Sample Research Problems Identified By CII

This document lists some of the research problems identified by Construction Industry Institute (CII) and member companies in its annual Request For Proposals (RFPs) in recent years. You may find some of these problems interesting to you and decide to take one of these challenges to be your research topic. Or, these topics may inspire you to develop your own new research idea. Please note the following:

1. CII research statements only identify the industry issues and expected deliverables. Researchers must come up with the solution/methodology to solve these problems.
2. These topics are typically developed into research projects that can take 2-3 years to complete. Therefore, if you take one of the topics, you are advised to consider limit and refine the work scope so it is realistic to accomplish in a 2-semester master research.

2014 Research Topic Slate

The topics as defined in this appendix have yet to be submitted to CII’s Board of Advisors. Therefore minor changes to the topic statements are possible before the research is awarded.

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RTS # 1
Definition and Measurement of Engineering/Design Deliverable Quality

Essential Task
Develop a uniform definition and method of measurement for engineering/design deliverable quality, usable by project stakeholders such as owners, constructors/craft, equipment suppliers, and engineer/designers.

Background
In recent years, the quality of engineering deliverables has become increasingly important for successful project delivery. However, because project stakeholders necessarily have diverse points of view, the industry lacks a shared understanding of the most common failures in design deliverables. By being able to define the quality of certain key deliverables, project teams could better measure their quality. The project improvement that would likely result from high-quality engineering/design deliverables would include the following:

- alignment of project team expectations
- project cost reductions
- project schedule improvement
- reduced rework and claims
- improved project risk management
- better predictability of project documentation and value
- data integrity and completeness.

Note to Team
The research team should consider conducting a workshop to broaden its understanding of quality definitions and common quality problems among all project stakeholders. Following the workshop, the team should consider a survey to gauge industry support for a uniform definition and method of measurement for engineering/design deliverable quality.
**RTS #2**  
**Best Practices for Succession Planning**

**Essential Question**  
What are the best practices for effective succession planning?

**Background**  
The current project professional workforce is nearing retirement age, and it is critical for companies to sustain effective leadership and workforce. Which practices are most effective for identifying and preparing mid-career and early career employees to assume leadership roles? Are there established practices in other industries that the project delivery industry can adopt that would meet a universal need? Are there proven practices that are most effective for specific sectors of our industry?

**Notes to Team**  
- New hires are looking for an understanding of a clear career/succession path.
- Which practices are best suited to accommodating the career needs and desires of the early career generation?
- Members of this research team should include some HR/organizational development individuals.

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**RTS # 3**  
**Can We Utilize Next--Gen Experience to Maximize Virtual Team Performance?**

**Essential Question**  
Does the construction industry trail other industries in its use of information technologies and, if so, does this lag affect virtual team performance? Further, can the construction industry learn from its Next-Gen’s experience to maximize the performance of virtual teams?

**Background**  
- Even though our Next-Gen makes significant use of information exchange technologies, the construction industry may still be lagging in the efficient adoption of these technologies. The research team should first determine whether the industry’s technology use is indeed inadequate, and then identify and develop any beneficial learnings and practices—including those from the millennial generation—to maximize virtual team performance.

**Notes to Team**  
The following should be considered part of the research:

- Investigate how a virtual environment could affect career development.
• Identify any personality traits that affect virtual team performance.
• Assess ways that cultural differences might affect virtual teams.
• Identify any relationships between Next-Gen aptitudes/perspectives/know-how and high-performing virtual teams.

### RTS #4
**Rethinking Supplier Data**

#### Essential Question

What are the most efficient and breakthrough approaches to ensuring accurate and timely transfer of Supplier data and documentation to the design, construction, and commissioning Contractor and Owner team(s)?

#### Background

The objective is to determine user requirements, identify automation opportunities, and establish standards that will reduce waste and delay in the life cycle work processes.

The intended scope would examine the entire work process for the request, delivery, formatting, review, access, distribution, and handover of Supplier data on capital projects. The team should identify opportunities to standardize and streamline the requirements and delivery processes for Supplier information.

Supplier information is the primary input that supports detailed engineering. Requesting, generating, receiving, reviewing, approving, and making this information available to the design, construction, and commissioning teams is critical to project success. Late or incomplete Supplier information results in out-of-sequence work, rework, and delays. The current capital project work processes of Contractors, Owners, and Suppliers often generate waste, non-value activities, inefficiencies, and non-standard requirements/nomenclatures; these by-products then feed back into the work processes and further propagate themselves.

Some opportunities for improvement would include the following:

1. *Standardize the data request format for the most common equipment and fabrication data components.*
2. *Standardize the data requirements to support Owner spare parts and life cycle requirements and information.*
3. *Explore better ways to ensure the following conditions:*
   - *The Supplier data are accurate, timely, and available to all downstream users, and support proper change management.*
- Supplier is able to make the information available so that all users can "pull" what they need, when they need it.
- Efficient and economical processes are established for requesting, expediting, receiving, logging, reviewing, returning, distributing, and, eventually, handing over all supplier information at the end of the project.

**Note to Team**

Consider the needs and involvement of Supplier, Engineering, Construction, Commissioning, and Owner teams. Also consider use of technology to facilitate improvement in data management.

**RTS #5**

**Improving Productivity Measurement through a Translatable Standard Code of Accounts**

**Essential Task**

Establish a translatable standard code of accounts to drive construction productivity improvement through consistent measurement and reporting.

**Background**

RT 252 recently concluded a six-year effort to identify, develop, and validate new techniques, methods, and initiatives to improve construction productivity on CII projects. One of the study’s key lessons learned was that it is difficult to improve productivity without consistent measures of productivity unit rates (e.g., work hours/output). The team found that a significant impediment to such improved productivity measurement was the industry-wide lack of clearly defined and universally utilized cost accounts (i.e., a code of accounts that would be usable within a single company or across companies).

Establishing a standard code of accounts that could be used directly, or translated to one currently used within a company, would give multiple stakeholders several benefits: improved, reliable benchmarking efforts; improved predictability of future project costs and schedule requirements (for both contractors and owners); and a better understanding of the impacts of regulations and policy on industry performance.

The team should consider the following research activities:

- Evaluate the variety of codes of accounts used by companies (actual projects).
- Establish the core code of accounts required to determine construction productivity.
- Determine the level of detail needed in the code of accounts to give confidence in the productivity calculation.
- Provide recommendations on the use of the standard code of accounts and the resultant productivity calculation to drive project improvement.
Notes to Team

- Review the CII Benchmarking Productivity structure as a starting point.
- Consider ways that individual companies with years of productivity measurement experience could easily translate their data to the new code of accounts.
- Evaluate how the code of accounts aligns with or could be used in tandem with the CII Performance Assessment Committee activities.
- NIST has been reporting on construction industry productivity since 1964; however, this assessment is based on a crude industry metric that does not allow for the measurement of industry-sector or project-level productivity and the improvement it would enable.
- A goal of finding a reliable construction productivity metric is to enable users to compare project construction productivity within a company, to drive continuous improvement.
- Investigate the Electronic Data Interchange (EDI) translation technologies to see if the EDI approach can be adapted to this topic.

RTS # 6
Advancing Modularization/Pre-Fabrication in the General Building Industry

Essential Question
What are the best approaches to significantly increasing the depth and breadth of modularization/pre-fabrication in the general building sector?

Background
CII RT 255 Transforming Modular Construction for the Competitive Advantage through the Adaptation of Shipbuilding Production Processes to Construction provided a framework for creating modular design along with key barriers to implementing on projects. In Research Summary 255-1, the team stressed the importance of the Interim Product Database (IPD) concept to standardizing modular design for the construction industry. A recent McGraw-Hill Construction SmartMarket Report titled Prefabrication and Modularization assessed the current state of prefabrication and modularization in the construction industry. According to this report, the advancement of modularization in the general building sector is hindered by the resistance of current design approaches to incorporate the IPD concept or to address standardization and construction work packaging cohesively (to minimize the number of unique project elements). Because the current custom design approach (i.e., building-by-building and floor-by-floor) is not conducive to modularization, the industry is not able to realize any of its opportunities for cost, schedule, and other improvements.

The industry now needs clear guidance on creating project modularization plans that increase the depth and breadth of modularization. Establishing a plan template would allow project teams—at project inception—to address the business case/performance opportunities for modularization including team set-up, deliverables, interface of modules with other elements, and logistics.
Notes to Team

- The focus of this research should be on commercial and institutional construction, and not on residential or industrial process construction.
- The team should reference the work of RT 283 on the early formulation of a modularization business case.
- Designers (architects and engineers) should be included on the project team.

References
CII RT 171 – PPMOF
CII RT 283 – Industrial Modularization

RTS # 7
Construction Transformation through Robotics

Essential Question

How can CII members prepare for and implement current and future robotics technologies on our projects? How can we effectively influence robotics technology development to match our particular needs?

Background

The adoption of robotics has already transformed other industries (e.g., manufacturing and the military), particularly with respect to their use of and need for labor. Because the construction industry is just starting down the path towards robotics use, we must identify the lessons learned from these other industries, and understand the changes that robotics have necessitated in organizational structure, workforce skill, and work activities.

As the construction industry begins its own technology transformation, it could benefit from identifying categories of robotics and formulating their value propositions. To provide context for this future automation, the research team might create reasonable scenarios of how robotics will change construction techniques and implementation.

Following are items for the team to consider:

- What is the current landscape and direction of robotics in construction?
- What are the lessons learned from robotic-enabled industries?
- Who are the current thought leaders in construction robotics, and what can we learn from them?
- What does the construction industry need from robotics?
- Are technology development and industry needs aligned today?
- How should robotic technologies be effectively introduced to the field?
- How will skills need to change for the implementation of robotics?
• How do robotics change construction management and the job site?

Notes to Team

Consider collaboration with the International Association for Automation and Robotics in Construction\(^1\) (IAARC), and learn from the International Symposium on Automation and Robotics in Construction and Mining\(^2\) (ISARC). Explore owner uses of robotics in manufacturing to investigate opportunities for adaptation for construction.

**RTS # 8**

*Using Precursor Analysis to Prevent Low-frequency High-impact Events, Including Fatalities*

**Essential Question**

Are there precursors or leading indicators of low-frequency high-impact events such as fatalities and near-fatals? If so, what are they, and how can they be identified, analyzed, and utilized?

**Background**

Industry has a long history of developing and implementing safety best practices, and most of the learnings have occurred in the wake of serious injures or fatalities. And, while many corporations have mature safety cultures, the number of fatalities within their operations seems to have plateaued. While every fatality generates root-cause documentation and/or diagnostic information, the maturity of an organization’s HSE program often determines the rigor applied to the root-cause analysis of non-recordable events. Because of this inconsistent treatment across the industry, trends pointing to impending high-severity events are not readily or reliably detectable.

Are rare but highly severe injuries random occurrences? Or do foreseeable precursors point to their impending occurrence? Are there differences between the precursors of frequent low-severity events and these infrequent high-impact events? Can data on near-fatal events be leveraged or normalized to predict conditions that may lead to high-impact events? Are such precursors affected by variables such as industry sector, project type, and/or workforce characteristics? Or are they universal and stable?

**Note to Team**

- Explore whether other industry groups are pondering the same question. If so, capture the status of their investigations.
- The ideal team member would have an understanding of safety systems and processes, and significant field experience with pertinent/relevant events.
- The ideal team would have a good cross-section of industries, markets, project sizes, and stakeholders.
• The team should revisit other CII or industry research topics applicable to this subject, and determine their applicability.

RTS #10
Improving Project Progress and Performance Assessment

Essential question

How can we better assess project progress and performance, and provide data for future project improvement? What are the more useful parameters and indicators?

Background:

Identifying the parameters and indicators of both high- and low-performing projects should enable more effective ways of assessing project progress and performance. Organizations measure project performance differently: some track the Cost Performance Index (CPI) and the Schedule Performance Index (SPI); some assess profitability; and others look at cycle time variance to plan. The team should consider the following:

• Which parameters and indicators work best and why?
• Which metrics provide the most insight into an organization’s performance as the basis for improvement? For example, should process plant projects track variance to plan for issued-for-design P&ID schedules—and does this result in improvement over time across the project portfolio?
• What are new ways of gauging high- and low-performing projects for more effective project assessment and design? Which metrics should be considered for assessing project performance in different project phases, from baseline definition to completion?
• Which subjective factors (e.g., leadership and project management/team capability) should be included in the scope

Note to Team

RT 291 identified four key practice areas associated with improved predictability on project outcomes. This research differs in that it focuses on the specific performance assessments and measures that enable effective project management, governance, and monitoring, rather than on practices correlated with predictability.

