations.

It also reveals how frequently they track and measure many of their efforts for continual improvement of their approach, since being a data-centric organization is an ongoing process rather than a single achievement.

All of the approaches they use are assigned points and tallied into a score that places them in one of three categories of data-centric engagement: limited, moderate, high. The rest of the report utilizes these categories to demonstrate how data-centric engagement impacts their use of digital technology and the benefits they are able to experience, at both project and organizational levels.

Next, the report examines owner engagement with seven digital technologies on their projects. It reveals how essential each technology is to the role of those using it, and it explores the degree to which owners currently deploy these technologies across an asset's lifecycle, including in capital planning, design and construction. commissioning, operations and maintenance and decommissioning.

Once the use of the technologies is established, the report reveals the degree to which users of each technology experience several project, process and digital benefits. Users are asked to identify the technologies that yield these benefits to such a degree that they make a major impact on their projects and/or their organizations.

Finally, the study examines the challenges that prevent owners from getting more out of the technologies they use or investing more in better data management.

Note About the Data

The findings in this study are based on the responses of 188 owners to an online survey conducted from November 2024 to February 2025.

In addition to indexes created based on their use of data-centric approaches and technology (which are described in detail on pages 30 and 45), two other variables are considered, especially in the sections benchmarking use.

TYPE OF ORGANIZATION
Includes four categories: local government, state and federal agencies, private, commercial companies and public/private institutions.

SIZE OF ORGANIZATION
Includes four categories determined by value of annual construction activity:
- Small: $5M to less than $25M
- Midsize: $25M to less than $100M
- Large: $100M to less than $500M
- Very Large: $500M or more

For more information on the respondents, see the **Methodology on page 71**.

Data-Centric Policies and Practices

Introduction

Owners who can effectively leverage project data across the asset lifecycle can improve capital planning, operations and long-term management.

While many now use or require digital technologies (see pages 33–34), technology alone is not enough to unlock data's full value. Maximizing its impact requires data-centric goals, processes and standards that ensure consistency, accuracy and timeliness.

This chapter includes six sections that provide an in-depth examination of the degree to which US owners have data-centric policies and practices in place.

- **Organizational Approaches to Improve Data Management:** Describes the organization-wide goals, processes and approaches they have adopted, their use of data-centric processes to support collaboration, the strategies they employ to leverage data throughout their organization, and how frequently they measure and track the impact of these efforts on their organization.

- **Creating and Using Data for Project Delivery:** Examines how owners use different data-centric approaches to project management, what data-centric procurement and contracting practices they deploy, and how frequently they measure and track the impact of these practices.

- **Creating and Using Data for Asset Management:** Reveals how frequently asset handover information is digitized and what share of owners deploy digital operations and asset management practices.

- **Owner Requirements for Data Creation, Sharing and Reuse:** Examines the frequency of requiring specific approaches to data creating, sharing and reuse by their project teams, including the specific data standards required, and explores the future data information requirements that owners expect to implement in the next three years.

- **Tracking Data Management Performance:** Shows how frequently owners use automated performance management tracking, quality assurance processes and metrics to document conformance to standards, and how frequently they update their data standards.

- **Data-Centric Engagement Index:** Utilizes the responses to the other sections in this chapter to place the owner respondents in low, moderate and high categories of data-centric engagement. These categories are used in the rest of the report to demonstrate how an organization's commitment to being data-centric impacts their use of digital technologies and the benefits they achieve from its use.

Data-Centric Policies and Practices

Organizational Policies and Investments That Support a Data-Centric Approach

The charts on this page show (at bottom left) the share of owners who use any of five policies and investments to support a data-centric approach at their organization, and (at bottom right) the percentage using each one.

OVERALL USE

Nearly all owners (86%) use at least one of these policies or investments, which reveals the importance that owners place on using data at their organizations.

- **Variation by Type of Organization:** 97% of respondents from public/private institutions and 94% of those from state or federal government agencies utilize at least one of these approach, more than those in local government (84%) or with private/commercial companies (76%).

- **Variation by Size of Organization:** 92% of those from large organizations have implemented at least one, but so have many small and midsize ones (86% and 78%, respectively).

USE OF EACH APPROACH

- Owners most frequently invest in technology infrastructure (64%), especially those in state/federal government (82%).

- Unfortunately, despite that level of investment in technology infrastructure, far fewer (30%) have a formalized process in place for new technology adoption.
    - > Despite their high level of investment, only 42% of those at state and federal agencies have these processes are in place.
    - > Public/private institutions are the least invested in these processes, with only 17% reporting them
    - > Large organizations more frequently report them (41%) than smaller ones.

- Many owners are committed to continual improvement through research, the second most widely selected approach.
    - > More large owners (65%) engage in this than smaller ones.
    - > State/federal owners (76%) also have these commitments more frequently than other types of organizations.

- Just under half report using core principles (48%) and resources (42%).
    - > Again state/federal owners lead the way (64% and 58%, respectively).
    - > Size of owner organizations is not as relevant for using core principles, with 45% of both small and very large owners using them.
    - > Resources, though, are more widely available at large owners (51%) than small (29%) or midsize (33%) ones.

Owner Organizations That Use at Least One of Five Organizational Policies and Investments to Support a Data-Centric Approach
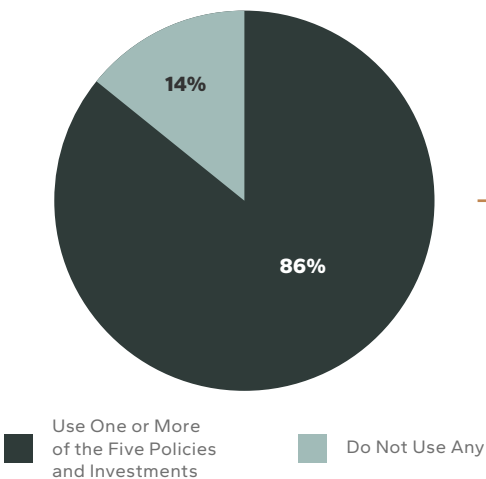
14%

86%

- Use One or More of the Five Policies and Investments
- Do Not Use Any

Policies and Investments Used

TECHNOLOGY INFRASTRUCTURE: Hardware, services, cybersecurity, cloud-based solutions, etc.	64%
CONTINUAL IMPROVEMENT: Conduct research to continue to improve use of data at your organization	56%
CORE PRINCIPLES: Have your organization's goals, mission, vision, values and objectives include utilizing data	48%
RESOURCES: Appoint a champion, planning group or dedicate other resources to promote effective use of data	42%
PROCESS FOR NEW TECHNOLOGY ADOPTION: Formalized process for technology adoption	30%
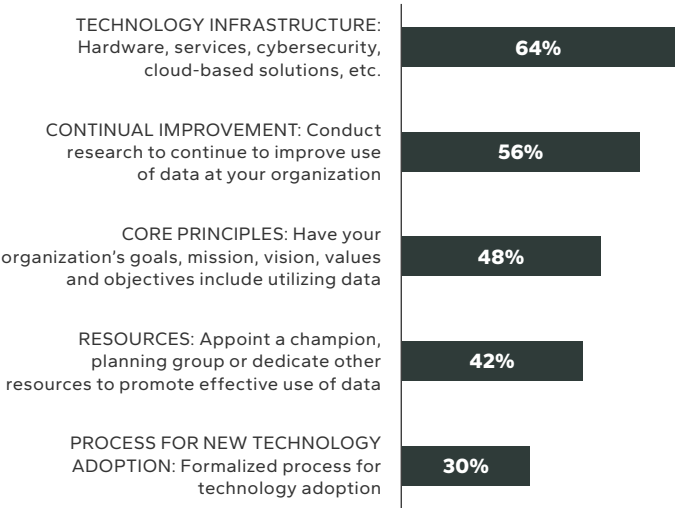
Use of Data-Centric Policies and Practices

Data-Centric Processes to Support Collaboration

As shown below, most owners (79%) use at least one of two data-related approaches that support internal or external collaboration, reinforcing that consistent, accurate and timely data can enhance those processes.

INTERNAL PROCESSES AND REQUIREMENTS FOR THE PRODUCTION AND USE OF PROJECT DELIVERY AND ASSET DATA

As shown at bottom right, 70% have internal processes and requirements for the production and use of project delivery and asset data. These findings underscore an overall commitment to internal digital workflows leveraging data beyond the immediate function for which it was gathered. This strongly aligns with a previous study conducted by Dodge Construction Network in 2023.[1]

DEFINITION OF DATA-CENTRIC PROCUREMENT PROCESSES, QUALIFICATIONS AND CONTRACT LANGUAGE/REQUIREMENTS FOR PROJECTS

However, owners less frequently use data-centric processes and requirements intended to support external project team collaboration. In fact, only 32% include these in their procurements, requests for qualifications or contract language.

As owners become increasingly reliant on good data, they should come to recognize the importance of working with project teams that collaborate digitally and will more reliably support their data standards. Enabling improved data from external parties will allow owners to utilize it more effectvely across their internal organizations, in turn encouraging better digital collaboration throughout the industry.

VARIATION BY TYPE AND BY SIZE OF ORGANIZATION

Notably, there is no significant difference in how many owners have instituted these processes or requirements, either by the type or size of the organization.

This suggests that designers and contractors may have an opportunity to build better relationships with most of their clients by explicitly understanding and meeting their data needs, and that this may give them a competitive advantage until these types of requirements become more common throughout the industry.

[1] Connected Construction: The Owners' Perspective SmartMarket Brief: https://www.construction.com/resource/connected-construction-the-owners-perspective/

Owner Organizations That Use Data-Related Approaches That Support Collaboration
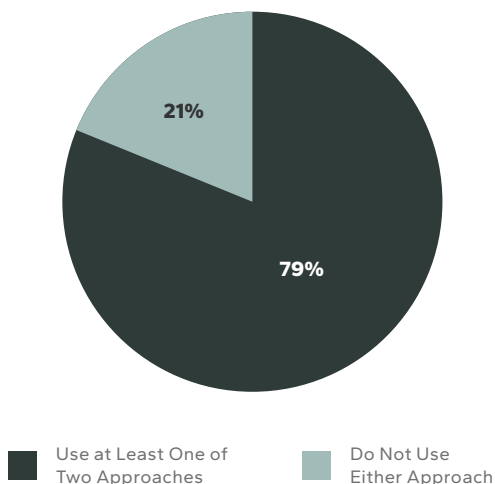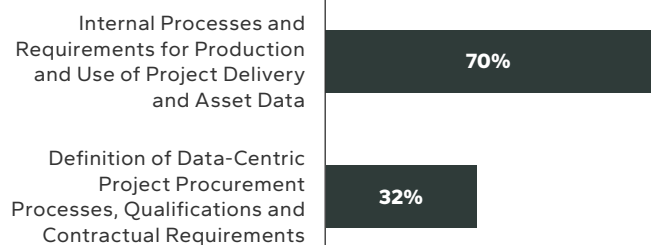
- 21%
- 79%

Legend:
- Use at Least One of Two Approaches
- Do Not Use Either Approach

Approaches Used

Internal Processes and Requirements for Production and Use of Project Delivery and Asset Data — **70%**

Definition of Data-Centric Project Procurement Processes, Qualifications and Contractual Requirements — **32%**

Use of Data-Centric Policies and Practices

ORGANIZATIONAL APPROACHES TO IMPROVE DATA MANAGEMENT

Leveraging Data Throughout the Organization

In order to leverage data in multiple departments, owners need a consistent approach to data. They were asked whether they employ five strategies to provide that consistent approach. Their responses are shown in the chart below.

OVERALL USE

72% report using at least one of these strategies, which suggests that most owners recognize the importance of having a consistent approach to data.

There are no significant differences in overall use by type or size of organization, suggesting that all find this important.

SPECIFIC APPROACHES USED

DATA INTEGRATION

The largest share of owners are engaged in integrating data, including the integration of data sources to enable efficient data transfer for organizational tasks across projects and the integration of data and information across most functional/business units. While this engagement with internal data integration mirrors the industry-wide shift toward integrating point

solutions that is revealed in numerous other studies by Dodge, these approaches are only currently being used by 50% or less of owners.

OTHER STRATEGIES

Less common practices—used by only about a third of owners—include adopting industry standards for data exchange, implementing data quality control and maintaining libraries of data-rich model components. This highlights the need for greater focus on standards, shared components and data quality.

- **Variation by Type and Size of Organization:**
  The use of all of these approaches is relatively consistent between public and private owners. It is also consistent by size of organization, with one exception: Large owners (53%) more frequently integrate data and information across their functional and business units than do midsize (24%) or small (38%) ones.

Owners Using at Least One of Five Approaches to Leverage Data Consistently Throughout Their Organization
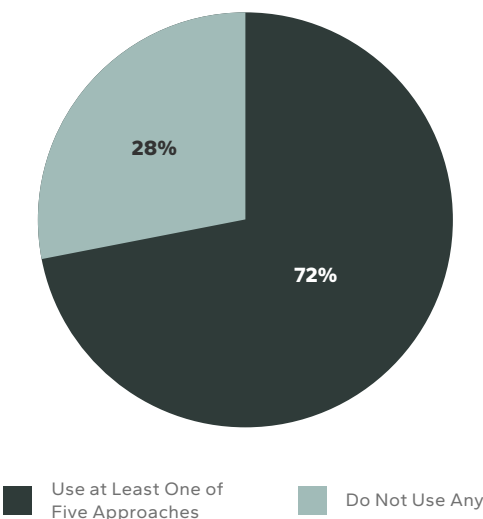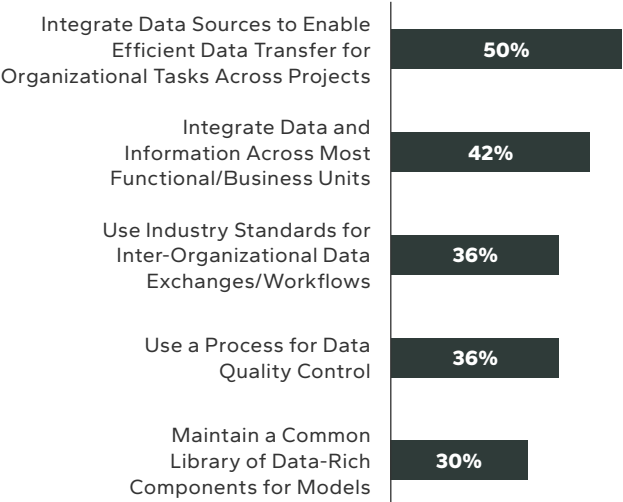
- 28%
- 72%

Use at Least One of Five Approaches

Do Not Use Any

Approaches Used

Approach	
Integrate Data Sources to Enable Efficient Data Transfer for Organizational Tasks Across Projects	50%
Integrate Data and Information Across Most Functional/Business Units	42%
Use Industry Standards for Inter-Organizational Data Exchanges/Workflows	36%
Use a Process for Data Quality Control	36%
Maintain a Common Library of Data-Rich Components for Models	30%

Data-Centric Policies and Practices

ORGANIZATIONAL APPROACHES TO IMPROVE DATA MANAGEMENT

The Data-Centric Owner

People-Related Approaches That Support Better Data Management

People are as crucial to data management as the technologies they use. While 79% of owners use at least one of two key staff-focused approaches, each is used by only about half, highlighting significant room to improve the human side of data management.

- **Regular Education and Training on Technology and Data Use:** 55% of owners provide regular education and training, but this still leaves 45% without training on a regular basis. There are no significant differences by the size of organizations in how many provide this, suggesting that small owners can invest in this area if they recognize its importance to their use of data across their organization. There are also no significant differences between public and private owners.

- **Each Business Unit Has a Role With Responsibility for Effective Use of Data:** If data is to be effectively leveraged throughout an organization, the responsibility for it cannot just fall on a single department or a single person. Every part of the organization that generates or uses data needs to have responsibility for ensuring the quality and consistency of that data. Currently, less than half (47%) of the owners report that each business unit has a role that is responsible for the data they produce and use, suggesting that this is one of the potential areas that could significantly improve data use across many organizations.

  > While public and private owners are similar in their responses to this question, small owners (26%) lag behind midsize (57%) and large (51%) ones in utilizing this critical approach.

Owners Using at Least One of Two People-Related Approaches That Support Better Data Management
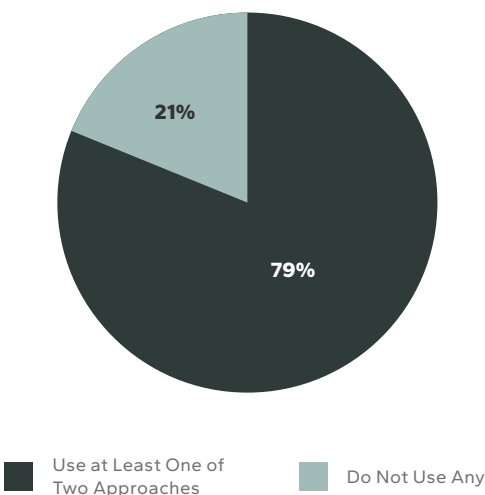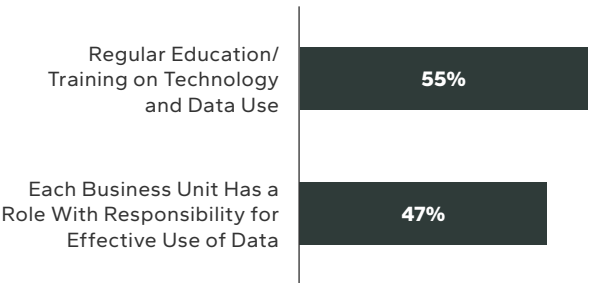
21%

79%

- Use at Least One of Two Approaches
- Do Not Use Any

Approaches Used

Regular Education/ Training on Technology and Data Use — 55%

Each Business Unit Has a Role With Responsibility for Effective Use of Data — 47%

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Data-Centric Policies and Practices

Use of Metrics and Tracking for Organizational Approaches

Data-centric policies are more effective when their implementation is monitored and tracked.

Owners were asked how often they formally measure data-centric activities that support collaboration, data use, and staff engagement. As shown below, the majority (71%) do so at least some of the time.

- There are no differences between public and private owners in the share who track their use of at least one measure.

- While the differences are not statistically significant, the share of those who are not sure about whether their organizational data-centric approaches are tracked and measured goes up as the size of the organization increases, with only 6% unsure at small owners, 15% at midsize organizations and 23% at large ones. This suggests that large owners may not be communicating about how effectively they are implementing these measures, even if they are tracking them.

TRACKING THE IMPLEMENTATION OF APPROACHES THAT SUPPORT COLLABORATION
Fewer than half of owners using collaboration-supporting approaches track them quantitatively for continuous improvement. Without input from project teams and staff, enhancing collaboration and digital workflows remains challenging.

As technology evolves and data use grows more sophisticated, owners must periodically update data requirements, guided by feedback from business units on their real-world challenges in deriving value from the data. Many owners that define data-centric procurement processes, qualifications and contract requirements, though, do not track their impact for continual improvement.

The Data-Centric Owner

Owners Using Metrics and Tracking on Any of the Nine Organizational Data-Centric Practices, Policies and Approaches They Use

- 71% — Track at Least One of Nine Approaches
- 10% — Do Not Track Any
- 19% — Not Sure
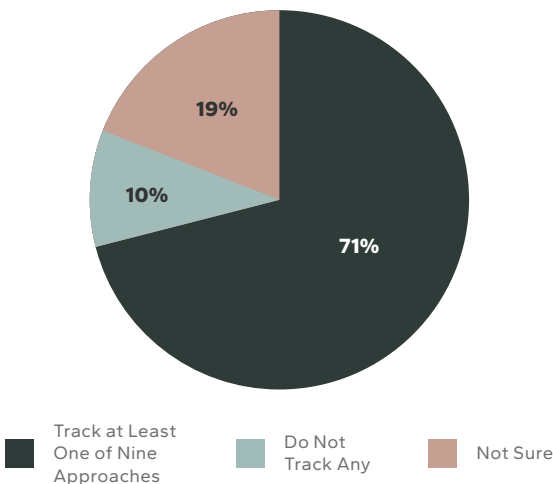
Share of Owner Organizations That Quantitatively Track and Manage Approaches That Support Collaboration for Continual Improvement
(AMONG THOSE WHO REPORT USING THEM)
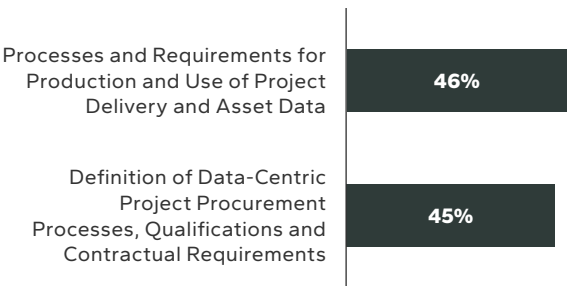
Processes and Requirements for Production and Use of Project Delivery and Asset Data	46%
Definition of Data-Centric Project Procurement Processes, Qualifications and Contractual Requirements	45%

Data-Centric Policies and Practices

Use Metrics and Tracking for Organizational Approaches CONTINUED

APPROACHES TO LEVERAGE DATA ACROSS THE ORGANIZATION

Four out of five of these approaches are measured and tracked by about half of owner organizations that use them.

- Integrating data and information across most functional and business units is the most frequently tracked and managed practice, which is important since it is also the most widely used one (see page 13). This suggests the importance that owners place on utilizing data across departments.

- However, owners are less successful at tracking and improving how they integrate data sources to enable efficient data transfer for organizational tasks across projects, despite the fact that this is the second most widely used measure.

- While only about one third of owners use of a process for data quality control or an industry standard for inter-organizational data exchanges and workflows, over half of those doing so are

able to track and manage these processes for continual improvement. This suggests that many owner organizations that invest in these approaches recognize that data improvement is an ongoing process, rather than a one-time project.

PEOPLE-RELATED DATA MANAGEMENT ACTIVITIES

A majority (61%) of owners who offer regular training on data and technology track it for continual improvement. This is the highest rate among data management approaches. Its relative frequency likely reflects both rapid technology adoption and a strong organizational commitment to training.

Over half (53%) of owners with data roles in each business unit also track their effectiveness, showing a commitment to ongoing data maturity. Gathering feedback and sharing responsibility helps broaden data use and benefits across the organization.

Share of Owner Organizations That Quantitatively Track and Manage Approaches to Leverage Data for Continual Improvement
(AMONG THOSE WHO REPORT USING THEM)

Integrate Data and Information Across Most Functional/Business Units	55%
Use Industry Standards for Inter-Organizational Data Exchanges/Workflows	55%
Use a Process for Data Quality Control	51%
Maintain a Common Library of Data-Rich Components for Models	45%
Integrate Data Sources to Enable Efficient Data Transfer for Organizational Tasks Across Projects	38%
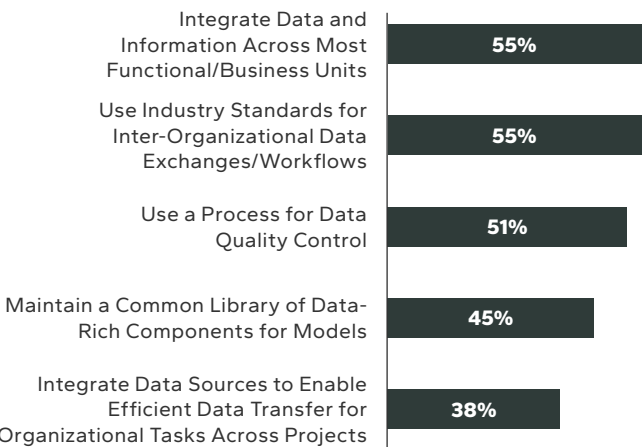
Share of Owner Organizations That Quantitatively Track and Manage People-Related Data Management Activities for Continual Improvement
(AMONG THOSE WHO REPORT USING THEM)
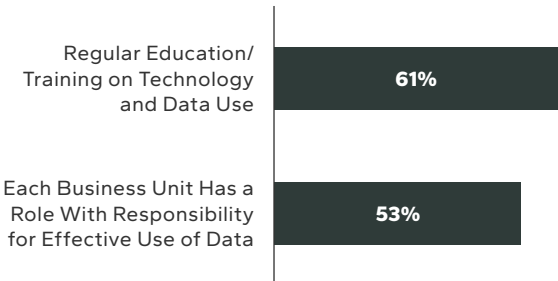
Regular Education/Training on Technology and Data Use	61%
Each Business Unit Has a Role With Responsibility for Effective Use of Data	53%

Data-Centric Policies and Practices

Data-Centric Project Management

Owners were asked about seven data-driven project management approaches shown in the chart at lower right. 80% use at least one, showing broad recognition of data's value. Adoption rises with organization size, with 92% of large owners using at least one, compared with just 73% of midsize and 69% of small owners.

USE OF INDIVIDUAL APPROACHES
Despite the widespread use of at least one approach, none of the individual ones are currently used by over half of the owners, reflecting the still-evolving state of data-centric project management among owners.

- **Most Widely Used:** The largest share of owners create data-related goals on their projects. This is a good foundation for prioritizing other data-related practices, but even this is only done by 47%.

- **Moderately Used:** Between 34% and 39% use three approaches.
  > 39% have created a documented approach to information security. Small owners (24%) do this less frequently. As digital project delivery continues to accelerate, information security will become even more important.

> 36% have devised some means to support achieving their data-centric goals, including establishing committees, assigning funds and having a change management strategy. Again, this is an area that small organizations (21%) do less frequently than the others.

> 34% provide regular training, but that is fewer than those who report that they conduct regular education/training on technology and data use in general (55%—see page 14). This suggests a relatively easy opportunity for some of those already investing in training to better support data-driven project management. However, training appears to correlate with resources since 46% of large organizations offer it, compared with 27% of midsize ones and only 14% of small ones.

- **Least Frequently Used:** Fewer than one quarter of owners utilize a well-defined change management strategy, automate quality control or select an information champion. That suggests that these are more advanced activities that may be more widely adopted as more owners invest in becoming data-centric organizations.

Owners Using at Least One of Seven Approaches to Support the Use of Data for Project Management
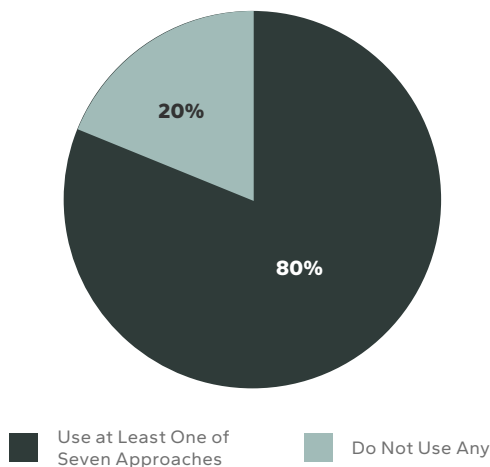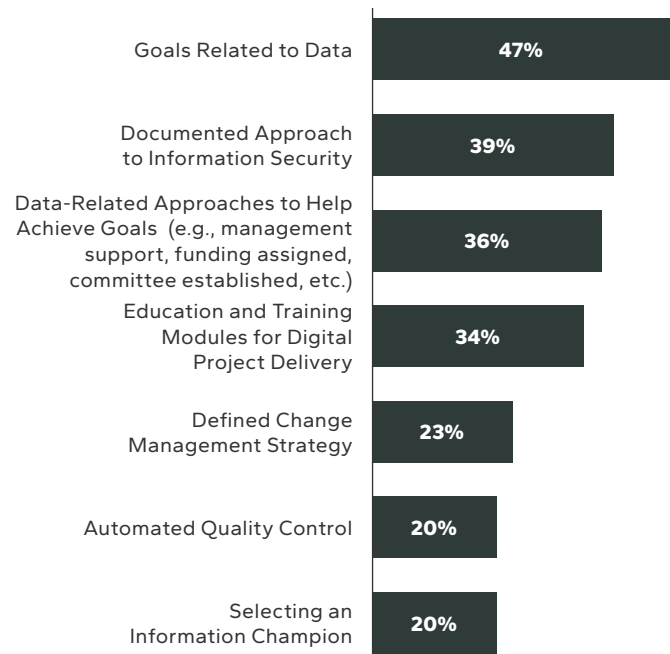
- Use at Least One of Seven Approaches
- Do Not Use Any

Approaches Used

Goals Related to Data	47%
Documented Approach to Information Security	39%
Data-Related Approaches to Help Achieve Goals (e.g., management support, funding assigned, committee established, etc.)	36%
Education and Training Modules for Digital Project Delivery	34%
Defined Change Management Strategy	23%
Automated Quality Control	20%
Selecting an Information Champion	20%

Data-Centric Policies and Practices

Data-Centric Procurement and Contracting

Owners were asked whether they use any of the four data-centric procurement and contract approaches shown in the chart below. Again, most owners (71%) use at least one, but no individual approach is used by more than half.

- The most common method is using contracts that support data-centric delivery. This is most effective when based on widely adopted industry standards (see page 24). Standardizing data requirements would help project teams deliver consistent data without adapting to new terms for each owner or project.

