



Front End Engineering Design (FEED)
Maturity and Accuracy Total Rating System (MATRS)

Implementation Resource 331-2

Front End Engineering Design (FEED) Maturity and Accuracy Total Rating System (MATRS)

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

Implementation Resource 331-2

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Executive Summary

Welcome to the FEED MATRS tool. CII Research Team 331 (RT-331), Assessing the Maturity and Accuracy of Front End Engineering Design (FEED) to Support Phase-gate Approvals, developed this resource to help stakeholders of large industrial projects to assess both the maturity and accuracy of FEED deliverables during the front end planning (FEP) process. In addition to producing this publication, the team created a macro-enabled Excel file that combines the maturity and accuracy tools into one spreadsheet. RT-331 named both this book and its accompanying software the Front End Engineering Design (FEED) Maturity and Accuracy Total Rating System (MATRS) tool, which it shortened to FEED MATRS (pronounced “FEED matters”).

With this publication, CII fills a critical gap in the FEP body of knowledge. This document and its accompanying tool help project teams evaluate FEED maturity and accuracy for large, complex industrial projects, whether they involve new construction, renovation and revamp, or both. The FEED MATRS tool is complementary to Implementation Resource (IR) 113-2, *PDRI: Project Definition Rating Index – Industrial Projects*, and IR320-2, *Tools for Enhancing the Quality of Problematic Design Deliverables*.

Project teams and owners expend substantial effort to develop scope definition during the front end planning (FEP) of large industrial projects. Many times, however, these projects have either immature or inaccurate front end engineering design (FEED). As an initial part of this research effort, RT-331 developed a standard definition of FEED: “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.” This implementation resource summarizes the motivations and efforts of RT-331 to develop an FEP tool to assess the maturity and accuracy of engineering design during FEED for large industrial projects, and then shows users how to deploy that tool.

RT-331 reviewed and adapted the Project Definition Rating Index (PDRI) for Industrial Projects and other past CII work to develop a set of 46 maturity elements and 27 accuracy factors that correlate with project performance. Forty-six of the 70 elements from the PDRI–Industrial were considered to be engineering elements, and therefore included in the maturity-assessment section of this

publication. The accuracy factors were developed from past FEP literature and finalized in workshops.

The FEED MATRS tool assesses the maturity of FEED deliverables in ways that are similar to the PDRI, but FEED MATRS only evaluates the PDRI elements that are associated with the engineering design effort during FEP activities – specifically, during detailed scope (Phase 3) leading up to Phase Gate 3. The maturity tool can be used in a variety of ways; for example, at the beginning of FEED to set expectations, or at the end of FEED as an auditing tool. It may be used on its own, with a facilitator, or in conjunction with the PDRI–Industrial to output a maturity score at Phase Gate 3.

In addition to delivering a maturity assessment, FEED MATRS can also determine the accuracy of FEED deliverables by evaluating the *enabling* or *external* factors associated with FEED processes that have the potential to affect project performance. These factors include the experience of the individuals developing FEED deliverables and the resources available to develop FEED. In all, RT-331 identified 27 accuracy factors from literature, and then FEED industry professionals vetted these factors through a series of data collection workshops.

The development effort included four industry-sponsored workshops where the maturity elements and accuracy factors were evaluated by 48 professionals with an average of 20 years of project management and engineering experience. These engineering professionals also prioritized and rank-ordered the accuracy factors to develop a corresponding weighted score sheet through statistical analysis. The RT-331 tools were tested on 33 completed and 11 in-progress projects. These analyses showed that industrial projects whose FEED was more mature and accurate outperformed those with less FEED maturity and accuracy in terms of four performance areas: cost, changes, financial performance, and customer satisfaction. Specifically, they found that projects with high maturity and high accuracy outperformed projects with low maturity and low accuracy by 24 percent regarding cost changes, and 12 percent in terms of change orders.