This investigation is independent of CII benchmarking and performance assessment efforts across the industry.

RTS #11
Future Construction Needs of Virtual Design Models

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Essential Question

What are the near-term needs (i.e., within three to five years) for better and expanded use of project models such as 3D CAD, BIM, and Virtual Design and Construction (VDC) on construction projects? Further, how can the construction industry best prioritize the gaps in development focus?

Background

McGraw-Hill Construction SmartMarket Reports have recently chronicled a significant increase in the use and definition of 3D CAD/BIM/VDC in the design and construction industry. Yet, while the process industries have widely deployed 3D and 4D CAD for years, the construction industry has not provided any significant leadership in the development of these tools (software and hardware alike) to date. With the current rapid expansion of VDC—primarily the creation of 3D models—the industry has an opportunity to provide clear direction to developers on what it needs to maximize the value of VDC during the construction phase of projects. This input could cover a range of activities such as safety, quality, logistics, workforce issues, simulation, and as-built documentation.

The team should identify which future model processes are most relevant to construction. Then it should identify any gaps in model development and formulate recommendations to developers to fill the gaps.

Notes to Team

- Review SmartMarket Reports to determine the current status of these tools in the industry.
- The team should have a blend of VDC and field construction experience.
- Contact FIATECH regarding work already undertaken in this area.

RTS #12

A Closer Look at Material Planning; a New Look at Jobsite Delivery Timing Strategies

Essential Question

What are the optimal elements, best practices, and documentable benefits of Material Planning (a component of Materials Management)? Further, as part of an enhanced Material Planning process, can project material and equipment inventories (and associated inventory carry costs) be optimized?

Background
Material Planning—also known as Material Requirements Planning—is the oversight of the entire project material and equipment life cycle, from conceptual design through project close-out. Material Planning ensures that the right material is in the right place at the right time, with a minimal level of surplus.

The research team should devise an analytical process to select the optimal balance between just-in-time and just-in-case delivery strategies for various types of project materials and equipment, without jeopardizing project schedules?

**Just-in-time (JIT)** is classically defined as an inventory strategy that strives to receive goods only as they are needed in the production process, and thereby improves a business’s return on investment by reducing in-process inventory and associated carrying and handling costs.

**Just-in-case (JIC)** is classically defined as an inventory strategy that aims to maintain large inventories of in-process supplies, parts, and warehousing resources in order to minimize the possibility that adequate inventories will be unavailable in the face of varying or unpredictable production and supply chain contingencies.

In practice, JIT and JIC can be viewed as two extremes that can be applied in varying degrees to various types of supplies.

Further, the team should consider developing enhanced metrics for site Materials Management effectiveness, including receiving, storing, staging and rigging for movement minimization, loss and damage reduction, double-handling, and search-time elimination.

**Note to Team**

Ideal team members might include those familiar with economic evaluation as well as materials planning expertise.


**RTS #13**

Safety in our Supply Chains
Essential Question

Can a “business case” be made for addressing Safety in our supply chains?

Background

- Contractors and Owners typically have some varying standards for evaluating the Safety performance of Suppliers in their prequalification and selection processes, but they rarely go deeper into the supply chain to include sub-Suppliers, and even sub-sub-Suppliers.

- Subcontracting is routinely and effectively addressed, with any Subcontractors and lower-tier Subcontractors performing work on our project sites fully engaged with and subjected to our entire company and project Safety programs.

- But what about the activities in our offsite Suppliers’ and their sub-Suppliers’ shops and facilities as they fulfill our orders?

- How would a Contractor or Owner feel to complete a major project with extraordinary onsite Safety performance involving hundreds of thousands of work-hours without a single lost-time incident, only to learn later that x number of people were actually killed in Supplier or Sub-supplier shops while working on material and equipment directly for that project? Would they still brag about the Safety performance on that project?

- Some thoughts to consider in addressing this topic and providing a recommendation for the Industry:
  - Even though there is generally no legal or insured liability for Purchasers does the industry have a moral obligation to ensure the safety and health of the Supplier and sub-Supplier employees who fulfill our orders?
  - Over and above any moral issues, is there a business case? For example, are “safe” suppliers and the sub-Suppliers they engage inherently “better” suppliers in terms of performance reliability or other factors such as Quality and Schedule?
  - What other business benefits would be realized by more proactive Owner and Contractor attentiveness to Supplier and sub-Supplier safety?
  - Should a Supplier’s Safety performance and how effectively they scrutinize and manage the Safety performance of the sub-Suppliers they engage be included as a significant prequalification and evaluation component, as it is for Subcontractors?
  - What sort of geographic reach should we consider?
  - What changes in contracting approach with suppliers and their sub-Suppliers should be considered?

RTS # 14
Finding Leading Indicators to Prevent Premature Starts, and Assuring Uninterrupted Construction
Essential Question

What are the best leading indicators to signal construction readiness?

Background

Even though we have numerous planning tools and templates, we still experience costly stops or holds on many of our projects. And, since at least one stakeholder on virtually every project benefits from a premature start to construction, project teams nearly always feel pressure to begin construction—whether or not they are in fact ready. When they start construction prematurely, the result is frequently that they must stop construction at least once. Complicating matters, when they experience these stops and starts, they often seem to react rather than take a proactive management approach.

Are there any leading indicators that could predict a trend early enough to help manage/prevent these situations? What are the external factors that drive the premature start of a construction phase? How do these external factors affect the construction flow? How do we demonstrate and/or communicate to our owners and stakeholders the severity of the inevitable outcome of a premature start to a project?

The research team should consider and evaluate the following external factors: cash flow requirements; financing methods; equipment/material availability; political/public input; environmental concerns; permitting and regulatory; labor availability; engineering/design completion.

Note to Team

Is this the next evolution of the PDRI process? Could a dashboard-style indicator be developed that could help predict and/or manage status on a weekly or monthly basis for all stakeholders?

RTS # 15

Soft Skills for Successful Project Leaders on Global Projects

Essential Question

Which soft skills make project leaders successful in different regions/cultural environments around the globe? How do we assess these individuals’ abilities to adjust to unfamiliar conditions and customs, and to lead a project successfully?

Background
While we have a plethora of published information on project management best practices and soft skills, we have yet to understand the nuances of successfully executing projects in unfamiliar regions and in differing religious and cultural environments. Such an understanding requires different behavioral and communication skills, as well as a wider and deeper awareness of religious and cultural variety.

Are such soft skills just as important as or more important than technical skills? Why do successful project leaders thrive in one location, but fail in another? Which industry training resources will properly prepare future project leaders for global projects? How can we determine which skills are most important? Does team composition (i.e., local versus expatriate) influence outcomes?

**Note to Team**

- HR resources with experience staffing successful foreign projects would be useful on the team.
- Team membership should include individuals with global project experience.

The team would benefit from having an academic researcher with a soft-skills background, who is also familiar with global construction.
## 2013 Research Topic Slate

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### RTS #1
Best Practices for Commissioning and Start-up

**Essential Question**
What are the BPs for commissioning and start-up that define, achieve, and maintain owner operational performance?

**Background**
CII RT 121 Planning for Start-up developed a resource with 18 model activities to support start-up. These activities were planning-oriented and did not focus on construction execution. The industry now needs best practices that are specific to commissioning activities, e.g., requirements definition, planning, testing, documentation, and construction activities.

To close the gap that now exists between actual and expected operational performance and production levels, the industry needs a comprehensive tool (e.g., the PDRI) that will
address the components critical to achieving desired operational performance. A common understanding of terms is essential.

Notes to Team
- Additional resources include:
  - ISPE Baseline Guide 5
  - ASHRAE Guideline 0, Commissioning Process
  - ASHRAE Guideline 1, Commissioning Process for Mechanical Systems

**RTS # 2**
Successful Delivery of Fast Track Projects

**Essential Question**
Which innovative improvements in project delivery methodology could be made to compress project durations, while maintaining safety, quality, and project risk tolerance? How are barriers to delivering shorter project durations overcome?

**Background**
Businesses increasingly demand faster project delivery, from concept to completion. This schedule compression frequently requires project teams to perform traditional construction sequences as either parallel or overlapping processes. A clear understanding of the barriers to success is required. What the industry really needs is an established set of project delivery tools that can be used to speed up the process while maintaining project risk tolerance. A common understanding of these tools and a clear grasp of the associated risks and any opportunities for reducing those risks would help the industry move forward.

Notes to team
CII Research Team 222 addressed CII Best Practices for design on fast-track projects. This new research should not focus only on the design aspects or on CII Best Practices. It should instead focus on compression of the full scope of project delivery, from concept to delivery.

**RTS # 3**
Improving Engineering and Procurement Alignment and Coordination with Construction

**Essential Question**
Which specific owner and contractor practices would facilitate engineering and procurement alignment to support an optimized construction execution plan?

**Background**
Industry practitioners and past researchers alike view effective coordination of engineering, procurement, and construction as a pre-requisite to breakthrough approaches to improving productivity and predictability. Recent experience by COAA has shown that otherwise effective work packaging efforts have been stymied by poor design support for construction. Current engineering, procurement, and construction work processes independently optimize each function, resulting in a sub-optimized overall project. CII has a large corpus of knowledge on front end planning, as well as recently published research products that outline recommendations for improved processes. This research will take these products as a starting point and focus on finding the root causes of problems and the detailed enablers of more effective practice.

Notes to team
The result of this research should include a roadmap or project delivery process that, while informed by the barriers that exist, is not simply a list of those barriers. The research team should identify how various contracting strategies affect the achievement of these goals and/or the methods to achieve them.

RTS # 4
Creating Standards for Industry-wide Quality Metrics

Essential Question
What the construction industry really needs are ways to assess Quality performance and drive improvement. Can we establish a method and a set of standard metrics that can be used to effectively measure, categorize, and benchmark Quality performance across the project delivery process?

Background
A real breakthrough for our Quality function and goals would be first to create an industry-wide set of quality metrics—possibly similar to the DART, TRIR, and other standard measures we have for safety—and then have CII collect member data to track them, just as it does now for the safety metrics.

The beauty of the safety statistics lies in their simplicity and wide applicability:
- They are few in number.
- They can be precisely and objectively defined.
- They can be applied on a project, within a company, or across an entire industry
- They are valid (and comparable), regardless of company or project size.

A potential benefit of established quality metrics would be the opportunity to utilize them to understand issues and trends in order to prevent future incidents. These metrics should also be useful in assessing the impact or severity of issues
Note: We recognize that Research Team 254 did an excellent job of establishing a) how to define and implement a quality management system (QMS), b) how to assess maturity of QMS, and c) how to improve a company’s QMS.

This research team should focus its efforts on metrics and measurement. The team should not just consist of Quality personnel, but should also include operations staff.

**RTS # 5**

**PDRI Tool for Small Projects**

**Essential Task**
The task is to produce an effective, simple, and easy-to-use scope definition tool (e.g., the Project Definition Rating Index, or PDRI) for small industrial projects.

**Background**
Small projects account for over 50 percent of existing facilities’ capital budgets. And, while the PDRI for industrial projects is a well-established tool that is used by many member companies, it does not focus on small projects. A new PDRI focused on small industrial projects would benefit the industry.

CII Research Team 161, Executing Small Projects, developed a tool kit for the execution of small projects. The team encouraged the use of the PDRI and described it as an effective tool, but also acknowledged that the PDRI had not been developed to address small projects. Thus, small projects using the PDRI have a large number of non-applicable elements. The recommendation from the team was to consider adapting the PDRI to small industrial projects.

**Notes to team**
Since the CII Benchmarking and Metrics database includes a small project questionnaire, the team can use it and the RT 161 documents as references.

**RTS # 6**

**Safety Performance through Operational Discipline**

**Essential Question**
Can a sustainable step change in safety performance be achieved through an enhanced culture of rigorous operational discipline, also known as performance excellence?

