Sample Research Problems Identified By Industry Organizations

This document lists some of the research problems identified by Construction Industry Institute (CII) and various industry organizations 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. These 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.

APPENDIX A

2016 CII Research Topics

CATEGORY 1 – PROJECT PROCESSES AND PRACTICES
RTS 1 - Performance Metrics & Benchmarking to Support Modularization Business Case Analysis
RTS 2 - Controlling Scaffolding Costs
RTS 3 - Corporate Best Practices for Successful Productivity Improvement Programs
RTS 4 - Standardized Design versus Customization
RTS 5 - Capital Budgeting and Front End Planning Interface Improvement
CATEGORY 2 – EMERGING AND FUTURE INDUSTRY ISSUES
RTS 6 - Application of Wireless Communication Technologies on Construction Sites
RTS 7 - Integrated Project Delivery for Industrial Projects
CATEGORY 3 – PEOPLE ISSUES
RTS 8 - Optimal Owner Team Organization
RTS 9 - Wearable Worker-Monitoring
RTS 10 - Effective Transition of Project Team Roles and Responsibilities As Resources Change during the Project Delivery Cycle
CATEGORY 4 –BREAKTHROUGH
RTS 11 - Breaking through to Collaborative Scheduling: Approaches and Obstacles
RTS 12 - Improved Integration of the Supply Chain in Materials Planning and Work Packaging
RTS 13 - Redesigning EPC Processes to Leverage the Latest Design and Communications Technologies

RTS 1

Performance Metrics & Benchmarking to Support Modularization Business Case Analysis

Essential Question
Which key performance metrics can be used for business case analysis of modular facility/component construction? These performance metrics would include relevant industry data, addressing—at a minimum—the impact of modularization on safety, quality, and productivity.

Background
The industry has used modularization for more than 70 years to deliver constructed facilities and components in remote, often inhospitable, locations. Recently, modularization has been employed to relieve mega-project teams of the excessive labor resources required to stick-build complex industrial facilities in such adverse environments. In these scenarios, modularization mitigates the socio-economic impacts of relocating thousands of construction workers to the jobsites. When projects in remote/harsh environments cannot be efficiently constructed in place, the usual approach is simply to assess the cost and schedule requirements for modular construction of the facilities. However, the decision to use modularization to reduce local labor requirements for such difficult stick-building requires a careful business analysis of comparative cost, schedule, quality, and safety.

Notes to Team
This team should identify and gather benchmarking data that can help project teams evaluate the benefits and drawbacks of modular execution. Also, the team could consider modularization of commercial buildings and hospitals in addition to traditional industrial projects.

Some performance metrics to consider include the following:

1. What are the impacts of modularization on project safety and quality, both for work at the module assembly site and at the construction site (i.e., module installation site)?
2. How does modularization affect overall productivity? For example, does the fabrication environment enable higher productivity?
3. Is the work executed within a module yard executed with higher safety performance and fewer incidents? How does the new work created (e.g., module transportation, setting, and hook-up) affect overall safety performance?
4. What is the impact to project duration? Does modularization shorten or lengthen projects?

References

CII RT 171, Prefabrication, Pre-assembly, Modularization, and Offsite Fabrication
CII RT 255, Adaptation of Shipbuilding Systems to Construction
CII RT 283, Modularization
CII Modularization COP

RTS 2

Controlling Scaffolding Costs

Essential Question
How can the industry effectively reduce, plan, and manage scaffolding costs by means of the following:
- eliminating teardown and rebuilds
- using best-of-breed planning systems for multidiscipline builds
- moving certain modular scaffold builds to the yards to be included with shipment
- initiating constructability to justify permanent platforms versus bulk scaffolds
- evaluating the tradeoffs between JLG/scissor-type access versus fixed scaffolding.

Background
A recent study by the Construction Owners Association of Alberta (COAA) estimates that scaffolding consumes between 15-23 percent of direct project work hours, while anecdotal estimates range even higher, at between 35-40 percent. These extraneous costs are often due to inefficient planning, management, and coordination across the disciplines requiring co-located scaffolding. Moreover, scaffold planning traditionally has been reactive rather than proactive —coming only as an afterthought to support work packages. However, were project teams to leverage the dimensional information and spatial planning requirements readily extractable from virtual construction models, they could optimize both permanent construction and scaffold construction. Without such comprehensive proactive planning, scaffolding will continue to be excessively put up, torn down, and put back up again.

During FEED, the objective is to calculate a basic scaffolding estimate. A rule-of-thumb approach calculates scaffold requirements as an average of overall scaffold-to-linear-pipe ratios found on past similar projects. If the industry were to push this standard to be more proactive (based on specific 3D designs), it could drive a real change in this calculation process. During construction on a multidiscipline site, the current planning process can become reactive, and field control is often quite weak. By linking proactive calculations and planning to work packages, the industry could develop a process for truly comprehensive and proactive scaffold management. This improvement could realize significant savings through better constructability, scheduling, materials use, productivity, site layout/access, and safety, among other benefits.

Note to Team
RT 272 and RT 319 performed the CII research on Advanced Work Packaging. The research team should link scaffold planning to these work packaging efforts, determining the extent to which it can or should be integrated into work packaging. The team could also develop processes for integrating scaffold planning into virtual design. The RT may consider developing a business case analysis tool similar to the one in the modularization tool kit, or a stage gate workflow map similar to the one presented as an AWP best practice.

References
CII RT 272, Workface Planning, from Design through Execution
CII RT 282, Managing Indirect Costs
CII RT 319, Validating Advanced Work Packaging as a Standard (Best) Practice
http://www.coaa.ab.ca

RTS 3

Corporate Best Practices for Successful Productivity Improvement Programs

Essential Question

What are the enterprise-level best practices for implementing productivity improvement programs; and what are the most significant barriers to their implementation?

Background

Beyond providing schedule and cost benefits, productivity improvement programs can engage the workforce and may reduce absenteeism and turnover. Although project management teams have implemented various types of these programs over the years, their efforts have been inconsistent, and construction industry productivity has remained flat for several decades now. To unlock the potential of productivity improvement programs, the industry needs a clear understanding of what creates the barriers to progress. Also, if owners and contractors knew the benefits and costs of removing these barriers, it would help them determine the types of programs appropriate to their projects.

This research should first identify the barriers to implementing current productivity practices and then determine and document the corporate-level best practices for developing programs for productivity improvement.

Note to Team

While the efforts of RT 252 focused on field productivity improvement practices, this research should investigate corporate strategies for productivity improvement. The preferred team for this topic would consist of senior-level corporate executives. The team could investigate companies that have already initiated enterprise-level improvement programs. While such programs are not yet comprehensive, specific program elements could be examined. Quantification of such benefits as schedule savings, cost reduction, or less rework would encourage other companies to consider implementation of corporate productivity improvement programs.

References

CII RT 252, Construction Productivity Research Program

RTS 4

Standardized Design versus Customization

Essential Question
How can we effectively establish and communicate the value of using industry-proven standard designs and components to reduce risk in execution (i.e., cost, time, quality, and safety risks)?