The accuracy and maturity assessment tools are designed to be used in parallel to output both maturity and accuracy scores. These scores can be plotted on a four-quadrant matrix that is correlated with project performance. This document gives the user the tools to achieve high maturity and high accuracy on large industrial projects.

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Introduction

CII Research Team 331 (RT-331) prepared this tool to address a critical industry need: the assessment of maturity and accuracy of front end engineering design (FEED) as part of the front end planning (FEP) process at the end of the detailed scope phase (Phase 3).

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 the term “front end planning” is used in this document, it should be considered synonymous with the analogous term within the user’s business process.

Phase 1 of the FEP process is known as “feasibility,” Phase 2 is known as “concept,” and Phase 3 is known as “detailed scope” (See Figure 1.1.) Each phase is followed by a phase gate that marks a decision whether to move forward to the next stage of the project. For many projects, FEP is considered to be the most important process within the project lifecycle.

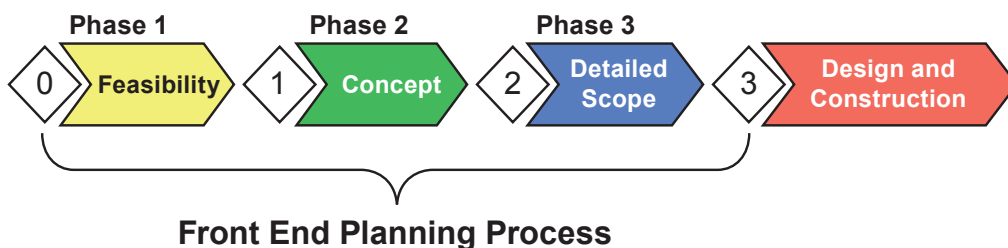


Figure 1.1. Front End Planning Process

A consistent understanding of all aspects related to FEED within the FEP process has not been established within the engineering and construction community. There is neither a universally accepted definition nor established, non-proprietary evaluation requirements for the maturity and accuracy of FEED. The impacts of maturity and accuracy on project performance are also not well understood. An owner expects to be able to make reliable, sound, and informed

project decisions based upon FEED development, including cost and schedule predictions. These decisions can determine whether a project should move forward to detailed design, and ultimately can lead to better project performance. A clear definition of FEED, combined with its maturity elements and accuracy factors, would provide a missing link in scope definition within FEP. RT-331 developed a measurement tool to assess FEED maturity and accuracy, and to correlate their effects to project performance predictability.

Defining FEED, Maturity, and Accuracy

RT-331's first goal was to develop definitions for the terms FEED, maturity, and accuracy, in order to frame the research and to establish industry-accepted definitions. The results of an industry survey gauged the perceptions of industrial project professionals and, through four industry-sponsored workshops, the team was able to develop credible definitions for all three terms. Moreover, the survey indicated that the industry rule of thumb for FEED design effort is when approximately 30 percent of engineering design work hours are complete at the end of Phase Gate 3, providing sufficient information to support an Association for the Advancement of Cost Engineering International (AACEi) Class 3 cost estimate.

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 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. Figure 1.2 illustrates the FEED definition and its relationship to the various other deliverables that are associated with the project definition package. This development effort led to a consensus definition of FEED. (Note that the list of deliverables in Figure 1.2 is not meant to be exhaustive. Also note that other terms may be used synonymously and sometimes incorrectly with FEED, including basic engineering design, basic design, preliminary engineering, project definition, and concept design.)

