Metrics That Matter: Improving Project Progress and Performance Assessment

RT-322
Acknowledgements

Construction Industry Institute®
Research Team 322
RT-322

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Matthew R. Ware, Day & Zimmermann
Construction projects are suffering from significant performance inefficiencies

Only ONE in twenty projects is under budget and on time

Source: Construction Industry Institute, 2012
Performance issues cause major cost and schedule deviations, particularly in bigger projects

98% of megaprojects incur cost overruns and schedule delays.

The average cost increase is 80% of the original budget.

The average slippage is 20 months behind original schedule.

Adverse effects of low project performance is crippling the industry

$100 million of every $1 billion invested in projects is wasted.

Only TWO out of five projects are profitable for contractors.

Sources: Project Management Institute, 2017; Construction Industry Institute, 2014
Majority of project managers believe most of their projects are performing well and meeting targets.

PM/Executive perception

- Successfully met the original goals of the project: 69%
- Finished within their initial budgets: 57%
- Finished within their initially scheduled time: 51%

Source: A.T. Kearney, 2012; Project Management Institute, 2017
Main objective is to improve project control systems for assessment of current and future performance

Objective #1
Develop a systematic project controls framework

Objective #2
Identify the core project control metrics

Objective #3
Generate guidelines for improving the reliability
The research approach is aligned with the objectives to deliver desired outcomes

Objective #1
Develop a systematic project controls framework

Objective #2
Identify the core project control metrics

Objective #3
Generate guidelines for improving the reliability

Metric Framework and Typology

Metric Classification

Reliability Improvement

Project Controls Improvement Tool
Various research methods are utilized to produce deliverables and achieve objectives.
Various research methods are utilized to produce deliverables and achieve objectives

<table>
<thead>
<tr>
<th>Literature Review</th>
<th>Expert Panel</th>
<th>Online Survey</th>
<th>Exploratory Analysis</th>
<th>Delphi Method</th>
<th>Statistical Analyses</th>
<th>Case Studies</th>
</tr>
</thead>
<tbody>
<tr>
<td>![Book Icon]</td>
<td>![People Icon]</td>
<td>![List Icon]</td>
<td>![Graph Icon]</td>
<td>![People Heating up Icon]</td>
<td>![Graph Icon]</td>
<td>![Chat Icon]</td>
</tr>
</tbody>
</table>

>100 documents

Scholarly articles

Professional publications (e.g., CII, PMI, AACE)

Government agency reports (e.g., DoD, DoE, DoT)
Various research methods are utilized to produce deliverables and achieve objectives

- Literature Review
- Expert Panel
- Online Survey
- Exploratory Analysis
- Delphi Method
- Statistical Analyses
- Case Studies

Research Team

13 industry professionals
290+ years of cumulative experience
Representing owner (5) and contractor (8) perspectives
Various research methods are utilized to produce deliverables and achieve objectives

- Literature Review
- Expert Panel
- Online Survey
- Exploratory Analysis
- Delphi Method
- Statistical Analyses
- Case Studies

**Part I**
- Background Information

**Part II**
- Metrics used in the project

**Part III**
- Reliability information

44 completed responses
- Owner vs. contractor balanced
- Predominantly heavy industrial
- Average size: ~$120 million
- Average duration: ~2 years
Various research methods are utilized to produce deliverables and achieve objectives

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<td>![List Icon]</td>
<td>![Chart Icon]</td>
<td>![Hot Tub Icon]</td>
<td>![Graph Icon]</td>
<td>![Chat Icon]</td>
</tr>
</tbody>
</table>

**Metric Importance**

- Low – High
- High – High
- Low – Low
- High – Low

**Metric Usage**
Various research methods are utilized to produce deliverables and achieve objectives

- Literature Review
- Expert Panel
- Online Survey
- Exploratory Analysis
- Delphi Method
- Statistical Analyses
- Case Studies

Project controls
Subject Matter Experts (SMEs)

16 industry professionals
360+ years of cumulative experience
Representing owner (2) and contractor (14) organizations
Various research methods are utilized to produce deliverables and achieve objectives.
Various research methods are utilized to produce deliverables and achieve objectives

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<td>![Chat Icon]</td>
</tr>
</tbody>
</table>

In-depth analysis of selected projects

- 10 projects selected
- Contractor (6) and owner (4) perspectives
- Interviewed 17 project personnel
Various research methods are utilized to produce deliverables and achieve objectives.
A systematic framework and typology that allow transforming data into meaningful insights

Strategic Level Decisions
- Diagnostic Metrics
  - Help identify progress and performance issues to inform corrective actions.
- Predictive Metrics
  - Help forecast project cost and duration outcomes based on current project progress and performance.

