



کنترل پروژه پیشرفته و ارزیابی عملکرد در پروژه‌های پیچیده (بر اساس اسناد CII)

فصل ششم:
ابزار PCI و بهبود ارزیابی عملکرد پروژه

ارائه دهنده:

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What we will learn?

- ☐ What is the Issue?
- ☐ What is the Solution?
- ☐ Overview of PCI Tool
- ☐ PCI Tool Structure and Components
- ☐ Core Metrics Directory
- ☐ Reliability Improvement Checklist
- ☐ User Guide
- ☐ Use Cases

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What is the Issue?

What is the issue?

Construction projects are suffering from significant performance inefficiencies



Only
ONE
in twenty projects
is under budget and on time



Source: Construction Industry Institute, 2012

What is the issue?

Performance issues cause major cost and schedule deviations, particularly in bigger projects

98

98% of megaprojects
incur cost overruns
and schedule delays.

80

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

20

The average **slippage is 20 months** behind original schedule.

Source: McKinsey & Co, 2015



What is the issue?

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

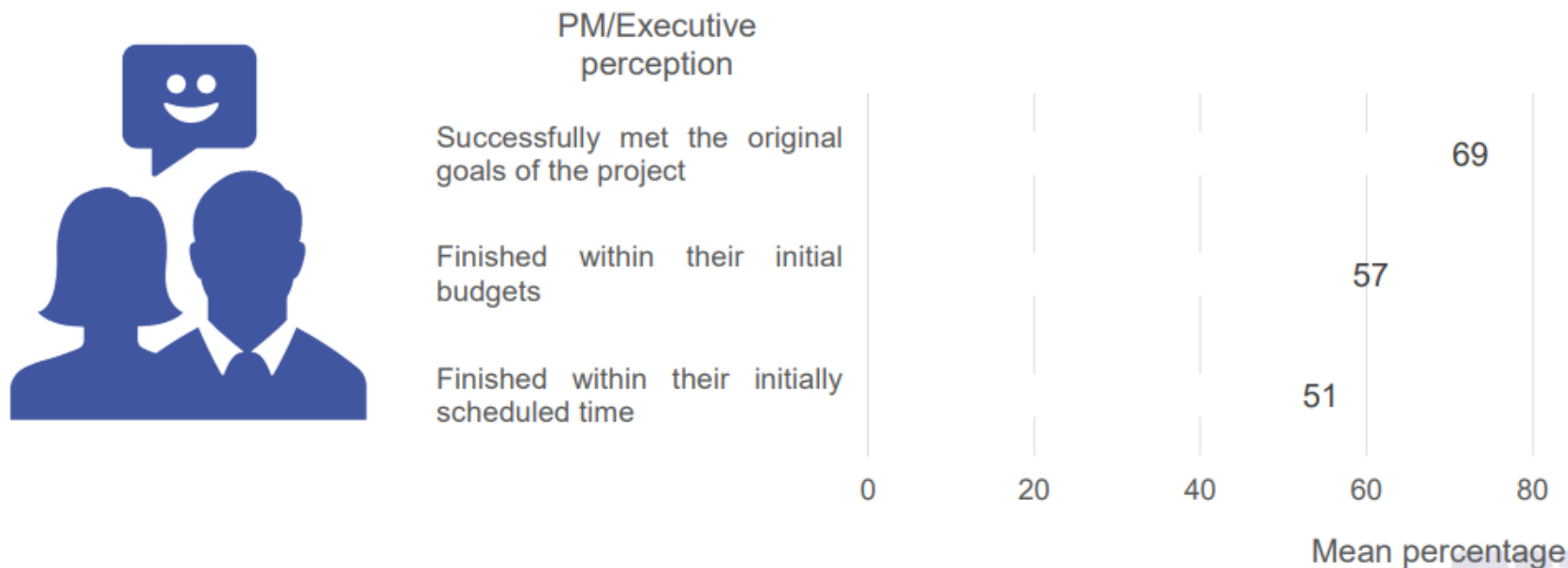


Sources: Project Management Institute, 2017; Construction Industry Institute, 2014



What is the issue?

Majority of project managers believe most of their projects are performing well and meeting targets



Source: A.T. Kearney, 2012; Project Management Institute, 2017

What is the Solution?

What is the solution?

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



Project controls improvement (PCI) tool

❑ **CII Research Team 322 (RT-322)** developed the Project Controls Improvement (PCI) Tool to

1. **address** these industry-wide questions and
2. **identify** potential gaps in **current in-flight** project control practices.

❑ Based on surveys, case studies, and review by a panel of experts with more than **350 years of experience**, as owners and contractors,

RT-322 crafted a tool that contains valuable information on

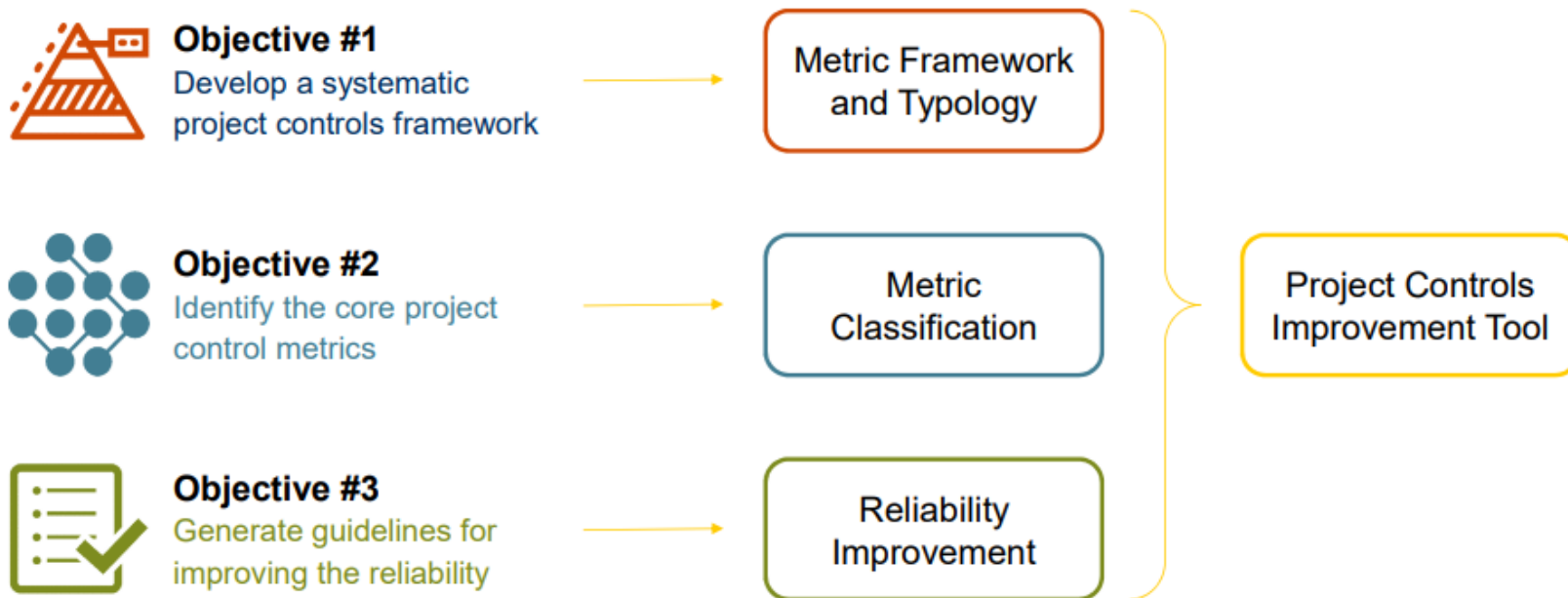
1. Core metrics and
2. Critical Reliability Factors

to ensure robust project progress and performance assessment.

*This **software** is an **effective tool** to improve cost and schedule outcomes at **both** the project and organizational levels.*

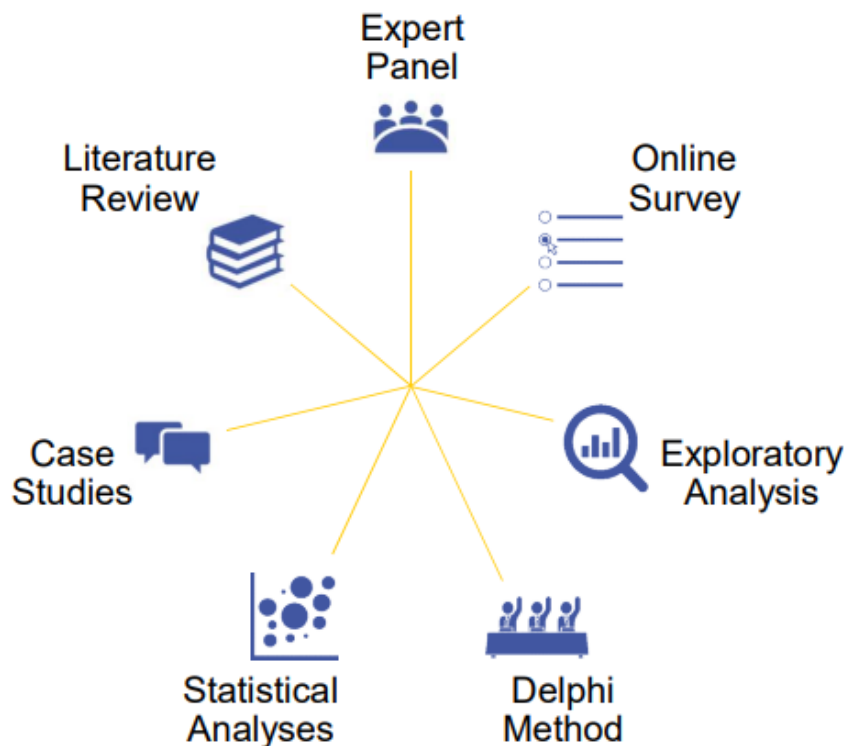
Introduction

The research approach is aligned with the objectives to deliver desired outcomes



Introduction

Various research methods are utilized to produce deliverables and achieve objectives



Introduction

Various research methods are utilized to produce deliverables and achieve objectives

Literature
Review



>100 documents

Expert
Panel



Scholarly articles

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

Government agency reports
(e.g., DoD, DoE, DoT)

Online
Survey



Exploratory
Analysis



Delphi
Method



Statistical
Analyses



Case
Studies



Introduction

Various research methods are utilized to produce deliverables and achieve objectives

Literature
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Method



Statistical
Analyses



Case
Studies



13 industry professionals

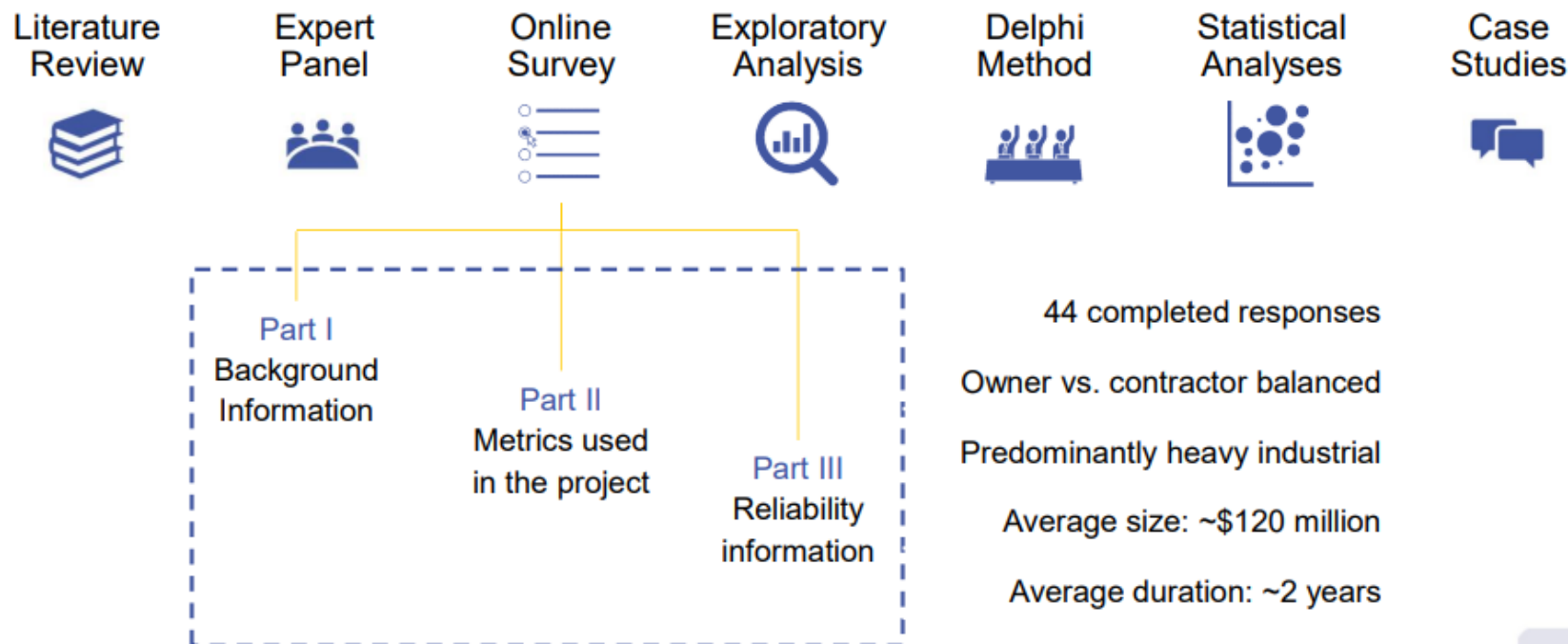
290+ years of cumulative
experience

Representing owner (5) and
contractor (8) perspectives



Introduction

Various research methods are utilized to produce deliverables and achieve objectives



Introduction

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



Metric Importance

Low – High High – High

Low – Low High – Low

Metric Usage



Introduction

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

Introduction

Various research methods are utilized to produce deliverables and achieve objectives

Literature Review



Expert Panel



Online Survey



Exploratory Analysis



Delphi Method



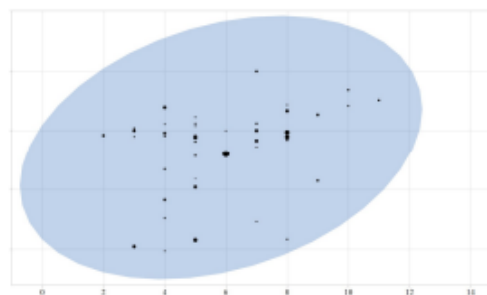
Statistical Analyses



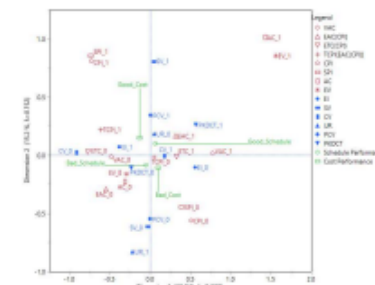
Case Studies



Spearman's Rank Correlation



Multiple Correspondence Analysis



Introduction

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



In-depth analysis
of selected
projects

10 projects selected

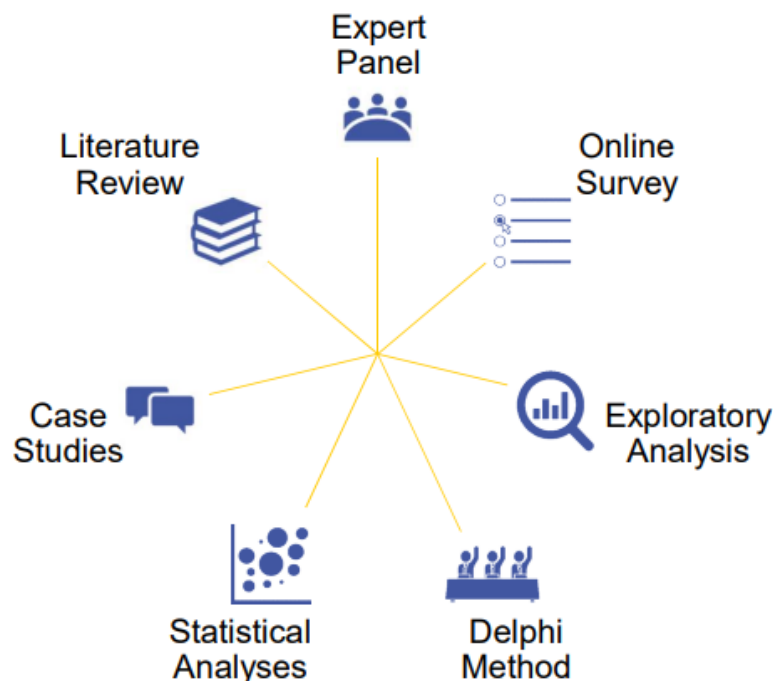
Contractor (6) and owner (4)
perspectives

Interviewed 17 project
personnel



Introduction

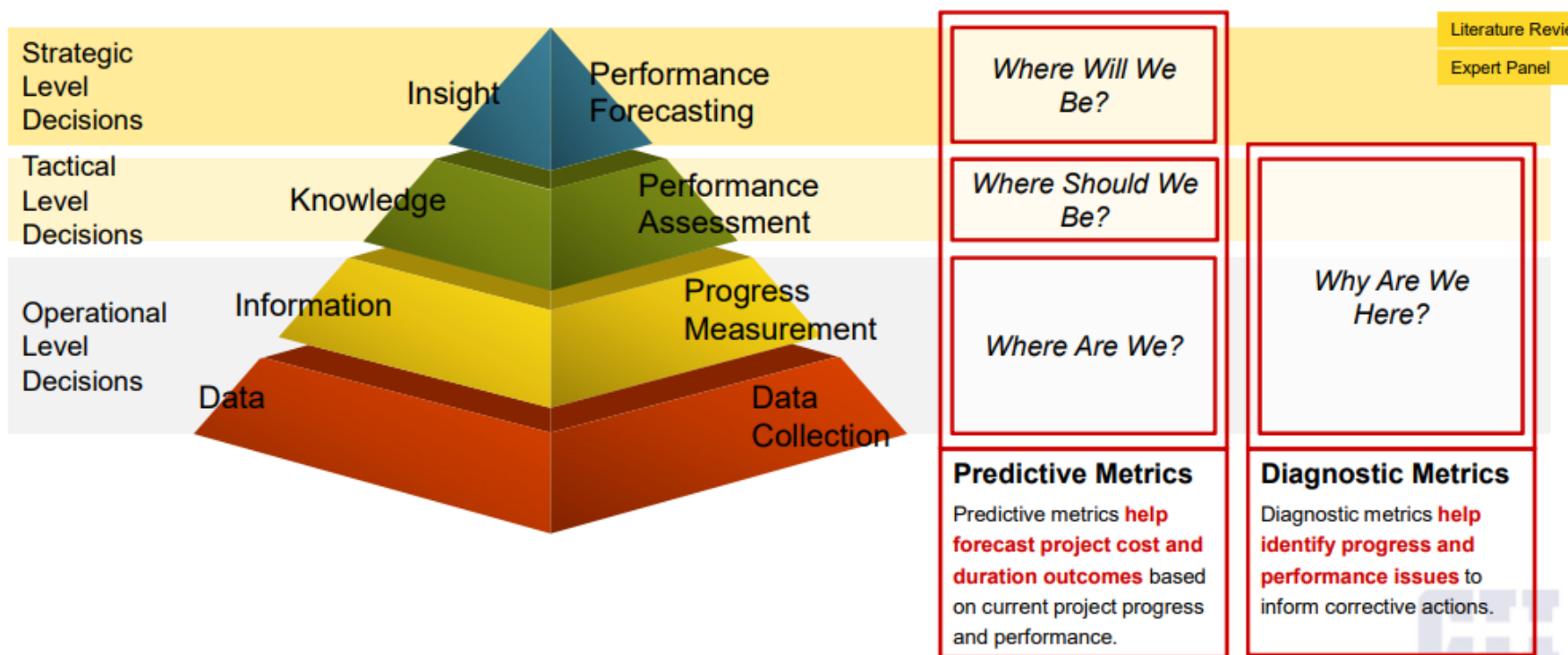
Various research methods are utilized to produce deliverables and achieve objectives



Overview of PCI Tool

Introduction

A systematic framework and typology that allow transforming data into meaningful insights



Introduction

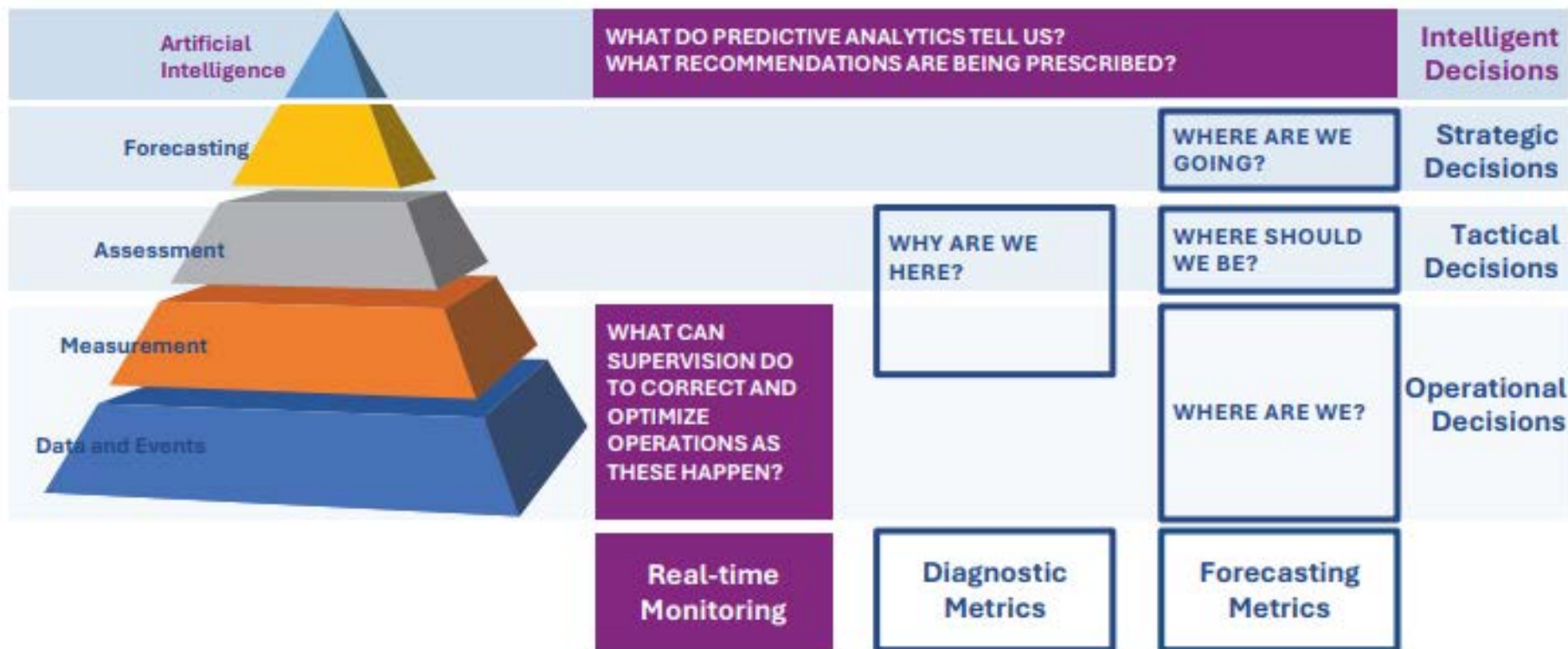


Figure 6. Information Layers

Project controls improvement (PCI) tool

- ❑ The PCI Tool has **four main components** to **identify possible gaps** and **provide resources for improvements** in progress and performance assessment:
 1. The Metrics Gap Analysis module enables project stakeholders to identify strengths and areas for improvement in their current project control plans.
 2. The Reliability Gap Analysis module provides a resource for stakeholders to examine their metrics on a holistic level and determine if projects are achieving Critical Reliability Factors, to ensure that assessment is meaningful and robust.
 3. The software also includes a Metrics Dictionary and Maps module to promote standardization of metrics definitions, usage, and selection.
 4. The Project Controls Utilities module further explains detailed aspects of the software's module analysis and provides resources for implementation and training.

Project controls improvement (PCI) tool

- ❑ This user guide consists of a **detailed explanation** of
 1. the different components and features of the tool (Chapter 2),
 2. step-by-step user instructions (Chapter 3), and
 3. different implementation use cases (Chapter 4).

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Project controls improvement (PCI) tool

- ❑ Project management and control teams can use the **PCI Tool** to **evaluate** current practices regarding **project progress** and **performance assessment**.
- ❑ Users receive **customized suggestions** for potential improvements to their metric implementation, enabling project teams to make improvements based on **identified gaps and recommended actions**.
- ❑ The **software's customized reports** can be saved and shared **among stakeholders and partner organizations**.
- ❑ In addition, since the PCI Tool includes information related to diverse metrics and reliability factors, it can also be **used for educational or training purposes** in owner and contractor companies.

Project controls improvement (PCI) tool

❑ Some **potential applications** include the following:

- ❖ a **reference** for project managers and control teams for project control plan development
- ❖ a **gap analysis tool** to evaluate **current** in-flight project control practices
- ❖ a **source** of **potential corrective actions** to improve current progress and performance assessment practices
- ❖ a document to **track** **reliability improvement practices** across different project **phases**
- ❖ an **owner's reference** for formulating **contractual** project control requirements
- ❖ a **training reference** for entry-level project control professionals.

Project controls improvement (PCI) tool

- ❑ The PCI Tool enables **project stakeholders** (e.g., project managers, project control teams, engineering managers, cost engineers, and schedulers in both owner and contractor organizations) to **better** monitor, control, and communicate project progress and performance assessment.