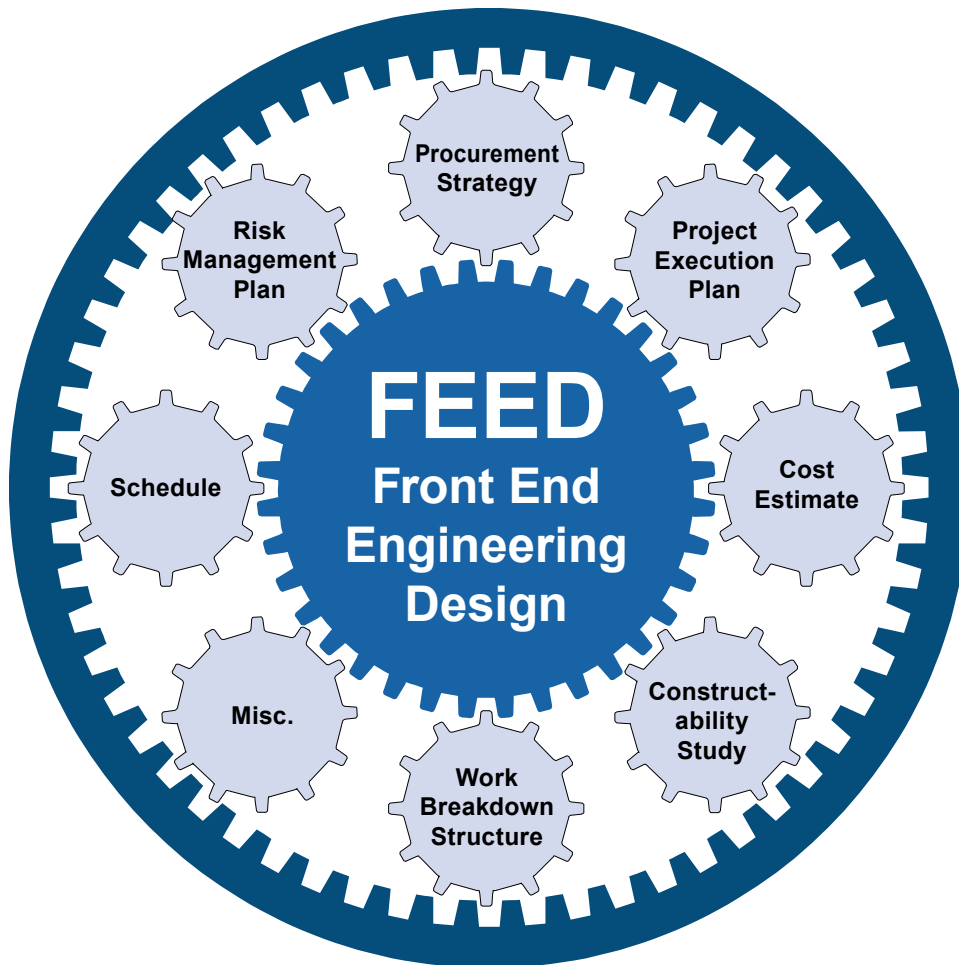


Figure 1.2. The Project Definition Package
(also Known as the FEED Package)

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).

Maturity and accuracy are both critical for effective FEED to occur. **Maturity** is how well the deliverables have been done. **Accuracy** involves the people, teams, and resources that create the environment where a mature FEED can be developed. The RT-331 research analysis showed that both of these metrics can inform the project decision-making process and help to predict project performance outcomes. Specifically, project success is significantly affected by maturity and accuracy of FEED in terms of cost growth, change order performance, financial performance matching expectations, and customer satisfaction. (The RT-331 research is summarized in Research Summary 331-1, *Assessing the Maturity and Accuracy of Front End Engineering Design (FEED)*, and fully detailed in Research Report 331-11, *Maturity and Accuracy of Front End Engineering Design (FEED)*.)

This implementation resource provides guidance on the tool RT-331 developed to address both the accuracy and maturity of FEED: the Front End Engineering Design (FEED) Maturity and Accuracy Total Rating System (MATRS). The ultimate goal of this maturity and accuracy tool is to enable its users to plot maturity and accuracy scores on a four-quadrant matrix and to correlate these scores with performance, as shown in Figure 1.3. RT-331 developed threshold values for maturity (80) and accuracy (76) through statistical analysis of the collected project data. Figure 1.3 shows 32 projects plotted for maturity and accuracy.