Background
Industry organizations generally accept that any customization required by an owner/operator has a significant cost; at the same time, they understand that customization is felt to be paramount to the project's value proposition. However, since these ideas about customization are based on anecdotal information, many in the industry have little understanding of the real overall impacts of customization on a project. Thus, the industry needs researched information on its safety, schedule, and monetary costs.

Additional risk is introduced to a capital project with the following

- customization of specifications
- lack of adoption of PIPs
- extensive addenda to PIPs
- "CYA" – that is, onerous allocation of risk to suppliers/contractors
- increased bidding costs
- preferences without basis
- unrecognized disruption caused by implementation of preference changes.

Has the industry successfully demonstrated the application of standardization?

Note to Team
The research might benefit from having vendor experience on the team, to give input on product design to industry standards (e.g., API). The team should examine the work of Process Industry Practices (PIP), reviewing its publications as an initial source of information. PIP should also be considered as a funding source, as either a sponsor or co-sponsor.

Expected Outcomes
Consider creating an early development checklist, highlighting areas to consider application of industry-proven standardization. Case studies of successful adoption of standardization would be useful. The team should also determine whether the research requires one or two years to complete.

Resources
CII RT 255, Adaptation of Shipbuilding to Construction
CII RT 283, Modularization

RTS 5

Capital Budgeting and Front End Planning Interface Improvement

Essential Question
What are the critical success factors for tying the business planning aspects of capital budgeting to the front end planning process?

Background
Oftentimes, the anticipated financial returns from a capital project turn out to be overly optimistic. This may arise from a poor understanding of the product's market, optimistic estimates of the project's cost and schedule, or both. CII research has conclusively shown that full funding authorization should not be awarded to projects with poor scope definition or inadequate business planning, since both lead to poor project performance. Decision-makers and project team members need to know what to do to enhance capital budgeting and business performance in owner organizations. They need to understand the barriers to successful interfacing between capital budgeting and front end planning.

Achieving optimal levels of financial returns from capital projects is CII's mission. While the institute has accomplished much to reach this aim, more remains to be done. The purpose of this project is to find further ways to achieve optimal business results.

Note to Team
The team may consider developing a PDRI-like assessment of projects in the capital budgeting process. This assessment tool could focus on the business case governance and finance issues surrounding projects, and should encompass the entire front end planning process, including capital budgeting. This effort would move back upstream of the past work done on front end planning and tie portfolio management techniques and capital budgeting practices into this past work. Such an integrated expansion of CII research on front end planning would significantly improve owners' ability to deliver projects profitably and would build contractors' capacity to support that effort.

Resources
CII RT 213, Front End Planning Toolkit
CII RT 303, Project Portfolio Management

RTS 6

Application of Wireless Communication Technologies on Construction Sites

Essential Question

How can the construction industry overcome impediments to deploying wireless communication technology on secure construction sites; and what are the applications with the highest payoffs?

Background

Wireless communication technologies have advanced tremendously since CII last sponsored research on how wireless communication can enhance productivity, cost effectiveness, quality, and safety. Compared to the early versions studied, these new applications have many more capabilities and are far more affordable to implement. Because most new and recent entrants to the construction industry have arrived already familiar with and adept at wireless technologies, the transition to wider use should entail fewer change management and training challenges. Options for wireless data availability on active jobsites have also improved drastically in recent years. However, deployment can still experience technical and work process impediments.

Typical applications include materials and equipment tracking, as well as mobile computing with rugged tablets to capture data on field progress, initiate RFIs, and document quality inspection approvals. Many firms report some success at integrating wireless communication technologies into these and other construction site work processes. Yet frustration persists regarding the speed and success of utilizing this technology for the overall benefit of the construction industry.

This research should assess the current state of wireless technology usage on construction sites and identify technologies that are proving to be successful at supporting construction field operations. The team should examine technologies successfully being deployed by CII member companies, and share their implementation strategies and lessons learned. Documenting any work process modifications required to implement these technologies could be a useful outcome of this research. The types of technologies and bandwidth demands that may be considered include the following: various types of mobile computing in the field, including ruggedized tablets, materials tracking, smart helmets (e.g., DAQRI and Oculus Rift), and augmented reality.

Note to Team

This research should address the industry's current level of wireless technology implementation, as well as any barriers to successful use. These barriers may include technical (e.g., bandwidth), security, and/or cultural issues. The team might also explore any limitations particular to wireless technology use on construction sites. Examples of best practices for overcoming barriers could help CII members struggling with implementation. Further, the team could identify and discuss emerging applications and any current usages not yet deployed by the industry. The team could enlist vendor expertise for this topic. This research might only require a one-year time frame.

References

CII RT 136, Jobsite Wireless Computing (1997)
CII RT 240, Leveraging Technology to Improve Construction Productivity
Relevant FIATECH references regarding these technologies and their use.

RTS 7

Integrated Project Delivery for Industrial Projects

Essential Question

Which best practice can offer a step-change in the industry's experience-based project execution paradigm (i.e., design-bid-build) and, thus, improve collaboration among all project team members (e.g., owner, designers, contractors, and trade partners). Such an improved project delivery method would enable project cost/schedule predictability, remove non-value-added processes (lean), and use the latest technology in design (e.g., BIM), construction (e.g., robotic layout), and operations (e.g., augmented reality).

Background

Owners increasingly question the traditional design-bid-build (DBB) project delivery paradigm, since more and more projects have become long and costly, and often do not achieve the desired results for all project team members. These frustrations and failures include misalignment of expectations, incomplete hand-offs between phases, and hierarchical team organization, as well as contentious project delays, change orders, and claims.

Commercial construction projects have successfully implemented the integrated project delivery (IPD) approach over the past 10 years. However, IPD has had a slow and limited implementation in the industrial sector, often due to concerns that industrial projects are more complex, that they generally have a specific system turnover sequence, and their owner requirements carry greater weight than on typical commercial IPD projects. Recent research indicated that only three of 59 IPD projects recently completed or underway in the U.S. and Canada were industrial. In spite of this indication of low IPD use on industrial projects, the interest shown by owners such as Intel, DuPont, and others suggests that more integrated industrial project delivery must be in planning or underway.

This research should identify the obstacles to industrial implementation of IPD. It should also identify and define the IPD best practices an industrial project could implement to achieve a step-change in project planning and execution. Topics to evaluate might include the following:

- What would an industrial IPD project execution strategy look like?
- Would roles and responsibilities be different than on a DBB project?
- Which commercial issues should be considered on such a project?

Notes to Team

Address use of lean techniques, such as co-location of all project team members during design, cluster-type project organization, shared risk and reward, and pull planning.

