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HOW WILL WORKING FROM HOME *Catalyze Industrialization?*

Construction still strongly relies on the skilled trades for its final installation and any information and feedback leading up to that point, making physical presence and interaction by the jobsite and field workforce a requirement.

But in the aftermath of COVID-19, remote work will be accelerated. The examples and methods provided in this article can help you down the path of visibility to the work environment, which will lead to expanding the horizon of prefabrication to be more than just building assemblies.

Reliance on Data

In construction, the need for face-to-face communication and exchange is due to the lower (or complete lack of) reliance on generation, reduction, and presentation of data than is needed in other industries.

Not unlike the analog transition to digital in the world of science (which has been taking place since the invention of calculus by Newton and Leibniz), the construction industry is transitioning from traditional skilled trade analog and tribal production to that of a prefabricated, modular, and industrial approach.[1]

To facilitate this transition, the analog information must be digitalized, collected, codified, analyzed, and presented for usage to enable measurement and decision-making to reduce waste, cost, and time. This process, in turn, will help reduce the cost of production and hence the cost of shelter.

The digitalization, commonization, and interconnectivity of the data requires data quality control, which will have the following components:

1) Data collecting

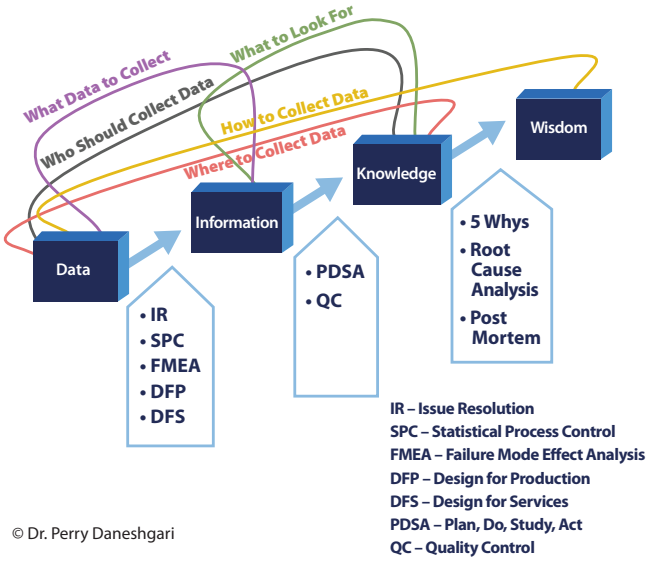
2) Data recording

3) Data reporting/reduction

4) Data presenting

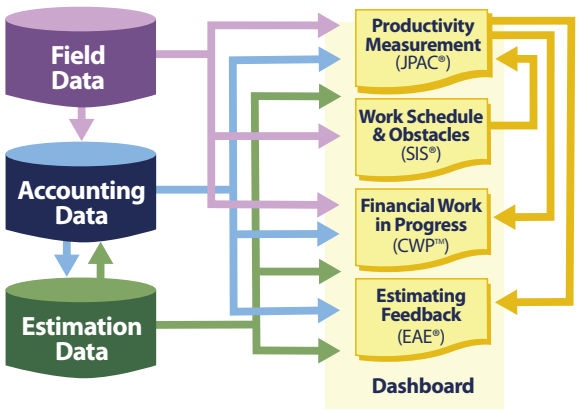
To assure the quality of these four components, the transition taxonomy of data to information, knowledge, and wisdom must be established by using the process displayed in Exhibit 1,

Exhibit 1: **Translating Data as a Learning Based Organization**



IR – Issue Resolution
SPC – Statistical Process Control
FMEA – Failure Mode Effect Analysis
DFP – Design for Production
DFS – Design for Services
PDSA – Plan, Do, Study, Act
QC – Quality Control

Exhibit 2: **Three Sets of Databases**



which presents the questions required and the processes and tools used by learning-based organizations that are looking to use data to improve business.

Data can be collected by using software or manual methods, but in order for the data to translate into useful information, knowledge, and wisdom requires asking the right questions. Remote monitoring and management of work sites will require assurance that the information being collected, recorded, reported, and presented represents the pure reality of the work environment.

Project Visibility Through Data

To replace the personal job visits with reliable and useful data, the *kinds* of data must be segregated. For most contractors, project estimate data and accounting data are the two most common available types. The estimate acts as the baseline budget, while the accounting acts as a rate of resources used. The missing link is the source of data about project progress, which is what the skilled trades know but is seldom captured or digitalized.