- 38% also include well-defined digital delivery requirements. These requirements help designers and contractors by establishing clear terms up front that can help them better meet their clients' needs. In particular, there are no notable differences by size of company or by type of owner in their use of well-defined requirements.

- 34% use procurement strategies that support data-centric project delivery. These strategies

are more widely used by large owners (41%) and least frequently used by private, commercial owners (24%).

- Only 27% of owners use clear data-centric criteria when selecting project teams. While assessing data capabilities can be difficult, growing reliance on project data may push owners to prioritize partners who can meet their data needs. This emphasis will certainly encourage designers and contractors to strengthen their data practices to remain competitive.

Owners Using at Least One of Four Data-Centric Procurement and Contract Approaches
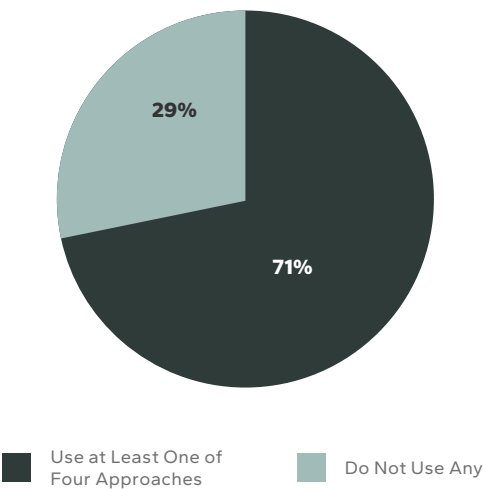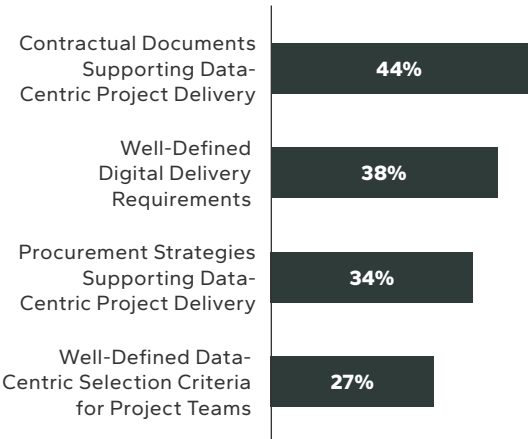
29%

71%

■ Use at Least One of Four Approaches　　■ Do Not Use Any

Approaches Used

Contractual Documents Supporting Data-Centric Project Delivery	44%
Well-Defined Digital Delivery Requirements	38%
Procurement Strategies Supporting Data-Centric Project Delivery	34%
Well-Defined Data-Centric Selection Criteria for Project Teams	27%

The Data-Centric Owner

Data-Centric Policies and Practices

Metrics and Tracking for Approaches to Create and Use Data for Project Delivery

Only 59% of the owners using data-centric project or procurement approaches are quantitaively tracking them for improvement, compared with 71% for their internal practices. This suggests a notable trend of owners currently prioritizing internal data efforts over those involving their project teams.

- Even though very few (23%) of owners define a change management strategy, over half of them (53%) track how well it performs.

- Half or more also track the success of the contractual documents they use to support data-centric project delivery and their data-centric procurement strategies.

- Overall, this data supports two conclusions.
  - > Many owners are committed to continuing to improve the effectiveness of these approaches.
  - > There is an opportunity for more owners to measure and improve the ways they encourage data-centric project delivery.

Owners Quantitatively Tracking and Managing Their Use of Data-Centric Project Management and Procurement Approaches
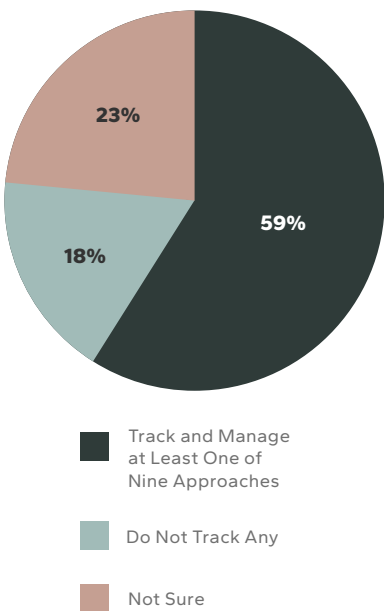
- 23%
- 18%
- 59%

■ Track and Manage at Least One of Nine Approaches

■ Do Not Track Any

■ Not Sure

Share of Owner Organizations That Quantitatively Track and Manage Data-Centric Project Management Approaches
(AMONG THOSE WHO REPORT USING THEM)

Defined Change Management Strategy	53%
Documented Approach to Information Security	46%
Automated Quality Control	46%
Education and Training Modules for Digital Project Delivery	43%
Selecting an Information Champion	24%
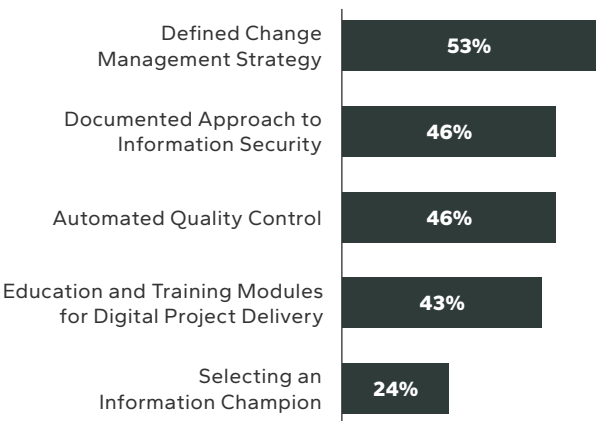
Share of Owner Organizations That Quantitatively Track and Manage Data-Centric Procurement and Contracting Approaches
(AMONG THOSE WHO REPORT USING THEM)
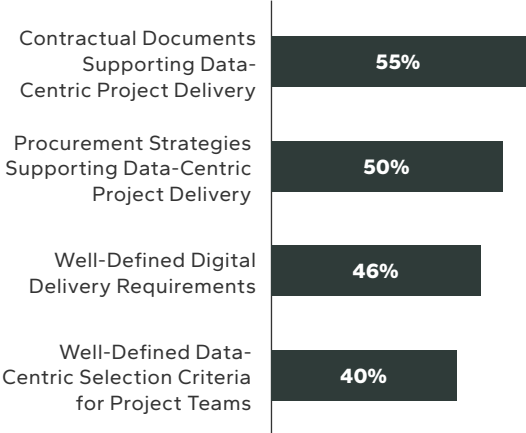
Contractual Documents Supporting Data-Centric Project Delivery	55%
Procurement Strategies Supporting Data-Centric Project Delivery	50%
Well-Defined Digital Delivery Requirements	46%
Well-Defined Data-Centric Selection Criteria for Project Teams	40%

The Data-Centric Owner

Data-Centric Policies and Practices

Digitization of Asset Handover Information

Getting consistent, reliable digital information at asset handover helps owners utilize that data across their organizations during operations, asset management and for capital planning.

Owners were asked to identify which of the six types shown in the chart below best describes the handover data they most frequently receive. The findings reveal a wide variety, making consistency and reliability difficult to achieve.

- Encouragingly, only 15% report that their handover information is limited to static digital documents and paper.

- Digital documents are quite common, but over one third of those who receive them report that they do not include models. For owners who use or are considering using digital twins for operations and asset management (see page 33), a model is an important deliverable.

- Only 18% typically receive digital documents and model data files that meet their data requirements. However, as page 18 reveals, only

38% of owners have well-defined digital delivery requirements, so it is not surprising that so few owners are reporting that their requirements are met.

VARIATION BY SIZE AND TYPE OF OWNER

- **Size of Owner:** While about one third (34%) of very large owners receive digital documents that meet their data needs—more than any other group—they also have the highest share (23%) receiving only paper or PDFs, well above the 15% overall average who are not receiving digital deliverables.

- **Type of Owner:** State and federal agencies (27%) and public/private institutions (23%) more often receive paper or PDFs than local governments (11%) or private firms (7%). Yet all groups report similar rates (18–23%) of receiving data-compliant digital files, suggesting some organization types are receiving a wider range of handover formats than others.

Digitization Level of Asset Handover Information
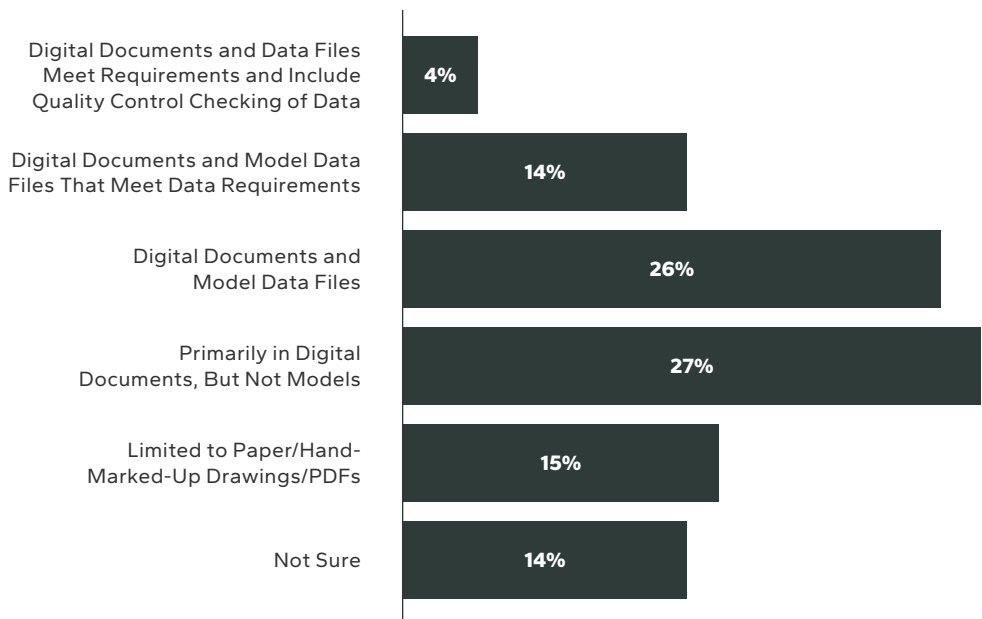
Category	Percentage
Digital Documents and Data Files Meet Requirements and Include Quality Control Checking of Data	4%
Digital Documents and Model Data Files That Meet Data Requirements	14%
Digital Documents and Model Data Files	26%
Primarily in Digital Documents, But Not Models	27%
Limited to Paper/Hand-Marked-Up Drawings/PDFs	15%
Not Sure	14%

Data-Centric Policies and Practices

Digital Operations and Asset Management

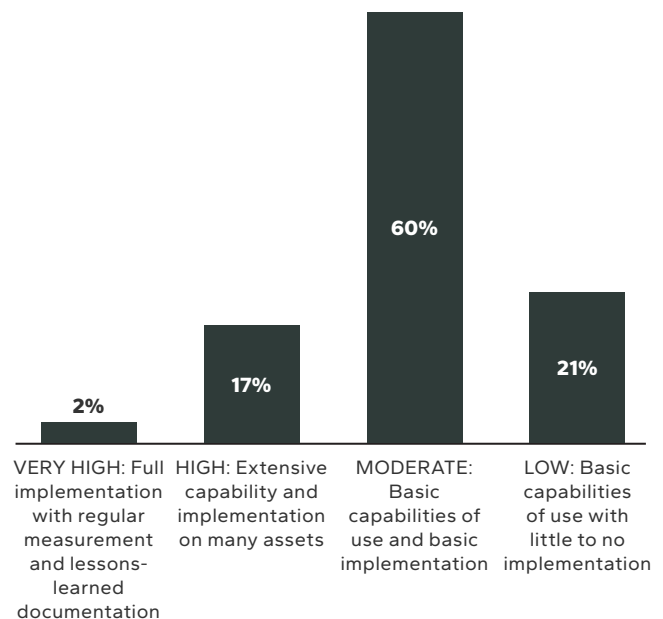Owners were asked two questions about operations and asset management, and their responses are reflected in the charts below and at right.

- **Digitizing Tasks:** As the chart below reveals, 71% of owners have digitized at least one of three operational/asset management tasks.
  - > By far, the most common is managing assets digitally (61%), although fewer than half of small owners (48%) are conducting that task digitally.
  - > Owners less commonly report that the tasks they use to monitor the performance of their assets (37%) and manage space (34%) are digitized. Over half of public/private institutions (57%) have digitized tasks to manage spaces at their organizations.

- **Deployment of Digital Asset Management:** As the chart at right shows, most owners (79%) are engaged in some basic implementation of digital asset management, but very few report extensive capabilities (19%) and almost none (2%) believe they have full digital implementation at their organization.

Considered together, these findings suggest that digital asset management is becoming established among owners, but the maturity level is still relatively low.

Level of Deployment of Digital Asset Management Approaches

2%	17%	60%	21%
VERY HIGH: Full implementation with regular measurement and lessons-learned documentation	HIGH: Extensive capability and implementation on many assets	MODERATE: Basic capabilities of use and basic implementation	LOW: Basic capabilities of use with little to no implementation

Owner Organizations That Have Digitized at Least One Operational/Asset Management Task
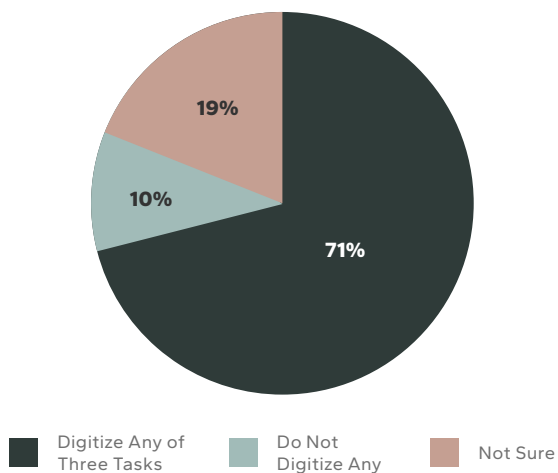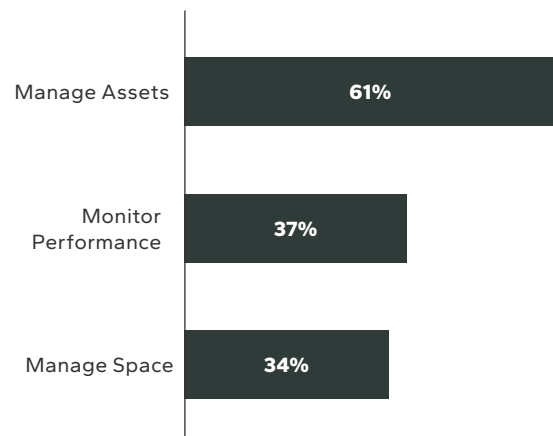
- 19%
- 10%
- 71%

Digitize Any of Three Tasks
Do Not Digitize Any
Not Sure

Tasks Digitized

Manage Assets	61%
Monitor Performance	37%
Manage Space	34%

The Data-Centric Owner

Data-Centric Policies and Practices

Project Team Requirements for Data Creation, Sharing and Reuse

One of the best means for an owner to ensure that the project data they receive will be useful for other parts of their organization is to provide designers and contractors with basic guidelines and plans for data creation, sharing and reuse.

- The chart below shows how many owner organizations require at least one member of a project team to use five data guidelines: data standards, BIM execution plans, a common data environment, data governance plans and defined metrics to measure success for data creation, sharing and reuse.

- The chart on the following page shows the different companies on the project team from which these measures are required.

DATA STANDARDS
57% of owners require that their project teams establish data standards, including naming templates, automated alerts, export formats, file sizes and upload recurrence.

- This is the only type of data guideline or plan that is utilized by over half of owners.

- Among the owners who require data standards, nearly two thirds do so on more than half of their projects, suggesting they find high value in this practice.

- **Variation by Type of Organization:** A slightly smaller share of private, commercial owners (49%) and public/private institutions (41%) require data standards than those in local government (61%) or federal/state government (63%). However, a high share of private commercial owners (70%) and public/private institutions (78%) that require these standards do so on more than half of their projects.

- **Variation Across Project Team:** Data standards are more frequently required from architects (41%) than general contractors (28%) or construction managers (23%). This may limit the usefulness of the final handover data owners receive, and it suggests that data standards are largely focused on design phase activities rather than the final digital deliverables.

BIM EXECUTION PLAN
Nearly half (48%) require a BIM execution plan, and they are evenly split between those who do so on less than half of their projects and those who do so on more than half.

- **Variation by Type of Organization:** Fewer government agencies (39%) require them than commercial companies (62%) or public/private institutions (51%).

- **Variation by Size of Organization:** Large ones (59%) more frequently require them than smaller ones (36%), who also are much less likely than large ones

Frequency of Requiring the Project Team to Use Guidelines/Plans for Data Creation, Sharing and Reuse
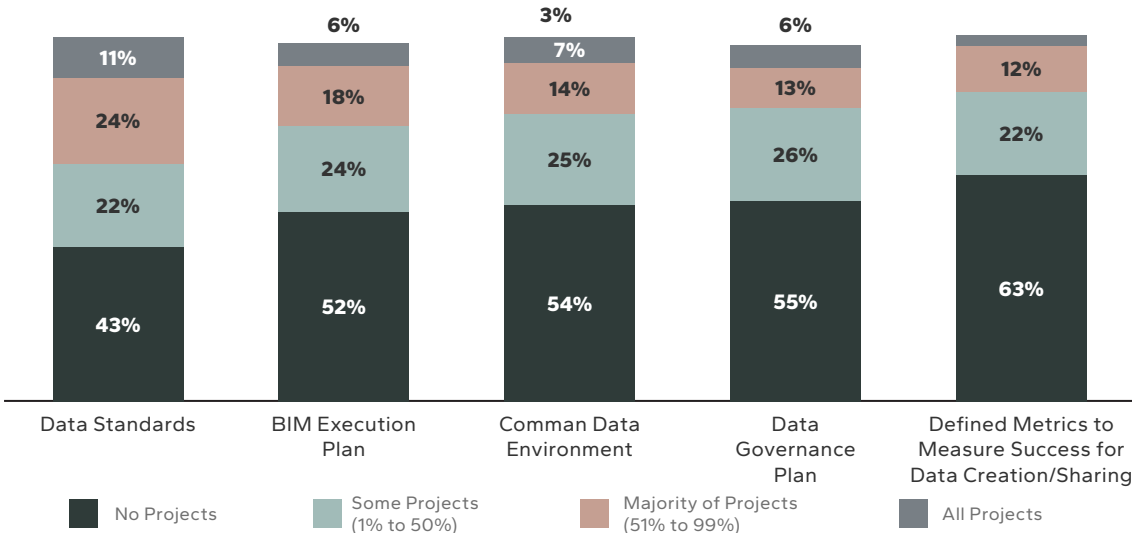
	Data Standards	BIM Execution Plan	Comman Data Environment	Data Governance Plan	Defined Metrics to Measure Success for Data Creation/Sharing
All Projects	11%	6%	3%	6%	
Majority of Projects (51% to 99%)	24%	18%	14%	13%	12%
Some Projects (1% to 50%)	22%	24%	25%	26%	22%
No Projects	43%	52%	54%	55%	63%
			7%		

Legend: ■ No Projects   ■ Some Projects (1% to 50%)   ■ Majority of Projects (51% to 99%)   ■ All Projects

Data-Centric Policies and Practices

Project Team Requirements for Data Creation, Sharing and Reuse CONTINUED

to require them on more than half of their projects (19% versus 61%).

- **Variation Across Project Team:** Fewer owners require BIM execution plans (31%) from architects than data standards (41%), but nearly the same share require each of them from general contractors (27% and 28%, respectively).

COMMON DATA ENVIRONMENT
Nearly half of owners (46%) also require that their project teams establish a common data environment (CDE).

Similar to the use of a BIM execution plan, they are nearly evenly split between those who require it on more than half of their projects (21%) and less than half (25%).

Variation Across Project Team: Given its importance for data sharing across a project team, it is not surprising that there is less variation overall between requirements of architects (32%), consulting engineers (26%), general contractors (23%) and construction managers (21%) than for most of the other data requirements. Trade contractors, however, are still infrequently included.

DATA GOVERNANCE PLAN
45% of owners require their project teams to define a data governance plan, which includes a set of strategies

and goals that outline the collaboration process between project parties. Currently, more owners require this on half or fewer of their projects (26%) than those who require it on the majority of projects (19%).

Variation Across Project Team: Similar to data standards, a data governance plan is more widely required of architects (31%) than the other companies in the project team. This suggests that the collaboration being fostered is more frequently between owners and architects than with the other members of the project team.

METRICS
Only 37% of owners require project teams to define metrics to measure the success of data-centric processes. This is consistent with the findings on pages 15, 16 and 19, which suggest that using metrics to support continual improvement of data-centric processes is still an emerging capability among owners.

- Even when owners require these metrics, only about one third of those from local, state and federal government and public/private institutions do so on the majority of their projects.

- Private, commercial owners are more advanced in this practice: Nearly two thirds (61%) of those who require these metrics do so on more than 50% of their projects.

Required Guidelines/Plans for Data Creation, Sharing and/or Reuse
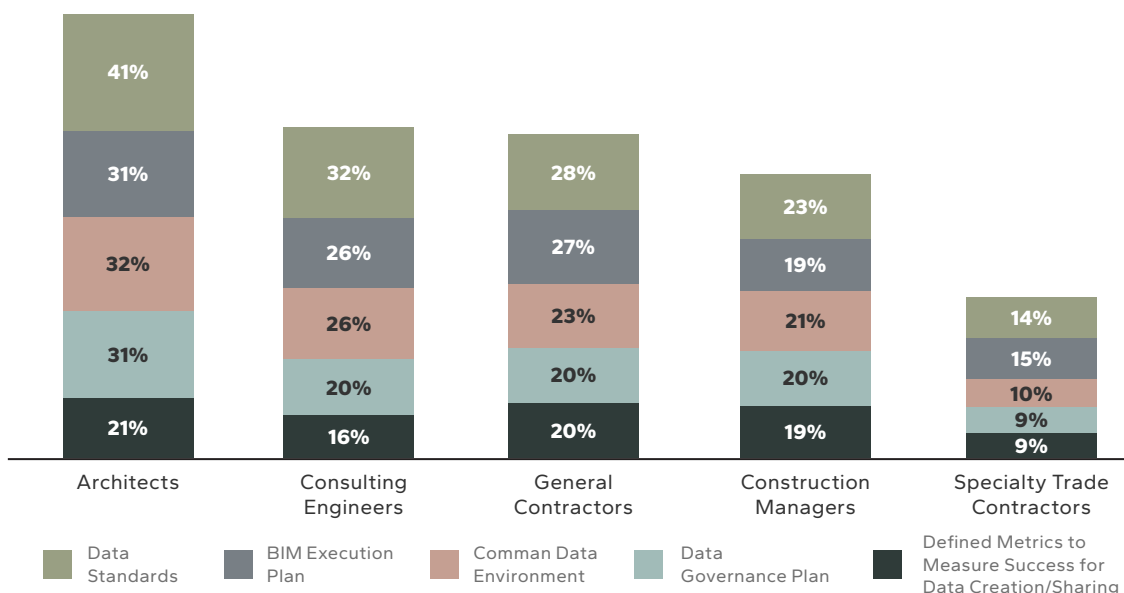
	Architects	Consulting Engineers	General Contractors	Construction Managers	Specialty Trade Contractors
Data Standards	41%	32%	28%	23%	14%
BIM Execution Plan	31%	26%	27%	19%	15%
Comman Data Environment	32%	26%	23%	21%	10%
Data Governance Plan	31%	20%	20%	20%	9%
Defined Metrics to Measure Success for Data Creation/Sharing	21%	16%	20%	19%	9%

Data-Centric Policies and Practices

Data Standards Required for Digital Documents at Handover

The previous finding on page 22 revealed that 57% of owners require their project team members to establish data standards. Owners who receive digital documents and data during handover (see page 20) were also asked about the data standards that they require for those deliverables. The chart below shows how many require any data standards and which ones they require.
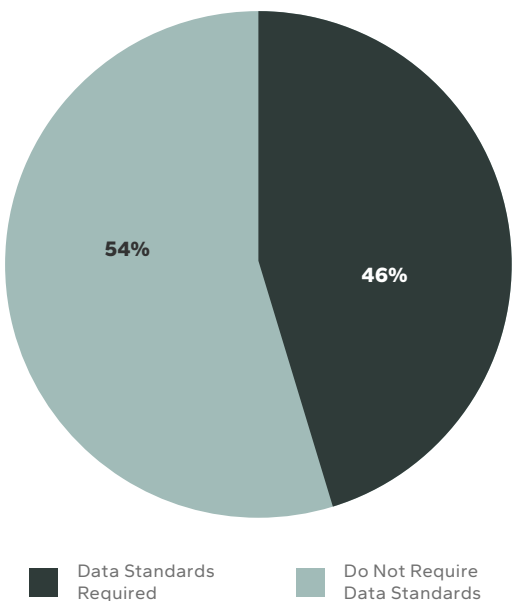
Having digital files conform to specific data standards increases the owner's ability to use the data for different functions in their own organization. Also, using a recognized standard places less stress on the rest of the project team, who work with many owners and who are more likely to be able to provide better data if the requirements are similar or the same for most of the clients that they work with.

- Only 46% of owners who receive digital documents at handover have specific data standards those documents need to meet.

- > 68% of respondents from state/federal agencies require data standards, more than the other types of owners in the study.

- While the National BIM Standard is the most widely used, no single standard is dominant among the owners who require them.
  - > The National BIM Standard is the most widely used regardless of owner type or size.

- 32% of respondents from state/federal agencies require ISO 19650, more than twice the share of any of the other types of owners.

- Owners also identified other standards they use that were not included in the survey:
  - > Three mentioned that they had their own internally developed data standards.
  - > Other standards reported by individual respondents include: ISO 55001, GSA CDX Standard, ISA Standard for Automation and Village Standard.

Require Data Standards for Digital Documents and Data Files Provided During Handover
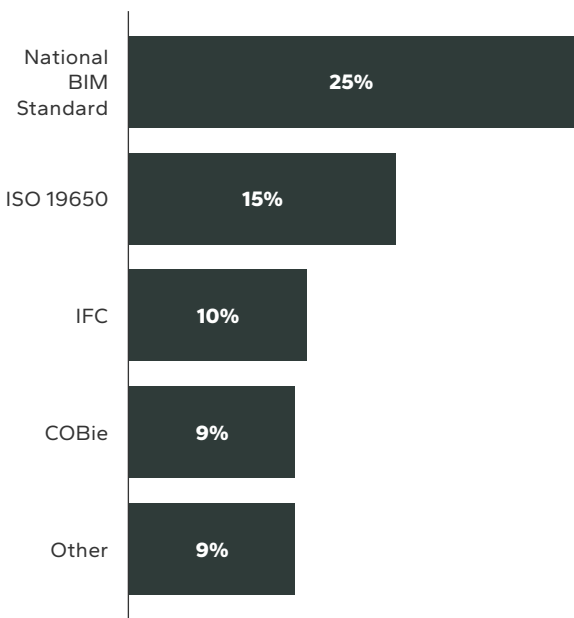
54%

46%

Data Standards Required

Do Not Require Data Standards

Data Standards Required

National BIM Standard	25%
ISO 19650	15%
IFC	10%
COBie	9%
Other	9%

Data-Centric Policies and Practices

Plans to Require Digital Information Creation, Sharing and/or Reuse in the Next Three Years

One indicator of how rapidly owners are transforming their organizations to be more data-centric is the large number that are planning to adopt digital information creation, sharing or reuse requirements for the first time.

As shown below, 72% of the owners who do not currently have data requirements plan to implement them in the future. This clearly suggests owners will increasingly demand and rely on digital data. Therefore, the companies that work on their projects need to be prepared to comply in order to remain competitive.

- Design firms are the most likely to see these requirements grow in the next three years, with 62% of those who do not already have them for their primary design firms expecting to institute them, and 53% for consulting engineers.

- General contractors and construction managers should also prepare for more owners to require digital data creation, with around half expecting to implement these for general contractors (47%) and construction managers (44%).

- Trade contractors can expect less demand for digital information creation directly from owners, since only 28% expect to have similar requirements for them. However, it is likely that general contractors and construction managers will increase their requirements from the trades to meet the owners demands.

- **Variation by Type of Organization:** Private, commercial owners (40%) and state/federal government agencies (32%) more frequently expect to require digital data from trade contractors than local governments (19%) or public/private institutions (23%).

- **Variation by Size of Owner Organization:** Significantly more very large owners expect to require data from consulting engineers (67%), construction managers (56%) and trade contractors (44%) than do small owners (36%, 24% and 12%, respectively).

