NAC Executive Insights

Systemic Innovation

Key Points

- Since about 1970, U.S construction industry productivity has at best been a laggard as compared to other industries.
- Systemic innovation is that form of innovation that requires "multiple specialist firms to change their process in a coordinated fashion."
- Innovation is critical to renewal of industries; systemic innovations produce the largest productivity gains.
- Weak relational stability exacerbates problems associated with implementing systemic innovation in a network of firms and leads to much slower diffusion.
- Key to the ability of such inter-organizational networks to promote systemic innovation is the degree to which knowledge and lessons learned are shared within the network.
- Self-organization of the engineering and construction network without a change agent will be a slow and largely unfocused process.
- The key characteristics of innovation that influence systemic adoption rates include:
  - Relative advantage
  - Compatability
  - Complexity
  - Trialability
  - Observability
- Systemic issues the engineering and construction industry is facing include:
  - New business models (changed project delivery models (PPP, D/B) and long-term supplier or service relationships)
  - Information and knowledge (not just data) technologies
  - Increased "value" focus (life-cycle costs, flexibility, resiliency)
  - Performance based standards and regulations
  - Human resources
  - Sustainability
- The spirit of creativity that were the hallmarks of the industry's "Master Builders" must be re-ignited.

Introduction

Periodically it is necessary to question whether a current paradigm will suffice into the future. This Executive Insight is intended as one such look at a current paradigm: the engineering and construction (E&C) industry model. The purpose of this Executive Insight is to raise questions, challenge the current paradigm, and leave the reader with more questions than they had at the outset of reading this Executive Insight.

Silver bullets or charted paths to improvement will not be suggested here, but the debate will be fostered regarding whether the E&C industry model is broken, whether it should be improved it, and whether large programs utilizing a program management approach offer one path to improvement.

Is the E&C Industry Model Broken?

The engineering and construction industry is the one of the largest industries in the world. And in many ways, today's projects are larger and more complex than any faced before. They now include not only mega-programs, but even larger, more complex versions in the form of "giga" programs.

Yet as an industry, since about 1970, U.S. construction productivity has at best been a laggard as compared to other industries. Cost overruns, unanticipated risks. and schedule slippages are still too common. Why? And what can be done to change this situation?

Today's E&C industry model was in many ways established following World War II. Its structure is "industrial" in nature and based on the "serial specialization" that existed in manufacturing at that time. The 21st century is not like the late 20th century, however, and experience in other industry sectors has shown that significant productivity gains coincide with industry models that facilitate systemic innovation.

What Is Systemic Innovation?

Systemic innovation is that form of innovation that requires "multiple specialist firms to change their process in a coordinated fashion." It differs from incremental innovation, which can be accomplished within a single, firm context or within a discrete project context.

Examples of systemic innovation in the engineering and construction industry include:

- Integrated supply chain management
- Prefabrication of building systems

- 3D CAD virtual design and construction tools
- Building information models (BIM)
- Project finance initiatives (PFI) and public private-partnerships (PPP)
- Modularization

Many of these are characteristic of successful large programs.

Why Is Systemic Innovation Important to the E&C Industry?

Innovation is critical to renewal of industries. Systemic innovations produce the largest productivity gains.

Studies have shown that more industries are migrating from functional hierarchies to project forms of organization, where innovation is not as well understood and where systemic innovations diffuse more slowly. As such the understanding of barriers to systemic innovation are of growing importance not only to our industry, but also to many other industries.

The E&C industry may be on par with manufacturing when incremental innovation is considered (minor changes in product). It is, however, a laggard in systemic innovation where multiple firms must change their processes. Simply put, the industry has an innovation deficit, one where it largely harvests from past innovation efforts, but one where we very few new seeds are being sown.

Improving the industry's systemic innovation is important and yet it may be constrained by its own model. An new industry model is needed that promotes sustainable innovation, one not simply focused on the short term.

