

Improving Performance With Project Data

How Improved Collection and Analysis Is Leading the Digital Transformation of the Construction Industry

Premier Partner:



VIEWPOINT
A TRIMBLE COMPANY

SmartMarket Report

Dodge Data & Analytics

Chief Executive Officer

Michael Petruccio

Dodge Data & Analytics Research & Analytics/ Industry Insights

Senior Director, Research & Analytics

Burleigh Morton

Senior Director, Industry Insights Research

Stephen A. Jones

Director, Industry Insights Research

Donna Laquidara-Carr, Ph.D., LEED AP

Reproduction or dissemination of any information contained herein is granted only by contract or prior written permission from Dodge Data & Analytics.

Copyright © 2019,
Dodge Data & Analytics,
ALL RIGHTS RESERVED

Improving Performance With Project Data SmartMarket Report

Executive Editor

Stephen A. Jones

Managing Editor

Donna Laquidara-Carr, Ph.D., LEED AP

Chief Marketing Officer

Sharon Lubrano

Contributing Art Director

Alison Lorenz

Contributing Art Director

AD-BOUTIQUE, INC.
Terumasa Yamada

Contributors

Bruce Buckley
Katharine Logan

Research Project Manager

Dana Gilmore, MRA, PRC

Media Contact

Nicole Sullivan
AFFECT Public Relations
& Social Media
212-398-9680
nsullivan@effectstrategies.com

For further information on this *SmartMarket Report* or for any in the series, please contact:

**Dodge Data & Analytics
Research & Analytics
34 Crosby Drive
Bedford, MA 01730**

1-800-591-4462

**[www.construction.com/
toolkit/reports](http://www.construction.com/toolkit/reports)**



About Dodge Data & Analytics

Dodge Data & Analytics is North America's leading provider of analytics and software-based workflow integration solutions for the construction industry. Building product manufacturers, architects, engineers, contractors and service providers leverage Dodge to identify and pursue unseen growth opportunities and execute on those opportunities for enhanced business performance. Whether it's on a local, regional or national level, we make the hidden obvious, empowering our clients to better understand their markets, uncover key relationships, size growth opportunities and pursue those opportunities with success. Our construction project information is the most comprehensive and verified in the industry. We are leveraging our 100-year-old legacy of continuous innovation to help the industry meet the building challenges of the future.

To learn more, visit
www.construction.com.

Introduction

Data from the field has always been vital for contractors to understand the progress and health of their projects. Advancing technology is making all kinds of field data easier to collect, analyze and share with teams. But what types of data, and which tools and processes do contractors work with most frequently and find to be the most valuable? The *Improving Performance With Project Data SmartMarket Report* addresses these questions in order to provide guidance to all contractors who want to improve project performance by more effectively gathering and leveraging field data.

The findings presented in this report are based on a survey of construction managers, general contractors, specialty trade contractors and design/build firms in the U.S. that focus primarily on buildings.

- Since specialty trades are closely involved with managing site labor and equipment in the field, the report compares their responses with all others when the differences are meaningful.
- To provide a balanced perspective, the respondents range from the C-suite to manager level and estimators, and represent a good mix of small, midsize and large companies.

While there are many types of data that could potentially be valuable for analysis, this research focuses on five key types that are widely applicable:

- **Project progress**
- **Man hours**
- **Productivity**
- **Safety**
- **Equipment management**

Respondents were asked how they currently gather, store, manage, secure, analyze and report on each of these types of field data with a specific focus on their current level of satisfaction and plans for making future changes. Key trends that emerged among those findings are explored more fully in the report, including:

- **A rapid shift away from paper-based forms/reports and spreadsheets to digital tools and platforms, some leveraging cloud technology.**
- **Increasingly frequent use of apps on mobile phones and digital cameras in the field.**
- **The desire for more accurate field data that enables trend analysis across projects.**
- **Keen focus on data security with frequent use of anti-malware software and enterprise-grade firewalls.**

Contractors who said they have improved their capabilities to gather and analyze field data over the last three years report numerous benefits that are explored more fully in the report, including:

- **Better budget and schedule compliance**
- **Greater productivity and profitability**
- **Improved safety**

Lastly, the study explores contractors' current understanding of and engagement with several emerging technologies and processes that are poised to dramatically impact the industry:

- **Predictive analytics**
- **Machine learning**
- **Artificial intelligence**

This report is part of an extensive body of research conducted by Dodge Data & Analytics that examines the business benefits of technology for companies in the construction industry. We thank Viewpoint for being the Premier Partner for this study. We hope it inspires current users of these technologies to expand their field data gathering and analysis initiatives while encouraging others to get involved.



Stephen A. Jones
Senior Director
Industry Insights Research
Dodge Data & Analytics

Stephen A. Jones leads DD&A's Industry Insights Research division. He is active in numerous industry organizations and frequently speaks at industry events around the world. Before DD&A, 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).



Donna Laquidara-Carr, Ph.D., LEED AP
Industry Insights
Research Director
Dodge Data & Analytics

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

TABLE OF CONTENTS

4 **Executive Summary**

7 **Recommendations**

8 **Data**

8 **Gathering Data From the Jobsite**

- 8 Relative Importance of Different Types of Jobsite Data
- 9 Current Methods of Gathering Onsite Data
- 10 Satisfaction With Current Methods of Gathering Jobsite Data
- 12 How Current Methods of Gathering Jobsite Data Will Change
- 14 Use of Advanced Devices to Gather Jobsite Data
- 15 **SIDEBAR Metrics That Matter**

17 **Storing and Managing Data**

- 17 Approach to Storing Data
- 18 Reasons for Choosing Cloud Storage
- 19 Concerns About Cloud Storage
- 22 Approach to Data Management
- 23 Approach to Data Security
- 24 **SIDEBAR Coming to Grips With Cyber Risk**

25 **Analysis of Data by Contractors**

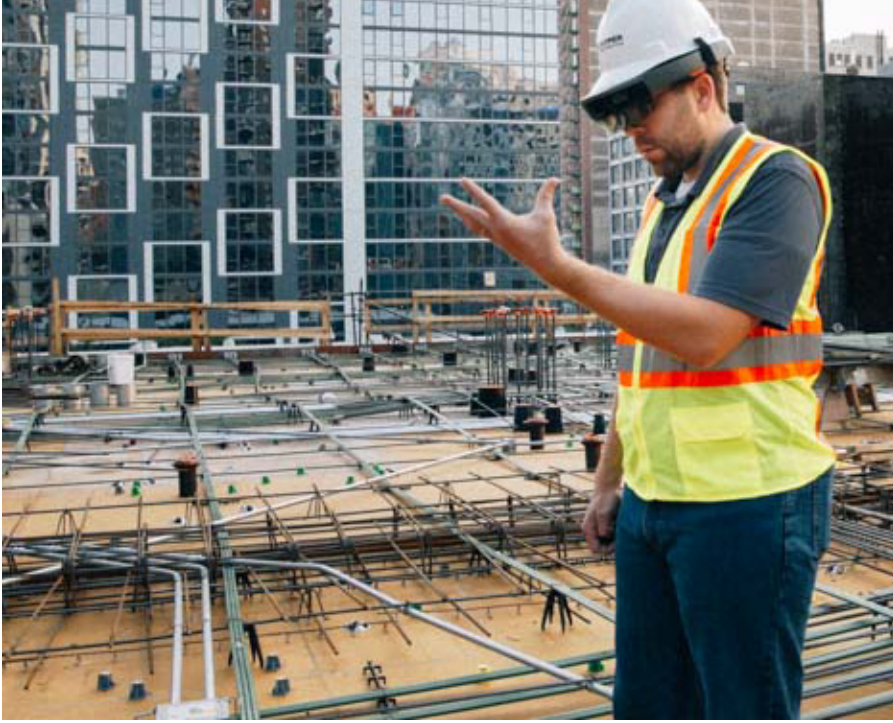
- 25 Use of Automated Analysis and Standard Reports
- 26 Types of Reporting and Analysis Conducted by Contractors
- 27 Roles That See Project Analysis and Reports
- 28 **SIDEBAR Data-Integrated Decision Making**

30 **Benefits of Improved Data Gathering and Analysis**

- 30 Improvements and Benefits Experienced in the Last Three Years
- 32 Capabilities That Contribute to Benefits
- 33 Improvements Needed to Increase Benefits

36 **Emerging Technologies Built on Data**

- 36 New Approaches to Gathering and Using Data
- 37 **SIDEBAR Wearable Sensors and Safety**
- 38 **SIDEBAR The Future of Data for Construction: Predictive Analytics, Machine Learning and Artificial Intelligence**



This page (left): Augmented reality provides Pepper Construction with a new way to access information onsite.

This page (below): The Pepper Construction team uses a digital form of pull planning in their Lean practice.



Case Studies

20 **Using the Cloud to Enhance Productivity on Projects**
Leander Construction, Canton, Illinois

34 **Better Building Through Data**
Pepper Construction, Chicago, Illinois

Thought Leader

29 **Jit Kee Chin, Executive Vice President and Chief Data Officer, Suffolk**

40 Methodology

41 Resources

Executive Summary

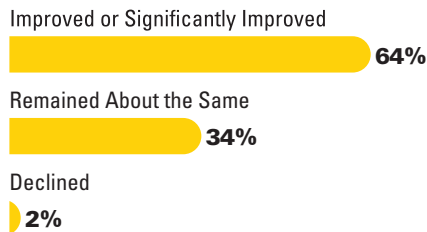
Technology tools are revolutionizing how contractors gather, analyze and report on field data to improve project performance, profitability and competitiveness.

The findings of this study reveal how contractors are gathering and analyzing data now, the benefits of improving those capabilities and the potential for using this data to improve projects in the future.

Improvements in Data Gathering and Analysis Capabilities

Most contractors report improvements in their data gathering and analysis capabilities over the last three years. This is especially true at larger companies.

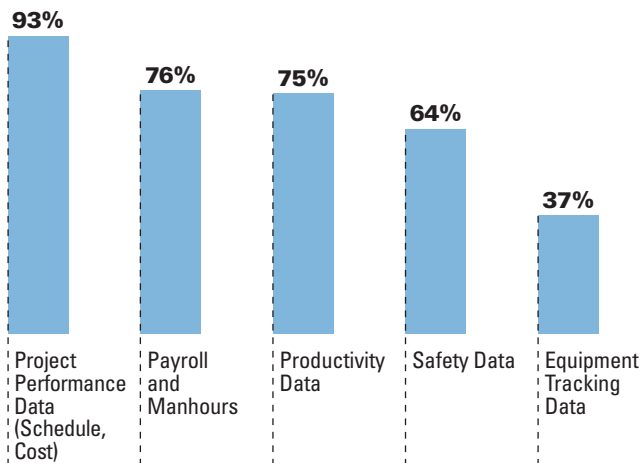
Dodge Data & Analytics, 2019



Most Important Project Data to Gather

Contractors assign highest value to project performance, payroll and manhours, productivity, and safety data from the field. Collection of equipment tracking data is still emerging.

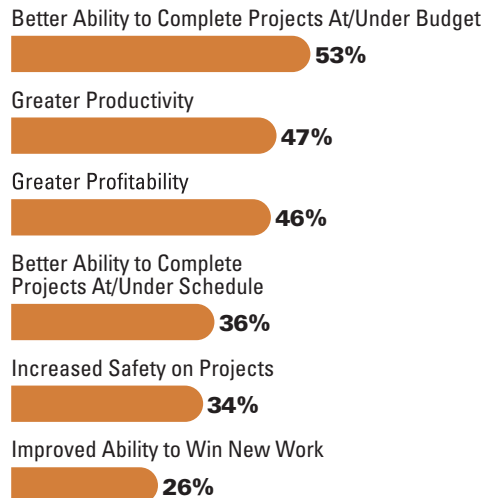
Dodge Data & Analytics, 2019



Benefits of Improved Data Gathering and Analysis Capabilities

Contractors who reported improved data gathering and analysis selected the top three benefits generated by that improvement. Below are the percentages that include each benefit among the top three. Better budget compliance tops the list, followed closely by improved productivity, profitability and safety.

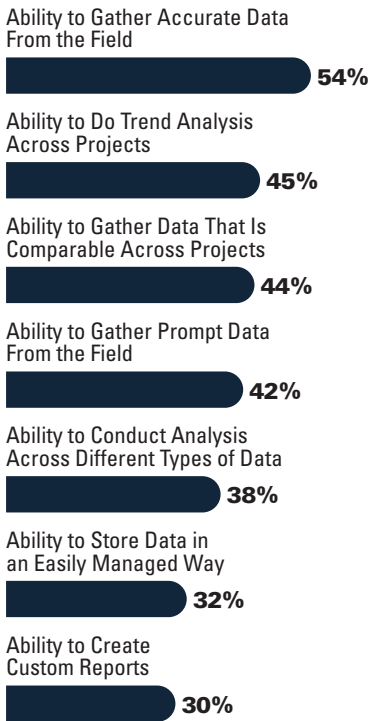
Dodge Data & Analytics, 2019



Most Important Capabilities to Improve Over Next Three Years for Better Data Gathering and Analysis

Contractors selected the three most important capabilities that need to be improved over the next three years in order to help them continue to advance in data gathering and analysis. The percentages below represent total top-three inclusion, led by ensuring better data accuracy and followed by cross-project data and trend analysis.

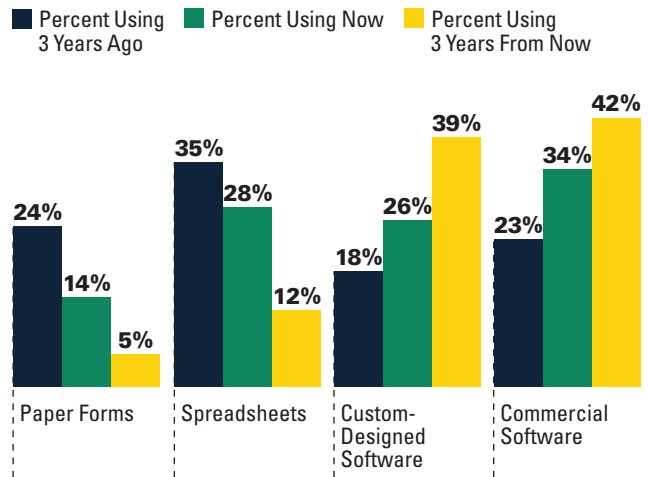
Dodge Data & Analytics, 2019



Methods of Data Collection

The use of paper forms and spreadsheets for data collection are both in sharp decline. Meanwhile, custom-designed and commercial software each show dramatic growth.

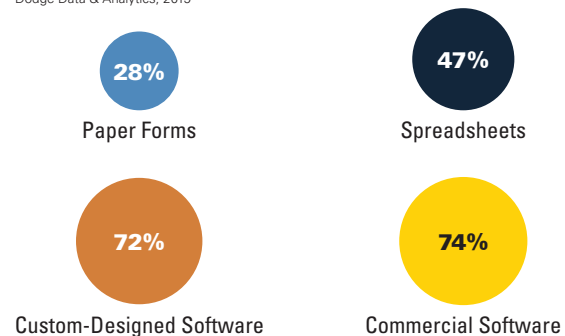
Dodge Data & Analytics, 2019



Satisfaction With Collection Methods

The percentage of contractors reporting satisfaction with the effectiveness of each method aligns closely with the usage trends, reinforcing the rapid industry shift toward software.