Plans To Require Project Team Companies to Engage in Digital Information Creation, Sharing and/or Reuse
(AMONG THOSE THAT CURRENTLY DO NOT REQUIRE THIS)

28%

72%

■ Plans to Require   ■ Does Not Plan to Require
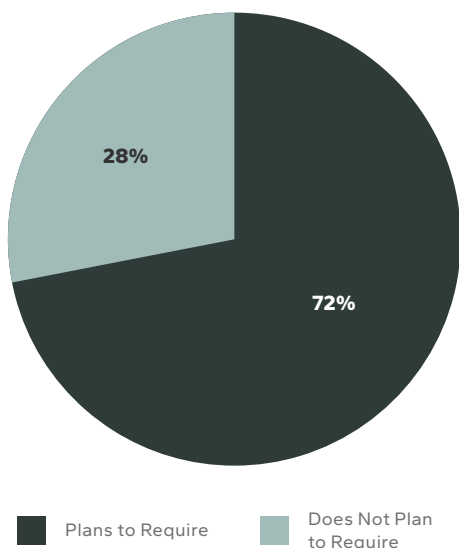
Share of Owners Expecting to Have Digital Information Requirements From Each Type of Company
(AMONG THOSE THAT CURRENTLY DO NOT REQUIRE THIS BUT PLAN TO IN THE FUTURE)

Primary Design	62%
Consulting Engineers	53%
General Contractors	47%
Construction Managers	44%
Specialty Trade Contractors	28%

The Data-Centric Owner
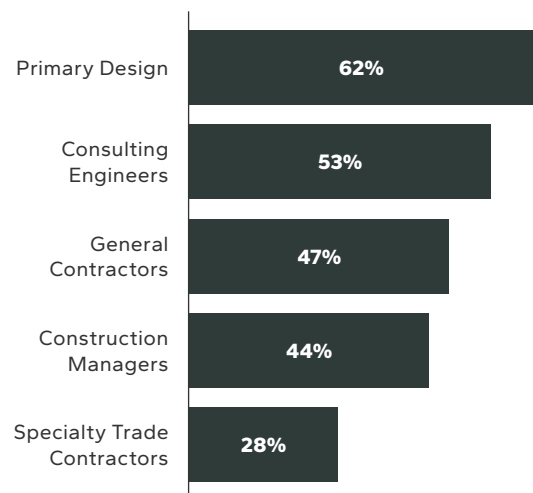
NBIMS Standard 4.0 Helps Bring Continuity to the ACEC Industry

As building techniques improve and structures become more complex, the need for accurate construction information and data is greater than ever. This is why standards such as the National Bim Standard Version 4 (NBIMS 4.0) are increasingly being employed by project owners and team members.

THE NEED FOR A STANDARD
"The standard allows an opportunity to create a common starting place where we set up contracts consistently to leverage the use of BIM deliverables and technology, speak the same language, and target value and the right outcomes between the different stakeholders" says Alex Belkofer, CM-BIM senior VDC director, McCarthy Building Companies, Inc. "Without the standard, many people use things in different ways, and they call things by different names. They might chase different value points and not fully realize the potential for how BIM can drive value long-term for an asset owner."

Belkofer, who is also on the National Institute of Building Sciences (NIBS) Digital Technology Council, says McCarthy uses the framework and modules of the National BIM Standard as a component of how McCarthy delivers projects to help "drive the partnering and alignment of the deliverables with our engineering, architecture and owner partners."

THE NBIMS 4.0 STANDARD
The NBIMS 4.0 was released by the National Institute of Building Sciences (NIBS) in 2023. The standard outlines cohesive processes to support the adoption of BIM on projects, from identifying BIM requirements, to developing detailed BIM execution plans through defining information exchanges. The modules within NBIMS-US help guide owners and project teams through the process of defining high-value use cases for adopting BIM, putting in place requirements to ensure quality BIM adoption and defining a structured approach to planning for BIM execution on a project.

Since initially made available, NBIMS 4.0 has had more than 186,000 page views from 86,000 users, and it has been accessed at a steady rate for the last year, says Roger J. Grant, FbSI, Vice President Building Technology, National Institute of Building Sciences.

ADVANTAGES FOR OWNERS
Grant says standards are important for owner organizations that want efficient ways to receive information about how their project has been designed and constructed and verify that they are getting what they paid for. "Standardizing requirements and having a way to validate that you are receiving things that you asked for is important for owners, and a standard way of doing that makes it more simple."

He describes the example of an owner who wants "the BIM model to represent the locations of all HVAC equipment in the building and have it show all the duct work and wiring that connects everything . Then, when they operate the facility, they see where those things are identified in the model before going to the facility to maintain or work on them."

USING THE STANDARD TO CREATE ALIGNMENT AMONG STAKEHOLDERS
Belkofer says there could always be a discrepancy between two dimensional drawings and the 3-D model representation, so if a contractor is not carefully aligned with the designer who created the drawing, then there will be trouble.

"If the architect, engineer and contractor are not talking about how BIM can drive the collection of asset data early in the project, like during design, then a lot of rework happens to get the model to a place where it can be handed over to the owner for asset management or facility use," says Belkofer. "So having upfront discussions to leverage a standard and set up the models in a way that they can be used downstream, protects against inefficiencies, because there's a lot of rework that happens to a building information model if you're not planning from the beginning to use it for asset management."

David Morales, associate vice president and BIM manager with engineering and technical services firm Salas O'Brien, says his company uses the NBIMS 4.0 standard to guide its execution planning as it provides more clarity across stakeholders.

"This version of the Standard is very modular. It allows teams to use what is needed for the particular project or specific needs of a client," says Morales. "We use it because we are committed to structuring project data with the end in mind, whether it's for better operations from day-to-day or in the long-term of the facility. It facilitates coordination and clear exchanges of information between stakeholders."

He likes that there is a section for owners in the standard. "If we have better definition from an owner's perspective of what the end-use is going to be and how they are going to manage the facility, then the design team and construction team can work together in that framework to deliver the project effectively and with the end in mind," he says.

Data-Centric Policies and Practices

Automated Performance Management Tracking

One advantage of having standardized data across an owner organization is that it can support automated performance management tracking. Owners were asked whether they track performance management, and if so, to what degree that process is automated. As the chart below reveals, currently most owners track performance management, but very few can currently automate the majority of that work.

- 86% of owners track performance management, with no significant differences by the type or size of the organization.

- However, the majority of owners (70%) also rely on manual methods for at least some of this work, with only 16% who have this process largely automated. Again, neither the size nor the type of owner organization makes a meaningful difference in the use of manual methods for this function.

Automating these processes will make them more reliable and will free up time for staff members to focus on improving their organizations based on the analysis provided by the tracking rather than on gathering and analyzing the data.

Owner Organizations That Track Performance Management
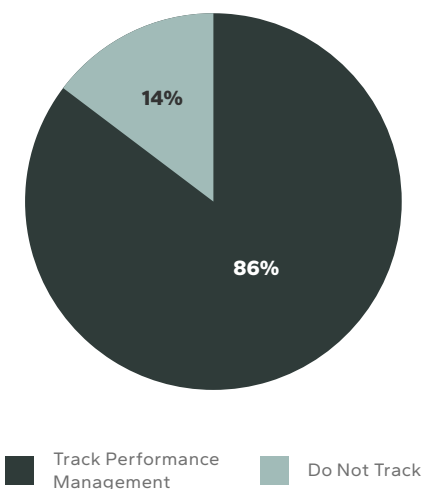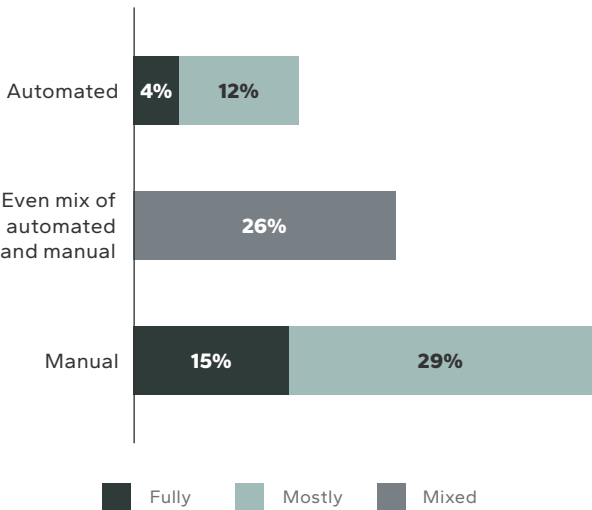
14%

86%

■ Track Performance Management   ■ Do Not Track

Level of Automation

Automated   4%   12%

Even mix of automated and manual   26%

Manual   15%   29%

■ Fully   ■ Mostly   ■ Mixed

Data-Centric Policies and Practices

Data Quality

A high level of data quality is essential to be able to automate various processes, conduct high-level analytics and utilize data more effectively across an owner organization. A data-centric organization needs to have quality assurance processes in place, typically including those that involve metrics that can document how well data deliverables conform to standards and policies. This can include data deliverables from internal organizations and from project teams.

Owners were asked how frequently they have implemented these quality assurance processes by the share of projects on which they have been implemented. The responses reveal that this is yet another area where owners seem to be in the midst of a transition to becoming more data-centric organizations, since they are relatively evenly split between those who frequently implement these quality assurance processes and those who do so less frequently or not at all.

- 53% of owners have implemented these processes on 50% or more of their projects.
  - > 32% of very large owners implement these processes on all of their projects, far more than large (5%), midsize (6%) or small owners (12%).

- 47% have either implemented them on fewer processes, not implemented them at all or are unsure whether their organization has implemented them.
  - > Notably, almost half of those who fall in the less engaged group are implementing these processes, even if they do not do so on the majority of their projects. This indicates a relatively high level of familiarity with these processes and suggests that owners may be on the tipping point of utilizing these processes more broadly.

Frequency of Implementing a Quality Assurance Process and Metrics to Document Conformance to Standards and Policies
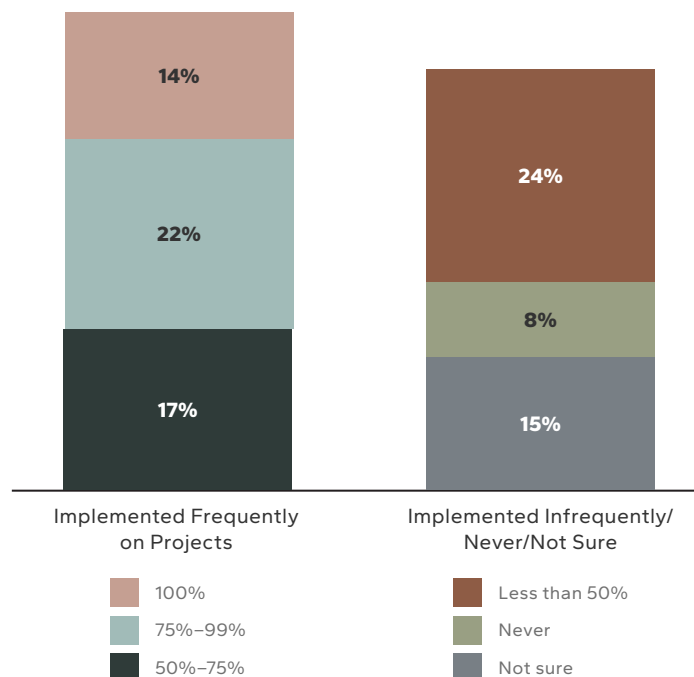
Implemented Frequently on Projects
- 100% — 14%
- 75%–99% — 22%
- 50%–75% — 17%

Implemented Infrequently/ Never/Not Sure
- Less than 50% — 24%
- Never — 8%
- Not sure — 15%

Data-Centric Policies and Practices

Updating Data Standards to Conform to Metrics and New Technologies

Data-centric organizations recognize that data standards must be actively managed—not set once and forgotten—due to evolving technologies, uses, integrations and partners.

Respondents were asked how often their organization updates its data standards based on conformance to metrics and new technologies.

- 61% report doing so at least occasionally, demonstrating a widespread awareness that data standards need to be considered and updated after they are initially launched.
  - **> Variation By Type of Organization:** This level of engagement is highest among local governments, with 73% reporting at least occasional updates, and lowest at public/private institutions, where only 46% are at least occasionally updating their data standards. However, that low level of engagement at public/private institutions may

be driven by the very high share of those who are not sure about the frequency with which these standards are updated (35%).
  - **> Variation By Size of Organization:** Interestingly, this level of updating is more common at small organizations (70%) than large ones (56%). This may suggest that small organizations that are committed to data-centric practices may be more nimble and able to make changes and adapt than are larger institutions.

- 38% of owners are either not sure what their organization is doing, or report that it never or rarely updates its data standards, revealing a clear opportunity for improvement in the industry.

- Again, these findings confirm that owners in the US overall are still in the midst of transforming their organizations to be more data-centric.

Frequency of Updating Data Standards Based on Conformance to Metrics and New Technologies
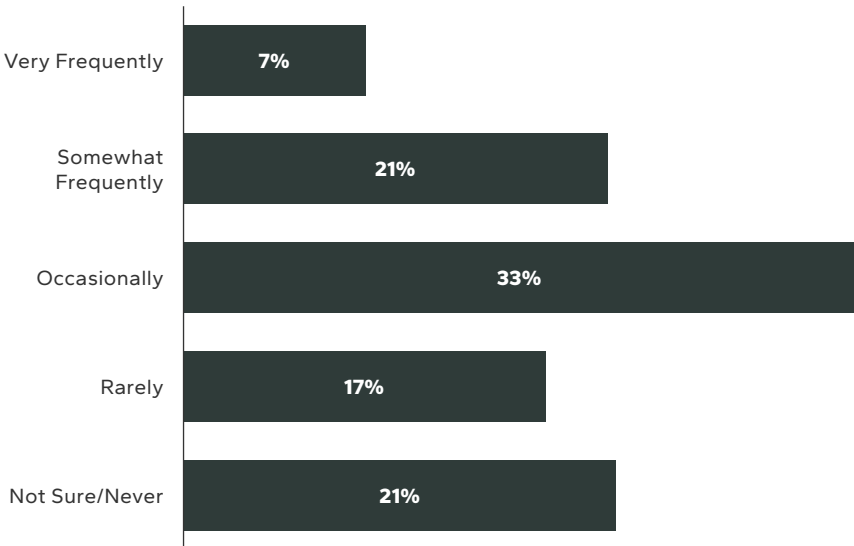
Category	Percentage
Very Frequently	7%
Somewhat Frequently	21%
Occasionally	33%
Rarely	17%
Not Sure/Never	21%

Data-Centric Policies and Practices

Data-Centric Engagement Index

As the findings in this section reveal, the owners surveyed have different levels of engagement with various data-centric policies, requirements and practices. To capture those differences and understand how they impact owners' use of technology and the benefits they gain from that use, the responses to the questions in this section were used to create a Data-Centric Engagement index.

- Response options were assigned a point value.
  - > Use of specific policies, requirements and practices were each assigned one point.
  - > Questions about the frequency with which specific approaches are applied were assigned ascending points from 1 for low frequency to 4 for high levels of frequency.

- The scale was created based on the share of total points assigned:
  - > **Limited Data-Centric Engagement (40% of Owners):** Less than 25% of the total possible points.
  - > **Moderate Data-Centric Engagement (37% of Owners):** 25% to 49% of the total possible points.
  - > **High Data-Centric Engagement (23% of Owners):** 50% or more of the total possible points.

Only 3% of the owners have 75% or more of the total possible points. They are currently included in the total of high data-centric engagement, but in the future, if more owners adopt these approaches, the scale could be expanded to include a very highly data-centric category.

The overall distribution of owners across this spectrum suggests that owners in the US as a whole are in the process of transitioning to more data-centric approaches. While the largest share (40%) fall in the lowest category, nearly as many (37%) are in the moderate category. And, while the share who are highly engaged (23%) is smaller than the other two groups, it is also large enough to show that a deep commitment to data-centric approaches is already occurring.

VARIATION BY TYPE OF ORGANIZATION

Not all types of owners, though, are distributed in this way across the spectrum.

- Over 60% of local government and private/commercial organizations have moderate to high data-centric engagement.

- In contrast, the public/private institutions and state/federal government agencies are more evenly split between a limited level of engagement and a moderate or higher level.

Owner Engagement With Data-Centric Approaches
(TOTAL AND BY TYPE OF ORGANIZATION)
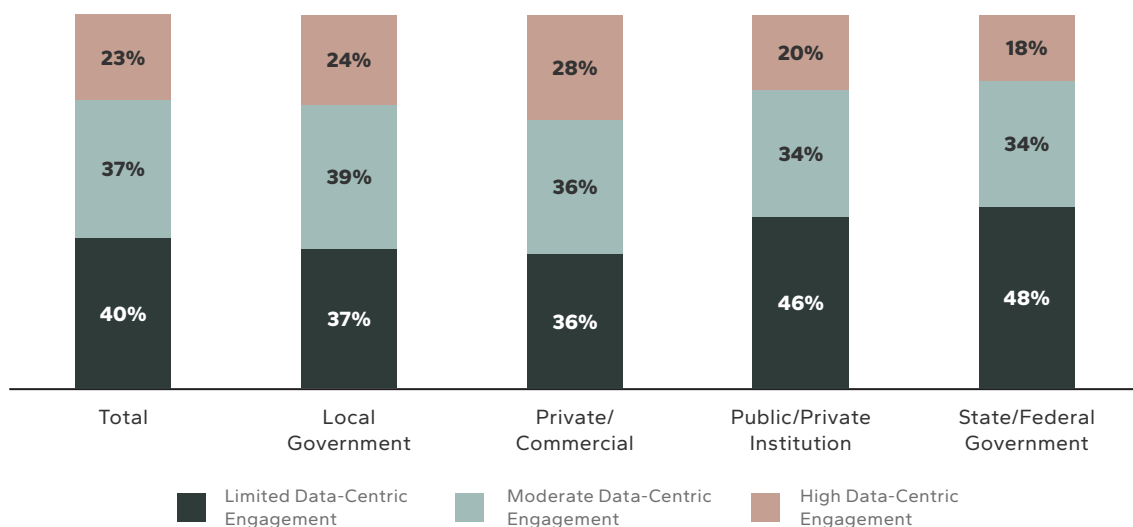
	Total	Local Government	Private/ Commercial	Public/Private Institution	State/Federal Government
High Data-Centric Engagement	23%	24%	28%	20%	18%
Moderate Data-Centric Engagement	37%	39%	36%	34%	34%
Limited Data-Centric Engagement	40%	37%	36%	46%	48%

Legend:
- Limited Data-Centric Engagement
- Moderate Data-Centric Engagement
- High Data-Centric Engagement

Data-Centric Policies and Practices

Data-Centric Engagement Index CONTINUED

VARIATION BY SIZE OF ORGANIZATION

Size appears to be more consequential than type of organization in determining how data-centric an owner is likely to be. However, unlike the level of engagement with technology, which steadily increases as the size of the organization increases (see page 46 for more details), the degree to which owners are engaged with data-centric approaches is somewhat more variable.

- Organizations with revenues of less than $50M have a much higher share with limited data-centric engagement than larger companies. However, the smallest ones with less than $25M in projects annually are actually slightly more data-centric than those that are slightly larger.

- A larger share of organizations with revenues of $100M or more are highly data-centric than smaller companies, but the largest companies with $500M or more in annual projects also have a large percentage (39%) who fall into the limited category.

Certainly, these findings suggest that owners with more resources and more investment in technology are more able and interested in implementing a broad array of data-centric approaches. However, they also suggest that size alone is not necessarily the chief determinant of engagement. It may actually be the case that some smaller owners can be more agile in their adoption of certain approaches.

Taken as a whole, these findings suggest that even the smallest owner organizations can engage with many of these data-centric approaches and policies, and many of the largest ones still need to actively consider how they manage and use data.

Owner Engagement With Data-Centric Approaches
(BY SIZE OF ORGANIZATION)

	Less Than $25M	$25M to LT $50M	$50M to LT $100M	$100M to LT $500M	$500M+
High Data-Centric Approach	14%	7%	24%	36%	27%
Moderate Data-Centric Approach	46%	36%	29%	36%	34%
Limited Data-Centric Approach	40%	57%	48%	28%	39%

■ Limited Data-Centric Approach   ■ Moderate Data-Centric Approach   ■ High Data-Centric Approach
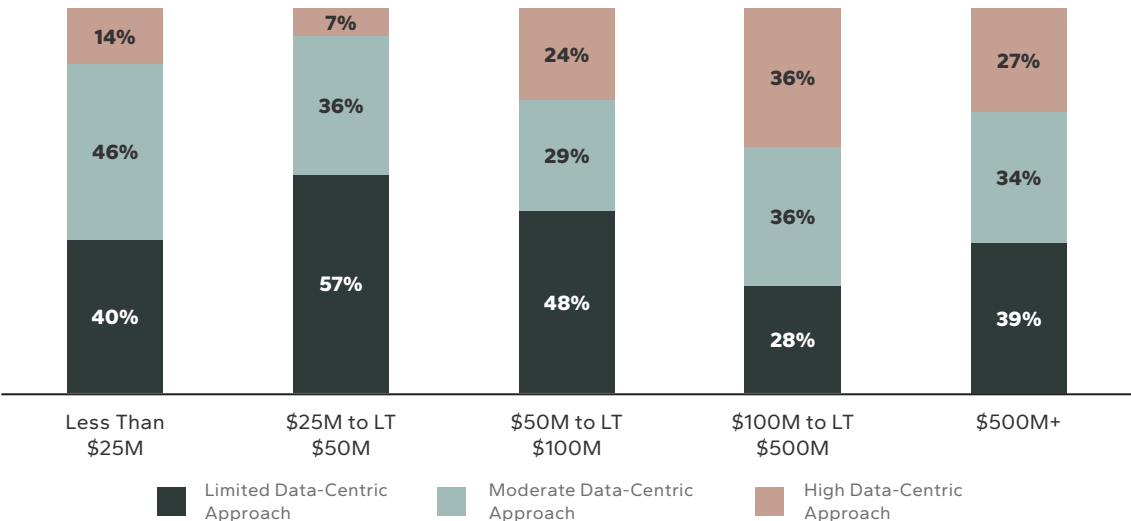
Effective Data Management
Aligns With Lean

Effective data management aligns, to varying degrees, with all of the six key principles that inform the work of becoming a Lean enterprise, but for three of these principles—continuous improvement, waste reduction and respect for people—it is especially strong.

CONTINUOUS IMPROVEMENT

For the past 11 years, Lean construction principles and practices have framed the capital projects of the Massachusetts Port Authority (Massport). Luciana Burdi, chief infrastructure officer at Massport, credits Lean with such successes as enabling an airport terminal expansion to recover from a three-month delay and open on time. She sees validation of Lean in contractors continuing to apply it even after they have gone on to work for clients who are not mandating it. And she is continuing to work toward an organization-wide adoption of Lean principles at Massport. Throughout, she says, "data management is critical."

For each project, Massport develops a dashboard to track such metrics as percent plan complete, decisions needed and decision-required dates, as well as key performance indicators (KPIs) such as schedule and cost. Over the course of construction, project teams conduct iterative retrospectives based on the dashboard data, applying learnings for real-time improvement. "End-of-project retrospectives are too late to drive change in the project itself," Burdi says. "When done regularly, and we try to do them every three months, they become a powerful (Lean) tool for continuous learning and smarter project delivery." She adds that the consistency of Massport's project typologies—terminals, runways, ports—means that project learnings are highly transferable: Managing data to facilitate tracking across projects has enabled the organization to envision and forecast more effectively.

WASTE REDUCTION

A corollary of the use of data to inform continuous improvement is the need to reduce waste. Cultural change, focused on understanding the purpose and "customers" of data rather than implementing technology for its own sake, is essential. "Oftentimes, we collect data just because we collect data," Burdi says. "That is really no reason." Instead, Lean data management starts with a kind of pull planning to identify the information's purpose: Who will use this data? What decisions will it inform? What actions will it enable? How will it be updated? What do we want to learn, and what are the processes by which it's going to lead to learning and improvement?

Crucially, the data must be trustworthy; otherwise, it becomes a type of waste: If teams don't trust the data, don't understand how to use it, or aren't engaged in the learning process, it won't drive change. Central to data's reliability is standardization. Massport, for example, spent months porting legacy data from its infrastructure condition assessment, scrutinizing and scrubbing the data before integrating it into a new dashboard. "Even simply naming the same things the same way across projects allows whatever we are doing on project A to impact project B as well," Burdi says. "We should not underestimate the data normalization effort that needs to happen."

RESPECT FOR PEOPLE

Yet standardization, so crucial to the reliability of data, can encounter resistance if the people responsible for implementing standard protocols feel that those protocols are boxing them in. In practice, however, standardization can be liberating, and that is something worth making an effort to communicate. If a team understands the standard way to store, label, index and apply data, "it actually frees you to be more creative, innovative and thought provoking with that data set," says Tammy McConaughy, director of education and certification at the Lean Construction Institute (LCI). "We can have better conversations. We're not re-inventing the wheel every time."

Another way that data management can demonstrate respect for people—as Massport's dashboard example illustrates—is through prioritizing visual communication. Visual management can help make data more accessible and actionable, enhancing communication and decision-making, something that is particularly true in the AEC sector, where large numbers of workers are visually oriented.

Perceiving data as fixed or static, and human factors such as learning and respect as evolutionary, sets up a false dichotomy, McConaughy says. Effective data management in a Lean organization encompasses both the cultural and the technological: the value of tools and dashboards is a function of the behaviors and habits around them.

Use of Digital Technologies

Owner Engagement With Digital Technology

Owners were asked about which digital technologies are used on their projects, and whether they use the technologies themselves or just require the project team to use them. Owners whose organizations do not currently use or require these technologies were also asked if they plan to adopt them in the next two years.

The charts on this page and the next show the overall level of use of each of these technologies on their projects and the degree of owner engagement with each technology (used, required or both).

OWNER USE OF BIM AND CAD
OVERALL USE ON PROJECTS
Nearly all of the owners (86%) report that CAD is still used on their projects, more than those who report the use of BIM (62%). However, that gap is likely to narrow, since the growth in owners using CAD on their projects is only 3%, while four times as many (12%) expect to begin using BIM on their projects in the next three years.

USE/OWN A LICENSE VERSUS MANDATE
As the chart on page 34 reveals, the biggest difference between the use of CAD and BIM is that more owners own a license for CAD software and use it themselves, without also mandating its use on their projects. In contrast, more owners require the use of BIM on their projects yet are not using this software internally themselves. It will be interesting to see if the expected

growth in the use of BIM on their projects translates into more owners with licenses for BIM and using it themselves versus just requiring BIM on their projects. Either way, it will further cement the use of BIM in design and construction in the US.

- **Variation by Size of Organization**
  - > 66% of very large organizations own/use BIM at their organizations, far more than any smaller organizations, including large ones (41%), midsize ones (24%) and small ones (21%).
  - > In contrast, while 84% of very large owners also own/use CAD, there is far less difference between them, and large (72%) or midsize (71%) owners. The only sizable difference in ownership/use is with small owners (55%).

- **Variation by Type of Organization:** Only 24% of owners from local government own/use BIM directly, versus 49% of both private, commercial owners and public/private institutions. On the other hand, CAD ownership/direct use is relatively common across all types of organizations.

OWNER USE OF GIS
GIS is one of the top three most widely used technologies on owner's projects, and it is one that they tend to use themselves, with 57% reporting that their organization owns a license for it. In fact, its use is

Current and Future Owner Engagement With Digital Tools

	BIM	CAD	GIS	Reality Capture	Project Management Software	Asset Management Software	Digital Twins	AI/Machine Learning
Plan to Adopt	12%	3%	4%	9%	12%	5%	10%	16%
Use or Mandate	62%	86%	72%	51%	80%	70%	18%	28%

Use or Mandate Currently   Plan to Adopt in the Next Two Years
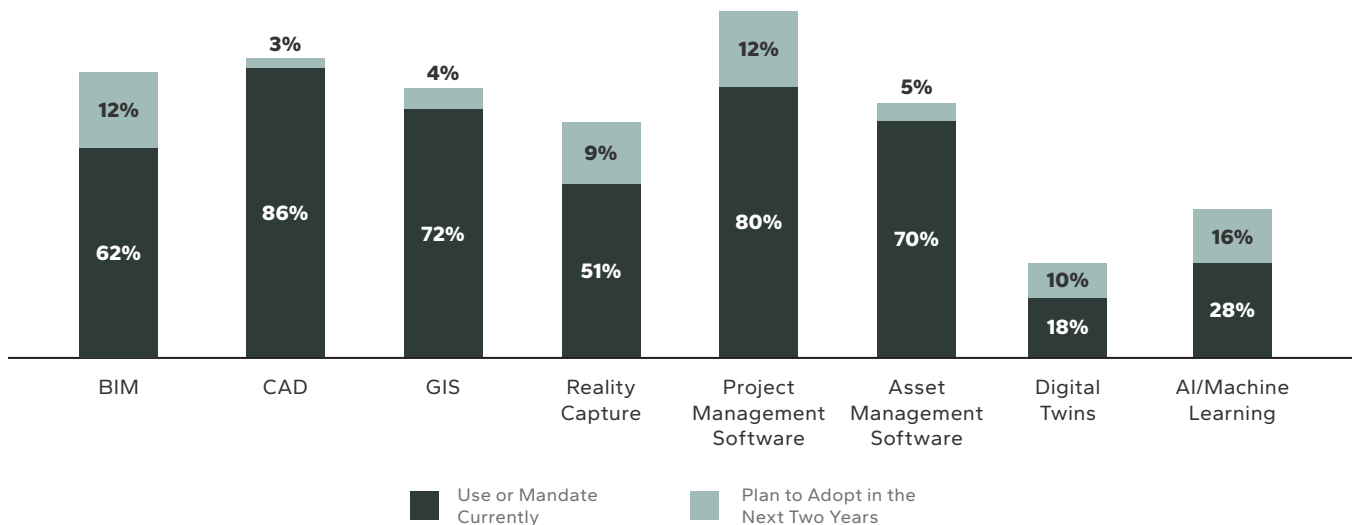
Use of Digital Technologies

Owner Engagement With Digital Technology CONTINUED

more concentrated within their organizations than the use of CAD or BIM, with only 23% mandating its use on projects, compared with 36% for BIM and 39% for CAD.