Attributes of Industries with Successful Systemic Innovation

The hallmarks of industries that experience strong systemic innovation include:

- Strong relational stability, that is, a tendency to use a small number of firms per specialty
- Corporate interests that are more networked in nature
- Boundaries that facilitate redistribution of work
- Strong "network-level" agents for change

These are not the hallmarks of the E&C industry, where project teams come together with wide variety, sometimes driven by owner preferences, to preserve the "serial specialization" model of the industrial era and sometimes driven by a sole focus on first cost. Rigid trade or corporate structures together with limited flexibility in redistributing work across the various components of a

project team also act to limit the opportunities for systemic innovation and real productivity improvement. While meaningful incremental improvement will continue to be achieved, does the current industry model essentially preclude the opportunity for broad and meaningful systemic improvement?

Here again, major programs, especially those employing a program management approach, may offer the opportunity to overcome many of these systematic barriers. An examination of these attributes key to systemic innovation follows.

Relational Stability

Research into relational stability has been ongoing for over 35 years. Since 1981, when researcher Robert G. Eccles' investigated the "quasifirm" (a general contractor and special trade subcontractors working together), the U.S. construction network has evolved to shorter-term relationships with a larger set of partner firms. This trend is not common across various manufacturing industries or even within the E&C industries in other countries.

Weak relational stability exacerbates problems associated with implementing systemic innovation in a network of firms and leads to much slower diffusion than one might expect. In contrast, strong relational stability in a network of firms (such as those in the Finnish E&C industry and the Danish wind turbine industry) mitigated the impact of shifting allocations of work associated with each systemic innovation.

The deeper the "embededdness," the more likely firms in a network are to see their interests as aligned rather than as opposed.

When interests accumulated at the level of the firm, the effect was to exacerbate the diffusion rate of systemic innovation. By considering only their firm's interests and not attempting to share the benefits of the innovation with their partners, firms were restricting the rate of diffusion of the innovation.

In contrast, networks where the interests were defined at the network level alleviated fears of opportunism and increased the willingness to share the benefits of innovation with partners. In these networks, the network level accrual of *interests* expedited diffusion.

Networked Corporate Interests

Inter-organizational networks provide for integrating the corporate interests of member firms. Strong networks aid in the diffusion of systemic innovations. In inter-organizational networks, groups of two or more firms work together in the interdependent production of goods or services. This area has been well researched. Arguments for quasifirm and hybrid organizational arrangements were rooted principally in terms of economic exchanges that contain aspects of both market and within-firm hierarchical exchanges.

Key to the ability of such inter-organizational networks to promote systemic innovation is the degree to which knowledge and lessons learned are shared. This is not easily accomplished and any assessment of the strength of an inter-organizational network must look carefully at the ability or difficulty of making learning portable in the inter-organizational networks.

The question of where interests are centered (firm vs. network) affects the ability to achieve systemic innovation. The project model currently employed by the E&C industry as well as other decentralized industry structures promotes innovation at the project level, but makes broader industry adoption more difficult. Systemic innovations will diffuse more slowly than incremental innovations given this weaker (more transient) form of networked corporate interests. The continuous breaking of learning and feedback loops, as projects reach completion and new project teams are assembled, negatively impacts the ability of construction industry networks to innovate.

Industry Boundaries

Boundary strength is a measure of how strongly defined and rigid the barriers between firms are and how they act to limit systemic innovation within a network. An example of the detrimental effects to systemic innovation associated with high boundary strength can be seen in the failure of Buckminster Fuller's Dymaxion house. In this example of boundary strength within the E&C industry, established contractors resisted integrated prefabrication by insisting they be paid to take apart the prefab structures and then put them together again.

Integration of firms into a single enterprise (sometimes known as a special purpose vehicle or SPV) promotes systemic innovation within this redefined network, but only to the extent the previous constituent parts increase their knowledge about the detailed impacts of their decisions on the balance of the network and modify those decisions to improve overall network efficiency rather than sub-optimizing for their sole tasks' sake.

Design-build (D/B) done with a fully integrated team, for example, is a first step in the engineering and construction industry. The creation of SPVs for delivery of public-private partnerships (P3s) represents a more comprehensive vertical integration and further expands the opportunities and value proposition associated with systemic innovation.

