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HOW INDUSTRIALIZED ARE YOU?

Measuring Your Company's Progress



According to Dr. Perry Daneshgari, “A swimmer can never measure the depth of the water while in it.” Similarly, job productivity measurement requires independent reference points.¹ This also applies to construction companies and the industry as a whole; they are on the path of industrialization, but how far and how fast are they going? What lies ahead and how can they keep up?

Building on MCA, Inc.’s research and publications on the Industrialization of Construction[®], including articles in *CFMA Building Profits*,² this article will provide a framework for companies in construction to evaluate their progress along the trajectory of industrialization. This article will also review the impediments to moving forward and revisit the role of the CFO with examples on how they can support industrialization.

INDUSTRIALIZATION OF CONSTRUCTION[®]

Industrialization, which occurs in any industry that is skilled-trade-centric (such as agriculture, manufacturing, and now construction), happens when work is transferred from the tacit knowledge of humans to digitized explicit knowledge.³ Through the five steps of industrialization (Exhibit 1), the results that occur include significant productivity improvement, market expansion, and labor force expansion.

Research conducted by MCA, Inc.⁴ indicates that the construction industry has made progress over the last decade toward Industrialization of Construction[®], moving from Step 1 to Step 2 (Exhibit 2). However, moving through the next steps requires a transition away from the current reliance on the tacit knowledge of the skilled trades toward an environment where the trade knowledge is explicit and work operations become optimized through additional roles and resources, which results in more, better, faster, and cheaper products for consumers.

INDUSTRIALIZATION SELF-REFLECTION

To assess the construction industry's state of industrialization, MCA, Inc. translated the five steps of industrialization and developed an Industrialization Index and a self-evaluation for companies to reflect on and evaluate their own status of industrialization.⁵

ELECTRI International and MCA, Inc.'s Industrialization Index Self-Evaluation⁶ is a 15-question assessment that a company can take with a response-based scoring system that determines the degree of industrialization by evaluating which and how often different practices, measurements, or models are applied within an organization and/or across projects for each of the five steps of industrialization.

The assessment generates a score (0-100%) for the overall level of industrialization, as well as for each of the five steps of industrialization, so participants can easily assess their position on the industrialization spectrum — from traditional to transitional and all the way to an industrialized state of operations.⁷

- 1) **Traditional (score 0-57%):** Low degree of industrialization. Business operations are largely technically-oriented and heavily rely on tacit knowledge of individuals — particularly of the skilled trades — and their experience and memory. Completion of work depends more on people and less on defined processes and procedures.

Outcomes and productivity are largely invisible and are assessed retrospectively, leading to high business risk due to high variation and low predictability of outcomes.

Exhibit 1: Five Steps of Industrialization

- | | |
|-----------------------------|--|
| 1) Management of Labor | Labor & Work Needs to be Managed |
| 2) Management of Work | Increase Efficiency of Machines |
| 3) Lean Operations | Track the Machine Efficiency for Improvement |
| 4) Modeling & Simulation | Improve Effectiveness of the Labor |
| 5) Feedback From the Source | |

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- 2) **Transitional (score 58-85%):** Intermediate state of industrialization where the operational model is in transition from the traditional to the industrial state.
- 3) **Industrial (score 86-100%):** The planning, execution, and control of the work is largely independent of skilled trade tacit knowledge. Clear responsibilities and structure through common processes and procedures allow for effective management of work and resources with continuous improvement and input from the field for efficient and more profitable business operations.

Construction's Self-Evaluation

Data collected from the Industrialization Index Self-Evaluation over the past year resulted in an average index score of 49%,⁸ indicating that the industry remains in the traditional state. Exhibit 3 illustrates and summarizes the industrialization scores representing local as well as national construction companies of all sizes across the U.S.