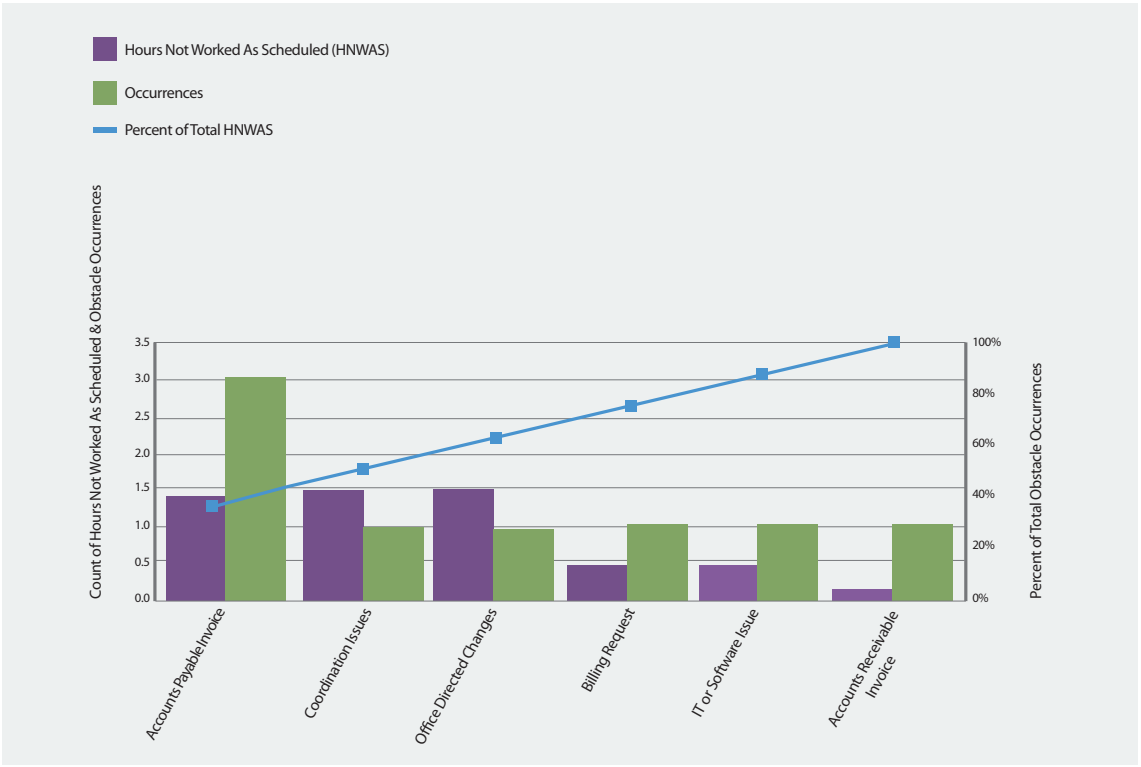
In other words, project progress as far as quality, change in burn rate acceleration or deceleration, and uncaptured changes due to weather, schedule, design, code, or any other causes are not captured during the project progress. To complete this circle and enable the remote production and control, a third data set is needed.

Exhibit 2 shows the three sets of databases needed to have a fully interconnected dashboard for project and company management, which is the most important when physical access to the work environment for data and measurement is not available. The interconnectivities of the three databases can be achieved with various tools or processes.[2]

As depicted in Exhibit 2, the items on the dashboard should have the following components independent of the tools used:

1) Quantitative measurement of work and obstacles of achieving goals
2) Qualitative measurement of work progress and its acceleration and deceleration
3) Tabulation and presentation of the quantitative and qualitative measurements for decision-making
4) Connectivity to the money
5) Codification of the results for various levels of the company and the project to make decisions remotely based on data

Exhibit 3: **One Week of Scheduled Work Activities, Allowing Remote Work Visibility**



