



Assessing the Maturity and Accuracy of Front End Engineering Design

Construction Industry Institute

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Assessing the Maturity and Accuracy of Front End Engineering Design

**Prepared by
Construction Industry Institute
Research Team 331, Assessing the Maturity and Accuracy of Front
End Engineering Design (FEED) to Support Phase-Gate Approvals**

**Research Summary 331-1
April 2018**

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Executive Summary

Assessing the maturity and accuracy of front end engineering design (FEED) to support phase-gate approvals for large industrial projects is a critical task with significant influence on overall project success. This research summary provides an overview of the work of RT-331, Assessing the Maturity and Accuracy of Front End Engineering Design (FEED) to Support Phase-Gate Approvals. RT-331's research found significant correlations between a project's FEED maturity and accuracy scores, and that project's performance.

More specifically, RT-331 found that projects with high FEED maturity and accuracy metrics outperformed projects with low maturity and low accuracy by 24 percent in terms of cost growth, and 12 percent in terms of change order performance in relation to the approved budget at Phase Gate 3. Projects with high FEED maturity and accuracy also outperformed those with low maturity and low accuracy, both in terms of financial performance and relative to how well customer satisfaction matches expectations. These results are based on a data sample of 33 completed and 11 on-going large industrial projects representing over US\$13.9 billion of total installed cost in 10 different countries, with the majority of projects in the U.S. and Canada. The researchers collected the input of 128 individuals from 62 organizations.

As an initial part of this research effort, RT-331 developed a standard definition of FEED as *a component of the FEP process performed during detailed scope (Phase 3), consisting of the engineering documents, outputs, and deliverables for the chosen scope of work*. The team based this definition on the input of 80 survey responses from 33 organizations.

The RT-331 work culminated in the development of the FEED Maturity and Accuracy Total Rating System (FEED MATRS) tool (pronounced “feed matters”). FEED MATRS generates two separate scores for a project; a maturity score and an accuracy score, which are each normalized to a zero to 100-point scale and are plotted on a maturity-accuracy matrix. The maturity-accuracy matrix is divided into four quadrants and gives

users a high-level understanding of where a project stands in terms of maturity and accuracy at the end of detailed scope (Phase Gate 3).

- The **maturity assessment** component of FEED MATRS consists of 46 engineering elements presented in a weighted checklist format. The tool provides a method for quantifying the level of maturity of the engineering design effort during FEED at the end of detailed scope (Phase Gate 3). The tool's weighted index, derived from the PDRI–Industrial tool, allows users to measure the level of maturity of the FEED deliverables and correlates this maturity score with project performance outcomes.
- The **accuracy assessment** component of FEED MATRS consists of 27 FEED accuracy factors and is also presented in a weighted checklist format. This new assessment method provides, for the first time, a method for evaluating *contextual* or *external* factors associated with the FEED process. FEED accuracy factors were derived from a number of past CII research efforts, as part of an extensive literature review, and set the stage for several industry workshops in which RT-331 developed the weighted accuracy assessment component of FEED MATRS.

The resulting tool was subsequently tested during front end planning by eight different organizations on 11 ongoing projects. Data from these project assessments showed that FEED MATRS provided the project teams with an understanding of FEED development risks and helped project team members identify critical gaps.

Introduction

For many projects, Front end planning (FEP) is considered to be the most important process within the project lifecycle (Special Publication (SP) 268-3, *Adding Value through Front End Planning*). FEP is defined as the process of developing sufficient strategic information with which owners can address risk and make decisions to commit resources in order to maximize the potential for a successful project. FEP is also known as front end loading, pre-project planning, feasibility analysis, conceptual planning, programming/schematic design, and early project planning (SP268-3). Although this summary uses the term “front end planning,” it is considered to be synonymous with whatever analogous term is employed in the user’s business process.

Phase 1 of FEP is known as “Feasibility,” Phase 2 is known as “Concept,” and Phase 3 is known as “Detailed Scope.” (See Figure 1.) Each phase is followed by a phase gate that marks a decision whether to move forward to the next stage of the project. Points 1, 2, 2i and 3 are potential application points for the FEED MATRS tool. Detailed descriptions of these potential application points can be seen in Implementation Resource (IR) 331-2, *Front End Engineering Design (FEED) Maturity and Accuracy Total Rating System (MATRS)*.