- **Variation by Size of Organization:** Two thirds (66%) of large/very large owners use GIS directly, compared with 49% of midsize and 43% of small owners.

- **Variation by Type of Organization:** Public or public/private owners (66%) use GIS themselves more frequently than private, commercial owners (33%) . Public owners may need to have more data on existing populations to make decisions on projects than do private companies.

OWNER USE OF REALITY CAPTURE TECHNOLOGIES

Reality capture technologies can take a variety of forms. The survey included examples like Lidar, laser scanning, photogrammetry, machine control and sensors when asking owners to identify whether this type of technology is used on their projects.

Currently, the use of reality capture software lags considerably behind the use of CAD, BIM or GIS. Only 51% currently report that their organization uses it directly or mandates it. An additional 9% expect to use it in the next two years, which will not narrow the gap

in owner use with other, more prevalent digital tools. Responses are nearly evenly split between those who own these tools but do not mandate them (24%) and those who mandate them but do not own them (20%). Only a small share (7%) do both. This lack of consistency suggests that different owners have very different goals for the use of these tools on their projects.

- **Variation by Size of Organization:** 55% of very large owners directly own, license and use reality capture tools, far more than large (33%), midsize (22%) or small (14%) ones. Mandates are equally common to all sizes of owners.

- **Variation by Type of Organization:** Nearly half of state and federal agencies (48%) directly own/use reality capture tools, but very few local government owners (19%) do so.

OWNER USE OF PROJECT MANAGEMENT AND ASSET MANAGEMENT SOFTWARE
OVERALL USE ON PROJECTS

Project management and asset management software are both in wide use on owners' projects: 80% and 70%, respectively, report using them. The percentage using asset management software may be even higher, since the question asked specifically about the use of this software on projects.

Owner Type of Engagement With Digital Tools

	Own a License/ Use Software	Mandate Use on Our Projects	Own/Use and Mandate on Projects
BIM (TOTAL 62%)	26%	23%	13%
CAD (TOTAL 85%)	46%	15%	24%
GIS (TOTAL 72%)	49%	15%	8%
Reality Capture (TOTAL 51%)	24%	20%	7%
Project Management Software (TOTAL 80%)	43%	15%	22%
Asset Management Software (TOTAL 70%)	54%	7%	9%
Digital Twins (TOTAL 18%)	11%	4%	3%
AI/Machine Learning (TOTAL 28%)	21%	5%	2%
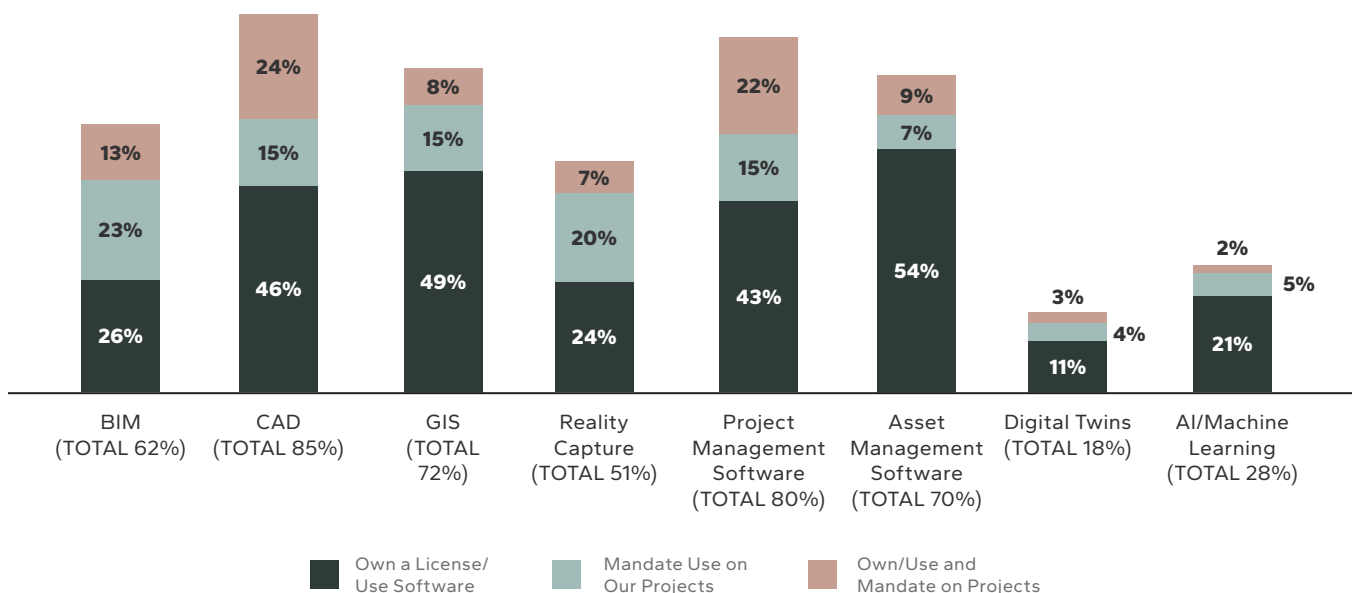
Use of Digital Technologies

Owner Engagement With Digital Technology CONTINUED

USE/OWN A LICENSE VERSUS MANDATE

Nearly the same share of owners report that they own a license or directly use their project management (65%) and asset management (63%) software. Far more mandate that their project teams use project management software (37%) than asset management software (16%). However, even though the percentage is small, the key takeaway here may be that some owners are requiring that their project team use asset management software at all, since it is more typically utilized by owners.

- **Variation by Size of Organization:** Owning a license for both does vary, somewhat predictably, by size, especially for project management software. Only 43% of small owners directly own/use that software, compared with 63% of midsize owners and 77% of large/very large ones. 55% of small and midsize owners own asset management software, compared with 72% of large/very large ones.

- **Variation by Type of Organization:** Private, commercial owners most frequently own/directly use project management software (73%), but there is no significant difference by type of owner in the ownership of asset management software.

OWNER USE OF DIGITAL TWINS AND AI

AI is quickly becoming well-established at owner organizations, with 28% reporting use now and 16% expecting to use it in the next two years.

Digital twins involve a high degree of integration between disparate technologies, so it is not surprising that their current use is lower than that of AI and the share expecting to adopt in the future is smaller as well.

As the chart on page 34 reveals, more owners currently own and/or directly use these technologies than require their use by companies on their project teams.

- **Variation by Size of Organization:** Very large owners lead the way in the ownership and direct use of these technologies, with 30% using digital twins and 36% using AI.

- **Variation by Type of Organization:** While there are no notable differences for digital twins, private,commercial owners (33%) are the biggest investors in AI/machine learning.

DATA-CENTRIC ENGAGEMENT

As the chart below reveals, owner organizations that are better equipped to manage data also invest far more in digital technologies than do those that are less data-centric, and high and moderate data-centric organizations mandate its use more frequently than smaller ones do.

This finding suggests that access to reliable, consistent data is easier if you own the technology generating that data, and it also suggests that having good, reliable, consistent data can help owners derive greater value from their technology investments.

Use or Require Use of Technology (By Level of Data Centric Engagement)

High Data-Centric Engagement: 59%, 31%
Moderate Data-Centric Engagement: 43%, 28%
Low Data-Centric Engagement: 39%, 17%

Legend:
- Average That Own/Use Software
- Average That Mandate Use by Their Project Teams
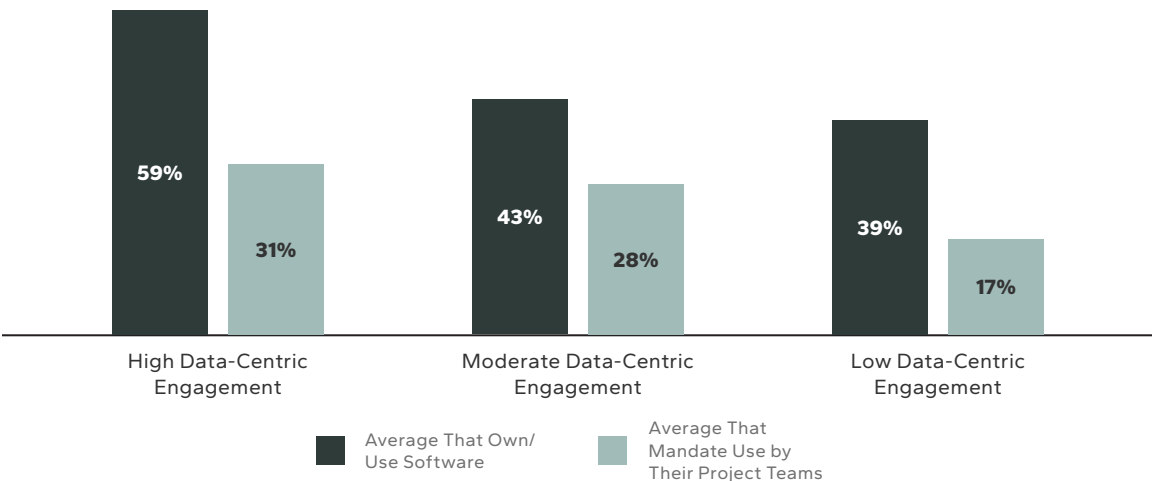
Use of Digital Technologies

Use of Digital Technology by Phase in the Asset Lifecycle

The digital technologies discussed on pages 33–35 can be used for other phases throughout the lifecycle of an asset than design and construction, including capital planning, commissioning, operations and asset management, and decommissioning. Owners were asked which technologies they currently use in each phase, and for which phases they plan to make new technology investments in the next two years.

TOP PHASES FOR DEPLOYMENT OF DIGITAL TECHNOLOGIES
PROJECT DESIGN AND CONSTRUCTION

Not surprisingly, project design is the top phase in which these technologies are used, followed closely by project construction.

- Most of the digital tools are more widely used in design than construction, including GIS, reality capture, and AI/machine learning. A relatively high share of those using digital twins (42%) also report doing so in the project design phase.

- Project management software is the only digital tool used more widely in the construction phase than in design. The majority of those using BIM (75%), GIS (50%) and reality capture (63%) do so during the construction phase.

- Only 10% of state/federal government agencies use asset management software in project design, a far lower share than other types of owners.

CAPITAL PLANNING AND OPERATIONS/ASSET MANAGEMENT

There is also a relatively high level of use of these technologies in capital planning and operations/asset management phase.

- Access to data for capital planning is likely a major driver of technology use during this phase, with 63% of owners using GIS, 53% using project management software and 50% using asset management software. The data provided by these tools can help them make planning decisions based on data about other assets they own and/or have built, the demographics of the neighborhood in which the project is located, and many other types of information that can inform their planning processes.

- While the use of asset management software is expected during the operational phase, it is notable that more than half of those using GIS (51%) and digital twins (54%) do so during this phase. This demonstrates the importance of these tools in maximizing the performance of an asset in the operational phase.

Use of Digital Technology by Phase in the Asset Lifecycle
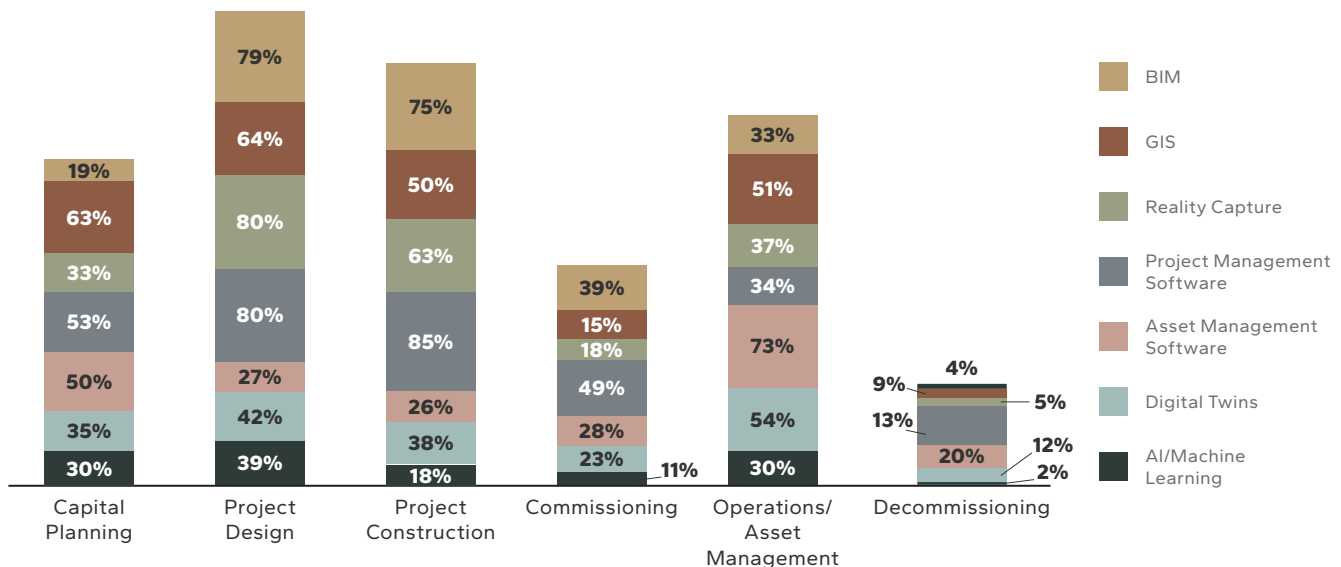
Use of Digital Technologies

Use of Digital Technology by Phase in the Asset Lifecycle CONTINUED

COMMISSIONING AND DECOMMISSIONING
Owners currently are getting the least use out of these digital technologies during the commissioning and decommissioning phases.

- No software is used by more than 50% during commissioning. The most widely used are project management software (49%) and BIM (39%), but the rest of these tools are used by fewer than 30%.

- No more than 20% of any of the users of these digital tools deploy them during the decommissioning phase. In some cases, this may be because owners are still relatively new to using these tools, and they do not have enough usable data on assets they are currently decommissioning. It will likely be several years before use increases considerably for this phase.

PLANNED INVESTMENTS IN TECHNOLOGY BY ASSET LIFECYCLE PHASE
Many owners are planning to invest in technology for several phases across the lifecycle of their assets. The generally high level of interest in making these investments shows how owners are accelerating their engagement in digital project and asset management.

- Between 39% and 49% of owners are planning to invest in technology for capital planning, project design and construction and operations/asset management. Digital technologies are currently most widely deployed in these phases, and many owners clearly see further opportunities to increase the benefits they experience from doing so.

- Size of organization does not have a significant impact on plans for technology adoption during any of these phases.

- Only 21% of state and federal government agencies have plans to invest in technology for capital planning in the next two years, the only type of owner organization under 40% for that phase.

- More than half of highly data-centric owners plan to invest in technology for capital planning (58%), project design (63%) and construction (60%), and especially operations and asset management (74%). These owners get the highest level of benefit from the technologies they deploy (see pages 48 to 58), and clearly, they also see opportunities to increase those benefits from using even more digital technologies.

Owners Planning to Invest in Any Digital Technology for Each Phase in the Next Two Years

Capital Planning	Project Design	Project Construction	Commissioning	Operations/ Asset Management	Decommissioning
39%	44%	49%	15%	45%	3%
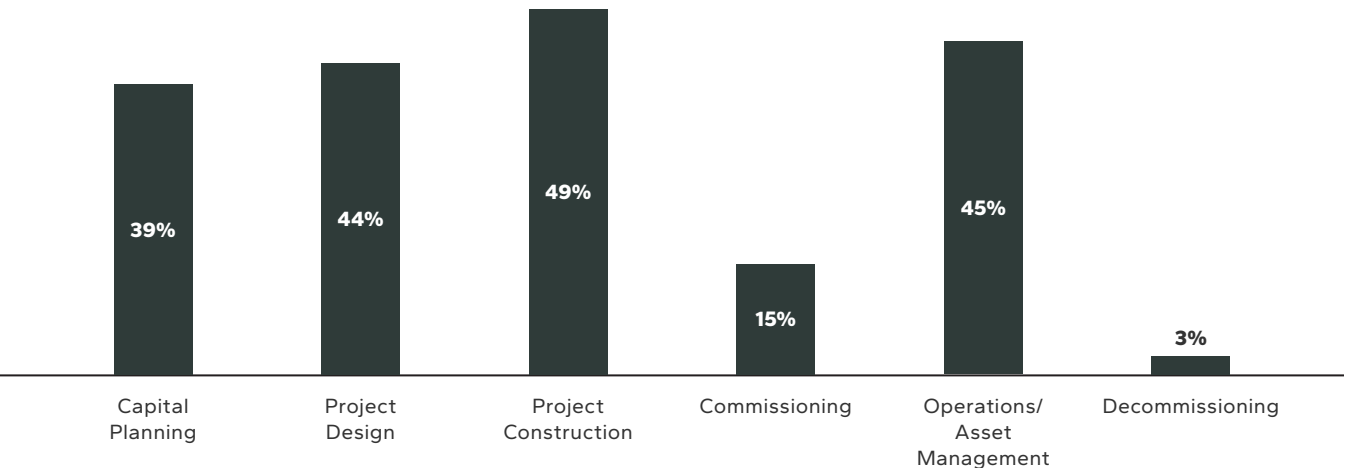
Use of Digital Technologies

Activities Conducted Using Digital Technology and Data

What an owner can do with their digital technologies is more important than the specific technologies used. Therefore, the number of core planning, project, operational and asset management functions for which owners use digital technologies and data reveals more about how far along they are in the process of digital transformation than the type or number of technologies used.

In this study, owners were asked whether they use digital technologies for 16 different functions for planning, design, analysis, construction, and asset management and operations on at least 25% of their projects/assets. The charts on the next three pages reveal the total number of owners using digital technologies for each of these functions and how that correlates to their level of engagement with data-centric practices.

These findings reveal that owner organizations with a high data-centric engagement make more extensive use of digital tools to conduct these core functions, and therefore get the most out of the investments they and their project teams are making in digital technologies.

OVERALL ENGAGEMENT

The total percentage of owners that use digital technologies for each function are shown after the name of each function. These totals reveal that, while many functions are conducted with digital technology and data, fewer than half of owners do so for any one function. Owners are utilizing data and digital technologies, but their use is not yet the status quo for any function included in the survey.

TOP FUNCTIONS CONDUCTED USING DIGITAL TECHNOLOGY AND DATA

In each phase of the asset lifecycle, 40% or more owners use digital technology and data on at least one function for at least one quarter of their projects/assets: production of construction documents in planning and design, create quantities and cost estimates for analysis, coordinating design and construction and layout for construction, and asset management for asset management/operations.

- The functions most commonly conducted digitally are **production of construction documents and**

Use Digital Technology and Data for at Least 25% of Projects: PLANNING AND DESIGN
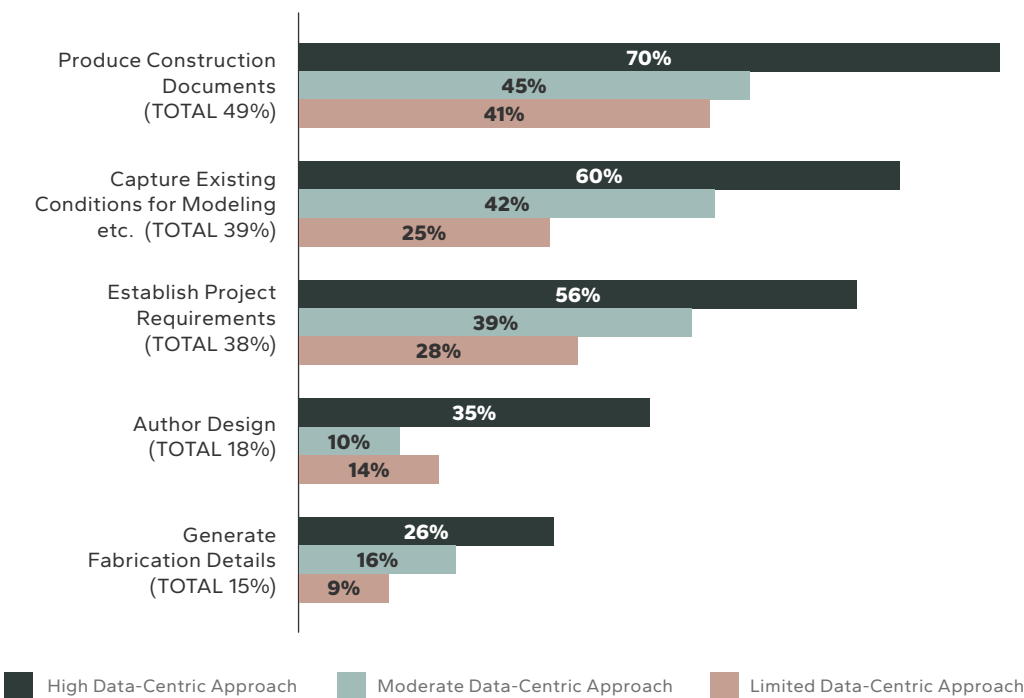
Function	High Data-Centric Approach	Moderate Data-Centric Approach	Limited Data-Centric Approach
Produce Construction Documents (TOTAL 49%)	70%	45%	41%
Capture Existing Conditions for Modeling etc. (TOTAL 39%)	60%	42%	25%
Establish Project Requirements (TOTAL 38%)	56%	39%	28%
Author Design (TOTAL 18%)	35%	10%	14%
Generate Fabrication Details (TOTAL 15%)	26%	16%	9%

■ High Data-Centric Approach   ■ Moderate Data-Centric Approach   ■ Limited Data-Centric Approach

Use of Digital Technologies

Activities Conducted Using Digital Technology and Data CONTINUED

coordinating design and construction, both reported by 49%.

> At least 70% of highly data-centric owners use digital technologies for these functions.

> The gap between those with moderate and limited data-centric engagement is much wider for coordinating design and construction, which suggests that the owner's digital engagement may be influential in driving the use of digital technology and data for this coordination.

• Owners appear to be less influential in **layout** during construction, since there is less variation by data-centric engagement than for the other functions for which digital tools are widely used.

• 70% of highly data-centric owners use digital technologies and data for **asset management,** which demonstrates the importance of utilizing project data for this activity for these owners.
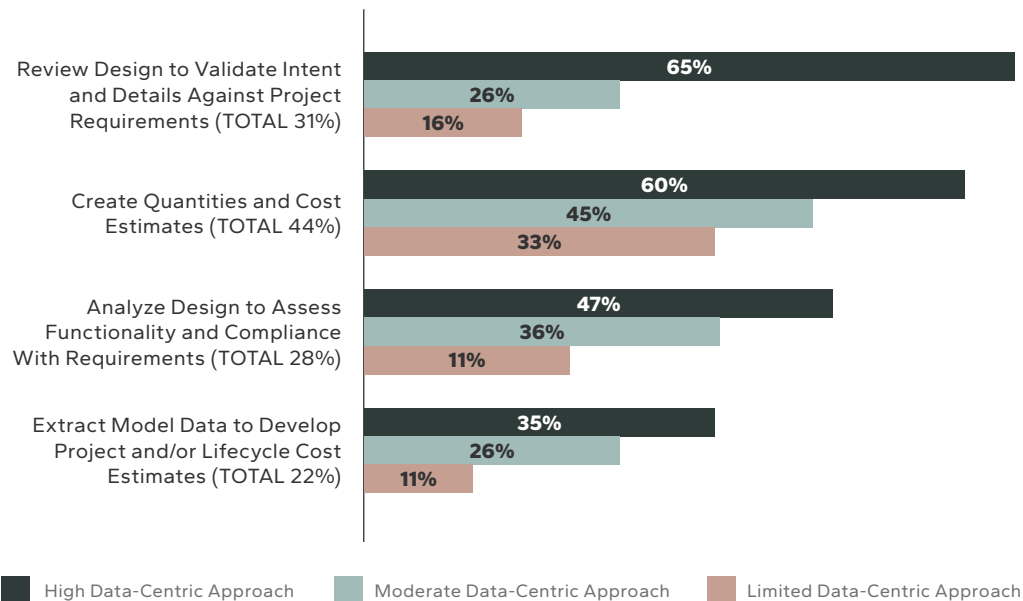
• The level of data-centric engagement also correlates with the degree to which digital tools are used to **create quantities and cost estimates,** but even so, only 60% of highly data-centric owners use technology for this function.

FUNCTIONS CONDUCTED USING DIGITAL TECHNOLOGY AND DATA AT A MODERATE LEVEL

Between 30% and 39% of owners report five functions that utilize digital technology and data: capturing existing conditions for modeling, establishing project requirements, compiling record deliverables at project completion, sequencing construction and reviewing design to validate intent and details against project requirements.

• Data-centric engagement appears to be influential on all of these, since they show a large gap between those with limited and higher level engagement.

• Approximately two-thirds of highly data-centric owners use digital technology to **compile record deliverables at project completion** and **review design to validate intent and details against project requirements. T**heir high level of use is likely influenced by the value of being able to access data that can support their internal analysis, project management and other functions, which they would gain from their use of technology for these functions.

Use Digital Technology and Data for at Least 25% of Projects: DESIGN/MODEL ANALYSIS

Review Design to Validate Intent and Details Against Project Requirements (TOTAL 31%)
- 65%
- 26%
- 16%

Create Quantities and Cost Estimates (TOTAL 44%)
- 60%
- 45%
- 33%

Analyze Design to Assess Functionality and Compliance With Requirements (TOTAL 28%)
- 47%
- 36%
- 11%

Extract Model Data to Develop Project and/or Lifecycle Cost Estimates (TOTAL 22%)
- 35%
- 26%
- 11%

■ High Data-Centric Approach   ■ Moderate Data-Centric Approach   ■ Limited Data-Centric Approach

Use of Digital Technologies

Activities Conducted Using Digital Technology and Data CONTINUED

FUNCTIONS INFREQUENTLY CONDUCTED USING DIGITAL TECHNOLOGY AND DATA
Fewer than 30% of owners have six functions conducted digitally on at least one quarter of their projects: analyze design to assess functionality and compliance with requirements, managing and/or monitoring physical space of built environment assets, extract model data to develop project and/or lifecycle cost, author design, generate fabrication details and author temporary work.

- Fewer than half of even the highly data-centric owners use digital technologies for these, suggesting that they are still emerging in use.

- Highly data-centric owners, though, see technology utilized on their projects for most of these at a much higher level than those with less data-centric engagement.

- Highly data-centric owners least frequently report using digital technology for the **generation of fabrication detail** and **authoring temporary work.** This may be a function of a much lower degree of digital engagement with the trades (see page 23) by owners.