Lean Construction Institute – IPD.
Book – *Team of Teams*, McChrystal, 2015.
Design Build Institute of American (DBIA), www.dbia.org.
Book – *Scrum: The Art of Doing Twice the Work in Half the Time*, J. Sutherland.
CII conference presentation: *Maximizing Success on Integrated Projects: An Owner's Guide,* Integrated Project Delivery Alliance, www.ipda.ca.
No Business as Usual, (BP) 1996.

RTS 8

Optimal Owner Team Organization

Essential Question
What are the optimal owner staffing and capability requirements for project success? Which processes might help owners determine the project roles and functions essential to each unique project?

Background
The formation, organization, and skill level of the owner team on capital projects has a significant impact on the success of a project; and owner PM teams are increasingly downsized and are often too lean. Moreover, owner team size, makeup, and capability tend to vary throughout the project delivery cycle. In spite of these staffing challenges, little guidance is available for owners on determining and documenting the proper project staff and capability requirements. This lack of guidance is due to the difficulty of accounting for the many dynamic project considerations involved, including the following:

- project complexity
- owner risk tolerance
- project procurement strategy
- owner organizational structural constraints
- owner engagement
    - owner experience/level of involvement
    - approval process
    - site support
    - quality management
- individual/owner team skill
    - operating experience
    - project experience
    - qualifications
    - disciplines

Notes to Team
This research should provide owners with an approach to forming the proper organization for any project, along with a process for aligning individual participants, to make each project successful. The focus should be on the people aspects of project organization and on the challenges that owners face in creating, aligning, and sustaining a team (e.g., organization, skill, training, and HR). The owner staffing element of this research should focus primarily on those providing oversight rather than on third-party specialists.

Resources
CII RT 181, Integrated Project Risk Assessment
CII RT 204, Owners' Role in Project Success
CII RT 261, Optimizing Jobsite Organization
CII RT 280, Probabilistic Risk Management

RTS 9

Wearable Worker-Monitoring

Essential Question
What are the current and emerging best approaches to protecting craft worker health and safety through wearable monitoring technologies?

Background
By using emerging off-the-shelf wearable technology products like the FitBit that monitor body state (e.g., heart rate or temperature), categorize activities (using input on inertial motion, vibration, or other data), or track location (with RFID, GPS, and/or other location applications), project teams should be able to track worker body state and activity categories, to effect timely interventions necessary to avoid injuries. Wearable location tracking applications (e.g., Redpoint Positioning products) can alert workers to proximity to hazards. By providing data on pupil dilation and head-nodding, virtual reality headsets might also provide information about impairment and fatigue based on head nodding (e.g., Mercedes).

Combinations of these kinds of sensor inputs might be used for gait analysis, for example, to detect impairment due to drug/alcohol use or even fatigue (e.g., geriatric monitoring). Using these sensors with an awareness of the work being performed (such as placement of concrete masonry units) can help project teams determine cumulative and peak musculoskeletal joint loads and, thus, enable timely intervention to prevent injuries and worker "burn-out." These types of sensors can also be used to support advanced training for improved practices.

Note to Team
This is not a technology development research project. The team should focus on off-the-shelf and emerging commercial products, how they could be used, and their possible HSE benefits. Some field validation of effectiveness of one or two technologies would be expected. The research should also assess the future of this domain and its possible impact on HSE. The team should also determine the appropriate level of monitoring (e.g., personal versus managerial) and assess likely ease of acceptance. This topic could be suitable for either a one-year or two-year study, depending on the proposed scope.

References
CII RT 269, Real Time Pro-Active Safety in Construction

RTS 10

Effective Transition of Project Team Roles and Responsibilities as Resources Change During the Project Delivery Cycle

Essential Question

How can project teams effectively transition roles and responsibilities when resources change during projects?

Background

Resource-constrained owners and contractors are frequently forced to make changes to project teams to accommodate any of a number of eventualities:

- promotions
- transfers
- retirements
- departures
- gaps in project funding (challenges of holding teams together)
- specialty projects requiring specific expertise.

The transition/loss of teammates causes disruption on a project and can be detrimental to its outcome. When changes happen, how can the project team best capture the knowledge of the person leaving, transfer this information to the new team member, and successfully integrate that person into the team—all while maintaining project continuity.

Note to Team

The team should consider including a behavioral scientist as part of the research.

References

- RT 253, Estimating as a Competency in Capital Projects
- RT 281, Project Management Skills of the Future
- RT 292, Knowledge Transfer from the Near-Retirement Generation to the Next Generation

RTS 11

Breaking through to Collaborative Scheduling: Approaches and Obstacles

Essential Question
While the Critical Path Method (CPM) has become the industry standard for scheduling, other industries are using new, apparently more collaborative methods. How do the collaborative capabilities of CPM compare to these new methods; and how might the new methods be used with or as a replacement for the CPM method?

Background
While all types of construction projects use CPM scheduling, it often does not produce desired outcomes. Indeed, project teams seem challenged to use CPM collaboratively to communicate project progress for better controls. To understand whether the problem is in the CPM method or in its implementation, the industry should consider the following questions:

- Has the schedule become a deliverable for contracting and litigation rather than a tool for collaboration (among owners, designers, contractors, and trade partners), commitment, and accountability?
- Is scheduling effort focused on justifying the baseline schedule because of contract requirements, or is it put towards better solutions?
- Are schedulers now merely computer technicians or do they facilitate team planning and subsequent re-scheduling?
- Is it understood that planning and scheduling are two different skill sets?
- How significant are the differences between level of detail during CPM development and during execution?
- Do project teams perform life cycle planning and scheduling from the owner’s perspective, integrating and aligning schedules with important owner milestones.

Notes to Team
Other industries (e.g., software development and product development) and, to a degree, the construction industry have successfully used lean techniques and collaborative scheduling approaches/tools (e.g., critical chain, pull planning, scrum, and lines of balance), to position the schedule as a tool for achieving the desired project outcome. The team should investigate the limitations of CPM and explore collaborative scheduling approaches used in other industries. When a project has multiple partners engaged for shorter periods across the project delivery cycle, the team should study the application of several tools throughout all project phases. Finally, the team should provide guidance on how the industry can learn from and/or adopt these tools to improve collaborative scheduling, clarifying the roles and skillsets of project participants.

References
Book – *Scrum: The Art of Doing Twice the Work in Half the Time*, Jeff Sutherland
Lean/Lean Construction Institute: Pull planning in all industries; Last Planner system
Book – *CPM Scheduling for Construction – Best Practices and Guidelines*, PMI, 2014
CII RT 291, Improving the Accuracy of Project Outcome Predictions
CII RT 302, Interface Management
CII RT 316, Instantaneous Project Controls
CII RT 322, Improving Project Progress and Performance Assessment

RTS 12

Improved Integration of the Supply Chain in Materials Planning and Work Packaging

Essential Question

What are the new tools, practices, and documentable benefits improving supply chain visibility, advanced work packaging, and risk mitigation? Further, as part of an enhanced supply chain visibility, 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

Some examples of new tools available in the industry include improved IT communications, RFID and automated risk monitoring. One such application is to have manufacturers place RFID chips on their products with links back to all required documentation and certifications

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.)