Schedule Date: 03/20/2019 – Job Billings:								
Task	**Quantity**	**Scheduled Hours**	**Percent Complete**	**Reason Code for < 100% Complete**	**# of HNWAS**	**Detailed Reason Code**	**Notes**	**Files**
SIS™		0.25	100%		0			
Vendor waivers		0.75	100%		0			
Deposit – checks & ACH		0.75	100%		0			
Contract billings	3	3	100%		0			
Send invoices out – mail/e-mail	6	0.5	100%		0			
Bill customer through custom application		0.5	0%	Billing request	0.5	Multiple rush billings	Several billings with a due date were turned in last minute	
Attach invoices in accounting software		0.5	100%		0			
Schedule Date: 03/20/2019 – Job Controller:								
Task	**Quantity**	**Scheduled Hours**	**Percent Complete**	**Reason Code for < 100% Complete**	**# of HNWAS**	**Detailed Reason Code**	**Notes**	**Files**
E-mail/misc requests		2	100%		0			
Accounting software webinar		1	100%		0			
R&D survey		1	100%		0			
Special requests reports for PM		0.5	100%		0			
Crystal report updates		3.5	60%	Office directed change	1.5	Requested by management	Report request from CEO	

The CFO's Role in Increased Visibility

The CFO's role in making the work visible in this time of remote work is more important than ever. All resources in the form of manpower, money, and material will need to have a reference point for performance measurement.

In the remote work environment, the measurement of the resource usage must be adjusted to enable correct decision-making and planning. Relying on hours reported without considering the actual outcome and output will short the company and CFO in situational awareness of projects and their progress.

In addition to hours spent, a second and possibly third independent variable must be measured in order to triangulate the project and company's instantaneous short- and long-term options and alternatives. Any autonomous variable, such as observed percentage of completion of the work, can be used independent of the hours spent and relative to the trades' definition of work and activities to complete the project using the work breakdown structure.

In addition, measurement of obstacles to performance can be leveraged to provide the needed second or third independent variable. The tools and the algorithms to interpret the data are readily available. Analytical tools (i.e., Gantt, Pert, Run, and Pareto charts) as well as statistical tools (i.e., boxplots, first-time pass, and Failure Mode Effect Analysis) can help draw a much clearer picture of the resource usage and progress of the projects, where onsite observations or access are reduced or limited. Some alternative methods in managing the resources in the remote work environment are explained in the following sections.

Feedback from Remote Workers & Influencers

While mainly used for short-term scheduling on the jobsite, Short Interval Scheduling (SIS®)[3] is helping many remote workers share their daily tasks, obstacles, and reasons for distractions and performance issues.

Categorized and codified based on the common obstacles to completing work, the results are then tabulated on a daily basis to identify the system-level issues with procedures, processes, access, feedback, availability of the resources, etc.

Design in Seattle, **Build** in Phoenix & **Install** in Denver

Once prefabrication exceeds the critical mass percentage of production, the local, regional, national, and international application of remote work and production will catapult construction to different levels of operation. The concept of a construction industrialization megacenter was introduced in the article "The Operational Model for Modular Construction," which appeared in the May/June 2020 issue of *CFMA Building Profits*.[1] The work in this model is almost completely remote with assemblies and subassemblies produced in the megacenter and shipped onsite.

In other words, the elements of the work can be broken down and conducted in their most "effective" location. If a certain building or infrastructure design and layout expertise resides in Seattle and the production of the components is done most effectively in Phoenix, the final installation location could be Denver or anywhere.

An example of these beginnings happened a few years ago, when Holmes Electric, a company out of Seattle, determined that its expertise on in-wall rough-in was trumped by an outfit out of Phoenix that could produce it faster, better, and cheaper. With a few trial runs to perfect the data and information exchange between the two companies, Holmes now orders these kits regularly from a third party.

This sounds very simple but is still unorthodox for many of the trade contractors that cannot fathom anything but doing all of the work onsite. Sheet metal and roofing contractors are closer, with decades of history now on fabricating ductwork and trusses, respectively. The initial drive of both was due to their subassembly sizes; with little lay-down area on a jobsite, larger items like trusses and ductwork were the first to go. However, all manipulations and assemblies from all trades can be done off-site and will ultimately result in a better product for the end user due to the quality in expertise and specialization.

Endnote

1. *www.cfmabponline.net/cfmabp/20200506?pg=33.*

Exhibit 3 shows a one-week look into an office environment (particularly, an accounting department), which consists of onsite and remote workers. The Pareto chart at the top depicts the categories of obstacles to completing scheduled work, and the tables at the bottom show the level of visibility into the specific work as scheduled by the workforce. Reviewing Pareto charts on a weekly basis enables the managers and decision-makers to help all onsite and remote workers reduce obstacles. The visibility of the work gives visibility to managers about their resources:

- Is the right work being scheduled, and are priorities correct?
- Is there anything missing (is there something that should be a higher priority than what is scheduled)?
- Where does the time go (how much time is scheduled for specific activities)?
- What prevents workers from finishing scheduled tasks?
- Are there any unique or new tasks being scheduled due to remoteness?