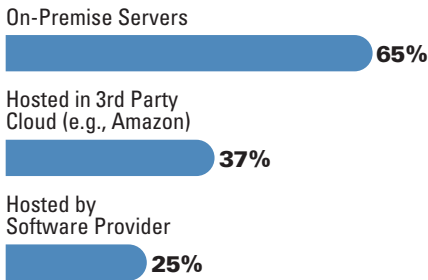
Dodge Data & Analytics, 2019



Approaches to Hosting

While most contractors are still storing the data gathered from the field in on-premise servers, a growing number are also using commercial cloud service providers and software providers.

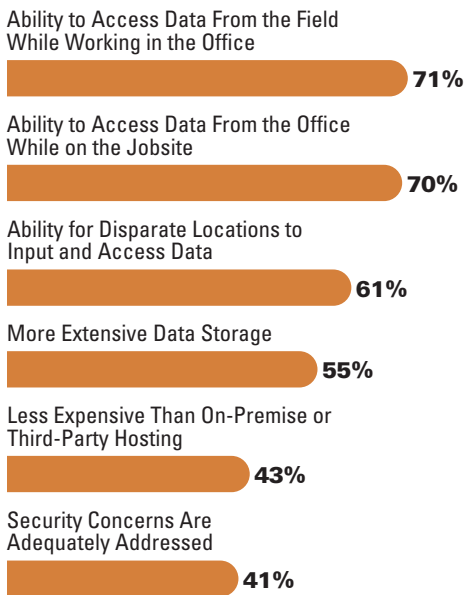
Dodge Data & Analytics, 2019



Benefits of the Cloud

Ease of data access and input from disparate locations are the three most common benefits reported by contractors who are using cloud services.

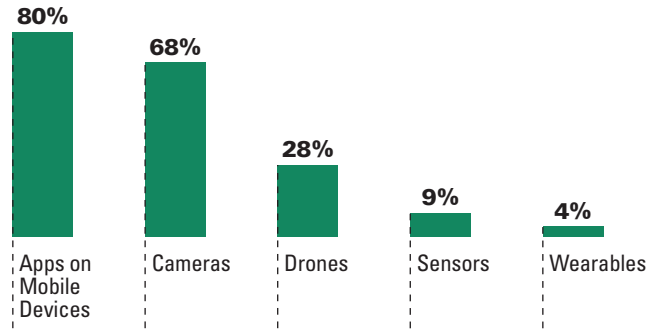
Dodge Data & Analytics, 2019



Advanced Devices for Data Collection

Well over half of contractors are now using mobile phone apps and cameras to gather and input data from the field. Drones, sensors and wearables are still emerging, but can be expected to grow.

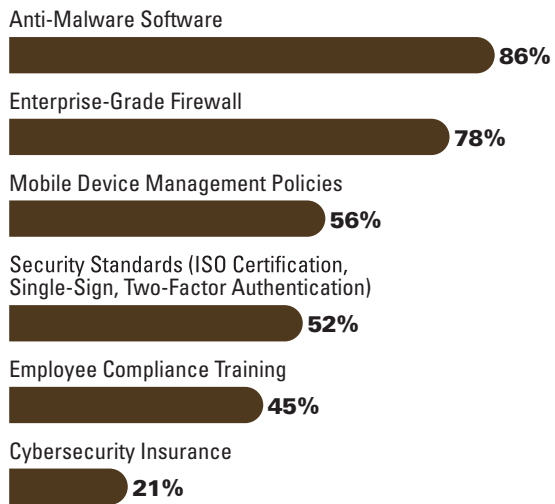
Dodge Data & Analytics, 2019



Approaches to Data Security

As device usage expands, contractors report taking a variety of approaches to manage data security, with anti-malware software and enterprise firewalls being the most common.

Dodge Data & Analytics, 2019



Recommendations

Construction companies are revolutionizing the ways they gather, analyze and report on field data to improve their project performance, profitability and competitiveness.

The recommendations on this page are intended to provide actionable insights based on the findings of the research presented in this report for companies at all stages of their digital transformation journey.

Maintain a Tight Focus on What Matters for Your Company

This four-step process to structure your company's data collection, analysis and reporting initiative can help to make it successful.

1. INFORMATION: Thinking with an end in mind, first determine what aspects of your project delivery process would benefit the most from better information to support good decision making, for instance:

- **More current project status updates?**
- **More reliable productivity figures?**
- **More accurate equipment usage records?**

The right answers are unique to your company and essential to your data strategy.

2. DATA: From that, the next steps are to:

- **Identify which specific types of field data will best enable the proper analysis to generate that critical decision-support information.**
- **Think carefully about the minimum level of completeness, accuracy and timeliness required for each type,** because that will greatly impact the feasibility and level of effort involved in gathering and managing it for analysis. What will be "good enough" to be helpful?

3. PLAN: The first two steps form the basis for your company to develop a focused technology and process plan for data collection, analysis and reporting, including:

- **Specific data needed and types of analysis required**
- **Types and amounts of financial and human capital investments required**
- **Time frames for implementation**
- **Clear roles and responsibilities**
- **Measurable goals for success**

4. IMPROVE: As the benefits accrue, don't get complacent. Regularly revisit the three previous steps to continually improve and expand your company's data initiative.

Embrace the Shift to Software, the Cloud and Advanced Approaches to Data Collection

The findings of this report clearly demonstrate two key trends:

- **Contractors are rapidly adopting these innovations.**
- **Those who are implementing them effectively are receiving a wide variety of meaningful benefits and are planning to expand their initiatives.**

Your company can be a leader or a follower as suits your strategy and resources, but non-participation is no longer a viable option in order to remain competitive in your market and attractive as an employer.

Acknowledge That Data Expertise is a Core Competency for Construction Companies and Recruit, Hire, Train, Measure and Nurture Your Talent Accordingly

The effective use of data that reveals how well a company operates is becoming increasingly central to the success of every business. So, both as a hiring filter and a condition for advancement, incorporate whatever levels of data literacy make sense in particular roles to best support your collection, analysis and reporting initiative.

And remember, your company doesn't have to do this all by itself. Take advantage of industry organizations, trusted peers, technology companies and consultants who can all help.

Data: Gathering Data

From the Jobsite

Relative Importance of Different Types of Jobsite Data

IMPROVING PERFORMANCE WITH PROJECT DATA SMART MARKET REPORT DATA

THE BIG PICTURE

Not all data is created equal. Contractors can invest time and effort into establishing processes to collect and analyze many kinds of data, but which ones are the most useful for better decision making and improved outcomes?

Research and Chart

To explore this question in the survey, contractors were asked to rate five different types of data in terms of how important each one is to the success of their projects. The chart at right shows the percentages of general contractors and specialty trades who rated each as having either high or very high importance.

Overall Findings

While most firms gather data on each of these items, project performance, man hours, productivity and safety are rated as valuable by considerably more than half of the respondents.

DIFFERENCES BETWEEN GENERAL CONTRACTORS AND SPECIALTY TRADES

Although it is not surprising that all respondents assign top value to project performance data, some interesting differences emerged between general contractors and trades on the other data types:

- Because labor is so critical to trades, more of them consider tracking payroll/manhours and productivity data to be a high priority.
- Also, because a lot of the equipment on a jobsite is related to specific trades, they are also more focused on tracking that type of data.

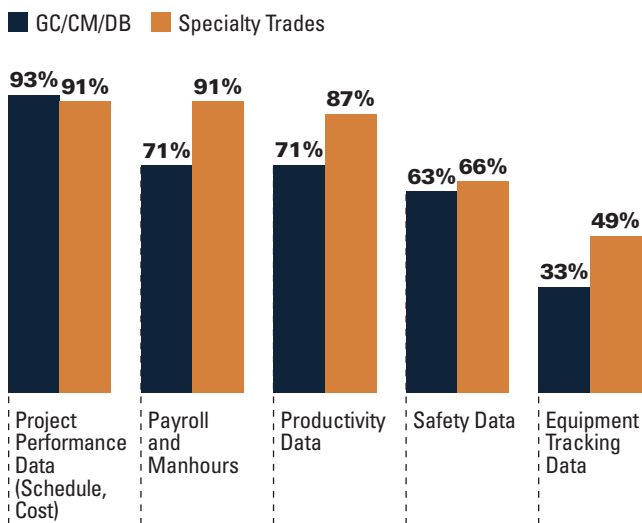
Encouragingly, there is a nearly equal focus on safety data, with about two thirds of all contractors rating it among the most important.

DIFFERENCES BY SIZE OF COMPANY

There is no significant difference in ratings by firm size for any of the categories studied.

Percentage of Contractors Attributing High/Very High Importance to Collecting Different Types of Data

Dodge Data & Analytics, 2019



Current Methods of Gathering Onsite Data

THE BIG PICTURE

Once contractors decide what data they want to focus on collecting, they have choices to make about methods for gathering and tracking it, ranging from traditional paper forms to specialized software solutions that are either commercial (off-the-shelf) or custom designed.

Research and Chart

To establish a baseline of current industry practices, contractors were asked how they currently gather five specific types of data from the field. The chart shows the combined percentages of both general and specialty trade contractors who report using one or more of these four methods to gather each type of data:

- Paper forms
- Spreadsheets
- Custom-designed software
- Commercial (off-the-shelf) software

Overall Findings

Commercial software is well established as the most frequently used solution except for safety, where paper forms and spreadsheets are still common. This may indicate an underserved need that software companies could address.

Project performance (schedule, cost) data has the most advanced collection process of the five types:

- Least use of paper forms
- Highest use of commercial software
- Second-highest use of custom-designed software

However, project performance also has the highest use of spreadsheets, reflecting either their role as an important part of the digital workflow, or some resistance to abandoning all existing tools in favor of a specialized software solution.

Though scoring the lowest, traditional paper forms are still being used for every data type studied, and it may require a generational shift to fully retire them from the jobsite.

DIFFERENCES BETWEEN GENERAL CONTRACTORS AND SPECIALTY TRADES

There is no significant difference between how general contractors and specialty trades gather these five types of data.

DIFFERENCES BY SIZE OF COMPANY

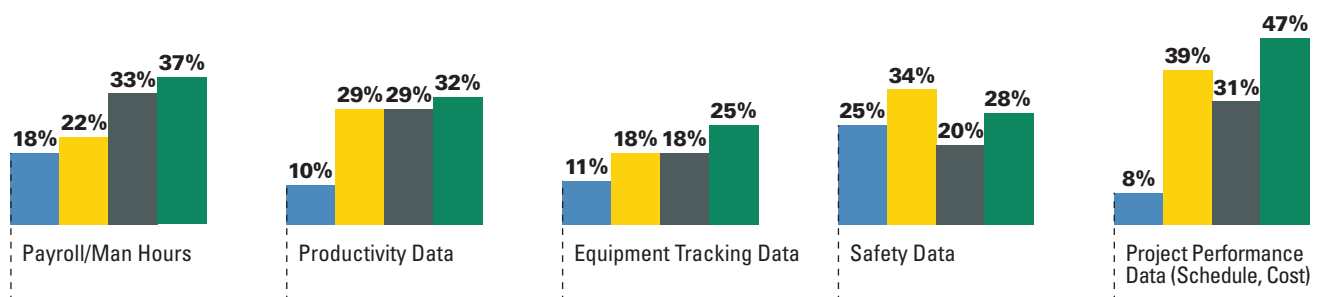
There are some differences related to company size:

- More small firms still more frequently use paper forms for payroll/man hours.
- Larger firms more frequently use custom-designed software for safety and project performance data.

Current Means of Collecting Data

Dodge Data & Analytics, 2019

■ Paper Forms ■ Spreadsheets ■ Custom-Designed Software ■ Commercial Software



Satisfaction With Current Methods of Gathering Jobsite Data

THE BIG PICTURE

To optimize the use of data collected from the field for better analysis and decision-making, it is critical that the data is timely, accurate, sufficiently detailed and comprehensive enough to extrapolate across multiple projects. Different methods of data collection have varying strengths and weaknesses in these regards.

Research and Charts

To determine experienced users' perspective on the relative effectiveness of four different methods of data collection, contractors who reported using each one were asked about their level of satisfaction with it (Not Satisfied, Somewhat Satisfied, Satisfied, or Very Satisfied), specifically related to four aspects of its value:

- The timeliness of data gathering
- The accuracy of the data being gathered
- The ability to analyze data across multiple projects
- The level of detail that is made available on the data

The charts show the combined percentages of both general and trade contractors who report either being satisfied or very satisfied with each aspect of the four methods.

Paper Forms

The least satisfactory of the four methods is using paper forms.

- They have the lowest rating for each of the value metrics, resulting in an average satisfaction level of just 28% across all four.
- 3% or fewer report being very satisfied with any aspect of using paper forms.
- Paper forms are particularly poor for supporting the ability to analyze data across projects, with only 17% reporting satisfaction.

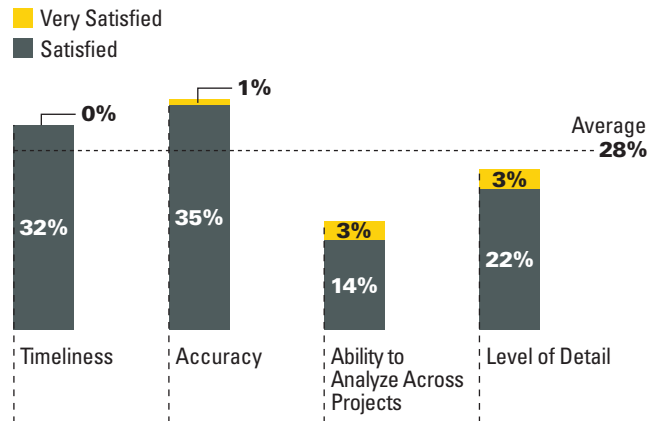
Spreadsheets

Spreadsheets are better than paper forms but not as effective as software in any category.

- Accuracy is the best aspect of using spreadsheets, with 50% of contractors satisfied with this means and another 8% very satisfied.
- Nearly twice as many are satisfied with the level of detail (48%) than with paper forms (25%).

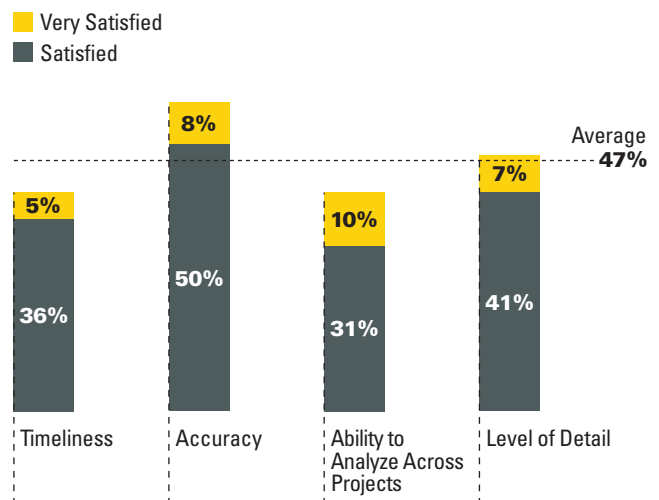
Contractor Satisfaction With Data Gathered on Paper Forms

Dodge Data & Analytics, 2019



Contractor Satisfaction With Data Gathered in Spreadsheets

Dodge Data & Analytics, 2019



- Satisfaction with timeliness is better than with paper (41% versus 32%) but not nearly as effective as software (average 76%).
- 41% of contractors report satisfaction with multi-project analysis ability (versus just 17% with paper), but that is far fewer than software’s satisfaction ratings (average 68%).
- Spreadsheets earn an average satisfaction rating of 47% across the four categories.