> ***Materials 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: *materials 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:**
> 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

For an example of one such assessment tool, see the following study:
Polat, G., Arditi, D., Mungen, U. (2007). "Simulation-Based Decision Support System for Economical Supply Chain Management of Rebar." *ASCE Journal of Construction Engineering and Management*, 133 (1), 29-39.

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 13

Redesigning EPC Processes to Leverage the Latest Design and Communications Technologies

Essential Question
What would capital project work processes look like if they were redesigned for more efficient and effective transfer of engineering design to the field?

Background
Industry has recently seen significant advances in the tools used for engineering design, project planning, and project execution. Among these, the latest tools for 3D modeling, generative design, and virtual design have been widely adopted for commercial and industrial construction. Indeed, standard work practices now routinely incorporate sophisticated software packages for structural, piping, and electrical system design. However, while these tools have evolved significantly over the years, the work processes have not significantly changed since their introduction. For example, although piping is designed on a 3D model software platform, projects still use 2D drawings for designing, checking, calculating, listing, and eventually communicating with fabricators and installers. So, while the 3D tools may have made the design work process more productive than ever, the fact that the process has largely remained unchanged may mean that projects are not leveraging the full value of the tools.

Alongside these ever-evolving work process tools, communications technologies have changed rapidly in recent decades. New technologies can better connect 3D design work to the field. Younger workers are more comfortable with new technologies and use them on a daily basis; thus, they can be catalysts for using the new technologies for the transfer of 3D design information to the field. Such new practices can optimize work processes, enabling real-time and effective communication between engineering and construction. For instance, field workers could view design information in multiple formats (various views from the 3D model generated on demand).

By so combining the latest design/execution technologies with the latest forms of communication to the field, the industry could develop EPC processes that use and re-use virtually generated information all the way through a project (rather than recreating it at different stages). In this way, companies could redesign the way work happens, maximize interoperability, and achieve a breakthrough in productivity.

Notes to Team
The team should identify the technology toolset used as the basis for the research. These tools should include both design and communication tools. The research should be aligned with previously known critical success factors identified in past CII research.

Resources
RT 311, Successful Delivery of Flash Track Projects
RT 324, Future Construction Needs of Virtual Design Models
RT 327, Innovative Delivery of Information to the Crafts

2015 Research Topic Slate - CII

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.

CATEGORY 1 – PROJECT PROCESSES AND PRACTICES
RTS 1 – Methods and Metrics for Shutdown/Turnaround/Outage (STO) Execution
RTS 2 – Assessing the Maturity and Accuracy of FEED to Support Phase-gate Approvals
RTS 3 – Best Practices for Preventing Out-of-sequence Construction Activities and Minimizing their Impacts
RTS 4 – Corporate Best Practices for Successful Productivity Improvement Programs
RTS 5 – Emerging Best Practices for Integrating Global High Value Engineering Centers
RTS 6 – Capital Budgeting and Front End Planning Interface Improvement
RTS 8 – Transition Management between Construction Completion, Pre-commissioning, Commissioning, and Operations
RTS 12 – Mitigating the Risks Resulting from Late Receipt of Supplier Data
RTS 13 – The Minimum Amount of Engineering Required to Sustain Construction Flow
RTS 14 – The Impact of Modularization on Safety and Quality
CATEGORY 2 – EMERGING AND FUTURE INDUSTRY ISSUES
RTS 9 – Leveraging Augmented Reality/Serious Gaming to Improve Project Outcomes
RTS 11 – Measuring the Productivity of Model-based Engineering
CATEGORY 3 – PEOPLE ISSUES
RTS 7 – Removing the Barriers to Recruiting and Developing Non-traditional Craft Labor

RTS 1
Methods and Metrics for Shutdown/Turnaround/Outage (STO) Execution

Essential Question

What are the best methodologies for Shutdown/Turnaround/Outage (STO) execution and performance; specifically, what are the best methods for organizing and managing STO execution, and what are the best metrics for monitoring and assessing its performance?

Background

CII has conducted significant research on STO planning, having recently produced the Shutdown Turnaround Alignment Review (STAR) tool for STO readiness (IR 242-2). However, the industry still needs methodologies and metrics for STO execution. Areas in particular need of detailed methods and metrics include the following: STO resource ramp-up and management; productivity monitoring, earned value progressing, and change management during STO; and the coordination of STO activities with ongoing facility maintenance.

Note to Team

The team should broadly assess the requirements for improved STO execution, looking for all possible opportunities for the safest and the most efficient delivery of STO projects.

While this topic may be applicable primarily to the industrial sector, it is not specific to a particular region.

References

CII RT 242, Front End Planning for Renovation/Revamp Projects
CII RT 160, Making Zero Accidents a Reality: Focus on Shutdowns, Turnarounds, and Outages
CII RT 316, Instantaneous Project Control Systems (team still in progress)

RTS 2
Assessing the Maturity and Accuracy of FEED to Support Phase-gate Approvals

Essential Question

How do we best quantify and communicate the maturity and accuracy of engineering in the early FEL phases to allow for informed stage-gate approvals?

Background

Both owner and engineer/designer have to be aligned as the project design process moves forward. The owner's expectation is to be able to make reliable cost and schedule predictions to determine whether the project is a “go” or a “no-go”. What level of FEED maturity should owners expect in order to make such decisions? What is the best way to quantify and communicate the accuracy of these data, considering their criticality to overall project quality?

Since schedule compression may lead to challenges with design maturity and accuracy, this research should determine how to cope with design quality issues that develop due to schedule compression. When is enough FEED enough? Are there any methods for ensuring and communicating FEED quality?

Note to Team

RT 320, Definition and Measurement of Engineering/Design Deliverable Quality, is developing a definition and method of measurement for engineering/design deliverable quality; however, the scope of its effort excludes FEED and focuses on detailed engineering and design through IFC deliverables. This research team should review the list of key deliverables required at the end of FEED, as identified by the PDRI.

References

CII RT 320, Definition and Measurement of Engineering/Design Deliverable Quality (team still in progress)

RTS 3
Best Practices for Preventing Out-of-sequence Construction Activities and Minimizing their Impacts

Essential Question

What are the best practices for preventing out-of-sequence construction activities and minimizing their impacts?

Background

Two key reasons for activities being performed out of sequence relative to the plan are 1) a poor baseline plan or 2) changes that have happened subsequent to the plan. Most projects experience some activities performed out of sequence because of changes that include the following: engineering drawing date variation; equipment delivery variability; difference in assumed field conditions; inadequate site labor conditions; and schedule acceleration. By understanding and measuring primary and secondary impacts of performing tasks out of sequence, industry can improve decision-making for more efficient planning, execution, and change management.