The FEED MATRS tool builds on the PDRI–Industrial tool, providing a more consistent mechanism for evaluating the level of definition for engineering design deliverables. It also provides a new evaluation method for assessing the environment under which an accurate FEED should be developed.

The subsequent sections of this implementation resource are organized in the following manner: Chapter 2: FEED MATRS Tool Structure; Chapter 3: Benefits of FEED MATRS; Chapter 4: Guidelines for Using the Tool; Chapter 5: Instructions for Assessing a Project; Chapter 6: The Meaning of Maturity and Accuracy Scores; and Chapter 7: Concluding Remarks.

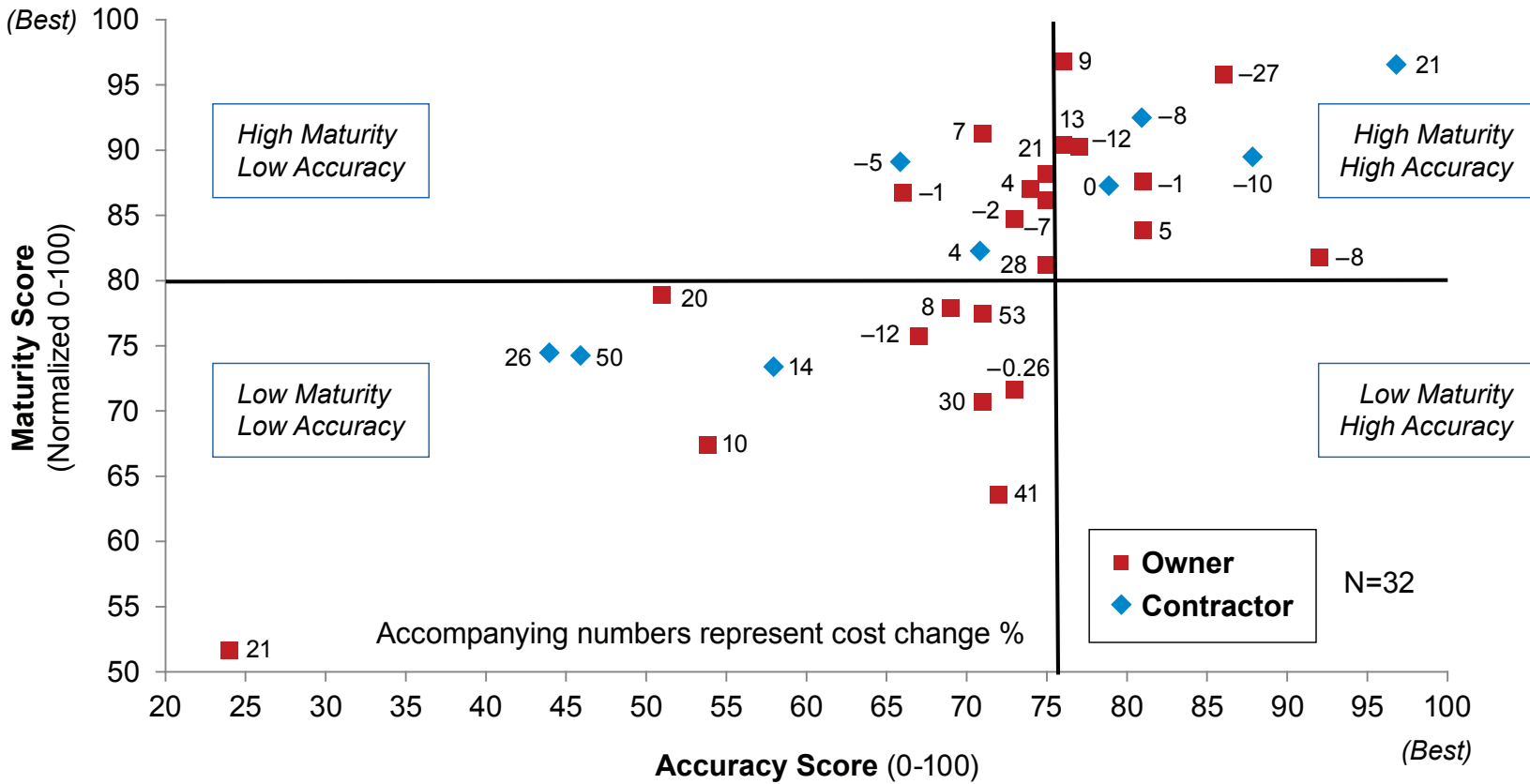


Figure 1.3. Maturity-Accuracy Matrix (Cost Change Performance)

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FEED MATRS Tool Structure

This chapter focuses on RT-331's efforts to develop the FEED MATRS tool, documenting the maturity tool and accuracy tool structures, outlining associated elements and factors, and offering a brief development methodology.

FEED MATRS Maturity Tool Structure

The maturity assessment tool presented in this resource is an extension of the Project Definition Rating Index for Industrial Projects (IR113-2, RR113-11). FEED MATRS was created to help the stakeholders of large industrial projects assess the maturity of FEED. (Recall that the maturity of design is defined as “the degree of completeness of the FEED deliverables to serve as a basis for detailed design at the end of detailed scope (Phase 3).”) Specifically, RT-331 adapted the 46 elements from PDRI–Industrial that reflect the engineering deliverables associated with FEED, and used them in the maturity assessment tool.

The maturity tool is organized into three sections: Section I – Basis of Project Decision, Section II – Basis of Design, and Section III – Execution Approach. Each section is then organized by category and further divided into elements within those categories that reflect the typical engineering design deliverables of FEED. Each element is given a score for each definition level. In all, 46 elements constitute the FEED deliverables in the maturity tool. Each element receives a definition level from 0 to 5. (See Appendix B for detailed maturity element descriptions.)

The definition levels indicate the following potential impacts:

- **Definition Level 0** – The element is not required for the project, and thus will not affect the overall maturity assessment.