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PCI Tool Structure and Components

PCI tool structure and components

□ Figure 1

1. shows **how these modules connect to each other** within the PCI Tool and
2. presents their **targeted approach** to improve in-flight project controls and reliability.

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PCI tool structure and components

- ❑ Each of these modules requires separate input from the user to automatically generate unique outputs.



Figure 1. Overview of PCI Tool Components

Key terminology for better understanding the PCI tool

❑ Forecasting versus Diagnostic Metrics

❖ **Forecasting** and **Diagnostic** metrics represent the two **major metrics categories** based on their roles.

1. Forecasting metrics help users **predict** project cost and schedule outcomes based on a **current understanding** of project progress and performance.
2. Diagnostic metrics help users **identify** progress and performance **issues**, to **inform corrective actions**.

Key terminology for better understanding the PCI tool

❑ Core, Validation, Innovative, and Other Significant Metrics

❖ In terms of importance, **metrics** are first categorized into **two groups**:

1. Core metrics are the “**must have**” metrics that provide the **greatest insight** into project controls.
2. Significant metrics **supplement** or complement **Core metrics**, and they have the **potential** to **become Core metrics** if more widely tested and adopted in the industry.

Key terminology for better understanding the PCI tool

❑ Core, Validation, Innovative, and Other Significant Metrics

❖ In terms of importance, **metrics** are first categorized into **two groups**:

✓ Significant metrics are further classified into three categories:

- a) **Validation metrics** (e.g., Monthly Cost Growth, Critical Path Length Index) are useful as checks or proxies for the indicators of Core metrics.
- b) **Innovative metrics** (e.g., Earned Schedule) are not extensively used in the industry, but are still deemed highly beneficial within organizations that utilize them.
- c) **Other Significant metrics** (e.g., Project Buffer Index, Number of Backlog Activities) are metrics that might add value to a project if resources were available to incorporate their use.

Key terminology for better understanding the PCI tool

❑ Critical Reliability Factors and Reliability Indicators

❖ The PCI Tool employs **15 Critical Reliability Factors (CRFs)** that individually and collectively **influence** the reliability of a project's progress and performance assessment metrics:

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

Key terminology for better understanding the PCI tool

- ❑ Within these factors, **83 Reliability Indicators** contribute to **improving** the **reliability** of a project control system and related metrics.
- ❑ **Each Reliability Indicator** has a unique timeline, **determined** by five milestones related to the **phases** in which they are used (e.g., prior to, at the beginning, during, at the end, post).
- ❑ These **specific timing milestones** should be carefully considered for **effective implementation** of CRFs and indicators.

Metrics Gap Analysis

- ❑ The Metrics Gap Analysis module helps users to identify gaps between
 - ❖ **currently used in-flight** project control metrics and
 - ❖ the **Core** and **Significant** metrics determined by RT-322 research.
- ❑ The **PCI Tool** provides **recommendations** that **identify** which **additional metrics** should be considered.
- ❑ **Users** are asked to **select** the Forecasting and Diagnostic metrics **currently used** in their projects from the list of metrics on the **input page**.

Metrics Gap Analysis

- ❑ Based on their selections, users **receive a report** that includes the following information:
 - ❖ the Core, Validation, Innovative, and Other Significant metrics **currently being used** in the project
 - ❖ **additional** Core, Validation, Innovative, and Other Significant metrics that **should be considered to improve** project progress and performance assessments
 - ❖ an **overall score** that indicates the **extent of any gap** in the project's use of Core Forecasting and Diagnostic metrics.

Reliability Gap Analysis

- ❑ The Reliability Gap Analysis module enables users to **assess CRFs** related to progress and performance assessment at the **current** or **desired project phase** (i.e., pre-detailed design, detailed design, construction, or startup and commissioning).
- ❑ For each project phase, users select the **reliability indicators** already achieved in their project.
- ❑ Based on their selections, **users obtain** an analysis report that includes the following information:
 1. a reliability score based on the overall Critical Reliability Factors and indicators achieved in a specific phase
 2. CRFs and indicators that need improvement
 3. a timetable showing the appropriate timing for implementation of each CRF and indicator.

Metrics dictionary and maps

- ❑ The Metrics Dictionary and Maps give users a **comprehensive database** of in-flight project control metrics.
- ❑ The Metrics Dictionary **includes** rich information related to metric categories (i.e., Forecasting or Diagnostic), definitions, equations, uses and interpretations, references, additional resources, and metrics maps.
- ❑ Its **search function** enables users to **search metrics** by name or specific attributes, such as by **metric category** or **level of importance** (i.e., Core, Validation, Innovative, or Other Significant).
- ❑ The Metrics Dictionary serves as a **valuable reference** for project management and control teams to learn about, correctly calculate, and utilize various metrics.

Metrics dictionary and maps

□ **Appendix A** provides the **complete definitions** of all Core and Significant metrics, and

Appendix B includes **metrics maps** that show how to calculate each metric.

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Project controls utilities

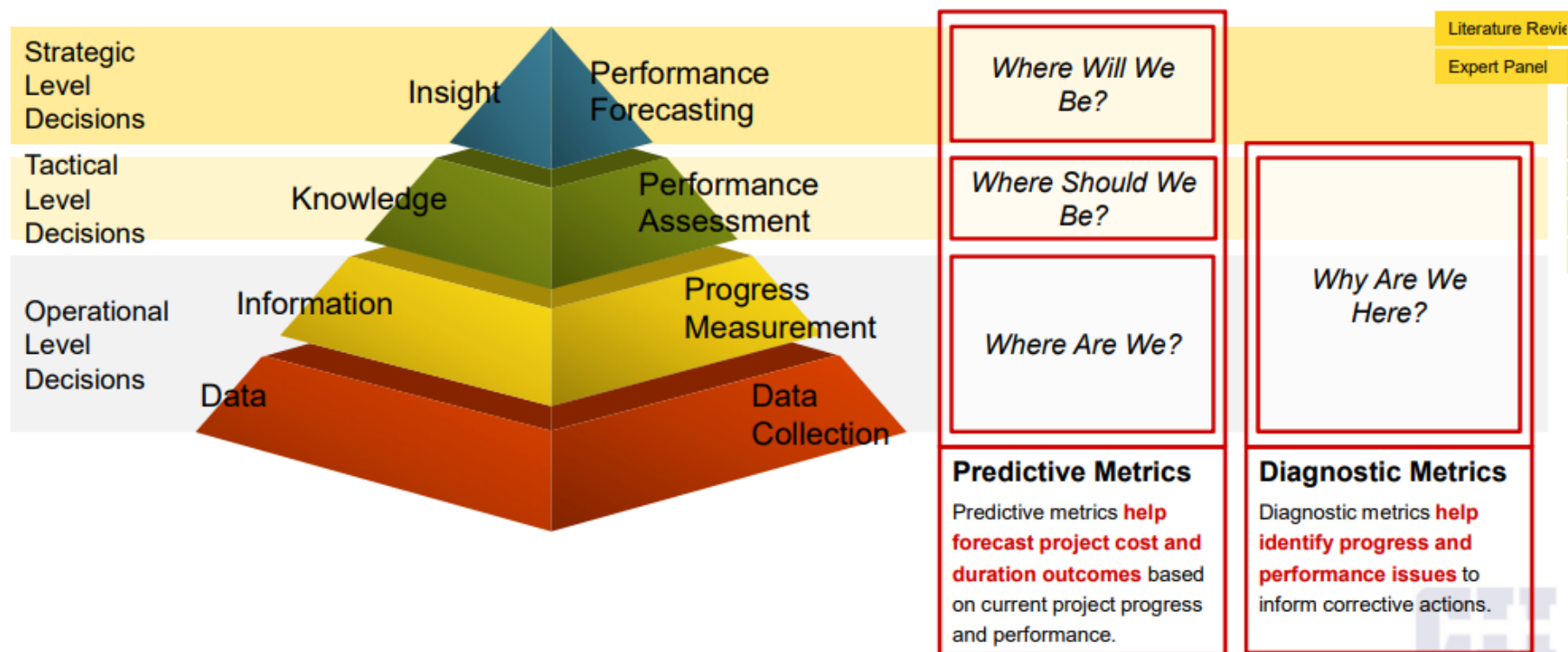
- ☐ By using the Project Controls Utilities of the PCI Tool, users have access to essential information related to Core (and Significant) metrics and Reliability Improvement.
- ☐ Its **two sub-modules** allow users to create **printable documents** that show detailed information.

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Core Metrics Directory

Introduction

A systematic framework and typology that allow transforming data into meaningful insights



Introduction

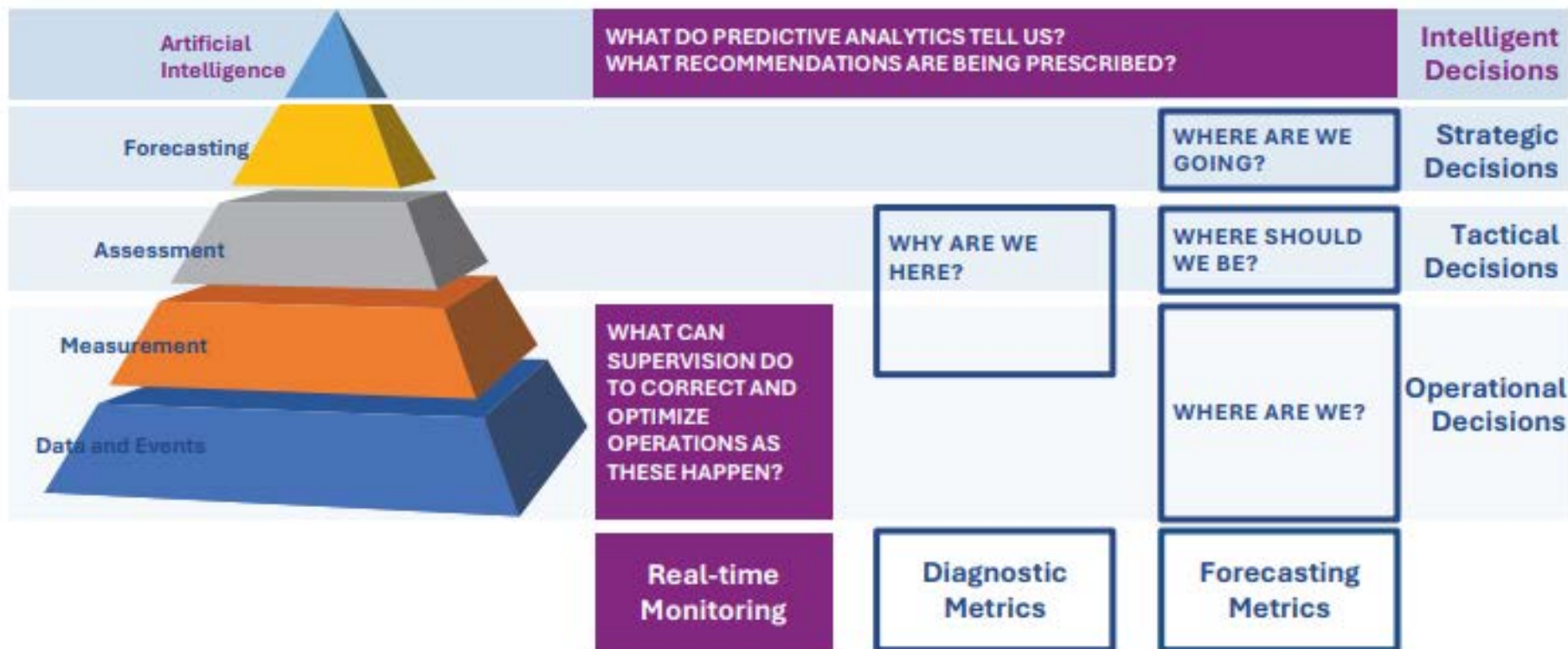
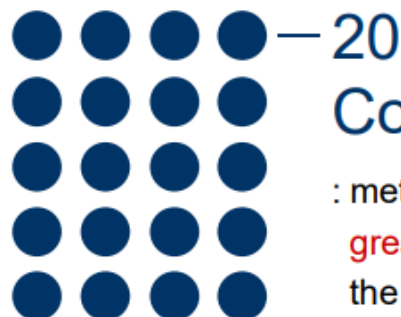
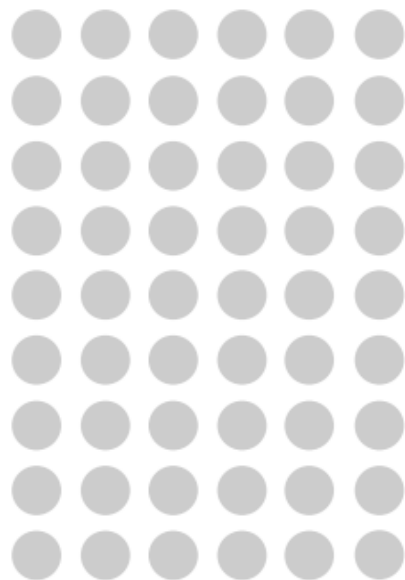


Figure 6. Information Layers

Introduction

Metric classification was finalized by subject matter experts (SMEs)



Core metrics

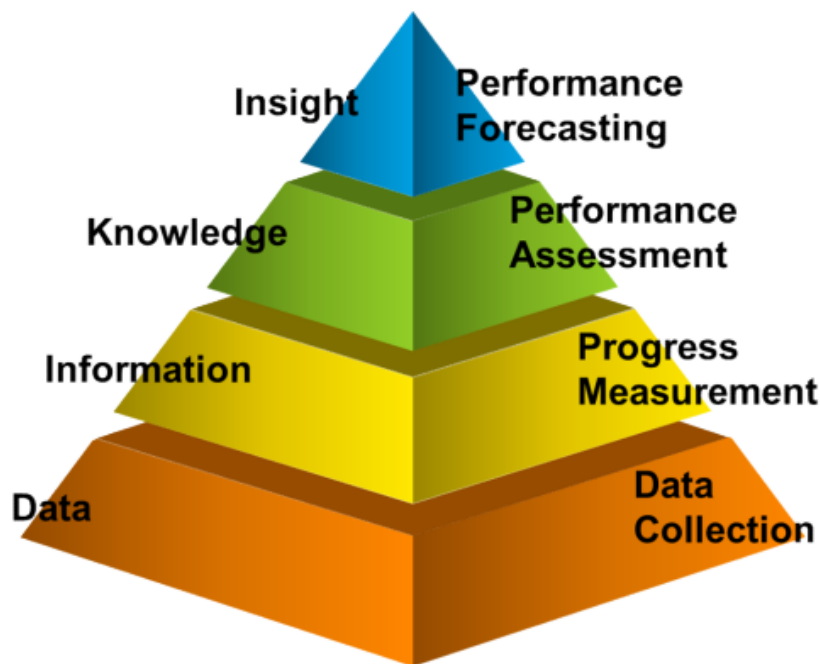
: metrics that provide the
greatest insight for indicating
the likely project outcomes

Delphi Method



Introduction

Metric Pyramid – *Distribution of Core Metrics*



WHERE ARE WE GOING?
● ● ● ●

WHERE SHOULD WE BE? ● ● ●

WHERE ARE WE?
● ●

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

● ● ● ●
● ● ● ●
● ●

WHY ARE WE HERE?

Diagnostic Metrics
Diagnostic metrics **help the user to identify progress and performance issues** to inform corrective actions.

Introduction

20 Core Metrics

Forecasting

Category	Metric
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

Diagnostic

Category	Metric
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



Introduction

7 Significant Validation Metrics

Forecasting

Category	Metric
Performance Forecasting	Estimate at Complete (SPI)
	Estimate to Complete (SPI)
Performance Assessment	Monthly Cost Growth

Diagnostic

Category	Metric
Schedule Diagnostics	Percent Activities Started on Time
	Percent Activities Finished on Time
	Critical Path Length Index
Cost Diagnostics	Percent Work Packages on Budget

Introduction

7 Significant Innovative Metrics

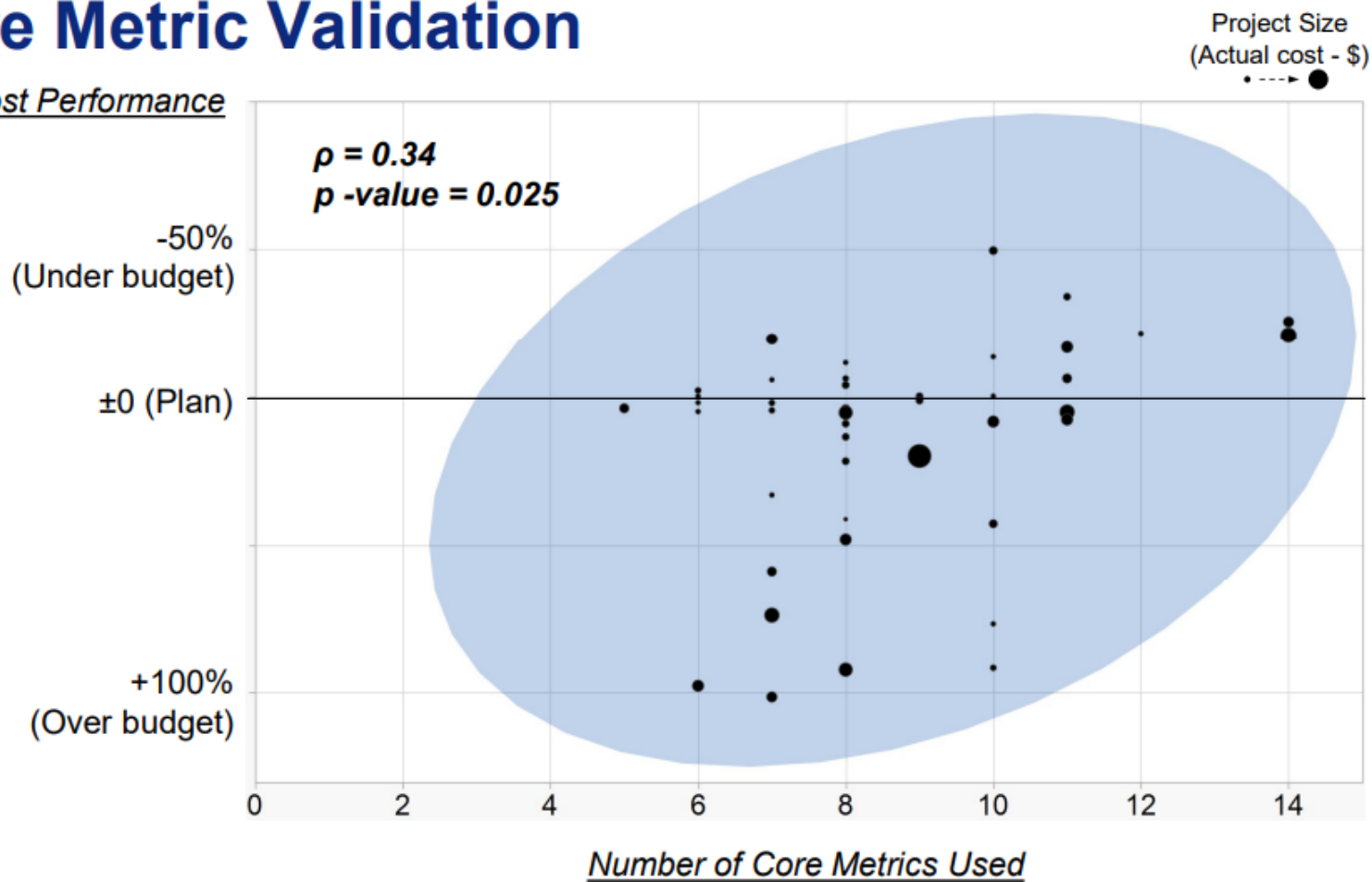
Forecasting	
Category	Metric
Performance Forecasting	Estimate at Completion - Time
	Estimate to Completion - Time
Performance Assessment	Schedule Performance Index – Time [SPI(t)]
	Earned Schedule
Progress Measurement / Data Collection	Actual Duration
	Planned Duration

Diagnostic	
Category	Metric
Schedule Diagnostics	Schedule Variance – Time [SV(t)]

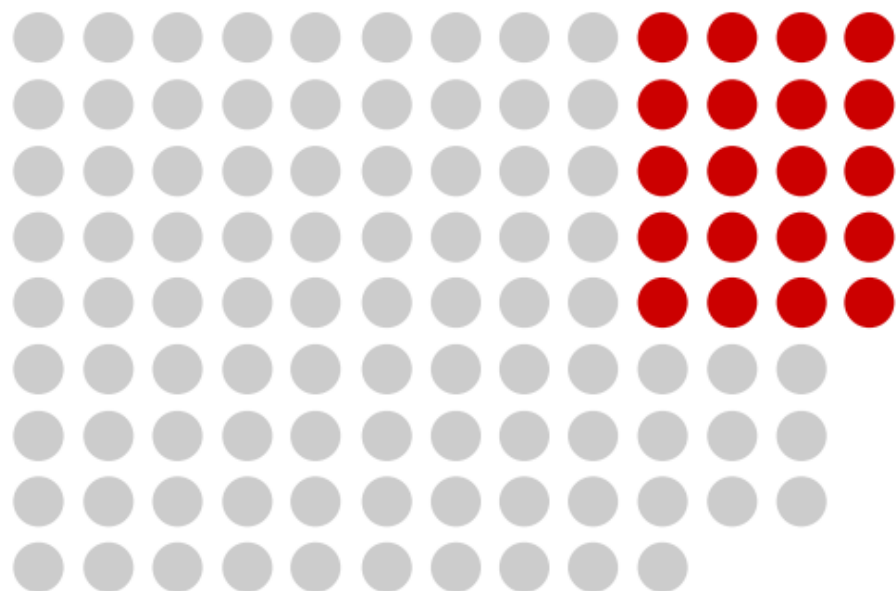
Introduction

Core Metric Validation

Cost Performance



Metric Classification – Summary



Data
↓
Core Metrics
↓
Insight

In projects using
more **Core Metrics**

50%

**Cost
Reduction**

30%

**Schedule
Improvement**

Literature Review
Expert Panel
Survey
Exploratory Analysis
Delphi Methods
Statistical Analysis



Appendix A - Details of Core and Significant Metrics

- ☐ Tables A1–A4: Forecasting Metrics
- ☐ Tables A5–A8: Diagnostic Metrics

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Appendix B - Core and Significant Metrics Maps

- ☐ Maps 1–22: Forecasting Metrics Maps
- ☐ Maps 23–43: Diagnostic Metrics Maps

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Reliability Improvement Checklist

Appendix C - Reliability Improvement Factors and Indicators with Specific Timing

- ☐ Tables C1–C3: All Phases
- ☐ Tables C4–C6: Pre-Detailed Design Phase
- ☐ Tables C7–C9: Detailed Design Phase
- ☐ Tables C10–C12: Construction Phase
- ☐ Tables C13–C15: Startup and Commissioning Phase

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User Guide

Running the PCI tool

- ❑ The **PCI Tool** is an interactive tool for
 1. Core project control metrics and
 2. reliability factor analyses.
- ❑ It is an **executable software** that can be **run on Windows-based machines**.
- ❑ **Figure 2** depicts the **input-output structure** and **flow** of the PCI Tool.

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Running the PCI tool

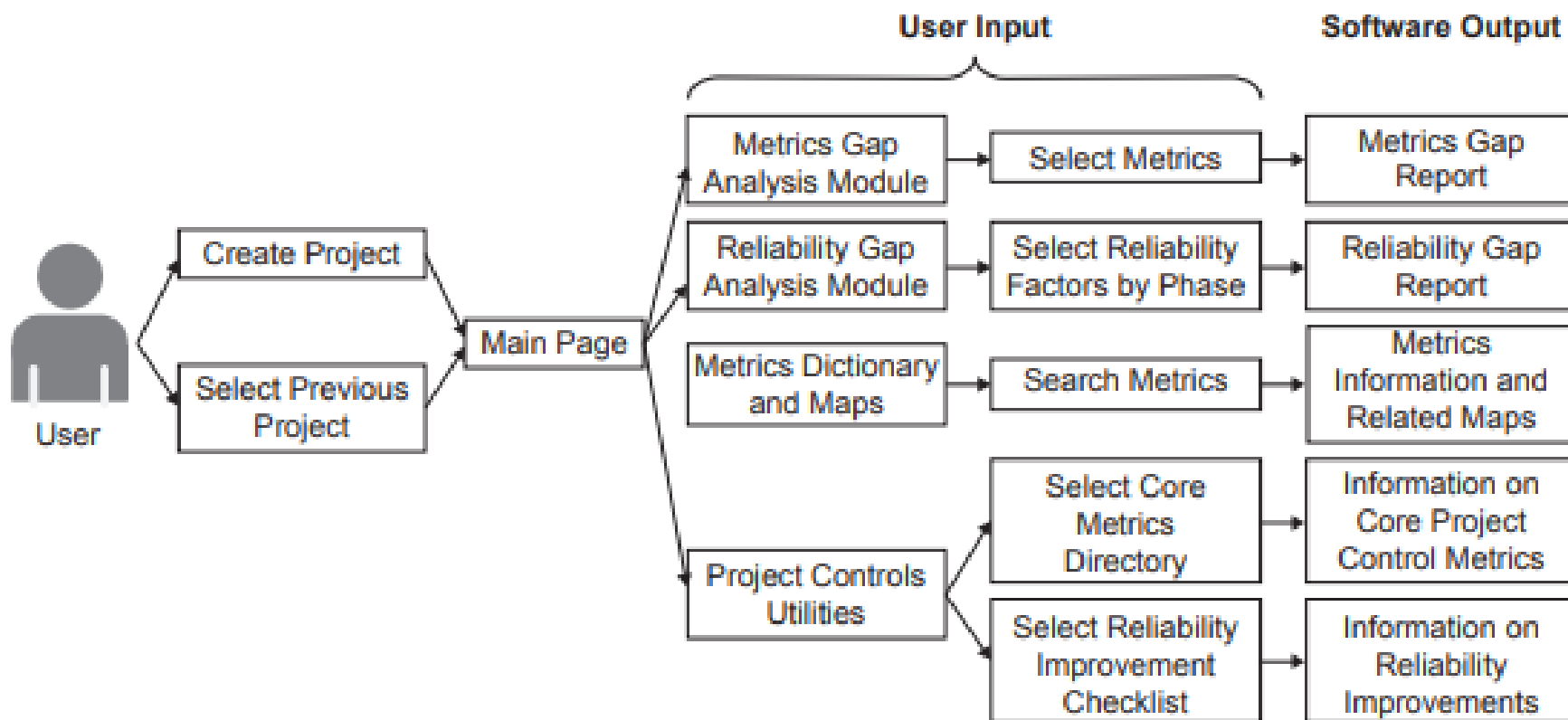


Figure 2. Overview of PCI Tool Structure and Information Flow

Running the PCI tool

CommonFiles	6/30/2016 12:40 PM	File folder	
images	6/30/2016 1:34 PM	File folder	
JavaPortableLauncher	6/30/2016 12:44 PM	File folder	
lib	6/30/2016 12:44 PM	File folder	
config.xml	6/30/2016 12:40 PM	XML Document	1 KB
launch4j.log	6/30/2016 12:40 PM	Text Document	6 KB
PCI-Tool.exe	6/30/2016 12:40 PM	Application	67,247 KB
PCI-Tool.jar	6/30/2016 12:40 PM	Executable Jar File	67,119 KB

Figure 3. Executable File for Running the PCI Program

Starting an Analysis – or “Getting Started”

- ☐ **After opening** the program, the user is **asked on the PCI Startup page** to choose whether to start a new analysis or to continue with a saved analysis.
(See **Figure 4**.)
- ☐ The user can also access the **user guide** by clicking the **“User Guide”** button. (This user guide provides **detailed instructions** on how to use the software.)