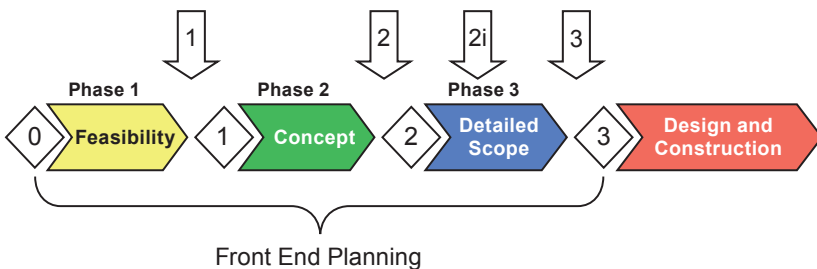


Figure 1. Front End Planning Process

While past CII research efforts have addressed the FEP of projects in general, they have not focused specifically on assessing the maturity and accuracy of the engineering component of Front End Engineering Design (FEED) for large industrial projects. Additionally, a global CII definition for FEED had yet to be agreed upon, so that term's meaning was unclear and it was used inconsistently in the industry.

Both owner and engineer/designer have to be aligned as the project design process moves forward. The owner's expectation is to be able to make informed decisions, including cost and schedule predictions to determine whether the project should proceed to the next phase, the level of contingency needed for the project, and the predicted impact of FEED maturity and accuracy on the success of follow-up phases. This work provides a missing link in a scope definition area focused on the industrial sector served by CII.

CII formed Research Team 331 (RT-331) to help quantify and communicate the design effort completed during FEED activities; specifically, the maturity and accuracy of the FEED deliverables at the end of detailed scope (Phase Gate 3). This research summary discusses RT-331's research effort and describes the development of the FEED Maturity and Accuracy Total Rating System (or FEED MATRS, pronounced "feed matters"), a tool that quantifies the maturity and accuracy of FEED for large industrial projects including key findings. The literature review, methodology, statistical analyses, testing process, and results that are summarized in this document are discussed in more detail in Research Report (RR) 331-11, *Maturity and Accuracy of Front End Engineering Design (FEED)*.

RT-331 set forth the following objectives:

1. Develop an objective, scalable, effective, and efficient framework to evaluate engineering quality (focused on the team doing the work) during FEP for industrial projects
2. Tie the stand-alone framework to PDRI and other existing FEP tools, to ensure consistency in the definitions:
 - Identifying, defining, quantifying, assessing, and communicating, the maturity and accuracy of key engineering deliverables of FEED.
 - Evaluating the enabling factors that drive effective engineering design during FEED (i.e., capability of the engineers, turnover of key design team members, and time allowed for FEED).
 - Testing and proving the framework through the research and ensure broad applicability to CII members.
3. Test the tool by comparing the level of maturity and accuracy definition at the end of FEED versus corresponding project performance factors for a sample of completed industrial projects.
4. Test the tool in a team environment on projects in the planning stage to determine its efficacy.

In order to proceed with its research, RT-331 had to develop consistent definitions for the key terms related to the investigation, since none existed. Therefore, through input from the literature review, the team's members, an industry survey, and workshops, RT-331 was able to develop definitions of FEED, FEED maturity, and FEED accuracy.

RT-331 defined **FEED** as:

A component of the FEP process performed during detailed scope (Phase 3), consisting of the engineering documents, outputs, and deliverables for the chosen scope of work.

In addition to FEED, the project definition package (also sometimes known as the FEED package) typically includes a cost estimate, a schedule, a procurement strategy, a project execution plan, and a risk management plan among other deliverables. Note that other terms that may be used synonymously and sometimes incorrectly with FEED include basic engineering design, basic design, preliminary engineering, project definition and concept design. Figure 2 illustrates the FEED definition and its relationship to the various other deliverables that are associated with the project definition package. (The list of deliverables in Figure 2 is not meant to be exhaustive.)

