PerspECCtive

Reinventing construction: Practical steps to improve productivity and predictability
Agenda

- Welcome and introductions: 5 mins
- Reinventing construction: Practical steps to improve productivity and predictability: 10 mins
- Facilitated panel discussion: 35 mins
- Audience Q&A: 10 mins
Our moderator and panelists

Matthew Parsons
(Moderator)
Partner, Capital Projects & Infrastructure
McKinsey & Company

Glenn Ballard
Director, UC Berkeley Project Production System Laboratory

Todd Zabelle
President, Strategic Project Solutions

Wayne Crabtree
Advisor, Chevron Capital Project Management System

David Parker
CRO, Cloudleaf
In the United States alone, construction labor productivity has declined since 1968 in contrast to rising productivity in other sectors.

<table>
<thead>
<tr>
<th>Year</th>
<th>Overall economy</th>
<th>Construction</th>
<th>Manufacturing</th>
</tr>
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<tbody>
<tr>
<td>1947</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>1950</td>
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<td>1960</td>
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<td>2010</td>
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**Compound annual growth rate, 1947-2010**

- Overall economy: 3.5%
- Construction: -69%
- Manufacturing: -88%

*Source: World KLEMS, BLS, BEA, McKinsey Global Institute analysis*
Specific action is needed within each of the seven areas identified

<table>
<thead>
<tr>
<th>Areas needing action</th>
<th>Areas needing action</th>
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<tbody>
<tr>
<td>Regulation</td>
<td>Onsite execution</td>
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<tr>
<td>Contractual framework</td>
<td>Technology</td>
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<tr>
<td>Design, engineering processes</td>
<td>Workforce</td>
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<tr>
<td>Procurement and SCM</td>
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- Regulation, processes, approvals
- Technology
- Large-scale construction
- Tendering process
- Culture
- Contract structure
-Prefab, standardization, and modularization
- Design requirements
- Constructability
- Lessons learned
- Digital and AA
- Live real-time predictive practices
- Planning and scheduling
- KPIs, performance dialogues
- Mobilization / demobilization
- Waste and variability management
- Coordination, accuracy, transparency
- Advanced materials
- Automated construction processes
- Apprenticeship model
- Front-line worker training
- Culture of knowledge management

Boost productivity by 50%
Achieve up to 40% cost savings

SOURCE: McKinsey Global Institute analysis
Last Planner System: defining the fundamentals of planning for execution to improve workface performance

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<tr>
<th>Should</th>
<th>Master Scheduling</th>
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<tr>
<td></td>
<td>Set milestones, phase durations, and overlaps</td>
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<table>
<thead>
<tr>
<th>Can</th>
<th>Phase Scheduling</th>
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<tr>
<td></td>
<td>Specify handoffs and conditions of satisfaction between processes within phases</td>
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<th>Will</th>
<th>Lookahead Planning</th>
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<tr>
<td></td>
<td>Identify and remove constraints</td>
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<td>Breakdown tasks from processes into operations</td>
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<td>Design operations</td>
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<tr>
<th>Do</th>
<th>Commitment Planning</th>
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<td></td>
<td>Make reliable promises</td>
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<th>Learning</th>
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<td></td>
<td>Measure PPC(^1), TMR(^2) &amp; TA(^3)</td>
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<td>Use “5 Whys” to identify countermeasures</td>
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<td>Act to prevent reoccurrence</td>
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1 PPC: percent plan complete
2 TMR: Tasks made ready
3 TA: Tasks anticipated
Three Eras of Project Delivery

1910's
Era 1
Productivity

Workers won’t work but will soldier
Separate planning and doing
Bar Chart, Time and motion studies, ..

1960's
Era 2
Predictability

Focus on functional activity
Measure progress to baseline
Operations management excluded

2000's
Era 3
Profitability

Project as Production System
Apply Operations Management/Research
Eliminate variability, reduce inventory

CURRENT APPROACH

Evolution of project delivery to a discipline focused around a production system
Project Production Management: apply operations sciences to the construction context

Project Management

Cost, Time & Cash = Scope & Quality + Process Design + Resource use

Production Management

Cost, Time & Cash = Scope & Quality + Process Design + Capacity + Inventory + Variability
Gorgon Trains: demonstrating real world impact through effective project production management

Train 1 performance (no production control)
- Work not calibrated to demand
- $4B+ logistics costs
- Un-sequenced material delivery
- Work started but not completed
- Non-progressable work
- Tie up of capital
- Higher indirect/direct labor ratio
- More HES incidents
- Construction not sequenced with Systems Completion

$280M in surplus material (2017)

Train 2 and 3 performance (with production control)
- Greater visibility, clear ownership and accountability, and synchronized execution generated $270-$540M in savings