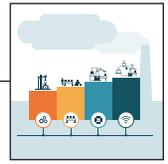
Exhibit 3 indicates that the industry is moving into the transitional state for management of labor and management of work, but Steps 3, 4, and 5 are remaining in the traditional state. With the work breakdown structure (WBS) and the use of cost codes and labor codes becoming more widely and consistently applied, the research study further validates that the industry and construction companies have started to move toward the transitional state of industrialization. The results further show that the respondents, mostly representing skilled trade contractors, are not as cohesive on understanding and moving beyond Step 2. Step 3, lean operations, is often associated with Lean Construction™, but these are not one in the same. As in other industries, lean operations can only happen when the skilled trades are not relied upon for every operation and decision needed on a jobsite.

In manufacturing, the skilled trades are not involved in the actual final assembly; they are busy with laying out the production lines, workflow, and machine maintenance with the use of their trade knowledge to optimize the flow and quality of output. The activities of how to assemble have been decoupled from the individual tradespeople, and therefore the “one best way” to produce can be decided with data for each product. Construction still relies on the tacit knowledge of the trades to build, and work operations cannot be optimized until that knowledge is available and understood.

The fourth step in industrialization is also misunderstood, as indicated by the variation in responses shown in Exhibit 3.

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Modeling and Simulation in industrialization includes models of work, information, and resources to get the best outcome for the end user. Current modeling in construction is primarily based on the physical building components rather than the work processes. Building information modeling (BIM) is a very small representation of the modeling required in Step 4 compared to other industries.

For example, models used in agriculture consider knowledge about the crops, landscape, equipment, weather, etc. to drive a combine. In manufacturing, simulations take into consideration the optimized system productivity, safety, and quality of the product. In construction, data about these types of factors that is readily accessible in agriculture and manufacturing does not even exist yet to simulate and optimize.

It's important to remember that, while industrialization in construction has only had a few decades of progress, it took manufacturing 100 years and agriculture three times that long.⁹ Forward movement and pace are a matter of understanding and learning from what other industries went through, as well as understanding the dependencies and sequence of the steps of industrialization.

Some industries have been able to move through Steps 3, 4,

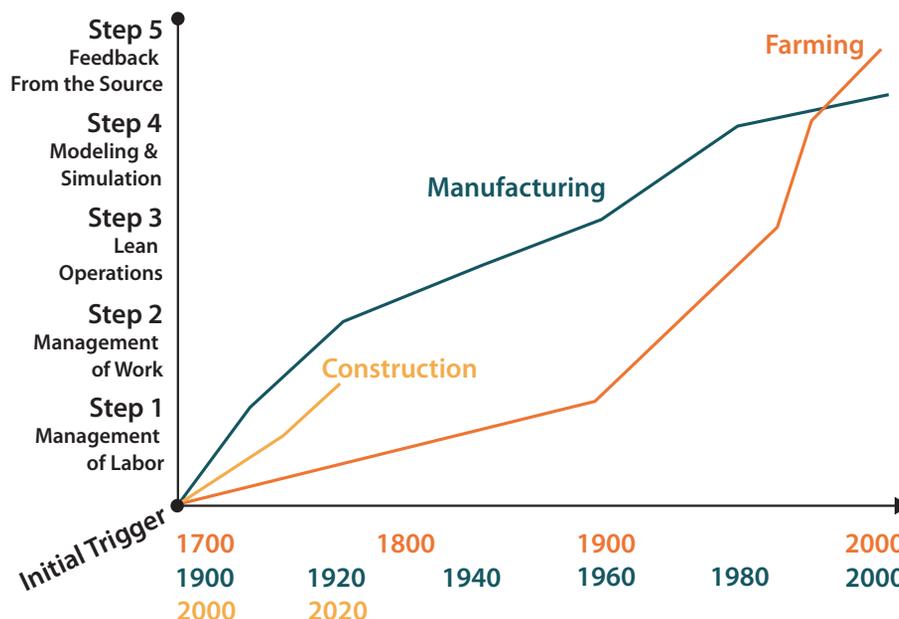
and 5 in parallel, but no industry has been able to jump the sequential requirements of Steps 1 and 2. Labor and work must be managed *before* lean operations, modeling and simulation, and feedback from the source can be implemented.¹⁰