Tactical Level Decisions
- Where Will We Be?
- Where Should We Be?
- Where Are We?

Operational Level Decisions
- Why Are We Here?

Data Collection
- Data
- Information
- Knowledge
- Insight
- Performance Measurement
- Performance Forecasting
Metric classification was finalized by subject matter experts (SMEs)

Core metrics: metrics that provide the greatest insight for indicating the likely project outcomes
Diagnostic Metrics help the user to identify progress and performance issues to inform corrective actions.

Forecasting Metrics help the user to predict project cost and duration outcome based on understanding of the current project progress and performance.

Diagnostic Metrics help the user to identify progress and performance issues to inform corrective actions.
# 20 Core Metrics

## Performance Forecasting
- Variance at Completion
- Estimate at Completion (CPI)
- Estimate to Complete (CPI)
- To Complete Performance Index (EAC-CPI)
- Budget at Completion

## Performance Assessment
- Cost Performance Index
- Schedule Performance Index

## Progress Measurement / Data Collection
- Physical Percent Complete
- Earned Value
- Planned Value
- Actual Cost

## Schedule Diagnostics
- Baseline Execution Index for Critical Path
- Number of Critical (or Near Critical) Paths
- Schedule Variance

## Cost Diagnostics
- Unit Rate
- Cost Variance
- Procurement Cost Variance

## Physical Progress Diagnostics
- Efficiency or Productivity Index
- Ratio of Actual to Planned Progress
- Percent Key Deliverables Completed on Time
# 7 Significant Validation Metrics

## Forecasting

<table>
<thead>
<tr>
<th>Category</th>
<th>Metric</th>
</tr>
</thead>
<tbody>
<tr>
<td>Performance Forecasting</td>
<td>Estimate at Complete (SPI)</td>
</tr>
<tr>
<td>Performance Assessment</td>
<td>Estimate to Complete (SPI)</td>
</tr>
<tr>
<td>Performance Assessment</td>
<td>Monthly Cost Growth</td>
</tr>
</tbody>
</table>

## Diagnostic

### Schedule Diagnostics

<table>
<thead>
<tr>
<th>Category</th>
<th>Metric</th>
</tr>
</thead>
<tbody>
<tr>
<td>Percent Activities Started on Time</td>
<td></td>
</tr>
<tr>
<td>Percent Activities Finished on Time</td>
<td></td>
</tr>
<tr>
<td>Critical Path Length Index</td>
<td></td>
</tr>
</tbody>
</table>

### Cost Diagnostics

<table>
<thead>
<tr>
<th>Metric</th>
</tr>
</thead>
<tbody>
<tr>
<td>Percent Work Packages on Budget</td>
</tr>
</tbody>
</table>
# 7 Significant Innovative Metrics

## Forecasting

<table>
<thead>
<tr>
<th>Category</th>
<th>Metric</th>
</tr>
</thead>
<tbody>
<tr>
<td>Performance Forecasting</td>
<td>Estimate at Completion - Time</td>
</tr>
<tr>
<td></td>
<td>Estimate to Completion - Time</td>
</tr>
<tr>
<td>Performance Assessment</td>
<td>Schedule Performance Index – Time [SPI(t)]</td>
</tr>
<tr>
<td></td>
<td>Earned Schedule</td>
</tr>
<tr>
<td>Progress Measurement / Data Collection</td>
<td>Actual Duration</td>
</tr>
<tr>
<td></td>
<td>Planned Duration</td>
</tr>
</tbody>
</table>

## Diagnostic

<table>
<thead>
<tr>
<th>Category</th>
<th>Metric</th>
</tr>
</thead>
<tbody>
<tr>
<td>Schedule Diagnostics</td>
<td>Schedule Variance – Time [SV(t)]</td>
</tr>
</tbody>
</table>
Core Metric Validation

Cost Performance

-50% (Under budget)

±0 (Plan)

+100% (Over budget)

\[ \rho = 0.34 \]

\[ p -value = 0.025 \]
Metric Classification – Summary

In projects using more Core Metrics:
- 50% Cost Reduction
- 30% Schedule Improvement

Data → Core Metrics → Insight
Implementation Resource:
Project Controls Improvement Tool
Components of the Project Control Improvement (PCI) Tool

• Features
  – Automated
  – Interactive
  – Dynamic
  – User-Friendly
  – Customized Reporting
Metrics Gap Module