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<tr>
<th>Time, months</th>
<th>Completion, %</th>
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Train 1: 20 months
Trains 2, 3: 6-7 months

0 10 20 30 40 50 60 70 80 90 100

Trains 2 and 3 performance (with production control)
And achieving success beyond the typical learning curve

Production Control enabled Gorgon to achieve a **29% time reduction from Train 1 to Train 2**, more than 2x the improvement seen in the historically best-performing Project 3.
Sensor networks: supply chain visibility and variance optimization in complex capital projects

| Cloud                  | New innovative low-energy sensor networks  
<table>
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<tr>
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<th>Real time visibility into operations</th>
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<tbody>
<tr>
<td>Gateways</td>
<td>Analyzing inventory and work flow processes</td>
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<td></td>
<td>Improving precision and optimization strategies to assess variance</td>
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<tr>
<td>Sensors</td>
<td>Ubiquitous communications to support enterprise scale</td>
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Questions?
BACKUP
Why construction matters: Construction related spending accounts for 13% of the global GDP

Global GDP, 2014

$T

$74 trillion

64.5 (87%)

9.5 (13%)

Construction industry spending

$T

2014A 15A 16F 17F 18F 19F 20F 21F 22F 23F 24F 2025F

9.5 10.0 10.5 10.9 11.4 11.4 11.9 12.4 12.9 13.4 13.9 14.0

3.6% p.a.

SOURCE: World Bank; IHS; ISSA
Topics for discussion

- How have principles of lean manufacturing and production control been applied in the construction industry since 1990? What have been the results?
- What are the key differences between conventional project management and project production control? What are impediments to innovation?
- What can be learned of the benefit of project production control from the Gorgon project?
- What role can technology play in managing variability and inventory?
## Matt Parsons
**Partner, McKinsey & Company**

### Broader Practice Leadership
- Leader and convener of the Americas Capital Projects and Infrastructure Practices
- Formerly led and convened McKinsey’s Nuclear Power Service Line

### Capital Productivity Experience
- Has support project recoveries with multiple owners, operators, and EPC firms on distressed large projects ranging in investment level from $300M to $20B
- Led a comprehensive capital projects and engineering transformation for a leading global chemicals manufacturer, who spends $2B a year in capital across a range of projects and business units
- Supporting the development and implementation of a corrective action plan related to the major cost and schedule overrun of a reactor plant new build — the TVA WBN2 project
- Developed a contracting strategy for a European JV seeking to develop a technologically-complex, major offshore natural gas deposit
- Supported the precommissioning, commissioning and ramp-up planning for a $10B iron ore mine in South America
- Coordinated the systematic de-risking of two multi-billion dollar materials mines in remote geographies confronted with substantial cost and schedule overruns or development challenges
- Conducted due diligence on several EPC firms and guiding the award process and follow-on terms and conditions negotiation for the EPC contract for a $6B project
- Led confirmatory due diligence for a major Energy and Oil & Gas acquisition in the EPC space
- Helped devise a go to market, development, and execution strategy for an engineering services firm in the nuclear power space
- Led a regulatory risk improvement effort related to utility sector investment in carbon capture and sequestration technologies for fossil generation plants, including technological, commodity, and infrastructure risk assessment

### Prior Experience
- Spent ten years in the Nuclear Navy, where he held various responsibilities related to the construction, operations, and maintenance of nuclear powered submarines, including three years forward deployed in Guam as the plant manager of a 165MW reactor plant on USS San Francisco
- Spent two years in the Pentagon on the Chief of Naval Operations Staff in the Planning, Programming, and Budgeting office where he coordinated $13B of annual capital investment in naval shipbuilding
Glenn Ballard
Director, Project Production Systems Laboratory at University of California, Berkeley

- Glenn is currently Director of the Project Production Systems Laboratory at UC Berkeley while also serving as an Adjunct Professor at the Norwegian National Technological University
- His research interests include:
  - Design of project production systems: adapting lean production theory from manufacturing to construction management
  - Contracting strategies, relational contracting, negative and positive incentives
  - Design management: target costing and set based design
  - Production control systems analysis, from design through construction, and from execution strategies to production unit work planning, with emphasis on material and information flows
  - Construction work methods design and improvement, including the application of traditional industrial engineering techniques and mimeomotion, employee participation in the development of work methods, the use of techniques such as decoupling through buffers, and the practice of First Run Studies
- In 1933, Glenn co-founded with Lauri Koskela of VTT, Finland, the International Group of Lean Construction (IGLC), which is an association of like-minded thinkers from industry and academia, dedicated to the development and application of production management concepts and techniques in the construction industry
  - IGLC holds annual conferences to share research ideas and findings, with conferences having taken place in Australia, Brazil, Chile, Denmark, Finland, Israel, Norway, Peru, Singapore, Taiwan, the United Kingdom, and the United States
- In 1997, Glenn was one of the four equity partners in the Lean Construction along with Todd Zabelle, Gregory Howell P.E. and Iris Tommelein PhD (LCI was made a not for profit in 2000)

- PhD Civil Engineering, University of Birmingham, U.K.
- MBA, Holy Names College
- Founding member of the International Group of Lean Construction (IGLC)
- Co-Founder and Member of the Lean Construction Institute
Todd R. Zabelle
Founder & CEO, Strategic Project Solutions Inc.