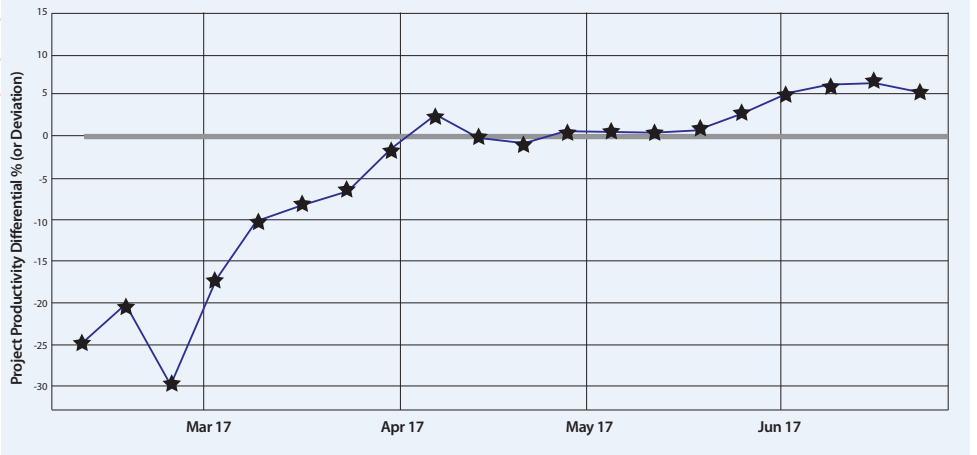
Prefabrication & Modularization to Reduce Reliance on Field Data

Since prefabrication and modularization are more like a production environment than a construction environment, tracking and managing the resources as well as the production outcome is much simpler.

Tracking production rates in a controlled environment like prefabrication suffers less from the production rate change and variations, and the output is very often equal to the outcome of the process.

Exhibit 4: **Summary & Trend Analysis of Jobsite Productivity Using JPAC®, an Application of ASTM E2691**

Task Description	Cost Code	Task Notes	BLHB	C/O	New BLHB	% Work for Cost Code	% Work for Project	Observed % Completed	Acct. Hours	Prod. Diff.
Project Total			980	5	980			97.35%	1064.5	5.01%
DISTRIBUTION | - GROUNDING	1220		8	0	8	6.9%	0.21%	0%		
DISTRIBUTION | - INSTALL BREAKER	1220		24	0	24	20.69%	0.63%	5%		
DISTRIBUTION | - INSTALL BREAKER FOR BALER	1220		4	0	4	3.45%	0.11%	0%		
Total For Cost Code Preferred Name: *DISTRIBUTION EQUIPMENT*	1220		116	0	116	100%	3.06%	4.48%	45	-765.4%
FEEDER CABLE | - FULL	1250		300	0	300	75.75%	7.92%	10%		
FEEDER CABLE | - TERMINATE	1250		80	0	80	20.2%	2.11%	0%		
FEEDER CABLE | - PULL FOR BALER	1250		16	0	16	4.04%	0.42%	0%		
Total For Cost Code Preferred Name: *FEEDER CABLE*	1250									
BRANCH POWER | - PIPE OUTLETS	13									
BRANCH POWER | - FANS	13									
BRANCH POWER | - REBLOCK SYSTEM	13									



In the prefabrication environment, the production rate change measurement gives way to precision measures such as first-time pass and line yield. These measurements are a part of much more predictable and established measurements in the manufacturing industry.

Where the currently used production rate change tracking tools such as Job Productivity Assurance and Control (JPAC®) (Exhibit 4) are used across the country on hundreds of construction sites, production rate tracking tools such as Tracking Profit Accounting with Control (TPAC™) (Exhibit 5) are used on the more controlled environments such as modular or prefabricated production sites.

The changes in production rate are shown graphically with a run chart in Exhibit 4 and could be due to:

- Labor productivity
- Rework
- Working on change orders
- Changes in work sequencing
- Changes in site conditions

The change in production rate is measured by comparing two independent variables – observed percent complete and labor hours spent – for situational awareness. Without being on the jobsite, field supervisors, project managers (PMs), and managers can watch the change in production rate by comparing these two independent variables.

The production rate tracking in Exhibit 5 compares the burn rate of the dollars in each cost code with the estimate, which projects where the code will finish (better or worse than the estimate) based on the database sources listed in Exhibit 2.