User Input: Selection of Currently Used Metrics

Performance Forecasting
Performance forecasting: Metrics related to future performance outcomes based on current performance

- Estimate at Completion (CPI)
- Estimate to Completion (CPI)
- Variance at Completion
- To Complete Performance Index (EAC(CPI))
- Estimate at Completion (SPI)
- Estimate to Completion (SPI)
- Estimate at Completion time
- Estimate to Complete time
- Estimate at Completion (Optimistic)
- Estimate to Completion (Optimistic)
- Estimate to Completion (CPI*SPI)
- Estimate at Completion (CPI*SPI)
- Estimate at Completion (Bottom-up)
- Estimate to Completion (Bottom-up)

Generate Report

Close
Metrics Gap Module

Output: Scorecard of Current Status and Additional Recommended Metrics

This report provides an analysis on the progress and performance metrics that are used in your project. In PCI software, metrics are categorized into four classes based on their importance to project control:

- Core metrics: Metrics that provide key insight into project progress and performance
- Validation metrics: Good to have as a way to validate the core metrics
- Innovative metrics: Metrics that are not currently in use but identified as beneficial
- Other significant metrics: Other metrics that were perceived to have value but their value-adding insight into improving project progress and performance does not warrant the effort for monitoring them throughout a project.

Each metric in the previous list belongs to one class. A detailed analysis of the usage of metrics and recommendations of additional metrics based on the distinctions of the four classes of metrics is provided below for forecasting and diagnostic category respectively.

Overall Selected Forecasting Core Metrics

Out of 14 core metrics identified for the forecasting category, you used 8 in your project.

Performance Forecasting

- Selected Metrics: Variance at Completion
- Estimate to Completion (EAC)
- Cost at Completion (CPI)
- Additional Metrics

Validation - selected 1 out of 2 metrics

- Selected Metrics: Estimate to Completion (SPI)
- Additional Metrics

Performance Assessment

- Selected Metrics: Cost Performance Index
- Earned Value
- Additional Metrics
- Schedule Performance Index

Validation - selected 0 out of 0 metrics

There are no Performance Assessment Validation metrics identified in this study.

Progress Measurement/Data

- Selected Metrics: Physical Percent Complete
- Planned Value
- Additional Metrics
- Actual Cost
- Budget at Completion

Validation - selected 0 out of 0 metrics

There are no Progress Measurement/Data Validation metrics identified in this study.

Sharpen the Metrics Dashboard
Metrics Gap Module

Output: The Radar Graph

Sharpen the Metrics Dashboard
Reliability Gap Module

User Input: Evaluation of Reliability Factors

Please select a Phase
- Pre Detailed Design
- Detailed Design
- Construction
- Startup and Commissioning

Critical Reliability Factor (CRF)
1. Project Scope Definition
2. Project Execution Planning
3. Project Control Planning
4. Progress Measurement
5. Schedule and Cost Development and Tracking
6. Change Management
7. Risk Management
8. Schedule Forecasting
9. Communication
10. Teamwork
11. Accountability
12. Project Control Audits

1. Clear scope of work and baseline documents are defined
2. Project Definition Rating Index (PDRI) assessment is planned and/or implemented
3. A detailed and integrated work breakdown structure (WBS) that accurately captures project scope is created and implemented

Generate Report
Close
Reliability Gap Module

Output: Scorecard of Current Status, Gaps, and Recommended Improvements

<table>
<thead>
<tr>
<th>Pre Detailed Design</th>
<th>Detailed Design</th>
<th>Construction</th>
<th>Startup and Commissioning</th>
</tr>
</thead>
<tbody>
<tr>
<td>Critical Reliability Factor (CRF)</td>
<td>Percentage of Indicators Achieved</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Project Execution Planning</td>
<td>100%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Project Control Planning</td>
<td>50%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Progress Measurement</td>
<td>33%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Schedule and Cost Development and Tracing</td>
<td>100%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. Change Management</td>
<td>80%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. Risk Management</td>
<td>60%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8. Progress Audits</td>
<td>0%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9. Metric Trend Analysis</td>
<td>50%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10. Schedule Forecasting</td>
<td>0%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>11. Cost Forecasting</td>
<td>60%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12. Communication</td>
<td>0%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>13. Teamwork</td>
<td>66%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>14. Accountability</td>
<td>75%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>15. Project Control Audits</td>
<td>100%</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Overall Percentage of Reliability Indicators Achieved in This Phase: 42%