**Background**
The benefits of a more structured and procedure-based approach to a business are well understood, and thought to improve cost, cycle time, and quality. Anecdotal reports indicate that safety performance improves dramatically on projects or operations where high levels of process discipline are deployed. Yet, it remains to be proven that such a culture of operational discipline positively affects the safety performance of an
organization. If it does, how and what key elements (or degrees of operational discipline) are required to produce the improved safety performance? To achieve a genuine breakthrough in the next level of safety performance, the principles that underlie these outcomes must be clearly understood and routinely applied.

**Notes to team**

Some things to consider are isolation of operational process discipline as the indicator of safety performance, as opposed to the impact of factors such as cultural, geographic, or organizational structure on safety performance. The intent is to establish correlation and causation of the relationship.

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**RTS # 7**

**Successful Delivery of Mega-projects**

**Essential Question**

What sorts of changes in project development and execution are needed to ensure that mega-projects are successful?

**Background**

Recent IPA work concluded that two-thirds of mega-projects (defined as being valued at more than $1B) fail. This assessment suggests that, while mega-projects are more sensitive to practices used than other projects, their very size and complexity makes their deployment of best practices more difficult and less likely. The Construction Owners Association of Alberta and many others have also studied this issue and come to similar conclusions. Does CII data support this conclusion? Are some CII practices more difficult to implement on mega-projects, or are certain practices in need of modification to suit mega-projects? Conversely, are there other practices that are critical to the success of mega-projects (such as, for example, breaking them into multiple smaller projects)? Other research has suggested that mega-projects produce a culture of optimism. If this is the case, how can we avoid unrealistic expectations with regard to capital costs, execution schedule, and impacts?

**Notes to team**

The research effort should go beyond interviews with personnel and case studies on mega-projects. It should present an assessment of the dynamics that develop around mega-projects, potentially including a macro-economic context and a study of some historic mega-projects through which a longer view might be considered. It is expected that this team will build upon (not duplicate) the body of knowledge that currently exists.

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**RTS # 8**

**Instantaneous Project Control Systems**

**Essential Question**
The ability to gather and analyze project controls information instantaneously would constitute a meaningful breakthrough for project execution. What methods and measures could be developed to collect and analyze project controls information in real time?

**Background**
The industry has indicated that it takes too long to collect project controls data. Current project controls data is lagging in the reporting cycle. The ability to respond in an efficient amount of time is hampered by this lag in reporting. How do we go from reactive to proactive in this regard?

**Notes to team**
Are there opportunities to simplify current project controls processes? How are other industries collecting, measuring, and using comparable data?

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**RTS # 9**

**Is There a Demographic Craft Labor Cliff That Will affect Project Performance?**

**Essential Question**
What are the labor, productivity, safety, and project cost impacts of major shifts in the demographics of craft labor availability?

**Background**
While craft availability in the U.S. has been an issue for 20 years and has not improved in recent years, the industry lacks a clear understanding of the challenges and impacts of any future craft labor shortages. Further definition and analysis of emerging demographic issues geographically, by trade, age group, years to retirement, etc. are needed in order to understand and project the cost, safety, and productivity impacts to future projects.

Predicting the influence on project performance of a diminished labor pool will support the development of short-term mitigation and project execution strategies.

**Notes to team**
Additional resources:
- CII RT 231 Construction Industry Craft Training
- CII RT 182 Addressing Shortages of Skilled Craft Workers in the U.S.

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**RTS # 10**

**Accelerating the Development, Deployment, and Value of New Construction Technologies**

**Essential Question**
How can project uncertainties that are typically associated with the early adoption of new technologies (e.g., cost, schedule, performance, safety, and regulatory compliance, among others) be reduced or removed to lower risk and enable the achievement of improved performance and increased value?

**Background**
The construction industry has traditionally been conservative about adopting new materials and technologies. Limited time and resources available during a project’s design and construction phases prevent extensive research into emerging technologies. Uncertainty about cost, performance, availability, and other critical information discourages departure from standard practice. Furthermore, building codes and engineering standards represent practice that is proven and well known. As a result, material and technology innovations that could have a significant positive impact and value for capital project performance are underutilized or ignored altogether, until others, the early adopters, take the risks. This disinclination to take risks on new materials and technologies, in turn, inhibits innovation in the construction industry.

A system of technology evaluation and validation is necessary to reduce the risk of adopting materials and construction technologies. Such a system will allow companies to adopt these innovations without having to rely exclusively on a long history of performance. This approach will, therefore, accelerate the accrual of value for capital projects.

**Notes to team**
Consider developing a SYSTEM to identify, prioritize, evaluate, and validate innovative construction materials, methods, techniques, and technologies, as opposed to producing a one-time process or product. This system may be analogous to a code compliance service, such as the International Code Council’s Evaluation System ICC-ES.

Consider applying a performance approach; examine what a material or technology is intended to do, as opposed to what it is. This approach will help avoid limited definitions of “acceptable” and “unacceptable” imposed by prescriptive, material-oriented specifications, standards, and other forms of engineering and regulatory guidance.

Consider the impact a given construction material or innovation may have on a capital program, i.e., whether there could be a broad application and greater value, or a more limited application. Once broader applications are identified, they can be prioritized as potentially adding more value. After the candidates have been prioritized, the capital program can direct more resources toward their adoption.

Consider the maturity of the technology and the maturity of the people in the field who will implement the technology (in terms of their ability to accept new technologies and materials).
RTS # 11
A Closer Look at Material Planning; a New Look at Jobsite Inventory Strategies

Essential Question
What are the optimal elements, best practices, and documentable benefits of Material Planning (a component of Materials Management)? Further, as part of an enhanced Material Planning process, can project material and equipment inventories (and associated inventory costs) be optimized? Specifically, can an analytical process be devised to select the optimal balance between just-in-time and just-in-case delivery strategies (for various types of project materials and equipment) without jeopardizing project schedules?

Background

[Note: Although this topic might appear to be Contractor-centric, it actually offers considerable benefits to Owners in that the "inventory carrying costs" it seeks to significantly reduce are ultimately (directly or indirectly) borne by Owners. Thus, Owners should have significant interest in this topic as well.]

Because this research addresses a relatively unexplored component of Materials Management and requires an understanding of terms more commonly used outside the industry, the following definitions will be helpful. (These definitions are open to research team refinement.)

Material Planning — also known as Material Requirements Planning—is the oversight of the entire project material and equipment life cycle, from conceptual design through project close-out. Material Planning ensures that the right material is in the right place at the right time, with a minimal level of surplus. Material Planning is an essential component of a comprehensive Materials Management program and applies to all materials, equipment, and fabricated components required for a specific project. (Note: Material Planning is not to be confused with a project’s material management execution plan.)

Just-in-time (JIT) is classically defined as an inventory strategy that strives to receive goods only as they are needed in the production process and thereby improves a business’s return on investment by reducing in-process inventory and associated carrying and handling costs.

Just-in-case (JIC) is classically defined as an inventory strategy that aims to maintain large inventories of in-process supplies, parts, and warehousing resources in order to minimize the possibility that adequate inventories will be unavailable in the face of varying or unpredictable production and supply chain contingencies.

[In practice, JIT and JIC can be viewed as two extremes that can be applied in varying degrees to various types of supplies.]
Inventory is classically defined in two ways:
1. From the lean perspective, inventory is waste. In-process inventory has no real value until it is used and incorporated into finished goods (or projects).
2. From another perspective, inventory is an accepted buffer—along with capacity and time—against process variability, including supply chain variability.

Notes to Team
This research contemplates two results: first, (1) a comprehensive definition of the Material Planning process and documentation of the associated benefits; and second, (2) as part of an enhanced Material Planning capability, the development, testing, and validation of a means to more accurately assess and determine the optimal balance between JIT and JIC inventory strategies for specific project materials, equipment, and fabricated components.


While the term inventory is not commonly used in the engineering and construction industry, in reality, all materials and equipment that are delivered to and then stored on a project site awaiting installation are indeed in-process inventory; they are thus subject to the same characterizations of inventory found in manufacturing and other industries.

Although there are instances of JIT materials delivery in our industry—ready-mix concrete, some locally-supplied commodities, and certain heavy-lift components are examples—most large industrial projects tend to follow more of a JIC strategy. Materials, equipment, and fabricated components often arrive months before they are actually needed or used. Depending on project size, the JIC approach can result in inventories valued in the millions of dollars (or even in the hundreds of millions of dollars) essentially sitting idle for extended periods and with an associated financial cost.

RTS # 12
Craft Input as a Source of Innovation and Improvement

Essential Question
What innovations in productivity, safety, quality, and delivery of engineering data could be achieved from a comprehensive engagement of actual craft workers in the field?

Background
CII has had numerous efforts in productivity, safety, quality and delivery of engineering data, but none of the Institute’s research efforts have elicited any significant input from
actual craft on these issues. A broad and comprehensive engagement of actual craft could provide new insights and opportunities for significant improvements in these areas.

Notes to team
We would envision surveys, interviews, workshops, and other methods of securing candid input and recommendations from a wide range of craft, trades, project types, or other opportunities. We would also envision that literally hundreds of craft would be engaged during the course of this research and that these workers would contribute their perspectives in an environment conducive to candid feedback (i.e., no management influence or presence).

RTS # 13
A Paradigm Shift in Project Management

Essential Question
What this industry really needs is a step change in project planning and execution methodology that would improve project predictability, especially in unfamiliar environments. Can we find a theory behind managing projects that would enable us to improve on our current experience-based paradigm of practices and methods?

Background
Our industry spends billions of dollars managing projects without really understanding the theory behind project management. (Theory comprises concepts and the causal relationships among these concepts.) When projects work extremely well, or perform poorly, we can’t clearly articulate why except by means of forensic analysis (regression), whether implicit or explicit. Even more importantly, our ability to design a project management system to accommodate the constraints of a specific project is extremely limited, based either on intuition or on recent empirical evidence. The current paradigm of project management as codified by PMBOK, CII best practices, AACEI recommended practices, among others, reflect experiences, but are not based on an underlying causal theory. The current paradigm lists practices (e.g., front end planning), methods (e.g., scheduling), techniques (e.g., change management) and measurement (e.g., earned value) without presenting any conceptual relationships.

As an example, as recently as the early twentieth century, foundation design was based on intuition and experience, with little to no supporting theory. Only with the development of fundamental geotechnical engineering theories of soil strength and settlement could project personnel clearly understand failures deploy predictive designs targeted to the particular conditions for a given foundation. The result was a step change in the size and complexity of structures that could be supported within a wide range of ground conditions. Furthermore, using theory, designers can directly consider factors of safety and thoughtfully apply conservatism to risks. Experience-based designs by definition can only be appropriate to the conditions experienced, and the impacts of changes to those conditions can only be addressed by over-conservatism or painful new experience—neither of which is a desirable outcome. How much safety factor is in our
current project management systems? This is a question we cannot now begin to answer at present.

Example of current paradigm: planning, controlling, and executing processes
Example potential theories: flow theory; adaptive control theory; production and operations theory (ins/outs, inventory, processing); and complexity theory.

Examples of PM factors of safety: float (explicit and implicit); contingency and reserve; contractual terms (payment schedules, liquidated damages); resource “hogging”; resource prioritizing; and inventory buffers.

Notes to team
Consider the following
• Should cross into other business lines, including IT project management, manufacturing, and marketing projects
• Determine whether modeling a project according to any specific theory helps to explain behaviors and whether it changes what we expect from our project execution teams. (Ex: managing deliverables to the last responsible moment instead of delivering as soon as possible).

**RTS # 14**

Adapting Your Organization to Benefit from New Technology and Innovation

**Essential Question**
What changes and degree of adaptability are needed within the typical project’s organizational structure for the project to benefit from new, rapidly changing technology and Next-gen innovation and to produce a step change in productivity in the capital project delivery cycle?

**Background**
Most engineering and construction organizations (Owner and Contractor) still utilize the same organizational structures that existed 30 years ago. Multiple disciplines working in the same model produce inefficiencies and conflicts. With all of the technology that we have today, we should rethink and explore the ways that we assign and accomplish work. For example, in the 3D design world, specialists could be utilized to create rules for rule-based design, as well as verify that these rules are being applied correctly. We could then utilize a generalist to design the majority of the model (e.g., foundations, steel, equipment, pipe, and cable tray, among other project elements), which would be more efficient than a discipline specialist for each design area.