Use Digital Technology and Data for at Least 25% of Projects: CONSTRUCTION

Coordinate Design and Construction (TOTAL 49%)
- 74%
- 55%
- 30%

Compile Record Deliverables at Project Completion (TOTAL 38%)
- 67%
- 35%
- 24%

Layout Construction (TOTAL 46%)
- 56%
- 45%
- 41%

Sequence Construction (TOTAL 32%)
- 49%
- 33%
- 22%

Author Temporary Work (TOTAL 9%)
- 23%
- 4%
- 5%

■ High Data-Centric Approach   ■ Moderate Data-Centric Approach   ■ Limited Data-Centric Approach
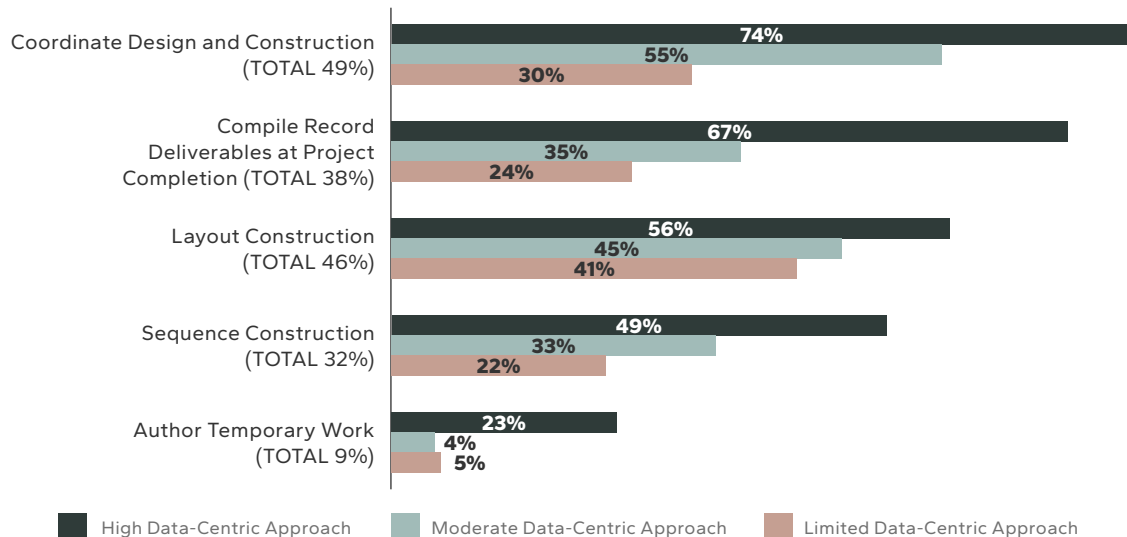
Use Digital Technology and Data for at Least 25% of Projects: ASSET MANAGEMENT/OPERATIONS

Asset Management (TOTAL 41%)
- 70%
- 38%
- 29%

Managing and/or Monitoring Physical Space of Built Environment Assets (TOTAL 24%)
- 47%
- 26%
- 9%

■ High Data-Centric Approach   ■ Moderate Data-Centric Approach   ■ Limited Data-Centric Approach
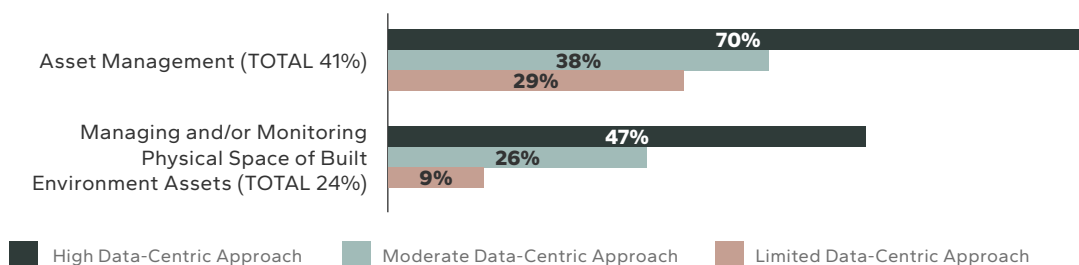
Use of Digital Technologies

Digital Deliverables Required at Project Closeout

Digital as-built data, if provided in a usable format, can help owners in the operations phase of an asset. It can also ultimately assist with future renovations and with planning new projects. That is probably why most owners (76%) require digital as-built data of some sort. However, as noted on page 40, only 38% report that digital technology and data are used to compile record deliverables at project completion to capture work performed and compliance with project requirements.

Surprisingly, there is no variation in overall digital requirements by level of data-centric engagement. This may be because most owners need some legal deliverable, and most are not interested in paper documents. The difference is likely in the degree to which owners can use these deliverables: The data standards and other requirements that highly data-centric owners utilize allow this data be leveraged more effectively across an asset's lifecycle and for an owner's portfolio management.

TYPES OF DIGITAL AS-BUILT DATA REQUIRED
The most common type of as-built data required are digital survey as-builts. Nearly all (83%) owners who require any kind of digital as-built data mandate that they receive this data, although this requirement does vary across different types of owners.

- **Variation by Type of Organization:** Only 45% of the state and federal government agencies have these requirements.

- **Variation by Data-Centric Engagement:** 88% of highly data-centric organizations require this data.

Other types of as-built data are only required by 20% or fewer owners, including Lidar/image as-builts or digital machine control as-builts. Several respondents also mentioned PDF versions of drawings and project plans, models and CAD files, and record documents and pictures. The mixture of static documents like PDFs and project plans with more dynamic, data-rich deliverables like models suggests that data from many digital deliverables that owners receive cannot necessarily be easily ingested into their operations, asset management or future capital planning tools.

Require Digital As-Built Data

24%

76%

■ Require Digital   ■ Do Not Require
As-Built Data   Digital As-Built Data

Type of Digital As-Built Data Required

Digital Survey	63%
Digital Machine Control Data	20%
Lidar/Image	20%
Other	18%

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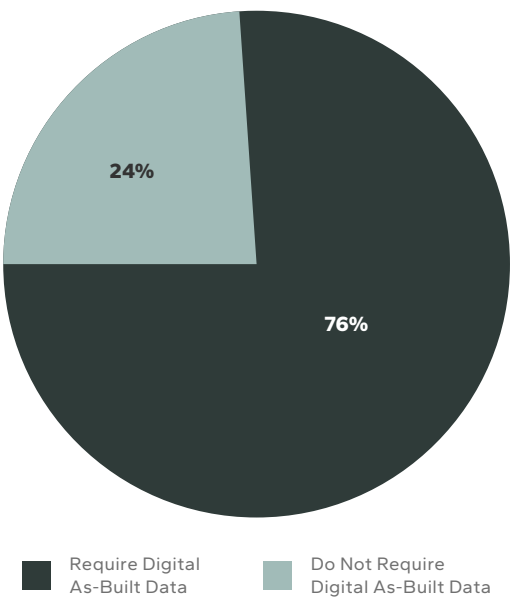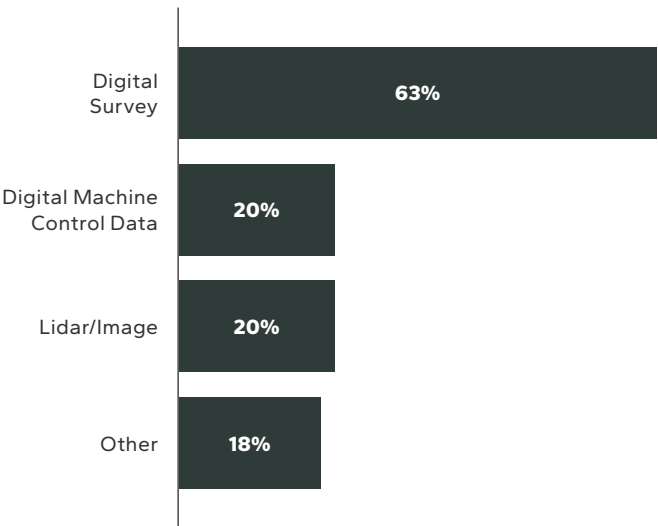
Use of Digital Technologies

Data Utilization From Mandated Technologies

Owners who require their project teams to use specific digital technologies (see page 34) were asked whether they directly use and/or have access to materials created from the data generated by those tools, with the findings shown in the chart below.

- Not surprisingly, most owners find some way to utilize data from the technologies that they require their project teams to use.

- Over half report that their organizations directly use the data themselves that was generated by their project teams' project management software and digital twins.

- Between 30% and 40% directly use the data from all of the other digital tools.

- Over half of respondents rely on materials generated from their project teams' use of reality capture, BIM, CAD and asset management software.

- **Variation by Data-Centric Engagement:** Respondents from highly data-centric organizations directly use data from BIM (50%), GIS (38%) and project management software (89%) more than those from less data-centric organizations.

These findings show that many owners are already able to utilize data directly from many technologies. In addition, the use that owners have for this data is likely to grow in the future as they invest in technology for capital planning and operations (see page 37).

Many owners also clearly want their project team members to generate materials that are useful to them. Companies that can support the owners' need for data and materials generated from that data will be more competitive as the use of digital data becomes more entrenched at owner organizations.

Use or Have Access to Materials Generated From Data From Digital Technologies
(ACCORDING TO OWNERS USING OR MANDATING EACH DIGITAL TECHNOLOGY)

Technology	See Materials Generated by Others But Does Not Utilize Data Directly	Utilizes Data
Project Management Software	30%	67%
Digital Twins	36%	57%
Reality Capture	58%	35%
BIM	51%	40%
CAD	51%	40%
Asset Management Software	53%	37%
GIS	49%	35%
AI/Machine Learning	38%	38%

See Materials Generated by Others But Does Not Utilize Data Directly   Utilizes Data
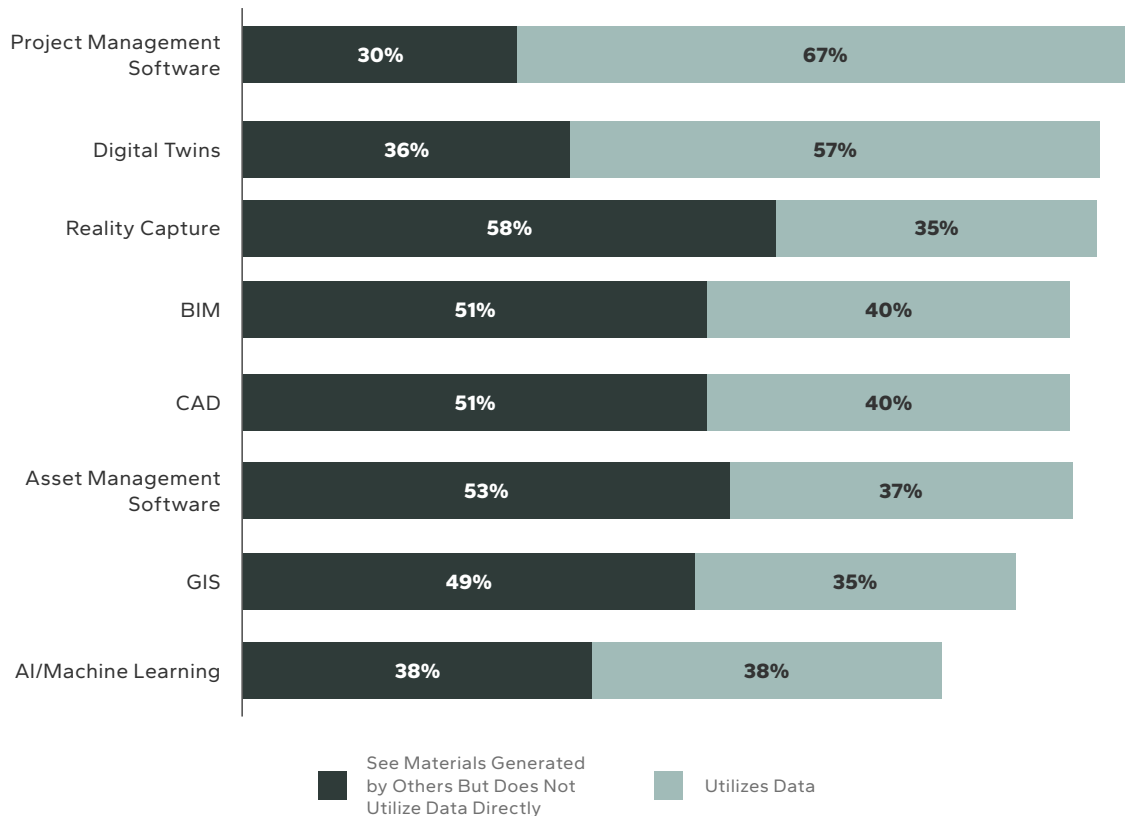
Use of Digital Technologies

Technologies Considered Essential to Owner's Role

Owners whose organizations either use any of the eight digital technologies themselves or mandate their use by their project teams (see page 33) were asked whether they consider any of these technologies to be essential to their role at their organization.

The chart below shows the responses of all the owners using or mandating that particular technology and those from highly data-centric organizations.
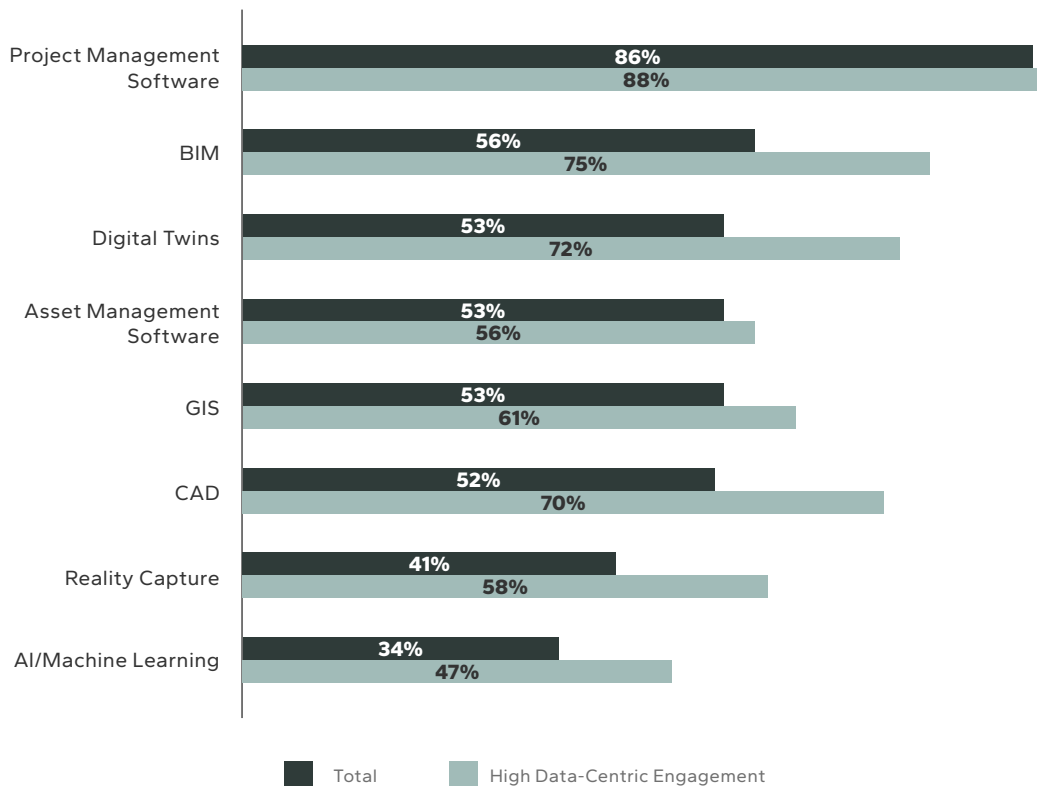
- Nearly all respondents who use project management software consider it essential, with little difference in the responses of those from highly data-centric organizations. Since this is software widely used by the owners themselves (see page 34), they do not necessarily need to be highly data-centric to see its value.

- The same is likely true for asset management software, which also has no significant difference in importance between highly and less data-centric organizations.

- Highly data-centric owners find more of the other technologies vital to what they do than those from less data-centric organizations.
  - > 70% or more of the data-centric owners who use/mandate these technologies consider BIM, digital twins and CAD essential to their roles. These technologies allow them to engage more effectively with their project teams in managing the design and quality of their projects.
  - > Highly data-centric owners also consider GIS, reality capture and AI/machine learning essential to their roles more frequently than do those whose organizations are less data-centric. GIS and reality capture both provide data that can be critically important to capital planning and operations, while AI helps organizations analyze and benefit from data from other technologies.

Consider Specific Digital Tools to Be Essential to Their Role
(ACCORDING TO OWNERS USING OR MANDATING EACH DIGITAL TECHNOLOGY)

Technology	Total	High Data-Centric Engagement
Project Management Software	86%	88%
BIM	56%	75%
Digital Twins	53%	72%
Asset Management Software	53%	56%
GIS	53%	61%
CAD	52%	70%
Reality Capture	41%	58%
AI/Machine Learning	34%	47%

Legend: ■ Total ■ High Data-Centric Engagement

Use of Digital Technologies

Use of Artificial Intelligence With Digital Technologies

Owners who directly use any of the seven digital technologies included in the study were asked whether those tools employ artificial intelligence (AI). Their responses are shown in the pie chart below.

Only 19% report that the tools they use deploy AI. This may not be an accurate portrayal of how frequently these tools use AI, though, since many respondents say they don't know. It is likely that in many cases AI is embedded in the functionality of some of the digital technologies they use.

- **Variation by Data-Centric Engagement:** 33% of owners with highly data-centric organizations report that at least one of the technologies they use has AI functionality. Even the 26% of those from moderately data-centric organizations exceeds the average. This difference could be influenced by a few factors.
  - > Data-centric owners may be actively seeking digital tools that include AI.
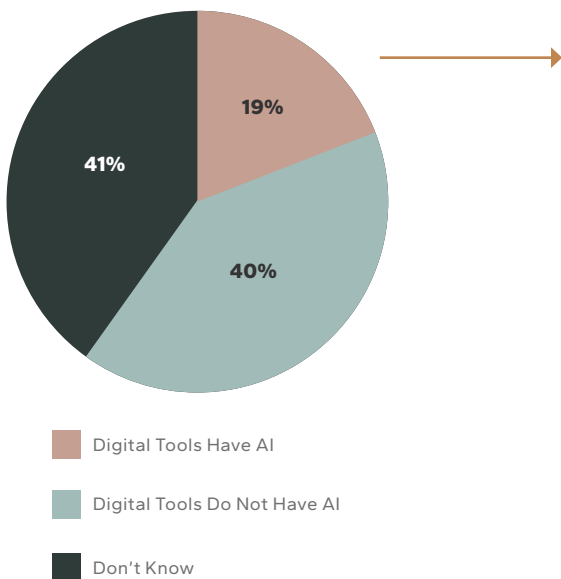
- > They may also be able to better utilize the AI functionality available in their existing digital technologies because their data standards and requirements create more usable data for the AI engines.
- > The increased engagement with data could contribute to a higher awareness of how that data is utilized by their tools, making them more aware of their AI functionality.

CURRENT AND FUTURE USE OF AI IN DIGITAL TECHNOLOGIES

AI use is currently reported most frequently for digital twins and reality capture, but it is not highly prevalent even among users of those two technologies.

Encouragingly, the findings reveal that owners are very interested in using AI in the future with most of these technologies, especially project management software, digital twins, BIM and asset management software.

Utilize Digital Tools With AI on Their Projects
(ACCORDING TO OWNERS USING OR MANDATING AT LEAST ONE DIGITAL TECHNOLOGY)

- Digital Tools Have AI — 19%
- Digital Tools Do Not Have AI — 40%
- Don't Know — 41%

Specific Digital Tools and AI
(ACCORDING TO OWNERS USING EACH TECHNOLOGY CURRENTLY)

Technology	Believe Current Tools Use AI	Interested in Seeking Tools Augmented With AI in the Next Three Years
Digital Twins	24%	58%
Reality Capture	12%	42%
Project Management Software	10%	57%
GIS	10%	36%
Asset Management Software	9%	49%
BIM	8%	49%
CAD	6%	29%

- Believe Current Tools Use AI
- Interested in Seeking Tools Augmented With AI in the Next Three Years
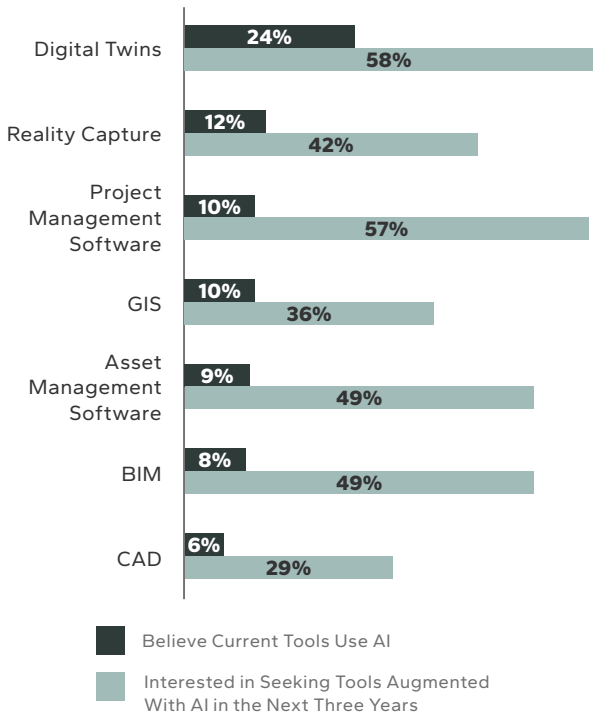
Use of Digital Technologies

Technology Engagement Index

The findings in this report establish that owner organizations that create policies, practices and mandates to ensure high quality data get more out of the technologies that they invest in. However, adopting multiple technologies also has advantages: Organizations that are highly engaged with digital technologies are likely to have good access to the data they need to effectively manage projects and portfolios.

To confirm this premise, the owners who participated in the study are also organized into three groups in a tiered technology engagement index: low, moderate and high.

WHAT IS INCLUDED IN THE TECHNOLOGY ENGAGEMENT INDEX
Three data elements are converted into points, which are used to calculate the technology engagement index.

- Their use and mandating of digital technologies (see page 34)

  > One point for every technology that they require their project teams to use.

  > Two points for every technology that they license or use themselves.

- The intensity of their use of data generated by these technologies (see page 42)

  > One point if they see materials that others generate.

  > Two points if they directly utilize the data.

  > Three points if they do both.

- Activities conducted using digital technology and data (see pages 38 to 40)

  > One point for each activity conducted digitally on at least 25% of their projects.

Their score is then calculated based on the total share of available points, with identical ranges to the data-centric index.

- Low (37%): Less than 25% of available points.

- Moderate (50%): 25% to 49% of available points.

- High (13%): 50% or more of available points.

The distribution suggests that the owners' technology use is slightly more mature than their use of data-centric approaches, with the highest percentage falling in the moderate range. However, with only 13% in the

Owner Engagement With Digital Technology
(TOTAL AND BY TYPE OF ORGANIZATION)

	Total	Local Government	Private/ Commercial	Public/ Private Institution	State/Federal Government
High Tech Engagement	13%	11%	22%	9%	9%
Moderate Tech Engagement	50%	48%	40%	60%	58%
Low Tech Engagement	37%	40%	38%	31%	33%

Legend: ■ Low Tech Engagement ■ Moderate Tech Engagement ■ High Tech Engagement
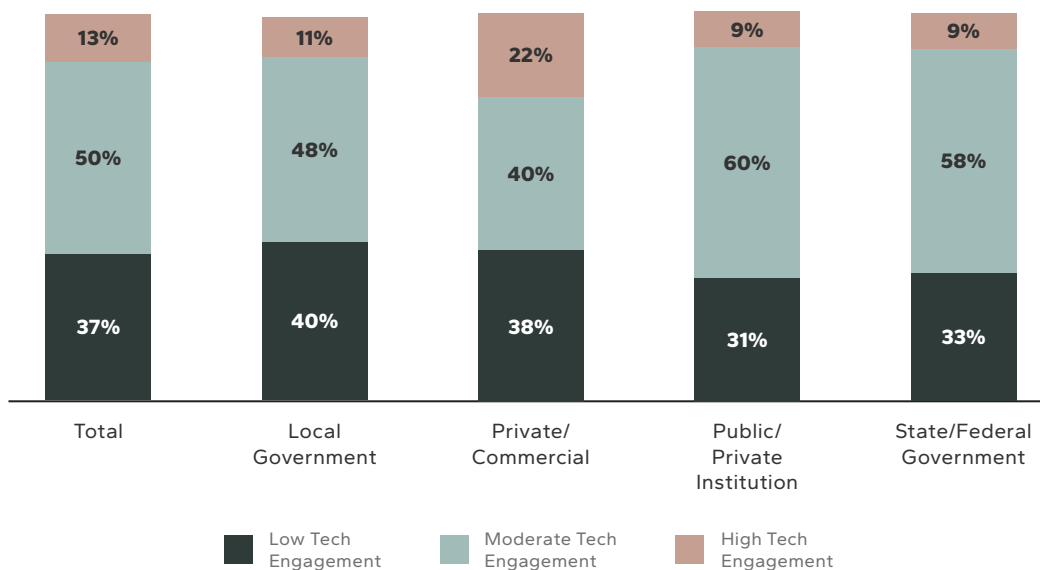
Use of Digital Technologies

Technology Engagement Index CONTINUED

high range, it is also very clear that most owners still do not fully utilize the technologies available to them.

TECHNOLOGY ENGAGEMENT BY TYPE OF ORGANIZATION

The chart at the bottom of the previous page shows the level of technology engagement by the type of organization.
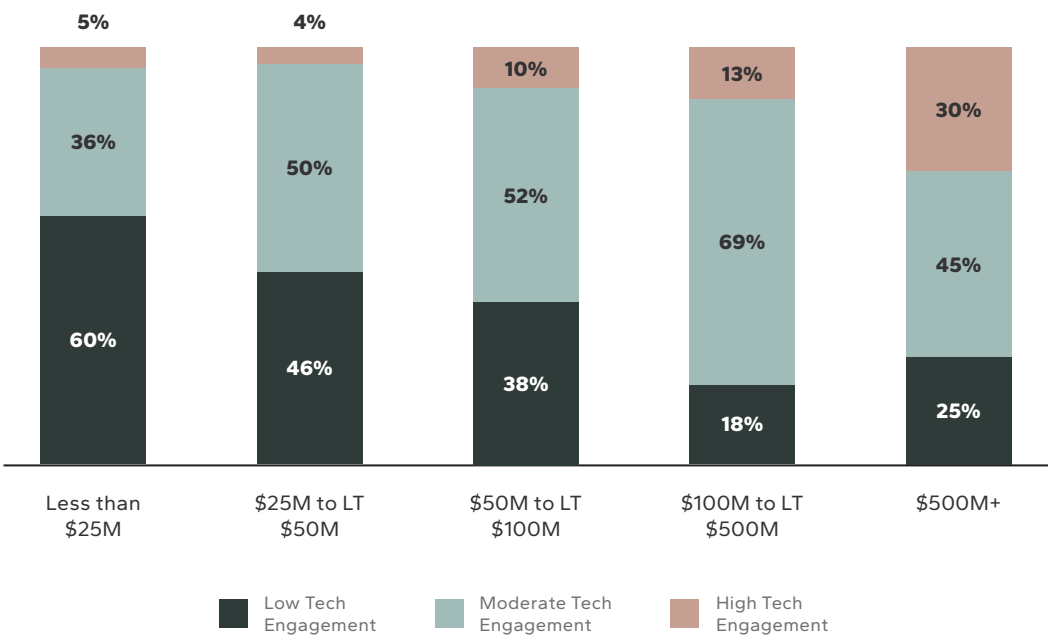
- Private/commercial companies have the largest share of those with a high level of technology engagement (22%). However, 38% of them also fall in the low technology engagement category, slightly more than the overall average (37%).

- Public/private institutions and state and federal government agencies have the highest share who are moderately engaged, and they are both below average at the high and low end of the index.

- The distribution of high, moderate and low in local government conforms the most closely to the overall average.

TECHNOLOGY ENGAGEMENT BY SIZE OF ORGANIZATION

The chart at the bottom of this page shows the level of technology engagement by the size of organization. Unlike the more complicated picture painted by type of owner, this chart reveals a clear pattern, with the majority (60%) of small organizations (less than $25M in annual project value) at the low end of the scale, and a high percentage (30%) of very large institutions at the top of the scale.

Interestingly, the owners with annual project volumes between $100M and $499M have the fewest in the low tech engagement category (18%), suggesting a high organizational interest in deploying technology. But their 13% at the highest level is less than half of the share held by the very large owners. This may suggest that the greater resources lavailable to the largest owners make a difference in meeting the bar of high technology engagement. But, as the cost of technology continues to come down and the ease of implementation improves, this group may be poised for significant growth.

Owner Engagement With Digital Technology
(BY SIZE OF ORGANIZATION)

	Less than $25M	$25M to LT $50M	$50M to LT $100M	$100M to LT $500M	$500M+
High Tech Engagement	5%	4%	10%	13%	30%
Moderate Tech Engagement	36%	50%	52%	69%	45%
Low Tech Engagement	60%	46%	38%	18%	25%

Legend: Low Tech Engagement · Moderate Tech Engagement · High Tech Engagement

Unleashing the Potential of AI Requires Quality Data

AI is a topic that's on everybody's mind, and almost every construction company I engage with has made some concerted effort to deploy AI in their own business," says Erin Roberts, Global Engineering and Construction Sector Leader at Ernst & Young, "but I would say the impact to date is fairly limited."

Among owners, the situation is similar, according to Ivan Panushev, CEO and co-founder of Twin Knowledge, an AI solutions provider. "In my experience, owner organizations are familiar at a high level with the potential of AI, and they've all dipped their toes into what is available from large software vendors like Microsoft, Amazon and OpenAI," he says, "but I've seen only initial implementations of AI to facilitate workflows."

THE AI PROSPECT, THE DATA CHALLENGE

Currently available AI has the potential to boost productivity and efficiency at every stage of a project's lifecycle. Whether it is turning design parameters into massing models, spotting conflicts in drawing sets, analyzing models for the most efficient sequence of work, estimating quantities and costs, monitoring site safety or serving as a virtual assistant to facilities management staff, AI can help streamline projects' information flows and support more effective decision-making, all at electric speed. The challenge for organizations wanting to tap into this potential, Roberts and Panushev agree, is to get their data in order. "All these implementations of AI to facilitate workflows really depend on the quality of the data that AI is working from," says Panushev. Conversely, he adds, the consequences of poor data quality epitomize the adage, "garbage in, garbage out."

What defines data quality? The watchwords are consistency, completeness, accuracy and currency, Panushev says. The crucial first step in generating results that can be trusted is to understand what data is important for an objective or organization. Then identify that data's sources: Examples might include ERP data; a project management system of record; data that remains constant from project

to project, such as code requirements and design guidelines; and data that is project-specific, such as schedules, estimates and designs. Then there is the issue of how the data is governed, including security and compliance in how it is created, moved and stored. Here, standardization is key, especially for achieving the benefits of scalability in multiple-project portfolios.

