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Engineering Deliverables: Get It Right the First Time

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Engineering Deliverables: Get It Right the First Time

**Prepared by
Construction Industry Institute
Research Team 320, Definition and Measurement of
Engineering/Design Deliverable Quality**

**Research Summary 320-1
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Executive Summary

High-quality design deliverables are essential to project success, yet quality is challenging to define and to predict. Project teams are diverse, so stakeholders often hold diverse opinions about and use diverse definitions of quality deliverables. Project stakeholders also often determine quality by utilizing lagging, rather than leading, indicators, and subsequent responses are inherently reactive. The industry lacks a shared understanding of quality defects and the tools to help detect design quality risks.

Identifying these challenges as significant opportunities for project advancement, the Construction Industry Institute (CII) chartered Research Team 320 (RT-320), Definition and Measurement of Engineering/Design Deliverable Quality, to develop a uniform definition and method of measurement for engineering/design deliverable quality, usable by project owners, managers, and quality managers, and contractor design managers and discipline leads. RT-320 defined high-quality design deliverables as complete, correct, and timely. Through a survey of experienced design professionals, the team identified 11 common detailed design deliverables that often suffer from quality problems. By focusing on these 11 deliverables, the team gained a better understanding of common and significant deliverable defects, the impacts of these defects, and their causes.

Armed with this information, RT-320 identified leading indicator metrics that can warn of defect-prone deliverables. Concurrently, the team used published literature, corporate tools, knowledge of deliverable defects, and team experience to formulate a completeness checklist for each of the 11 problematic deliverables. To enable proactive design quality actions by project teams, RT-320 integrated these findings into two tools

that assess design deliverable quality and completeness throughout detailed design, beginning with Front End Engineering Design (FEED) validation and continuing through issued-for-construction:

- The **Design Deliverable Quality Assessment (DDQA) tool** identifies threats to deliverable quality by focusing on leading indicators.
- The **Completeness of Design Deliverable Checklist (CDDC) tool** provides a method for the consistent measurement of deliverable completeness.

The application of these two tools can help project teams to achieve complete, correct, and timely results for the 11 commonly problematic design deliverables. By aligning project expectations and better predicting deliverable completeness, projects should benefit from reduced rework and improved cost and schedule performance.

Introduction

Every year, late, incomplete, and incorrect design deliverables cause billions of dollars of cost increases and countless months of project schedule delays. Although tracking such costs and delays is difficult, a recent survey-based study of 139 projects in Australia found that the average direct and indirect costs of design errors amounted to 14.2 percent of a project's contract value. This alarming figure climbed to an average of 26.2 percent of contract value for large projects (those costing over \$100 million in Australian dollars) (Love et al. 2014). Previous research by CII and others found that field rework, much of which is caused by design error, can increase project total installed direct cost (TIC) by five percent or more (CII 2004, Hwang et al. 2009). Related findings from an Research Team 320 (RT-320) analysis of CII benchmarking/performance assessment data indicate that completeness of engineering deliverables has a statistically significant impact on construction cost growth. Collectively, this evidence shows that failed design quality leads to substantial added costs, and constitutes a call for industry action.

Purpose and Objectives

The quality of project design deliverables has a great impact on project success. Poor quality in design deliverables commonly leads to design, procurement, and field construction rework; delayed schedule performance; and increased project costs. Unfortunately, rework and delays are often tracked as lagging metrics, providing little opportunity to take the corrective actions required to improve project performance.

Responding to these challenges, RT-320 sought to define engineering/design deliverable quality, and to develop metrics that can assess deliverable quality, in order to deliver the following benefits:

- alignment of project team expectations
- reduction of rework in design, procurement, and construction
- improvement of project schedule performance
- reduction of project costs.

Thus, RT-320 set out to improve the quality of engineering/design deliverables of capital projects by taking the following steps:

- defining engineering/design deliverable quality and developing methods of measuring it
- identifying indicators that effectively forewarn of needed improvements in the quality of engineering deliverables.

In order to accomplish these research objectives, the team identified the most problematic engineering/design deliverables, defined quality for these problematic deliverables, and developed metrics to assess both the quality and completeness of design deliverables.

Scope and Limitations

This study focused on enhancing the quality of design deliverables during the Detailed Design phase, from Front End Engineering Design (FEED) validation through final Issued-for-Procurement/Construction (IFP/C). The research excludes pre-FEED activities. The scope of the research also excludes the schedule performance of design services, the cost of design efforts, and the quality of cost estimates that are based on engineering deliverables.

Regarding terminology, “FEED” is defined as a component of the Front End Planning (FEP) process performed during the Detailed Scope phase (Phase 3 or FEL 3), and consists of the engineering documents, outputs, and deliverables for the chosen project alternative scope of work. In addition to preliminary or basic design and site factors, the FEED delivery package typically includes a cost estimate, a schedule, a procurement strategy, a project execution plan, and a risk register. This definition of FEED reflects the combined efforts of CII Research Teams 320 and 331.

Methodology

Terminology and Research Considerations

RT-320's first challenge was to define the term *design quality*. The team reviewed the considerable research already devoted to design quality, seeking a consensus description of the term. Andi (2003), Chalabi et al. (1987), and Tilley et al. (1997) identified completeness, correctness (accuracy), and timeliness as the most essential attributes of design documentation quality. For this study, RT-320 adopted these three terms as the Design Quality Essentials. (See Figure 1.)

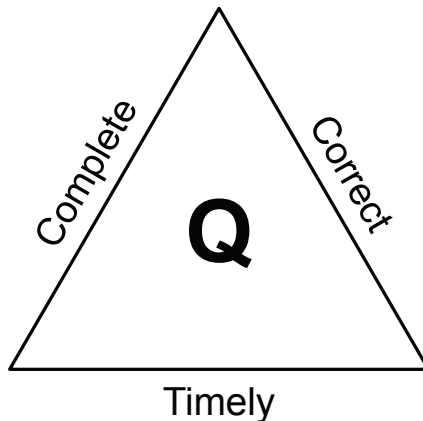


Figure 1. Design Quality Essentials

The team then identified and defined additional key terms relevant to the research process (see Table 1), along with determining the key research considerations necessary to formulate leading and lagging design quality metrics (see Figure 2). First, an improved understanding of quality-problematic deliverables allowed for assessment of common deliverable defects. Then, that knowledge of deliverable defects made it possible to examine the impacts of defects and to identify defects' causal factors. This knowledge, collectively, allowed for the formulation of leading and lagging design quality metrics.