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Starting an Analysis – or “Getting Started”



Figure 4. PCI Startup Page

Starting an Analysis – or “Getting Started”

☐ Starting a New Analysis

- ❖ If the user chooses to **conduct a new analysis**, he or she will be directed to enter the Project Name and Project Manager. (See Figure 5.)
- ❖ The **information entered is saved**, and the user can then continue to the Module Section page by clicking on “Start Analysis.”

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Starting an Analysis – or “Getting Started”

- ☐ Continue with an Existing Analysis

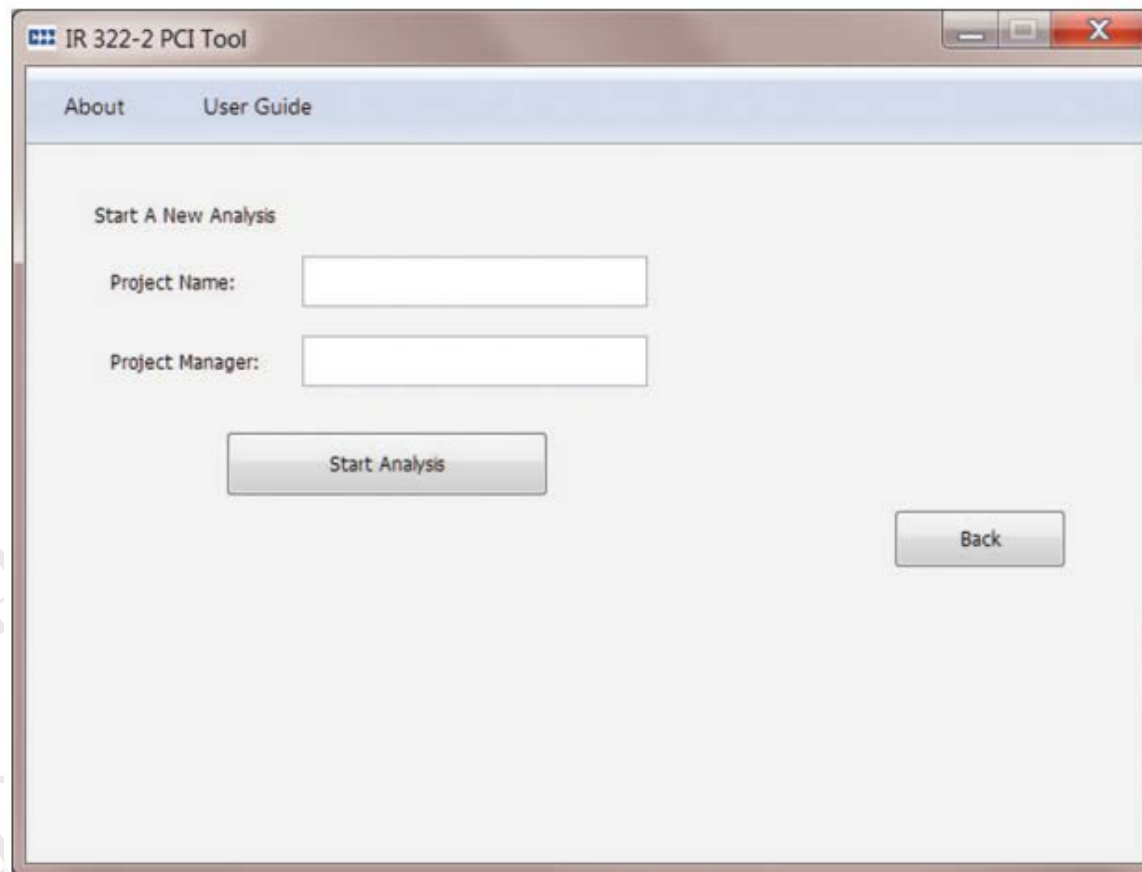


Figure 5. Starting a New Analysis

Starting an Analysis – or “Getting Started”

☐ Continue with an Existing Analysis

- ❖ If the user chooses to **continue with an existing analysis**, the existing analysis can be selected from a list of saved analyses. (See Figure 6.)
- ❖ After the intended saved analysis has been selected, the user can continue the analysis, using the previously saved information.

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Starting an Analysis – or “Getting Started”

☐ Continue with an Existing Analysis

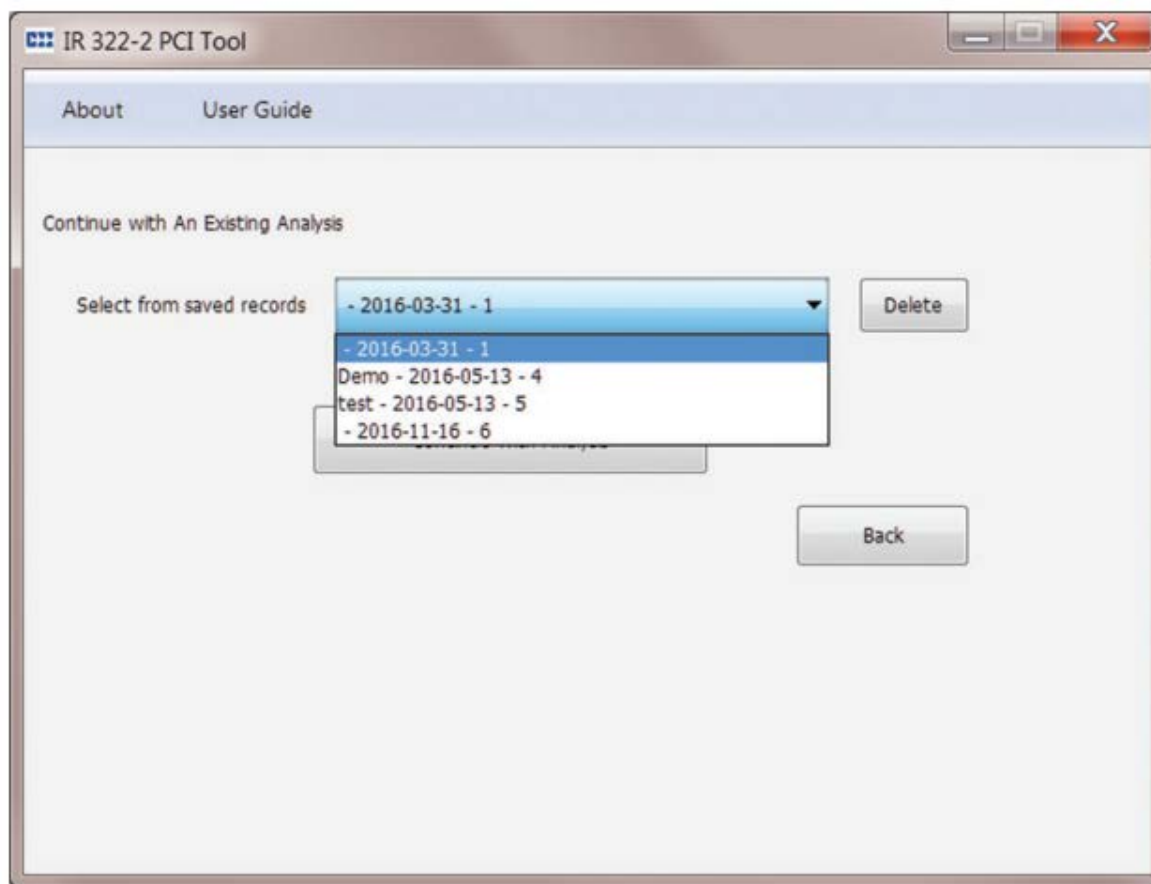


Figure 6. Selecting an Existing Analysis

Module Selection Page

- ❑ After defining a **new analysis or selecting an existing analysis**, the user is directed to the Module Selection page. (See Figure 7.)

- ❑ Here, the user can select among the following modules:
 - ❖ Metrics Gap Analysis
 - ❖ Reliability Gap Analysis
 - ❖ Metrics Dictionary and Maps
 - ❖ Project Controls Utilities.

Module Selection Page

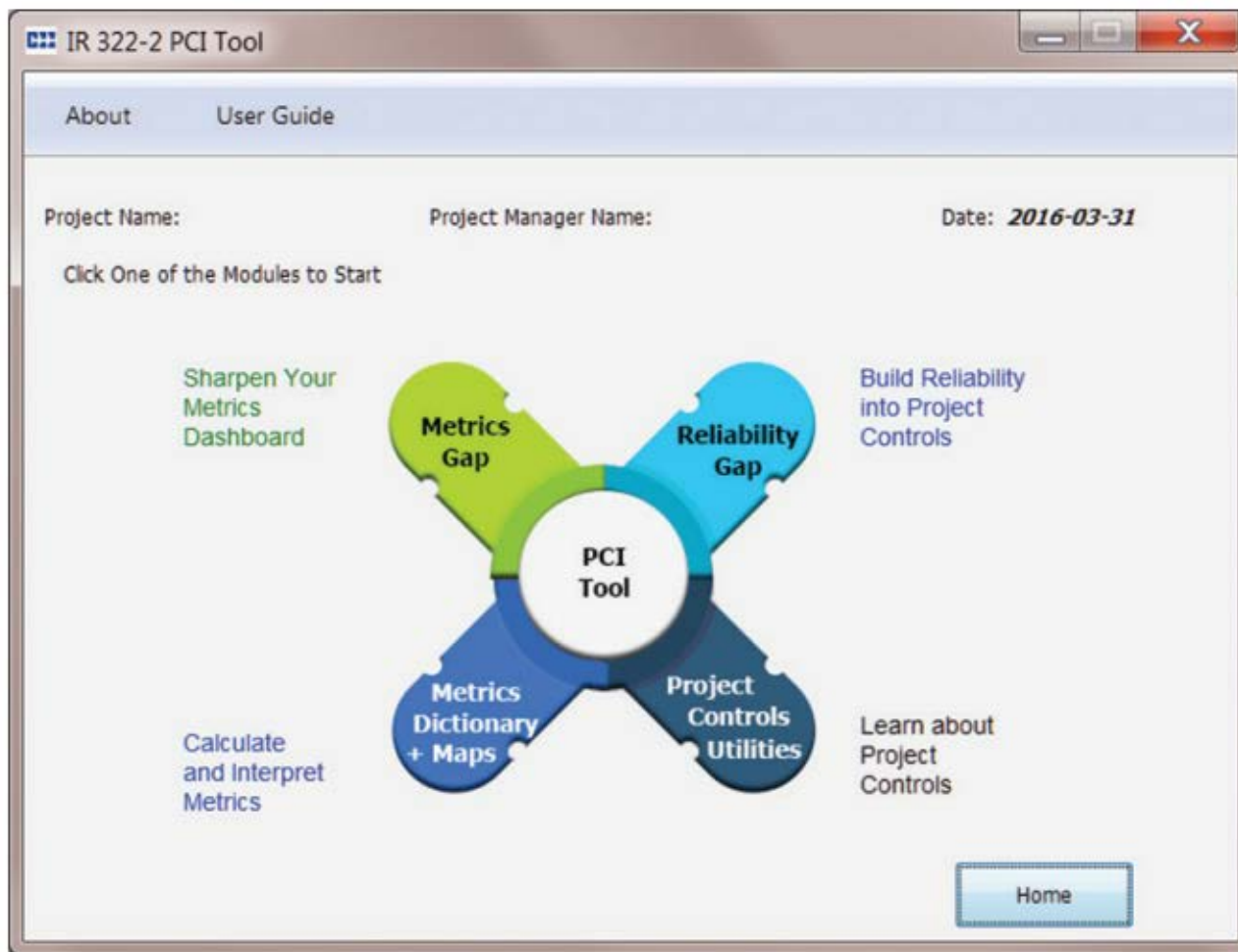


Figure 7. Module Selection Page

User Guide

(Metrics Gap Analysis)

Metrics gap analysis

❑ The **Metrics Gap Analysis** module enables a user to investigate

1. the gaps and
2. required improvements

in a project's metrics.

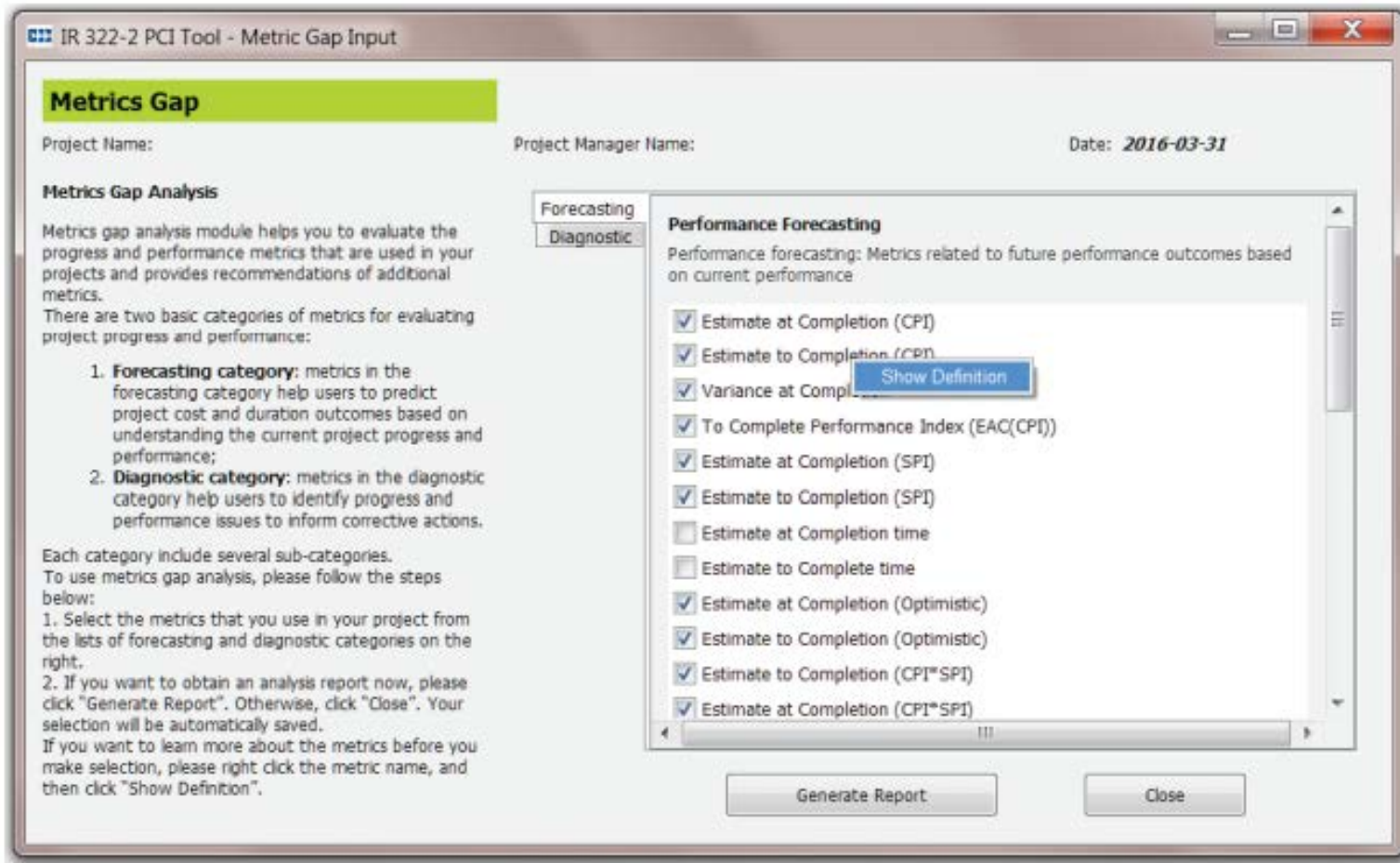
❖ For example, an organization's project control manager can use the Metrics Gap Analysis module to assess ways to make his or her company's performance assessment metrics more robust.

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Input Interface

- ❑ On the **User Input page** of this module, **instructions** are provided on the **left section of the window**. (See Figure 8.)
- ❑ These **instructions** include definitions related to **different metrics classifications**, as well as **step-by-step explanations** of how the module works.
- ❑ On this page, the user needs to specify the metrics currently used by the project (or company), for both the Forecasting and Diagnostic categories (as defined in Chapter 2.)
- ❑ For each classification, **metrics are listed** under **different categories**.

Input Interface



IR 322-2 PCI Tool - Metric Gap Input

Metrics Gap

Project Name: _____ Project Manager Name: _____ Date: **2016-03-31**

Metrics Gap Analysis

Metrics gap analysis module helps you to evaluate the progress and performance metrics that are used in your projects and provides recommendations of additional metrics.

There are two basic categories of metrics for evaluating project progress and performance:

- Forecasting category:** metrics in the forecasting category help users to predict project cost and duration outcomes based on understanding the current project progress and performance;
- Diagnostic category:** metrics in the diagnostic category help users to identify progress and performance issues to inform corrective actions.

Each category include several sub-categories.
To use metrics gap analysis, please follow the steps below:

- Select the metrics that you use in your project from the lists of forecasting and diagnostic categories on the right.
- If you want to obtain an analysis report now, please click "Generate Report". Otherwise, click "Close". Your selection will be automatically saved.

If you want to learn more about the metrics before you make selection, please right click the metric name, and then click "Show Definition".

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 [Show Definition](#)
- ☒ 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)

Generate Report **Close**

Figure 8. Input Interface of Metrics Gap Analysis Module

Input Interface

- ☐ If the user is **not familiar** with any of the **metrics**, he or she can **right-click** on its **name** to read its definition. (See **Figure 9**.)
- ☐ After selecting metrics, the user can click on “**Generate Report**” and view the **gap analysis output**.

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Input Interface

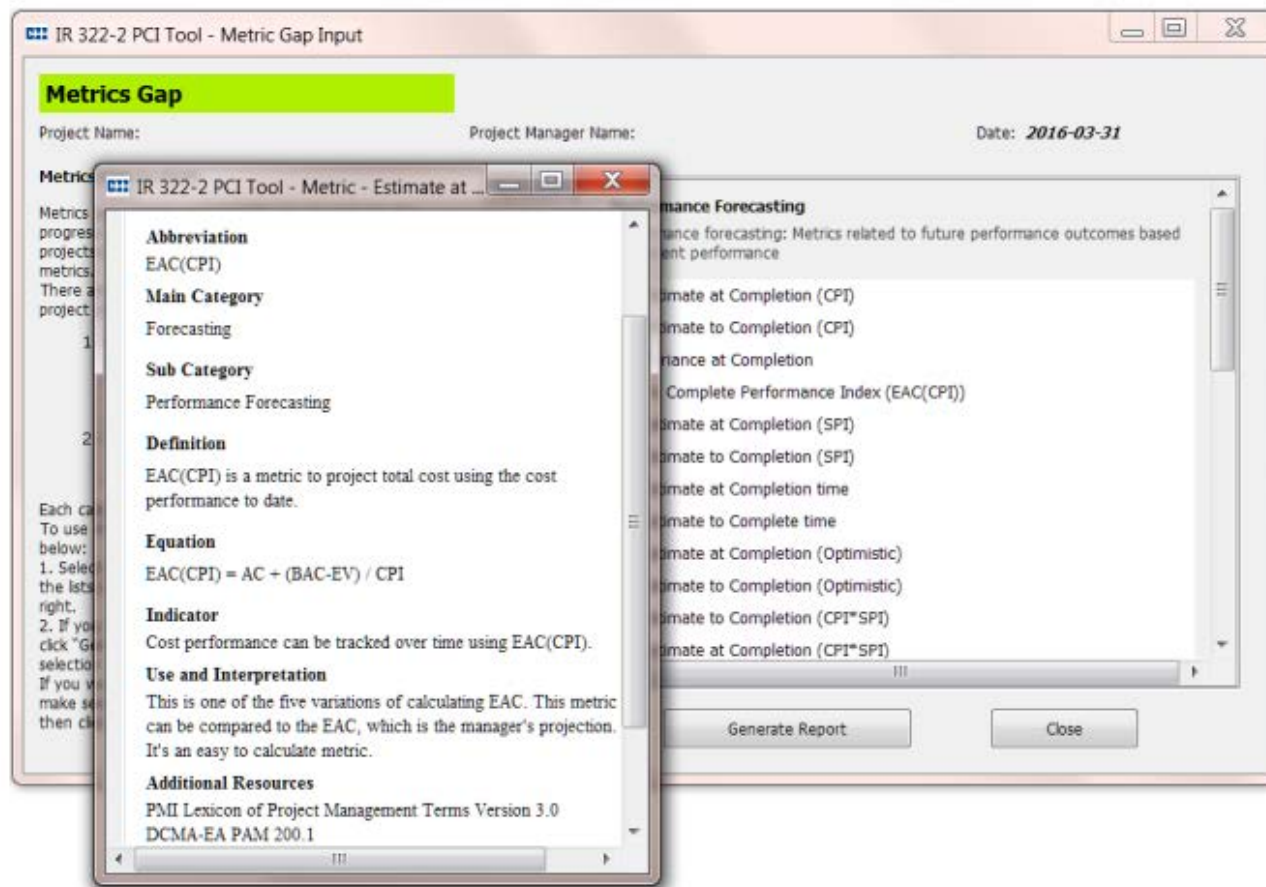


Figure 9. Definition Window for a Selected Metric within the Metrics Gap Analysis Module

Output Interface

- ☐ The **output interface** of the **Metrics Gap Analysis** module has several components.
- ☐ In the top section of the Output page, the module offers definitions for different categories of metrics (i.e., Core, Validation, Innovative, and Other Significant Metrics).
- ☐ These definitions can guide the user to **better interpret** the analysis output results.

Output Interface

- ❑ The tool provides **separate gap analysis output** results for Forecasting and Diagnostic metrics.
- ❑ The user can view these reports by **selecting the tabs** for Forecasting and Diagnostic metrics at the top of the report page, located under the definitions.
(**Figure 10** shows the Forecasting Metrics tab and **Figure 11** shows the Diagnostic Metrics tab.)
- ❑ The output results give the user an **overall assessment** related to the use of Core Forecasting and Diagnostic metrics.
- ❑ For example, in the project outputs displayed in Figures 10 and 11, the results indicate that the **user's company** utilizes 72 percent of the **Core Forecasting Metrics**, and 66 percent of the **Core Diagnostic Metrics**.