BUILDING THE DATA LAKE

For organizations whose data quality needs work, the good news is that these are early days. Yes, leading adopters are achieving significant gains. (Panushev cites the examples of Sound Transit, which serves the Seattle metropolitan area, using AI to review construction documents for compliance with design standards 20 times faster than by hand; and a housing developer, who builds 10,000 single-family homes a year, using AI to standardize and speed the evaluation of land acquisition options.) But for companies that will be looking to large software providers such as Procore, SAP and Oracle to embed AI in their offerings, the technology isn't yet ripe, Roberts says. "They're investing in it. But their readiness with a deployable, highly useful AI engine: I don't think it's quite there."

The advice to owners and builders in the meantime? "100% need to focus on how you structure your data," Roberts says. (Panushev, whose Ph.D. dissertation focused on data structure, seconds that.) For an organization that's dealing with 350 projects and 200 project managers all doing things differently, standardization may be a big lift, "but that's the prerequisite for data quality," Roberts says. He suggests starting with ERP, with standardized project management solutions that are deployed consistently, with a focus on integrated, rather than point, solutions, and with building a culture of innovation. "Build the data lake," he says. Depending on an organization's starting point, that could take years. "You have to have it before you can use it," Roberts says, "and it's impossible to make it standardized in the past. Start collecting the data now in a way that could be leverageable in the future."

Benefits From Using Digital Technologies

Project Benefits

Owners using at least one of seven digital technologies (see page 33) were asked if using that technology makes a major positive contribution to achieving one of these six benefits: more reliable schedule and cost estimates, improved quality, improved safety, improved sustainability and final asset exceeding expected functionality/performance.

This section examines the specific findings by technology for each benefit, but it is also useful to understand overall how many owners report any major benefits due to their use of technology. These findings are shown in the chart below.
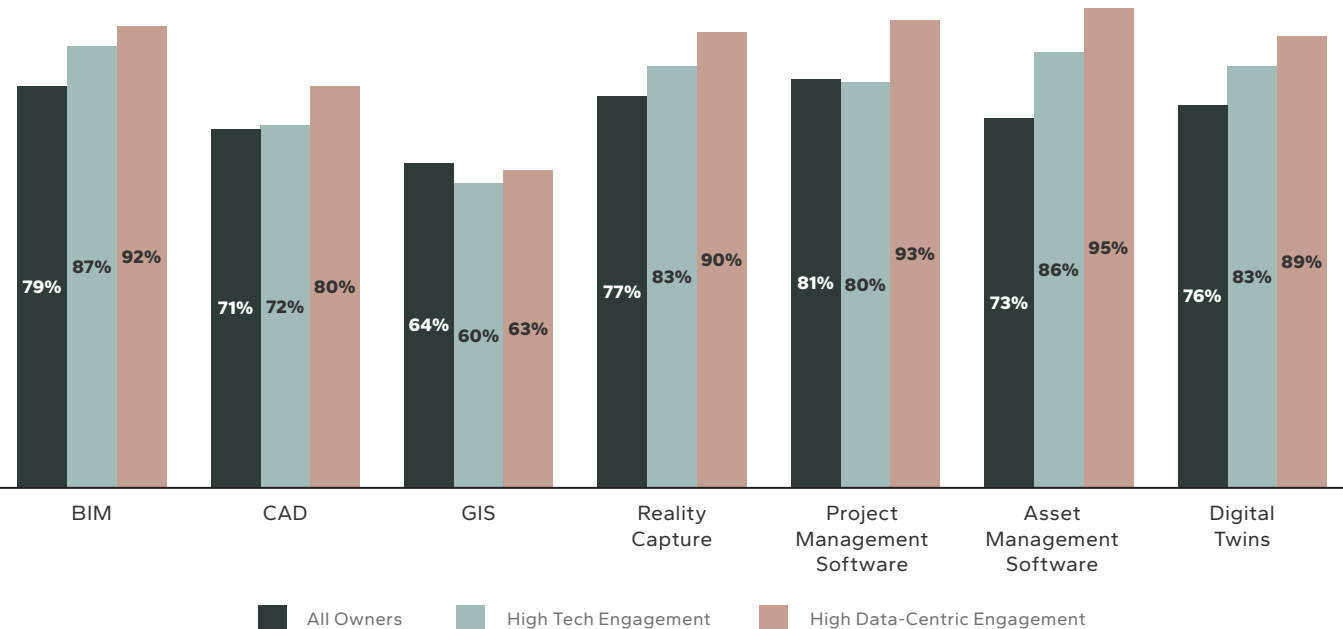
- **Overall:** The columns on the left reveal why so many owners are investing in all of these technologies, since 64% to 81% see a major impact from the use of each.
  - > **Project management software** tops the list at 81%, a finding that clearly supports why it is also the type of technology considered most essential to their role by users.

- > Many also experience major positive impacts from the use of **BIM, digital twins** and **reality capture.**

- **Variation by Level of Technology and Data-Centric Engagement:** Being more deeply engaged in technology leads to increased benefits from the use of many of these tools, but those from highly data-centric organizations most consistently experience meaningful benefits from the use of digital technologies.
  - > Being highly engaged in technology helps users get more out of BIM, reality capture, asset management software and digital twins.
  - > Over 90% of users from highly data-centric organizations experience benefits from asset and project management software, BIM and reality capture. They also significantly exceed all other groups in the impact on their projects of their use of CAD and digital twins.

These findings clearly demonstrate that better data management increases the value of using technology.

Experienced Benefits* That Had a Major Impact on Projects Due to Use of Specific Technologies

(ACCORDING TO THOSE USING EACH TECHNOLOGY)

	BIM	CAD	GIS	Reality Capture	Project Management Software	Asset Management Software	Digital Twins
All Owners	79%	71%	64%	77%	81%	73%	76%
High Tech Engagement	87%	72%	60%	83%	80%	86%	83%
High Data-Centric Engagement	92%	80%	63%	90%	93%	95%	89%

*Includes at least one of six benefits: more reliable schedule, more reliable cost estimates, improved quality, improved safety, improved sustainability and final asset exceeding expected functionality/performance

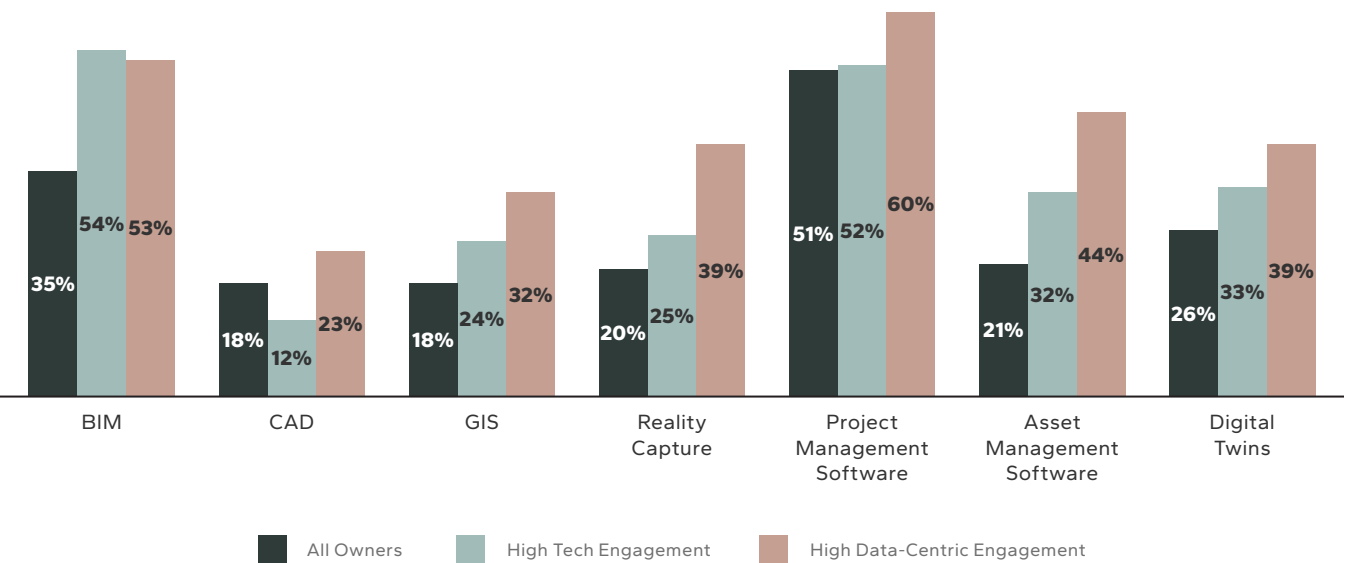# Benefits From Using Digital Technologies

Project Benefits CONTINUED

MORE RELIABLE SCHEDULES
Many studies conducted by Dodge Construction Network in the past have found that the use of technologies like BIM and project management software leads to more reliable schedules on projects. Owners clearly concur, although the frequency with which they experience these benefits is again dependent on the degree to which they have invested in data-centric approaches.

The frequency with which they achieve more reliable schedules varies by the type of technology.

- **Project management software** has the biggest impact. 51% of all users believe it improves the reliability of project schedules. The responses from users highly engaged with technology are similar to the overall average, but good data management appears to amplify that benefit, with 60% of highly data-centric owners agreeing.

- The impact of **BIM** on schedule reliability is less frequently felt by most users, but those whose organizations are highly engaged in technology and/or highly data-centric are nearly as frequently reporting this benefit as those using project management software.

- **Digital twins** are the only other type of technology that more than one quarter of the users find to make a notable difference in schedule reliability. Again, being more engaged with technology and especially more data-centric helps more organizations to experience this benefit.

- Highly data-centric owners find that schedule reliability is notably improved through the use of **asset management software.** This software has the biggest gap between overall user responses and those from highly data-centric organizations, which suggests that being able to integrate data from other functions increases the ability of this software to impact schedules.

Benefits With Major Project Impacts Due to Technology Use: MORE RELIABLE SCHEDULES

Chart data:

Technology	All Owners	High Tech Engagement	High Data-Centric Engagement
BIM	35%	54%	53%
CAD	18%	12%	23%
GIS	18%	24%	32%
Reality Capture	20%	25%	39%
Project Management Software	51%	52%	60%
Asset Management Software	21%	32%	44%
Digital Twins	26%	33%	39%

Benefits From Using Digital Technologies

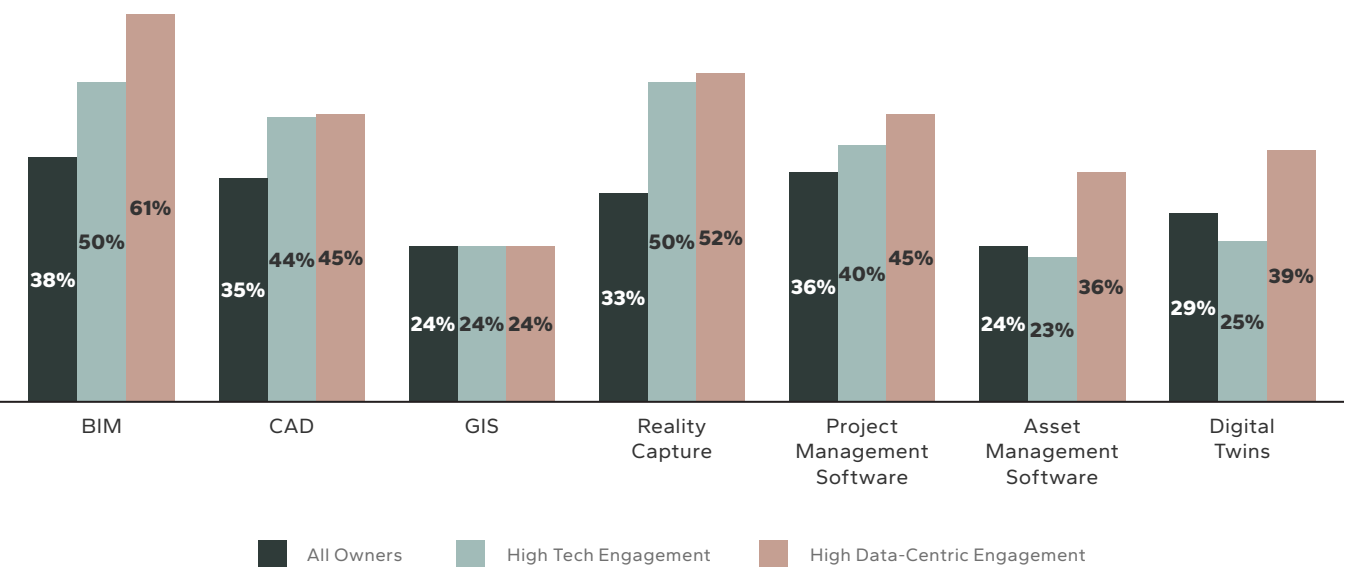## Project Benefits CONTINUED

MORE RELIABLE COST ESTIMATES

Having a reliable project cost while maintaining project quality and functionality is one of the most critical measures of success for projects. Many owners find that several of these technologies impact the accuracy of the cost estimates they create. Again, similar to the findings about reliable schedule, high technology engagement and especially high data-centric engagement increases the likelihood that a user will experience this benefits with many technologies.

- **BIM** has the greatest impact on reliable cost estimates. While only reported by 38% overall, half of the users with a high level of technology engagement and 61% of those from highly data-centric organizations find BIM makes costs more reliable.

- Highly technology-engaged and data-centric users also find that **reality capture** impacts their ability to have more reliable cost estimates on

their projects. Reality capture can help project teams identify and mitigate issues that can raise costs on projects, but to do so, the data they gather has to be analyzed effectively and integrated into other systems, which is probably why the overall share of users who find it yields this benefit is significantly smaller than those who have good data management.

- **Project management software** and **CAD** are the only other types of digital technologies that positively impact cost estimates for one third or more of users. For both, being highly engaged in technology and highly data-centric increases their effectiveness.

- Highly data-centric owners more frequently have reliable cost estimates due to their use of **asset management software** and **digital twins** than do other owners.

Benefits With Major Project Impacts Due to Technology: MORE RELIABLE COST ESTIMATES

BIM: All Owners 38%, High Tech Engagement 50%, High Data-Centric Engagement 61%
CAD: All Owners 35%, High Tech Engagement 44%, High Data-Centric Engagement 45%
GIS: All Owners 24%, High Tech Engagement 24%, High Data-Centric Engagement 24%
Reality Capture: All Owners 33%, High Tech Engagement 50%, High Data-Centric Engagement 52%
Project Management Software: All Owners 36%, High Tech Engagement 40%, High Data-Centric Engagement 45%
Asset Management Software: All Owners 24%, High Tech Engagement 23%, High Data-Centric Engagement 36%
Digital Twins: All Owners 29%, High Tech Engagement 25%, High Data-Centric Engagement 39%

Legend: All Owners | High Tech Engagement | High Data-Centric Engagement

Benefits From Using Digital Technologies

Project Benefits CONTINUED

QUALITY

Quality is the most widely experienced benefit of using digital technologies. Around half of owners report that **BIM, reality capture, project management software** and **digital twins** improve project quality.

It also appears to be the benefit which results most directly from the use of **GIS** and **digital twins** since the average share of users who report experiencing improved quality from using these tools is similar to the share of those highly engaged with technology and whose organizations are highly data-centric.

- Owners with a high degree of technology engagement most frequently report experiencing improved quality from the use of **BIM** and **project management software.**

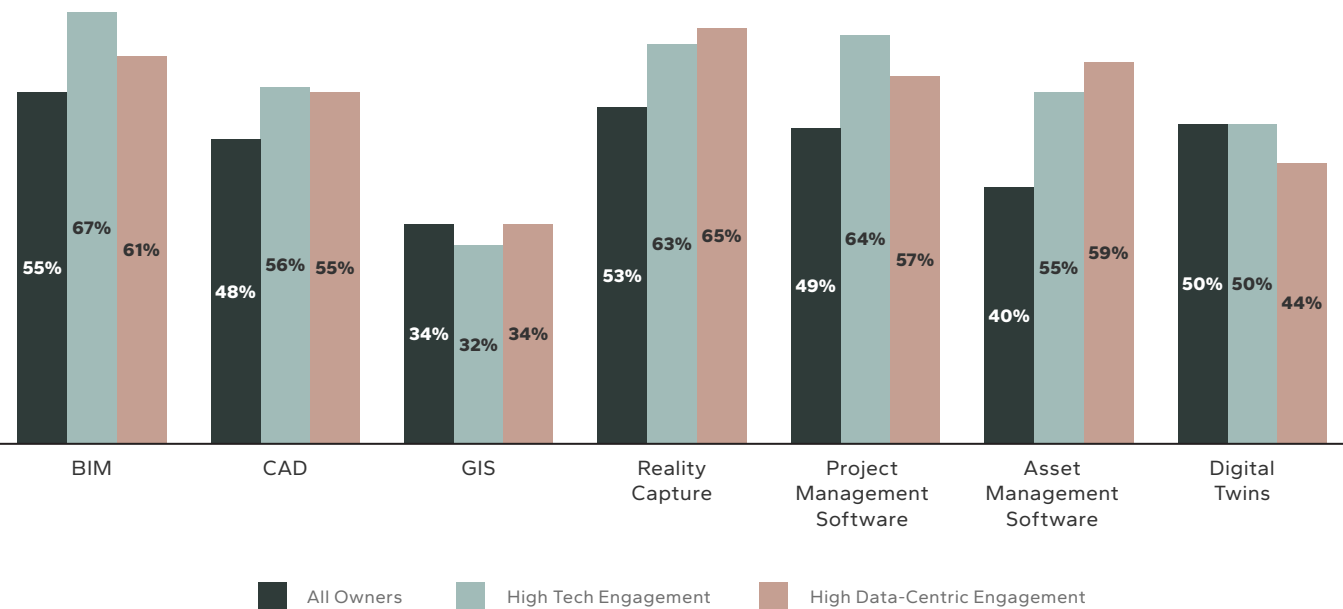- Nearly the same percentage of users with high technology engagement and high data-centric

engagement experienced improved quality from deploying many other technologies, including **CAD**, **reality capture** and **asset management software**. The findings suggest that wider use of technology is a critical factor for improving quality on projects.

- It is certainly notable, though, that data-centric engagement leads to a much more frequent experience of improved quality than the average for all of the technologies except **GIS** and **digital twins**.

OTHER BENEFITS ASSOCIATED WITH TECHNOLOGY

The study also looked at three other project benefits that owners less frequently associate with the use of digital technologies: improved safety, improved sustainability and final asset exceeding expected functionality/performance. Since there were fewer notable differences between those with high

Benefits With Major Project Impacts Due to Technology: IMPROVED QUALITY

Category	All Owners	High Tech Engagement	High Data-Centric Engagement
BIM	55%	67%	61%
CAD	48%	56%	55%
GIS	34%	32%	34%
Reality Capture	53%	63%	65%
Project Management Software	49%	64%	57%
Asset Management Software	40%	55%	59%
Digital Twins	50%	50%	44%

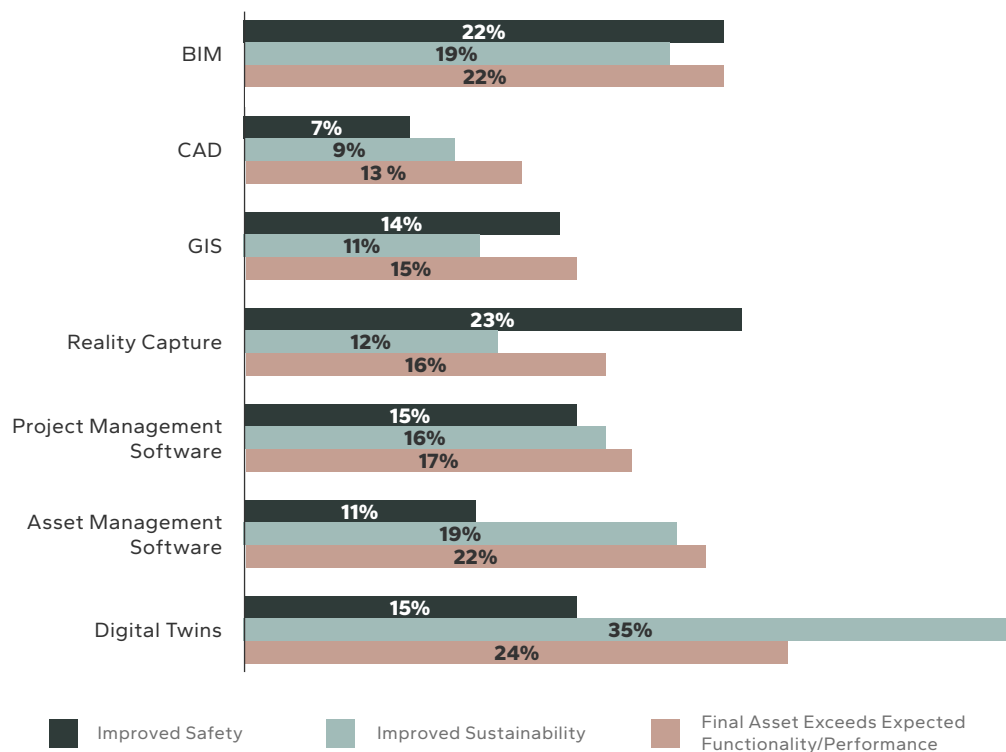Legend: All Owners • High Tech Engagement • High Data-Centric Engagement

Benefits From Using Digital Technologies

Project Benefits CONTINUED

technology and data-centric engagement than the average responses, just the totals for all three are shown in the chart below, and any differences are noted in the analysis below.

- **Improved Safety:** Fewer than one quarter of users of digital technologies find that any of them improve safety on their projects. It is possible that many owners are not as aware of how these they are used to improve safety as they are of their impacts on schedule, budget and quality.
  - > More than one fifth of users think **BIM** and **reality capture** improves safety on projects enough to have a major impact.
  - > 42% of users with high technology engagement believe that **BIM** has a major positive impact on safety.
  - > Only 4% of users with limited data-centric engagement observe that p**roject**

management software has a major impact on safety, compared with 21% of those from organizations that are more data-centric.

- **Improved Sustainability:** 35% of **digital twin** users see a major impact on sustainability from its use, significantly more than any other technology. A digital twin can help improve sustainable performance by optimizing the performance of the building from design through operations.

- **Final Asset Exceeds Expected Performance:** Over one fifth of users think the use of **BIM, asset management software** and **digital twins** leads to the final asset exceeding expected performance. While the percentage is low compared with other project benefits, it is clear that technologies that are used most frequently during operations are most often perceived to help the asset's performance exceed expectations.

Benefits With Major Project Impacts Due to Technology:
OTHER BENEFITS ASSOCIATED WITH TECHNOLOGY

Technology	Improved Safety	Improved Sustainability	Final Asset Exceeds Expected Functionality/Performance
BIM	22%	19%	22%
CAD	7%	9%	13 %
GIS	14%	11%	15%
Reality Capture	23%	12%	16%
Project Management Software	15%	16%	17%
Asset Management Software	11%	19%	22%
Digital Twins	15%	35%	24%

Legend: Improved Safety | Improved Sustainability | Final Asset Exceeds Expected Functionality/Performance

Benefits From Using Digital Technologies

Process Benefits

Project benefits are important, but owners can also enjoy processs improvements from the use of digital technologies on their projects. Some impact the way that owners and project team members can engage with each other, such as better ability to track project progress, greater transparency about design/construction activities, and enhanced ability to collaborate with, convey goals to and provide input to the project team.
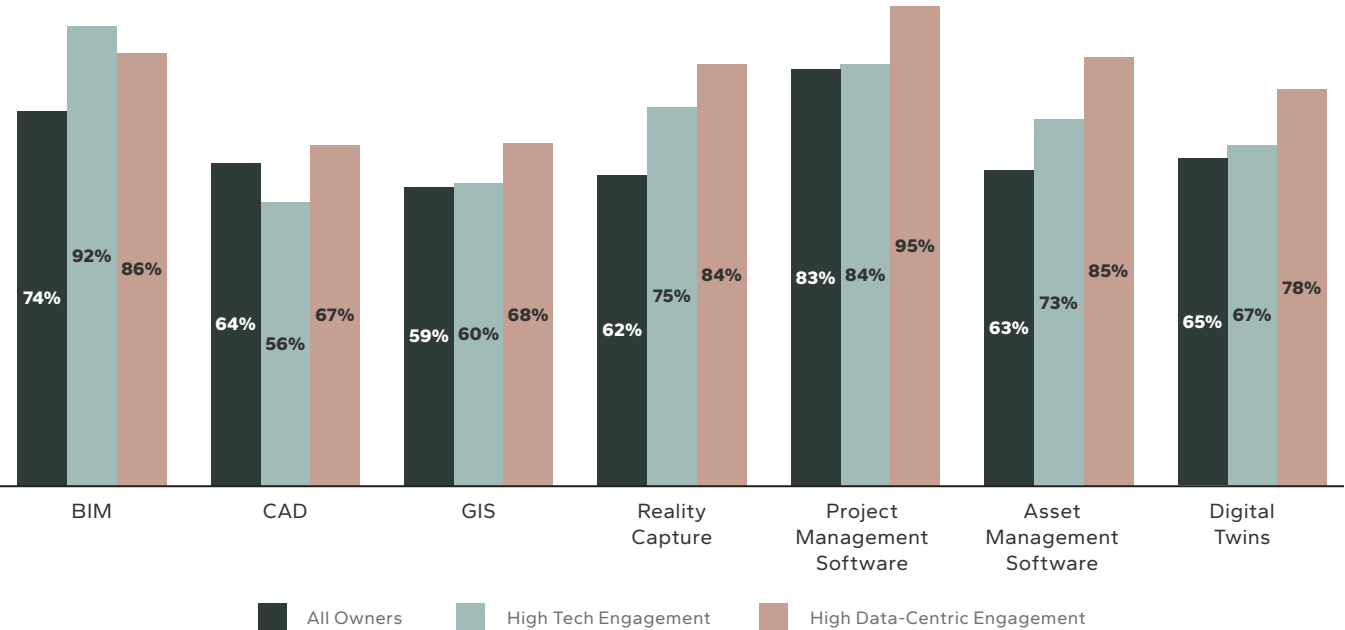
Owners were asked to identify which, if any, of the seven digital technologies in the study generated any of these process benefits to the degree that they had a major impact on their organization. The chart at bottom shows the share of those using the technologies who found that they experienced any of these benefits, and the analyses on pages 54 to 55 look in greater detail at which technologies most frequently delivered these benefits.

OVERALL EXPERIENCE OF PROCESS BENEFITS
Most owners report that the technologies that are used on their projects have generated at least one process benefit that had a major impact on their organizations, ranging from 59% who experienced these benefits from **GPS** to 83% from **project management software**.

- **Level of Technology Engagement:** Many more owners with high technology engagement experienced benefits from the use of **BIM, reality capture** and **asset management software** on their projects than the average users.

- **Level of Data-Centric Engagement:** As with the project benefits, data-centric engagement had the biggest impact on the likelihood of experiencing these benefits. More highly engaged owners experienced process benefits from six of the seven technologies than the average, including **BIM, GIS, reality capture,** both **project** and **asset management software,** and **digital twins**.

Experienced Process Benefits* That Had a Major Impact on Their Organizations Due to Use of Specific Technologies
(ACCORDING TO THOSE USING EACH TECHNOLOGY)

	BIM	CAD	GIS	Reality Capture	Project Management Software	Asset Management Software	Digital Twins
All Owners	74%	64%	59%	62%	83%	63%	65%
High Tech Engagement	92%	56%	60%	75%	84%	73%	67%
High Data-Centric Engagement	86%	67%	68%	84%	95%	85%	78%

■ All Owners ■ High Tech Engagement ■ High Data-Centric Engagement

*Includes at least one of four benefits: tracking project progress, greater transparency about design and construction activities, more collaboration with the project team and better ability to convey goals and provide input to the project team

Benefits From Using Digital Technologies

Process Benefits CONTINUED

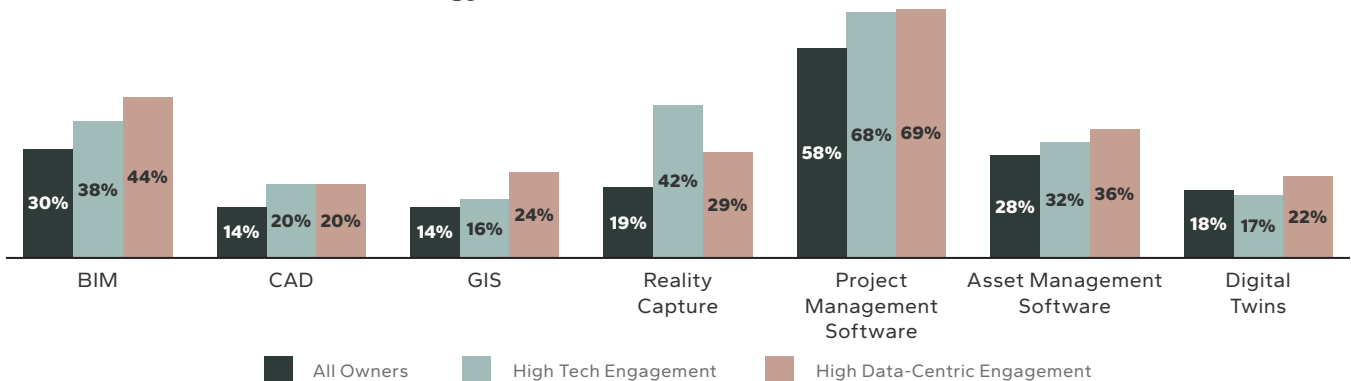**TRACKING PROJECT PROGRESS AND TRANSPARENCY**

Owners can more fully engage with their project teams if they have a real-time understanding of how a project is progressing and transparency about design and construction activities. This allows an owner to be more of a partner, helping their project teams to address risks as, or even before, they arise.