Custom-Designed Software

Custom-designed software is more satisfactory than paper forms or spreadsheets.

- An average satisfaction rating of 72% across the four categories of value.
- All metrics score strongly, with timeliness (75%) and accuracy (74%) as the leaders, but level of detail (72%) and multi-project analysis support (68%) are close behind.
- Among the 68% citing satisfaction with multi-project analysis support, over one third say they are very satisfied, the highest of any category in the study.
- Custom-designed software garners a 72% average satisfaction rating across the four metrics.

Commercial Software

This is the overall satisfaction leader.

- Outperforming the other three methods in every category, commercial software has the highest average satisfaction rating (76%).
- It particularly excels in the level of detail it makes available for analysis and decision support (79%), the highest satisfaction score earned in this study.

Comparison of Satisfaction Ratings

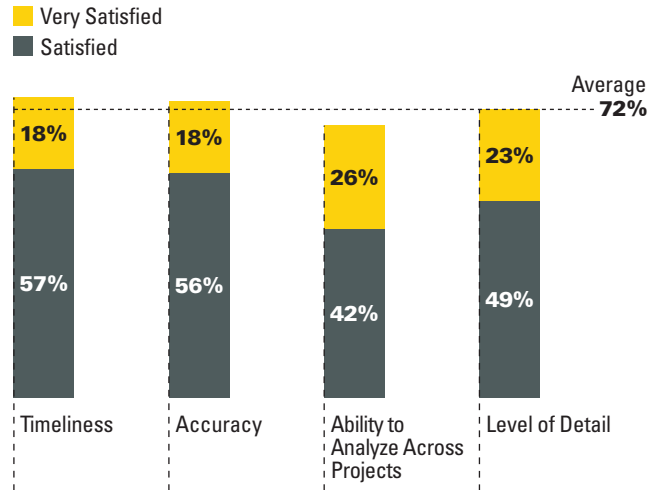
The table shows the percentage of contractors who are satisfied or very satisfied with each data gathering method across the four value metrics studied.

Contractors Satisfied/Very Satisfied With Aspects of Data Gathering by Various Means

	Paper Forms	Spreadsheets	Custom-Designed Software	Commercial Software
Timeliness	32%	41%	75%	78%
Accuracy	36%	58%	74%	76%
Analyze Across Projects	17%	41%	68%	69%
Level of Detail	25%	48%	72%	79%
AVERAGE	28%	47%	72%	76%

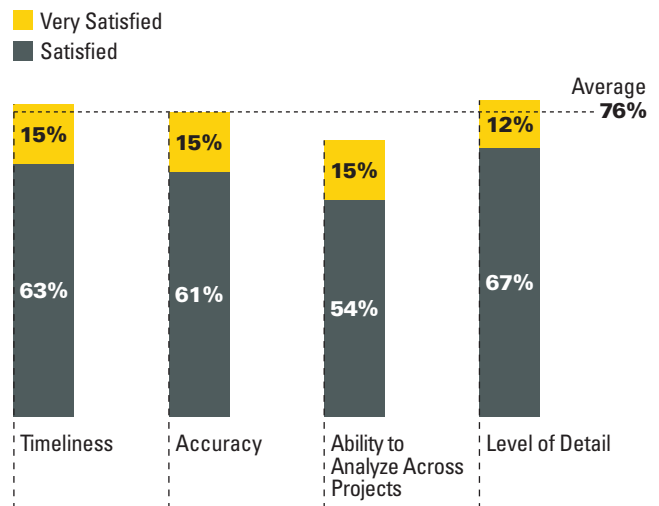
Contractor Satisfaction With Data Gathered From Custom-Designed Software

Dodge Data & Analytics, 2019



Contractor Satisfaction With Data Gathered From Commercial Software

Dodge Data & Analytics, 2019



How Current Methods of Gathering Jobsite Data Will Change

THE BIG PICTURE

The process of gathering data from the field is evolving rapidly and can be expected to continue to advance as technologies mature, common platforms become established and more project teams embrace fully digital workflows.

Research and Charts

To show how dynamically the construction industry is changing its approach to data gathering, contractors were asked about the method(s) they used to collect each of five types of data three years ago, now and three years in the future. The charts show how the practices of all respondents (general contractors and specialty trades) are evolving.

Payroll/Manhours

- Three years ago, there was about an even split among use of each of the four methods studied, but both commercial and custom-designed software solutions are projected to strongly dominate by 2021.
- There are no significant differences by firm size or between general contractors and specialty trades in how they expect to gather this data in 2021.

Productivity

- There is a major drop from the previously very high (42%) use of spreadsheets in 2015 to only 12% by 2021, replaced by a strong uptake of both commercial (42%) and custom-designed (44%) software, about doubling their usage from 2015.
- Paper forms were already the least used method in 2015 and fall to nearly zero in 2021.
- There are no significant differences by firm size or between general contractors and specialty trades in how they expect to gather this data by 2021.

Equipment Tracking

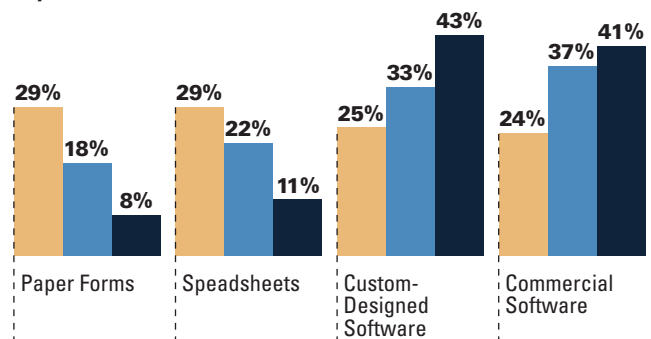
- In 2015, contractors were relying most frequently on spreadsheets (27%) and paper forms (21%), but use of both of those methods is expected to reduce sharply by 2021, especially paper (5%).
- The adoption of software is not as strong as is projected for the other four data types. This may relate to the applications for that specialized use being less mature and to possible required adaptation or replacement of the equipment itself.

Means of Gathering Payroll/Man Hours, Productivity and Equipment Tracking Data (Past, Current and Future)

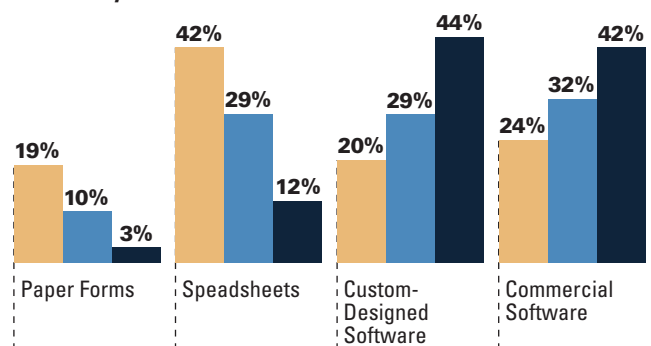
Dodge Data & Analytics, 2019

■ Three Years Ago ■ Current Method ■ Three Years From Now

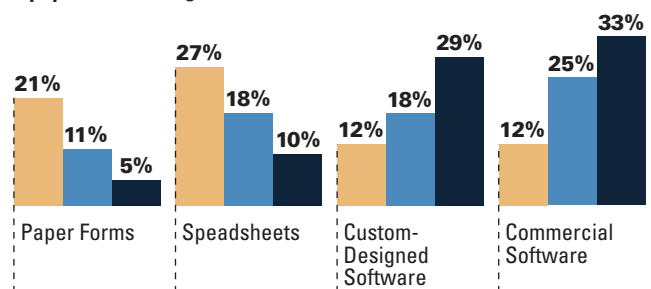
Payroll/Man Hours



Productivity Data



Equipment Tracking Data



- While advances are predicted for equipment tracking data, no method is forecasted to be used by more than one third of contractors.
- There are no significant differences by firm size or between general contractors and specialty trades in how they expect to gather this data in 2021.

Safety

- This is another data type that was dominated in 2015 by spreadsheets (39%) and paper forms (34%). However, those top positions will be supplanted by custom-designed (35%) and commercial (44%) software solutions by 2021.
- A significantly higher percentage of large firms say they plan to use custom-designed software to track safety data by 2021.
- There are no significant differences between general contractors and specialty trades.

Project Performance

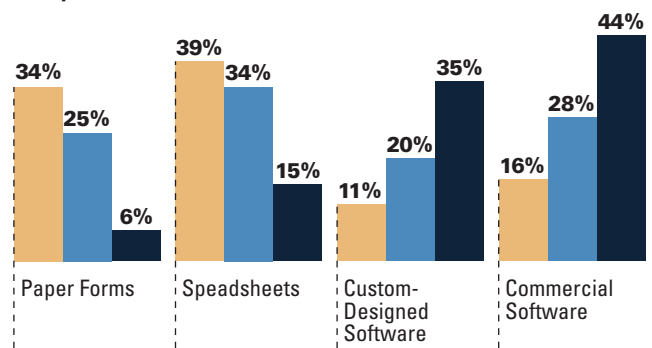
- In 2015, commercial software was already the most well established with this data type (41%) and is projected to continue to show the highest penetration (51%) in 2021, but mostly with general contractors rather than trades.
- Custom-designed software is growing the most quickly, projected to nearly double over the period, with a particularly high percentage of large firms expecting to use it.
- Spreadsheets were a highly popular (40%) method in 2015 but drop to only 14% by 2021.
- Paper forms were not significant in 2015 (16%) and nearly disappear (4%) by 2021.

Means of Tracking Safety and Project Performance Data (Past, Current and Future)

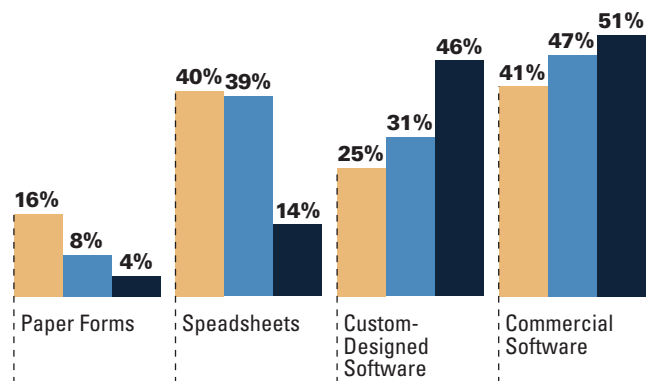
Dodge Data & Analytics, 2019

Three Years Ago Current Method Three Years From Now

Safety Data



Project Performance Data



Use of Advanced Devices to Gather Jobsite Data

THE BIG PICTURE

Like all other major industries, an exciting array of new electronic methods are emerging for construction that help automate data gathering and enable effective integration of the data into digital workflows and analytical processes.

Research and Chart

To determine the current level of adoption, we asked general contractors and specialty trades to identify the electronic tools and methods they are currently using to capture data in the field. The chart shows the percentages of contractors who report some level of use of each.

Overall Findings

Apps developed to work on mobile devices are the most common overall, which aligns with the general growth of this category in all parts of the economy. Wearable devices on workers and sensors in the field to track movement and environmental conditions are both still in the early stages of emergence.

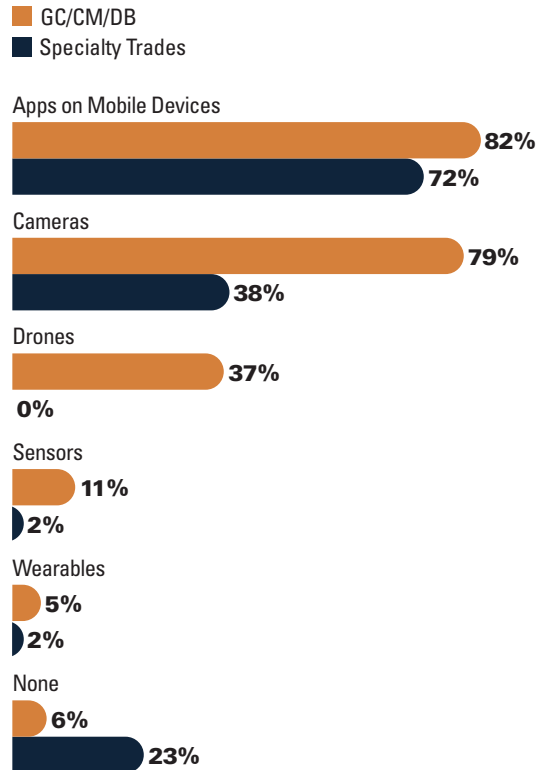
DIFFERENCES BETWEEN GENERAL CONTRACTORS AND SPECIALTY TRADES

Overall, general contractors are much more likely to be using at least one of these devices than specialty trades.

- **While the use of cameras to capture jobsite data is common among general contractors (79%), less than half as many (38%) specialty trades report doing so.** This may reflect a focus on using cameras to document progress, or to illustrate questions and provide clarifications, both of which tend to be handled more commonly by the general contractor.
- **Drones are an even more extreme example of a tool being used primarily by general contractors (37%) compared with the trades (no use).** Again, this probably represents the nature of their use for capturing existing conditions, measuring bulk material usage and other site-related issues, and documenting construction progress.
- **Almost all (94%) of the general contractors are using at least one of these devices, but nearly a quarter (23%) of trades are still not using any.**

Electronic Tools Used to Capture Field Data (by Percentage of Contractors Using Each)

Dodge Data & Analytics, 2019



DIFFERENCES BY SIZE OF COMPANY

Other Dodge research studies often show that large organizations tend to lead the industry in early adoption of new technologies. This trend holds true again here, where large companies report more frequent use of mobile device apps, drones and sensors than smaller firms.

Metrics That Matter

Tracking key performance indicators has already been widely recognized as critical to improving projects, but knowing what data to gather can impact whether contractors fully benefit from the information.

Data gathering and analytics allow construction professionals to track metrics like never before, but to avoid drowning in all this new data, practitioners need to track the metrics that matter. So which are they?

Most Frequently Used and Valued Metrics by Contractors

RFIs, change orders, schedule, costs, errors and omissions, and safety rank among the most tracked and most valued metrics. A study of key performance indicators (KPIs) for contractors, conducted by Dodge Data & Analytics in 2018, revealed the following:

- Nearly 90% of general contractor/construction manager respondents routinely log RFIs on a majority of projects.
- Nearly 70% document the majority of change orders and evaluate their schedule impact.
- 60% frequently capture errors, omissions and constructibility issues in construction documents.
- Over half make regular use of software to help manage safety and inspections.

Metrics Sought by Owners

Anecdotally, many owners would welcome data from their peers on the number or dollar value of projects managed per person, and salaries paid, but the Construction Owners Association of America's (COAA)

general counsel warns that that type of sharing could run afoul of antitrust regulations.

Other kinds of data that could be usefully tracked and safely shared, suggests Howie Ferguson, COAA's executive director, include multi-project comparisons of predicted versus actual duration of design and construction phases. Such data would update a 2003 study by the University of Texas of its own projects, which found that its predictions of construction duration were, on average, accurate within 3%, but its predictions of design phase duration underestimated by, on average, 88%.