- **Definition Level 1** – The element has been completed, documented, and approved by key stakeholders for FEED design, minimizing uncertainty, and will not affect cost and schedule estimates when moving to detailed design.
- **Definition Level 2** – The element is mostly complete with minor issues, and should not adversely affect cost and schedule estimates when moving to detailed design.

- **Definition Level 3** – The element is somewhat addressed, with holds for deficiencies, and will more than likely adversely affect cost and schedule estimates through further development.
- **Definition Level 4** – For this element, only initial thoughts have been applied to the design effort, and little or no meeting time or design/consulting hours have been expended. It is expected that elements with definition level 4 have high levels of uncertainty and will adversely affect the cost, schedule, and operational characteristics of the project.
- **Definition Level 5** – Work on this element has not started, thus significantly affecting uncertainty around the cost, schedule, and operational characteristics of the project.

Table 2.1 depicts the typical layout of a maturity element showing how the maturity of each definition level is graded. It should be noted that each element also contains additional technical details unique to each.

Table 2.1. Structure of FEED Maturity Elements

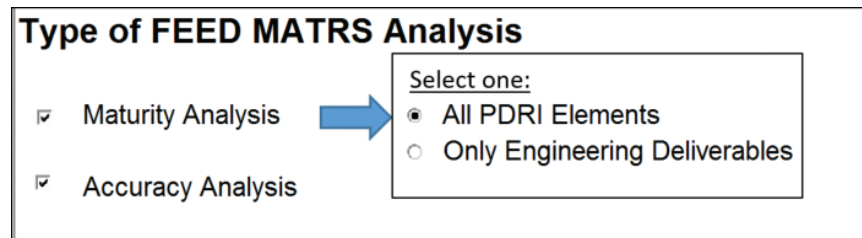
SECTION	Definition Level					
	N/A	BEST	MEDIUM		WORST	
CATEGORY	0	1	2	3	4	5
Element <i>Element description</i>	Not required for project	All element descriptions are satisfied and approved by key stakeholders as a basis for detailed design.	Most element descriptions are documented and under review, but not yet approved. There may be minor deficiencies.	Some element descriptions have been defined with holds for deficiencies.	Some initial thoughts have been applied to this element; however, little to no meeting time or design hours have been expended and little has been documented.	Not yet started
Renovation and Revamp <i>R&R description</i>		Items related to R&R have been documented and approved by key stakeholders.	Most items related to R&R have been documented and are under review, but not yet approved.	Some items related to R&R have been identified and are being assessed.	Little or no meeting time or design hours have been expended on R&R items.	