Output Interface

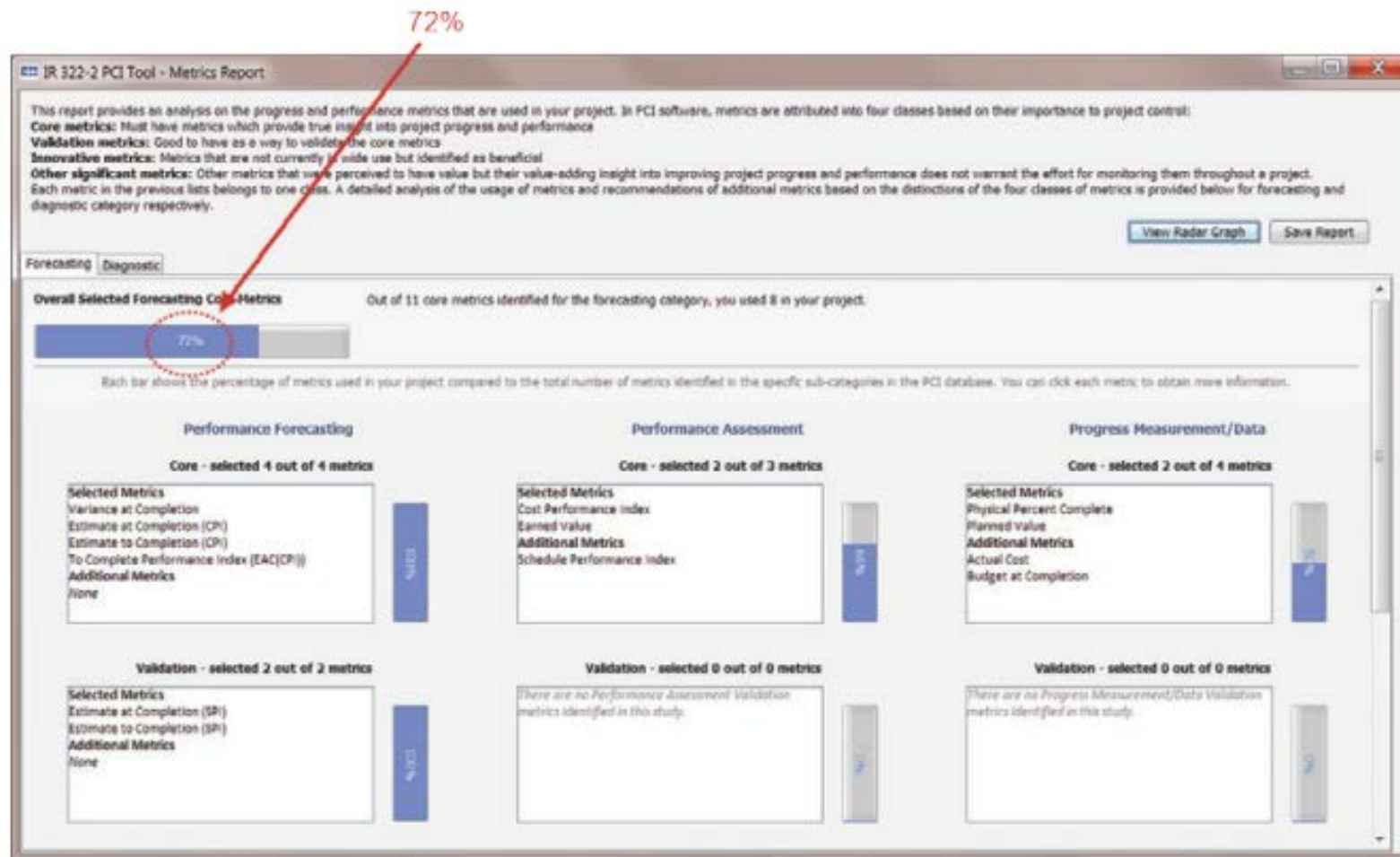


Figure 10. Metrics Gap Analysis Output Interface for Forecasting Metrics

Output Interface

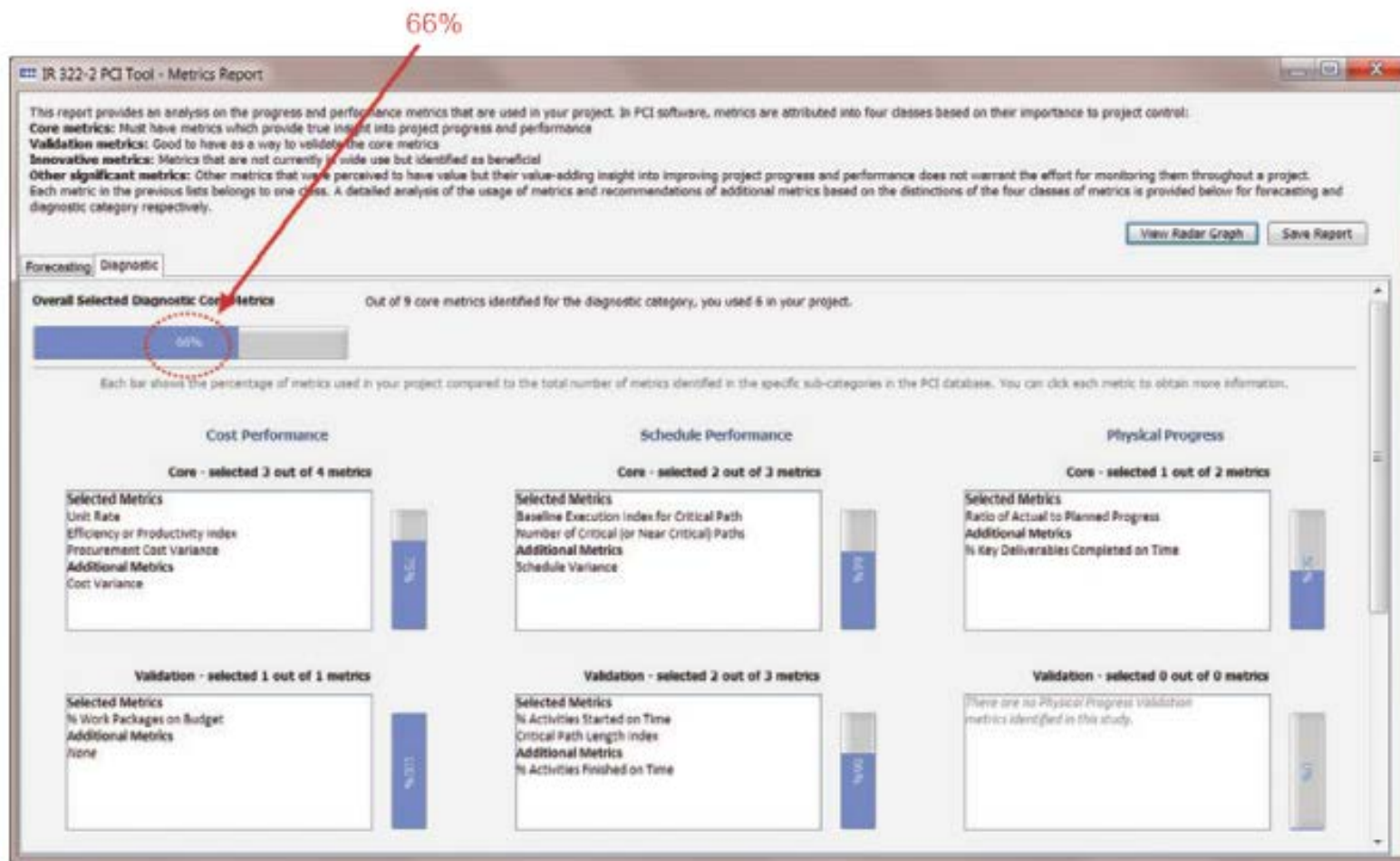


Figure 11. Metrics Gap Analysis Output Interface for Diagnostic Metrics

Output Interface

- ❑ **After reviewing** a project's **overall assessment** for Core metrics use, the user can view the detailed information provided in the **Output Results page** to identify possible additional metrics to consider for improving **current measurements** of project progress and performance.
- ❑ **Output results** include information related to the metrics that a project or company currently uses, as well as additional potential metrics for different categories.
- ❑ This detailed information enables users to specifically identify gaps in metrics usage and to better communicate required improvements to other team members.

Output Interface

- ❑ The radar diagram, another important component of the **Metrics Gap Analysis** module output, illustrates the usage of **Core metrics** (by percentage) for different categories of Forecasting and Diagnostic metrics.
- ❑ The **radar diagram** provides a useful visual means of identifying the gaps in a company or project's current practices.
- ❑ For example, the demonstration radar diagram in **Figure 12** indicates that improvements could be made in the use of Core metrics in the Schedule Performance, Cost Performance, and Physical Progress categories of Diagnostic metrics.
- ❑ The radar diagram can be **saved and used** in company and project reports, and in other documents.

Output Interface

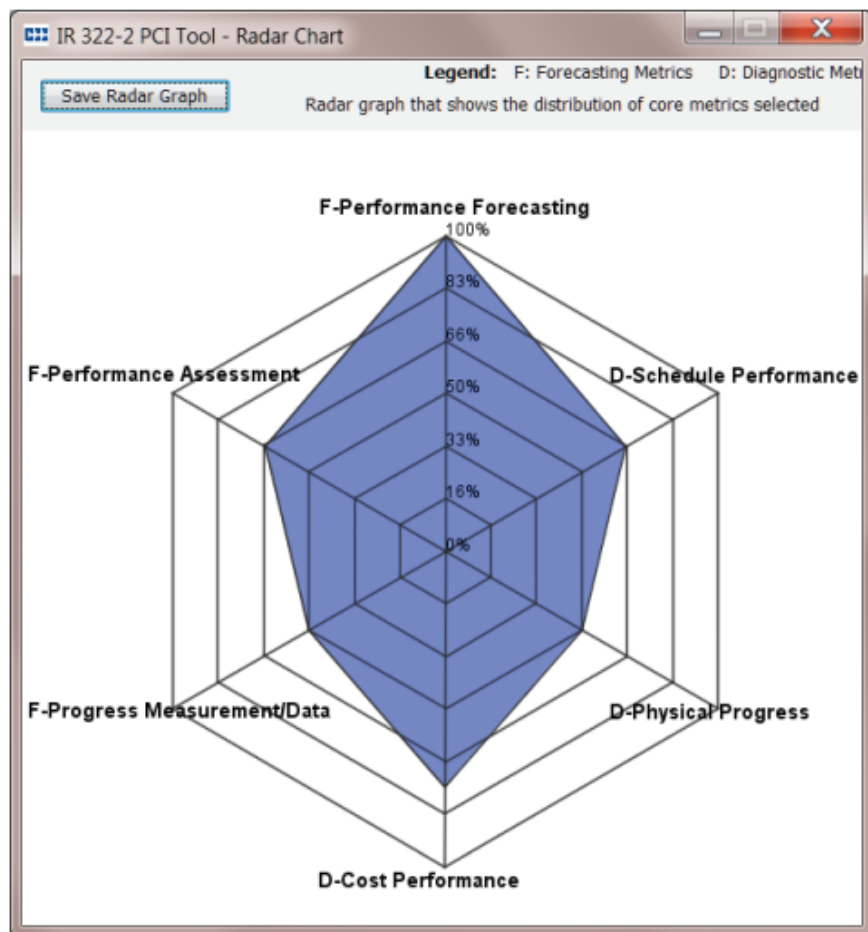


Figure 12. Radar Diagram for Core Metrics Gap Analysis
F: Forecasting Metrics; D: Diagnostic Metrics

Metrics Gap Analysis Report

- ❑ Users can save the Metrics Gap Analysis output as a **PDF file** and **print** or **share** it with the project team and other divisions of their company. (See **Figure 13.**)
- ❑ The report includes the gap analysis results, suggestions for additional metrics, and definitions and equations for currently used and additional metrics.
- ❑ This report can serve many purposes. *For example, a **project control manager** could use the report to communicate needed improvements to a company's metrics system.*
- ❑ At a **project level**, **owners** can use the report to communicate monitoring and reporting **requirements**, for both Core metrics and any additional metrics that need to be implemented.

Metrics Gap Analysis Report



Figure 13. Snapshot of the Metrics Gap Analysis Report

User Guide

(Reliability Gap Analysis Module)

Reliability gap analysis module

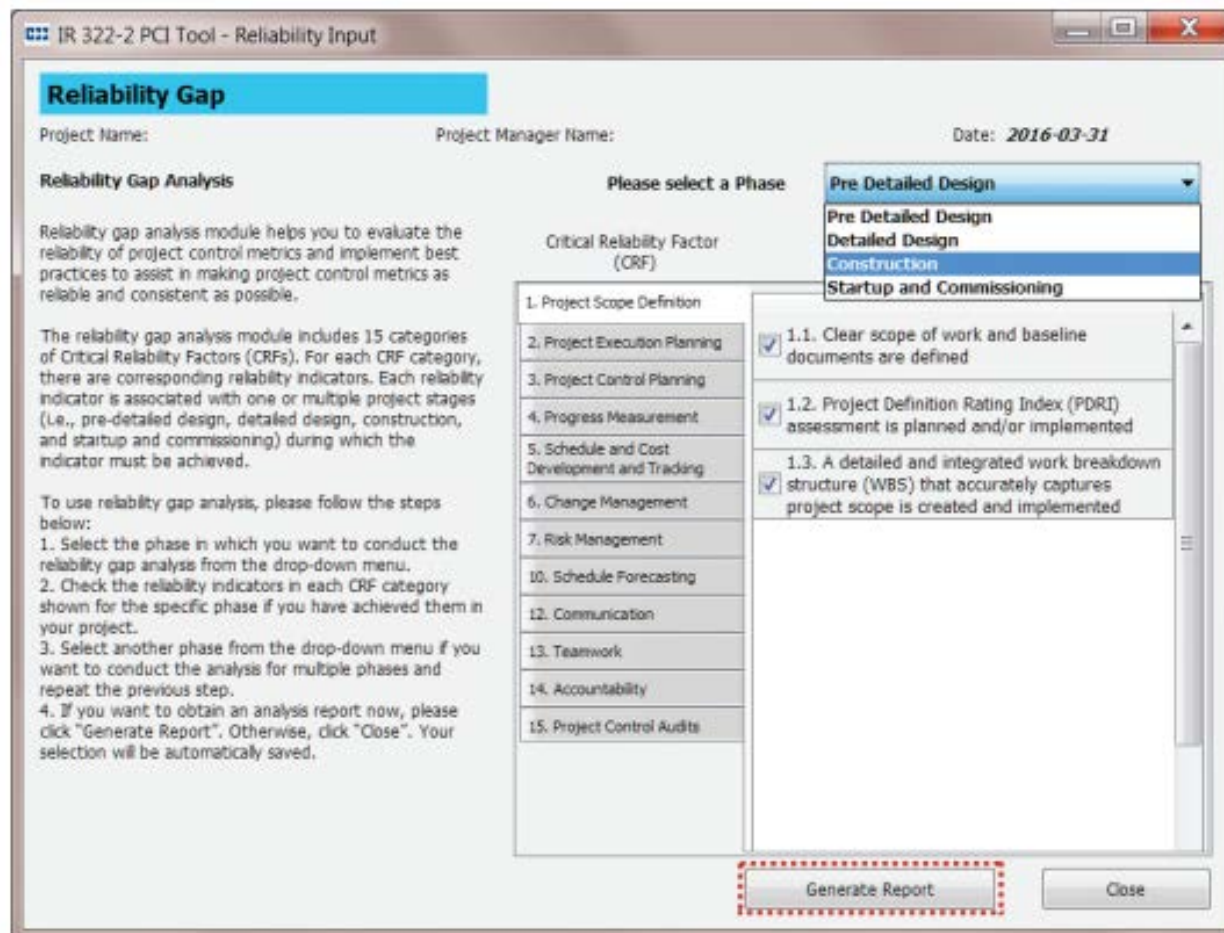
- ❑ The Reliability Gap Analysis module enables the user to **investigate reliability** gaps and required improvements for a **project or company's** progress and performance assessment metrics at **different project stages**.

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Input Interface

- ❑ Reliability Gap Analysis can be conducted for different project phases (i.e., pre-detailed design, detailed design, construction, or startup and commissioning).
- ❑ This feature enables the user to evaluate the Critical Reliability Factors and indicators related to each project phase in order to continually **assess reliability issues**.
- ❑ **Figure 14** illustrates an example input interface for the Reliability Gap Analysis module.
- ❑ The **instructions** for the analysis steps are provided in the **left section** of the input interface.
- ❑ **After selecting** a project phase for analysis, the user can **review** the Critical Reliability Factors and indicators relevant to that specific project phase and determine which indicators have been achieved.
- ❑ After selecting the achieved reliability indicators, the user can click the “**Generate Report**” button in order to see the output results.

Input Interface



IR 322-2 PCI Tool - Reliability Input

Reliability Gap

Project Name: _____ Project Manager Name: _____ Date: 2016-03-31

Reliability Gap Analysis

Reliability gap analysis module helps you to evaluate the reliability of project control metrics and implement best practices to assist in making project control metrics as reliable and consistent as possible.

The reliability gap analysis module includes 15 categories of Critical Reliability Factors (CRFs). For each CRF category, there are corresponding reliability indicators. Each reliability indicator is associated with one or multiple project stages (i.e., pre-detailed design, detailed design, construction, and startup and commissioning) during which the indicator must be achieved.

To use reliability gap analysis, please follow the steps below:

1. Select the phase in which you want to conduct the reliability gap analysis from the drop-down menu.
2. Check the reliability indicators in each CRF category shown for the specific phase if you have achieved them in your project.
3. Select another phase from the drop-down menu if you want to conduct the analysis for multiple phases and repeat the previous step.
4. If you want to obtain an analysis report now, please click "Generate Report". Otherwise, click "Close". Your selection will be automatically saved.

Please select a Phase

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

10. Schedule Forecasting

12. Communication

13. Teamwork

14. Accountability

15. Project Control Audits

Pre Detailed Design
Pre Detailed Design
Detailed Design
Construction
Startup and Commissioning

1.1. Clear scope of work and baseline documents are defined

1.2. Project Definition Rating Index (PDRI) assessment is planned and/or implemented

1.3. A detailed and integrated work breakdown structure (WBS) that accurately captures project scope is created and implemented

Generate Report

Close

Figure 14. Reliability Gap Analysis Module Input Interface

Output Interface

- ❑ **Figure 15** shows an example of the output interface for the **Reliability Gap Analysis** module.
- ❑ At the **top** of the output interface, the user can **read explanations** regarding how to use the output results.
- ❑ The user can then select the **project phase** for which the analysis is conducted and view the **reliability gap** results.
- ❑ For example, **Figure 15** details analysis results for a project's construction phase.

Output Interface

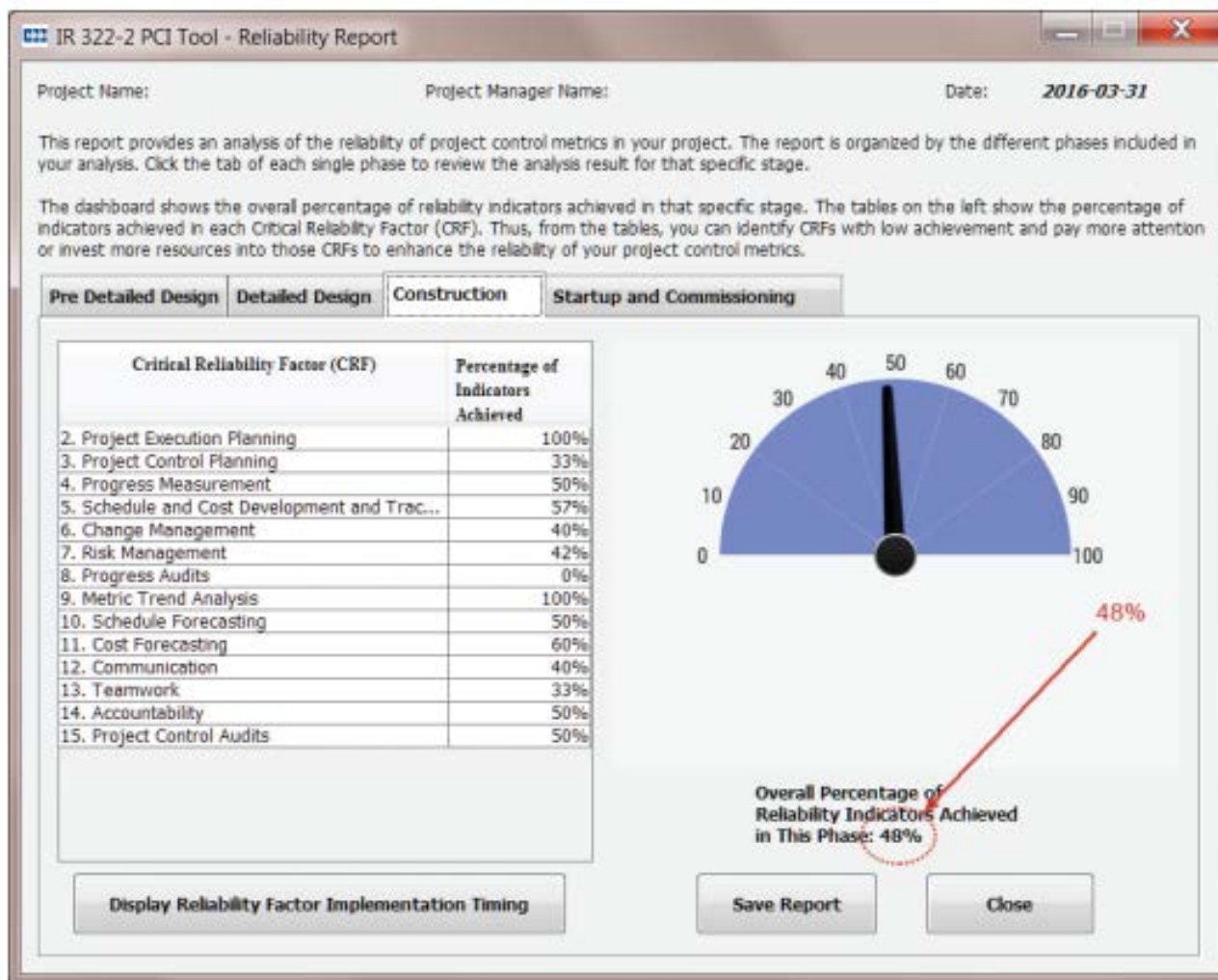


Figure 15. Output Interface of the Reliability Gap Analysis Module

Output Interface

- ❑ The results for each project phase include **two outputs**:
 - ❖ An **overall score** for achievement of Critical Reliability Factors and indicators –
 - ✓ The **overall score** indicates level of achievement for reliability indicators relevant to a specific project phase.
 - ✓ For example, in the demonstration results shown in **Figure 15**, the project team received an overall score of **42 percent** for Reliability Indicators.
 - ✓ This result informs the project team that they could **do more** to improve the **reliability** of their project control metrics.

Output Interface

- ❑ The results for each project phase include two outputs:
 - ❖ A **percentage score** for each Critical Reliability Factor –
 - ✓ In order to identify which Critical Reliability Factors (CRFs) need improvement, users can review the results achieved by specific indicators in each CRF category.

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Output Interface

- ❑ The results for each project phase include two outputs:
 - ❖ A **percentage score** for each Critical Reliability Factor –
 - ✓ Looking at the same example in Figure 15, the project team needs to take action in the areas of Progress Audits, Schedule Forecasting, and Communication, since the achievement percentage for each of these categories is 0 percent.

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Output Interface

- ❑ The results for each project phase include two outputs:
 - ❖ A **percentage score** for each Critical Reliability Factor –
 - ✓ After users identify the CRFs that need improvement, they can click on the “Display Reliability Factor Implementation Timing” button in the lower left corner (see Figure 15) to access a guide that shows implementation timing recommendations for the reliability indicators in a specific project phase. (See Figure 16.)
 - ✓ Users can then plan accordingly to deploy the reliability indicators missing from their current practice.

Output Interface

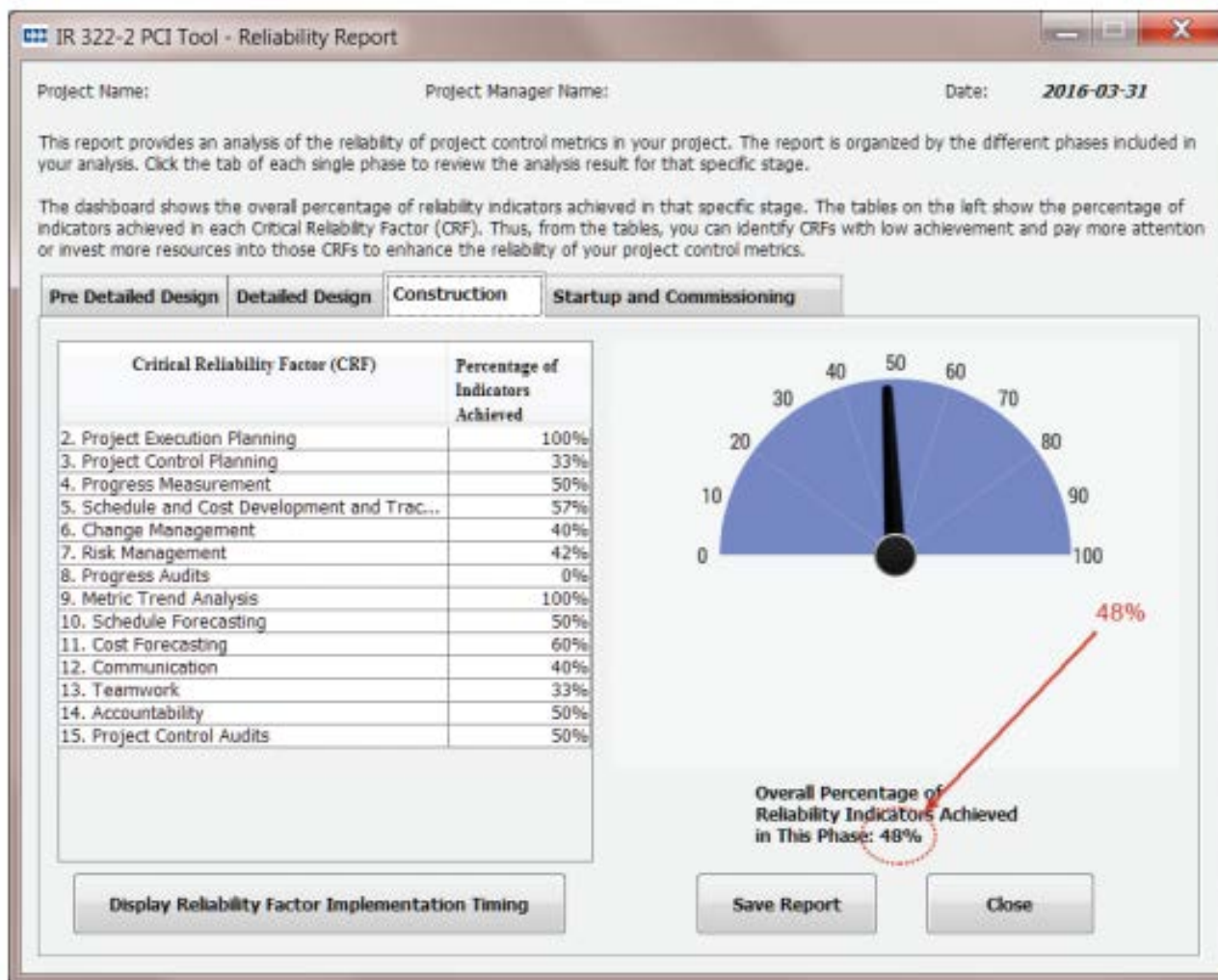


Figure 15. Output Interface of the Reliability Gap Analysis Module

Output Interface

Reliability Improvement Checklist Construction Phase											
Project Control Critical Reliability Factor (CRF)	Indicator of CRF Achievement	CRF Achievement Check Point						Notes			
		Construction									
		PR	B	D	E	PO					
1. Project Scope Definition	1.1. Clear scope of work and baseline documents are defined										
	1.2. Project Definition Rating Index (PDRI) assessment is planned and/or implemented										
	1.3. A detailed and integrated work breakdown structure (WBS) that accurately captures project scope is created and implemented										
2. Project Execution Planning	2.1. Project organizational chart is developed and maintained										
	2.2. Detailed execution and labor contracting strategies are created, maintained, and communicated to all stakeholders										
	2.3. Project execution plan adequately addresses project scope										
	2.4. Priority between cost and schedule are defined										
	2.5. The project organizational chart includes all the positions listed and associated roles and responsibilities are defined clearly										
3. Project Control Planning	3.1. Metrics and their thresholds are determined based on project characteristics (e.g., size, type, and complexity)										
	3.2. Metrics are aligned with contractual requirements										
	3.3. The quality and detail requirements of the schedule is defined										
	3.4. Project control plan defines reporting requirements										
	3.5. The commercial and technical subelements are aligned with project delivery requirements										
4. Progress Measurement	4.1. Rules of credit for project deliverables are defined to provide accurate progress measurement										
	4.2. Consistent rules of credit are tied to tangible deliverables to provide accurate progress measurement										
	4.3. Level of effort and percent complete are aligned for project deliverables										
	4.4. Discipline-specific and trade-specific rules of credit are used consistently										
	4.5. Discipline-specific quantity-based commodity curves are used										
	4.6. Commodity curves based on project schedule are used										
5. Schedule and Cost Development and Tracking	5.1. A detailed resource-loaded schedule (including quantities, man-hours, and productivity rates) for all WBS work packages is developed										
	5.2. Key project deliverables are identified and updated the different phases										
	5.3. Milestones are defined at the appropriate level for the project schedule										
	5.4. Project milestones are tied to critical path activities										
	5.5. Third party or peer reviews are conducted to ensure schedule quality										
	5.6. Baseline schedule is developed without contingency										
	5.7. The original budget is set to align with project control estimate										
	5.8. Project progress is periodically evaluated with respect to both forecasted completion date and physical progress of work packages										
	5.9. Cost curves are aligned with the schedule of expenditures (i.e., cost and schedule are integrated)										
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 * Indicates scoring prior to Pre-Detailed Design phase are mostly programming requirements that must be done prior to request approval/authorization.											