A metric that could help owners avoid duplication of effort is the percentage of design feedback that a project team fails to address in successive deliverables—and which therefore has to be repeated. "That metric could tell me whether I wanted to work with that team again," says Ferguson.

Some owners track requests for information (RFIs) as an indicator of a poor set of design documents, but in Ferguson's experience, that is not productive. "RFI data could be an indicator of something to look into," he says, "but raw quantity doesn't tell you anything." An RFI may indicate a gap in the documents, but it could just as easily indicate an inferior contractor asking unnecessary questions, or a capable one taking proper care on a complex project.

Lagging Versus Leading Indicators

Asking what is behind a metric and why it matters constitutes the first step toward identifying indicators that go beyond describing to actually predicting outcomes—especially successful outcomes. "Too often we're doing failure analysis based on the root causes of a problem," says Sue Klawans, a senior construction executive and Lean management consultant. "But what if we looked at the root causes of success?"

As a starting point, Klawans refers to the concept of visual management, a crucial element in the Lean paradigm and a rubric for monitoring and communicating information. Visual management enables key data to register at a glance, fostering both micro-advancement (what we're doing onsite for the week becomes more clear) and macro-advancement (our project is more profitable, and we're achieving agreed deliverables). It expresses a team's shared understanding of what to measure and why. And it enables the team to see where a given metric stands relative to a shared goal, so the information can inform action.

"People think that the things they want to measure are whether a project was on budget, or on schedule, or how many change orders it had," says Klawans, "but when you really look at visual management systems, you begin to understand that all of those things are lagging indicators. They're consequences." The leading

indicators, the ones that predict a consequence, are what Klawans calls “metrics that matter.”

Identifying predictors of success poses more of a challenge than tracking lagging indicators, especially as the definition of success can vary from project to project. However, in a 2017 session of the Associated General Contractors of America (AGC)’s Public/Private Industry Advisory Council (a group set up to promote dialogue with public and private owners involved in facility construction), some 40 to 50 owners, architects, general contractors and trade contractors took a crack at it, with subsequent sessions at COAA conferences expanding the effort.

Team Health Is a Leading Metric

At the outset, most participants reported measuring lagging indicators, often without ploughing the knowledge gained back into improving the next project. However, in the course of reflecting on what made some of their projects successful and others just average, the group reached what Klawans calls an “aha!” moment. “The people in the room, practitioners who run projects for their universities and their hospitals, were arriving at a shared conclusion that it’s the team’s functionality that drives success,” she says. “Team health is the leading indicator.”

The COAA session defined team health as a function of the group developing a culture, process and capability that sustains it through the project. Good team health means you don’t have to stack a project team with A-plus players: competent

people with the right mind-set and a strong framework can achieve extraordinary results.

A pair of quantitative studies conducted by Dodge Data & Analytics for the Lean Construction Institute supports the group’s finding. In each study, one conducted with owners and one with architects and designers, a strong team culture was a common feature on the best projects that respondents had worked on and far less common on typical projects.

But if team health is the metric that matters, how do you track it and integrate it into decision-making? To make a start, the COAA session developed options for participants to pilot. For example, would it be effective for a team to gather together its obstacles, assess their relative significance and the team’s capability to clear them, and then monitor progress monthly? Or would it be useful to conduct a short monthly survey focused on team health and review observations at the next team meeting, with sample questions perhaps including:

- Are all project team members actively and meaningfully engaged in the project?
- From my own point of view, am I modeling behaviors to ensure a safe site? Am I seeing all the others on the team model behaviors to ensure a safe site? Is there a difference between those two answers, and why?
- Do we have open and transparent dialogue? Or is information being withheld?
- Do I enjoy being part of this team, and am I proud of what we’re creating?

However project teams try to get at the metric of team health, “it’s relatively new in the industry for an owner to take a serious look at the intangibles of a project, and specifically at the morale and health of its project team,” says Ferguson. “But in the last two to four years, people have started coming around to the idea that, even with all this technology, it’s still people who make projects succeed. Those people, their buy-in, their ownership of the process, that actually does matter.” ■

Data: Storing and Managing Data

Approach to Storing Data

THE BIG PICTURE

As jobsite data is increasingly being gathered from the field for analysis, contractors are using a variety of on-premise and cloud capabilities to store and manage it.

Research and Charts

To examine how firms are currently dealing with data storage and management, contractors were asked to identify which method(s) they are now using. The charts show the responses broken out by company type and by company size.

Overall Findings

Looking at the aggregate responses from all the contractors surveyed:

- On-premise servers are currently the most popular approach, with two thirds (65%) reporting using them.
- Over half (62%) are taking advantage of third-party hosting, with the use of commercial vendors such as Amazon reported more frequently (37%) than working directly with a software provider (25%).

DIFFERENCES BETWEEN GENERAL CONTRACTORS AND SPECIALTY TRADES

Almost three times as many general contractors (average 36%) are engaged with third-party hosting than specialty trades (average 13%), the great majority of which (85%) report self-hosting with on-premise servers.

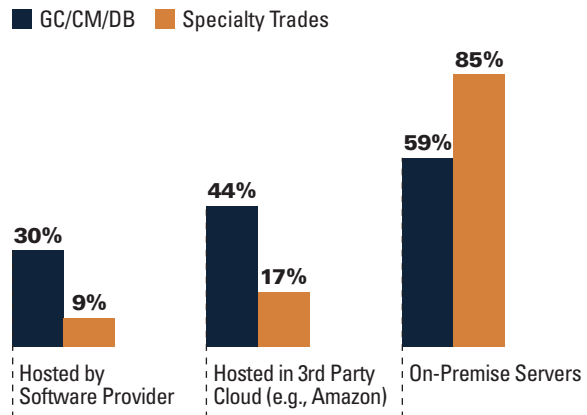
DIFFERENCES BY SIZE OF COMPANY

As the second chart makes clear, there is a direct relationship between a company's size and its comfort level using third-party hosting.

- About 50% more small companies (77%) are maintaining their data on-premise than large ones (55%).
- Three times as many large contractors (38%) work with a software vendor for hosting as do small firms (13%).
- Commercial cloud vendors are somewhat more accepted by smaller contractors than having their data hosted by software providers, which may point to future growth.

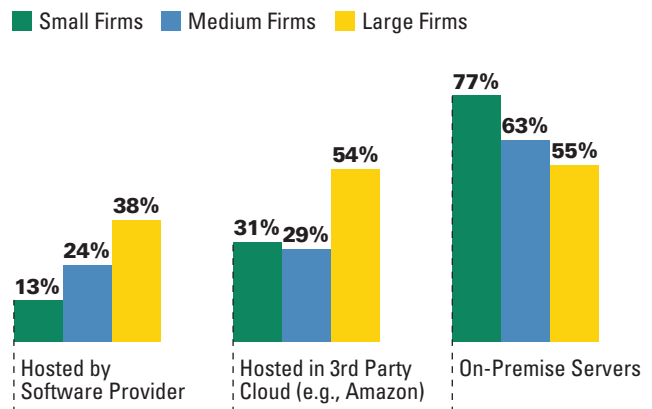
Where Data Is Stored (By Company Type)

Dodge Data & Analytics, 2019



Where Data Is Stored (By Company Size)

Dodge Data & Analytics, 2019



Reasons for Choosing Cloud Storage

THE BIG PICTURE

Cloud computing is a rapidly advancing trend throughout all facets of global industry. The advantages and risks of using third parties to host data (and sometimes software functionality as well) are the topic of extensive evaluation as an increasing number of contractors are electing to use cloud-based services.

Research and Charts

To establish the drivers for this dynamic trend, contractors who indicated they use the cloud to manage data were asked to identify, among seven reasons, all the ones that influenced them to choose it, and from those, to select the most important one. The chart shows these results for all contractors surveyed, in order of the most important reason.

Overall Findings

The top three most-cited reasons by all contractors relate to effectively connecting the office and the field to each other and to disparate locations. They also rank first, second and fourth among the most important drivers.

Adequate security is core to the use of the cloud for multi-location data exchange. Having it satisfactorily addressed is the third most important reason, yet it only ranks next to last among all options, so those who chose it are very focused on it.

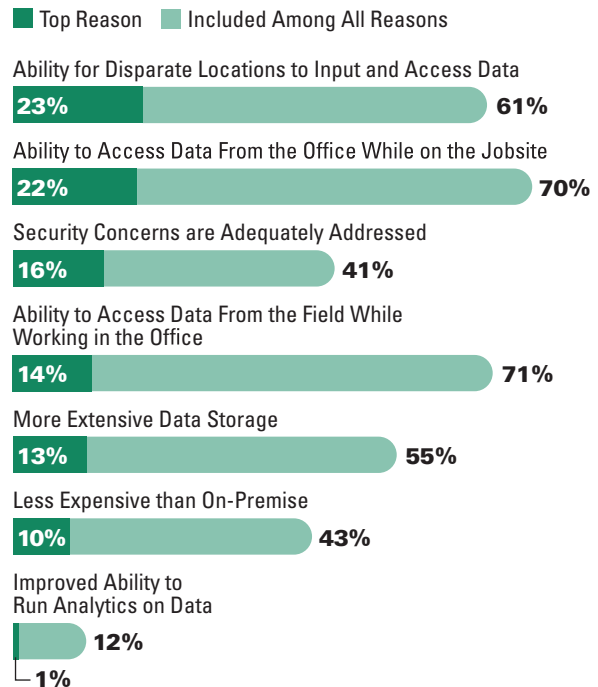
Over half (55%) of respondents identify more extensive data storage as a reason for using the cloud, but it just ranks low (fifth) among top drivers. This priority may change as contractors store ever-larger quantities of data and come to appreciate cloud capacity.

Conversely, lower cost rates high (third) among all reasons, but next to last among the most important. While almost always included in “check the box” concerns, cost falls back when considering important process improvements with tangible benefits.

The low score for running better data analytics in the cloud is likely because this is still an emerging practice among contractors, and it can be expected to increase significantly as a driver once more firms take advantage of this powerful capability.

Reasons for Managing Data in the Cloud

Dodge Data & Analytics, 2019



Concerns About Cloud Storage

THE BIG PICTURE

In large industries such as construction, participants have varying degrees of comfort with new technologies and changing processes. They typically become the late adopters of trends after others have already made them standard operating procedure.

Research and Charts

To understand their perceived obstacles to adopting cloud-based data management, the contractors who indicated they are not yet using the cloud were asked to select, from a list of five, all of the reasons that are influencing their reluctance. The chart shows the percentage who identified each.

Overall Findings

Satisfaction that there is adequate security emerged as an important driver among contractors who are using cloud-based data management, and the issue appears again here as the top reason non-users have not yet adopted. These findings should be a clear message to providers that security is top-of-mind for both users and prospects.

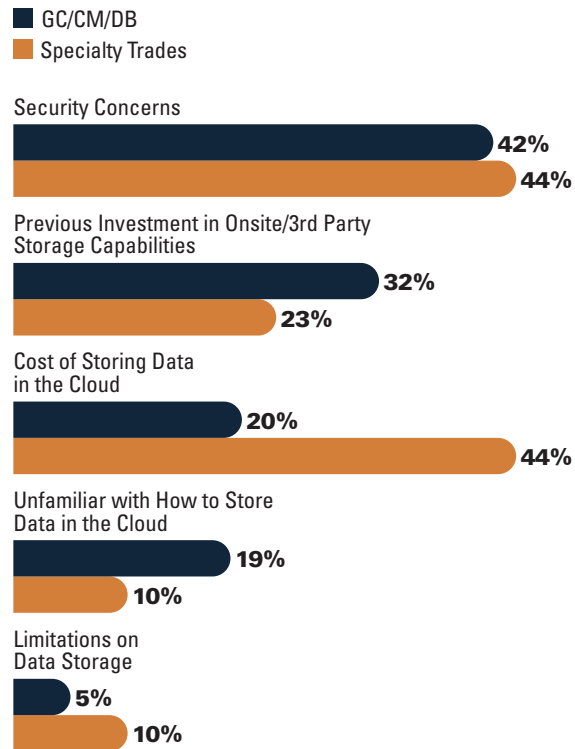
The second and third most-cited objections (previous investments in other storage solutions, and cost) score about equally. And they are compounded in that if a non-user is concerned about the cost of cloud-hosting, it makes it even worse if they are already investing in other data storage solutions, making the new cost completely incremental.

DIFFERENCES BETWEEN GENERAL CONTRACTORS AND SPECIALTY TRADES

Nearly half (44%) of trade contractors report that they are not using the cloud because of cost, compared to just 20% of general contractors.

Reasons for Not Managing Data in the Cloud

Dodge Data & Analytics, 2019



Using the Cloud to Enhance Productivity on Projects

Leander Construction
CANTON, ILLINOIS



Using a cloud-based system has made Leander more productive on projects like the Eldridge Wastewater Treatment Plant.

For project managers, superintendents and other key project staff, the burden of administrative tasks can negatively affect productivity. At Leander Construction, an Illinois-based water and wastewater contractor, project staff members are expected to keep track of submittals, requests for information, updated drawing sets and other critical project data without the aid of support staff.

Automating Submittals and RFIs

In 2017, the company added a cloud-based solution that works with its existing project management software and helps automate many of the tasks that they had previously done manually. “We used to assemble submittals and put them in

an email and track them manually,” says Bobby Asbury, senior project manager at Leander. “Any comments were on emails back and forth or on the submittal itself.”

Instead of pulling data from its submittals register, exporting it and attaching it to emails multiple times, much of that work can be scheduled in advance and automated. Leander’s project staff no longer has to manually update the progress of its submittals—subcontractors and vendors can log in to the system, add required information and move the submittal on to the next step in the process. “It’s seamless because it’s all interconnected,” he adds.

Asbury says the process does require more upfront work at the beginning of a project. He sets up the submittals register and schedules the dates for when submittal information

is due. Based on that schedule, the system can automatically send reminders to subcontractors and vendors about upcoming due dates. Subcontractors and vendors are able to interact with the system without having to purchase any software.

“Once you get it set up, then you can concentrate on the project,” he says. “You’re not worrying about emailing people about when things are due.”

Asbury estimates that, even with the added upfront work, he has reduced the time invested in submittals by more than 25% since using the cloud-based system. “Time spent constantly hounding subs and vendors has gone out the door,” he says. “You’re not constantly tracking and checking and double-checking.”

Subcontractors and vendors can also issue RFIs through the system,

Leander Construction

CANTON, ILLINOIS

which Asbury says helps the team track requests more efficiently and consistently. “We set it up so that RFIs are routed directly to the project manager, who can either answer it or get an RFI over to the engineer,” he says. “It significantly reduces email correspondences by keeping everything in one package.”

Improved Team Access to Drawings

Since first adopting the new cloud-based system, the company started leveraging additional capabilities. Leander now uses the system to manage and store drawings, allowing the team to have an easily accessible single source for up-to-date as-built drawings. Asbury says the new process helps reduce the risk of errors. “I’ve had superintendents put an RFI in early on a project, but when we were three-quarters of the way into the project and finally hit that spot (referenced in the RFI), it wasn’t noted on the hard copy they have in the trailer,” he says. “That’s the error of not updating the hard set. Now, we keep these drawing sets updated electronically. I have a superintendent who, the first thing he does before he goes out to build a new task is check the drawings on [the system] to make sure it’s the current set.”