Table 2.2 shows the maturity sections, categories, and elements that make up the maturity tool. The table includes all 70 PDRI elements from PDRI–Industrial – the 24 non-engineering elements that are not part of the FEED MATRS scope appear in italics.

Table 2.2. Maturity SECTIONS, Categories, and Elements

I. BASIS OF PROJECT DECISION	
A. Manufacturing Objectives Criteria A1. Reliability Philosophy A2. Maintenance Philosophy A3. Operating Philosophy B. Business Objectives B1. Products B2. Market Strategy B3. Project Strategy B4. Affordability/Feasibility B5. Capacities B6. Future Expansion Considerations B7. Expected Project Life Cycle B8. Social Issues	C. Basic Data Research and Development C1. Technology C2. Processes D. Project Scope D1. Project Objectives Statement D2. Project Design Criteria D3. Site Characteristics Available vs. Required D4. Dismantling and Demolition Requirements D5. Lead/Discipline Scope of Work D6. Project Schedule E. Value Engineering E1. Process Simplification E2. Design and Material Alternatives Considered/Rejected E3. Design for Constructability Analysis
II. BASIS OF DESIGN	
F. Site Information F1. Site Location F2. Surveys and Soil Tests F3. Environmental Assessment F4. Permit Requirements F5. Utility Sources with Supply Conditions F6. Fire Protection and Safety Considerations G. Process/Mechanical G1. Process Flow Sheets G2. Heat and Material Balances G3. Piping and Instrumentation Diagrams (P&IDs) G4. Process Safety Management (PSM) G5. Utility Flow Diagrams G6. Specifications G7. Piping System Requirements G8. Plot Plan G9. Mechanical Equipment List G10. Line List G11. Tie-in List G12. Piping Specialty Items List G13. Instrument Index	H. Equipment Scope H1. Equipment Status H2. Equipment Location Drawings H3. Equipment Utility Requirements I. Civil, Structural, and Architectural I1. Civil/Structural Requirements I2. Architectural Requirements J. Infrastructure J1. Water Treatment Requirements J2. Loading/Unloading/Storage Facilities Requirements J3. Transportation Requirements K. Instrument and Electrical K1. Control Philosophy K2. Logic Diagrams K3. Electrical Area Classifications K4. Substation Requirements/Power Sources Identified K5. Electrical Single Line Diagrams K6. Instrument and Electrical Specifications
III. EXECUTION APPROACH	
L. Procurement Strategy L1. Identify Long Lead/Critical Equipment and Materials L2. Procurement Procedures and Plans L3. Procurement Responsibility Matrix M. Deliverables M1. CADD/Model Requirements M2. Deliverables Defined M3. Distribution Matrix	N. Project Control N1. Project Control Requirements N2. Project Accounting Requirements N3. Risk Analysis P. Project Execution Plan P1. Owner Approval Requirements P2. Engineering/Construction Plan and Approach P3. Shutdown/Turnaround Requirements P4. Pre-Commissioning Turnover Sequence Requirements P5. Startup Requirements P6. Training Requirements

Figure 2.1 shows the selection switch in the Setup Sheet tab of the FEED MATRS tool. Users can set this switch to use the tool to evaluate only the 46 FEED elements (the scope of this research), or to evaluate all 70 elements in PDRI–Industrial (including the non-engineering elements that appear in italics in Table 2.2).