Some of the impacts of out-of-sequence work are as follows: rework; extra validation work; efficiencies lost; craft productivity lost; equipment (crane costs); safety impacts; impact to reputation; increased material costs; impacts on the entire project life cycle (O&M costs); start-up and commissioning key dates breached; engineering impacts; quality impacts; performance impacts (process); financing impacts; and environmental impacts. Out-of-sequence activities can occur during engineering/design, in the field, during shop module fabrication, or in the commissioning/start-up phases. The team should consider narrowing this to only field activities.

Note to Team

The team could consider how and why decisions to perform out-of-sequence work come about, and explore ways to measure the impacts discussed above. Do we typically underestimate the costs and time impacts; do decision-makers feel a lack of control? Are poor front end planning and the amount of out-of-sequence activities correlated? The team could also investigate the cost/schedule impacts associated with multiple or constant plan changes (cumulative effects) as they relate to out-of-sequence activities.

While the team may develop a tool, a conceptual framework to evaluate the impact of out-of-sequence work might be more broadly applicable. Although this work should ideally be applicable to all industry sectors, if the team chooses to focus on a particular sector, it should communicate this change in scope with the Research Committee in advance.

References

CII RT 300, True Impacts of Late Deliverables

CII RT 323, Leading Indicators of Premature Starts (team still in progress)

Cooper, K and Reichelt, KS. "Project Changes: Sources, Impacts, Mitigation, Pricing, Litigation and Excellence" in *The Wiley Guide to Managing Projects*

Engineering & Construction Risk Institute Best Practices for Managing Secondary Impacts of Project Change (ECRI-CM-004).

RTS 4

Corporate Best Practices for Successful Productivity Improvement Programs

Essential Question

What are the industry barriers to and the enterprise-level best practices for implementing productivity improvement programs?

Background

Construction industry productivity has remained flat for an extended period of time. A clear understanding of the barriers to progress, including their drivers, is needed to unlock the potential for productivity improvement programs. What are the benefits and costs to owners and contractors of barrier removal through effective implementation of productivity programs? For example, a productivity improvement program that engages the workforce may reduce absenteeism and turnover, as well as improve productivity and schedule performance. This research should develop a productivity improvement program guidance document that includes key elements for a successful program at the enterprise level.

Note to Team

The efforts of RT 252 focused on field productivity improvement practices, while this research should investigate corporate strategies for productivity improvement. The preferred team for this topic would consist of senior-level corporate executives.

References

CII RT 252, Construction Productivity Program

RTS 5
Emerging Best Practices for Integrating Global High Value Engineering Centers

Essential Question

What are the emerging best practices and most effective new technologies for integrating the work processes of globally dispersed High Value Engineering Centers (HVECs)?

Background

RT 211, Effective Use of the Global Engineering Workforce, focused on the planning needed to form global virtual engineering teams. Project team readiness was a key concern. Nearly a decade later, RT 326, Maximizing Virtual Team Performance, is exploring the most effective use of various emerging information technologies. Virtual teams are now a reality, and interest in them has shifted from organizational issues to effective support through physical IT infrastructure and processes, particularly for teams using High Value Engineering Centers (HVECs).

In recent decades, the use of HVECs has steadily increased, in part due to a business demand for optimizing engineering performance in terms of cost, schedule, and quality, and also as a result of the advancement of remote capabilities. This research should identify and prioritize innovative strategies and best practices for organizing, aligning, communicating, measuring, collaborating, and developing the infrastructure required for successfully integrating HVECs into projects.

The complexities of varying locations, time zones, technologies, cultures, and standards should be addressed as core elements of successful implementation. Also, the research team should address the barriers to implementation and how to overcome them. While the scope of this effort is expected to include global HVECs, the team should also address the applicability of these practices across domestic regions.

Note to Team

The team is encouraged to develop implementation guidance for both novice and experienced users of HVECs.

References

CII RT 211, Effective Use of the Global Engineering Workforce
CII RT 263, Globalization

CII RT 294, Deploying Best Practices in Unfamiliar Countries
CII RT 302, Interface Management
CII RT 326, Maximizing Virtual Team Performance (team still in progress)

RTS 6
Capital Budgeting and Front End Planning Interface Improvement

Essential Question
What are the critical success factors to tying the business planning aspects of capital budgeting to the front end planning process?

Background
Oftentimes, the anticipated financial returns from a capital project turn out to be optimistic. This may arise from a poor understanding of the product's market, optimistic estimates of the cost and schedule of the project itself, or both. CII research has conclusively shown that full funding authorization should not be awarded to projects with poor scope definition or inadequate business planning, since this leads to poor project performance. What can decision-makers and project team members do to enhance capital budgeting and business performance in owner organizations? What are the barriers to successful interfacing between capital budgeting and front end planning?

Achieving optimal levels of financial returns from capital projects is CII's mission. While the institute has accomplished much to reach this aim, more remains to be done. The purpose of this project is to find further ways to achieve optimal business results.

Note to team
The team may consider developing a PDRI-like assessment of projects in the capital budgeting process. This assessment tool could focus on the business case governance and finance issues surrounding projects, and encompass the entire front end planning process, including capital budgeting. This effort would move back upstream of the past work done on front end planning and tie portfolio management techniques and capital budgeting practices into this past work. Such an integrated expansion of CII research on front end planning would significantly improving owners' ability to deliver projects profitably, and contractors' capacity to support that effort.

Resources
CII RT 213, Front End Planning Toolkit
CII RT 303, Project Portfolio Management

RTS 7
Removing the Barriers to Recruiting and Developing Non-traditional Craft Labor

Essential Question
What can the industry do to remove the barriers to recruiting and developing non-traditional craft labor?

Background
Recognition of shortages in skilled and unskilled labor points to the potential for use of non-traditional craft labor. Potential pools of non-traditional labor in the domestic market include women, at-risk students and youth, residential construction workers, returning military personnel, agricultural workers, ex-offenders, and immigrant workers.

Note to Team
The team should research and identify specific current programs for developing craft labor from non-traditional sources. This research should also generate a guidance document on the success of these programs and how they could be generally implemented. If no success stories emerge, the team should work with industry to identify potential sources of labor and key components of a development program that would likely lead to success.

References
CII RT 252, Construction Productivity Research Program (RS 252-1c)
CII RT 318, Demographic Craft Labor Cliff (team still in progress)

RTS 8
Transition Management between Construction Completion, Pre-commissioning, Commissioning, and Operations

Essential Question
How can the industry clarify and/or establish the accountabilities and responsibilities between construction completion, pre-commissioning, commissioning, and operations?

Background
The transfer of new assets from construction to commissioning, and then on to the owner, can be confusing and create significant controversy. Today, transfer practices approaches vary considerably across the industry. The practices and methods for defining mechanical completion and identifying responsibilities and accountabilities are typically not well-defined, and disputes have resulted over the readiness of assets for transfer to commissioning and owner groups. Moreover, confusion is common with respect to the roles and responsibilities for testing and verification of installation and functional performance. This confusion often generates disputes and ultimately delays turnover to the owner.

Traditional approaches to construction do not always align with the commissioning teams' need for the prescribed sequences of systems-based turnover processes. Thus, construction has offered incomplete or out-of-sequence systems at commissioning that often cause delays that have detrimental impacts on production and/or return on investment.