**Notes to team:**
The expected breakthrough for the industry would be the step change in organizational effectiveness/productivity that is needed to offset issues related to changing demography, such as lack of experience and lean workforce.
2012 Topic Slate

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**CATEGORY 3 – SPECIAL RESEARCH TOPIC**

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**Topic Sources:** ¹Fall Board Meeting; ²Research Committee; ³Breakthrough Strategy Committee; ⁴Sustainability COP

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**RTS #1**

**The True Impact of Late Deliverables at the Construction Site**

**Essential Question**

What is the real cost of late deliverables to a construction site? How are project outcomes (i.e., safety, quality, cost, and schedule) affected when permits, completion of FEED, detailed engineering, P&IDs, special studies, procured items, tagged equipment, bulks, and specialty items arrive later than anticipated?

**Background**

Project schedules, construction contracts, and subcontracts are all based on assumed delivery dates. Inevitably, some components arrive later than anticipated. In other cases, design/engineering decisions are put off by the design/engineering team because they are not critical; but tracking, monitoring, and closing them out later takes up the execution team’s time and effort. These resources could instead be used to get ahead and build in some of the schedule...
insurance needed for unforeseen events. Design and engineering teams often iteratively review and refine their designs, assuming that any given design/engineering decision can be put off to a later date. This practice is common, even when a project’s original execution plan requires that such a decision be made earlier, and even when future planning assumed that the decision would be made as planned. The knock-on effect of several (or many) deferred design/engineering decisions is that the activities on a schedule end up getting stacked to the right, which, in turn, puts unwanted pressure on project goals (i.e., safety, quality, cost, and schedule).

Generally, site construction managers and project managers do their best to work around these issues. Depending on the contractual arrangement, sometimes additional impacts on project costs or schedules are identified in change orders. However, some EPC organizations include no explicit change mechanism in their contracts. Others have found ways to accommodate late deliverables by developing project control mechanisms for predicting such delays, adequately pricing their cost impacts, evaluating the schedule impacts, and then communicating these effects back to the design and engineering teams. This communication is aimed at convincing these teams that they should make the decisions as planned, deliver the deliverables to the field as planned, and ease the unwanted pressure on the field execution team by not using up all of the project float in the design/engineering part of the project.

The hypothesis is that the true costs of late deliverables exceed any that are easily identified and that would typically be contained in costs. For example, if prefabricated pipe is delivered late to site, typical cost collection may cover impacts caused by rescheduling work in the field to accommodate revised work flows, e.g., some crane costs. However, not included are the opportunity costs associated with the revised schedule - Could the fabricator have been released later and the P&IDs released later as a result? What is the wasted effort associated with unplanned work at the workface (e.g., re-work)?

Notes to Team
Consider extending this effort to investigate the impact not only of late deliverables, but of any deliverables with a variance to plan (i.e., whether they are early or late). Consider whether studying the same craft (e.g., piping) on various projects—as opposed to many different crafts across the various projects—would improve data quality and applicability. Focus on quantifying the overall impact rather than proposing solutions for the root cause. The results should be presented in such a way that they are independent of contract type. It is not important who bears the impact contractually; the focus should be what the impact is totally. Also of interest would be an assessment of how effectively current project control mechanisms capture and mitigate the primary and follow-on costs of late deliverables.

Suggestions for Data Collection
Case studies where RT members hire interns to collect data on specific job sites. Compare actual data with the perceived impact that is only based on “expert opinion.”

RTS #2
Using Near Miss Reporting to Enhance Safety Performance

Essential Question
How can near miss reporting be used as a tool to help project teams identify the gaps, learn from the events, and significantly improve safety performance?
Background

In the safety environment, systemic change does not typically occur until after disasters or significant safety incidents occur.

Most project organizations regard near miss reporting as fundamental to their safety success. The Safety Pyramid is widely recognized as a representation of the hierarchy of incidents, and its introduction of near miss reporting to the industry has given organizations opportunities to improve their safety programs. However, the majority of focus has been on injury statistics, with much less on near miss potential. Indeed, near miss incidents are often viewed as a function of luck, and the rigor applied to incident investigations is placed more on injuries and not on events in which there was no injury. The Safety Pyramid has been a valuable safety tool, but it is driven by statistics—and statistics-driven safety programs do not always focus on extremely low-probability, high-consequence accidents.

James Reason’s “Swiss cheese” safety model shows how layers of protection against incidents fail after an event. Are project teams focused on gaps in their layers of protection, or are they focused more on lagging indicators? The main concern is that project teams may not be focusing on the gaps in their safety programs, a lack of focus that can lead to more serious incidents. For example, on one project, the project team discovered that daily equipment inspections were not being performed (near misses). Although the gap was addressed verbally, the regular performance of inspections was not verified in the field. Later, the project team suffered a serious equipment failure, resulting in serious injury to the operator. One of the latencies later discovered was that the operator had not completed a daily inspection of the equipment. Had the near miss report on the lack of inspections been followed up aggressively, this incident could probably have been prevented.

This research should first identify the most effective methods for assessing non-injury events. It should then determine the most effective means of systematically applying these methods to improve organizations’ safety programs and to fortify their layers of protection.

Suggestions for Data Collection

- Define “near miss” to standardize terminology and support communication industry-wide.
- Review prior CII research and ongoing research around this topic.
- Catalog near miss practices and identify which are most effective.
  - Survey (one page)
  - Follow-up interviews to identify potential case studies
- Observe near miss investigations and results.
Essential Question

What practices, techniques, and processes are most effective for improving the critical interfaces among globally dispersed project teams, multiple project partners, and an increasingly diverse labor force?

Background

The following conditions in the current project delivery environment have made it necessary to properly address interface management issues:

- globalization
- high-value engineering/low-cost centers
- increased technical complexity
- requirements for local content
- complex contracting arrangements
- competing organizational drivers that lead to poor results or outcomes
- increased scope management complexity
- a less experienced workforce due to resource constraints.

As a result of these developments, project delivery teams struggle to overcome these challenges to project success. The capital delivery industry could benefit from discovery of the best practices in interface management. These best practices would ensure that the right information is communicated, that the right practices are used, and that the processes used are employed in a timely and effective manner.

Notes to Team

Examine prior CII research on information management and consider input from the CII Information Management COP. Following are some additional research objectives to consider:

- identification of project situations (e.g., internal, external, JVs, etc.) that require formal interface management
- development of organizational models for implementing interface management (i.e., methods for determining when stand-alone interface managers are needed and when interface management is a normal part of project engineer/manager duties)
- identification of skills required for today’s and tomorrow’s interface manager
- identification of recommended practices, tools, and/or systems that promote effective management of interfaces
- identification of gaps and needs for improved technologies, information management, or other areas in need of improvement
- approaches to addressing organizational, work process, and terminology interfaces between entities
prioritization and timing for addressing the following aspects of interface management:

- human (team building and alignment)
- organizational (work processes and procedures)
- physical (information management and mechanical).

**RTS #4**  
**Measuring Unintended Waste**

**Essential Question**

How can a project identify and quantify the unintended waste involved in a project?

**Background**

The execution of a project, in practice, includes unintended and—many times—undetected waste. Examples of such waste include excessive engineering rework (including over-analysis), out-of-sequence work, excessive inventory at fabrication shops, unintended overtime, excessive time for suppliers to understand specifications, excessive quality inspection, or a poor commissioning sequencing.

The purpose of this research is to identify the cost of unintended waste so that management can make informed business decisions.

**Note to Team**

The study should exclude the consideration of waste due to buffers. The study can include both work process and physical waste.

**RTS #5**  
**Managing a Portfolio of Projects—Metrics for Improvement**

**Essential Question**

What practices, techniques, technology, and processes are most effective for managing a portfolio of projects?

**Background**

It appears that, in the next few years, portfolios of companies will have a tendency to move away from the “mega-project.” In response to the volatility of today’s business market, more and more ventures will be gravitating towards small projects, or to projects within a larger program/business portfolio. While best practices have been developed for
project directors/project managers to manage individual projects, these project professionals need to know how to apply these best practices when they manage multiple projects or multiple project managers. How can they maintain the program view and not revert to a focus on individual projects? Some items to consider include the following:

- management skills—how to maintain a business focus versus project focus
- resource management—how to balance manpower, equipment, suppliers, assets, across the portfolio
- financial management—how to focus on integrating cash, sales, and other financial considerations at the portfolio level
- risk management—how to prioritize risks by business need versus individual project need
- metrics - how to determine which metrics are key indicators of the state of the portfolio.

**RTS #6**

**Sustainability Practices and Metrics for the Construction Phase of Capital Projects**

**Essential Question**

What are the most effective practices and associated metrics for deploying sustainability-focused initiatives during the construction phase of a project?

**Background**

CII Research Team 250, *Sustainable Design and Construction for Industrial Construction*, documented a number of recommendations to support broad industry interest in sustainability initiatives. The research focused on the full capital project life cycle, including environmental, social, and/or economic perspectives.

The CII Sustainability COP has proposed a number of follow-on research projects, all addressing the full project life cycle perspective. Although the COP proposals have had great support from some CII member sectors, the complexities of the full project life cycle sustainability goals and their associated efforts can be daunting.

This research topic is offered as a more practical, next-step alternative to the previously offered full project life cycle sustainability research pursuits.

This research envisions a more limited, but nonetheless, valuable, scope and objective. It would focus only on the sustainability opportunities available during the construction phase of a capital project, irrespective of the sustainability design, goals, and character of the completed capital facility under construction. Moreover, this research would be consistent with and supportive of CII’s strategic initiative to pursue industry
sustainability goals and objectives. It would also provide valuable insights into the practical challenges encountered in sustainability initiatives, while demonstrating the kind of positive results that can indeed be realized in this important and high-interest area.

**Notes to team**

IR 250-3 *Sustainable Design and Construction for Industrial Construction: Implementation Resources* includes a “Checklist for Sustainable Industrial Construction Sites.” It provides a battery of practices for many elements of construction operations: site layout; energy use; fleet management; materials handling; control of dust, water, and atmospheric pollutants; and many others. While this checklist provides a general, qualitative description of these practices, it does not include observable or measurable (i.e., it does not provide specific standards). However it can serve as a springboard for further development of sustainability metrics.

**RTS #7**

**Effective Supplier Quality Surveillance (SQS) Processes and Practices**

**Essential Question**

What are the most effective processes and practices for ensuring that project materials and equipment are produced, manufactured, or fabricated in strict accordance with all applicable specifications, and that they are delivered to the project site without any need for rework?

**Background**

CII has conducted numerous research projects related to classic Quality Control and Quality Assurance practices and processes. A component of such practices and processes is the Supplier Quality Surveillance (SQS) function, responsible specifically for verifying the compliant quality-related performance of suppliers in capital project supply chains. The intent of this research is to explore the scope and objectives of this important function and to identify the most effective processes, practices, and metrics (both traditional and enhanced) for improving supplier quality qualification and performance.

Related subjects include the role, function, and career development of SQS professionals, as well as the sourcing (direct-hire or third-party) of SQS personnel and shop inspection resources.

In addition, recommendations from the SQS function to other EPC functions could be among the research deliverables.

**Note to Team**
Although counterfeit materials can be a threat to supply chain reliability and performance, the issue of counterfeit materials should not be a particular focus of this research.

RTS #8
Mitigating Threats of Counterfeit Materials in the Capital Projects Industry

Essential Question
What are the necessary, prudent, and most effective processes and practices for ensuring that counterfeit construction materials and equipment do not enter capital project supply chains?

Background
CII Research Team 264, Product Integrity Concerns in Low-cost Sourcing Countries, dramatically documented the variety, scope, and impact of counterfeiting threats affecting the capital projects industry. Since the RT 264 research was published and presented, the scope, variety, and significance of the threat has only increased. Although RT 264 included some recommendations for mitigating the threat to capital project supply chains, a more detailed exploration of effective and reliable mitigation strategies, practices, and methods is desired. This exploration should include the potential for collaborative industry action and initiatives.