- **Tracking Project Progress:** As one of the charts below reveals, **project management software** most often leads to improving an owner's ability to track project progress. Of course, this is part of its core functionality, and thus is no surprise. A few findings are more revealing:
  - > Highly data-centric owners more frequently report getting this benefit from **BIM, GIS, reality capture** and a**sset management software** than owners on average do.
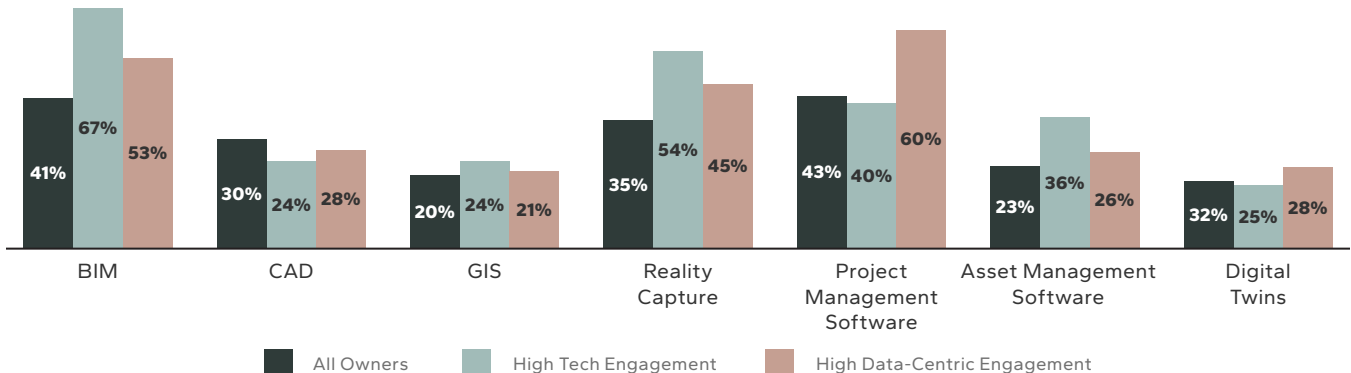 - > 42% of users with a high degree of technology engagement get this benefit from **reality**

capture, suggesting it works best in combination with other technologies to help track project progress.

- **Transparency About Design/Construction Activities:** Again, **project management software** is the technology that most owners associate with this benefit. However, nearly as many also report that **BIM** is important for transparency.
  - > 67% of users with a high degree of technology engagement find **BIM** meaningfully increases transparency, and 54% report the same for **reality capture** technologies. In both these cases, and with **asset management software,** higher technology engagement yields better results than being highly data-centric.
  - > Highly data-centric owners see more transparency than the average from **BIM, reality capture** and **project management software.**

Process Benefits With Major Organizational Impacts Due to Technology Use: TRACKING PROJECT PROGRESS

	BIM	CAD	GIS	Reality Capture	Project Management Software	Asset Management Software	Digital Twins
All Owners	30%	14%	14%	19%	58%	28%	18%
High Tech Engagement	38%	20%	16%	42%	68%	32%	17%
High Data-Centric Engagement	44%	20%	24%	29%	69%	36%	22%

Process Benefits With Major Organizational Impacts Due to Technology Use: TRANSPARENCY ABOUT DESIGN/CONSTRUCTION ACTIVITIES

	BIM	CAD	GIS	Reality Capture	Project Management Software	Asset Management Software	Digital Twins
All Owners	41%	30%	20%	35%	43%	23%	32%
High Tech Engagement	67%	24%	24%	54%	40%	36%	25%
High Data-Centric Engagement	53%	28%	21%	45%	60%	26%	28%

Benefits From Using Digital Technologies

Process Benefits CONTINUED

COLLABORATION AND THE ABILITY TO CONVEY GOALS AND PROVIDE INPUT TO THE PROJECT TEAM

Between one and two thirds of users of these technologies find that they help improve collaboration with their project teams. However, only one fifth to one third find that their ability to convey goals and provide input to the project team is improved sufficiently to have a major impact on their organization.

- **Collaboration: BIM** and **project management software** most commonly support collaboration between owners and the project team, with over half (57%) of users reporting this benefit.
  - > Nearly all (83%) of users with high technology engagement find that **BIM** is effective at promoting collaboration between the owner and the project team.
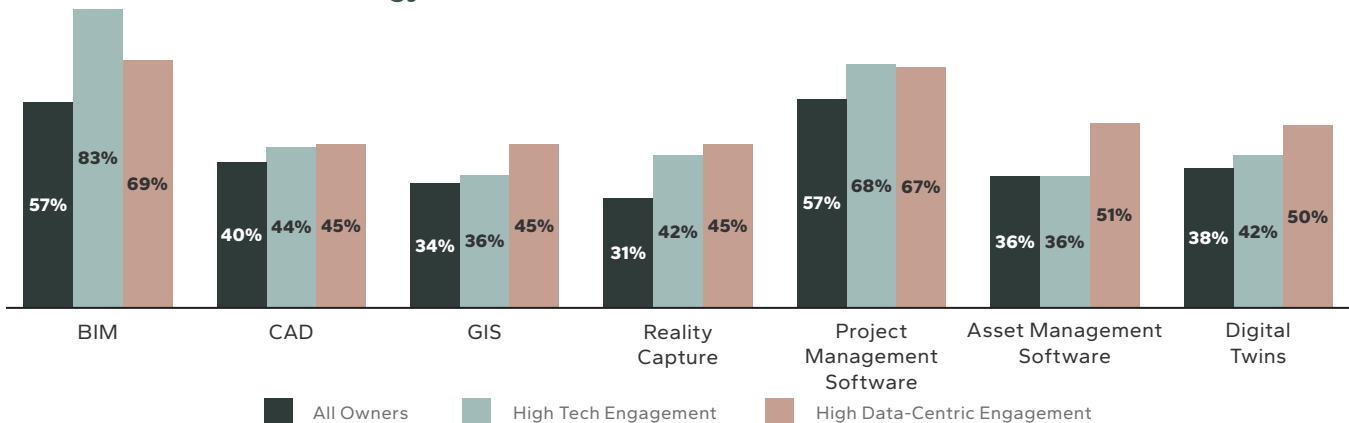 - > Significantly more users with organizations with high technology or data-centric

engagement also find **project management software** improves collaboration than the rest.
  - > About half of highly data-centric owners who use **asset management software** and **digital twins** see increased collaboration as a result.
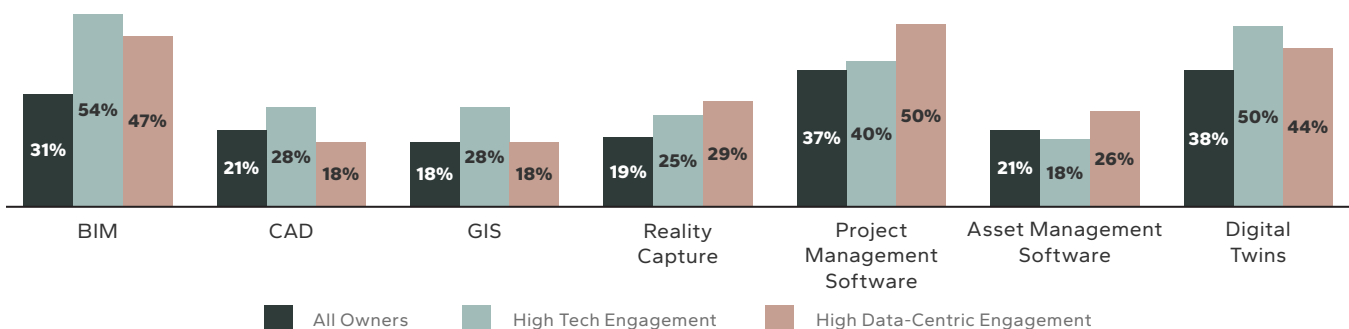
- **Ability to Convey Goals and Provide Input:** About one third of users of **BIM, project management software** and **digital twins** find their ability to convey goals and provide input to the project team improved as a result. These technologies also see the biggest increase in the percentage of highly engaged technology or data-centric users reporting this benefit.
  - > High technology engagement also leads to notably wider reporting of this benefit among users of **CAD** and **GIS**.
  - > High data-centric engagement also makes a difference in the share of **reality capture** users who report this benefit.

Process Benefits With Major Organizational Impacts Due to Technology Use: COLLABORATION WITH PROJECT TEAM

	BIM	CAD	GIS	Reality Capture	Project Management Software	Asset Management Software	Digital Twins
All Owners	57%	40%	34%	31%	57%	36%	38%
High Tech Engagement	83%	44%	36%	42%	68%	36%	42%
High Data-Centric Engagement	69%	45%	45%	45%	67%	51%	50%

Process Benefits With Major Organizational Impacts Due to Technology Use: CONVEY GOALS AND PROVIDE INPUT TO PROJECT TEAM

	BIM	CAD	GIS	Reality Capture	Project Management Software	Asset Management Software	Digital Twins
All Owners	31%	21%	18%	19%	37%	21%	38%
High Tech Engagement	54%	28%	28%	25%	40%	18%	50%
High Data-Centric Engagement	47%	18%	18%	29%	50%	26%	44%

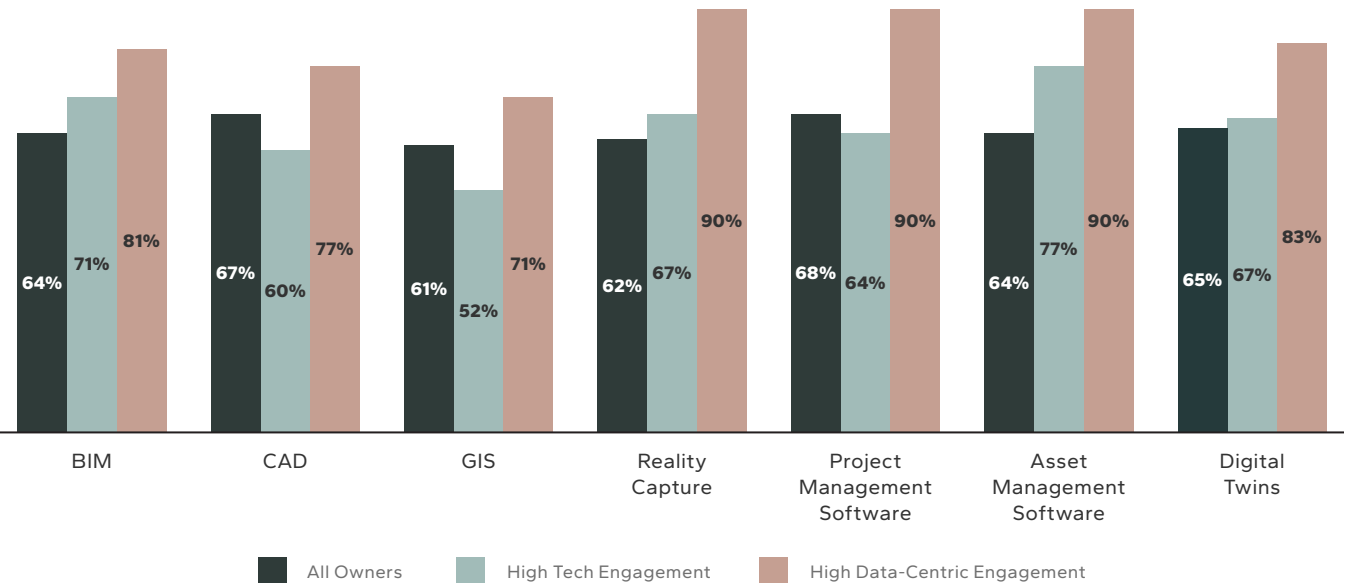# Benefits From Using Digital Technologies

Digital Benefits

Most of these digital technologies are directly used to manage the design and construciton of capital projects, but they can also be used to support other functions, including planning, operations and asset management, if the project data meets the owner's standards and is consistent and reliable. Therefore, it is not surprising that data-centric organizations see the biggest digital benefits on their organizations, as the chart below reveals.

- 90% or more of the highly data-centric respondents can use the digital deliverables from **reality capture, project management** and **asset management software** in asset lifecycle phases outside of design and construction. Over 70% report the same for every other technology shown.

- While high technology engagement is beneficial**,** investing in good data management helps many more users in an owner organization to deploy the data beyond the design and construction phases.

- These findings clearly reveal that owners are seeking to utilize data from these tools across the project lifecycle. Over 60% of owners using these technologies on their projects report that they can use the data provided for the other three phases. This suggests that project team partners who can deliver data from these tools to their clients in a useable format are likely to build stronger relationships with their clients in the future.

The analysis on pages 57 to 58 reveals which technologies provide data that are most widely used in other asset lifecycle phases.

Experienced Digital Benefits* That Had a Major Impact on Their Organizations Due to Use of Specific Technologies
(ACCORDING TO THOSE USING EACH TECHNOLOGY)

	BIM	CAD	GIS	Reality Capture	Project Management Software	Asset Management Software	Digital Twins
All Owners	64%	67%	61%	62%	68%	64%	65%
High Tech Engagement	71%	60%	52%	67%	64%	77%	67%
High Data-Centric Engagement	81%	77%	71%	90%	90%	90%	83%

Legend: ■ All Owners ■ High Tech Engagement ■ High Data-Centric Engagement

* Includes using digital deliverables for planning, operations and maintenance, and/or asset management
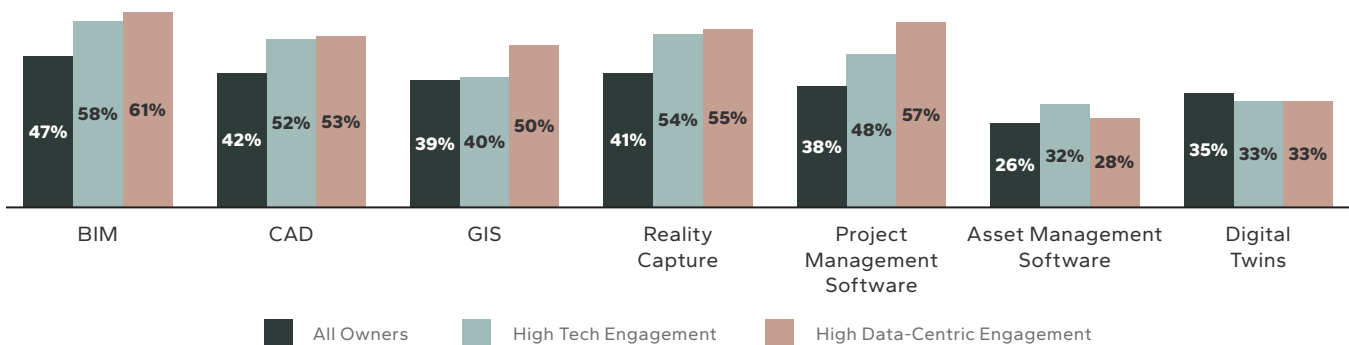
Benefits From Using Digital Technologies

Digital Benefits CONTINUED

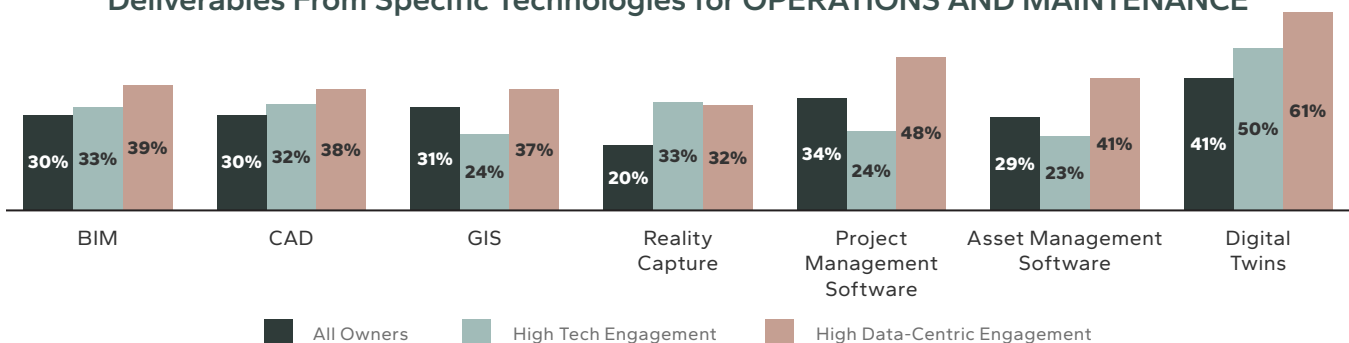**PLANNING, OPERATIONS AND MAINTENANCE (O&M) AND ASSET MANAGEMENT**
The technologies providing digital deliverables most frequently for planning differ notably from those that are most useful in the O&M and asset management stages.

- **Planning:** Six technologies provide data deliverables that can be used in the planning stages for between 35% and 47% of users.
  > **BIM** and **CAD** are reported by the highest share.
  > Five out of six technologies provide data deliverables that are used in planning by over half of respondents in highly data-centric organizations: **BIM, CAD, GIS, reality capture** and **project management software.**
  > High technology engagement leads to wider use of data in planning from four of those technologies: **BIM, CAD, reality capture** and **project management software.**

> Users of **asset management software** and **digital twins** less frequently capitalize on the digital deliverables they provide in the planning stage, and there is no difference by either technology or data-centric engagement in these findings.

- **O&M:** Owners still appear to struggle to leverage the digital deliverables of many of their digital technologies during the O&M phase.
  > **Digital twins** are the exception, with 41% users able to leverage their digital deliverables during O&M. It makes sense that digital twins would lead in this area since many owners invest in them in order to be able to capitalize more on project data during operations.
  > Between 29% and 34% of users of most of the other technologies benefit from the data they provide during the O&M phase. This suggests that valuable data generated during the project phase is frequently lost in O&M.

Experienced Major Organizational Impacts From the Ability to Use Digital Deliverables From Specific Technologies for PLANNING

	BIM	CAD	GIS	Reality Capture	Project Management Software	Asset Management Software	Digital Twins
All Owners	47%	42%	39%	41%	38%	26%	35%
High Tech Engagement	58%	52%	40%	54%	48%	32%	33%
High Data-Centric Engagement	61%	53%	50%	55%	57%	28%	33%

Experienced Major Organizational Impacts From the Ability to Use Digital Deliverables From Specific Technologies for OPERATIONS AND MAINTENANCE

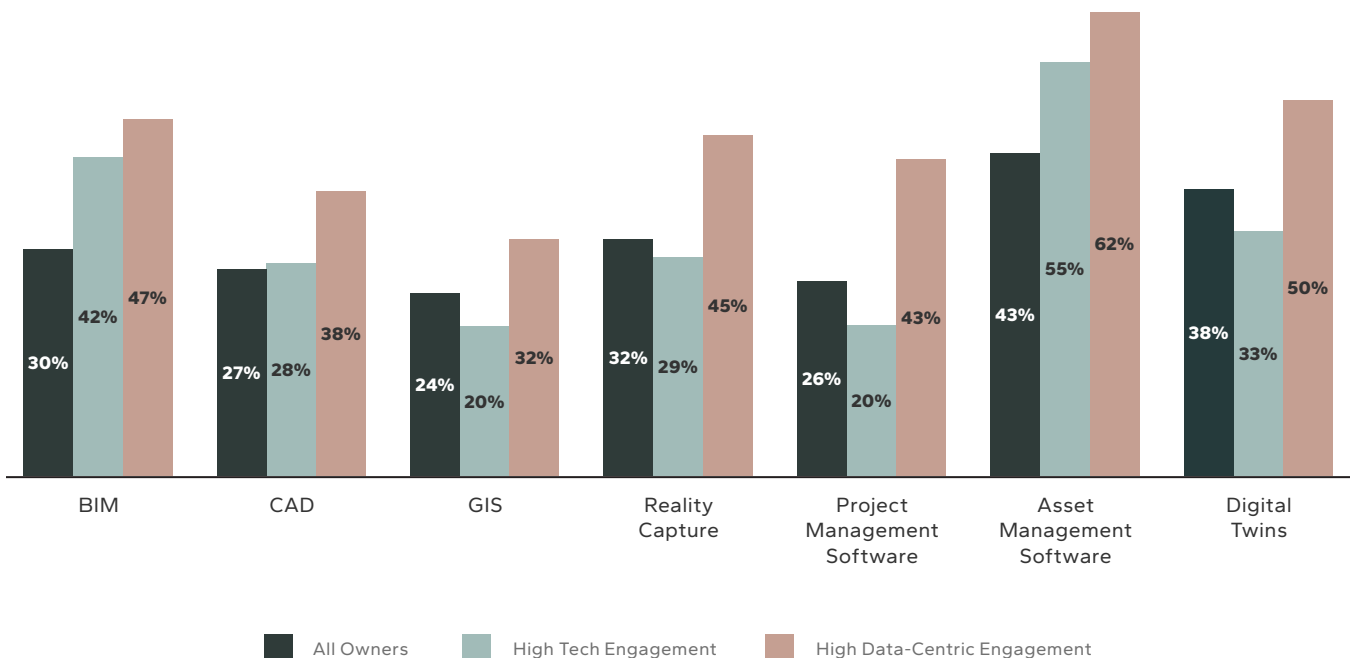|	BIM	CAD	GIS	Reality Capture	Project Management Software	Asset Management Software	Digital Twins
All Owners	30%	30%	31%	20%	34%	29%	41%
High Tech Engagement	33%	32%	24%	33%	24%	23%	50%
High Data-Centric Engagement	39%	38%	37%	32%	48%	41%	61%

Benefits From Using Digital Technologies

Digital Benefits CONTINUED

> Highly data-centric organizations are able to leverage the digital deliverables of **BIM, CAD, GIS, reality capture, project and asset management software** and **digital twins** more frequently than their peers. This again demonstrates that standardized, reliable project data can be more widely leveraged in the operations phase, regardless of the specific technology used.

> In contrast, users with high technology engagement only exceed their peers notably for **reality capture** and **digital twins.**

- **Asset Management:** While the digital deliverables of **asset management software** are most widely used during the asset management phase, in fact, the 43% who report that use seems quite low. This may be driven more by how the question was asked, rather than the usefulness of the data. The phrasing of the question specified that the use of the digital deliverables had to have a major impact on their organizations. It is possible that many

simply believe that asset management software digital deliverables are performing as expected in that phase and would not, therefore, classify their organizational impact as major.

> The findings for **BIM, CAD, GIS** and **project management software** largely mirror the findings for the use of their digital deliverables for operations.

> The digital deliverables from **reality capture** technologies are more widely used for asset management than for operations, especially by those with high data-centric engagement.

> The digital deliverables from **digital twins** are not as widely used currently for asset management as they are for operations.

> However, half of digital twin users with a high level of data-centric engagement are able to do so, which suggests the potential for much wider use of those outputs for asset management as owners improve their data quality.

Experienced Major Organizational Impacts From the Ability to Use Digital Deliverables From Specific Technologies for ASSET MANAGEMENT

BIM: All Owners 30%, High Tech Engagement 42%, High Data-Centric Engagement 47%
CAD: 27%, 28%, 38%
GIS: 24%, 20%, 32%
Reality Capture: 32%, 29%, 45%
Project Management Software: 26%, 20%, 43%
Asset Management Software: 43%, 55%, 62%
Digital Twins: 38%, 33%, 50%

All Owners | High Tech Engagement | High Data-Centric Engagement

Challenges and Opportunities

Obstacles That Prevent Owners From Experiencing More Benefits From Technology

Pages 48 to 58 clearly demonstrate that most owners whose projects employ digital technologies see significant benefits as a result. However, those benefits are still not universally experienced. Owners were asked about which of the factors shown in the chart below prevent them from experiencing more benefits from their use of technology, and, if they selected more than one, to identify the most important factor standing in their way.

93% identify at least one obstacle, and their responses reveal the opportunity for improvement in the industry.

TOP OBSTACLES

- **Resources Required to Maintain Data in Their Systems:** Over half of owners consider this a challenge, and nearly one in five (19%) select it as the biggest one. It is most frequently reported as a top obstacle by public/private institutions (52%). The barriers to investing in these resources are explored in more detail on the following page.

- **Inability to Move Past Legacy Software:** This is the second biggest obstacle, and it is a challenge shared across the industry. See page 61 for more information on this issue.

DATA-RELATED OBSTACLES

Several data-related obstacles are considered serious challenges by around one third of owners, including challenges incorporating data deliverables from external companies and the inability to share data effectively internally and externally.

A high proportion of those who find that external companies are not able to provide data deliverables consider this a top challenge. This findings suggests that architects, engineers and contractors who can meet the owners' data needs will have a competitive advantage.

These findings also indicate why highly data-centric organizations more frequently experience benefits from the use of technology on projects, since their data management efforts help address many of the challenges these owners raise.

Obstacles Preventing Owners From Getting More Out of the Technology Deployed on Their Projects

Total

Obstacle	Selected as an Obstacle But Not the Biggest	Selected as the Biggest Obstacle	Total
Resources Required to Maintain Data in Their Systems	33%	19%	52%
Inability to Move Past Legacy Software	30%	14%	44%
Inability to Easily Incorporate Data Deliverables From External Companies Into Their Systems	26%	9%	35%
Inability to Share Data Effectively With Other Divisions in Their Organization	28%	6%	34%
Inability to Share Data Effectively With External Companies	26%	5%	31%
Inconsistent Compliance With Their Data Standards by External Companies	24%	5%	29%
Lack of As-Built Data in Data Deliverables	23%	4%	27%
Too Few External Companies Able to Provide Data Deliverables	18%	8%	26%

■ Selected as an Obstacle But Not the Biggest   ■ Selected as the Biggest Obstacle

Challenges and Opportunities

Obstacles to Investing More in Data Gathering and Analysis

The findings of this report have consistently demonstrated the value of owner investment in good data management, but it is also important to recognize the challenges owners face as they seek to improve their data gathering and analysis capabilities. Owners were asked to identify which of the factors in the chart below prevent them from investing in these capabilities and, if they selected more than one, to identify the most important.

Only 7% of owners feel more investment is not necessary, which reveals that most owners recognize that they have more to gain from better use of data.

TOP OBSTACLES ARE RELATED TO RESOURCES AND ROI

Finding the resources needed to improve these capabilities is the biggest challenge owners face, including insufficient staff and funding. These challenges are directly related to the third most frequently selected challenge of not being certain about adequate return on investment. Owners need data like the findings of this report to justify committing more resources to developing these capabilities.

Concerns about the return on investment are more frequently selected as issues by those at organizations with high technology and data-centric engagement (50% and 56%, respectively). While this is counterintuitive, there is little benchmarking data available to demonstrate how their performance is impacted by their investments compared with others. The findings in this report will hopefully provide them with more data that demonstrate the effectiveness of the investments they have made.

OTHER CHALLENGES

About one third of owners are not certain about how to invest to improve their data-gathering and analysis capabilities and find the lack of leadership support to be a challenge. The challenge of knowing what to invest in is one shared by their project team members as well, especially since many are still early in their digital transformation process.

Cybersecurity is currently one of lowest concerns, but those who are with more highly data-centric organizations more frequently select it (37%), suggesting that greater attention to data includes greater attention to cybersecurity.

Obstacles Preventing Organizations From Investing More in Data Gathering and Analysis

Total

Obstacle	Selected as a Factor But Not the Most Important	Selected as the Most Important Factor	Total
Insufficient Staff	36%	16%	52%
Insufficient Funding	34%	16%	50%
Concern About Inadequate Returns on Investment	26%	11%	37%
Lack of Insight About the Best Investments to Make	27%	5%	32%
Lack of Leadership Support	22%	8%	30%
Cybersecurity Concerns	16%	7%	23%
Lack of Sufficient Data Sharing/ Collaboration Between Capital Construction and Building Operations	19%	2%	21%

■ Selected as a Factor But Not the Most Important
■ Selected as the Most Important Factor

Integrating Legacy Data

O rganizations—especially owner organizations—struggle with how to get the value out of information that they need, that they're paying for and that they can make better use of," says Roger Grant, vice president of building technology with the National Institute of Building Sciences. This is especially true, he says, in the case of legacy data, historical information that is difficult to access and use in current systems.

Whether it is printed manuals on a pallet in the basement, archived CAD drawings and other project documentation on superannuated software, material or cost records on old spreadsheets or outdated ERP systems, integrating such data can offer insights from past operations, performance and trends to better inform current and future decision-making.