Leander’s subcontractors in the field can also reduce errors by accessing the drawings from the system. “We recently had some mechanical and electrical guys trying to work from an old set,” he says. “I told them to get their guys connected to tablets so they can look at the updated sets moving forward. They each got tablets, and they can now pull up the drawings quickly onsite.”

Asbury says a critical part of the system’s success is making it easy for its vendors and subcontractors. Submittal information, for example, is provided in an easy template that is consistent across all of its projects. “All a sub has to do is wait to be invited to a job, and it’s pretty much set up on the front end for them,” he says. “You can tie a vendor to two dozen submittals, if you want to. It’s all set up in advance and consistent.”

Asbury hopes that by making its submittal and RFI processes easier that it gains a competitive advantage in attracting quality subcontractors and vendors to projects. “I get a lot of comments on how well organized we are on projects,” he says. “You’ve got everything laid out in front of you, so it all looks very organized. You don’t have to think too much—it’s all just there.”

Improved Collaboration

Asbury says the system opens up the possibility for better collaboration on projects. Leander and its partners can share important information more easily, both in the field and meetings, to make more informed decisions. Leander is also able to invite owners, representatives, engineers and other project members who are outside its silo to access information from its system. Asbury says he can set permissions that dictate what other team members can and can’t access. “They might see schedules, pictures or submittals, if they want to,” he says. “Some are pretty involved. Some aren’t interested.”

Data Organization

The company also recently moved its daily logs to the system to create

a standardized way of documenting the details of a project. “When you’re on the jobsite, you can take a picture and upload the picture right to that portion of the daily log,” he says.

By setting up templates and consistent processes, Asbury says the company has been able to better standardize its structures. Templates and folder structures—which can store schedules, photos, contracts, permits, RFIs, ASI and other project files—can be copied from one project to the next. Through this standardization, the company creates a sense of familiarity for its regular subcontractors and vendors, as well as its employees. If a project manager needs to be out of the office, for example, another member of the project team can step in to help cover a project more easily because they already know the standard processes. “Our goal is to be standardized across the company,” he says. “It’s boring, but effective. I want my job to look like the guy’s next to me.”

Adoption of the system has presented some challenges. Asbury says he’s seen “a bit of a learning curve” among some of its superintendents. “It can seem time consuming at the start, but eventually, it’s a time-saver for the field,” he says. “But some people are still old school in their approach.”

Leander provides some training on the system for staff, but Asbury says it relies on the system’s help section and tutorials to answer questions about using the system.

Overall, Asbury says the system has allowed the company to find new ways to improve its data management and keep employees focused on important tasks, improving productivity. ■

Approach to Data Management

THE BIG PICTURE

As the construction industry continues to adopt and deploy an ever-widening array of technology tools, data management is becoming a core capability for all types and sizes of contractors. This creates needs for technology leadership roles and centralized data management policies and strategies.

Responsibility for Data Management

To understand how they are currently approaching data management leadership, contractors were asked to identify who, if anyone, is primarily responsible for data management. The top chart shows how the approach varies across different sizes of construction companies.

There is a direct relationship between the size of a company and its likelihood of having an IT director/manager, with only about half (54%) of small firms reporting it compared with almost all (95%) large ones.

The converse applies to having no one responsible for data management, with almost one third (30%) of small firms in that category compared with 19% of midsize firms and only a few (5%) large ones. With data management becoming more important all the time, there is an opportunity to help smaller companies become more engaged.

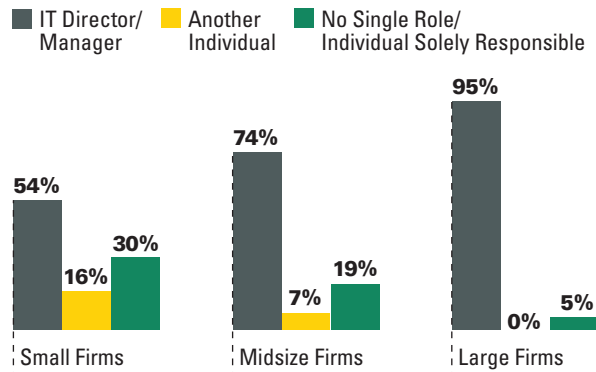
Database Strategy

To determine their strategies for managing databases and consolidated platforms, contractors were asked to characterize their approach in one of three categories. The chart compares the responses of large firms with the average of small and midsize ones.

While most companies begin their data management journey using a different database for every kind of data, most eventually consolidate to fewer, or even to a single platform. Interestingly almost half (43%) of large contractors, which are typically viewed as the most technologically sophisticated, still report having multiple databases for different types of data. Rather than a reluctance to advance, however, this finding may represent the greater challenge of centralizing data management in a larger operation. Smaller firms can be nimbler.

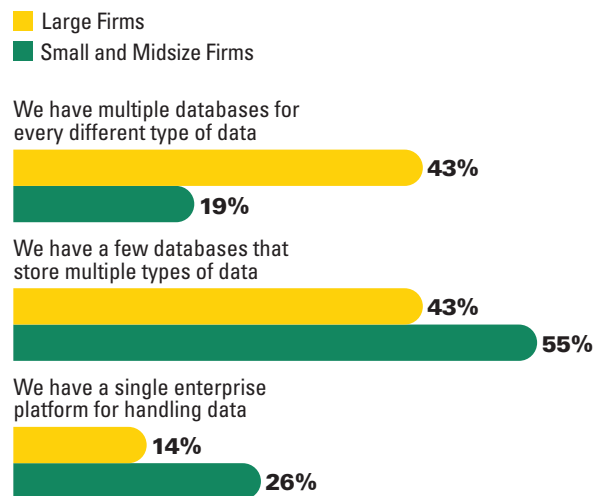
Role Responsible for Data Management (By Size of Firm)

Dodge Data & Analytics, 2019



Use of Databases (By Size of Firm)

Dodge Data & Analytics, 2019



Approach to Data Security

THE BIG PICTURE

As most industries around the world experience accelerating digital transformations, concerns about the security of confidential business data are increasingly top-of-mind. Findings in this section of the study about the influence of security issues on both adopters and non-users of cloud services exemplify this trend.

Research and Chart

To learn more about how contractors are addressing data security, all survey participants were asked to identify, from a list of six, all of the methods they are currently using to ensure data security. The chart shows their aggregated responses.

Overall Findings

Almost every contractor (98%) is using at least one of these measures, and most are deploying several.

- Well over three quarters are addressing security technologically, with anti-malware software (86%) and enterprise grade firewalls (78%).
- Over half are deploying policy-based solutions: mobile device management policies (56%) and/or security standards (52%).
- But less than half (45%) are working directly with data/device users through employee compliance training, and even fewer (21%) are investing in third-party cybersecurity insurance.

DIFFERENCES BY SIZE OF COMPANY

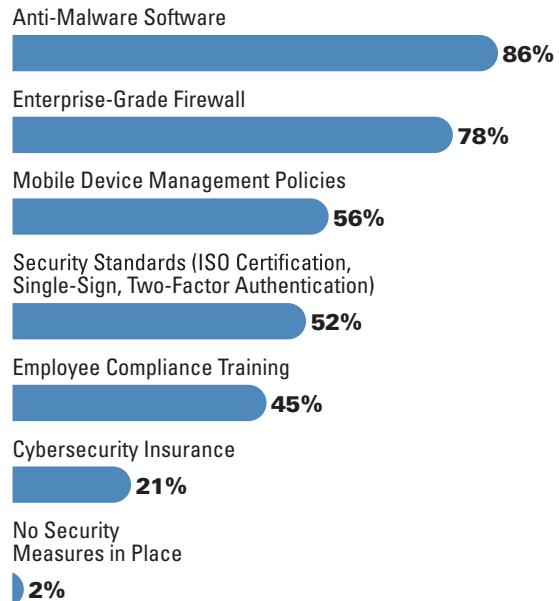
As the table shows, more large firms are actively deploying many of these measures than small firms. But since multiple companies are increasingly sharing data on projects through integrated digital workflows, this gap increases the risk of security breach for everyone. This is worthy of wider industry attention and development of means for smaller firms to upgrade their approach to data security.

DIFFERENCES BETWEEN GENERAL CONTRACTORS AND SPECIALTY TRADES

There are no significant differences in use of these measures between GCs and specialty trades.

Most Frequently Used Data Security Measures

Dodge Data & Analytics, 2019



Use of Data Security Measures (By Firm Size)

	Small Firms	Large Firms	Differential
Employee Compliance Training	33%	77%	2.3X
Cybersecurity Insurance	15%	32%	2.2X
Mobile Device Management Policies	41%	70%	1.7X
Security Standards	41%	70%	1.7X

Coming to Grips With Cyber Risk

Cyber risk is a real threat to construction companies, and it is one that the industry must be prepared to tackle in order to take advantage of the opportunities presented by new technology and data gathering approaches.

Construction companies do not typically amass large amounts of personal data or deal directly with the public, but if they think that means their exposure to cyber crime is low, they may want to think again. "Any business that transmits or receives information electronically is a potential target," says Nick Montera, vice president at Marsh, an insurance brokerage and risk management advisory company.

In fact, the AEC industry has its own vulnerabilities, including the fluidity of its workforce, field use of connected devices, the dozens of parties, including subcontractors, exchanging data on a typical project, and the significant quantities of confidential data involved, including bids, building information, employee records and corporate finances.

The consequences of a breach can be severe. "If you're not prepared," says Montera, "it's going to result in increased monetary loss, time loss and possible reputational harm." Multi-sector studies suggest that only 43% of companies with a major data loss reopen,¹ and only 6% survive more than two years.²

Safe Practice

To mitigate the risks of a cyber attack, Stephen Tullos, cybersecurity team lead at My IT, a consultancy with experience in the construction

sector, recommends conducting an audit of current practices to set a benchmark—ideally using a third party for greater objectivity.

General improvements might then include encrypting or otherwise protecting every device having access to the corporate network, providing training in cyber hygiene to employees at every level of the company, regularly reviewing firewalls and updating security patches, and developing protocols for managing cyber relations with collaborators. The specifics of each business will determine the most appropriate measures to take.

Cybersecurity practices should be consolidated into a comprehensive policy, which should also include a detailed response plan for if a breach does occur. "Time is critical in mitigating the monetary and reputational loss," says Montera.

Cloud Versus Closet

Some construction companies report a concern that cloud-based platforms and software as a service (SAAS) may expose their data to greater risk than if they stored it on their own server in the closet down the hall. The first thing to understand, says Tullos, is that despite the term "cloud," data is not just floating around out there; it is stored in secured and dedicated premises. And while it

is true that the higher profile of large data storage companies may attract more attention from malicious actors, says Montera, data companies are in the business of storing and protecting information. Their expertise and resources far outweigh what individual contractors are likely to provide for themselves. "Time will tell which is the better way to go," Montera says, and in the meantime contractors should evaluate the resources they're able to devote to cybersecurity, and make a facts-based decision about their options.

Cyber Insurance

An increasingly popular tool in the risk mitigation toolbox is cyber insurance. In the 12-month period ending September 2018, 28% of Marsh's construction practice-group clients were purchasing stand-alone cyber insurance policies, up from 19% the year before, but still well below the 53% to 63% of other sectors such as media, hospitality, education and healthcare.

Five years ago, contractors—especially small and medium-size ones—might have considered their exposure to cyber risk too low to spend time and money dealing with it. Now, that is changing fast. "You need to be prepared for this," says Tullos. ■

¹Data Center Knowledge "Disaster Recovery is Not Business Continuity" January 4, 2013 <https://www.datacenterknowledge.com/archives/2013/01/04/disaster-recovery-is-not-business-continuity/>

²Homeland Security News Wire "Gartner: only 6 percent of companies survive longer than two years after losing data" February 19, 2010 <http://www.homelandsecuritynewswire.com/gartner-only-6-percent-companies-survive-longer-two-years-after-losing-data>. Also: National Cyber Security Alliance <https://www.inc.com/thomas-kouloupoulos/the-biggest-risk-to-your-business-cant-be-eliminated-heres-how-you-can-survive-i.html>

Data: Analysis of Data

by Contractors

Use of Automated Analysis and Standard Reports

IMPROVING PERFORMANCE WITH PROJECT DATA SMARTMARKET REPORT DATA

THE BIG PICTURE

The spreadsheet is a well-established tool in global business for analyzing data and generating useful reports. It also serves as many users' first foray into digitization. But most construction companies are now transitioning to using data analysis software systems that have been developed specifically for the construction industry.

Approach to Using Automated Systems Versus Spreadsheets

To determine where the US industry currently stands in its transition, contractors were asked to characterize their use of automated systems versus spreadsheets to analyze and report on data collected from the field. The top chart shows the differences between the responses of general contractors and trade contractors.

- The majority (78%) are not at either extreme (i.e., exclusively spreadsheets or automated systems) but are in one of the three middle stages of transition.
- Among those, the largest group has progressed beyond the midpoint and are using more automated systems than spreadsheets.
- General contractors as a group are slightly ahead of specialty trades, but both company types are showing encouraging progress.
- There is no significant variation by firm size.

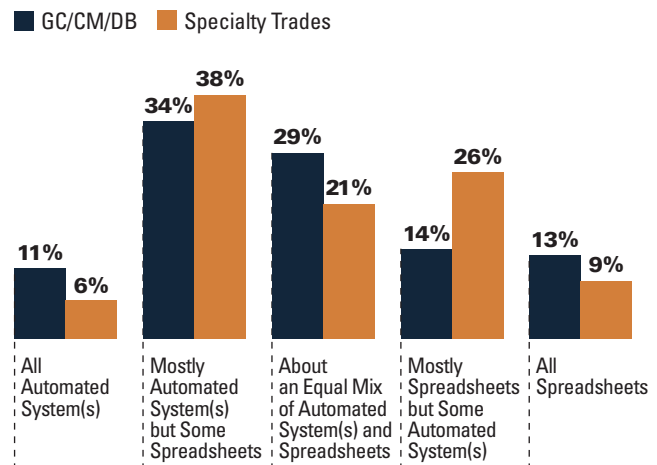
Standard Reports

Generating reports is a mission-critical functionality of any analytical tool. To establish the relative importance of various types of reports created from field data, contractors were asked to identify, from a list, which report(s) they use. The bottom chart shows the responses from all contractors.

- Almost every company (90%) creates reports on project financials, followed closely by project logs (83%) and safety reports (73%).
- Equipment management is reported on more frequently by specialty trades (60%), who often have a higher level of involvement with and responsibility for construction equipment than general contractors (49%).

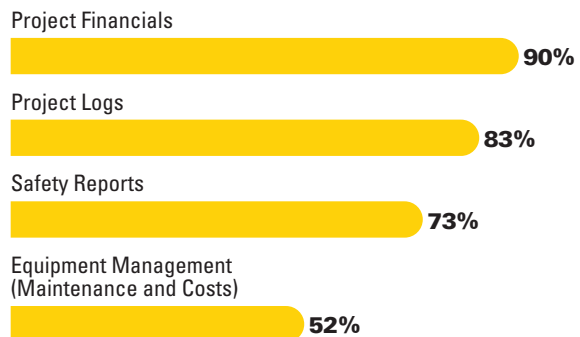
Use of Automated Systems Versus Spreadsheets (According to GCs and Specialty Trades)

Dodge Data & Analytics, 2019



Standard Reports Generated by Contractors

Dodge Data & Analytics, 2019



Types of Reporting and Analysis Conducted by Contractors

THE BIG PICTURE

Business data can be used for many types of analysis and reports. Determining which ones will enable better insight that improves decision-making is a critical and unique choice for every company.