Display Reliability Factor Implementation Timing

Save Report
Close
Calculate and Interpret Metrics Correctly

- Color coded
- 43 total maps
  - 22 Forecasting
  - 21 Diagnostic
## Project Controls Utilities – Core Metrics Directory

<table>
<thead>
<tr>
<th>Classification</th>
<th>Name</th>
<th>Definition</th>
<th>Equation</th>
<th>Use and Interpretation</th>
<th>Map ID</th>
<th>Reference</th>
<th>Additional Sources</th>
</tr>
</thead>
<tbody>
<tr>
<td>Metrics Gap</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Metrics Dictionary + Maps</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Project Controls Utilities</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reliability Gap</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

- **Learn about Project Controls**

---

**PCI Tool**

- **Metrics**
  - Gap
  - Dictionary + Maps
  - Project Controls Utilities

---

**Learn about Project Controls**
Project Controls Utilities – Core Metrics Directory

**MAP 23: Baseline Execution Index for Critical Path | BEI-CP**

<table>
<thead>
<tr>
<th>Name</th>
<th>Definition</th>
<th>Equation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline Execution Index for Critical Path</td>
<td>The ratio between the Number of Activities Actually Completed on the Critical Path (AAC-CP) and the number of Activities Planned to be Completed on the Critical Path (APC-CP)</td>
<td>BEI-CP = (AAC-CP) / (APC-CP)</td>
</tr>
</tbody>
</table>

**Use and Interpretation**
- BEI-CP ≥ 1: Favorable
- BEI-CP < 1: Unfavorable

BEI is used to indicate the efficiency with which actual critical path work has been accomplished when measured against the baseline. This metric provides insight pertaining to project progress performance on the critical path.
Critical Reliability Factors

1. Project Scope Definition
2. Project Execution Planning
3. Project Control Planning
4. Progress Measurement
5. Schedule and Cost Tracking
6. Change Management
7. Risk Management
8. Progress Audits
9. Metric Trend Analysis
10. Schedule Forecasting
11. Cost Forecasting
12. Communication
13. Teamwork
14. Accountability
15. Project Control Audits

CRF Achievement Check Point

<table>
<thead>
<tr>
<th>Indicator of CRF Achievement</th>
<th>Pre-Detailed Design</th>
<th>Detailed Design</th>
<th>Construction</th>
<th>Start-up and Commissioning</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Clear scope of work and baseline documents are defined</td>
<td>PR 1 1</td>
<td>B 1 1 1</td>
<td>D 1 1 1</td>
<td>E 1</td>
</tr>
<tr>
<td>2. Project Definition Rating Index (PDR) assessment is planned and/or implemented</td>
<td>PR</td>
<td>B 1 1 1</td>
<td>D 1 1 1</td>
<td>E 1</td>
</tr>
<tr>
<td>3. A detailed and integrated work breakdown structure (WBS) that accurately captures project scope is created and implemented</td>
<td>PR</td>
<td>B 1 1 1</td>
<td>D 1 1 1</td>
<td>E 1</td>
</tr>
<tr>
<td>1.1. Clear scope of work and baseline documents are defined</td>
<td>PR 1 1</td>
<td>B 1 1 1</td>
<td>D 1 1 1</td>
<td>E 1</td>
</tr>
<tr>
<td>1.2. Project Definition Rating Index (PDR) assessment is planned and/or implemented</td>
<td>PR</td>
<td>B 1 1 1</td>
<td>D 1 1 1</td>
<td>E 1</td>
</tr>
<tr>
<td>1.3. A detailed and integrated work breakdown structure (WBS) that accurately captures project scope is created and implemented</td>
<td>PR</td>
<td>B 1 1 1</td>
<td>D 1 1 1</td>
<td>E 1</td>
</tr>
<tr>
<td>2.1. Project organizational chart is developed and maintained</td>
<td>PR 1 1</td>
<td>B 1 1 1</td>
<td>D 1 1 1</td>
<td>E 1</td>
</tr>
<tr>
<td>2.2. Detailed execution and labor contracting strategies are created, maintained, and communicated to all stakeholders</td>
<td>PR</td>
<td>B 1 1 1</td>
<td>D 1 1 1</td>
<td>E 1</td>
</tr>
<tr>
<td>2.3. Project execution plan adequately addresses project scope</td>
<td>PR</td>
<td>B 1 1 1</td>
<td>D 1 1 1</td>
<td>E 1</td>
</tr>
<tr>
<td>2.4. Priority between cost and schedule are defined</td>
<td>PR 1 1</td>
<td>B 1 1 1</td>
<td>D 1 1 1</td>
<td>E 1</td>
</tr>
<tr>
<td>2.5. The project organizational chart includes all the positions listed and associated roles and responsibilities are defined clearly</td>
<td>PR</td>
<td>B 1 1 1</td>
<td>D 1 1 1</td>
<td>E 1</td>
</tr>
<tr>
<td>3.1. Metrics and their thresholds are determined based on project characteristics (e.g., size, type, and complexity)</td>
<td>PR 1 1</td>
<td>B 1 1 1</td>
<td>D 1 1 1</td>
<td>E 1</td>
</tr>
<tr>
<td>3.2. Metrics are aligned with contractual requirements</td>
<td>PR</td>
<td>B 1 1 1</td>
<td>D 1 1 1</td>
<td>E 1</td>
</tr>
<tr>
<td>3.3. The quality and detail requirements of the schedule is defined</td>
<td>PR</td>
<td>B 1 1 1</td>
<td>D 1 1 1</td>
<td>E 1</td>
</tr>
<tr>
<td>3.4. Project control plan defines reporting requirements</td>
<td>PR</td>
<td>B 1 1 1</td>
<td>D 1 1 1</td>
<td>E 1</td>
</tr>
<tr>
<td>3.5. The commercial and technical milestones are aligned with project delivery requirements</td>
<td>PR</td>
<td>B 1 1 1</td>
<td>D 1 1 1</td>
<td>E 1</td>
</tr>
</tbody>
</table>
## Project Controls Utilities – *Reliability Improvement Checklist*