Note to Team
Further investigation or documentation of examples of counterfeiting is not necessary (i.e., documentation of the threat) unless such additional investigation is required to identify and document effective mitigation strategies, processes, and practices.

RTS #9
Measuring Project Complexity and Its Impact

Essential Question
How do we measure project complexity; and how should the level of complexity drive project-related decisions?

Background
Because project complexity is widely believed to affect capital project outcomes, the industry should have a better understanding of its nature and impacts. This team should
define project complexity and the elements that influence the level of a project’s complexity. Examples of these elements may include size, schedule, contract strategy, location, technology risks, process scope, diversity of project team, supply chain reliability, among others. The team should also confirm the cause and effect to project outcomes, and recommend actions to mitigate the risks associated with complexity.

**Note to Team**

Can a tool be created to guide a company towards applicable best practices and the resources, actions, or responses that are appropriate to addressing the most suitable actions?

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**RTS #10**

Planning—how much is too much?

**Essential Question**

What is the minimum amount of planning required for successful project execution?

**Background**

The project controls, project management, and construction management communities have been told for years that detailed planning is a best practice, and that detailed scheduling and control is a prerequisite for project execution excellence. Furthermore, increasingly sophisticated software packages, ERP systems, and interconnectivity have made data collection, dissemination, and analysis easier and ever more powerful. The question is, have we gone too far?

This research would determine the minimum requirements for maintaining proper control of a project. Further, it would investigate whether all the effort we do in project planning is truly worthwhile? Have we reached the point of diminishing returns? Do current practices of detailed planning and controlling now inhibit rather than benefit projects by limiting needed flexibility, creativity, and discretion?

The team should consider whether we need more planning and less scheduling.

**Note to Team**

Planning is meant to include scheduling as well as project controls feedback.

**Data Collection Suggestions**

The research team could conduct surveys on the level of controls and scheduling work in place for given projects. It could collect data on how much time and effort is put into this work. It could also collect data on the experience level of the scheduling engineer or the
controls person to determine its effect on project success. Project team members (i.e., project engineers), as well as the controls group and the discipline engineering groups, could be interviewed to determine whether the amount of planning on a project helps or hinders its success. A comparison on the perspectives of each group would be valuable for this effort.

The team could count the number of changes in a given project’s schedule occurring over time.

The team could also simulate project performance on projects with and without a high level of planning included up front. It could also use probabilistic simulation to determine whether the level of effort is worth the potential mitigation.

**RTS #11**
*Quantitative Measurement of PM Competencies*

**Essential Question**

What measurements can be used to assess competencies of project managers in order to pinpoint areas for development?

**Background**

Successful projects are led by project managers with specific knowledge, skills, and behaviors. Technical knowledge and strong interpersonal and leadership skills and behaviors are some of the characteristics exhibited by successful project managers who are considered leaders in their field. Once the essential characteristics of these leaders are identified, and an approach to measurement is developed, training can be focused on developing strong project managers.

**Notes to Team**

As this team begins its research, RT 281 will have provided several tools that assess essential PM competencies, but they will not have fully explored the measurement question.

**RTS #12**
*Best Practices for Establishing International Relationships*

**Essential Question**

What are the best practices for establishing international relationships (e.g., JVs, consortia, alliances, partnerships, etc.)?
Background

Larger global projects continue to increase in project complexity. International factors such as differing business practices, cultural backgrounds, governmental regulations, as well as multiple funding sources, all add to the difficulty of establishing effective teamwork. Concerns such as risk management, resource availability, local content, and proprietary technology assume an added dimension of complexity when addressed on an international scale. This research should focus on the practical issues that attend the formation of international relationships, and not on the legalities.

Notes to Team

Investigate any differences between international and domestic relationships, and explore any added complexities at the international level. Coordinate with RT 294.

RTS #13
Effect of Commissioning on Life Cycle Costs

Essential Question

How does commissioning have a quantifiable effect on life cycle costs of facilities, systems, and equipment?

Background

Commissioning has been globally defined as “A well-planned, documented, and managed engineering approach to the start-up and turnover of facilities, systems, and equipment to the end-user that results in a safe and functional environment that meets established design requirements and stakeholder expectations.” This activity involves planning and testing to ensure that facilities, systems, and equipment meet defined design requirements. In addition, commissioning also includes the collation of documentation (e.g., drawings, specification, manuals, etc.) and the assurance of its accuracy and completeness as turned over to the owner. Finally, commissioning can include the establishment of maintenance strategies for the life cycle management of the facility. These strategies are often developed through Reliability Centered Maintenance techniques and provide a foundation for the life cycle management of facilities, systems, and equipment.

Some people view commissioning as simply start-up and turnover to the owner of facilities, systems, and equipment. Others view this activity as a more robust planned activity, as described above. This research team would explore various approaches and methods used for commissioning and determine a methodology for measuring the long-term life cycle cost of a facility, systems, and equipment. This team should determine the attributes of effective or enhanced commissioning, and those of less than robust commissioning.
Once commissioning approaches can be differentiated, then a measurement methodology for life cycle cost should be developed. This methodology should address operating expense, maintenance cost (i.e., reactive versus preventative cost), repairs (in the form of follow-up capital projects to fix problems), and post-project changes implemented (i.e., changes that address unmet original requirements). Applying this methodology, the team can determine the quantifiable differences in life cycle cost across projects (e.g., impact on operations, operational expense, maintenance, or recapitalization to maintain capability or meet original requirements) so that the appropriate commissioning approach can be applied.

What is the impact of a well-executed commissioning program? What is the impact of a poorly executed commissioning program?

**RTS #14**  
**Strategic Use of Social Media Technologies**

**Essential Question**

**Phase 1 (complete in one year or less)**  
How are social media being used in the business world today, and how might they be used in the future? Which areas are relevant to CII member companies?

**Phase 2 (complete in one to two years following Phase 1)**  
Given the results of Phase 1 regarding the technologies relevant to CII members, what are the recommendations for their adoption? Which are most likely to give CII member companies a competitive advantage, and which are not expected to affect or improve performance of member companies?

**Background**

The use of social media (i.e., web-based and mobile technologies used to turn communication into interactive dialogue and allow for the creation and exchange of user-generated content) in the construction industry is not well-understood by many CII member companies. Social media includes, but is not limited to online magazines, internet forums, weblogs, social blogs, micro-blogging, wikis, podcasts, photos or pictures, video, rating, and social bookmarking. Additionally, social media technologies are continually changing. Following are areas that might be improved by social media:

- team engagement and productivity
- knowledge transfer from the near-retirement generation to the newest generation in the workforce
- rapid and more effective communication of relevant results from lessons learned, benchmarking, best practices, etc.
The team should address security and IP issues related to use of social media. The team may also wish to consider whether advanced analytics may be used to improve current CII and/or member company functions.

Notes to Team

The CII NextGen Community of Practice is a potential source of information. Due to the rapidly changing nature of social media technology, the work should not focus on specific technologies.

During Phase 1, the team could employ undergraduate student teams at multiple universities in various locations, using various social media and networking. A comparison data set could include a group of CII member employees with one to three years of work experience to provide similar data. These CII employees could offer recommendations on ways their companies could utilize social media to foster their careers.

The report-out on Phase 1 could include an on-the-spot survey of CII member companies—conducted through social media—that would help guide the direction of the Phase 2 research.
2011 CII RFP

RTS #1 Improving the Accuracy of Project Outcome Predictions

**Essential Question**
How do we improve the accuracy of predicted project outcomes (i.e., our forecasts of costs, schedule, and performance) between project authorization and project completion? How do we guard against being overly optimistic or overly cautious?

**Background**
Periodically, project and construction teams need to provide forecasts of the total costs, schedule, and performance of their projects. These forecasts involve understanding the already completed work and expended costs, and adding them to an estimate of the costs, work, and time needed to complete the project. As a project gets underway, project teams use already identified scope changes, along with variances included in already defined baseline execution strategies, to address issues of cost, work, and time to complete; but, as the project progresses, project personnel still need to identify the trends, potential claims, and issues and outcomes that inevitably present themselves. For example, what is the outcome if the engineering drawing quality is suspect? How much more will construction change orders in the field cost if certain equipment suppliers begin to have fabrication issues? This research could determine best practices (i.e., processes, tools, and methods) associated with improving project predictability and could enable project teams to forecast final costs for interim status reports. Because project outcomes are likely a function of owner/contractor contractual relationships, this research should consider defining both owner and contractor expectations of forecasts.

**Notes to Team**
Be sure not to overlap with the work of RT 280: Applying Probabilistic Controls in Construction.

This is beyond a simple checklist exercise; focus on the judgments, knowledge, and experience needed to produce predictable results.

RTS #2 Knowledge Transfer from the Near-retirement Generation to the Next Generation

**Essential Question**
How can the construction industry effectively transfer the knowledge of its employees nearing retirement to the people who remain on the job or are new to the industry?

**Background**
Most organizations regard the intellectual capital of their employees as fundamental to their success. Many now believe that, because most of the individuals born between 1940 and 1955 will be leaving the workforce within the next decade, the industry needs to do
more to capture their most useful experiential knowledge. The main concern is that, without the pro-active transfer of this generation’s expertise, this valuable bank of knowledge will be irretrievably lost. Another concern is that the windows of opportunity for this transfer—the moments in which the replacement talent can be matched with the retiring talent—do not coincide. This research should identify the most effective methods for capturing and then disbursing this knowledge to the increasingly global replacement generation.

**Note to Team**
Consider generational learning, communication differences, and alternative training methods.

**RTS #3 A Closer Look at Material Planning; a New Look at Jobsite Inventory Strategies**

**Essential Question**
What are the optimal elements, best practices, and documentable benefits of *Material Planning* (a component of Materials Management)? Further, as part of an enhanced Material Planning process, can project material and equipment inventories (and associated inventory costs) be optimized? Specifically, can an analytical process be devised to select the optimum balance between *just-in-time* and *just-in-case* delivery strategies for various types of project materials and equipment without jeopardizing project schedules?

**Background**
Because this research addresses a relatively unexplored component of Materials Management and requires an understanding of terms more commonly used outside the industry, the following definitions will be helpful. (These definitions are open to research team refinement.)

*Material Planning*—also known as *Material Requirements Planning*—is the oversight of the entire project material and equipment life cycle, from conceptual design through project close-out. Material Planning ensures that the *right material* is in the *right place* at the *right time*, with a minimal level of surplus. Material Planning is an essential component of a comprehensive Materials Management program and applies to all materials, equipment, and fabricated components required for a specific project. (Note: *Material Planning* is not to be confused with a project’s material management execution plan.)

*Just-in-time* (JIT) is classically defined as an inventory strategy that strives to receive goods only as they are needed in the production process and thereby improves a business’s return on investment by reducing in-process inventory and associated carrying and handling costs.

*Just-in-case* (JIC) is classically defined as an inventory strategy that aims to maintain large inventories of in-process supplies, parts, warehousing resources in
order to minimize the possibility that adequate inventories will be unavailable in
the face of varying or unpredictable production and supply chain contingencies.

[In practice, JIT and JIC can be viewed as two extremes that can be applied in
varying degrees to various types of supplies.]

**Inventory is classically defined in two ways:**

3. From the *lean* perspective, inventory is *waste*. In-process inventory has no
real value until it is used and incorporated into finished goods (or projects).
4. From another perspective, inventory is an accepted buffer—along with
*capacity* and *time*—against process variability, including supply chain
variability.

**Notes to Team**

This research contemplates two results: first, a comprehensive definition of the *Material
Planning* process and documentation of the associated benefits; and second, as part of an
enhanced Material Planning capability, the development, testing, and validation of a
means to more accurately assess and determine the optimal balance between JIT and JIC
inventory strategies for specific project materials, equipment, and fabricated components.

For an example of one such assessment tool, see the following study:
for Economical Supply Chain Management of Rebar.” *ASCE Journal of Construction

While the term *inventory* is not commonly used in the engineering and construction
industry, in reality all materials and equipment that are delivered to and then stored on a
project site awaiting installation are indeed *in-process inventory*; they are thus subject to
the same characterizations of inventory found in manufacturing and other industries.