Research and Charts

Contractors were asked to identify the kind(s) of analysis/analyses they currently perform on data gathered from the field, and to designate the type(s) of person(s) most frequently conducting it. The top chart shows the percentage of contractors engaging in four different kinds of analyses. Among those performing any type of analysis, the lower chart indicates what role is typically responsible for generating it, divided between general and specialty trade contractors.

Types of Analyses Being Conducted

Half or more of the respondents are using each kind of analysis studied, indicating a broad-based approach across all companies.

- **Descriptive analysis is the most frequent (69%), which is useful to quickly document and share the current status of specific quantifiable metrics on a project or program.**
- **The other three types (Diagnostic, Predictive and Prescriptive) are somewhat less common, probably because they typically require more qualitative data, and often involve historical analysis, collaborative consultation and experienced input to be effective.**
- **Large companies (average 65%) are more engaged in all four kinds of analyses than small firms (average 48%). General contractors also do more than trades, but not by large margins.**

Who Conducts Analysis

Project leadership in the office is the most common source of analysis reports in all companies. Perhaps because trades tend to be smaller organizations than general contractors, they rely more frequently on their senior leadership to generate analysis and reports (77% and 64%, respectively).

Slightly more trades cite field staff but overall, they are much less frequently used. This may change as mobile and cloud capabilities increase.

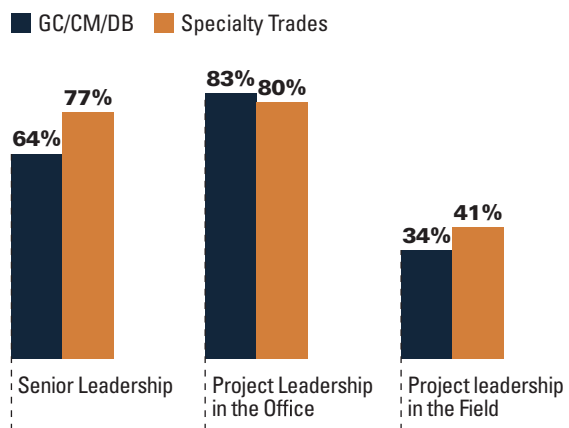
Frequency of Types of Reporting and Analysis Conducted on Projects

Dodge Data & Analytics, 2019



Roles That Perform Analysis (According to GCs and Specialty Trades)

Dodge Data & Analytics, 2019



Roles That See Project Analysis and Reports

THE BIG PICTURE

Reports created for management are intended to provide insight, identify issues for timely action and generally support better-informed decision-making. Therefore, when considering the best means to handle analysis and reporting, it is valuable to know which stakeholders inside an organization are most frequently receiving and using them.

Research and Chart

To establish how frequently various stakeholders at construction companies engage with reports created from field data, contractors were asked to identify which roles in their organization typically get to see the analysis reports. The chart shows the differences in these patterns between small, medium and large firms.

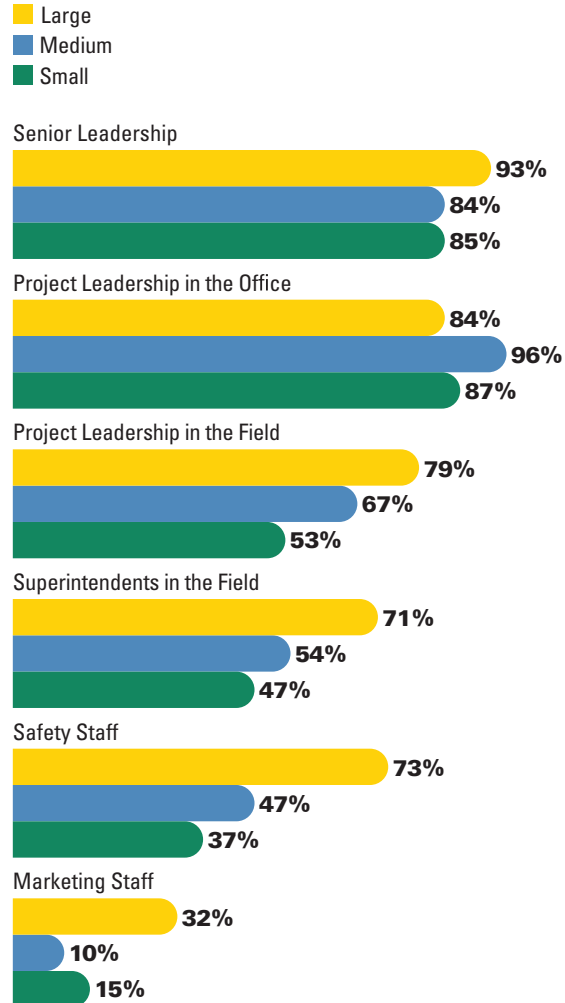
- Senior company leadership (average 87%) and project leaders in the office (average 89%) are the most frequently included by all sizes of companies.
- Inclusion of field staff is far more common at large companies (average 75%) than small (average 50%), as well as safety staff (73% and 37%, respectively).
- Larger contractors tend to have more sophisticated marketing departments that can leverage project statistics for business development value, so 32% include them in report distribution compared with midsize (10%) and small (15%) companies.

DIFFERENCES BETWEEN GENERAL CONTRACTORS AND SPECIALTY TRADES

While the approach to circulating analysis reports among stakeholders is similar between the two company-types, the table shows three cases where general contractors are notably more inclusive than trades.

Roles That Receive Reports (By Size of Company)

Dodge Data & Analytics, 2019



Roles That Receive Reports (According to General and Specialty Trade Contractors)

	Specialty Trades	General Contractors
Project Leadership in the Field	55%	70%
Superintendents in the Field	47%	60%
Marketing Staff	13%	20%

Data-Integrated Decision Making

When properly stored and analyzed, data can be a valuable tool to manage labor, estimate more accurately and keep existing projects on budget.

Contractors have been collecting data, in some cases for decades. Now, in response to the promise of increased safety, accuracy, predictability and profit, they are investing significant resources to digitize it. But once they've entered their data, many fail to make effective use of it.

Some do nothing, and conclude there was little benefit to the effort. Others become so absorbed in what they can now see of their past performance that they stall. The reason to collect and analyze data, however, is to use it to make more effective decisions.

Data can be used descriptively, diagnostically, predictively and/or prescriptively. "It really just boils down to business intelligence," says Mikeal Kanouff, operations manager at McClone Construction, a structural concrete and formwork company that is pioneering data-integrated decision making into several aspects of its business. "How do you know when a job is going well or not? That's what we're talking about, ultimately."

Historically business intelligence came from decision makers' intimate involvement in every aspect of a job. But for larger companies and projects, where managers cannot always get the information they need firsthand, analytics harness data to serve as the new intelligence. Accessible, timely and relevant intelligence enables decision makers to respond as—and ideally before—issues arise.

Risk Reduction

McClone, for example, is using data and analytics to manage its biggest risk factor: labor. "A lot of the WIP reports that we've seen out there are anywhere from a week to a month old," Kanouff says. "The issue obviously is that you've already spent the money." So the company has devised a solution that links information from its time sheet, cost report and accounting platforms. As soon as a site superintendent enters the day's cost codes, the software generates an update on where each code stands, and how many person-days the superintendent has left to work with. Next to the update, a projection area allows the superintendent to type in a crew mix, and see whether the planned mix and schedule will complete within budget. If not, instead of getting a report after the fact, the management team has a chance to resolve the problem in advance.

A second example pertains to McClone's estimating, again with a focus on labor costs. Because concrete production rates are a function of the specifics of each installation, McClone slices its project data finely enough for those specifics to show. Information is categorized not just by project, but by individual floor levels. Data per floor includes, for example, the general contractor, site superintendent, material and method of installation, floor height, slab type and production rate. The floor data is also linked to drawings so estimators can refer to them more easily.

With thousands of records to draw on, estimators can review identical form conditions or identical structure types. They can pull the most relevant four or five projects, and consider only the floor levels that most closely match the criteria of the project under consideration. For every production rate for every floor, estimators create like-job backup documenting exactly how McClone has executed the job before, giving the company confidence that its bids are as accurate as possible.

Measuring Success

McClone developed its systems for data-integrated decision making through trial and error. "We've created a lot of solutions that we think will be the miracle fix, but people just don't end up using them," says Kanouff. To evaluate a new system, the company goes back to what Kanouff calls "old school data": holding conversations, conducting interviews, checking whether people are using it and asking for feedback. "Data is there to allow a business to run more efficiently, to reach KPIs and to head off situations that you otherwise wouldn't know about," says Kanouff. "You'll know it's successful when people tell you, 'This is something I use day-to-day, and I plan my jobs out differently because of it.'" ■

Interview: Thought Leader



Jit Kee Chin
Executive Vice President and Chief Data Officer
Suffolk

Jit Kee Chin is responsible for leveraging big data and advanced analytics to improve Suffolk's core business.

What emerging technologies have the greatest potential for improving performance?

CHIN: I personally believe automated monitoring has great potential, and it comes in many forms. Image recognition, for example, is starting to become very pervasive. The ability to take pictures and analyze them using image recognition to extract features that you care about is very powerful. For example, we are starting to use image recognition to recognize safety hazards like PPE [personal protective equipment] non-adherence. By using automated monitoring techniques, we can help our project team members make better sense of the complex site environment and take action before something becomes an issue.

The challenge now is to make automated monitoring more widely adopted and to integrate that process into the daily workflow of project sites. There are far too many point solutions out there that require you to go to a different location on a site, access an application or read a whole bunch of dashboards. The people on project sites just don't have that kind of time. They need to do their everyday jobs, they need to work with trade partners, and they need to be solving problems constantly. Technologies that require too much change to their daily routines and workflows all at once are much more difficult to adopt.

What about the applicability of artificial intelligence for construction?

CHIN: So far, most environments where AI has been successfully applied include office jobs where someone is sitting at a computer but construction is inherently a very physical job ... It's not a job where you can spend hours in front of the computer reading dashboards or looking at numbers. That is one of the main factors that make AI in construction so different from other industries that have successfully adopted it.

In addition to that, in our industry, each project is different. There are many variables that need to be considered for AI to be useful and valuable.

Regardless of industry, AI needs data. It is difficult for one general contractor to manage the amount of projects necessary to create enough actionable intelligence from that data. Where is the big data that the AI can actually crunch to do something useful? Image data, which I mentioned earlier is one type of useful data. Data from sensors is another type. There is a lot of design-drawing data, cost estimate data and people data. You have to take all of these data into consideration in order to understand the entire job.

What would be the ideal circumstance to help deal with all these different data flows?

CHIN: You need a data architecture and a data strategy that allow you to integrate between data types. You need to be able to extract meaning from the data to create value. For example, what would you like to extract by combining images and financials and schedules together? What's the question you're trying to answer? People are often fuzzy about the business goals of their data strategies. They're just focused on data for data's sake.

In construction, we ask ourselves whether we're measuring enough on the construction site. Because all the data is so disparate, do we need to come up with a new way to measure onsite? I have the feeling that we're not measuring enough or that few are seeing the forest through the trees.

What are the challenges in deploying new technology?

CHIN: [Jobsites] are very decentralized, independent working environments. There is an entrepreneurial mind-set that exists on these sites that needs to be [addressed] when implementing new technologies. The challenge is that ... the pace of technology is out of kilter with the pace of the actual projects. The incentive structure on projects needs to be aligned with the introduction of new technologies. But that leads to other questions, like how do we prove the value of these new technologies to clients? ■

Data: Benefits of Improved Data Gathering and Analysis

Improvements and Benefits Experienced in the Last Three Years

IMPROVING PERFORMANCE WITH PROJECT DATA SMARTMARKET REPORT DATA

THE BIG PICTURE

After implementing any kind of business improvement, companies need to focus on continually improving their ability to take advantage of it, and on measuring the tangible, repeatable and scalable benefits it produces. For a construction company, that includes both internal business benefits, which make it more successful, competitive and valuable, and project-related benefits, which improve tangible delivery and performance metrics.

Degree of Improvement Over Last Three Years

To track the pace of advancement, contractors were asked to characterize the degree to which their data gathering, analysis and reporting capabilities have improved over the last three years. The upper chart compares the responses from small and large companies.

- About half of the small contractors (49%) reported that their capabilities stayed stable, while most of the rest (48%) experienced some level of improvement.
- This contrasts sharply with large companies, where over three quarters (78%) cited improvement and only a few (20%) had no change.
- Twice as many large firms (14%) claim to have had significant improvement than small ones (7%).

These disparities highlight that smaller firms are at risk of falling behind in the construction industry's journey of digital transformation.

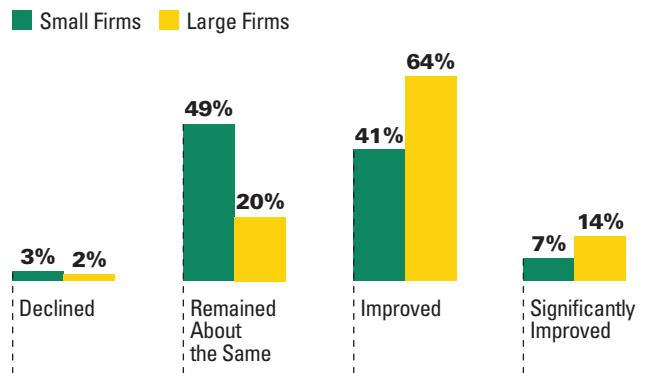
Business-Related Benefits of Improved Capabilities

To evaluate the positive impact on their businesses, contractors who cited some level of improvement in their data gathering, analysis and reporting capabilities over the past three years were asked to comparatively rate the frequency with which they received each of five specific internal benefits because of those improvements. The lower chart shows the ratings from all respondents converted to a 1–10 relative frequency scale.

Findings are similar between general and trade contractors and for all size ranges across these five business benefits except for the top one (ability to win new work) which both small firms and trade contractors rate notably lower.

Degree of Improvement Contractors Experienced in Data Gathering, Analysis and Reporting Capabilities in the Last 3 Years

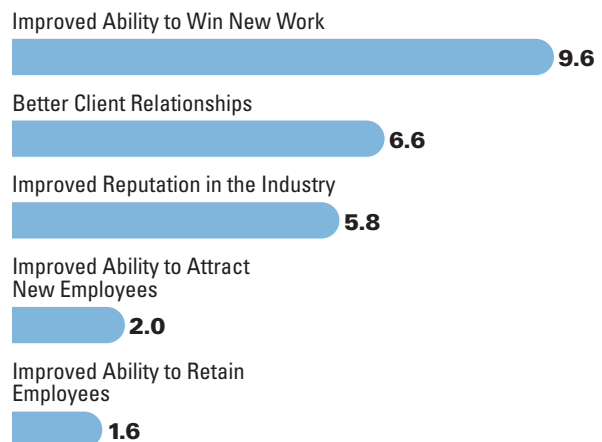
Dodge Data & Analytics, 2019



Business Benefits of Improved Capabilities on a 1–10 Relative Frequency Scale

(According to Contractors Whose Data Gathering, Analysis and Reporting Capabilities Improved in the Last 3 Years)

Dodge Data & Analytics, 2019



Project-Related Benefits of Improved Capabilities

To determine its impact on project performance, contractors who reported experiencing improvement in their data gathering, analysis and reporting capabilities over the past three years were asked to identify the top three most frequent benefits that they believe the improvements produced over that period. The chart at right shows these rankings from all respondents.