<table>
<thead>
<tr>
<th>Project Control Critical Reliability Factor (CRF)</th>
<th>Indicator of CRF Achievement</th>
</tr>
</thead>
<tbody>
<tr>
<td>4. Progress Measurement</td>
<td></td>
</tr>
<tr>
<td>4.1. Rules of credit for project deliverables are defined to provide accurate progress measurement</td>
<td></td>
</tr>
<tr>
<td>4.2. Consistent rules of credit are tied to tangible deliverables to provide accurate progress measurement</td>
<td></td>
</tr>
<tr>
<td>4.3. Level of effort and percent complete are aligned for project deliverables</td>
<td></td>
</tr>
<tr>
<td>4.4. Discipline-specific and trade-specific rules of credit are used consistently</td>
<td></td>
</tr>
<tr>
<td>4.5. Discipline specific quantity-based commodity curves are used</td>
<td></td>
</tr>
<tr>
<td>4.6. Commodity curves based on project schedule are used</td>
<td></td>
</tr>
</tbody>
</table>

### CRF Achievement Check Point

<table>
<thead>
<tr>
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<tbody>
<tr>
<td></td>
<td>PR B D E PO</td>
<td>PR B D E PO</td>
<td>PR B D E PO</td>
<td>PR B D E PO</td>
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<tr>
<td></td>
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</tr>
</tbody>
</table>

**PR:** Prior to; **B:** At the Beginning; **D:** During; **E:** At the End; **PO:** Post

- □ represents the reliability indicator observed at a specific time
- ✔ represents monitoring a reliability indicator over a certain period of time within the phase
- ◆ represents the reliability indicator achievement milestones

* Indicators occurring prior to Pre-Detailed Design phase are mostly programming requirements that must be done prior to project approval/authorization.
## Use of PCI Tool - Examples

<table>
<thead>
<tr>
<th>Who?</th>
<th>How?</th>
<th>When?</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Project manager</td>
<td>• Resource for project execution planning</td>
<td>• During project planning</td>
</tr>
<tr>
<td>• Project control manager</td>
<td>• Improve company-wide use of metrics and reliability</td>
<td>• During company-wide performance assessment enhancement</td>
</tr>
<tr>
<td>• Cost Engineer/Scheduler</td>
<td>• Benchmark core metrics and reliability practices across different projects</td>
<td>• During project execution</td>
</tr>
</tbody>
</table>
PCI Tool Structure

User Input
- Metric Gap Analysis Module
- Reliability Gap Analysis Module
- Metric Dictionary and Maps
- Select Core Metrics Directory
- Select Reliability Improvement Checklist

Software Output
- Metric Gap Report
- Reliability Gap Report
- Metric Information and Related Maps
- Information on Core Project Control Metrics
- Information on Reliability Improvements

User Input Flow:
- User
- Create Project
- Select Previous Project
- Main Page

Software Output Flow:
- Select Metrics
- Search Metrics
- Select Reliability Factors by Phase
- Information on Core Project Control Metrics
- Information on Reliability Improvements