In the era of industrialization, the construction industry will no longer be content with the know-how and expertise of the skilled tradespeople. They will also be looking for the know-why of resource management. Construction projects require many decisions to be made prior to their completion that are traditionally made by field labor on-site every day. Most of these decisions are made without any visibility or knowledge from management, as many contractors rely on the field to "make it work" when issues occur.¹¹

INDUSTRIALIZATION INDEX LITMUS TEST

While some decisions may seem insignificant in nature, their aggregate operational and ultimately financial impact on the business may not. These decisions not only impact the outcome of the construction projects and customer relationships, but they will likely prevent a business and its operations from becoming less labor-centric, therefore remaining stuck in a traditional model and unable to take the next steps towards industrialization.

Exhibit 2: Industrialization Trajectory: Timeline Comparison Between Construction, Farming & Manufacturing



Source: Moore, Dr. Heather; Daneshgari, Dr. Meik; & Parvin, Sydney. "Industrialization of Construction": Signal or Noise? Threat or Promise? ELECTRI International and MCA, Inc. March 2021. © MCA, Inc.

The Industrialization Index Litmus Test¹² (Exhibit 4) will further help determine and evaluate an organization's level of industrialization by looking at which decisions are made by technicians in the field and which are made by project managers (PMs), managers or executives, or even by members of the overall project delivery system, including independent prefabrication operations and vendors.

As a rule of thumb, the more decisions that are made by people in or closest to the field, the lower the degree of industrialization of the organization, and vice versa.

MOVING FORWARD

Once a company has done some data-driven self-reflection to know where it stands, it is time to evaluate how to get to the next levels. Exhibit 5 provides a set of practical applications and some guidelines on what a company can put in place depending on its level of industrialization and its industrialization index self-evaluation score.

Putting these applications into action has been proven in practice to help contractors move from traditional to transitional to industrial. However, there are also behaviors that can keep a company stagnant or sometimes move them backward on the curve, which all stem from over-reliance on internal reference points.

Disruption

Without studying, learning, and applying how industrialization happened in other industries, construction could be disrupted by another entity that gets there first.

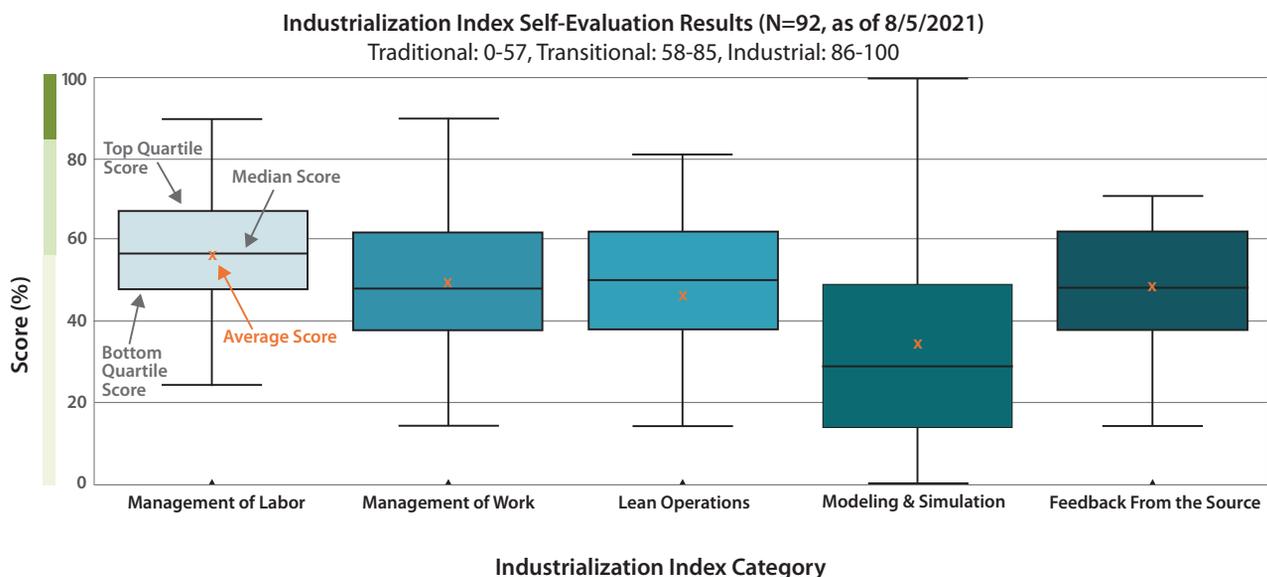
Disruption occurs when a company or industry is so entrenched in its current way of operating — yet consumers and end users are unserved or underserved — that a new product or service provider enters the market, typically in a “low quality” segment with a strong use of technology, and is able to grow exponentially, toppling the incumbent providers seemingly overnight.