One would expect the permanent combination of engineer and constructor in a permanent enterprise to promote innovation. This is consistent with findings in industries that typically rely on an engineer-procure-construct-manage (EPCM) or engineer-procure-construct (EPC) approach rather than those who rely on purposely assembled design and construction teams. Similarly, performance benefits from tighter integration of industry participants can be seen in performance results of D/B projects.

The more extensive the integration of this delivery network and the more permanent its nature, the more likely one should expect systemic improvements on a sustained business.

Network-Level Agents for Change

A change agent is essential to the improvement of the current industry model to benefit from systemic innovation. Self-organization of the E&C network without a change agent will be a slow and largely unfocused process. What are the change agents available to the industry today and which new ones are likely to emerge?

Industry-wide systemic innovations will be promoted by consistent types of changes across the industry's self-organizing networks. These changes may flow from some of the systemic issues the industry is now facing or from national imperatives. They will be further promoted by a clear understanding of the process by which networks adopt new innovations. The key characteristics of innovation that influence systemic adoption rates include:

- Relative advantage
- Compatability
- Complexity
- Trialability
- Observability

And one or more key factors must be present for real systemic innovation to occur. These include:

- Dissatisfaction with the status quo
- Existence of knowledge and skills

- Availability of resources
- Availability of time
- Rewards or incentives exist
- Participation
- Commitment

And most importantly, **leadership.**

Systemic Issues the E&C Industry is Facing

Systemic issues the engineering and construction industry is facing include:

- New business models (changed project delivery models (P3, D/B) and long-term supplier or service relationships)
- Information and knowledge (not simply data) technologies
- Increased value focus (life-cycle costs, flexibility, resiliency)
- Performance-based standards and regulations
- Human resources
- Sustainability

A New Paradigm?

Systemic and sustainable innovation requires patience. Such innovation is about *potential*, not *deliverables*. It will involve failure—multiple failures—that, in many ways, is a hallmark of true breakthrough, systemic innovation. It will cause a re-examination of planning horizons and how basic and applied research are conducted. How products and applications are developed will have to be re-examined as well. Can the current E&C industry model support this transformation? Or is that model instead a principle barrier?

What might a more networked industry model look like and how might relational stability appear in such a network? Will more vertical integration be seen in the industry? Will owners increasingly hire permanent consortia that come with a largely developed and integrated supply chain? Is competition of supply chains a potential end-state? And what degree of fluidity must be retained so that networks benefit from new industry-wide approaches and ideas? Is it reasonable to expect that early integrators of the supply chain will have at least temporal first-mover advantage?

Will procurement and management practices in the industry evolve to create and capture the systemic improvements such a changed approach could hold? Will consortia members share proprietary tools or perhaps develop consortia-specific ones? Will knowledge be shared openly and completely across consortia members?

Will EPC firms with strategic supplier relationship agreements provide the basis for them to come to a project with their supply chain in tow? Will a firm's integrated framework of systems be more broadly extended to encompass their strategic partners? Will leading knowledge systems create a common repository of knowledge shared between engineers, constructors, and their strategic suppliers?

And finally, what role can large programs and strategic program management play in fostering systemic innovation?

While some firms seek to answer these questions and create competitive advantage, it does not yet address the question of whether the industry model is broken or, maybe more fairly, has the industry outgrown its model now that it finds itself in the 21st century? If the answer is yes, then it will take a "network-level" agent of change.

Where Will that Leadership Come From?

The E&C industry is an important one. It affects the foundations of many other industries in the global economy. The spirit of creativity that were the hallmarks of the industry's "Master Builders" must be re-ignited. Where will that leadership come from? This is question that must be answered soon. The lessons learned in large programs will help point the way. So too will the leadership that the National Academy of Construction can provide.

About the Author

Bob Prieto was elected to the National Academy of Construction in 2011. He is a senior executive who is effective in shaping and executing business strategy and a recognized leader within the infrastructure, engineering, and construction industries.