Although there are instances of JIT materials delivery in our industry—ready-mix
concrete, some locally-supplied commodities, and certain heavy-lift components are
examples—most large industrial projects tend to follow more of a JIC strategy. Materials,
equipment, and fabricated components often arrive months before they are actually
needed or used.

Depending on project size, the JIC approach can result in inventories valued in the
millions of dollars (or even in the hundreds of millions of dollars) essentially sitting idle
for extended periods and with an associated financial cost.

**RTS #4 Deploying Best Practices in Developing Countries**

**Essential Question**

How do we systematically deploy best practices to achieve successful project results in
areas of the world where we have no previous professional or cultural experience?
**Background**
While many CII member organizations deliver projects globally, the best practices that ensure project success in familiar countries and regions may or may not be readily understood and/or accepted in unfamiliar areas. Cultural differences between newly arrived project team members and local partners and workers may introduce uncertainty when it comes to best practice execution and project performance. In spite of these differences, there will always be a set of project deliverables and measures that will define project success; however, they may have to be achieved in a way that both adapts to local cultural norms and preserves the essential elements and values of the applicable best practices.

**Note to Team**
The research team should focus on developing a process for deploying any/all best practices in unfamiliar cultural environments, rather than actually providing specific advice for deploying any particular best practice or set of best practices.

**RTS #5 Sustainability: The Next Steps for Industrial Capital Facility Delivery**

**Essential Question**
What are the next steps in sustainability for owners, contractors, and the industrial sector as a whole? Are they metrics and tools for life cycle cost investment analysis, a sustainability index, or supply chain sustainability metrics? Or are there other initiatives that would produce greater value in the pursuit of a sustainable future?

**Background**
CII has expended considerable effort in trying to establish a path forward on the topic of “Sustainability.” CII RT 250 developed a primer on sustainability for industrial construction and produced a number of recommendations for future research. These recommendations were supplemented and prioritized by the Sustainability Community of Practice (COP). The top three COP recommendations are the following: 1) develop a life cycle cost investment analysis tool, 2) develop a sustainability index metric for industrial construction, and 3) investigate supply chain sustainability. CII’s BM&M Committee also recommends a life cycle metric that would incorporate sustainability.

Are these the next steps to take in addressing industrial sustainability? Or should CII develop resources or recommendations of greater priority? This research proposes the creation of a CII research team, first to answer these questions and then to undertake the next steps—be they metrics and tools, or other initiatives of greater value.

**Note to Team**
The following article on new thinking in sustainability might be useful to the team:

RTS #6 Metrics for Assessing Emerging Information and Communication Technologies

Essential Question
What are the metrics for assessing the applicability of emerging information and communication technologies (ICTs) and for determining their value in capital project delivery? Demonstrate the use of these metrics to identify the emerging ICTs that are either in development or currently available but not yet broadly adopted.

Background
The construction industry has adopted many software applications for project management, computer-aided engineering, and materials management software. Construction practitioners have developed a healthy skepticism about the possible benefits of further investments in ICT.

By its nature, ICT develops at a tremendous pace, and other industries have been far more successful at rapidly adopting emerging ICT. The construction industry needs to improve its ability to make informed and prudent decisions on the deployment of ICT.

RTS #7 Evaluating Project Incentive Plans

Essential Question
Are the various types of contractual and worker-specific incentive plans (e.g., plans for cost, schedule, and/or safety) in the construction industry effective? Why are certain plans more effective than others?

Background
Owner and contractor organizations have deployed different types of incentive programs over the years, but, to date, there is no research on how best to assess their effectiveness. Since different types of assessments of incentivized performance often produce different, even contradictory, results, the industry needs a data-based evaluation method; companies need to know what evaluative measures are appropriate for the various types of incentive programs they might use. The goal is to help companies create an environment in which incentivized behavior does not simply achieve narrowly targeted production levels, but instead, will contribute to the overall project outcome.

Are there practices for developing incentive plans—plans based on clear, objective, and measurable KPIs—that will reliably lead to the targeted outcomes?

Notes to Team
The team should analyze the data on incentives that the CII Benchmarking & Metrics Program has collected from member organizations on their use of incentives.

A part of this research could be a case study analysis of companies who feel their incentive programs are effective.
RTS #8 Construction Robotics - What is the future?

**Essential Question:**
Realistically, what is the potential for the design, development, deployment, and use of construction robotics, now and in the near future; and, if positive, what would the potential benefits, likely barriers, and recommended path forward be for the industry?

**Background**
In the late 1980s and early 1990s, various highly-informed industry experts predicted that within 10 to 15 years, the use of industrial robots would be commonplace in the U.S. construction industry. Robots were to be used for all manner of repetitive construction activities—a development that was to create a rapid advancement in worker productivity, attract the “video-game generation” to construction, reduce accident exposure, and generally transform the industry. In the years since these predictions were made, the manufacturing sector’s use and deployment of robotics have dramatically exceeded all expectations, while the deployment of construction robotics is virtually non-existent, especially in the field.

**Notes to Team**
While this research should mainly focus on re-evaluating the potential applications of robotics in the industry, the research team is strongly encouraged to examine these highly-informed original predictions, analyze the barriers encountered since they were made, and explore why they did not materialize.

The research team is also encouraged to consider the apparent fact that the barriers to construction robotics have not changed: the same barriers that exist today, existed when the promising predictions were made 15-20 years ago. Exploring why these highly informed predictions did not materialize may help the team avoid making similar unfulfilled assessments.

Finally, while examples of specific robotic technologies may be useful to support the results of this research, the research team should recognize that the design and development of specific robots is not the aim of this project.

RTS #9 Strategies for HSE Hazard Recognition

**Essential Question**
What practices, techniques, and processes are effective in establishing and improving HSE hazard recognition in the construction industry?

**Background**
Currently, the construction industry employs a number of hazard recognition programs that are intended to improve safety by identifying and eliminating on-site health, safety, and environmental (HSE) hazards. While these programs have been widely adopted, they
have produced variable outcomes. What practices should be incorporated into a hazard recognition program, and how can both the practices and the programs be measured for effectiveness? Further, do combinations of practices produce synergistic effects, and can there be destructive combinations? If a program combining best practices were to be developed, how might it be refreshed and maintained as new practices and regulations emerge? How would hazard recognition programs/surveys be implemented/conducted? How might the good result of a successful implementation of practices, techniques, and programs be distinguished from simple good luck? How does one know that a program is working during a project?

**Notes to Team**
RT 284, Driving to Zero with Safety Leading Indicators, is currently conducting its research. The proposed research described here should not duplicate these efforts, but may benefit from being informed by them.
Essential Question:

What best or innovative practices are now available or utilized for managing construction indirect costs (and the associated component elements) such that risks, schedules, and costs are properly optimized for both contractor and owner?

Background:

Indirect construction costs include elements such as mobilization, demobilization, temporary buildings/utilities/furnishings, scaffolding, site supervision, field office costs (site QA program, craft payroll admin, IT facilities, etc), equipment rentals, site logistics and craft movement (i.e. lunch/break areas), stand down time, site cleanup and general housekeeping, heating and hoarding, permitting, warehousing, hoisting, material handling and preservation, safety programs (indoctrinations and meetings), drug testing, fall protection, personal protective equipment, site security, welder certifications, small tools and other construction consumables (i.e. welding rod). The scope includes indirect costs both at the primary job site as well as any offsite fabrication facilities.

Indirect costs make up a significant cost component of the overall construction costs, yet there has been little or no research as to the best way to estimate, manage, or control these costs. Some potential issues to explore are:

- How do local labor practices affect the management of indirect costs?
- How do multiple contractor interfaces, affect indirect costs, especially for elements such as scaffolding and hoisting?
- Are there contractual arrangements for indirect costs that are mutually beneficial to the project for (both owner and contractor)?
- If indirect costs are a hidden source of profit and/or risk for contractors, what can be done to mitigate them?
- What is the value of outsourcing aspects of indirect costs?

Expected/Potential Deliverables:

This research should result in a report that achieves the following objectives:

- Determines key indirect cost components and their impact on total construction costs.
- Ranks (highest to lowest) the total project impact of various indirect cost components on total project performance. This would include the cost of the initial indirect component plus the broader impact on other direct and indirect cost elements—elements such as total project cost, schedule, productivity, quality, and safety—to enable the team to focus on the greatest (highest) opportunities for improvement.
- Addresses the role technology might play in economizing indirect cost components (Note, however, this is not a technology topic.)
- Addresses the potential for breakthroughs (or breakthrough potential) in this topic.
- Explores the “outsourcing option” for certain indirect activities or functions.
• Provides data validating conclusions regarding best practices or recommended innovations.
• Generates data that provides insight as to how the industry estimates, manages and controls indirect costs and which is most effective, including what are the recommended metrics to apply.
• Contrasts various approaches, identifying positive/negative features of each.
• Explores and validates best practices and innovations, including optimized risk sharing, and other elements

2: Driving to Zero with Safety Leading Indicators

Essential Question

Which leading indicators of safety performance are the best predictors of enhanced safety outcomes? Are there measurable early indicators which can be shown to have a direct influence on prevention of negative safety outcomes? What opportunities are there to derive new leading indicators?

Background

The mostly widely utilized measures of safety performance used by the construction industry are lagging indicators such as Total Recordable Incident Rate (TRIR), Days Away and Restricted or Transferred (DART), or Experience Modification Rate (EMR). While accurate, they only measure past safety performance or occurrences and do not allow any interventions to prevent the very incidents they measure. In the construction industry in general and in the CII membership in particular, these lagging indicators have lost their ability to motivate or influence measurable safety performance improvement. Because the industry appears to have exhausted the measures it can take based on the lagging indicators, there is now a need to research and measure the positive effects that leading indicators can have on safety. Specifically, more research is needed on how pro-active safety interventions can contribute to the ultimate achievement of zero-injury projects.

The CII Safety Community of Practice conducted a focused survey to gauge industry interest in this research direction. The results indicate that 93% of respondents either use or want to use leading indicators as a key part of their safety management processes.

Potential Deliverables

This research seeks to identify those successful leading indicators with the likely potential of improving lagging indicators. The research will identify the best leading indicators currently in use in the construction industry and also those used more broadly outside the construction industry. This will include their application on different types of projects, domestic or international, and on various sizes of projects, for both owners and contractors. Metrics used to measure these leading indicators will be defined along with the thresholds that trigger responses to them. The characteristics of the best leading indicators will be described so that other leading indicators might be derived from them. The research will also describe leading indicator implementation processes, common barriers to implementation, and recommendations for overcoming those barriers.

3: Modularization

Essential Question
What changes or adaptations in the traditional EPC process (and its component design, engineering, procurement, and construction practices) would be required to create an optimum environment for a broader and more effective use of modularization?

Assignment:

To answer this question, start with the following exercise:

First, imagine a world in which every project is built using a modular approach – the stick-built method does not even exist.

Next, identify and describe the design and execution processes that would have evolved to optimally support that all-modular world. Define and document in detail how the engineering, procurement, and construction project execution elements would optimally function in an all-modular world.

Then, with this fully-detailed definition of capital project execution methodologies for this all-modular world in front of the research team, identify and explore the key differences between each of this new world’s processes and practices versus the counterpart elements in both (a) the current traditional EPC stick-built world, and (b) the current execution of modular projects. At a minimum, comparisons should include quantitative consideration of both cost and schedule.

Finally, for each element, identify the most efficient and highest-value practice from among the all-modular world, the traditional stick-built world, and the current modular world. Once the team has completed this exercise, answer the essential question presented above. Use what the team learned from the exercise to suggest ways to improve (a) mainstream EPC project execution strategies and (b) current modularization strategies.

The hypothesis is that many of the techniques, methods, and practices utilized in an all-modular world would be beneficial if applied to both traditional and modular executions; further, these all-modular approaches could also lead to a greater use of modular-style techniques and methods in traditionally non-modular projects.

Expected/Potential Deliverables:

1. Test and attempt to validate the hypothesis.
2. Compare the all-modular EPC process and the current, largely stick-built process, identifying key high-value practices.
3. Describe in detail the potential changes to the EPC process, along with analyses leading to the conclusion that these are the appropriate changes.
4. Describe the potential strategies for moving the market toward more optimum use of modularization strategies, if the research affirms the desirability of these strategies.