Although peer groups are valuable for gaining insight from outside of the company, over time, they can become stagnant if the measurements and reference points don't change and expand outside of the group.

“Not invented here,” or when outsiders or new research/concepts are not allowed until the company internalizes them, is another phenomenon that can slow companies down from this transition. Learning from, and trusting, the influence of those who have experienced or studied the next stages in the trajectory is required to get the industry to progress to the next step.

Exhibit 3: Industrialization Index Self-Evaluation Results

Your company can take the Self-Evaluation at forms.gle/g9BibMow2ZzVBpJE7.



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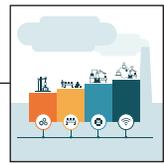


Exhibit 4: Industrialization Index Sample Litmus Test

See the sample below that indicates the person/function *primarily* responsible for making decisions pertaining to the topics listed in each row. If more than one person/function makes decisions on a row item topic, please select only the person/function who makes the decision most often. Your company can take the Litmus Test at forms.gle/9P9dMkXY63Xp7bh1A.

Who makes decisions regarding:		Technician	Foreman	Prefab Manager	Project Manager	Senior Project Manager	Manufacturer	Distributor	Executive
Material	Material Movement		X						
	Material Manipulation Prior to Installation*	X							
	Receiving Material				X				
	Returning Material		X						
	Material Storage		X						
Labor	Labor Movement				X				
	Labor Assignments		X						
	Labor Requests					X			
	Personal Illness/Issues		X						
	Labor Mix				X				
	Labor Productivity					X			
Cost	Material Cost				X				
	Equipment Cost				X				
Tools/ Equipment	Rental Equipment				X				
	Tools Ordering and Management				X				
Subs	Subcontractors Assignment and Management					X			

*Material manipulation includes activities such as bending pipe, cutting wire, punching holes, etc.

Source: Moore, Dr. Heather; Daneshgari, Dr. Meik; & Parvin, Sydney. "Industrialization of Construction": Signal or Noise? Threat or Promise? ELECTRI International and MCA, Inc. March 2021. © MCA, Inc.

Exhibit 5: Industrialization Practical Application Steps

Use your company's Industrialization Index Self-Evaluation results to review and apply the corresponding applications.

	If your company scored traditional (0-57%)	If your company scored transitional (58-85%)	If your company scored industrial (86-100%)
Management of Labor (Who Does What)	Jobsite Observation Checklist	Labor Codes	Task Management
Management of Work (When & Where)	Work Breakdown Structure	Decision-Making for Work Management	Work Packaging
Lean Operations (One Best Way)	Layout Guidance and Focus From Skilled Trade	Externalizing Work®	Variation Management
Modeling & Simulation (Prediction & Projection)	Expanding the Role of BIM	Project Scheduling as a Model for Work, Effort, and Time	Failure Mode Effect Analysis (FMEA)
Feedback From the Source (Human Input Into Continuous Improvement)	Identify the Sources of Data About the Work	Data Quality Management	Quality Circles

THE CFO'S ROLE

Exhibit 6 outlines the financial management implications for each of the five steps of industrialization, all of which require a stronger connection and balance between accounting and operations with new metrics, data, and information than what most construction companies use or collect today.