With the data and information available in Exhibits 3, 4, and 5, a financial manager can be completely remote and have the same (or perhaps even a better) view of the project.

How Will Prefabrication Help Working from Home?

There are many activities that can be conducted remotely if construction companies were to move the majority of their work to prefabrication facilities including:

- Drawings and layouts
- Building information modeling (BIM)
- Process design
- Procurement (Exhibit 6)
- Material management
- Transportation management
- Logistic management

Exhibit 5: **TPAC™, Tracking Profit Accounting with Control**

Task Description	Cost Code	Task Notes	Initial Cost	C/O	Rev. Cost	% for Cost Code	% for Project	% Complete	Incurred Cost	Prod. Diff.
Project Total			$208,373.20	2	$208,373.20			48.99%	$66,351.50	35.01%
Original Estimated Cost	100		$76,906.04	0	$76,906.04	98.72%	36.91%	50%		
Approved Change Order	100		$1,000.77	1	$1,000.77	1.28%	0.48%	0%		
Total for Cost Code Preferred Name: ***Labor***	100		$77,906.81	1	$77,906.81	100%	37.39%	49.36%	$34,597.53	10%
Original Estimated Cost	200		$117,444.91	0	$117,444.91	97.35%	56.36%	50%		
Approved Change Order	200		$3,195.94	1	$3,195.94	2.65%	1.53%	0%		
Total for Cost Code Preferred Name: ***Material***	200		$120,640.85	1	$120,640.85	100%	57.89%	48.68%	$29,520.77	49.7%
Original Estimated Cost	300		0	0	0	0%	0%	50%		
Total for Cost Code Preferred Name: ***Subcontractors***	300		0	0	0	100%	0%	0%	0	0%
Original Estimated Cost	400		$9,825.54	0	$9,825.54	100%	4.72%	50%		
Total for Cost Code Preferred Name: ***Other & Equipment***	400		$9,825.54	0	$9,825.54	100%	4.72%	50%	$2,233.20	54.5%

These activities and more can all be done away from the jobsite. Even if you don't have a prefabrication facility, your vendors may be able to accommodate space for these activities or even manage them. However, it requires collaborative planning and discussions that need to extend beyond just buying materials.

Using barcoding or any other kind of real-time physical tracking will allow the prefabrication usage to accelerate the contractor's movement toward industrialization. This will lead to the onset of application of automation and controls. A typical concern from the field about prefabrication is that the labor cannot see what is being built when it is not done onsite.

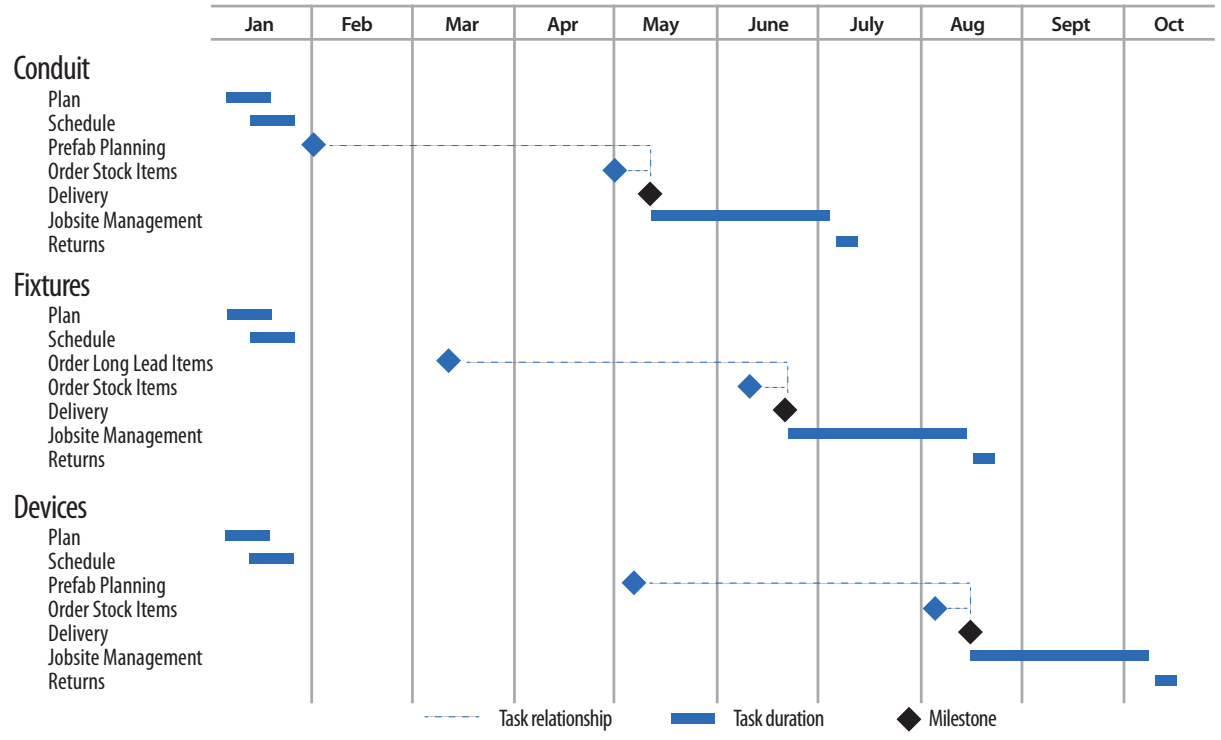
Similarly, the common complaint about material back orders is not knowing when the needed material will actually arrive. Every part carries information, and the ability to translate that information into knowledge, such that the labor's concerns, requires adherence to Exhibit 1. Technology alone will not resolve the concern; the right questions from Exhibit 1 must also be asked.