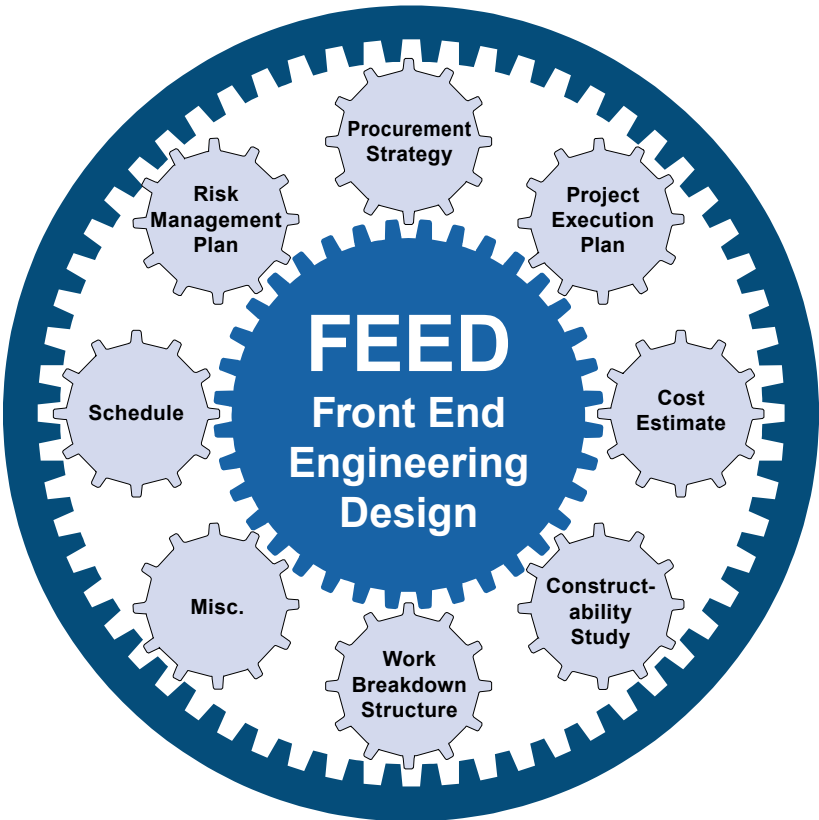


Figure 2. The Project Definition Package (sometimes known as the FEED Package)

RT-331 defined **FEED maturity** as:

The degree of completeness of the deliverables to serve as the basis for detailed design at the end of detailed scope (Phase Gate 3).

RT-331 defined **FEED accuracy** as:

The degree of confidence in the measured level of maturity of FEED deliverables to serve as a basis of decision at the end of detailed scope (Phase Gate 3).

The scope of the research was delineated to focus on projects with the following characteristics:

- Large complex industrial projects
- Total installed cost of at least US\$10 million (in some cases, respondents felt that their projects were complex and met the remaining criteria despite being below \$10 million)
- Construction duration of at least nine months
- More than 10 core team members (e.g., project managers, project engineers, owner representatives)
- The availability of core team members ranges from a combination of part-time and full-time, to completely full-time.

The remainder of this research summary outlines the work performed by RT-331. Chapter 2 discusses the research method, data collection, and FEED MATRS development process. Chapter 3 presents the key results and findings. Chapter 4 discusses the research conclusions and recommendations. These chapters are followed by appendices, references, and a team roster.

FEED MATRS Development Methodology

The research effort to develop the FEED MATRS tool occurred through the six step process shown in Figure 3.

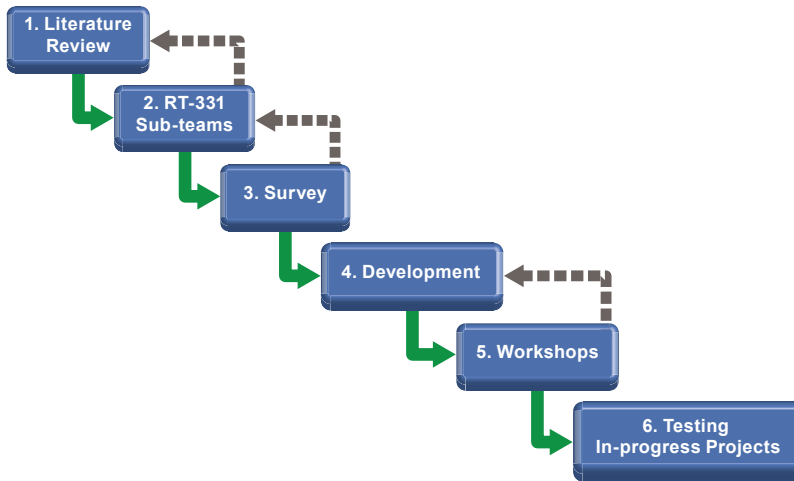


Figure 3. RT-331 Research Method

1. **Conducting a literature review.** First, the RT-331 researchers conducted an extensive literature review to identify FEED maturity elements, and also to understand how FEED accuracy can be quantified for large industrial projects.
2. **Holding research team focus groups.** Subsequent to the literature review, the industry members of RT-331 held several focus group meetings to help frame the research effort.
3. **Administering an industry survey.** Based on input from the literature review and the focus group meetings, the research team developed an industry survey to gauge the industrial construction sector's perceptions of FEED, maturity, and accuracy. The survey was distributed electronically to CII member organizations during the fall of 2015. RT-331 analyzed and discussed the survey results to finalize its definitions of FEED, maturity, and accuracy.