The CFO must play a critical role in leading the transformation toward industrialization by placing the right tools, the appropriate and correct measurements, and the applicable lead indicators in place, such as:

- 1) *An operational database structure* that interconnects to estimating and accounting. The database needs to house information about the work environment, based on the tacit knowledge and experience of the skilled trades, until the company has moved into Step 3 of industrialization.
- 2) *Longer-term planning of resources and market strategies* with a visible pipeline and backlog that allows for company-level decisions of who does what, when, and where much further in advance than in Steps 1 and 2.
- 3) *Understanding the implications of the revenue recognition changes* on capturing value transfer of

the work between skilled trade and owner/operator of built environments.¹³

WHAT'S NEXT: A PREDICTION FOR THE NEXT 3 YEARS

Research completed in early 2021 investigated *What's Next After Prefab*¹⁴ and the potential for expansion during transition to industrialization, as well as developed guidance for establishing internal standards and quality controls to achieve the industrialized expectations of the future construction environment. The projection of this future is shown in Exhibit 7.

Traditional contractors and distributors will be replaced by an interconnected supply chain system, while the progression will be dependent on advancements in technology, it will be even more dependent on the expanded knowledge and experience of skilled trades.

Other key findings from the research¹⁵ indicate:

- The construction industry of the future will move from loosely coordinated jobsites defined by individually planned and managed trades to highly integrated modular assembly facilities with common and consistent management of logistics and production processes.

Exhibit 6: Financial Management Implications in Industrialization of Construction®

Management of Labor

- Encourage operations to measure jobs independent of accounting measures
- Help develop cataloging to "account" for what labor does

Management of Work

- Use/enforce WBS and establishment of third database
- Setup common cost codes and labor codes
- Start building a Cost Book for work packages
- Initial prefab financial planning: capitalization and investments, tax laws, measurement methods

Lean Operations

- All databases are aligned to "one best way"
- Recognize and transmit between different business and financial models such as vendors, GCs, and trade contractors (spirit of integrated project delivery)
- Labor is no longer a separate "cost;" you are delivering, building, and selling work (spirit of Topic 606)

Modeling & Simulation

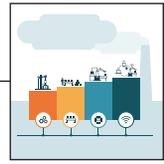
- Provide Cost Book data for decision modeling of best way to build

Feedback from the Source

- Assure financial measures and decisions are balanced with field and production data

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- These integrated, multi-trade production centers will feed jobsites with installation-ready modules that are seamlessly integrated into the final product.

CONCLUSION

Moving toward lean operations and modeling and simulation of information and work (from Step 2 to Step 3) as an industry will allow for major expansion of the construction market and a fundamental change in how construction is delivered.

Using the framework contained in this article to evaluate where your company stands will help to see where it lies on the trajectory of industrialization. It will also help organizations prepare as more work will be done off-site, and the role of suppliers and distributors will shift from product providers to logistics and service providers. ■

Exhibit 7: Projection of the Future of the Industrialized Construction Industry

- 1) New breed of contractors will be forming to replace the traditional ones
- 2) Through use of the Toyota Production System, a new breed of distributors will take the place of current distributors who:
 - Have a low first time pass in their warehouse
 - Focus on project management only with brute force
- 3) Digitalization, Commonization, and Interconnection™ (DCI™) will connect the distributors, manufacturers, and contractors seamlessly
- 4) A global architecture, engineering, and construction consortium will replace the current segmented industry
- 5) Cost, time, and quality of shelter, which is the main objective of construction, to satisfy the basic human need will be reduced to affordable levels of 25-30% of annual income vs. 300-600% at the current times