BETTER ABILITY TO COMPLETE PROJECTS AT/ UNDER BUDGET

- Over half of the contractors (53%) identify better budget performance as being among their top three benefits of improved data gathering, analysis and reporting.
- Over one quarter (26%) of them cite it as their most frequent benefit, significantly more than any other one and about 50% more first-place votes than the next highest scoring benefit (greater productivity).
- Almost half of general contractors (49%) include this benefit among their top three compared with just 38% of trades.
- Nearly twice as many large contractors (30%) give it a first-place ranking, compared with 17% of small companies.

GREATER PRODUCTIVITY

While ratings from general and specialty trade contractors are roughly equal, company size has a notable impact on designating greater productivity as a top benefit.

- Interestingly, more small companies (59%) include it among their top three than larger ones (39%).
- Far more of the small companies (34%) rank it in first place than either medium (13%) or large (11%) organizations.

These findings highlight the unique importance of the productivity metric to the small company segment of the market.

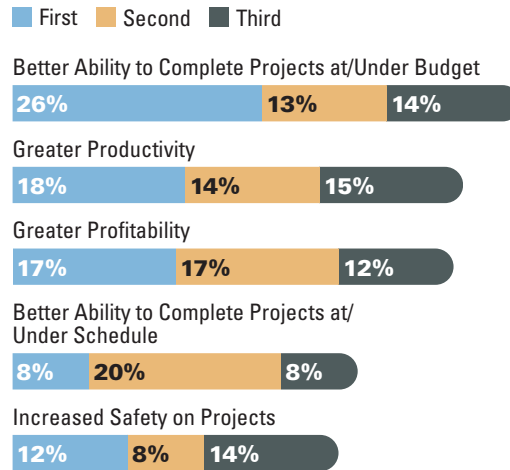
GREATER PROFITABILITY

Although almost half (46%) of companies include greater profitability somewhere among their top three benefits, there are interesting variances by size and type.

- 25% of specialty trades rate it as their first choice, compared with just 14% of general contractors.
- 24% of midsize companies rate it as their first choice, compared with 17% of small companies and just 9% of large ones.

Project Benefits of Improved Capabilities (According to Contractors Whose Data Gathering, Reporting and Analysis Capabilities Improved in the Last 3 Years)

Dodge Data & Analytics, 2019



BETTER ABILITY TO COMPLETE PROJECTS AT/ UNDER SCHEDULE

Twice as many general contractors (43%) include this among their top benefits than do trade contractors (22%). This likely reflects their typically greater level of control over the schedule and responsibility for overall project delivery performance.

INCREASED SAFETY ON PROJECTS

While only about one third (34%) of all contractors cite improvements in this critical metric of better safety performance, there are some encouraging signs in the findings.

Almost half (48%) of the large contractors include safety among their top three, versus only about a quarter of medium and small ones (combined average 27%). Since larger firms are often industry leaders, we can hope that this predicts more improvements in the future for the smaller organizations.

While more general contractors (38%) include safety among their top three benefits than specialty trades (25%), half of those trade firms (13%) give it a first-place ranking, compared with just 11% of GCs.

Capabilities That Contribute to Benefits

THE BIG PICTURE

Evaluating the specific ways in which improving a company's data gathering, analysis and reporting capabilities contributes to better performance will allow each company to map its journey of digital transformation toward providing the most benefits.

Research and Chart

Contractors were shown a list of seven data gathering, analysis and reporting capabilities and asked to identify the top three that contributed most to the benefits they achieved over the last three years. The chart shows the findings from all respondents.

Overall Findings

Among the seven capabilities, **gathering reliably accurate data from the field contributes most to improved performance**, with nearly two thirds (63%) of contractors including it among their top three and over one third (34%) ranking it first.

Tied for second place in the combined ranking (46%) are the promptness of gathering data and the ability to compare it over multiple projects. Importantly, these also earn double-digit percentages of the voting for first place.

While the other four capabilities score lower, none have a top three total of less than 29%, and all of them garner at least some first-place votes, indicating that each of these seven has contributed meaningfully to contractors' performance improvements over the last three years.

DIFFERENCES BY COMPANY SIZE

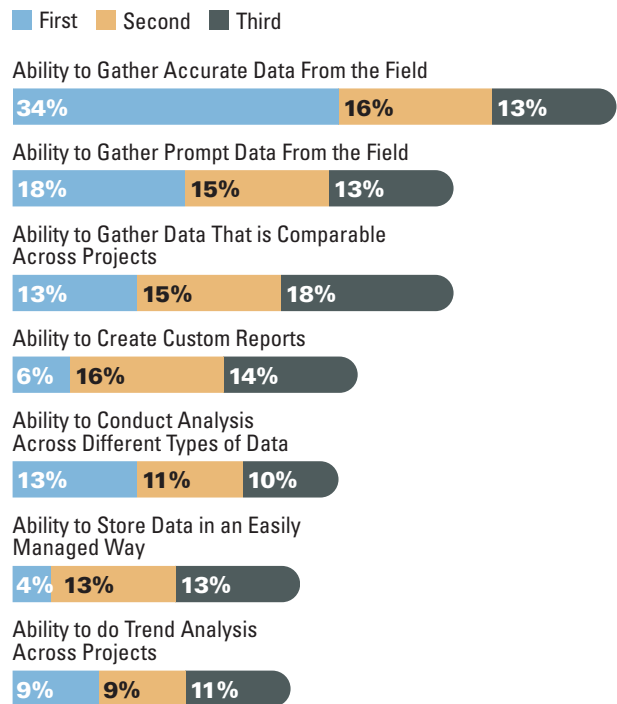
Ratings are largely similar for companies of all sizes, except for the ability to gather data that is comparable across projects, which scores a first-place rating from a quarter (24%) of small firms compared with far fewer medium (7%) and large (14%) ones. This indicates a particularly valuable benefit for that market segment.

DIFFERENCES BETWEEN GENERAL CONTRACTORS AND SPECIALTY TRADES

Cross-project comparison capability is also rated differently between company types, with 22% of trades designating it as the most important, versus just 10% of general contractors.

Top Ranked Capabilities That Contribute to the Benefits Achieved From Improved Data Gathering, Analysis and Reporting

Dodge Data & Analytics, 2019



The opposite holds true for promptness of data gathering, where over half (52%) of general contractors put it in their top three and 21% name it as the most important capability, compared with only 31% of trades including it overall and just 12% giving it a first-place ranking.

Improvements Needed to Increase Benefits

THE BIG PICTURE

As technology solutions continue to advance, their functionalities, workflows and capabilities become increasingly powerful. Knowing specifically which capabilities would make the most positive contribution to performance if they could be improved provides a valuable road map for users, managers and technology developers.

Research and Chart

Contractors were asked to rank the top three among seven capabilities in terms of which would make the greatest contribution to benefits in the future if they could be improved.

Overall Findings

Underscoring its top-place ranking for the capability that contributed the most to better performance over the last three years, contractors' ability to gather accurate data from the field is also the most important capability to concentrate on improving so that benefits will continue to increase in the future.

Interestingly, the ability to do trend analysis across projects rose to second-place in this future-oriented category, after having finished last in the retrospective evaluation. This dramatic move is an important voice-of-customer signal to the technology development industry.

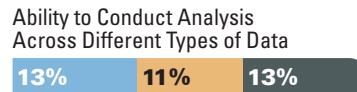
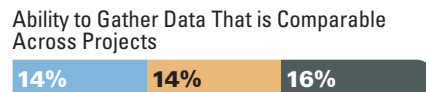
Conversely, the ability to do custom reports fell from fourth place to last, perhaps reflecting a view that improvements in out-of-the-box reporting from automated systems will make this custom capability less important going forward and will support more standardization across projects, companies and collaborative teams.

Variations by firm size or type are relatively small, indicating a common view of the capabilities that will be most meaningful in the future.

Improvements to Data Gathering, Analysis and Reporting Needed to Increase Future Benefits

Dodge Data & Analytics, 2019

■ First ■ Second ■ Third



Better Building Through Data

Pepper Construction

CHICAGO, ILLINOIS

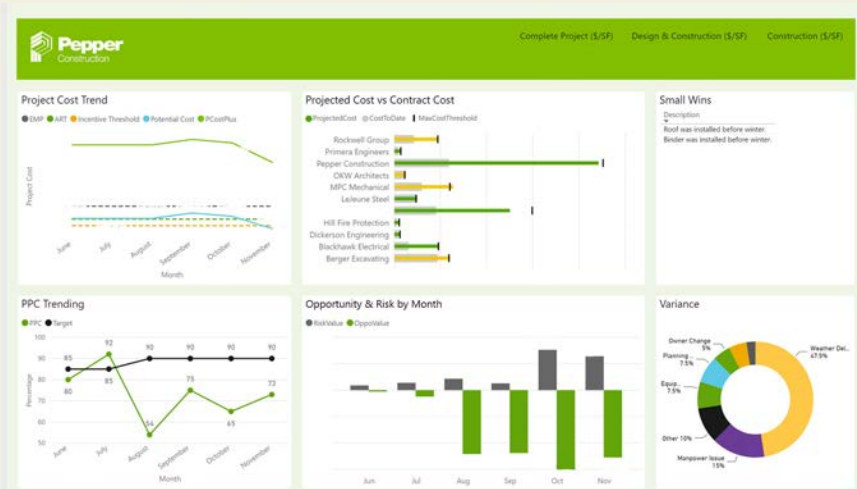
Productivity levels in the construction industry haven't budged in 50 years. That's the nut that Pepper Construction sees data and analytics having the potential to crack. "Construction is undergoing a period of profound change," says Jake Pepper, the company's vice president of integrated construction services. As built environment technology becomes a significant venture capital category, the number of funded construction tech startups in 2017 has tripled over the previous year. "Some of the technologies that are out there now are going to change the way we work," says Pepper.

Seeing What You Have

Pepper Construction's engagement with analytics began about two years ago when the firm acquired dashboarding software to make sense of the data it had. "A lot of what we create or utilize is data," says Jennifer Suerth, vice president of technical services at Pepper. "It's the 'I' in BIM, it's accounts receivable and bills outstanding, it's project imagery and safety incidents. Data could be anything."

The dashboard's capacity to gather, combine, manipulate and translate data into visuals immediately helped highlight some discrepancies across the firm's projects. Boxes were checked when it should not have been possible to have both at once. Apparently, operations teams had developed work-arounds so they could make internal reallocations without the necessary prerequisites. "Our system was broken," says Pepper.

Having revealed the problem



Typical dashboard of project data.

visually, the dashboard now supports solutions by helping to track key performance indicators (KPIs). For example, group managers overseeing multiple projects can pull all the change orders affecting their various projects together and classify them by status. An indicator that orders in the "work started, work not yet approved" category have increased allows the manager to investigate early enough to avert potential losses.

The company also uses its dashboard to track negative job swings, flagging any monthly drop of more than \$5,000 in a project's projected profit. With project management's natural preference for resolving issues independently, "that's visibility we've never really had before," says Pepper. "It allows us to say, 'Hey, it's okay to make a mistake, but let's jump on that immediately, and give the project the resources it needs to get back on track.'"

Some of the most valuable insights

the dashboard generates pertain to the firm's pipeline. Having the data presented graphically, rather than line by line, enables Pepper's management team to see at a glance what types of opportunities are coming up, their time frames, owners and design teams, and market-type breakdown, and facilitates week-to-week strategizing on how to win each job.

The company is now developing a standard dashboard for use at the project level, piloting options for making project data more visible on some of its current Integrated Project Delivery (IPD) jobs. "Trying this on a project that inherently has a culture of transparency and shared KPIs is a great opportunity," says Suerth. "It's been very, very successful."

Collaborating With Startups

Beyond dashboards, Pepper Construction is now collaborating with some of the software companies developing analytics for

Pepper Construction

CHICAGO, ILLINOIS

the construction sector. “There’s so much money focused on these startups and their solutions to problems that haven’t been addressed for so long,” says Jake Pepper. “We as a construction company can either develop our own solutions or partner with them.”

As an example of the latter, Pepper is experimenting with programs designed to extract value from one of construction’s most underused forms of data: the daily site photographs that tend to get dumped onto a server, with a date at best, rarely to be seen again. One program collates all of this daily visual data, including 360-degree images, and compares it with the project’s 4D building information model (BIM) to predict whether the work is on schedule. If not, it highlights the source of the holdup. Another program ties any type of visual data to a floor plan, using machine learning to recognize and align elements in the images. In some cases it is even possible to take measurements from the composite, using project images as if they are point cloud data.

The ability to monitor progress area by area in these ways is also helping Pepper to break down silos between trades in project coordination. If a trade is expecting to start work in an area where these visualizations show another trade has fallen behind, all parties have the advance notice they need to communicate and adapt.

Site data has the potential to benefit safety too. One predictive analytics company is building an engine that sifts jobsite imagery in chronological order, and identifies markers: Someone is not wearing

safety glasses, someone else has removed a hard hat. The software then signals if the likelihood of an accident on the project has reached a threshold of, say, 75% for the week ahead, and identifies the top risks that need attention. Interestingly, says Suerth, the more the firm shows clients their data, the more uses emerge for it. Having begun in safety, the startup is now expanding to productivity.

Mutual Transformations

Among the advantages of being an early adopter of useful-looking technologies is the opportunity to help shape them. For example, in its self-perform concrete work, Pepper uses a laser scan to document the location of in-slab components for future reference, prove compliance with last-minute site instructions without having to reopen the slab, and analyze the flatness of the slab for quality control. But initially that was only possible for horizontal surfaces. In response to Pepper’s feedback, it now works for ramps and core walls as well. Next they’re hoping to generate models from

point cloud data more easily.

As more and more GCs make their requests, the obstacle that Suerth identifies as one of the most significant for the effectiveness of data analytics is beginning to dissolve: software companies are becoming more open to communicating with one another to make their offerings compatible.

And it is not just the software companies that are changing. Through its connection with the safety analytics startup, Pepper is collaborating with some half-dozen other GCs for the benefit of all: sharing with the startup their jobsite photos and related safety incident data to help the predictive engine get smarter. “We realize that in this new environment, we’ve got to collaborate in some ways for the industry to get better,” says Pepper. “It’s a little bit anxiety inducing—because we all still want to maintain any perceived or real edge we have over our competitors—but we’re finally at the point where we have the chance to really improve productivity in construction.” ■



Visual data can be accessed onsite through mobile devices.

Data: Emerging Technologies

Built on Data

New Approaches to Gathering and Using Data

IMPROVING PERFORMANCE WITH PROJECT DATA SMART MARKET REPORT DATA

THE BIG PICTURE

Around the world, capital-intensive industries are in the midst of an unprecedented transformation driven by astonishing new technologies. Many of those rely on using large amounts of historical and sometimes real-time data to support better decision-making, improve efficiency and optimize processes.

Research and Chart

To gauge the current level of construction industry engagement with three emerging and potentially revolutionary technology trends, contractors were asked about their familiarity and experience with each.