This research should explore approaches to defining the transition between construction and commissioning, and between commissioning and the owner. The best approach should delineate a process or methodology for defining mechanical completion and transfer. This mechanical completion and transfer methodology should precisely define deliverables that include not only the state of the physical asset, but also the documentation requirements. This approach should also address how to manage any incomplete project elements after transfer, to resolve any issues.

This research should give guidance on how to define and manage roles and responsibilities between construction groups, commissioning teams, and owners. The transition process between groups on a project should be defined, so as to clarify responsibilities and, ultimately, to ensure the smooth transfer of asset control. One outcome might be to establish a minimum industry standard for transition, to include minimum requirements for developing transition processes that address mechanical completion expectations, as well as responsibilities and accountabilities.

Note to Team

Benchmarking across the industry may be a viable option for identifying current practices and methods. The team should consider the impact of contractual agreements and early planning efforts to establish clear agreements between contractors, commissioning teams, and owners on mechanical completion and accountabilities. Some companies have procedures for aspects of this effort, but gaps and failures at interfaces and during handoffs are common. The team should consider inadequate alignment/agreement in the planning and contractual phases as a cause of such problems, and explore other possible causes.

References

CII RT 312, Best Practices for Commissioning and Start-up (team still in progress)

RTS 9
Leveraging Augmented Reality/Serious Gaming to Improve Project Outcomes

Essential Question

What are the opportunities for implementing augmented reality/serious gaming (ARSG) approaches in the construction industry?

Background

Imminent breakthroughs in augmented reality/serious gaming (ARSG) hold out the possibility of reducing project schedules, minimizing risk, improving quality, and enhancing site safety. Moreover, these high-tech innovations promise to attract the next generation of employees to the construction industry. This research should determine whether ARSG technology is ready for implementation on construction projects.

Augmented reality (AR) is an enhanced version of the physical environment that overlays digital information (e.g., sound, video, graphics, or GPS data) on real-world images; this enhanced world is made interactive through advanced AR technologies (e.g., computer vision and object recognition). Serious games use advanced gaming technology designed for non-leisure purposes, e.g., education and training. The potential of using these innovations is becoming increasingly evident in several industries. Currently, ARSG applications for the construction industry—such as virtualization, heads-up displays, smart hard hats, integration with 4D models, and training—promise significant benefits. This research will seek to validate their value to construction.

The following short videos of these technologies offer useful information and demonstrations:

- For heads-up hard-hat displayed AR, see http://www.engadget.com/2014/09/07/android-hard-hat-augmented-reality/
- For Google's latest hand-held AR tools, see this new product by Google https://www.youtube.com/watch?v=Qe10ExwzCqk
- For a description of serious gaming, see http://www.igi-global.com/chapter/case-study-augmented-reality-serious/40733
- For a Mortenson take on AR, see https://www.linkedin.com/pulse/bim-ar-wearable-technology-ricardo-khan.

Note to Team

- Include a cost-benefit analysis and assess current availability for implementation.
- This topic is expected to apply across all industry sectors.
- Decide whether to pursue augmented reality or serious gaming technologies—or both.
- Team composition should include Next Gen representatives.
- Explore adaptable off-the-shelf applications, not the development of new technologies.
- Investigate ARSG use in other industries (e.g., manufacturing, military, and health care).
- This effort should require fewer than two years, but could generate one-year extensions.
- The team should not endorse proprietary products and should field test any claims.

References

CII RT 151, Radio Frequency Tagging
CII RT 240, Leveraging Technology to Improve Construction Productivity
CII RT 269, Real Time Pro-Active Safety in Construction

RTS 11
Measuring the Productivity of Model-based Engineering

Essential Question
How do we measure engineering productivity as the industry adjusts to a model-based approach?

Background
Engineering productivity has historically been measured on deliverables such as the percentage of drawings completed, percentage of time/money spent on engineering, or type of drawing completed (e.g., orthographic, P&ID, or structural). As the industry adjusts to a data-rich model-based approach to design, the challenge is now to develop effective means to measure and monitor engineering productivity.

This research should develop a standardized framework for ongoing measurement and monitoring of engineering productivity in a model-based approach.

Note to Team

Consider paralleling the Level of Development (LOD) structure created for aligning and communicating model progression, from conceptual to owner operation of a facility.

RTS 12
Mitigating the Risks Resulting from Late Receipt of Supplier Data

Essential Question
What are the most effective approaches to ensuring accurate and timely transfer of data and documentation from the supplier to the design, construction, commissioning contractor, and owner teams?

Background
Timelier delivery of vendor data will reduce the risk of construction delay and support earlier and more complete transfer of turnover documentation. Construction starts are often delayed by late procurement and design deliverables; frequently, the root cause of both the procurement and design delay can be traced to the late and inaccurate delivery of vendor data. Examples include late pipe spools caused by late delivery of inline instrument data, or late control room design caused by late delivery of equipment or cabinet sizing. Furthermore, complete and early receipt of vendor data will support timely transmittal of important turnover/start-up documentation.

Note to Team

This team should study the procurement time cycle, identifying the risks associated with late and inaccurate vendor data, and formulating effective mitigations strategies and tools. Consider supplier, engineering, construction, commissioning, and owner needs and involvement. Also consider use of technology to facilitate improvement of data management.

The objective is to identify user requirements, automation opportunities, and to 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 will identify opportunities to standardize and streamline the requirements and delivery processes for supplier information.

Supplier information is a primary input to 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.

References
RT 272, Advanced Work Packaging
RT 310, Improving Engineering and Procurement Alignment and Coordination with Construction (team still in progress)

RTS 13
The Minimum Amount of Engineering Required to Sustain Construction Flow

Essential Question
What is the minimum amount of engineering that should be completed prior to start to sustain construction activities on projects with overlapping engineering and construction phases?

Background
Many projects in the industrial and commercial sectors now have overlapping engineering and construction phases. As the industry requires ever faster schedules, this overlap becomes more the norm than the exception. On projects such as these, project teams are tempted to rush to the field as soon as possible; but, starting construction early is not always the best way to achieve accelerated schedules or efficient projects. Often, engineering cannot proceed fast enough to keep the construction work moving efficiently.

The industry needs a better understanding of the minimal amount of engineering that should be completed prior to start of construction. The question should be investigated on a discipline-by-discipline basis. The research team should examine projects varying in size, type, and industry sector, and focus on the engineering completeness required for effective construction starts.

Note to Team
For its deliverables, the research team should consider the development of a tool or a set of best practices for determining this minimal amount of engineering.

Resources
CII RT 323, Finding Leading Indicators to Prevent Premature Starts and Assuring Uninterrupted Construction (team still in progress)

RTS 14
The Impact of Modularization on Safety and Quality

Essential Question
How and to what extent do today's modularization processes and technologies improve safety and quality, compared to conventional approaches for equivalent project scopes of work?