4: Quantifying the Impact of Change from Project Authorization to Start-Up

Essential question

What is the comprehensive impact of change on a project when changes are made at each step of the project, from project authorization through start-up?
Background

In 1994, CII published SP43-1, Project Change Management and SP43-2, Quantitative Effects of Project Changes, delineating a change management process. Not only is this information outdated, but it was incomplete, in some cases not enough data were collected for statistically significant results. Also there was no attempt to address the extent to which companies tend to underestimate the cost of change, depending on when the change occurs during project execution. The hypothesis is that change costs more as a project progresses and that the variance between the estimate and the actual cost of change also increases over time.

Refer to Ibbs and Allen (1995) and Hanna (2000) that quantify the effects of change on engineering and construction productivity. Pinchao Liao’s (December 2008) dissertation shows the impact of change on engineering productivity based upon the recently initiated CII measure of engineering productivity.

“Comprehensive Impact” as listed in the essential question includes costs (engineering, design, craft labor, field materials, field and home office overheads, etc.), schedule, and planning (risk package, forecast accuracy, etc.).

The CII database and other quantitative sources isolate and capture the costs of change in the phases of work (if possible). Fully capturing the impact of changes is important. Utilize the CII database as a vehicle to capture costs where possible and use case studies to further determine the impact of changes.

Potential deliverables

1) This research should recommend updates on SP43-1 and SP43-2 as appropriate. Note: Focus only on the data and results of analysis in SP43-1 and make no changes to the document’s process work. Also update or provide graphs or equations showing the impact of change from project authorization to start-up.

2) This research may require case studies of companies whose change management processes carefully track change costs during the project life cycle.

3) Because it is difficult to isolate the costs of multiple changes, this research should concentrate on the effects of one or two major changes on a project as opposed to impact of many small changes. It should also explore all aspects of the change, including effects on design, engineering, construction, and start-up.

4) This research should offer guidance on a minimum benefit threshold for change at each project phase. An example of such guidance might be a recommendation not to initiate a change unless it provides at least 1MM$ of savings (or a minimum percentage of total capital).

5) This research should use case study examples to generate recommendations of the most successful change implementation practices on capital projects.
2009 CII RFPs

1: Methods for Dealing with Uncertainty – Applying Probabilistic Controls in Construction

Essential Question

What would be the benefits and implications of applying a probabilistic approach of analyzing cost estimating and scheduling risks for construction projects? What are the preferred techniques and methods?

Background

Traditional methods for applying contingencies to construction cost estimates and schedules are often influenced by a risk-avoidance mindset. These methods are arbitrary and usually based on historical norms/benchmarks which can produce very conservative project budgets and schedules that would likely not be consistent with those resulting from a more sophisticated analysis of project risks.

Objective of the Research

This research shall explore the benefits and drawbacks of using a probabilistic approach for construction estimating and scheduling, and if beneficial, shall recommend an approach that can be readily implemented in the construction industry.

Probabilistic analysis is not new. Several methods and techniques have been identified for probabilistic, or “most likely”, analysis of various risk applications; however, many of these techniques are theoretical in nature and are not readily useable, nor reliable, for construction applications.

Thoughts for Discussion

The application of probabilistic controls in construction may consider the following:

- What are the quantifiable benefits of using probabilistic techniques in lieu of conventional, deterministic methods such as CPM?
- What are the possible consequences of deviating from the more traditional critical path schedules for controlling projects? What might be immediate barriers to implementation?
- What applications are currently available and are they of benefit to construction estimating and scheduling?
- Do these methods and techniques allow for easy adjustment of estimates and schedules during a project to enable modeling of changing project conditions?
- How would new probabilistic analysis be benchmarked?
- What would be the implications for contractual issues such as compensation and liabilities?

Potential Deliverables
Review of current estimating and scheduling practices with respect to contingency setting.
Identification and analysis of currently available probabilistic methods including potential benefits and trade-offs.
Case study of any known projects in which probabilistic controls have been used in construction.

**Researcher Alternative Statement**

The researcher is encouraged to respond to the request as stated but also to propose any alternate objectives or deliverables.

2: Project Management Skills of the Future

**Essential Question**

As we continue to expand capital construction into an increasing global world with fewer and dispersed resources, what will be the skill sets for the project manager of the future?

**Background**

As project managers are assigned to more complex projects in a variety of countries, with fewer resources, there are studies that indicate the skill set of project managers will be changing in the future. Project managers may need to be more of a mentor or problem solver. They will need to manage the flow of integrated information systems, and facilitate communication among the team members. There is a need to develop the skill set of the future project manager and develop a method to ensure the construction industry is prepared to meet the challenges.

Components to consider include (but are not limited to) collaborative project management, outsourcing, global teams, offsite management, centrally located project teams, integrated information systems, sustainability issues and different paradigms for prefabrication and automation implementation.

Researchers should not be constrained by these thoughts as they develop the competencies and skills for a capital project manager in the 2020 time frame.

**Potential Deliverables**

Determine the key competencies and skill set for the future project manager. Contrast or compare current project manager skill sets to the future skill sets. Develop an agenda for a CII Project Manager course that addresses the future skill set for a capital project manager.

**Notes:**

Prospective researchers are encouraged to team with appropriate academic resources familiar with developing skills sets for successful professionals.

Researcher should consider the skill set for project managers in other industries.
3: Innovative Project Delivery Processes - Is there a better way? Essential question
If the Capital Project industry did not exist and a new need was created for it, what would it look like? Background Extensive research and published material exists addressing owner, contractor and supplier relationships and contracting methods. The general intent of this material is to improve the effectiveness of the capital facility delivery process. The purpose of this research topic is to put aside the conventional methods and iterative improvement approach and start from scratch to develop a new and innovative approach. By assuming a scenario where no convention exists, the researchers will not be constrained by the inefficiencies of legacy systems.

Topics for consideration:
- Value delivery
- New roles for all participants (defining objectives, removing barriers)
- Minimizing time to market
- Zero tolerance for delays
- Information management and integrated technologies
- Compensation for services
- Allocation of risks
- Use of incentives
- New build and retrofits

Potential deliverables
1) Innovative approaches for a new project delivery model
2) Comparison of new model with current delivery models demonstrating improvements

4: Quantifying the Impact of Change from Project Authorization to Start-Up

Essential question
What is the comprehensive impact of change on a project when changes are made at each step of the project from project authorization through start-up?

Background
SP43-1, Project Change Management published in 1994 delineated a change management process using data found in SP43-2 “Quantitative effect of project changes”. Not only is this information old but it was incomplete (in some cases insufficient data were collected to be statistically significant). Also there was no attempt to address the extent that companies tend to underestimate the cost of change, depending on when the change occurs. (The hypothesis is that change cost more the further into the project and the variance between the estimate and the actual cost of change increases).

Refer to Ibbs and Allen (1995) and Hanna (2000) that quantify the effects of change on
engineering and construction productivity. Pinchao Liao’s (December 2008) dissertation shows the impact of change on engineering productivity based upon the recently initiated CII measure of engineering productivity. “Comprehensive Impact” as listed in the essential question includes costs (engineering, design, craft labor, field materials, field and home office overheads, etc.), schedule, and planning (risk package, forecast accuracy, etc.).

Based on the CII database or other quantitative sources isolate and capture the costs of change in the phases of work (if possible). Fully capturing the impact of changes is important. Utilize the CII database as a vehicle to capture costs where possible and use case studies to further determine the impact of changes.

**Potential deliverables**

1) Recommend updates on SP43-1 and SP43-2 as appropriate. Note: do no update the process work contained in SP43-1, just the data and associated conclusions. Also update or provide graphs or equations showing the impact of change from project authorization to start-up.

2) This research may require case studies with companies that carefully track change costs during the project life cycle in the change management process.

3) The research should concentrate on one or two major changes in a project as opposed to studying the effects of many small changes since it would be very hard to isolate the cost of multiple changes. It should explore all aspects of the change including design, engineering, construction, and start-up.

4) Recommendations with guidance of a minimum threshold to which change should be considered at each project phase, e.g. don’t initiate a change unless it provides at least 1MMS of savings (or as a percentage of total capital).

5) Consider recommendations of the most successful practices for implementation of changes in projects based on actual case study examples.
2007 CII RFPs

1. Sustainable Design and Construction

**Problem Statement**
The construction industry is a large consumer of energy and materials and a significant generator of man-made waste. In addition to construction and demolition waste generation, the industry has a significant impact on the environment through greenhouse gas emissions, water consumption and air pollutants. The concept of sustainable design and construction has significant traction in the construction industry. CII’s Breakthrough Strategy Committee’s Sustainability white paper (available at www.construction-institute.org) advances the concept of sustainability as the “triple bottom line”. This concept is becoming well accepted but it is one of hundreds of definitions or concepts of sustainability floating around today. The “triple bottom line” makes sense conceptually when applied holistically to a business, but how this definition actually applies to a construction site is not understood.

**Objective of the Project**
The goal of this special project is to assist the engineering and construction industry to understand what sustainability is at the project level. To meet this goal, the research objectives are:

1. To determine the design and construction practices that are commonly implemented on projects to improve the project’s sustainability, and
2. To understand why these practices are selected for implementation on projects, and
3. To document how these practices are implemented on projects.
4. Indicate the potential financial benefits associated with the use of each practice.
5. This project is to address industrial and not building projects.

**Project Deliverables**
The expected product of this special project will be a CII primer on sustainability. The contents of this primer shall include (but not be limited to):

1. A listing and description of sustainable practices commonly used on construction projects, and
2. The industry segment that the practices are commonly used in, and
3. Reasons why the sustainable practices (design and construction) were chosen for implementation, and
4. The scope of possible future research projects to conduct in-depth case studies and evaluations of sustainable design and construction practices.

**Project Parameters**
This project is a special CII project. The project will start in the fall of 2007 and complete in the summer of 2008. A presentation to the 2008 CII Annual Conference is expected. The maximum price of this project shall not be greater than $75,000.

2. Nanotechnology and its Impact on Construction

**Problem Statement**
The U.S. National Nanotechnology Initiative (NNI) expenditures exceed $1 billion each year, with the Presidents 2008 budget for NNI at $1.5 billion. The resultant products may have broad
application to the design, construction and operation of constructed facilities. These include products such as:

- Lighter and stronger structural elements.
- Improved reflectivity and skid resistance of asphalt materials.
- Improved binding, quicker curing and improved maintenance of cementitious materials.
- New coatings to improve cleaning and maintenance of surfaces.
- Improved pipe joining materials and techniques.

The problem is the gap that traditionally exists between R&D and applications on a live construction project. The construction industry is generally not aware of the many advances being made, and the R&D community often lacks the in depth understanding of the tools, procedures and materials used in the building process. This CII research project should make clear recommendations, with specific products, for the CII to pursue as potential breakthrough products and/or strategies.

**Objective of the Research**

The objective of this research project is to review the current nanotechnology programs and to identify 3 to 5 application areas that could benefit from a close collaboration between the engineering and construction industry and the research community.

**Thoughts for Discussion**

- The cost effective production of a construction scale material may be an inhibitor.
- The adaptation of a nanotechnology based material to a specific construction product may require new computational algorithms or processes for construction related product design; sizing a structural component for example.
- A whole new design and/or construction process may be required to take advantage of a new nano-based material.
- An educational and training component may be justified, to increase awareness in nanotechnology to the CII members, and to support a focus in key areas to rapidly move from the research stage to operational products.

**Potential Deliverables**

1) Identify 3 to 5 application areas that have potential benefit to the design, construction or operation of a constructed facility.

2) Within the above application areas, focus in on a total of 3 to 5 products that could be rapidly transitioned from the R&D arena to a live project.

3) Provide an analysis and justification for each of the products listed in item 2, including:
   - potential to create a “step change” in the construction process,
   - anticipated changes required in the labor, process, schedule or cost, of current construction practice,
   - estimated time to production,
   - cost effectiveness,
   - safety of material and/or process.

4) Identify potential collaborators for each of the products identified to bridge between the R&D community and the construction industry.

**Researcher Alternative Statement**

The researcher is encouraged to respond to the Request as stated but also to propose any alternate objectives, methodologies, or deliverables consistent with the intent of the topic. The researcher is further encouraged to communicate with CII members that may have expertise in
nanotechnology, including the NIST Building and Fire Research Laboratory (BFRL) and the US Army Engineer Research and Development Center (ERDC).