SETUP FOR SUCCESS

Before jumping in, it's essential to identify the purpose of the initiative. "More data do not necessarily correlate with better information. It's very important to have a process in place to evaluate the quality of the data to make sure that it's information-worthy," says Tony Rinella, co-founder and senior director at Strategic Building Innovation. "And if we understand our objectives in managing our asset and in caring for the people who are in it, then beyond information, we can have insight."

In addition to a clear understanding of the data's purpose, experts agree that success depends on there being a designated champion for the process. Whether it's a member of the executive, a leader, a bottom-up manager or a team, "the champion steers the process through its pain points toward the value that mandated the initiative in the first place," says Calvin Kam, founder and CEO at Strategic Building Innovation.

COMMON CHALLENGES

Once the work of accessing, cleaning and integrating the data gets underway, common challenges can crop up. Often there are diverse sources of information, with varying levels of reliability: even a small building could have thousands of more-or-less-comprehensive documents accumulated over time. There may be uncertainty around the level of detail or candor that was available when each piece of information was created, or around the data's timing, making it difficult

to know which pieces of information have been superseded by which other ones. There's a role for AI in identifying anomalous or incorrect data, but it is no substitute for good data stewardship.

Challenges can also result from an organization-wide lack of clarity on the need. The facilities team or the procurement team may understand the data's value, for example, but the financial controllers and leadership team may not have been thoroughly briefed.

Other contractual and cultural challenges can arise. While value chain partners may pitch innovation and digitization, Kam says, "there may be legacy contracts, legacy benefits, legacy systems with functional requirements that are difficult to change, legacy incentives for them to work in the old way," making partners reluctant to share data, and increasing the owner's costs of migrating to a new system.

BEST PRACTICE: OPEN STANDARDS

At the top of the list of capabilities and practices for fostering a successful integration is reliance on open standards, publicly available specifications that guide digital practices and promote interoperability and data exchange between different systems and devices. "This will protect owners against changes in the marketplace," Rinella says, "and against reliance on a single vendor. Open standards users can always choose the best option available to them." These specifications also enable an owner to structure and manage their requirements more reliably, from specifications and compliance checking, through delivery, archiving and upgrading. "You may take a little bit more time," Kam says, "but then the ability to make it scalable and repeatable is huge."

Even if an organization has already made a big commitment to a particular application, Grant says, "It's never too late to step back and look at what you're doing and how to get the most out of it from end to end." He encourages organizations to map their information, the applications they are using and who is using them. Complementing that, he recommends an ongoing and methodical process of capacity development: "Assess your capability maturity," he says. "Measure your progress."

CalTrans

Kourosh Langari | Transportation Engineer
California Department of Transportation District 4, San Francisco Bay Area

> NOTE This interview does not reflect the official views or policies of the California Department of Transportation. Mr. Langari is solely responsible for the contents of the interview, including the facts and accuracy of the data and information.

What specific data management policies and practiceshave you implemented that have had the biggest impact on your organization?
Langari: Data is the cornerstone of whatever we do. We implemented technologies about a decade ago called the work breakdown structure (WBS) and resource breakdown structure (RBS). We are on release 15.0. The WBS and RBS are the mechanisms that we use to do our capital planning.

The WBS provides the work breakdown of the delivery of capital outlay projects and statewide uniformity in the development of project work plans to initiate, plan, control, execute and close out capital projects.

Data accumulated on the WBS feeds back into the RBS, so when we work on our project initiation document, we can look at the history of similar projects that were done in that category including the time scope and amount of cost associated with that type of work. We also have created a uniform digital dashboard for that across our 12 different districts.

Is that dashboard how you integrate different functions like capital planning, project management and asset management? Or do you think more integration is needed?
Langari: More integration is needed. We are a legacy organization, and different divisions often have their silos of databases. Our goal is to integrate across the project delivery spectrum to try to have one single source of truth.

We are currently going through the process of reassessing our asset management data dictionary for maintenance and operations and into the lifecycle of the projects moving forward.

For us, the process of seeking integration is essentially continuous. When you are dealing with the sixth largest economy in the world and the volume of projects that we handle, many of these integrations are not easy, and there is no off-the-shelf solution. You have to take an incremental approach. The RBS, WBS and our digital dashboard are currently our means of integration across 12 districts, but we are continuously trying to enhance that system.

What are the biggest challenges you have faced in your efforts to invest in data and technology?
Langari: The rapid pace of the technology change is a challenge, especially right now with most of our databases sitting in on-premises data servers. We are looking at the feasibility of utilizing cloud services for some databases that are uniform across the state, which would give us high resiliency, 24 by 7 availability and redundancy.

One of the challenges that we face is change management as we move into an age of digital construction. In the 1980s and 90s, we were more paper-based. In the first couple of decades of this century, we still had a lot of 2D PDFs. And now we're trying to make the transition to 3D modeling and documentation as a legal document. Standardization and modernization of our equipment is a challenge.

Developing and implementing methodologies to allocate resources to support our strategic policies is another area that we're focusing on, as well as promoting and implementing innovation and creative solutions.

How are you doing that?
Langari: We have a division called DRISI, The Division of Research, Innovation and System Information (DRISI), which advances California's transportation system, develops comprehensive transportation solutions, and creates and distributes transportation-related

knowledge and information. We continuously work to turn innovative ideas into sustainable solutions that address a wide range of transportation challenges.

DRISI's Strategic Plan (Plan) is a strategic tool that outlines the Division's priorities and initiatives. The 2024-26 Plan has been updated to align with the California Department of Transportation (Caltrans) Strategic Plan as well as the Planning & Modal Programs (P&MP) Strategic Plan.

How are you engaged with improving the use of data and technology in the industry?
Langari: Digital transformation of our legacy organizations like state DOT's departments, state water resources departments, the state Office of Emergency Services and CAL fire departments require development of workflows to examine relationships between information requirements and information models at the organization, asset and project level.

In the 1980s and 90s, we made the transition from the information technology architecture of a mainframe to a distributed on-premises file data and storage servers approach. After lessoned learned from late-20th-century approach, we have started transitioning into a more secure cloud-based environment. The cloud revolutionized how we store and access data, offering scalability and flexibility. It has provided opportunities for small startup companies and larger organizations to leverage tools

and solutions with greater ease of implementation.

We're starting to centralize our data by developing an organizational data dictionary. We are cognizant of what FHWA and ASHTO are doing at the national level, working on a national data dictionary for asset management, but when it comes to infrastructure right now, the 50 DOTs have 50 different data dictionaries.

Caltrans and a number of other DOTs are participating in funding studies through the Transportation Research Board, National Science Foundation and FHWA to develop a standard data dictionary that everybody can agree on. The goal is to have a standard database template, so all divisions can use the same template when it comes to identifying their assets and their attributes.

The effort includes developing a standard graphic user interface (GUI) to replace alphanumeric databases. And now we're integrating GIS, and we have 2D and 3D maps with a GUI, so you can graphically search for the data that you're looking for.

Having a one-stop shop for all the data goes a long way to closing that gap. For example, previously, each of our twelve districts used to keep track of the inventory of culverts in their own district, but in the past decade, we have standardized that across the state. There's a website on our intranet with the culvert inventory list that includes tens of thousands of items. You can get the photo of the culvert, its

history, its as-built data and the last time it was inspected.

How are you working with contractors to get the data you need on your projects?
Langari: Previously the construction contract documents didn't specifically identify the exact level of detail we wanted for the data. We've fixed that by having better construction document management that clearly defines what is expected from the contractor as they're building the facility. They turn over the final as-builts to the resident engineer to make sure that the data conforms to the requirements in the initial contract document.

We also must make sure that we provide a level playing field because we deal with major contractors that work nationally and with mom-and-pop-shop subcontractors that meet the DBE and SBE requirements. We have to be cognizant of that to make sure we provide enough training. The instructor-led and on-demand training we provide goes a long way to make sure that everybody's on board with the data requirements.

Occasionally, some people just don't want to use new technology. The challenge for us is to make sure that we provide the return on investment that everyone can see. There is a benefit to them because it's going to streamline their data for other audiences down the road that will be using the data set. You need to make sure that they can see the ROI for their company in making this transition.

How do you choose the technologies you invest in? What are your priorities?
Langari: This is an issue that a lot of the public works organizations—at the state, county and city level—face. To use the right technology, you must understand your own requirements. To do that, you need an assessment of your organization information requirements (OIR), asset information requirements (AIR), project information requirements (PIR), exchange information requirements (EIR), project information model (PIM) and the asset information model (AIM). Understanding these acronyms, depending on the size of your organization, may take six months or five years.

After you really understand those requirements, then you can start choosing the right technology. Doing that means having a standardized and developed data dictionary for any project-related database, an established standard template to develop any related databases and the flexibility to use in-house data storage versus cloud-based data storage, depending on which is more efficient.

What advice do you have for other owners who are seeking to use technology more extensively or manage their data better?
Langari: Again, really understanding your organization's information requirements when it comes to data exchange and data workflows. And part of that is understanding you don't necessarily need to pursue the

next big thing. There are a lot of people who want to jump on the bandwagon of AI or cloud services, but that may or may not be the right fit for you. The goal is to make sure you have utilized the right technology at the right time to make sure you get the highest rate of return when you implement that technology.

Also, it's all about people: Make sure you have the right people in the right places and have the appropriate training. One trap that a lot of people fall into is that they try to use the 1970s/1980s project delivery process, and they just keep throwing more technology at it. Technology may or may not be the right solution. Often, you have to go back and re-engineer your project delivery process, re-engineer your existing workflows so that you can take advantage of new technology. Buying a faster computer or putting your data sets in the cloud while using a 1970s project delivery approach will not solve your problem.

Any final thoughts on the digital transformation of the construction industry from an owner's point of view?
Langari: The DOTs and agencies that are not working to embrace this technology in the next four or five years are going to be left behind. It took 15 years in vertical construction to finally establish national data standards. Right now, the American Institute of Architects has a pamphlet that prescribes the level of development (LOD) needed for any vertical construction, but there is no similar prescription for infrastructure.

We essentially have a clean canvas. We've been working on it for a couple of years and still have another four to five years to develop a national standard. It's incumbent on us as an industry to get this right, because horizontal infrastructure is the backbone of mobility in the US. We must deal with environmental regulatory agencies, existing traffic operation, highway operations, so there's a lot of complexity. I hope that the owners take this message seriously and start investing time and effort to understand their organization requirements, so we can roll that up to FHWA and ASHTO and have a national solution moving forward.

Hopefully, by 2030, we will have a more integrated digital solution across the US as we build its infrastructure corridors.

Denver International Airport

Brendan Dillon | Director of Digital Facilities Infrastructure
Denver International Airport

What are the most effective technologies that your organization has deployed for capital planning, project management and/or asset management?
Dillon: The tools and processes we use that are most effective revolve around our cloud-based construction management and collaborative platform. We use it to manage our BIM information, both for projects as well as our asset information models or base files. We also use a computerized maintenance and management system (CMMS) to track most of our assets and the maintenance work conducted on those assets. We also have good BI dashboards to communicate about the state of those assets to state leadership stakeholders as well as other partners to ensure that we're continuing to get good information.

Could you expand on how it helps you get better data?
Dillon: What we really use it for is to highlight where we are not getting good data. But when we do get good data, it allows us to do a business risk exposure calculation on all of our assets. We rate the criticality of the asset on a scale of one to five, and then we rate the risk for that particular asset from one to five. We multiply the two together to get our business risk exposure.

An asset that is highly critical and really vulnerable because it's not in a great state would be scored a 25, and one that's not critical and low risk is a one.

The scores allow us to plan for appropriate repair or replacement of assets by letting us identify the business risk exposure of asset classes and individual assets based on the information coming from our facility condition assessments and from the maintenance work.

What are the policies and processes you have in place to ensure that you get good data on your assets?
Dillon: It comes down to two aspects of communication. The first is communicating those requirements to anyone who might be capturing that information. We put a lot of effort into making sure we have the right documentation for our contract language, and we review that documentation regularly as well.

The second is communicating with the people responsible for those contracts, because I have no authority to enforce those contracts. We can point out, "This is the language, this is the requirement," but we're not the ones telling the contractors or designers what they should do. We do a lot of engagement with project managers to point out why this information is important and show them the benefit of getting it, as well as the consequence of not getting it.

What are the top benefits you have experienced in the last few years from your investments in technology and data management?
Dillon: We've seen real benefits to our quality assurance staff, our warranty staff, commissioning staff as they have come together using a federated platform, the common data environment of our cloud-based construction management and collaborative platform.

A lot of those groups were working with paper processes previously. For example, when our quality assurance inspectors would go out in the field to inspect a project, they would bring some drawings and specs and their clipboard, and they would make notes about what was going on. Often, they would find that they don't have the right drawing or spec, so they would have to go back to the construction trailer. There was a lot of back and forth. At the end of the day, they input their notes into a Word document or something like that to finalize the inspection. It was not a great process.

With the current tools, they can take their tablet or their phone into the field. They've got the most current drawings and specs,

and they have progress photos from the entire construction project, and they can reference it all in the field as they're looking at the construction activities. In addition, because they can fill out their inspection reports on those devices, they don't have to take handwritten notes.

We have also rolled that process out to our safety inspectors, warranty staff and commissioning staff, so they all have access to the most current drawings and specs.

Are they able to add images?
Dillon: They can take photos and tag them to locations on the plans for reference, so they know exactly where they were taken. If there are issues with the construction activities onsite, they can capture those issues and assign them to the appropriate personnel as well.

I assume this process leads to greater productivity and improved accuracy. What other benefits does it result in?
Dillon: The first project we rolled this out on was a massive hotel and transit center. The construction staff were working with this platform, and they always had the most current set of drawings. There wasn't a question of, "This sheet got updated. Is this the most current version?" It always was.

We also found fairly large savings on paper. Every time a new drawing set came out, we had to print the whole thing and courier it over. This was a 12–13 story building, and we had to have multiple sets on each floor. Just by replacing the paper

versions of each of those sets, we estimated at least a $70,000 savings. And that was after paying for the software platform and the tablets that we issued to everyone.

What benefits have you experienced from the processes you have put in place to improve your data?
Dillon: A lot of those benefits are driven by asset management. We need to maintain our facilities once they get handed over. The construction might be complete, but we're still doing work on the facility constantly.

Asset data capture in the field has been a big benefit. They use their tablet or phone to tag pieces of equipment, whether it is a backflow preventer or an air handler unit. They capture information about manufacturer models, serial numbers, all the stuff we need to maintain it properly.

We have about 17 core asset data fields. On average, prior to implementing this process, we were capturing about five, on average. Once we got that process implemented, we were capturing 12, 13 or 14 before the project was even completed. We don't have to wait a year and try to capture the information from the drawings or by doing discovery after the project is completed. We know what assets we are getting at the end of design before construction even happened, so we can plan for that. We can let our maintenance personnel know, so if there is a substantial increase in certain categories of assets, they can plan to hire additional

staff or do some training on new types of assets.

By capturing that data as the project is being completed, on day one, we have the information we need to maintain those facilities.

Are there other ways you are able to integrate data from capital planning, design and construction, operations and maintenance, and asset management?
Dillon: In the last few years, we have been able to present the business risk exposure to the capital planning process. We go through a lot of factors to prioritize a project during capital planning: the ability to generate revenue, the priority of the customer that it serves, consideration of our Vision 100 plans.

Asset condition has always been a factor, but previously the rating to gauge it was highly subjective. Now that we have quantified the business risk exposure, we can look at this objective data and prioritize what needs to be addressed with a high degree of certainty. It has given us a chance to make much more data-driven capital planning decisions.

What challenges do you face?
Dillon: I said before that the key is communication. The challenge is also communication. We are a large organization with a lot of silos. Establishing good lines of communication to the right decision-makers can be tough. We have a huge capital plan, and getting everybody into a room for these discussions is difficult because everyone is so busy.

Do you have data and technology use requirements for the project teams you employ?
Dillon: We have a constantly evolving set of requirements. Specific to the asset management and the DFI team, we have a design standards manual for digital facilities and infrastructure, which outlines the data and technology requirements to meet our needs.

We also work with other groups to establish their needs and requirements, whether they're in operations, maintenance, planning or concessions. We integrate their requirements into our design standards manual, and we review all the information as it comes in from our designers and contractors. In the review process, we grade every submittal based on its compliance line by line. Some requirements are identified as more critical than others, not because the data or requirement is less important, but because of its downstream impacts. For example, something that has to do with the asset data requirements, we would identify as critical. If you're not complying with that, it's an automatic fail.

We look for around 70% compliance on the noncritical items, but we look for 100% on the critical ones. We have also been tracking that information over time for about nine years and provide it to the people who make the decisions about contract awards. Sometimes we get to sit in on the selection panels, and we'll ask how they will make sure that their sub consultants who have struggled to meet these requirements in the past can do so on the current project, and what initiatives they have to help with our digital delivery needs.

We also have our own three-year flight plan that feeds into Denver Airport's Vision 100 Strategic goals. (We initially called it a road map, but then we realized that, since we are an airport, it has to be a flight plan.) It includes a broad range of goals around model management, asset management support, contract language, strategic planning and digital twin deployment. We must make sure that we don't regard the process of developing our standards, models and technology as finished and pretend that the world isn't going to keep moving. Because it is. Technology keeps advancing, standards keep advancing and our customers' needs keep advancing. We use our flight plan to make sure to stay on top of that.

What advice do you have for the architects and contractors who want to improve their relationship with you as a client?
Dillon: I would tell them that we work really hard to have clear, concise, specific requirements, and they are there for a reason, even if the designer or contractor doesn't understand why they are there. If you are unclear about why a requirement exists, just ask us. We will tell you.

What advice do you have for other owners to help them improve their use of technology and data?
Dillon: Don't be afraid to reach out. We collaborate with other airports all the time. We do local outreach with other owners in our area to share what we are doing and hear what they are doing. As a government owner, we are not bound to protect trade secrets. We want to improve the process, and sharing is a big part of that. I find that when I have conversations with people who are just starting out on their journey, they'll ask questions that I never considered before, and that helps us improve our processes. It is incredibly beneficial for us and for them.

Also, don't be afraid to own your mistakes. We have made many of them, and we try to be open and honest about them when we have those conversations with other owners. The trust that engenders leads to incredibly beneficial conversations, much more than if you just sit there talking about your successes.

Princeton University

Pedro Fajardo | BIM Manager
Office of Capital Projects

What are the most effective technologies that your organization has deployed for capital planning, project management and/or asset management?
Fajardo: When I came to Princeton, we were very digitally mature already. Over the last 20 years, the capital projects team, and the facilities team overall, has a really good grasp on their goals for the future. In 2005, the first BIM spec was put out, and ever since we have had a clear set of instructions about what we want the future of our digital transformation to be.

Since I joined, one of the most effective technologies that our organization has deployed has been our cloud-based construction management and collaborative platform. We had been tinkering with different products in the past and dealing with a lot of platforms. We were constantly trying to innovate to bring all stakeholders together, all the data together. It wasn't until we deployed this platform that we saw the communication, collaboration, analysis and data visualization we were seeking. We use it for everything from documents to field communication. We also use it for BIM collaboration with other stakeholders, and we provide licenses to everyone—architects, engineers, general contractors—to encourage them to be part of this environment.

We are also seeing a huge AI boom in the technologies we implement. For example, we recently introduced code compliance into our workflow process, which allows us to automate and visualize compliance issues early in the design phase. It saves time, avoids rework and enhances quality control before we advance to later phases of the project.

What makes these technologies effective for us is the ease of use. That is particularly important when things are transforming rapidly. Collaboration functionalities are also a plus because we encourage everyone to engage and be part of everything. What makes that possible is this idea of interoperability and open ecosystems. We are not stuck with a rigorous set of steps that will only work if you do it a certain way. We are providing a flexible ecosystem and a platform that other tools can plug into. We need effective data, and we need to be able to provide effective frameworks that speak to each other.

What specific data management policies and practices have you implemented that have had the biggest impact on your organization?
Fajardo: The university implements a design standard manual (DSM), which they share

with the design team, providing a clear set of guidelines so they know what to expect. We also have our BIM execution plan. Like I said, we introduced this BIM spec that defined the standards for digital collaboration in the early 2000s. It includes naming conventions, asset data requirements, milestone-based data deliverables. Having these data management practices sets a clear expectation of all stakeholders, so everyone is aligned from the start.

In addition, the idea of having a centralized ecosystem where data is gathered is important for data management. Prioritizing our common data environment is important.

What are the top benefits you have experienced from your use of these technologies and data management strategies?
Fajardo: One of the first things we started seeing was improved collaboration. Everyone is working from a single, centralized source of truth. This creates a lot of efficiencies, like automated notifications. You don't have to send out an email or manually notify anyone when the "ball is in their court." The system is so smart that it automatically understands the information that is being entered and helps to alert the necessary stakeholders and keep everyone connected. For model coordination and early

issue detection, the AI tools are helping a lot.

We are able to integrate these tools with our expertise, and to resolve problems before they even arise onsite. For example, if we use the code compliance tools before we submit for permits, it reduces the timeline and efforts created when projects hit roadblocks during this phase, and it saves money.

Our data management allows us to tap into business intelligence tools that display analytic information from data we have always collected but have never been able to use. Now they allow us to visualize and be informed about the health of the project and make better decisions.

One example of this occurred on one of our largest capital campaigns. We asked all the contractors to submit estimates of how large their workforce was going to be on campus for each project. We used those inputs to build an analytic tool that gave us a visualization of the peak of our capital campaign. These workforce projections helped us understand the impact that the capital campaign was going to have on campus, mobilize everything we needed to keep everyone on campus safe and minimize the disruption that huge projects have on people's everyday lives.

How integrated are capital planning, project management and asset management at your organization and how integrated do you want them to be?
Fajardo: That's where we want

to be, to have a fully integrated ecosystem that speaks to each other and can inform each other. We are in a transitional phase at the moment, where project data is starting to inform capital planning more directly, especially with the introduction of a cloud-based collaborative platform. We are collecting the data and starting that process, but the long-term strategy is to be able to have a fully integrated system. Currently, our dashboards are structured data outputs that allow better-informed decisions on day-to-day campus impacts, but we want to start integrating the cost aspect.

We have had a lot of success with our asset management software, so there is a framework in place, but the challenge is how to integrate it. One of the ways we are doing that is to capture data directly from the models and use custom APIs to push the data from one platform to another. What we are looking for is a fully integrated lifecycle of systems from a digital perspective that can communicate back and forth to make the data visible across platforms.

What data requirements do you have for your project teams?
Fajardo: We are pursuing digital twins, but the data we get from subcontractors doesn't always include the data we need. A lot of them are tracking data in spreadsheets. But we don't demand that they follow a rigorous model-based process. That is why an ecosystem that allows flexibility is so important because we can say to these subcontractors, "We are looking

for manufacturer serial numbers and other types of specific information, but you can collect it in spreadsheets and plug it into our cloud-based common data environment." The platform allows for integrations with Excel spreadsheets, so we do not have to impose a specific set of guidelines.

This allows us to be nimble and transform the data between our project management and asset management platforms. The data needs to be clean, and you need to identify the keys for matching it. But once you can glue all the pieces of data together because the platforms allow that interconnectivity, you are setting yourself up for success. It also prevents us from relying on a specific system to do a set of tasks. With the new technologies, new workflows and new challenges that are coming out, flexibility is key.

Do you have any initiatives in place to help your project teams meet your digital needs?
Fajardo: Yes, we use the cloud-based platform to deploy this idea of a community, in which we provide training and open Q&A sessions to all stakeholders, so that they are part of this environment. We provide onboarding sessions to help them understand the platform. Onboarding early is important because in using a collaborative tool like this, the questions arise of who is going to provide the licensing and the training? I think the owner should be a leader in that, and that is what we are doing. We provide a framework and resources because we see

the value in it for us, but also for the other stakeholders as well.

What are the biggest challenges you face in your efforts to invest in and capitalize on data and technology?
Fajardo: Adoption and change management will take time, but ease of use helps with those challenges. Some partners are highly digital, while others are just starting that journey. But I think as you partner more with everyone, they will get exposure to using the technology and they will come along.

Having said that, clean, consistent data is important, especially in a common data environment. Getting the right data that will benefit us as an owner is a challenge. Aligning on standards is something we are working on constantly. We are providing flexibility and not asking our project teams to do something completely new, but we are asking them to transition from something they already know to a new process.

What are your next big initiatives?
Fajardo: Reality capture is one. We are already using those tools, but we would like to take it a step further by building a standard around them that validates what's being built against the digital information. We also want to have that validation support the model-based handovers because that feeds into our other initiative, which is digital twin readiness. We want to be able to have true data that we can use in our digital twin. We are almost there. The data is there, and our

standards are there. Our use of models is setting that foundation. Now, we just need to bring it all together.

We are also looking at expanding our use of AI tools. We want to be able to create forecasting and risk modeling together with digital visualization on dashboards. Integrating all that together will connect us to real-time planning and project metrics.

Finally, as a campus, we are looking at how 3D models can integrate with GIS information to support spatial planning, emergency response and sustainable initiatives.

What advice do you have for other owners seeking to improve their use of technology and data?
Fajardo: Building standards early on is important because that gives you a framework to prioritize and lets stakeholders know what your expectations are.

Choosing a platform with open architecture and integration options is also really important. It will keep you from being constrained and allow for the flexibility we've discussed. Accompanying the platform and common data environment with visualization tools is also important.

Finally, focus on training as much as you focus on the tools. You need easy-to-use tools because when you train the stakeholders, you want it to be simple and straightforward.

What advice do you have for designers and contractors to become better partners with a digital owner like you?
Fajardo: My advice is similar to that for the owners. Align with the owner's standards and expectations. Ask any questions early on. You do not want to ask questions close to turnover and be left scrambling at the last minute.

I also recommend understanding the client's long-term goals and being open to learning new technologies and how you use them so that they add value to the entire team.

Also, embrace the cloud collaboration common data environment as a true collaboration tool. I gave a presentation at Autodesk University about the fear of sharing data with an owner. What might the owner do if they see I am behind schedule? We are entering into a world where we want to make these challenges visible, not just for accountability, but so that we can collaborate and make decisions together. Because the owner is a collaborator and partner as much as the designer or contractor. Changing that mindset is very important.

Methodology

This study was conducted by Dodge Construction Network (Dodge) for the National Institute of Building Sciences (NIBS), with support from Autodesk, Esri and Trimble. The study establishes a baseline of owner use of data-centric approaches and digital technologies.

The research was conducted using an online survey from November 2024 to February 2025.

SURVEY SAMPLE
The sample was drawn from the following sources:

- Outreach by Dodge to owner contacts drawn from its database of construction projects

- Outreach by NIBS

- Outreach by the funding partners (Autodesk, Esri, Trimble)

- Outreach by research partners
  > American Road and Transportation Builders Association (ARTBA)
  > Construction Owners Association of America (COAA)
  > Construction Users Roundtable (CURT)
  > Design-Build Institute of America (DBIA)
  > InfoTech
  > Lean Construction Institute (LCI)

RESPONDENTS
188 owners responded to the survey. The respondents had to be part of an organization that has engaged in non-residential construction activity in the US, with $5M or more in annual project value. They also had to be directly involved with or managing construction-related activities at their organization.

- **Type of Organization Respondents Work For**
  > Local Government: 33%
  > Private/Commercial Company: 29%
  > Public/Private Institution: 19%
  > State/Federal Government Agency: 18%

- **Top Types of Assets Built/Maintained by Their Organization (Selected by at Least 10%)**
  > Institutional Buildings: 65%
  > Transportation Projects: 45%

- > Commercial Buildings: 42%
  > Water Utilities: 38%
  > Power/Energy Projects: 33%
  > Industrial Buildings: 26%
  > Manufacturing Buildings: 14%

- **Size of Owner Organization by Annual Project Value**
  > Small ($5M to Less Than $25M): 22%
  > Midsize ($25M to Less Than $100M): 26%
  > Large ($100M to Less Than $500M): 21%
  > Very Large ($500M or More): 23%

- **Respondents' Areas of Influence at Their Organization**
  > Design/Construction: 71%
  > Procurement: 62%
  > Technology Used for Design, Construction and/or Asset Management: 57%
  > Planning/Programming: 55%
  > Finance Related to Design/Construction/Asset Management: 39%
  > Asset Management: 34%

- **Location of Projects**
  > Top regions were South Atlantic (34%) and Pacific (28%).
  > At least 20% had projects in the East North Central (21%), West North Central (21%) and Middle Atlantic (20%).
  > Between 15% and 18% reported that they have projects in the remaining four Census regions.

INDEXES USED FOR ANALYSIS
Two indexes were created based on the responses to the study to examine the influence of the use of data-centric approaches at an organization and the influence of a high degree of technology use. The description of how these indexes were calculated and the number of respondents who fall into the low, moderate and high categories of each are described on pages 30 and 45.

Resources

Organizations, websites and publications to help you get smarter about the digital strategies owners are utilizing and how their investments will help further the digital transformation of the design and construction industry.

DODGE CONSTRUCTION NETWORK

DODGE CONSTRUCTION NETWORK
MAIN WEBSITE   www.construction.com

DODGE CONSTRUCTION CENTRAL
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