Background
The decision to modularize all or part of a project largely depends on project-specific factors and on the advantages and disadvantages inherent to the approach. Project-specific factors include the following: schedule pressure; lack of local skilled labor resources; and the availability of modularization and prefabrication facilities with feasible transportation links. Some of the most significant inherent advantages of prefabrication are lower shop labor costs and higher shop productivity. Chief among its perceived disadvantages are the site fit-up risks generated by imprecise fabrication.

In 2002, CII RT 171, Prefabrication, Pre-assembly, Modularization, and Offsite Fabrication, developed a widely used decision support tool that addresses these considerations in industrial construction. However, key questions around modularization processes remain unanswered, and technology has advanced substantially since RT 171 conducted its research. Although the industry has long assumed that modularization is linked with improved safety, no direct evidence supports this assumption. Likewise, modularization is widely believed to improve quality, yet, fabrication and design errors, project interface issues, and transportation risks make it difficult to realize its potential.

With today's advanced procurement approaches, 3D CAD design packages, precision fabrication shop fitting jig systems, 3D laser scanning, and integrated project information systems, it is possible that quality can be more readily assured than it be could ten years ago. Also, since modules with more integrated systems can now be reliably fit-up and connected on site, their installation should be substantially more productive than in the recent past. Because these and other advances in modular processes and technologies now hold so much potential to improve project quality and safety, the industry now needs a systematic investigation of the actual impact of modularization on these outcomes.

Note to Team

The research team should be able to gather data to clarify the current impacts of modularization on safety and quality. The effects of modularization on these two project outcomes may also be interdependent, and the team may wish to explore the extent and nature of this interdependence.

References

CII RT 171, Prefabrication, Pre-assembly, Modularization, and Offsite Fabrication
CII RT 255, Adaptation of Shipbuilding Systems to Construction
CII RT 283, Modularization

2015 National Cooperative Highway Research Program (NCHRP)

1. Applying Risk Analysis, Value Engineering, and other Innovative Solutions for Project Delivery

BACKGROUND

Managing stakeholders and permitting agencies while addressing complex constructability and technical issues requires innovation and a culture that is open to change in order to deliver transportation projects "on time and within budget." Project planners and decision makers need to understand the range of possible outcomes in a project and/or program to make intelligent decisions, and they also need effective tools and techniques to help guide those decisions.

Within the transportation sector in general and the highway sector in particular, innovative strategies aimed at improving the reliability of project planning, development, and delivery include alternative delivery methods, risk-based cost and schedule estimating, value engineering, constructability reviews, and alternative technical concepts. Most of these strategies involve teams thinking differently, generating alternative solutions, estimating costs and benefits, and championing new ideas. All of these strategies involve risk transfer and assignment, but risk has not always been allocated in a logical or deliberative fashion.

One significant approach to addressing these concerns is application of Value Engineering (VE), a systematic process that combines creative and analytical techniques to achieve a common understanding of project requirements, thus stimulating innovation and maximizing the use of resources to meet critical needs. At the project level, the goal of VE analysis is to achieve balance between project needs (e.g., quality, safety, operations, environment, etc.), and resources (cost, schedule, materials, etc.). VE follows a structured process that can be integrated effectively with other techniques to stimulate innovation and identify strategies for managing and allocating risk.

Budget constraints, increasing project complexity and stakeholder involvement are driving an ongoing need to increase innovation in project development and delivery. A number of processes and tools contribute to stimulating innovation and thinking differently. As the demand for innovation and value for money increases, there is increasing need to identify and use the appropriate tools and processes effectively.

OBJECTIVE

The objective of this research is to develop a guide that identifies available and proposes additional tools and techniques to foster useable and improved practices for key stakeholders to combine risk analysis, constructability reviews, value engineering, and other processes for improving project outcomes.

RESEARCH PLAN

The NCHRP is seeking the insights of proposers on how best to achieve the research objective. Proposers are expected to describe research plans that can realistically be accomplished within the constraints of available funds and contract time. Proposals must represent the proposers' current thinking described in sufficient detail to demonstrate their understanding of the issues and the soundness of their approach in meeting the research objective.

The proposed work plan should be divided into two phases with discrete tasks for each phase. Phase I will culminate in an interim report that will present the results of the initial components of the research, a detailed, annotated outline of the guide, and an updated work plan for Phase II. A face-to-face interim meeting with the NCHRP panel will be scheduled at the conclusion of Phase I to discuss and approve the interim report. Work on Phase II tasks will not begin until the updated work plan is approved by NCHRP. The project schedule will include 1 month for NCHRP review and approval of the interim report.

The research plan should include but not be limited to the following:

1. a kick-off teleconference meeting of the research team and the NCHRP project panel, to be held within 1 month of the contract's execution date;
2. a literature review that identifies and summarizes key products of previous research;
3. the aforementioned interim report which presents the output of Phase I, including a preliminary detailed, annotated outline of the guide;
4. a final version of the guide and associated templates and related tools and techniques that fulfills the project objective;
5. a final report documenting the research; and
6. a PowerPoint or similar presentation describing the project background, objective, research method, findings, and conclusions.

To accomplish the project objective, the research plan should identify and develop tools and techniques that can be used to stimulate innovative methods to allocate risk effectively while achieving maximum value for money invested. Further, the research plan should incorporate these tools and techniques into a guide for use by any transportation agency, enhancing opportunities for generating and applying innovative and effective project delivery strategies. This guide should provide decision makers, program and project managers, and value engineering practitioners with a consistent approach to integrate value engineering with risk analysis throughout the project planning, development, and delivery process.

In preparing these deliverables, the research plan should address a broad range of issues and procedures, such as the following:

1. How to measure value, i.e., how to integrate quantifiable risk, function analysis, and performance-based decision making;
2. How to integrate the unique perspective of each member of the core team: owner, designer, and contractor;
3. How to use performance-based techniques that foster innovation; and
4. How to use value engineering and risk analysis to foster innovation.

Final deliverables will be submitted in two stages: (1) draft final deliverables for review and comment by the panel, and (2) revised final deliverables following that review and incorporating proposed changes as appropriate. Deliverables will include the guide plus a final report that documents the entire research effort and other deliverables as described in the research plan. Deliverables should also include an executive summary in addition to a PowerPoint or similar presentation that can be used to present key issues and conclusions to critical stakeholders. Proposers may recommend additional deliverables to support the project objective.

2. Development of a Highway Construction Noise Prediction Model

BACKGROUND

In reaction to growing public concern and complaints about construction noise, FHWA developed the *Roadway Construction Noise Model* (RCNM). The RCNM is based on the construction noise model developed and utilized at the Central Artery/Tunnel Project in Boston. It has since been available for use with FHWA, state, and municipal projects. The data used for the RCNM has since been used as a reference source for construction equipment noise emissions and predictions. The model itself has been used for planning and environmental assessment, construction noise mitigation plans, regulations development, and specification enforcement. However, RCNM has limitations. It uses simplified assumptions (e.g., equipment usage factors) that limit its flexibility and accuracy. In addition, the construction equipment noise database in RCNM provides only broadband Lmax A-weighted levels, the calculation of time-dependent noise metrics is done by estimation, and there is no accounting for excess attenuation provided by ground effects and air absorption losses.