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

* Indicates scoring prior to Pre-Detailed Design phase are mostly programming requirements that must be done prior to project approval/authorization.

Figure 16. Snapshot of Reliability Indicator Implementation Timing Recommendations

Reliability Gap Analysis Report

- ❑ Users can save the output of the Reliability Gap Analysis as a PDF file, and then print it or share it with the project team and other company divisions. (See **Figure 17.**)
- ❑ The report includes the **overall reliability scores** for a specific phase, the **percentage** of reliability indicators **achieved** for different factors, **suggestions** for reliability improvement, and **implementation timing recommendations** for reliability indicators.
- ❑ This report can be used by different stakeholders for various purposes.
 - ❑ *For example, a project manager can use the report to communicate with the team any improvements needed to enhance the reliability of current project control practices.*
- ❑ At the company level, global project control managers can use the report to communicate requirements for enhancing project control reliability across projects.

Reliability Gap Analysis Report

Project Name:

Project Manager:

Creation Date: 2016-03-31

RELIABILITY GAP ANALYSIS REPORT

This report provides an analysis of the reliability of project control metrics in your project. The report is organized by the different phases included in your analysis. Click the tab of each single phase to review the analysis result for that specific stage.

The dashboard shows the overall percentage of reliability indicators achieved in that specific stage. The tables on the left show the percentage of indicators achieved in each Critical Reliability Factor (CRF). Thus, from the tables, you can identify CRFs with low achievement and pay more attention or invest more resources into those CRFs to enhance the reliability of your project control metrics.

Construction Phase

Critical Reliability Factor	Percentage of Indicators Achieved
2. Project Execution Planning	100%
3. Project Control Planning	33%
4. Progress Measurement	50%
5. Schedule and Cost Development and Tracking	57%
6. Change Management	40%
7. Risk Management	42%
8. Progress Audits	0%
9. Metric Trend Analysis	100%
10. Schedule Forecasting	50%
11. Cost Forecasting	60%
12. Communication	40%
13. Teamwork	33%
14. Accountability	50%
15. Project Control Audits	50%



Overall Percentage of Reliability Indicators Achieved in This Phase: 48%

Recommended for Reliability Improvement

Reliability Gap Analysis Report

3. Project Control Planning

3.1. Metrics and their thresholds are determined based on project characteristics (e.g., size, type, and complexity)

3.2. Metrics are aligned with contractual requirements

4. Progress Measurement

4.2. Consistent rules of credit are tied to tangible deliverables to provide accurate progress measurement

4.3. Level of effort and percent complete are aligned for project deliverables

4.4. Discipline-specific and trade-specific rules of credit are used consistently

5. Schedule and Cost Development and Tracking

5.3. Milestones are defined at the appropriate level for the project schedule

5.4. Project milestones are tied to critical path activities

Figure 17. Snapshot of the Reliability Gap Analysis Report

User Guide

(Metrics Dictionary and Maps)

Metrics dictionary and maps

- ❑ The **Metrics Dictionary and Maps** provide users with a resource to **access more information** about the metrics offered by the PCI Tool. (See **Figure 18**.)
- ❑ At the top of the page, the user can read instructions about the elements of the dictionary.
- ❑ By using the **search box**, the user can **locate metrics** by name.
- ❑ Metrics information can also be filtered by category and classification.
 - ❖ *For example, if a user wants to look up Core Forecasting metrics, he or she can select the “Forecasting” and “Core” options of the dictionary and click the search button, presenting all filtered results. (See Figure 19.)*

Metrics dictionary and maps

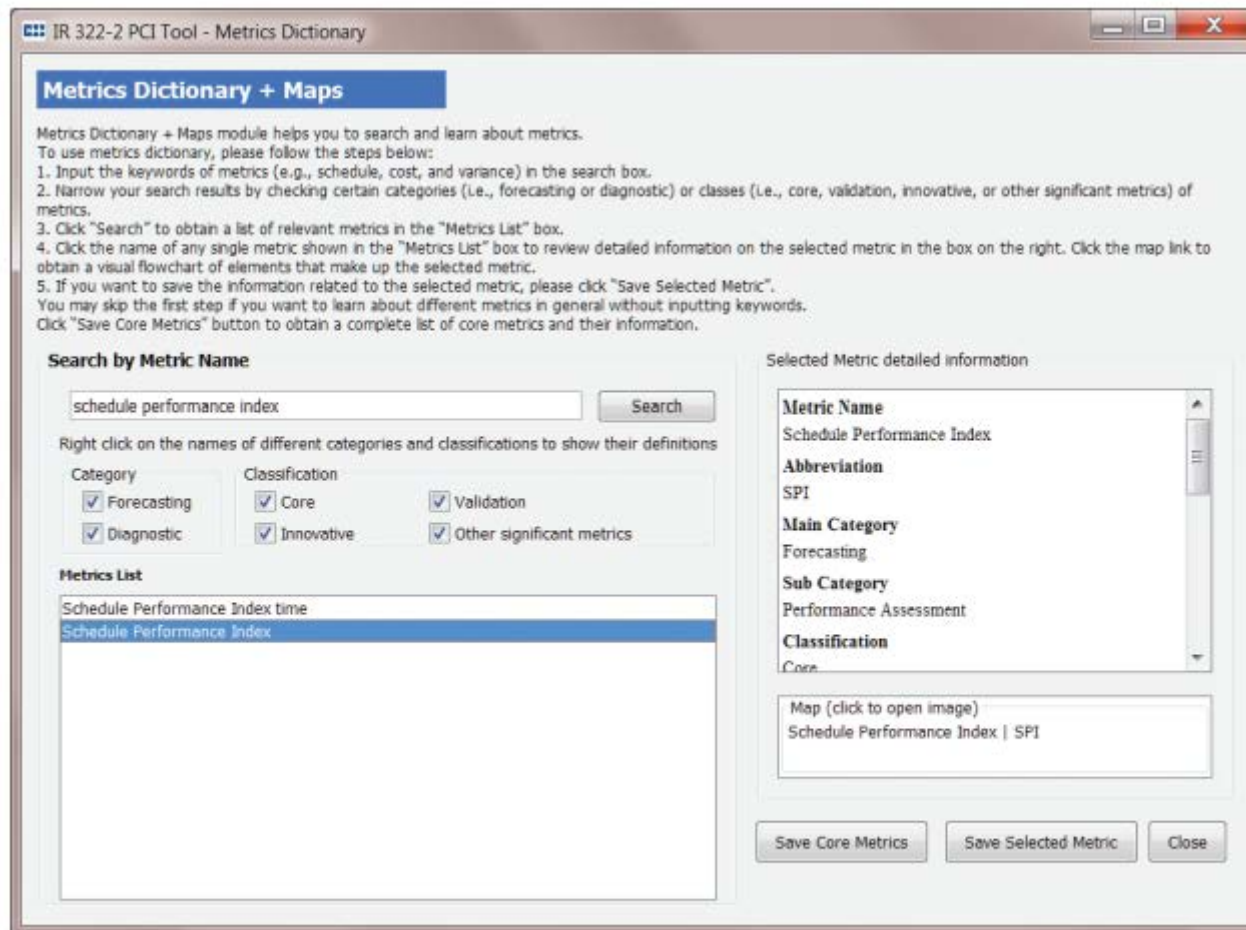


Figure 18. Metrics Dictionary and Maps: Searching for a Metric

Metrics dictionary and maps

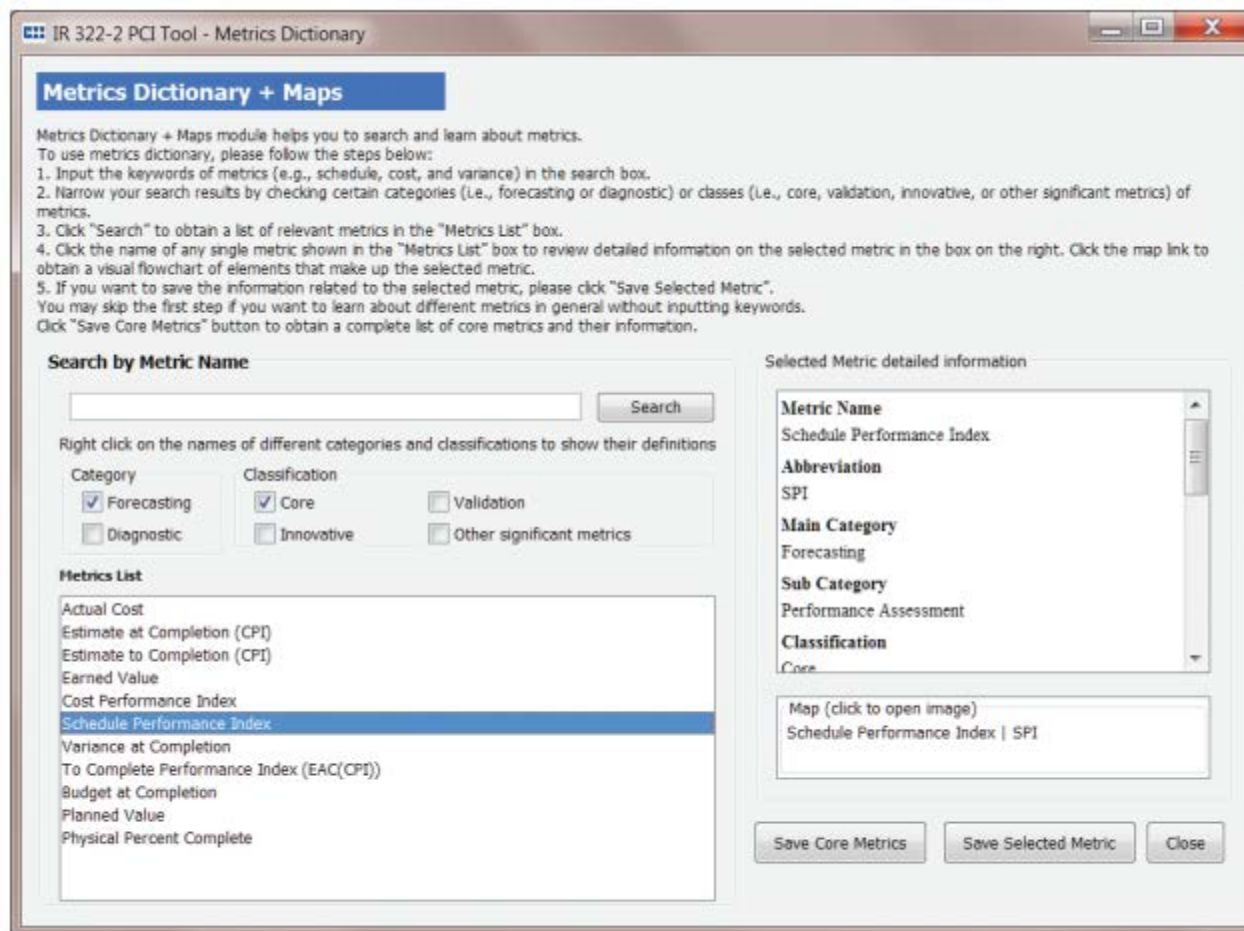


Figure 19. Filtering Metrics by Classification and Category

Metrics dictionary and maps

- ❑ When the user has found the **intended metric**, he or she can select the metric's name to bring up detailed information associated with that metric in the right pane, including its definition, equation, use and interpretation, indicators, and any additional references for **learning more** about that metric.
(See **Figure 20**.)
- ❑ Also, the user can **access** the **metric map** to see the data and information used in **calculating that metric**. (See **Figure 21**.)
- ❑ Each metric map demonstrates in **greater detail** how that metric was calculated by using other metrics (or data points).
- ❑ An **understanding** of these relationships is invaluable for all project stakeholders from **all levels**.

Metrics dictionary and maps

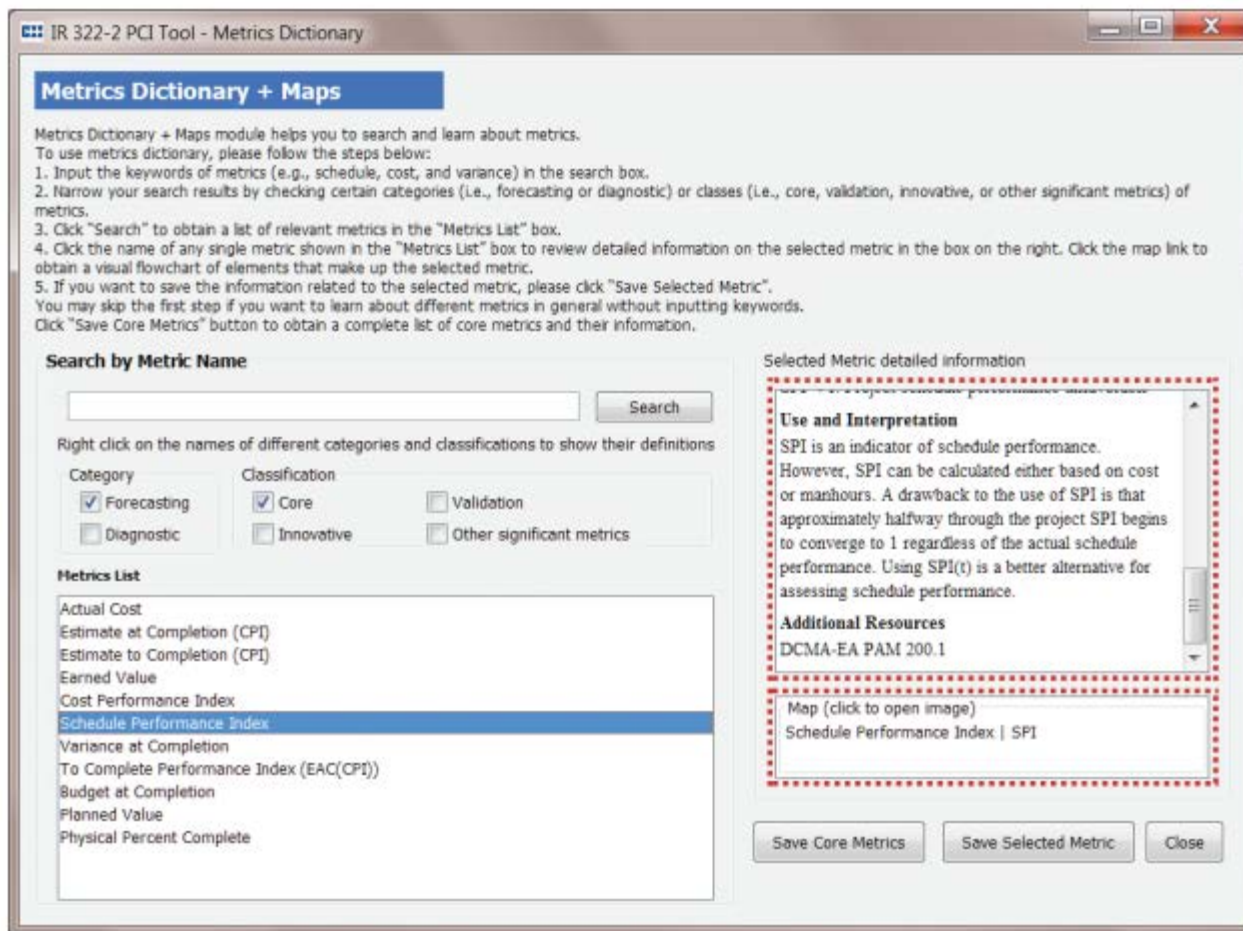


Figure 20. Detailed Information for a Selected Metric

Metrics dictionary and maps

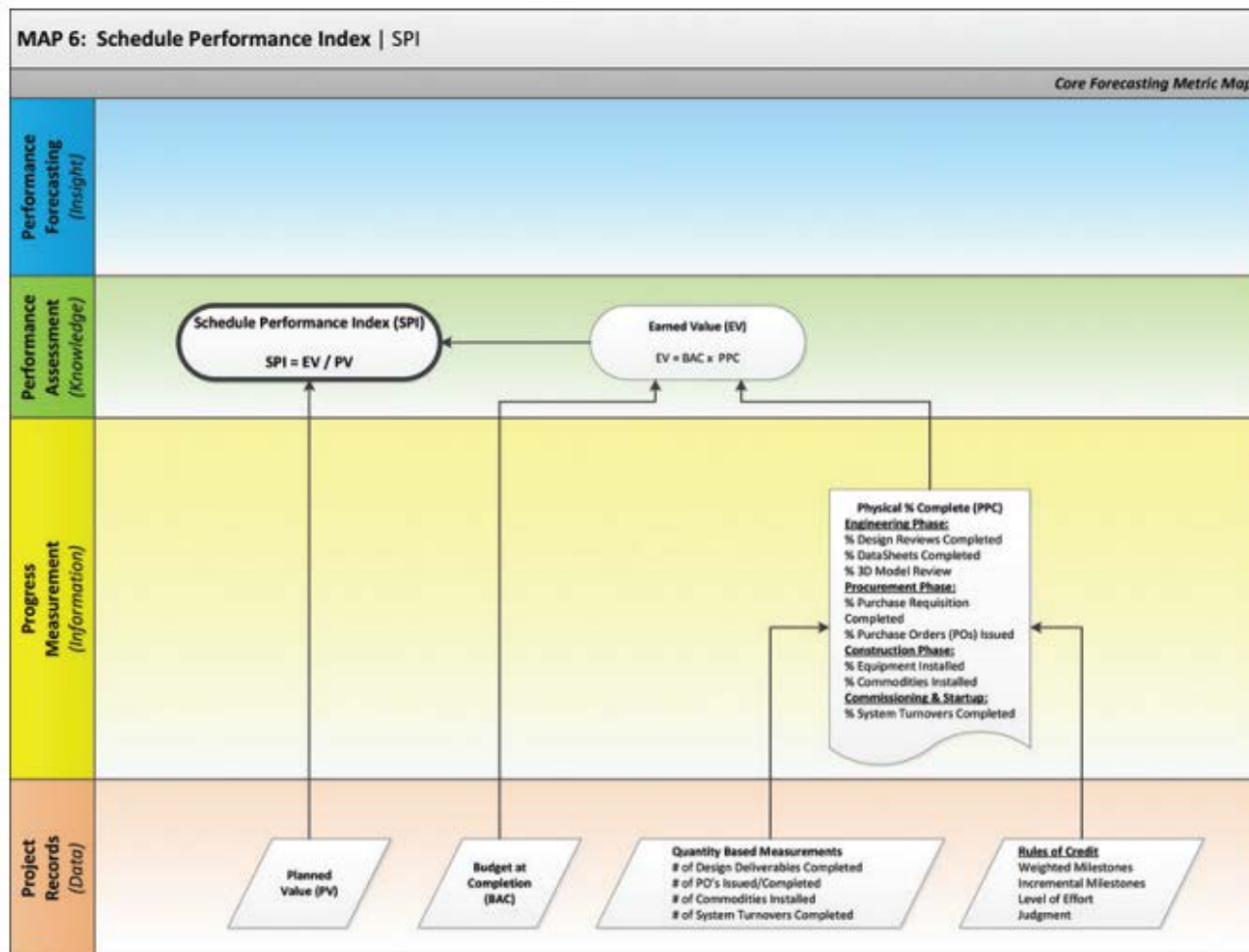


Figure 21. Metric Map for a Selected Metric in the Dictionary

Accessing the Core Metrics List

- ☐ The user can **directly access** a list of **Core metrics** (both Forecasting and Diagnostic) by clicking the “Save Core Metrics” button (shown enclosed in a dashed red line in Figure 22.).
- ☐ Clicking this button opens a PDF file that contains all information related to Core metrics.
- ☐ This file can be saved or printed for future reference.

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Accessing the Core Metrics List

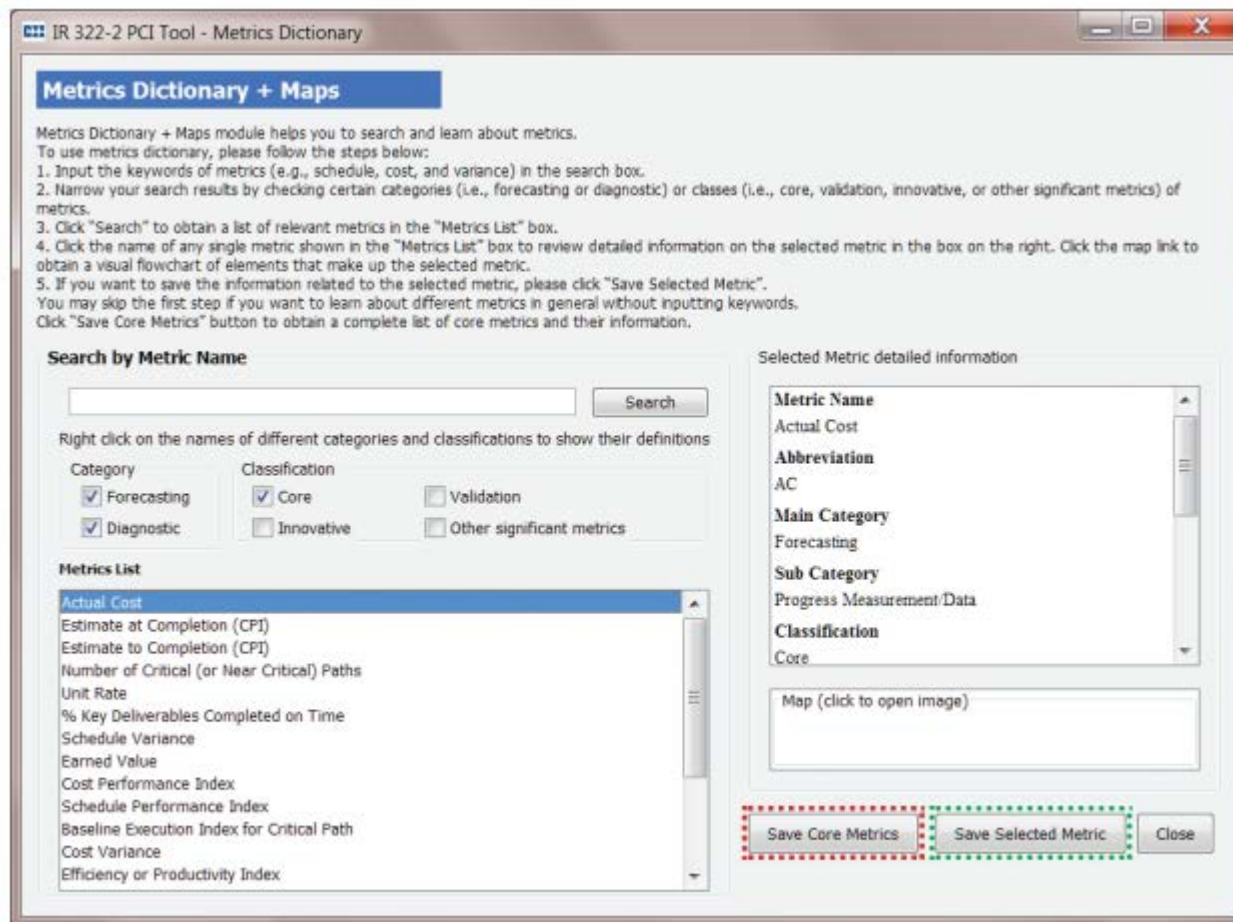


Figure 22. Core Metrics List Accessed from the Dictionary

Saving Metric Information

- ☐ The Metrics Dictionary enables the user to save information related to a specific metric, sharing it with others or **printing** it for **future reference**.
- ☐ By clicking the “**Save Selected Metric**” button (shown enclosed in a **dashed green line** in **Figure 22**), the user can select a destination for saving the PDF file that contains this metric information. (See **Figure 23**.)