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Endnotes

1. Daneshgari, Dr. Perry & Moore, Dr. Heather. "COVID-19: Another Tectonic Shift in Business Operation Models." *CFMA Building Profits*. September/October 2020. www.cfmaponline.net/cfmabp/20200910/MobilePagedArticle.action?articleId=1654301. Daneshgari, Dr. Perry & Moore, Dr. Heather. "New Productivity Measurement Standard Affects Revenue Recognition." *CFMA Building Profits*. March/April 2012. www.cfmaponline.net/cfmabp/20120304?pg=26.
2. Daneshgari, Dr. Perry & Moore, Dr. Heather. "The Operational Model For Modular Construction." *CFMA Building Profits*. May/June 2020. www.cfmaponline.net/cfmabp/20200506/MobilePagedArticle.action?articleId=1656009. Daneshgari, Dr. Perry & Moore, Dr. Heather. "Jobsite to Garage: Changing the Mindset of Prefab & Modular Construction." *CFMA Building Profits*. March/April 2020. www.cfmaponline.net/cfmabp/20200304/MobilePagedArticle.action?articleId=1656724. Daneshgari, Dr. Perry & Moore, Dr. Heather. "Industrialization: Is Construction Next?" *CFMA Building Profits*. January/February 2020. www.cfmaponline.net/cfmabp/20200102/MobilePagedArticle.action?articleId=1645219.
3. Daneshgari, Dr. Perry & Moore, Dr. Heather. "Industrialization: Is Construction Next?" *CFMA Building Profits*. January/February 2020. www.cfmaponline.net/cfmabp/20200102/MobilePagedArticle.action?articleId=1645219.
4. Moore, Dr. Heather; Daneshgari, Dr. Meik; & Parvin, Sydney "Industrialization of Construction®: Signal or Noise? Threat or Promise?" ELECTRI International and MCA, Inc. March 2021.
5. "Industrialization of Construction®." MCA, Inc. mca-soft.com/industrialization-of-construction.
6. "Industrialization Index Self-Evaluation." ELECTRI International and MCA, Inc. forms.gle/g9BibMow2ZzVBpJE7.
7. Moore, Dr. Heather; Daneshgari, Dr. Meik; & Parvin, Sydney "Industrialization of Construction®: Signal or Noise? Threat or Promise?" ELECTRI International and MCA, Inc. March 2021.
8. Research Department. MCA, Inc.
9. "State of Industrialization." ELECTRI International and MCA, Inc. electri.org/wp-content/uploads/2021/03/F3440-State-of-Industrialization-sheet-Final.pdf.
10. Daneshgari, Dr. Perry & Moore, Dr. Heather. *Competing in the New Construction Environment, A Compilation to Lead the Way. Book One: The Here and Now — How to Be Competitive*. MCA, Inc. 2015. Daneshgari, Dr. Perry & Moore, Dr. Heather. *Industrialization of Construction: A Compilation to Lead the Way. Book Four: Efficiency and Continuous Improvement: Survival of the Unfits*. MCA, Inc. 2017.
11. Moore, Dr. Heather. "Exploring Information Generation and Propagation from the Point of Installation on Construction Jobsites: An SNA/ABM Hybrid Approach." ProQuest LLC, Ph.D. Dissertation, Michigan State University. 2013. Parvin, Sydney & Daneshgari Dr. Perry. "Invisible Decisions." *EC&M*. April 7, 2021. www.ecmweb.com/construction/business-management/article/21160294/invisible-decisions.

-
12. "Industrialization of Construction® Index Litmus Test." ELECTRI International and MCA, Inc. *forms.gle/TPJQocj6CmV9jB6s8*.
 13. Moore, Dr. Heather & Daneshgari, Dr. Perry. "What Changes to FASB Requirements Will Mean to Electrical Contractors." EC&M. August 15, 2013. *www.ecmweb.com/construction/article/20897829/what-changes-to-fasb-requirements-will-mean-to-electrical-contractors*.
 14. Nimmo, Philip & Moore, Dr. Heather. "What's Next After Prefab?" ELECTRI International. 2021 (pending publication).
 15. Ibid.

The authors wish to thank Dr. Meik Daneshgari, Research Director at MCA, Inc., for his research and contributions to this article.

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