- Prior to establishing SPS, Todd founded Pacific Contracting. Established in 1993, Pacific Contracting was recognized in the mid 90’s for its use of various innovations including Lean Construction and Virtual Design & Construction. In July 1998, these efforts were acknowledged in the UK Government’s Re-Thinking Construction report aka the Egan report.
- In 1997, Todd was one of the four equity partners in the Lean Construction along with H. Glenn Ballard, Gregory Howell P.E. and Iris Tommelein PhD (LCI was made a not for profit in 2000).
- With widespread interest in the processes and technologies referenced in the Rethinking Construction Report, coupled with making LCI a not for profit, Todd launched Strategic Project Solutions, Inc. Since that time, SPS has enabled global leading owners and operators to effectively delivery complex and critical energy, industrial and civil infrastructure projects through the implementation of its Project Production Control (PPC) solutions.
- SPS has been instrumental in numerous successful projects including Heathrow Terminal 5, Channel Tunnel Rail Link 105 and Gorgon Trains 2 & 3 to name a few. SPS continues to be the recognized global leader in PPC solutions.
- To further propagate the understanding and application of the Project as Production System (PPS) framework along with the associated Project Production Management (PPM) body of knowledge, Todd created the Project Production Institute in 2013. Today, PPI works to gain understanding around the current “gap” in current project delivery practices through creating clarity and building capability around the effective application of PPM.

- Todd has 30+ years experience in delivering complex and critical capital projects
- In addition to being the Founder & CEO of SPS, Todd founded Pacific Contracting, an equity partner in the Lean Construction Institute (LCI) as well as the Project Production Institute (PPI)
- Over the past 20+ years, Todd has authored numerous papers on optimizing engineering, fabrication and construction
Wayne Crabtree
Continuous Improvement Advisor, Chevron Capital Project Management System

- Prior to his current position at Chevron, Wayne owned and operated businesses specializing in civil / structural construction and environmental remediation. During this time he was engaged in the successive waves of Total Quality Management, Value Engineering, Continuous Improvement, ISO 9001, Team Empowerment, and Lean Sigma. These methodologies were successfully applied to his own businesses and helped shape Wayne’s own understanding of broader applications within other corporate settings.

- Wayne is currently focused on the integration of the theory and principles of Project Production Management into the Chevron Project Delivery Model. This effort supports Chevron’s increased interest to be more in control of the design and execution of work on their Major Capital Projects.

- Wayne’s responsibilities include CPMS Knowledge Management, CPMS Continuous Learning System, and the development and application of continuous improvement methodologies on Major Capital Projects.

- Wayne has 30+ years of experience in project management and organizational development within the industrial and manufacturing business sector.

- Wayne is a Chevron Certified Lean Sigma Black Belt and has an MBA with an emphasis in Six Sigma.
David Parker
CRO, Cloudleaf

- David is the Chief Revenue Officer at Cloudleaf responsible for all aspects of sales pipeline creation, revenue generation and sales strategy. He is an experienced IT professional with an extensive background in business development, operational excellence and sales management, covering both business and technical areas.

- David has held various senior executive positions throughout his career across major industries that include Industrial Manufacturing, Oil & Gas, Distribution, Financial Services, CPG, Retail, Telecommunications and Academic institutions.

- Prior to joining Cloudleaf in 2017, David was the North American executive for the Internet of Things practice working within the IBM Watson Global Business Services business unit where he led the demand generation for services engagement and building strategic roadmaps with customers and partners.

- In early 2000, David joined the senior executive management team of Aleri, as a founder, to drive forward its Complex Event Processing product into fresh new markets domestically and later moved to New York to help grow the company over a ten period, until such time that Aleri was acquired by Sybase, and subsequently SAP in 2010, where he held the role of Senior Global Vice President of Big Data and Internet of Things (IOT).

- During 1990-2000 David held leadership positions at several banking institutions in the Financial Services industry before transitioning into management consultancy.

- David was educated in the United Kingdom and holds an MBA in Business Studies from Wolverhampton University.