To ensure compliance with state, local, and project-specific noise restrictions, an improved model is needed for predicting construction noise and the effects of noise reduction efforts. The developed model will optimize noise control strategies, assist with project delivery, and help users assess public complaints.

OBJECTIVE

The objective of this research is to develop and validate a noise model to calculate the acoustic environment associated with highway construction equipment and activities, to accumulate a database of noise sources, and to document the appropriate applications of the model.

The research may include, but not be limited to:

- Multiple metrics
- Interoperability with other models
- Established measurement standards
- Propagation effects
- Noise contouring
- Stochastic modeling
- Duration of construction noise
- Spectra
- Source height
- Directivity
- User-defined noise emission data
- Comparisons to limit criteria
- Operational characteristics of the equipment
- Shielding
- Temporary sites not on project corridor

RESEARCH PLAN

The NCHRP is seeking the insights of proposers on how best to achieve the project objective. Proposers must develop a detailed research plan to accomplish the project objective. Proposers are expected to describe research plans that can realistically be accomplished within the constraints of available funds and contract time. Proposals must present the proposers' current thinking in sufficient detail to demonstrate their understanding of the issues and the soundness of their approach to meet the project objective.

The work proposed must be divided into tasks and proposers must describe in detail the work proposed in each task. The tasks must be divided into two phases. Phase I will consist of information gathering and planning tasks, culminating in the task to prepare and submit the interim report (IR). The IR will describe in detail, the work completed in the Phase I tasks. In addition, the IR will include an updated Phase II work plan, which will describe the manner in which the proposer intends to use the information obtained in Phase I to satisfy the project objective. Also, the IR will provide an annotated outline of the final report to be published. The IR be presented and discussed at a face-to-face interim meeting with NCHRP. The project schedule should include 1 month for NCHRP review and approval of the Interim Report.

Work on the Phase II tasks shall not commence until the updated Phase II work plan is approved by NCHRP. Following receipt of the preliminary draft final report, the remaining 3 months shall be for NCHRP review and comment and for research agency preparation of the revised final report. A kick-off teleconference between the research team and NCHRP shall be scheduled within 1 month of the contract's execution to discuss the amplified work plan. A detailed description of any survey or field investigation shall be submitted to NCHRP for prior review and approval.

Final deliverables from this research must include:

- A final report that documents how the research was conducted.
- CD-ROM that contains the model (including all algorithms, source code, and software distribution package), the database that can be viewed and edited, users' guide including technical documentation of the model and database, and all other products described in the research plan to meet the project objectives.

2014 Research Topic Slate - CII

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.

CATEGORY 1 – PROJECT PROCESSES AND PRACTICES
RTS # 1 - Definition and Measurement of Engineering/Design Deliverable Quality
RTS #4 - Rethinking Supplier Data
RTS #5 - Improving Productivity Measurement through a Translatable Standard Code of Accounts
RTS # 6 - Advancing Modularization/Pre-Fabrication in the General Building Industry
RTS # 8 - Using Precursor Analysis to Prevent Low-frequency High-impact Events, Including Fatalities

RTS #10 - Improving Project Progress and Performance Assessment
RTS #12 - A Closer Look at Material Planning; a New Look at Jobsite Delivery Timing Strategies
RTS #13 - Safety in our Supply Chains
RTS #14 - Finding Leading Indicators to Prevent Premature Starts, and Assuring Uninterrupted Construction
CATEGORY 2 – EMERGING AND FUTURE INDUSTRY ISSUES
RTS # 7 - Construction Transformation through Robotics
RTS #11 - Future Construction Needs of Virtual Design Models
CATEGORY 3 – PEOPLE ISSUES
RTS #2 - Best Practices for Succession Planning
RTS # 3 - Can We Utilize Next--Gen Experience to Maximize Virtual Team Performance?
RTS #15 - Soft Skills for Successful Project Leaders on Global Projects

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.

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[i] (IAARC), and learn from the International Symposium on Automation and Robotics in Construction and Mining[ii] (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-fatalities? 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 injuries 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

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

[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.]

> ***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.

*For an example of one such assessment tool, see the following study:
Polat, G., Arditi, D., Mungen, U. (2007). "Simulation-Based Decision Support System for Economical Supply Chain Management of Rebar." *ASCE Journal of Construction Engineering and Management*, 133 (1), 29-39.

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 - CII

CATEGORY 1 – PROJECT PROCESSES AND PRACTICES (BEST OR OTHERWISE)
RTS #1 - Best Practices for Commissioning and Start-up
RTS #2 - Successful Delivery of Fast-track Projects
RTS #3 - Improving Engineering and Procurement Alignment and Coordination with
RTS #5 - PDRI Tool for Small Projects
1-RTS #11 - A Closer Look at Material Planning; a New Look at Jobsite Inventory
CATEGORY 2 – EMERGING AND FUTURE INDUSTRY ISSUES
3-RTS #4 - Creating Standards for Industry-wide Quality Metrics
RTS #6 - Safety Performance through *Operational Discipline*
RTS #7 - Successful Delivery of Mega-projects
RTS #8 - Instantaneous Project Control Systems
RTS #10 - Accelerating the Development, Deployment, and Value of New Construction
2-RTS #13 - A Paradigm Shift in Project Management
4-RTS #14 - Adapting Your Organization to Benefit from New Technology and
CATEGORY 3 – PEOPLE ISSUES (PROFESSIONAL AND CRAFT)
RTS #9 - Is There a *Demographic Craft Labor Cliff* That Will Affect Project
RTS #12 - Craft Input as a Source of Innovation and Improvement

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.

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.

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?

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.

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 emerging. 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 <u>project material and equipment inventories</u> (and associated inventory costs) be optimized? Specifically, can an <u>analytical process</u> 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.

For an example of one such assessment tool, see the following study:
Polat, G., Arditi, D., Mungen, U. (2007). "Simulation-Based Decision Support System for Economical Supply Chain Management of Rebar." *ASCE Journal of Construction Engineering and Management*, 133 (1), 29-39.

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 - CII

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.

RTS #3
Interface Management

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?

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.

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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:
Polat, G., Arditi, D., Mungen, U. (2007). "Simulation-Based Decision Support System for Economical Supply Chain Management of Rebar." *ASCE Journal of Construction Engineering and Management*, 133 (1), 29-39.

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:

Porter, Michael E. and Kramer, Mark R. "Creating Shared Value: How to Reinvent Capitalism and Unleash a Wave of Innovation and Growth," *Harvard Business Review*, Jan-Feb 2011, 62-77.

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.

2010 CII RFP - CII

1: Managing Indirect Costs

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 SP43-1and 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 - CII

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 1MM$ 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.