Remote Control or Quality of Production

The more that is done remotely, the greater the need for quality assurance and quality control (QA/QC) processes. To avoid "refab" (rework of prefabrication), the Process of Prefabrication[4] includes QA/QC plans, measurements, and feedback. In addition, MCA, Inc. is developing the first-ever industry standard for QA/QC of prefabrication for National Electrical Contractors Association (NECA) through the National Electrical Installation Standards (NEIS).[5]

It is the responsibility of the project team to ensure that all installed components, assemblies, subassemblies, and systems meet the customer's expectations and the company's

Exhibit 6: **Sample Procurement Schedule**



contractual obligations. This is very critical to recognize; the quality of the final installation cannot be abdicated to the remote operation.

In addition, prefabrication should not be done in a way that knowingly alters or adversely impacts any warranty, unless that information is properly communicated to the customer prior to execution. The expectation of the industry is that all installed work will perform as agreed and specified in the contract documents, independent of whether it is built onsite, at an off-site prefabrication facility, or at a third-party provider's plant.

The specific processes required for quality management include:

- Monitoring all incoming material, regardless of its source or state of assembly
- Assurance of quality during the staging, production, packaging, and delivery of material to the jobsite regardless of its place of origin or state of assembly
- Assurance of quality installation resulting in proper fit, function, and appearance of all systems, subsystems, assemblies, subassemblies, and components as appropriate to ensure satisfaction of the contractual obligations of the company

The QA/QC processes need to be documented and the results of all measurements retained for process improvement purposes. Prefabricated assemblies and products must be shipped in appropriate packaging for protection of the contents, in its intended destination and all intermediate storage locations, for the planned duration prior to installation. If any portion of this involves outdoor exposure for longer than loading and unloading a truck, then weather-tight and waterproof packaging should be used.[6]

Conclusion

Working from home is no different than prefabrication; it requires that work be identified, digitized, and codified for visibility and collaboration in place of a face-to-face environment. Between the office and the field, the in-person interactions can be partially replaced with data if that data can accurately reflect the reality of the work environment. This transition alone will help catalyze industrialization, which requires reliance on data more than the "gut feel" approach to job and project management.

Providing and utilizing organizational data is more critical than ever to create full situational awareness of the business and connect estimating, operations, and accounting databases. ■

Endnotes

1. Daneshgari, Dr. Perry & Moore, Dr. Heather. *Competing in the New Construction Environment: A Compilation to Lead the Way*. ELECTRI International. 2015.
2. Daneshgari, Dr. Perry. *Agile Construction® for the Electrical Contractor*. MCA, Inc. 2019.
3. Daneshgari, Parviz & Wilson, Michelle T. "The Impact of Job Planning on Profits." *CFMA Building Profits*. November/December 2005.
4. *www.cfmabponline.net/cfmabp/20200506?pg=33*.
5. Daneshgari, Dr. Perry; Moore, Dr. Heather; & Nimmo, Phil. "Recommended Practice for Prefabrication of Electrical Installations for Construction." National Electrical Installation Standards (NEIS). 2020.
6. Daneshgari, Dr. Perry & Moore, Dr. Heather. P*refabrication Handbook for the Construction Industry*. MCA, Inc. 2019.

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