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Saving Metric Information

Actual Cost

Metric Information

TITLE	DESCRIPTION
CLASSIFICATION	Core
CATEGORY	Forecasting
SUBCATEGORY	Progress Measurement/Data
DEFINITION	The actual cost of the work determined by the paid costs to date and accruals.
EQUATION	$AC = \text{Paid Costs (PC)} + \text{Accruals}$
INDICATOR	
INTERPRETATION	The actual cost reported by the project control group may be more current and complete than that reported by accounting.
REFERENCE	
ADDITIONAL RESOURCES	
ACRONYM	AC

Figure 23. Metric Information Saved as a PDF File

User Guide

(Project Controls Utilities)

Project Controls Utilities

- ❑ The **Project Controls Utilities** module includes two elements:
 1. a Core Metrics Directory and
 2. a Reliability Improvement Checklist.
- ❑ Users can **access the utilities** for project control **metrics** and **reliability improvement** by clicking their respective buttons. (See Figure 24.)
- ❑ Users can **save both** the Core Metrics Directory and Reliability Improvement Checklist **outside** the PCI Tool and use them for **training** and **communication** purposes.

Project Controls Utilities



Figure 24. Project Control Utilities Page

Core Metrics Directory

- ☐ The **Core Metrics Directory** is a spreadsheet composed of **information related to**
metrics, definitions, equations, classifications, and their use and interpretation, as well as metrics maps.
- ☐ A **complete list of metrics maps** can be downloaded from the **Project Control Utilities page**. (See **Figure 24**.)

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Core Metrics Directory

- ❑ The **Core Metrics Directory** has **several novel features**.
- ❑ First, the tool provides a categorization system that **distinguishes metrics** based on their
 1. role (i.e., Forecasting versus Diagnostic) and
 2. level of importance (i.e., Core versus Significant).
- ❑ Also, the **Core Metrics Directory** provides **guidelines** for
 1. project control metrics and
 2. their intended uses, formulae, and indicators to improve measurement standardization. (See Figure 25.)

Core Metrics Directory

Classification	Category	Name	Definition	Equation	Indicator	Use and Interpretation	Map ID *																						Reference	Additional Sources
							1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22		
Core Metrics	Performance Forecasting	Variance at Completion VAC	EAC(CPI) is a metric to project total cost using the cost performance to date.	$VAC = BAC - EAC(CPI)$	$VAC > 0$ The project is under budget; $VAC = 0$ The project is on budget; $VAC < 0$ The project is over budget.	VAC could be used in trending analysis for forecasting purposes. It can be used to communicate cost status of the project to senior management.	X																						PMI Lexicon of Project Management Terms Version 3.0	
		Estimate at Completion EAC(CPI)	EAC(CPI) is a metric to project total cost using the cost performance to date.	$EAC(CPI) = AC + (BAC - EV) / CPI$	Cost performance can be tracked over time using EAC(CPI).	This is one of the five variations of calculating EAC. This metric can be compared to the EAC, which is the manager's projection. It is an easy to calculate metric.		X																					A Guide to Managing Programs Using Predictive Measures (NDIA, 2014)	PMI Lexicon of Project Management Terms Version 3.0 DCMA-EA PAM 200.1
		Estimate to Completion ETC(CPI)	The expected cost to finish all the remaining project work.	$ETC(CPI) = (BAC - EV) / CPI$		This is one of the five variations of calculating ETC. A common practice is to use ETC personally during the life of project. ETC may be compared to project manager's estimate.			X																				PMI Lexicon of Project Management Terms Version 3.0	DCMA-EA PAM 200
		To Complete Performance Index EAC(CPI)/ETC(CPI) TCPI(EAC(CPI))	A measure of the cost performance that is achieved with the remaining resources in order to meet a specified management goal, expressed as the ratio of the cost to finish the outstanding work to the remaining budget.	$TCPI_EAC(CPI) = (BAC - EV) / (EAC(CPI) - AC)$	$TCPI_EAC(CPI) \leq 1$: Cost objective achievable; $TCPI_EAC(CPI) > 1$: Cost objective (EAC) becomes more difficult to achieve	TCPI is the future cost performance required to finish the project within EAC. TCPI is a check index for ETC which is used to validate whether or not the estimate to complete can be achieved. Once ETC and EAC are calculated, calculate TCPI to determine whether the EAC is reasonably achievable.				X																			PMI Lexicon of Project Management Terms Version 3.0	DCMA-EA PAM 200
	Performance Assessment	Cost Performance Index CPI	A measure of the cost efficiency of budgeted resources expressed as a ratio of earned value to actual cost.	$CPI = EV / AC$	$CPI > 1$: Project cost performance favorable; $CPI = 1$: Project cost performance on track; $CPI < 1$: Project cost performance unfavorable.	CPI is an indicator of cost performance. However, CPI can be calculated either based on cost or manhours.					X																		PMI Lexicon of Project Management Terms Version 3.0	DCMA-EA PAM 200
		Schedule Performance Index SPI	A measure of schedule efficiency expressed as the ratio of earned value to planned value.	$SPI = EV / PV$	$SPI > 1$: Project schedule performance favorable; $SPI = 1$: Project schedule performance on track; $SPI < 1$: Project schedule performance unfavorable.	SPI is an indicator of schedule performance. However, SPI can be calculated either based on cost or manhours. A drawback to the use of SPI is that approximately halfway through the project SPI begins to converge to 1 regardless of the actual schedule performance. Using SPI(2) is a better alternative for assessing schedule performance.						X																PMI Lexicon of Project Management Terms Version 3.0	DCMA-EA PAM 200	
		Earned Value EV	The measure of work performed expressed in terms of the budget authorized for that work.	$EV = BAC \times \text{Physical \% Complete}$	$EV > PV$: Project cost performance favorable; $EV = PV$: Project cost performance on track; $EV < PV$: Project cost performance unfavorable.	Accurately measuring physical progress is critical in calculating EV. However, earned value makes no distinction between a critical quantity and a non-critical quantity. Therefore, EV may not be closely tied to achievement of critical path.							X															PMI Lexicon of Project Management Terms Version 3.0		
	Progress Measurement Data	Physical Percent Complete PPC	Represents the amount of work performed as a percent of the total physical work required.		$PPC \geq$ Planned percent complete: Project component is on track; $PPC <$ Planned percent complete: Project component is lagging.	Physical percent complete is based on Quantity Based Measurements, Milestones, or Other methods (e.g., Rules of Credit and Level of Effort). Accurately measuring physical progress is critical in calculating EV.							X																CII RT-322	
		Budget at Completion BAC	The sum of all budgets established for the work to be performed.			BAC must incorporate all approved changes.																							PMI Lexicon of Project Management Terms Version 3.0	
		Planned Value PV	The authorized budget assigned to scheduled work.			PV is also referred to as Budgeted Cost of Work Performed which is the sum of the performance budgets for all work scheduled to be accomplished in a given time period. This includes detailed work packages, Level of Effort (LOE) packages, approved effort, and planning packages. Typically represents cumulative to date values, unless some other time period is specified.																						PMI Lexicon of Project Management Terms Version 3.0	A Guide to Managing Programs Using Predictive Measures (NDIA, 2014)	
		Actual Cost AC	The actual cost of the work determined by the paid costs to date and accruals.	$AC = \text{Paid Costs (PC)} + \text{Accruals}$		The actual cost reported by the project control group may be more current and complete than that reported by accounting.																							PMI Lexicon of Project Management Terms Version 3.0	
								* The symbol "X" at the intersection of a column (Map ID number) and a row (Metric Name) denotes the map that depicts how the targeted metric on that row is generated by utilizing other metrics. The symbol "o" denotes the maps in which the metric was utilized for generating other metrics.																						

Figure 25. Screenshot of Core Metrics Directory Spreadsheet

Reliability Improvement Checklist

- ❑ The **Reliability Improvement Checklist** is a spreadsheet that includes information about 15 Critical Reliability Factors (CRFs), 83 reliability indicators, and their implementation timing in **different project phases**. (See **Figure 26**.)
- ❑ The **checklist's first column** shows the CRF categories, and its **second column** lists the reliability indicators associated with **each category**.
- ❑ The **remaining columns** present reliability indicator timing information for the **different project phases**, using **specific shapes** to mark the timing for **different indicators**, as explained in the legend.
- ❑ Each indicator is associated with **one or multiple project phases** (i.e., pre-detailed design, detailed design, construction, or startup and commissioning) during which the related **CRFs** and **indicators** must be **completed**.

Reliability Improvement Checklist

Project Control Critical Reliability Factor (CRF)	Indicator of CRF Achievement	CRF Achievement Check Point					Notes
		Pre-Detailed Design					
		PR*	B	D	E	PO	
1. Project Scope Definition	1.1. Clear scope of work and baseline documents are defined						
	1.2. Project Definition Rating Index (PDRD) assessment is planned and/or implemented						
	1.3. A detailed and integrated work breakdown structure (WBS) that accurately captures project scope is created and implemented						
2. Project Execution Planning	2.1. Project organizational chart is developed and maintained						
	2.2. Detailed execution and labor contracting strategies are created, maintained, and communicated to all stakeholders						
	2.3. Project execution plan adequately addresses project scope						
	2.4. Priority between cost and schedule are defined						
	2.5. The project organizational chart includes all the positions listed and associated roles and responsibilities are defined clearly						
3. Project Control Planning	3.1. Metrics and their thresholds are determined based on project characteristics (e.g., size, type, and complexity)						
	3.2. Metrics are aligned with contractual requirements						
	3.3. The quality and detail requirements of the schedule is defined						
	3.4. Project control plan defines reporting requirements						
	3.5. The commercial and technical milestones are aligned with project delivery requirements						
4. Progress Measurement	4.1. Rules of credit for project deliverables are defined to provide accurate progress measurement						
	4.2. Consistent rules of credit are tied to tangible deliverables to provide accurate progress measurement						
	4.3. Level of effort and percent complete are aligned for project deliverables						
	4.4. Discipline-specific and trade-specific rules of credit are used consistently						
	4.5. Discipline specific quantity-based commodity curves are used						
	4.6. Commodity curves based on project schedule are used						
5. Schedule and Cost Development and Tracking	5.1. A detailed resource-loaded schedule (including quantities, man-hours, and productivity rates) for all WBS work packages is developed						
	5.2. Key project deliverables are identified and updated for different phases						
	5.3. Milestones are defined at the appropriate level for the project schedule						
	5.4. Project milestones are tied to critical path activities						
	5.5. Third party or peer reviews are conducted to ensure schedule quality						
	5.6. Baseline schedule is developed without contingency						
	5.7. The original budget is set to align with project control estimate						
	5.8. Project progress is periodically evaluated with respect to both forecasted completion date and physical progress of work packages						
	5.9. Cost curves are aligned with the schedule of expenditures (i.e., cost and schedule are integrated)						

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.

Figure 26. Screenshot of Reliability Improvement Checklist

Use Cases

Use cases

- ❑ The PCI Tool is intended for use in a **team setting** to
 1. evaluate projects' progress and performance metrics,
 2. better assess their reliability, and
 3. establish a common understanding of metrics definitions and usage in the industry.
- ❑ This software was developed for a **wide range** of owner and contractor organizations, project types, and project phases.
- ❑ **Figure 27** gives examples for **PCI implementation**.

Who?	How?	When?
• Project managers • Project control managers • Project control specialists • Engineering managers • Cost engineers • Schedulers • Entry-level project control professionals	• Resource for project execution planning • Standardization of project control metrics • Improve communication	• Project planning • Project execution • Team training and alignment

Figure 27. Potential PCI Implementation Alternatives

Use cases

❑ **Endless combinations of possible use cases** can occur during projects; **however**, several potential future applications include the **following suggestions**:

❖ An **aid** for **project managers** and **control teams** to use **when developing project control execution plans** for a specific project

✓ Project managers and control teams **can refer to**

Core Metrics and Reliability Improvement Checklist

in the PCI Tool to develop their project control execution plans during the **front end planning phase**.

Use cases

- ❑ **Endless combinations of possible use cases** can occur during projects; **however**, several potential future applications include the **following suggestions**:
 - ❖ A **tracking document** for reliability improvement practices throughout a **project's lifecycle**
 - ✓ By using the **Reliability Gap Analysis** module of the PCI Tool, project managers and control teams can perform a **reliability gap analysis** at different **timepoints** during a project to **track the changes** (in percentage) of Critical Reliability Factors completed,
 1. confirm that **previously identified** areas for improvement have been **addressed**, and
 2. ensure **continuity** of the project's **reliability practices**.

Use cases

- ❑ **Endless combinations of possible use cases** can occur during projects; **however**, several potential future applications include the **following suggestions**:
 - ❖ A **training reference** for entry-level project controls professionals
 - ✓ Thanks to its **interactive software platform**, the PCI Tool encourages entry-level project professionals to engage with the material and offers information on metrics and reliability assessment in a **user-friendly format**.
 - *For example, the software's metrics maps provide visual demonstrations of the interrelationships between different metrics.*
 - ✓ This might be especially beneficial for those new to project controls, helping them to
 1. **learn more** about how each metric is constructed and
 2. **see** the connections among metrics, as **part of initial** training on project measurement and assessment.

Use cases

❑ **Endless combinations of possible use cases** can occur during projects;
however, several potential future applications include the **following suggestions**:

❖ An **owner's reference** for **formulating** project controls in contractual requirements

✓ An **owner organization** can use the practices recommended in the PCI Tool, such as Core metrics and Critical Reliability Factors,
to develop the **contractual requirements** for improved project controls.

Use cases

- ❑ **Endless combinations of possible use cases** can occur during projects; **however**, several potential future applications include the **following suggestions**:
 - ❖ A **benchmarking** basis for performance assessment metrics and reliability practices
 - ✓ The PCI Tool provides a tool for owners and contractors to **identify** Core metrics gaps and **conduct** project controls benchmarking across **various projects**.
 - ✓ In addition, its Reliability Gap Analysis module enables companies to **implement benchmarking** related to **percent reliability indicators** achieved across **different phases** on various projects.
 - ✓ Through **continuous benchmarking** using the PCI Tool, **companies** can **identify** their **own thresholds** related to Core metrics and note **which** **reliability indicator percentages** lead to **successful project outcomes**.

Examples of PCI Tool Use Cases

❑ Case #1:

- ❖ A **project controls manager** or **operations manager** receives feedback that the company's project controls do **not meet industry standards**.
- ❖ He wants to **determine how** project control metrics can be improved to **increase accountability**.

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Examples of PCI Tool Use Cases

❑ PCI Tool Use:

- ❖ In this case, the project controls manager can
 1. select the **Metrics Gap Analysis** module (**Figure 7**) and
 2. use the radar diagram (**Figure 12**)
to **identify gaps** in the company's current use of metrics.
- ❖ The manager can then
 1. **identify additional metrics** from the analysis results (**Figure 13**) and
 2. **incorporate** them into the **company's practices** by using
 - ✓ Core Metrics Directory,
 - ✓ Metrics Dictionary, and
 - ✓ Metrics Mapsto **train personnel** on the calculation, use, and interpretation of the additional metrics.

Module Selection Page

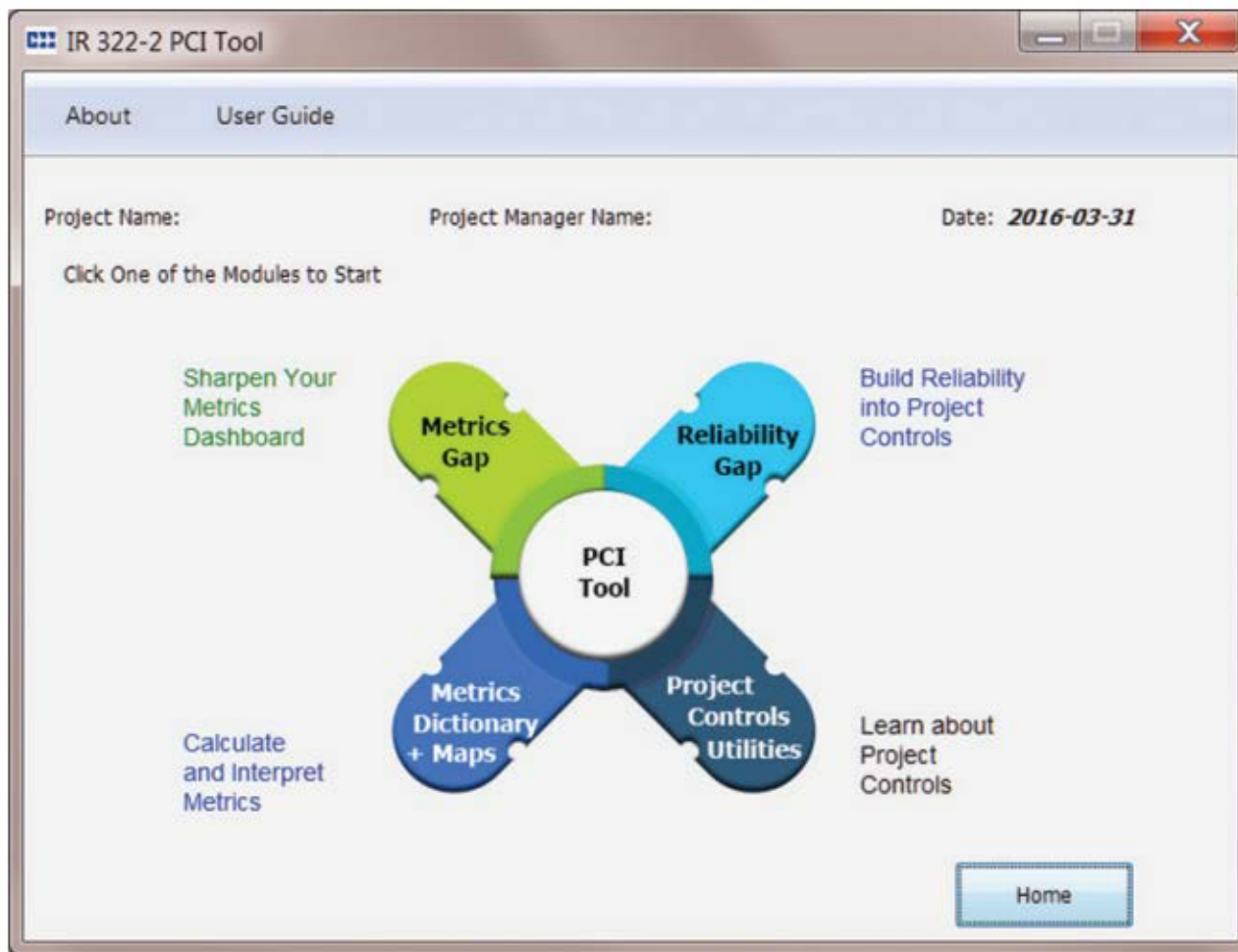


Figure 7. Module Selection Page

Output Interface

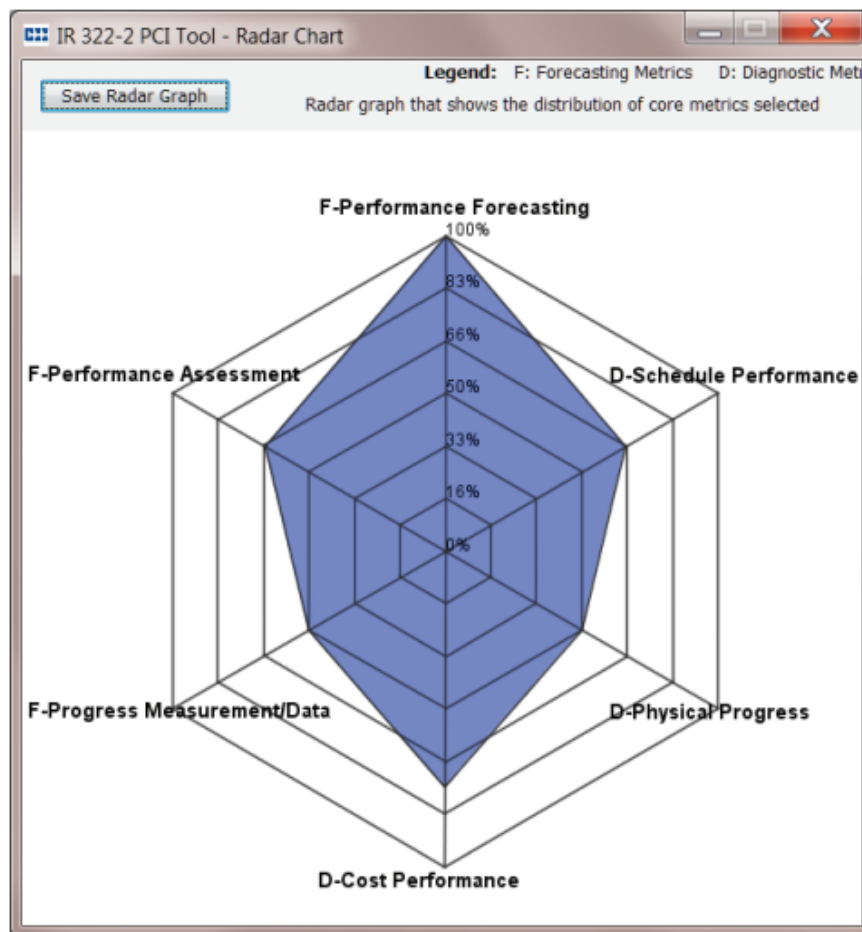


Figure 12. Radar Diagram for Core Metrics Gap Analysis
F: Forecasting Metrics; D: Diagnostic Metrics

Metrics Gap Analysis Report



Figure 13. Snapshot of the Metrics Gap Analysis Report

Examples of PCI Tool Use Cases

❑ Case #2:

- ❖ A **project manager** recognizes that her projects are **experiencing cost overruns and delays**, and
her project control metrics do **not seem to be reliable.**
- ❖ She wants to know **how to strengthen** the company's **progress** and **performance assessment processes** to improve project controls reliability.

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Examples of PCI Tool Use Cases

❑ PCI Tool Use:

- ❖ In this case, the **project manager** can use the **Reliability Gap Analysis** module (**Figure 7**) to determine **gaps** in her **company's** approaches to improving **project control reliability**.
- ❖ The **identified gaps** and analysis results (**Figure 15**) can be **saved** and **shared** with **other departments** in the company.
- ❖ In addition, the **project manager** can use the **Reliability Improvement Checklist** as a guide to **train personnel** and **implement Critical Reliability Factors** in her company.