**Level of Effort**
The final report of the results and recommendations from this effort are expected no later than April 1, 2008. A presentation will also be expected at the 2008 CII Annual Conference. The maximum level of effort shall not exceed $40,000, including all overhead, travel and related administrative costs.

3. Craft Productivity Research Program

1.0 **Program Proposal Procedure**
The proposed Craft Productivity Research Program is intended to be a five to six year program at an approximate total cost of $900,000. The CII envisions that the entire program will be completed. CII’s Research Committee will review the program at a minimum annually to insure satisfactory progress and quality and to approve the selection of the next project to be undertaken in the program. If progress and quality are not satisfactory or a satisfactory follow on for the next step is not found, CII may choose not to continue funding to the end of the proposed time period.

CII proposal guidelines in the RFP shall be followed except that the proposal may extend up to eleven pages including the cover page. The proposal shall include the initial productivity topic to be studied. CII’s vision is that this initial topic will be a substantial project with potential results to be significant on the path to achieving the program goal of a 50 percent improvement in craft productivity. Additionally, the submittal shall include a discussion of topics to be considered as future research projects.

The principal investigators successful research experience in the topic of craft productivity must be included in the submittal. CII believes this experience to be fundamental to the success of this project and therefore has increased the maximum allowable size of the proposal to allow space for the submittal to be detailed in this area.

CII believes that with this substantial commitment to a craft productivity research program that there is a potential that the CII funds can be leveraged. Each submittal shall clearly explain the proposed PI’s ideas for leveraging the CII commitment to this project.

2.0 **Problem Statement**
Improvement of construction worker productivity would reduce costs, mitigate labor and skill shortages and improve schedule performance in construction projects. Previous CII research have identified constraints that reduce productivity by evaluating the time spent doing support work or being idle. Work sampling of commercial building indicate from 45% to 50% direct work while the remainder of an individual’s time is either walking, transporting or getting instructions or personal and idle time. Industrial construction averages less than 45% “direct work,” thus there is even greater opportunity for productivity improvement.

Even though there has been productivity improvement by heavy equipment, tool and material advances, there is opportunity to employ technology to improve material and information availability at the work face. Furthermore, more effective crew level planning that insures the elements of work are provided to crews will improve productivity.

3.0 **Objectives of the Research Program**
The research that leads to substantial craft productivity improvement will require a comprehensive research program rather than be the focus of a single research topic. This program should include productivity benchmarking data that is being submitted by CII companies.

A program of craft productivity research program would include the number of years of study as well as costs. The program should envision potential research studies that will be reported to the membership during the program period. There should be enough flexibility in the research program that if a promising topic requires more time and resources the work will continue. In addition, the program should follow-up the CII Craft Worker Study, Lean Construction and Leveraging Technology to Improve Construction Productivity that was recently completed or is under way.

The research program should consider collaborating with other organizations such as FIATECH to increase the level of research effort. The study would have the benefit of continuity of research investigators and the CII team that will be guiding the work.

The ultimate objective of this research program is to identify and validate through (through field trials or other validation methodologies) one or more initiatives, techniques, methods, etc (or a series of such over a 5-6 year period) that, if implemented would result in a craft productivity improvement of 50 percent.

4.0 Thoughts for Discussion
- This research will require considerable field analysis and possibly implementation of technology as well as, training to determine the potential productivity improvement. Field study experiments should be considered that may have control crews as well as those that is implementing productivity improvement techniques.
  - If union involvement would benefit the research, the research team should seek their assistance to develop the research design
  - The research should provide an implementation guideline that will assist companies that want to utilize the research findings.
  - Since this is a multi-year study, productivity improvement data may be tracked utilizing CII benchmarking data when companies employ improvement techniques.
  - The research findings should be written based upon a possible audience of construction supervision that will likely have the task of implementing the results.

5.0 Potential Deliverables
- Findings and results will be presented to CII periodically in order to allow implementation within the time period of the research program, rather than at the end of the study. It is expected that beginning in 2009, the program will report out at the CII annual conference each year until completion of the program.
  - Field studies and experimentation results should indicate the potential productivity improvement based upon effective implementation of the findings.
  - Research findings should indicate a progression of results based based upon previous CII Research studies as well as other craft productivity research.
  - A comprehensive productivity improvement program could be presented at the end of the research program with guidelines for implementation.

6.0 Administration
The principal investigator(s) will meet with the CII Research Committee at least annually to review research progress and the forecasted work for the next year. Agreement between the
PI(s) and the Research Committee shall be reached that satisfactorily progress is meeting attained. It is CII’s intent to fund the entire program, however, if for any reason the CII research committee determines during its reviews that progress or quality is not acceptable the program may be terminated. CII shall determine the dates and locations for such review meetings at the beginning of each year.

Periodic interim reports, final project reports and webinars as specified in the RFP are a part of the requirements of this program.

7.0 **Research Alternatives**

The researcher is encouraged to respond to the request as stated, but also to propose any alternate objectives, methodologies, or deliverables consistent with the topic in the initial Letter of Intent and later in the Research Program proposal.

4. **Estimating as a Competency in Capital Projects**

**Problem statement**

Estimating is an integral competency in capital project planning and implementation. Without properly estimating the project costs (capital and operating), two key CII best practices are negatively affected: project pre-planning and alignment. Simply stated, without proper cost estimating, the very profitability of the firm can be in jeopardy.

Cost estimating entails: (i) construction estimating which includes material take off’s of bulk quantities and application of labor rates and unit material costs; (ii) total plant costing which includes estimating the purchased equipment, engineering and other indirect costs; (iii) project risk assessment, (iv) presenting the project costs to management for approval, (v)change management support through project life.

In the past, cost estimating was a competency in which key skills were honed over years, knowledge was transferred from one individual to another and there was pride in the profession manifested by career estimators. Over the past 10+ years, experienced professionals have retired or left the field and computer based tools (which have increased productivity) have not satisfactorily captured their experience and judgment. Current estimators may know the tools, but not the rationale or reasons behind the numbers. They may not know the right questions to ask, the right risks to assess or which assumptions need to be probed. This combined with the fact both costs and volatility are rising due to extremely tight labor and fabrication shop markets has produced a real crisis in estimating. Many companies are suffering overruns and/or the inability to quickly adapt to a changing cost environment.

**Objective of the Research**

The purpose of the research is to determine the best way to train and retain cost estimators in the capital projects profession. The research will identify the best ways to transfer cost estimating knowledge, which skills are most important for successful contractor and owner estimators, and how to establish a cost engineering career path. The research is to explore the state of estimating as an expert competency versus simply a function and to provide best practices accordingly. The research should also determine the current state of instructional and professional development.

CII is trying to determine how member companies can maintain both the conceptual estimating competencies, as well as the experience and judgment elements associated with the detailed estimating functions in the face of reported attrition among the ranks of
experience career estimating personnel and a diminishing career track for professional estimators.

**Thoughts for Discussion**
- Attached is recent article from the Association of the Advancement of Cost Engineering International that touches on many of the issues important to this project. Note that the critical concern is not the estimate per se, but rather the transfer of experience and judgment within the estimating function.

- The researcher may want to consider what competencies are needed and do a gap analysis between the current “as is” state and the “to be” future state. Recommendations regarding ways to close the gap would be a natural outgrowth.
- Researches many want to explore a workshop with AACE, American Society of Professional Estimators, ASCE Construction institute and PMI (Project Management Institute) to determine shortcomings in cost estimating instruction.
- Recent CII projects on lessons learned systems may be useful for this project.

**Potential Deliverables**
- Document the current state of expertise or competence in the field
- Document desired competencies and skills
- Document training and retaining best practices
- Research methods to build skills around estimating agility (to reflect the increasing speed of response necessary).
- Document ways to transfer knowledge and data
- Document preferred or alternative career paths
- Develop recommended curricula for engineering schools and/or short courses for working professionals

**Researcher Alternative Statement**
The researcher is encouraged to respond to the Request as stated but also to propose an alternate objectives or deliverables.

5. Quality Management Best Practice Refreshment

**Problem Statement**
In the early 1980’s the US construction industry was described as ill. Productivity was declining, delays and overruns on projects were common and litigation related to design and construction was accelerating. A significant cause of this poor performance was cited as the use of inadequate and outmoded management practices. The industry turned to the principals of the quality experts in the manufacturing world such as Deming and Crosby and worked to adapt these principals to the design, procurement, and construction and start up processes of the unique, one off world of capital projects.
CII was among the pioneers in researching the application of quality management principals and practices to the capital facilities industry. In 1985 the CII Quality Management Task Force was initiated resulting in the development of the Quality Performance Management System documented in CII document SD-10 published in 1990. Subsequent to the 1990’s research being completed and Quality Management being established as a CII Best Practice, much has been developed and published in the area of quality management including such processes as ISO 9001:2000 standards, Six Sigma methodologies. Today there are many Quality Management systems available for Capital Facilities Project Management including:

- The National Institute of Building Sciences “Total Quality Management”
- The Project Management Institute’s “Project Management Maturity Modeling”
- The University of California at Berkeley’s “Project Management Process Maturity”
- Carnegie Mellon’s “Capability Maturity Modeling Integration”
- American Productivity and Quality Center’s “TQC”

Which of these, or others, best apply in today’s highly competitive environment?

**Objective of the Research**

Determine through research the quality management practices that are a net value adder to a project and those that are a net value take away from a project.

Compare the current quality environment in the industry versus the “ill” state that was described in the 1980’s. Determine and define the fundamental quality management processes that are required to properly maintain and continue the quality improvements of the past.

The product(s) of this research are intended to provide a comprehensive study of Quality Management in the capital facilities delivery industry and will replace existing CII publications and Best Practices on this subject for possibly the next ten years.

**Thoughts for Discussion**

- Quality is often measured as rework. Have we now progressed beyond measuring defects and advanced to measuring improvements? What are the appropriate metrics for a functioning quality management process today and in the future?

- Does one quality management system increase the overall project quality greater than another one?

- Were the original quality management processes deployed in the 1980’s and 1990’s a one-time (and very necessary) fix for the industry’s ills?
  
  - Have these legacy processes now been replaced with *quality maintenance processes* – reliably sustaining those initial improvements: or
  
  - Are there new and evolving quality processes, which offer the promise of fresh and equally progressive *step changes* in quality, and with potential to bring the industry to even higher and more competitive quality levels; or
  
  - Has quality management become so *institutionalized* in the industry’s processes and practices, such that further improvements will have diminishing or negligible returns?
The ISO 9000:2001 certification is seen in project management, engineering, procurement/subcontracting and construction. In some instances all the phases and functions are certified and in others, only one or two of the functions are certified. Is there evidence that all or a subset of the functions certified as ISO 9000:2001 compliant gives more net value added?

Is it possible to identify where investment in quality practices (not just ISO 9000:2001 certification) provides the maximum net value addition to a capital project?

Are there or should there be practical quality gates during the planning, engineering, procurement, construction and commissioning of a capital project?

The audience for this research is the construction industry executive and the project manager.

Potential Deliverables

- An objective comparison of the quality management processes being utilized in the engineering and construction industry.
- Identification of the essential functions should exist in any quality management system utilized by companies in the engineering and construction industry.
- An evaluation of the value versus effort of further enhancements to the industry’s quality management processes.
- A definition of best in class in the construction industry and a picture of what we are potentially able to become.
- Tools for optimizing the investment in quality management for projects varying in size and scopes of work.
- Identification of practical quality gates that should be embedded in planning, engineering, procurement, construction and start up processes.
- Provide references to Quality Management publications which are deemed, by the Research Team, to be applicable to the AEC Industry.
- Provide guidance and tools for implementation of quality management.
- A description of what is best in class in QMS in the construction industry and what are we potentially able to become.

Researcher Alternative Statement

The researcher is encouraged to respond to the Request as stated but also to propose any alternate objectives, methodologies, or deliverables consistent with the intent of the topic. Also, this topic is fundamentally not an engineering subject; and prospective researchers are, therefore, encouraged to consider teaming with other knowledgeable academic resources as appropriate.

1 http://www.iaarc.org/  
2 http://isarc2013.org/