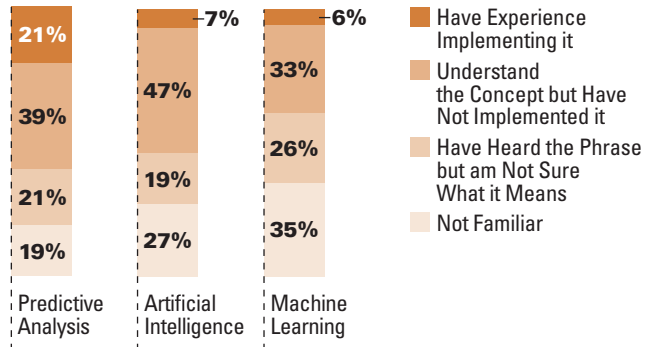
- **Artificial Intelligence (AI):** Leveraging computer algorithms and historical and/or real-time data to make informed decisions, mimicking human intelligence. Typical AI capabilities include speech recognition, learning, planning and problem solving.
- **Machine Learning:** According to the SAS Institute, "Machine learning is a method of data analysis that automates analytical model building. It is a branch of artificial intelligence based on the idea that systems can learn from data, identify patterns and make decisions with minimal human intervention."
- **Predictive Analysis:** Determining patterns from historical and/or real-time data to develop likely scenarios of future outcomes.

The practical application of these technologies is rapidly gaining traction in other industries, and though still in its infancy in construction, has enormous potential for transformative future impact. Examples could include:

- Evaluating safety data in conjunction with a wide variety of other project data to be able to better predict what combination of factors will trigger safety incidents so they can be proactively prevented. (An early example of this is featured in the case study on page 36.)
- Automatically revising project scheduling, workforce planning, material management and onsite/offsite production on-the-fly as a project proceeds, to optimize all resources in real time and execute the best possible project delivery.
- Deploying increasingly smart machines at the jobsite that can communicate with humans and each other, learn as they go, and continually improve quality and productivity.

Contractor Familiarity and Experience With Emerging Technologies

Dodge Data & Analytics, 2019



The chart shows all respondents' familiarity and experience with these trends. In addition, for a more in-depth look at these technologies and the construction industry, see the article on page 38.

Contractor Familiarity and Experience

- **Almost a quarter (21%) of contractors report experience with predictive analysis.**
- **The largest group (average 40% across all respondents) is comprised of contractors who understand the concepts but have not had any practical experience implementing any of the actual technologies.**
- **Machine learning is the least well-understood with 61% not knowing what it means or not recognizing the term.**

As technology continues to advance, these capabilities will increasingly be applied to the design and construction industry. It is an exciting future, and contractors should work with their industry organizations, technology partners and collaborative team members to learn about, embrace and prosper from these coming changes.

Wearable Sensors and Safety

Wearable sensors are expected to have a major impact on safety on construction sites, but many also hope they will improve productivity as well.

At 12:30 p.m. on a busy construction site, a sensor clipped to a worker's belt signals that he has fallen. The site's safety rep, automatically alerted as to who has fallen and where, rushes to the spot. But the worker is fine: "Must be a bug in the technology," he says. After a few days when this reoccurs, the safety rep goes to see what happens at 12:30 p.m. On cue, the worker vaults off the back of his truck after finishing his lunch. The ensuing conversation, about how easy it would be to botch the landing, could prevent a twisted ankle. And there are more serious examples: for instance, another worker's sensor reveals that he swings and drops twelve feet from floor to floor rather walking to the ladder. The conversation about avoiding that behavior could save a life.

Safety Insights

"How safe can we make a job, just based on knowing more information?" says Jason Pelkey, chief information officer at Gilbane Building Company. That's the question behind Gilbane's adoption of a system of wearable sensors and their associated equipment tags, evacuation alarms, dashboard and communication network. "Short of hiring an army to shadow people, you wouldn't have the understanding of what's happening on the jobsite that you get from an innocuous little clip that somebody's carrying," says Pelkey. "That data

allows us to improve the safety and productivity of the jobsite."

Because the sensors are all linked, including the ones attached to equipment, the system can signal a heads-up to a worker standing, for example, near a reversing backhoe. Or it can match equipment and users to ensure that only qualified people are operating the machinery. The sensors can cordon off areas electronically, reinforcing site communications with a warning if a worker gets too close to a danger zone. And a push-button alert enables workers to report worksite hazards or signal distress to designated supervisors from anywhere onsite.

Gilbane has been using the sensors for nearly two years on about a dozen sites, and is now collaborating with its insurer and the sensors' manufacturer to explore the technology's potential. "We're still early on," says Pelkey, "but already we're seeing significant results in terms of safety awareness."

Beyond Safety

From its roots in safety, sensor technology is expanding to enhance productivity. Data it generates about work patterns might lead a team to reconfigure its laydown area, for example, so that instead of workers taking 200 steps to get to the material they need, they only take five. Punch lists can be narrowed to the items closest at hand, and taking attendance is instantaneous.

A cloud-based dashboard enables onsite supervisors and offsite management to see and analyze construction operations in real time, and aggregated safety and productivity data can be filtered and analyzed according to individual subcontractor, trade or geographic location.

The system of clips that Gilbane are currently trying out are one of an increasing number of wearables now on the market. Other examples include sensing footwear that monitors location, status and environmental factors; ergonomics-focused sensors that monitor for risk of musculoskeletal injury; and apps for a device most people are wearing already—their phones—that facilitate the collection, analysis and communication of safety and other types of data.

Sensor Skeptics

A significant obstacle to the adoption of wearables on a jobsite is employee resistance. In Gilbane's experience, openness upfront is key to success: have a kick-off meeting to show people the technology, discuss the goals for it and what it does and does not do, and provide forthright answers to any questions. Regardless of workers' skepticism, says Pelkey, someone only has to need the system once and they're instantly converted. "I didn't have to leave my injured coworker to get help," he quotes a worker saying. "Somebody was already running down the hall." ■

The Future of Data for Construction: Predictive Analytics, Machine Learning and Artificial Intelligence

Contractors have just begun to experience the potential for data being gathered from jobsites. Use of data in other industries shows the potential for gains from using predictive analytics, machine learning and artificial intelligence.

Predictive analytics is the use of data, statistical algorithms and machine learning techniques to identify the likelihood of future outcomes.¹ In the AEC industry now, predictive analytics has the capacity to warn of impending losses, improve safety, help optimize project schedules and increase productivity. As analytics evolves, additional capabilities are coming over the horizon fast.

Industry experts consider these innovations crucial to the future of construction. “It’s the only way for our industry to survive,” says Ricardo Khan, senior director of innovation at Mortenson Construction. “If we continue doing what we’re doing, which is relying on people to review—and review and review—as our projects get faster and more complicated, and our budgets get tighter, we will hit a wall.”

Predictive analytics can leapfrog many of the lagging and leading indicators that depend on human observation. By automating data capture, leveraging algorithms to analyze the data and providing almost real-time feedback on potential outcomes, predictive analytics can:

- compare current expenditures against historical data and projected costs to provide advance warning of a cost overrun while there’s still time to prevent it;
- recognize and classify jobsite images and extrapolate from safety incident data to predict

the probability of an injury in the weeks ahead, and highlight the conditions and behaviors that need to change to avert it;

- analyze data from site images, wearables and IoT sensors to identify opportunities for increasing productivity;
- monitor information from IoT sensors to streamline maintenance;
- assess millions of scheduling options at electric speed to support project planning.

As well as helping construction managers keep up with—and ahead of—the increasing complexity and pace of construction, data-based forecasts are a powerful tool for supervisors and workers onsite. “If they have access to data that suggests slight changes to the current way they are doing things, they are more likely to be safe, save money and be more efficient—and that drives morale as well,” says Bruce Orr, chief data scientist at Pronovos Construction Analytics, a company that provides contractors with analytical solutions based on a range of project management products.

Coming Soon to a Computer Near You

What predictive analytics can do now is only a fraction of the AI solutions still to come. According to a 2018 publication from McKinsey & Company², existing technologies developed for other industries

are ripe for adaptation to the construction sector:

- Transportation route optimization algorithms could be translated to improve project planning and scheduling.
- For major projects, AI solutions from the pharmaceutical industry that forecast medical trial outcomes could be adapted to forecast the risk, constructibility and/or structural viability of a range of design solutions.
- As modularization and prefabrication become increasingly common in construction, retail sector applications to cut manufacturing downtime, reduce oversupply, and increase predictability of shipments will come into play, as will advances from the robotics industry.
- Healthcare-based breakthroughs in image recognition to support illness diagnosis could be transferred to jobsite imagery and digital models to improve quality control.

Machine learning (a branch of AI based on the idea that systems can learn from data, identify patterns and make decisions with minimal human intervention)³ holds barely tapped potential for automating a range of industry functions. Quality control and claims management, for example, could benefit from using deep learning techniques to review drone images, compare construction defects against design documents and predict the likelihood of claims.

¹ https://www.sas.com/en_ca/insights/analytics/predictive-analytics.html; ² Jose Luis Blanco, Steffen Fuchs, Matthew Parsons, and Maria Joao Ribeiro “Artificial Intelligence: Construction technology’s next frontier,” McKinsey & Company, 2018.; ³ https://www.sas.com/en_ca/insights/analytics/machine-learning.html

Project management could get a boost from automating the use of site images to make daily updates to a 3D digital twin, which marries sensor data to a BIM model. Design options under consideration by architects or engineers could be prioritized according to total cost of ownership, execution timeline or constructibility. And human resource management could benefit from AI-generated predictions of pinch points, such as local labor shortages, with recruitment plans ready made.

The more data AI can draw on, the more effective it becomes. To facilitate machine learning, and to realize the benefits of it sooner, software developers have begun asking their clients to consider another kind of change: the (anonymous) sharing of corporate data to generate sector-wide benchmarks. "The precedent exists in safety," says Khan, and although many companies are still leery at the prospect, "data sharing may be a way to contribute significant value to the industry as a whole."

Getting Started

So where should a company interested in leveraging its data for predictive insights start, and what should it look for? "Start where you are," is the advice that crops up again and again. Identify a pressing priority, like reducing safety incidents, improving estimate accuracy or reining in cost overruns. If you don't already have a tool that helps you analyze, segment and manage the data you have, get one. Clean up your data, implement a good data governance process, then deploy machine learning to advance your chosen priority.



For companies developing a wish list for their construction analytics platform, Orr has a few suggestions:

- **Use advanced analytics** including predictive and prescriptive, to generate timely, actionable information pertinent to your priorities.
- **Be data source agnostic**, so your data remains continuously accessible through the analytics platform, even if you switch systems.
- **Use a preconfigured data model**, with common categories and metrics based on industry best practices preloaded, so you can get up and running fast.
- **Make sure you have the capability to self-serve**, so you can explore your own data, and ask your own questions.
- **Use advanced visualizations**, so you can understand patterns, trends and correlations at a glance, rather than peering at rows and columns.
- **Enable intelligent data entry**, so information entered into the platform immediately contributes to the big picture.

- **Use natural language processing (NLP)**, so you can type in a question and let the system find answers.
- **Strive for pervasive analytics**, so the intelligence follows you from screen to screen no matter which application you're in.

The construction industry's uptake of machine learning and AI solutions lags behind that of other industries, ranking 11th out of 13 in a 2018 survey of current adoption, and last on three-year projected investment. Contractors developing a coherent program to leverage their data predictively will find themselves in the industry vanguard. In conversations over the past five years with more than 1,500 contractors, general and specialty, spanning revenues of \$20 million to \$3 or \$4 billion, "I have yet to meet a company that has adopted predictive analytics within their organization in any ongoing process," says Orr. "Once we're able to show how predictive analytics can be used, we see the mind-set change." ■

Methodology:

Impact of Technology Implementation Study Research

The purpose of the 2018 Impact of Technology Implementation Survey was to examine the types of data that contractors in the construction industry are collecting, how they collect and store data, and what they do with the data. Also covered are the benefits firms receive from data collection and analysis practices. Respondents were additionally asked to comment on what they could do to improve their analysis and increase benefits from their data collection efforts.

Survey Distribution

The research findings in this report are based on an online survey of construction contractors in the United States, conducted from August 14, 2017 to September 12, 2018. The survey was conducted using the Dodge Data & Analytics Contractor Panel and contacts provide by Viewpoint. General and specialty trade contractors were included in this sample. The survey took an average of 22 minutes (13-minute median) to complete.

Survey Respondents

A total of 187 responses are included in the final analysis.

■ Source of Respondents:

- 156 from the Dodge Contractor Panel
- 31 from Viewpoint contacts

■ Types of Respondents:

- 98 General contractors
- 28 Construction managers
- 4 Construction design/contracting firms
- 9 Design-build firms
- 1 Other prime contractor
- 47 Specialty trade contractors

Requirements to Participate in the Study

Respondents had to meet the following requirements to participate in the study.

- **A minimum of \$10 million of billings in 2017**
- **Collect data in one of the following categories:**
 - Productivity
 - Payroll
 - Equipment tracking
 - Safety records
 - Project improvement

Analytical Variables

A few analytical variables were used in the analysis of the data throughout the report.

■ Company Type

- General Contractors (Includes general contractors, construction managers, construction design/contracting, design-build firms and other prime contractors): 61%
- Specialty Trade Contractors: 39%

■ Company Size

- Small Companies (Revenue less than \$50M): 33%
- Midsize Companies (Revenues of \$50M to less than \$250M): 37%
- Large Companies (Revenues of \$250M or more): 30%

Resources

Organizations and websites that can help you get smarter about the impact of data gathering and analytics on improving construction projects.

DODGE DATA & ANALYTICS

Dodge Data & Analytics

Main Website: www.construction.com

DodgeConstruction Central: www.construction.com/products

Market & Competitive Intelligence: www.construction.com/products/construction-market-data

Sweets: www.construction.com/products/sweets

SmartMarket Reports: www.construction.com/toolkit/reports

ACKNOWLEDGEMENTS:

The authors wish to thank our premier sponsor Viewpoint for their vision and commitment to this research.

We would also like to thank Mikeal Kanouff, McClone Construction; Nick Montera, Marsh; Stephen Tullos, MyIT; Howie Ferguson, Construction Owners Association of America; Sue Klawans, senior construction executive and Lean management consultant; Ricardo Khan, Mortenson Construction; Bruce Orr, Provonos Construction Analytics; Jason Pelkey, Gilbane Building Company; and Jit Kee Chin, Suffolk for their willingness to be interviewed for this report. In addition, we thank the firms that provided information about their projects and experiences featured in each of the case studies as well as for their assistance in helping us secure images to supplement their project information.



Viewpoint
viewpoint.com

Premier Partner

Viewpoint: <https://viewpoint.com/>

Other Resources:

Associated General Contractors of America (AGC): www.agc.org

BuiltWorlds: <https://builtworlds.com>

The Center for Construction Research and Training (CPWR): www.cpwr.com

Construction Dive: www.constructiondive.com

Construction Executive: www.constructionexec.com

Engineering News Record: www.enr.com

For Construction Pros: www.forconstructionpros.com

Lean Construction Institute: www.leanconstruction.org

National Institute of Building Sciences: www.nibs.org

■ Design and Construction Intelligence

SmartMarket Report

www.construction.com

Dodge Data & Analytics SmartMarket Reports™

Get smart about the latest industry trends.

For more information on these reports and others, visit
www.construction.com/toolkit/reports