Module Selection Page

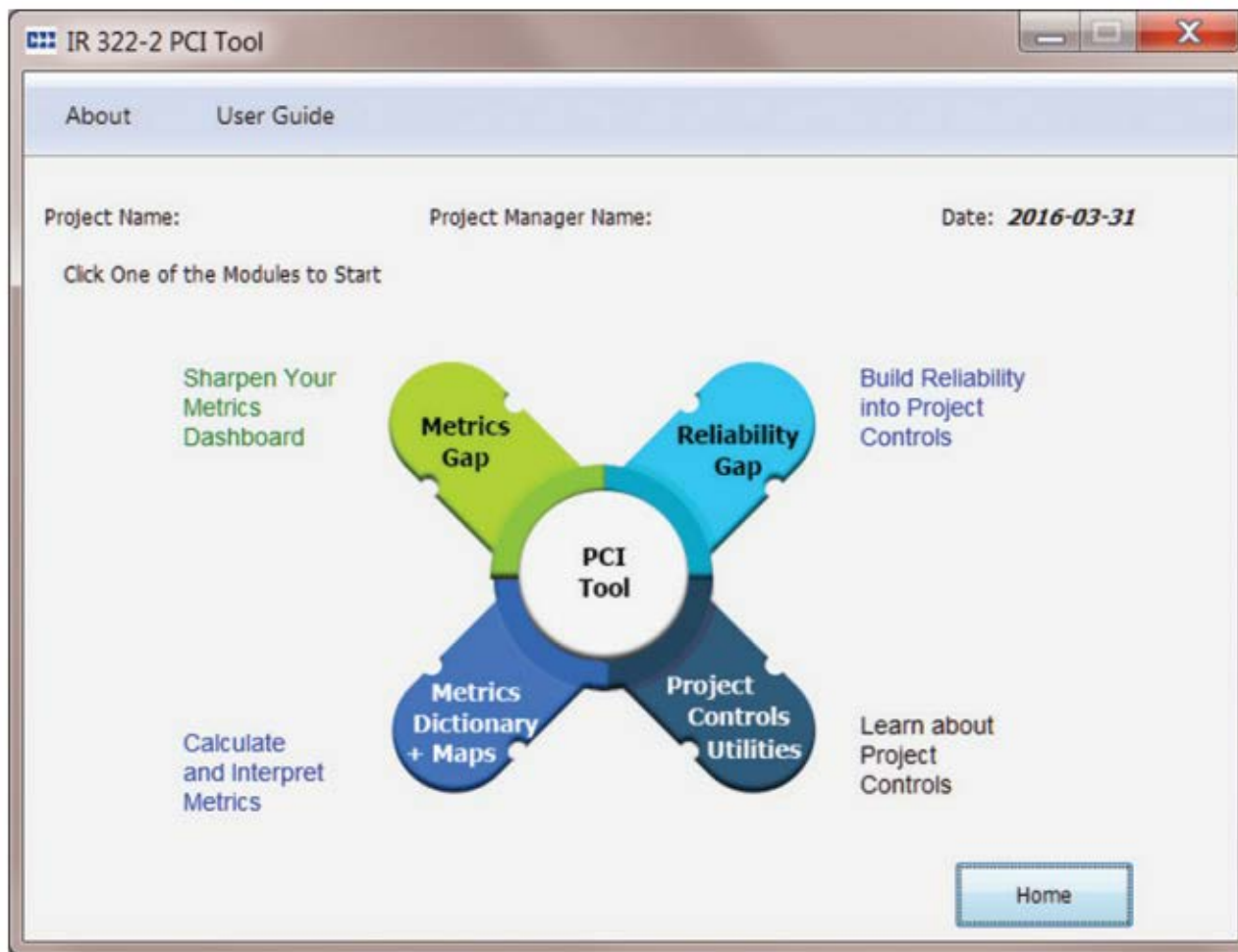


Figure 7. Module Selection Page

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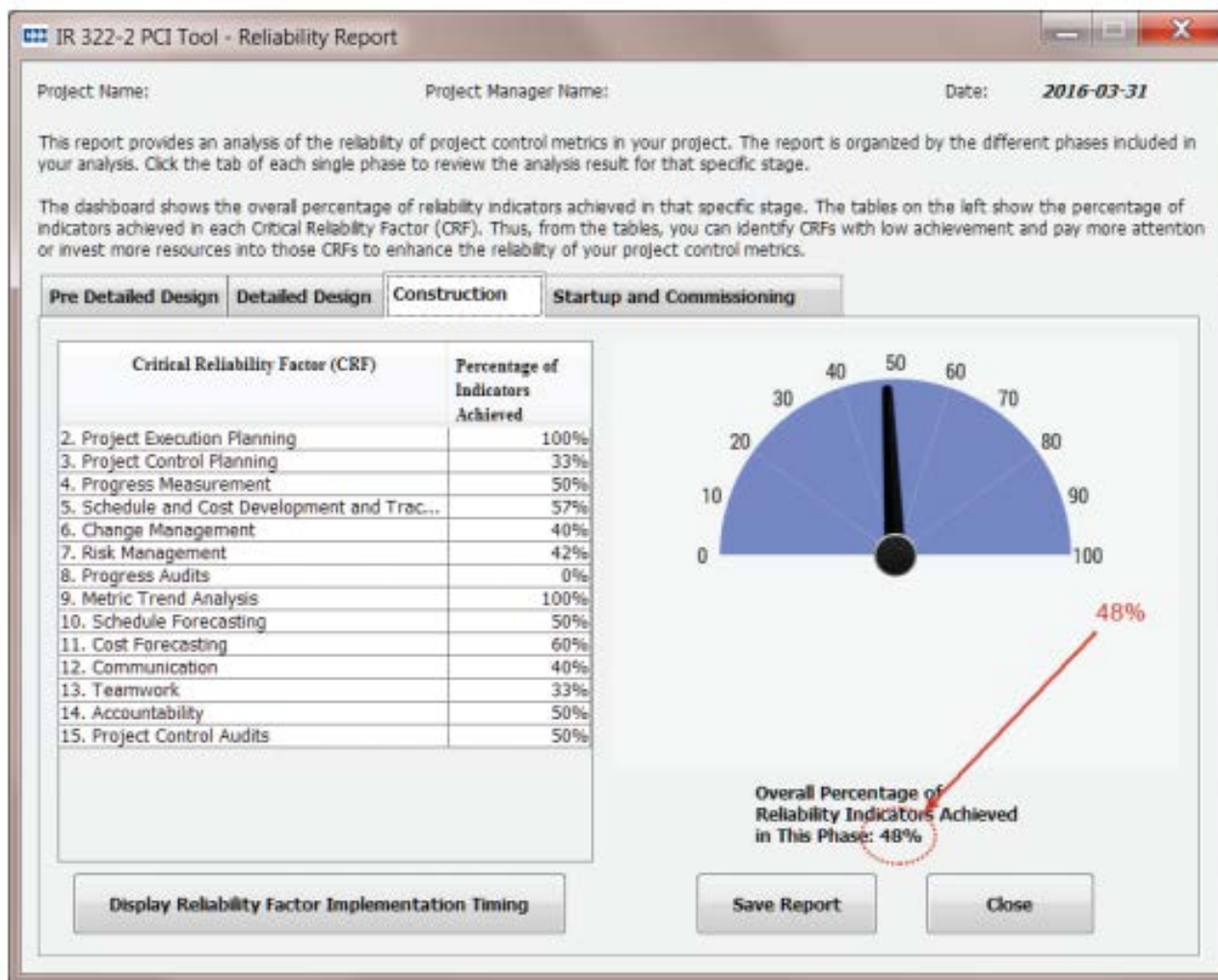


Figure 15. Output Interface of the Reliability Gap Analysis Module

Examples of PCI Tool Use Cases

❑ Case #3:

- ❖ A **project controls department** in an **owner organization** needs to determine **specifications** for an upcoming project's control requirements.
- ❖ The **project controls manager** wants to **identify** which **Core metrics** to monitor in order to increase the **likelihood of project success**.

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Examples of PCI Tool Use Cases

❑ PCI Tool Use:

- ❖ In this case, the **project controls manager** can use the Metrics Dictionary and Maps module (**Figure 7**) to
 1. review all Core metrics and
 2. compare them with
the upcoming project's goals and objectives,
as well as the company's past projects.
- ❖ The **list of Core metrics** (**Figure 28**), their definitions, and equations can be saved (**Figure 23**) and **incorporated** into the project's specifications.
- ❖ In addition, the manager can use the metrics maps (**Figure 21**) to ensure the proper and consistent calculation of and information flow between Core metrics.

Module Selection Page

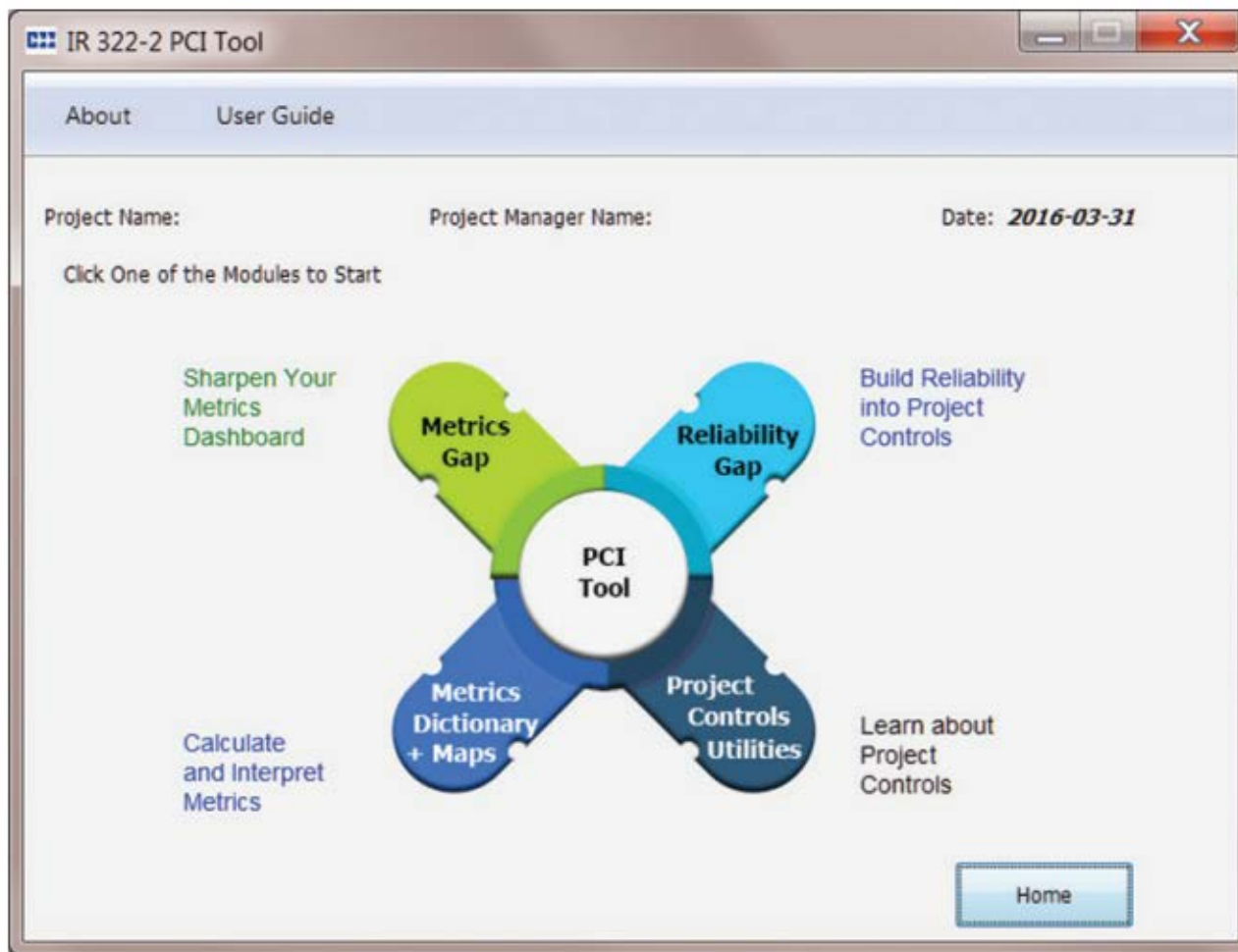


Figure 7. Module Selection Page

Metrics dictionary and maps

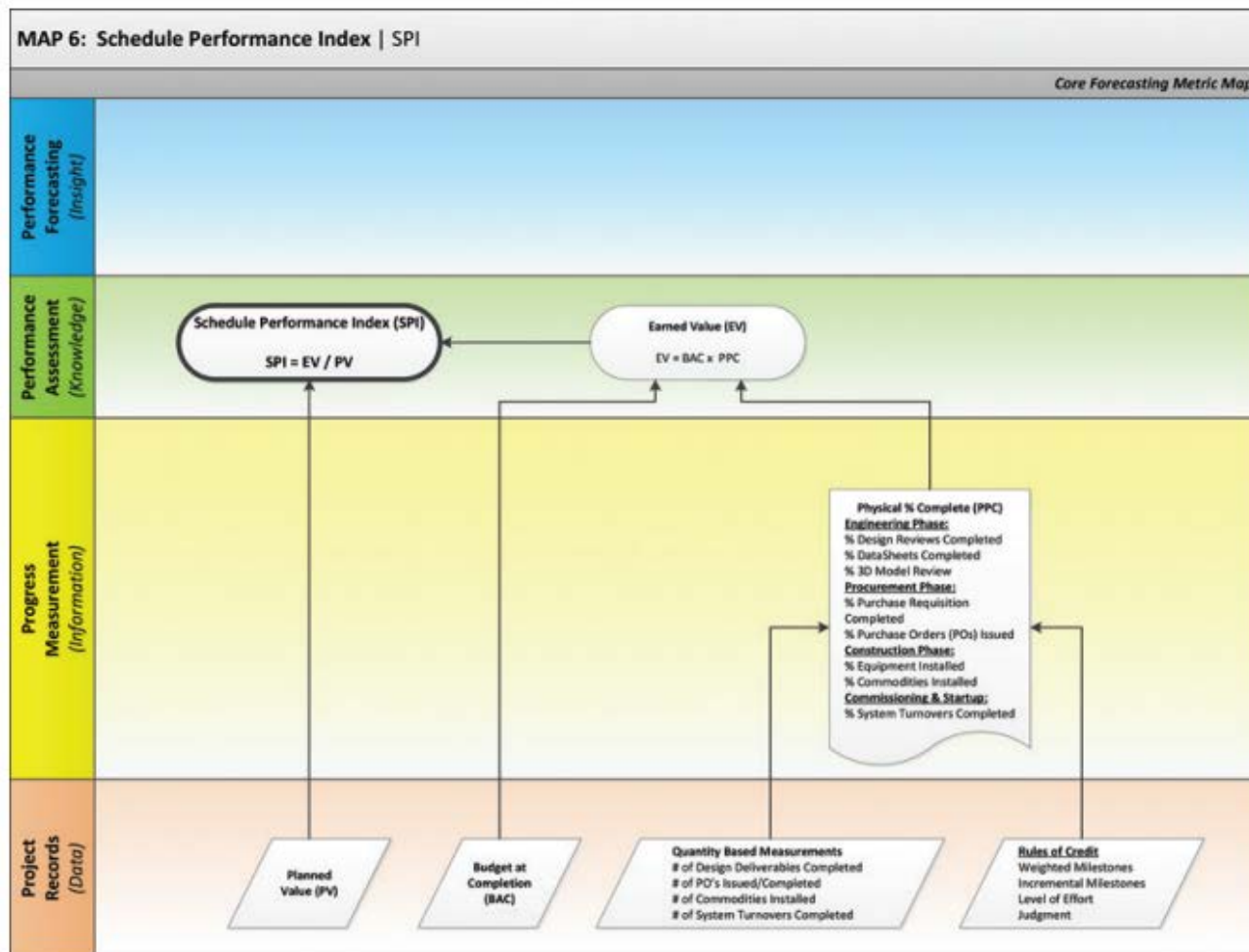


Figure 21. Metric Map for a Selected Metric in the Dictionary

Saving Metric Information

Actual Cost

Metric Information

TITLE	DESCRIPTION
CLASSIFICATION	Core
CATEGORY	Forecasting
SUBCATEGORY	Progress Measurement/Data
DEFINITION	The actual cost of the work determined by the paid costs to date and accruals.
EQUATION	$AC = \text{Paid Costs (PC)} + \text{Accruals}$
INDICATOR	
INTERPRETATION	The actual cost reported by the project control group may be more current and complete than that reported by accounting.
REFERENCE	
ADDITIONAL RESOURCES	
ACRONYM	AC

Figure 23. Metric Information Saved as a PDF File

Examples of PCI Tool Use Cases

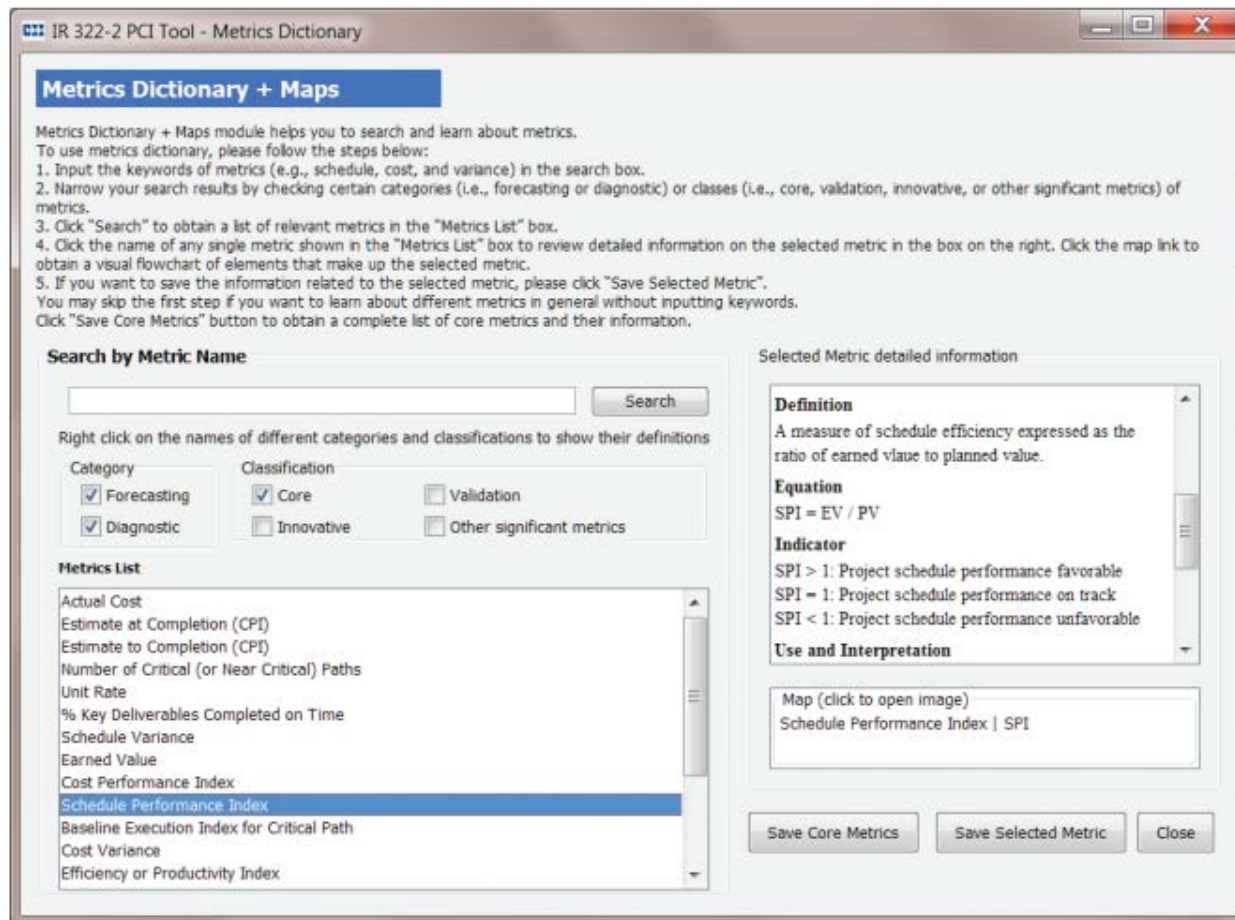


Figure 28. An Example of the Core Metrics Information Available in the Metrics Dictionary



کنترل پروژه پیشرفته و ارزیابی عملکرد در پروژه‌های پیچیده (بر اساس اسناد CII)

فصل هفتم:

ارزیابی فناوری‌ها و استفاده از هوش مصنوعی (AI) در کنترل پروژه

ارائه دهنده:

سید محمدرضا علوی پور

(PhD, PMP, CMIT)

CMAA Authorized Trainer

دانشگاه Illinois Tech آمریکا



What we will learn?

- ☐ Introduction to Technology Domains and AI Applications in APC
- ☐ Evaluation of Technology Domains
- ☐ Assessment of Technology Readiness in Projects
- ☐ Key AI Applications for Predictive and Pattern Recognition
- ☐ Examples of High-Value AI Applications

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Introduction to Technology Domains and AI Applications in APC

Technology domains

- ❑ During its research and focusing again on **streamlining** APC processes,
RT-402 characterized **30 prominent** sensing and information technologies,
all with the **potential to streamline** project controls.

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Technology domains

- ❑ **Computing technologies** applied to controls focus on the data analysis and generation of information, including **extracting information** from datasets such as videos, texts, or images.
- ❑ To **facilitate analysis and comprehension**, the team **grouped existing technologies** into seven technology domains:
 1. Mobile computing
 2. Wearables
 3. Visualization
 4. Automation and robotics
 5. Tracking and tracing
 6. Augmented reality (AR) and virtual reality (VR)
 7. AI.

Technology domains

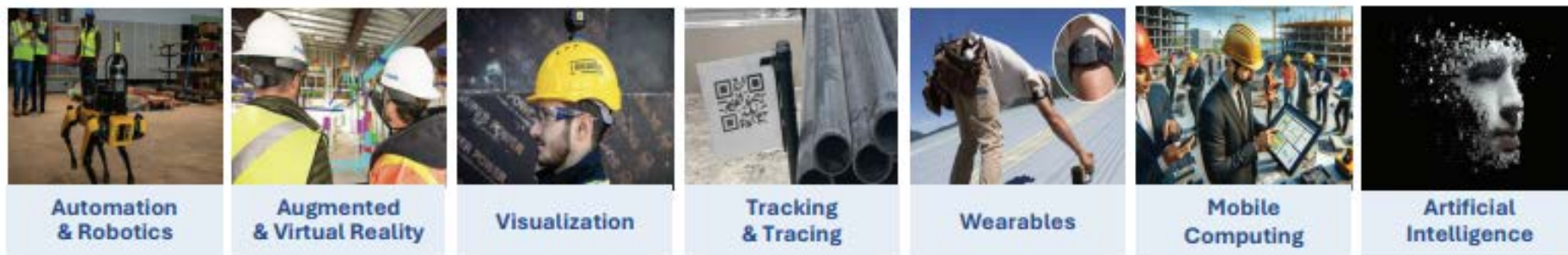


Figure 10. Technology domains

Technology domain groups

❑ Mobile Computing.

- ❖ **Mobile devices** include smart watches, smartphones, tablets, laptops, and visualization headsets.
- ❖ **Mobile computing** enables to a varying degree the pervasive input, access, manipulation, and retrieval of digital information.
- ❖ **Mobile computing** also enables
 1. seamless connectivity,
 2. real-time communication,
 3. data collection, and
 4. information retrieval and
 5. analysisregardless of the user's location.

Technology domain groups

❑ Wearables.

- ❖ Wearables are **biometric devices worn** (e.g., around the arm) by construction workers to **protect** their health and safety and **provide an alert** in case of an imminent or actual health issue or safety incident.
- ❖ Wearable devices are equipped with **location tracking**.
- ❖ While wearables are **designed** for health and safety, they have found applications in **resource management**.
 - ✓ For **project controls**, wearable devices provide essential information on site headcount.

Technology domain groups

❑ Wearables.

- ❖ When **combined** with workers' location, supervisors and managers **can assess** whether sufficient workers are **available** in a particular area or for a specific task or trade and reallocate workers accordingly.
- ❖ Another **documented application** include mitigating absenteeism, e.g., by **identifying absenteeism patterns** in the calendar.

Technology domain groups

□ Visualization.

- ❖ **Prevalent visualization** technologies include cameras, 360-degree hardhat-mounted cameras, or Light Detection and Ranging (LiDAR) (i.e., laser scanners).
- ❖ Visualization technologies enable detailed visual insights into the construction site to **enhance** site monitoring and controls, safety performance, or inform on installation progress.
- ❖ A **fundamental limitation** here is the need for a **direct line-of-sight** between the sensor and the objects or components in a scene.
 - ✓ **Such limitation** is especially notable with **stationary cameras**.

Technology domain groups

❑ Automation and Robotics.

- ❖ Technologies include but are **not limited** to robots, drones, autonomous vehicles, and power tools.
- ❖ The technologies cover **automated** or **semi-automated** tools, systems, and robots designed to handle repetitive, demanding, hazardous, or complex tasks.
- ❖ Automation and robotics products **directly perform** tasks or **aid human workers** in completing tasks, thereby increasing efficiency, precision, safety, and the ability to control and predict production and, hence, time to completion.
- ❖ **Complex autonomous** applications, such as autonomous vehicles, require advanced sensors and AI support for real-time decision making.
- ❖ A **distinct feature** of automation and robotics is the ability to facilitate, reduce, or virtually eliminate human intervention.

Technology domain groups

❑ Tracking and Tracing.

- ❖ Tracking aims to **gather** the location and status of an item using **auto-identification technologies**.
- ❖ Tracing focuses on **collecting** and **sharing** the digital thread of information on a tracked item.
- ❖ Tracing can **span back** to manufacturing and production, including certifications, test reports, transaction history, and vendor and supplier records.
- ❖ Tracking and tracing **applications** in project controls enable the **visibility of equipment and materials** either upstream (within the supply chain) or downstream (at the project site).
- ❖ Both technologies are **included in contract agreements**, which at a minimum provides **production/fabrication status** and **possible delays** that could affect planning and scheduling.

Technology domain groups

❑ Augmented Reality & Virtual Reality.

- ❖ AR and VR are visualization technologies that aim to create a realistic and interactive experience through head-mounted displays.
- ❖ AR overlays digital information onto visuals of the physical world, enhancing the human perception of a scene with virtual information.
- ❖ Overlaying the BIM model directly onto the project site, for example, enables an on-the-spot and real-time comparison between the design/plan and actual installation.
- ❖ Such comparison informs of progress and facilitates the identification of design issues and construction errors.

Technology domain groups

❑ Augmented Reality & Virtual Reality.

- ❖ VR immerses users in an entirely virtual landscape.
- ❖ When coupled with BIM, VR enables designers to navigate the BIM model and assess the quality of design, errors, or design for maintenance issues.
- ❖ VR has also been used to train safety identification and prevention through virtual settings that enable learning from situations specifically designed to meet the training objectives without exposing the trainees to hazardous scenes.
- ❖ In other sectors, VR is leveraged to train trades in manipulating and repairing equipment.

Technology domain groups

❑ Artificial Intelligence.

- ❖ In project controls, **AI** is still in **its infancy**.
- ❖ It encompasses various technologies and techniques, such as ML, large language models, convolutional neural networks, and digital twins.
- ❖ **AI** offers the ability to **parse vast datasets** and **find patterns** and **evidence** that would otherwise **remain hidden**.

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Technology domain groups

- ❑ **Appendix III** contains a catalogue of **30 key technologies** grouped by domain.
- ❑ The characterization of each technology includes
 - a description of features and capabilities,
 - costs,
 - applications,
 - technology users,
 - user-friendliness,
 - development and commercialization status,
 - intensity of adoption and use, and
 - availability.

Evaluation of Technology Domains

Evaluation of technology domains

- ❑ **Before** holding the **three workshops** with the **SMEs**,
the **team related information** to them about **each technology domain**, including
 1. definitions,
 2. audiovisual information, and
 3. practical applications.
- ❑ **Results** regarding their impressions on the technology domains follow.

Technology adoption

- ❑ During the workshops, the **SMEs** identified the **level of technology** use within their projects. See **Figure 11**.
- ❑ Visualization, mobile computing, and tracking and tracing are **consolidated technologies** within the construction industry and are **widely used**.
- ❑ This **level of adoption** shows a possible correlation with the maturity or the number of years a technology has been **available**.
- ❑ **Wearables**, in contrast, have only emerged **relatively recently**; this could **hinder** their adoption and market diffusion.

Technology adoption



Figure 11. Technology Adoption Rates (n=30)

Technology adoption

- ❑ Similar to wearables, **AI currently** has only been adopted in **less than 10 percent** of projects.
- ❑ While **AI research and applications** have existed for **more than 15 years**, the vast **majority of the SMEs** have **only been aware of AI** since large language model engines **became popular at the end of 2022**.

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- ❑ The intensity of the barriers against technology adoption was quantified for each technology domain.
- ❑ The team's research yielded 12 prevalent barriers:
 1. Purchase costs
 2. Maintenance costs
 3. Unclear or low return on investment (ROI)
 4. Complexity or difficulty of implementation
 5. Complexity or difficulty of use
 6. Difficulty or inability to integrate with other tools or systems
 7. Limited ability to automate tasks
 8. Limited functionality beyond project controls
 9. Lack of/limited awareness or adoption support by project teams
 10. Lack of/limited awareness or adoption support by upper management
 11. Limited project resources
 12. Privacy and cybersecurity issues

- ❑ The SMEs **rated the intensity** of each barrier on a scale from 1 (null intensity) to 5 (maximum intensity).
- ❑ On average, the **top obstacles** against technology adoption in project controls were found to be
 1. integration constraints,
 2. limited project resources,
 3. upfront investment,
 4. difficulty of use, and
 5. unclear ROI.

See **Figure 12**.

- ❑ These **results underscore** the combined importance of organizational support and **technical aspects**.



Figure 12. Top Barriers

Analysis of barriers by technology domain

- ☐ The team then analyzed the **barriers by domain**.
- ☐ That **detailed analysis** provides insights that practitioners should consider when selecting and implementing technologies in support of project controls.

See **Table 6** and **Figure 13**.

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Analysis of barriers by technology domain

Table 6. Barriers (n=23)

	Purchase cost	Maintenance cost	Unclear or low ROI	Difficulty to implement	Difficulty to use	Difficulty to integrate
Mobile Computing	1.83	1.57	2.00	1.41	1.48	2.41
Wearables	2.64	2.67	3.00	2.78	2.71	3.05
Visualization	2.45	2.23	2.40	2.68	2.85	3.29
Automation and Robotics	3.96	3.73	3.45	3.45	3.35	3.60
Tracking and Tracing	2.43	2.19	1.95	2.00	2.24	2.55
AR/VR	3.71	2.89	3.21	3.05	3.29	3.33
Artificial Intelligence	3.37	2.76	3.81	3.81	4.00	3.20
Average	2.91	2.58	2.83	2.74	2.84	3.06

Analysis of barriers by technology domain

	Limited ability to automate tasks	Limited functionality beyond controls	Lack of support by project teams	Lack of support by corporate managers	Limited project resources	Privacy and cybersecurity concerns
Mobile Computing	2.16	1.86	1.64	1.68	2.05	3.33
Wearables	2.33	2.32	3.05	2.76	2.95	2.73
Visualization	2.74	2.30	2.73	2.62	2.91	2.45
Automation and Robotics	2.80	2.43	2.90	2.78	3.23	1.90
Tracking and Tracing	1.95	2.00	1.91	2.00	2.23	2.52
AR/VR	2.61	2.55	3.05	3.00	3.57	2.50
Artificial Intelligence	2.00	1.83	3.33	3.17	3.76	3.35
Average	2.37	2.18	2.66	2.57	2.96	2.69

Analysis of barriers by technology domain

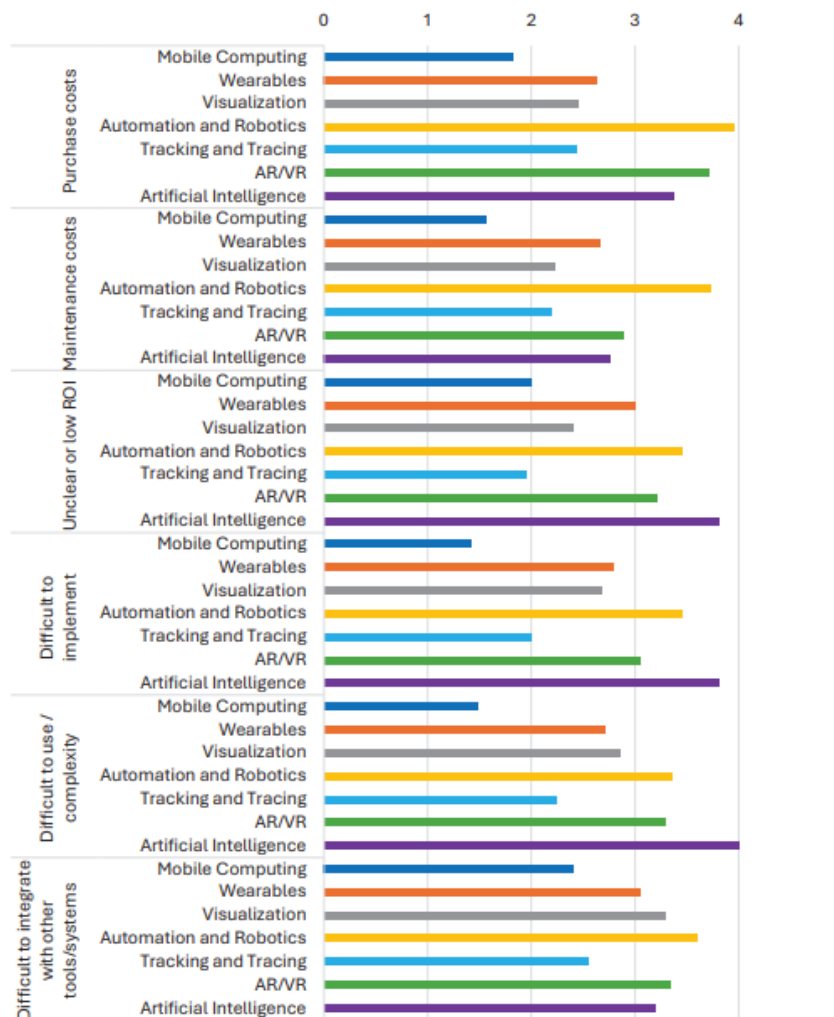


Figure 13. Intensity of Barriers (n=23)

Analysis of barriers by technology domain

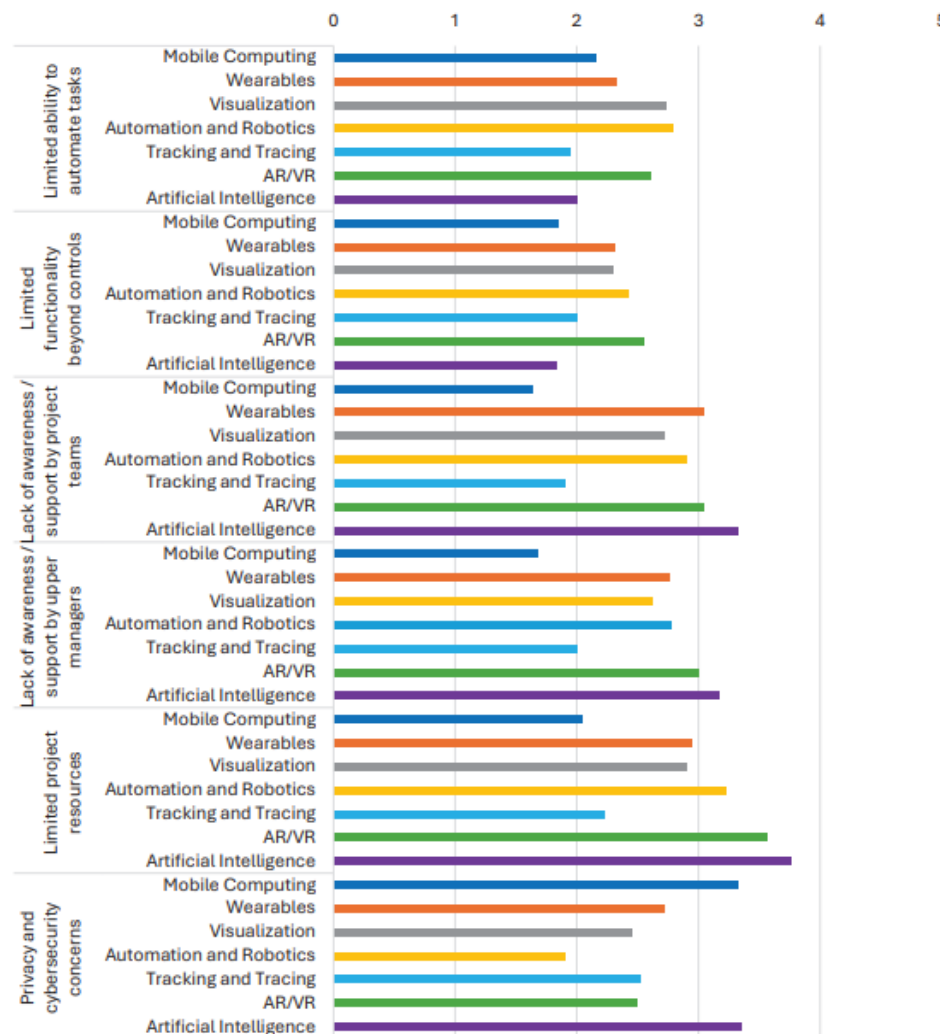


Figure 13. Intensity of Barriers (n=23)

Analysis of barriers by technology domain

- ❑ For example, established domains such as mobile computing or tracking and tracing show a **low intensity of barriers**.
- ❑ Such prevalent use can be **partially explained** through
 - ❖ the **small** and **reliable** investment needed for acquisition and implementation,
 - ❖ the **high level** of **awareness** among practitioners, and
 - ❖ the **low cybersecurity** and **privacy** concerns.
- ❑ **Mobile computing**, however, shows the **highest level of cybersecurity** and privacy concerns, **only topped** in this barrier by AI.
- ❑ **Expensive technology products** such automation and robotics and **AR/VR** show a **dominance of cost-related** and resource barriers.

Analysis of barriers by technology domain

- ❑ Regarding AI, this **innovative technology** with applications still in their infancy, is rapidly evolving, and is also **carrying high expectations**.
 - ❖ Therefore, the **noticeable intensity** of its **barriers**.
- ❑ For one, practitioners **question AI's ROI**.
- ❑ Perceived as complex, **AI** is also viewed as **needing sophisticated** use and implementation.
- ❑ The **perceived lack of understanding** by project and upper management was also the **highest for AI**.
- ❑ Concerns with AI also relate to **privacy** and **cybersecurity**.
- ❑ The barriers to AI may ease as its **use increases** and as **practitioners identify ways** to improve on the cyber and privacy issues as it evolves.

- ❑ **For each technology domain**, the team quantified the intensity of drivers or enablers of adoption.
- ❑ The **results revealed nine drivers** that can facilitate adoption:
 1. Proven ability to improve project controls
 2. Technology durability
 3. Technology reliability
 4. Timely access to data and information
 5. Ability to trial and test
 6. Technical attributes and features
 7. Ease of implementation and deployment
 8. Ability to integrate with tools and systems
 9. Ability to contribute to functions beyond project controls

- ❑ The **SMEs rated the intensity** of each barrier on a scale from 1 (null intensity) to 5 (maximum intensity).
- ❑ On average, the **top drivers towards technology** adoption in project controls were
 1. reliability,
 2. ability to improve project controls,
 3. ease of implementation,
 4. ability to trial and test, and
 5. durability.

See **Figure 14**.

- ❑ These drivers emphasize prioritizing operational effectiveness, risk mitigation, and long-term value in technology adoption decisions.

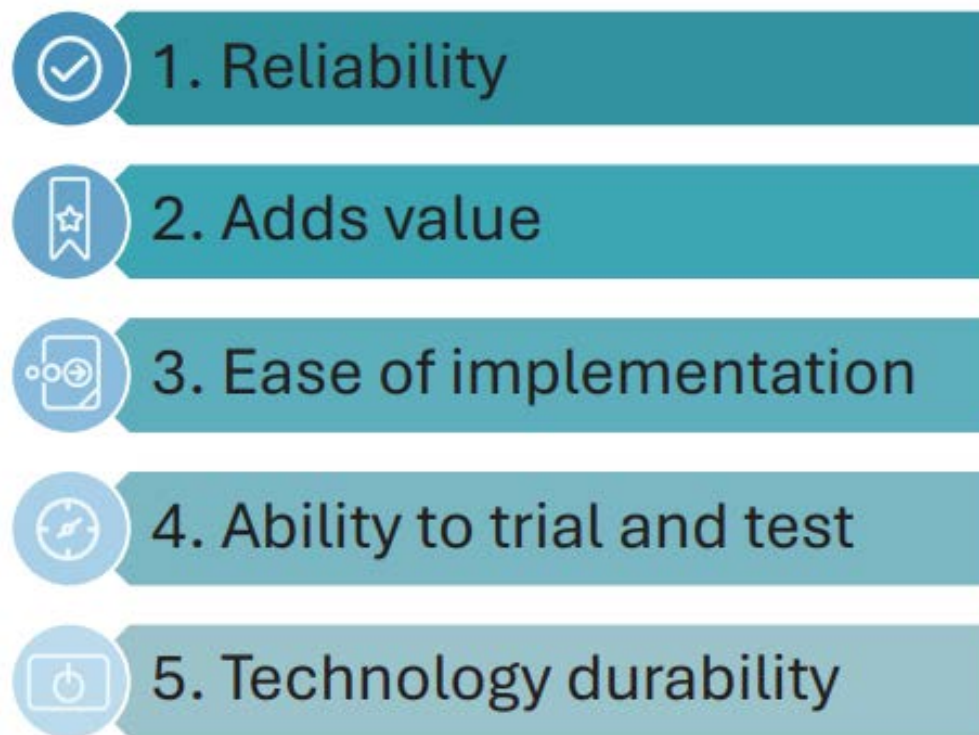
- 
1. Reliability
 2. Adds value
 3. Ease of implementation
 4. Ability to trial and test
 5. Technology durability

Figure 14. Top Drivers

- ❑ Additional insights came out of this. See **Table 7** and **Figure 15**.
- ❑ Technology domains common to construction projects, such as **mobile computing** and **tracking and tracing**, are **strong drivers** for implementation.
 - ❖ Thus, such technology domains show the **highest ability** to improve project controls, **immediate access** to data and information, and **straightforward integration** with other tools and systems.
- ❑ In general, practitioners consider **AI applications** to **lack pull for adoption**, with concerns regarding **ease of** implementation, reliability, or durability.
- ❑ Again, AI is regarded as the **least durable technology solution**.

Table 7. Drivers (n=27)

Project controls	Ability to improve	Durability	Reliability	Immediate data and information access	Triability	Technical attributes & features	Ease of implementation	Ability to integrate	Ability to contribute to other functions
Mobile Computing	4.27	3.88	4.12	4.42	3.90	3.50	3.89	4.04	3.69
Wearables	3.78	3.81	4.19	4.04	3.86	3.32	3.96	3.60	3.38
Visualization	3.85	3.42	4.19	3.83	4.10	3.33	3.88	3.88	3.42
Automation and Robotics	3.60	4.04	4.12	3.83	3.77	3.50	3.85	3.83	3.78
Tracking and Tracing	4.32	3.76	4.40	4.28	3.81	3.14	4.16	4.13	3.88
AR/VR	3.96	3.19	3.54	3.52	3.95	3.19	3.65	3.56	3.54
Artificial Intelligence	3.93	2.85	3.70	3.96	3.67	3.57	3.58	3.81	3.92
Average	3.96	3.57	4.04	3.98	3.87	3.36	3.85	3.83	3.66

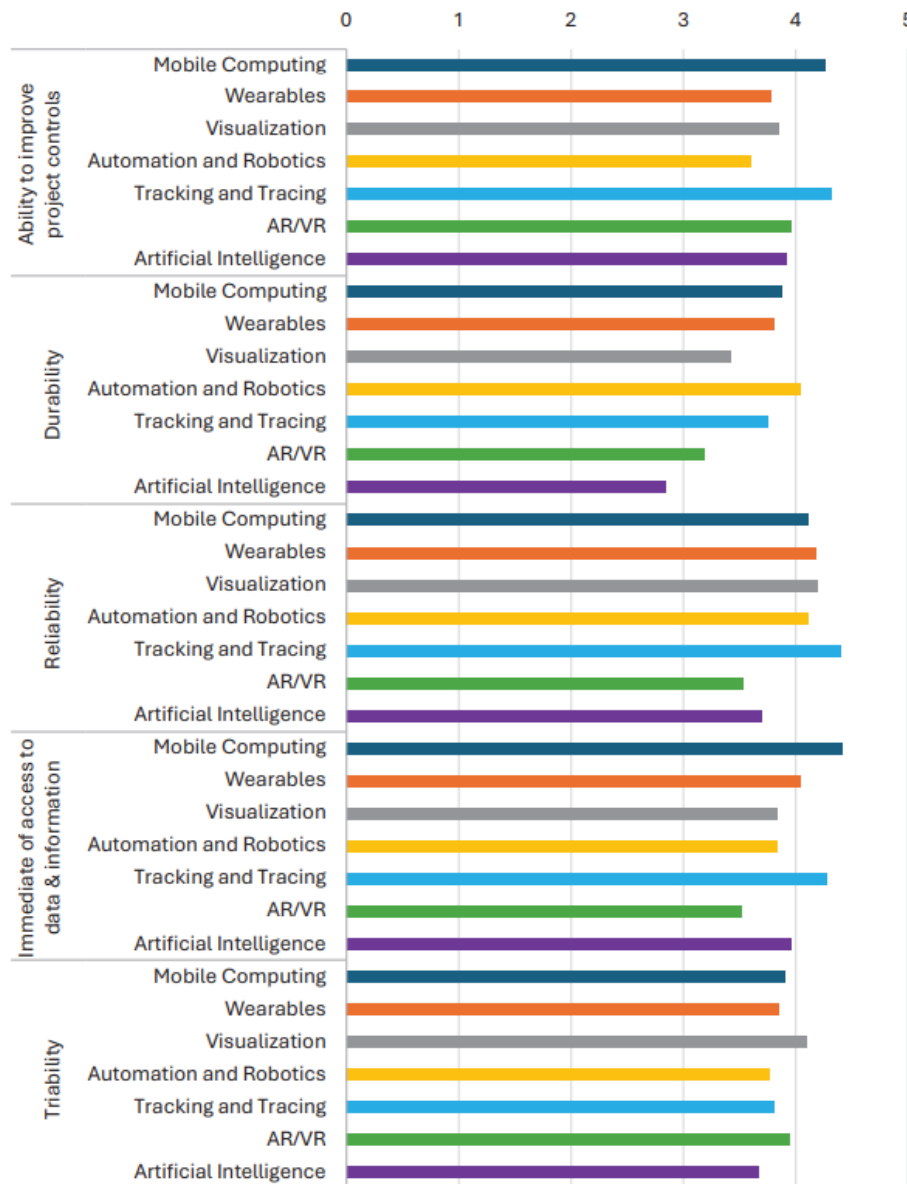


Figure 15. Intensity of Drivers (n=27)

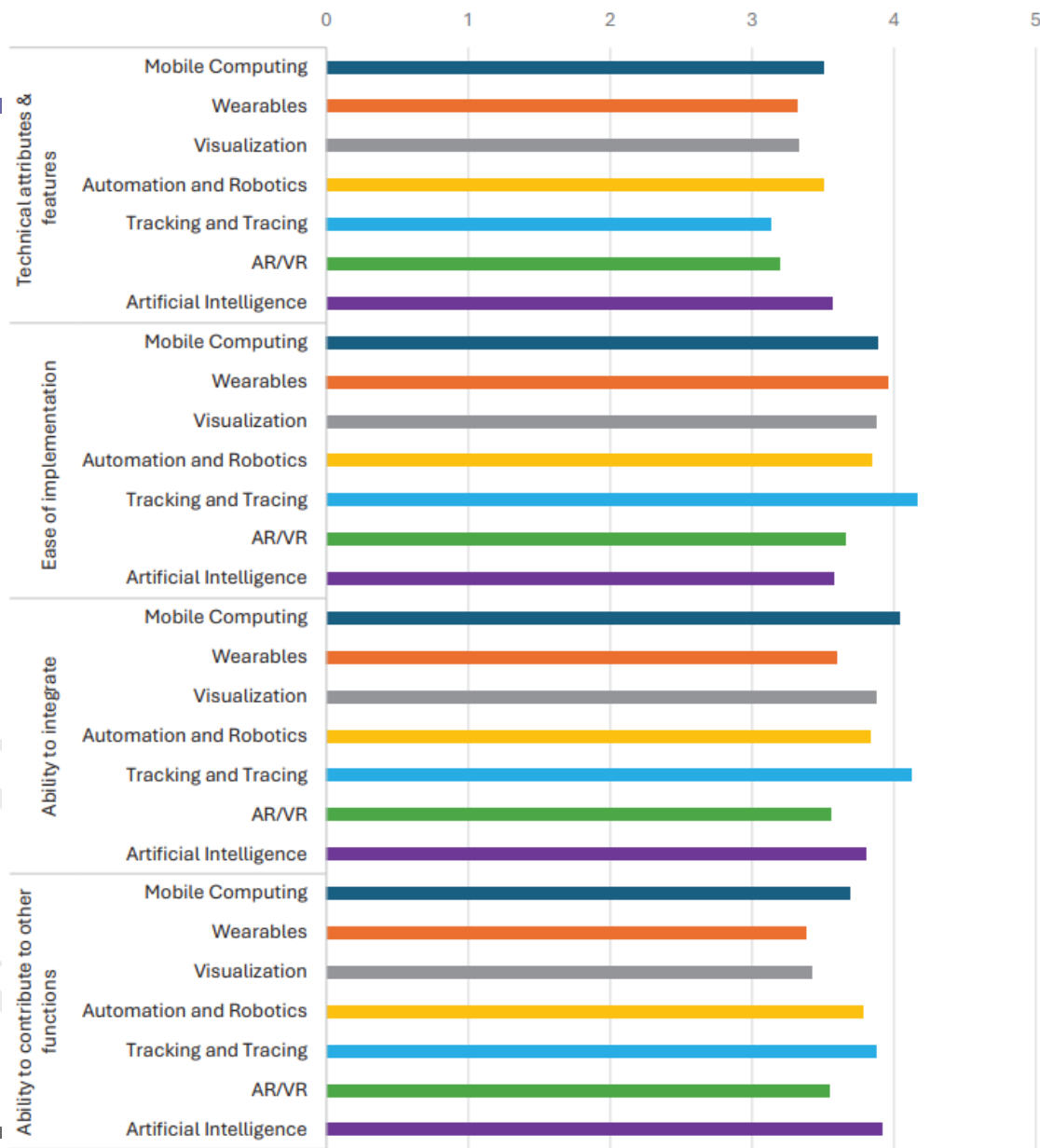


Figure 15. Intensity of Drivers (n=27)

User-related attributes

- ❑ The **research team** also quantified the relative importance of user attributes.
- ❑ Five key user attributes resulted:
 1. Personnel reduction
 2. Technical capabilities of users
 3. Ability to train and test
 4. Ease of use
 5. Effective customer support

User-related attributes

- ❑ The SMEs **rated each attribute** on a scale from 1 (null) to 5 (maximum).
- ❑ The importance of the attributes in **decreasing order** of magnitude were:
 1. customer support and resources,
 2. ease of use,
 3. training resources,
 4. enhancement of user capabilities and skills, and
 5. reduction of personnel.

See **Table 8** and **Figure 16**.

User-related attributes

Table 8. User Factors (n=26)

	Reduction of project controls personnel	Ease of use	Availability of training to optimize performance	Effective customer support and resources	Enhanced user capabilities and skills
Mobile Computing	2.16	4.20	3.60	4.38	3.56
Wearables	2.16	4.20	3.71	4.50	3.50
Visualization	2.16	4.00	3.92	4.63	3.52
Automation and Robotics	2.08	4.13	3.96	4.44	4.08
Tracking and Tracing	2.00	4.29	3.87	4.50	3.42
AR/VR	1.63	3.96	3.88	4.63	3.79
Artificial Intelligence	3.04	4.04	4.12	4.67	3.72
Average	2.17	4.12	3.86	4.53	3.66



Figure 16. Intensity of User Factors (n=26)

User-related attributes

- ❑ The **reduction** of project controls **personnel** is perceived as the **least important factor**.
 - ❖ For AI, a **strong expectation** exists of **reducing personnel**.
- ❑ Such an expectation can be explained by **AI's ability** to **automate tasks**.
 - ❖ Due to AI complexity, there is a perceived need for **customer support**.
- ❑ Also, **improving user capabilities** and skills ranks the highest for automation and robotics, likely due to this technology's ability to **automate processes** and tasks in an autonomous or semi-autonomous manner.



Appendix III

کنترل پروژه پیشرفته و ارزیابی عملکرد در پروژه‌های پیچیده (بر مبنای اسناد CII)
فصل هفتم: ارزیابی فناوری‌ها و استفاده از هوش مصنوعی (AI) در کنترل پروژه

☐ Technology Catalog

Prepared by Dr. Alavipour
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