Type of FEED MATRS Analysis

☒ Maturity Analysis 

☒ Accuracy Analysis

Select one:

- ☒ All PDRI Elements
- ☐ Only Engineering Deliverables

Figure 2.1. Selection Switch in the FEED MATRS Software Tool

To be effective, the maturity tool requires its users to possess experience, technical background, and training in the relevant subject matter. Elements in Categories A. Manufacturing Objectives Criteria and B. Business Objectives need be fully mature before an assessment can move to the other elements in the tool. (See Appendix B: Maturity Element Descriptions.)

FEED MATRS Accuracy Tool Structure

The FEED MATRS accuracy assessment tool is meant to help stakeholders assess 27 factors that affect the quality of FEED. Recall that accuracy is defined 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). Accuracy involves the people, teams and resources that create the environment where a mature FEED can be developed.”

The accuracy tool is topologically organized into four types of factors: 1) the project leadership team; 2) the project execution team; 3) project management processes; and 4) project resources. Each type contains six to eight accuracy factors related to the environment that supports the development of FEED. Table 2.3 illustrates how each accuracy factor is assessed. An assessor can choose one of five levels, ranging from *Not Acceptable* to *High Performing*, to describe each factor at the time of the assessment. Table 2.4 lists the 27 accuracy factors by type and ranked by order of importance. Boldface text highlights the key thoughts in each factor.

Table 2.3. Structure of FEED Accuracy Factor Assessment

N/A	<i>High Performing</i>	<i>Meets Most</i>	<i>Meets Some</i>	<i>Needs Improvement</i>	<i>Not Acceptable</i>
Not required for project.	Rating a factor <i>High Performing</i> indicates the factor's criteria are fully met within the context of their respective category, e.g., project leadership, execution, management, or project resources.	Rating a factor <i>Meets Most</i> indicates that the factor's criteria are consistently met and understood with minor deficiencies.	Rating a factor <i>Meets Some</i> indicates that the factor's criteria are partially met and without improvement, project success could be in jeopardy.	Rating a factor <i>Needs Improvement</i> indicates that the factor's criteria are not consistent in meeting project expectations and without improvement, the project is at risk. Substantial action to meet expectations is required.	Rating a factor <i>Not Acceptable</i> indicates that the factor's criteria are consistently below expectations and current performance is unacceptable. Project success cannot be achieved in this current state and actions are required to improve.

Table 2.4. FEED Accuracy TYPES and Factors

1. PROJECT LEADERSHIP TEAM 1a. Leadership team's previous experience planning, designing, and executing a project of similar size, scope, and/or location, including FEED 1b. Stakeholders are appropriately represented on the project leadership team 1c. Project leadership is defined, effective, and accountable 1d. Leadership team and organizational culture foster trust, honesty, and shared values 1e. Project leadership team's attitude is able to adequately manage change 1f. Key personnel turnover (e.g., how long key personnel stay with the leadership team)
2. PROJECT EXECUTION TEAM 2a. Technical capability and relevant training/certification of the execution team 2b. Contractor/engineer's team experience with the location, with similar projects, and with the FEED process 2c. Stakeholders are appropriately represented on the project team (e.g., contractor, operations and maintenance, key design leads, project manager, sponsor) and have a clear understanding of the project scope 2d. Level of involvement of design leads or managers in the engineering process 2e. Key personnel turnover including the stability/commitment of key personnel on the owner side through the FEED process 2f. Co-location of execution team members 2g. Team culture or history of the execution team working together
3. PROJECT MANAGEMENT PROCESS 3a. Communication within the team is open and effective; a communication plan with stakeholders is identified 3b. Organization implements and follows a front end planning process (e.g., phase gates, clear requirements), has a formal structure or process to prepare FEED, and implements planning tools (e.g., checklists, simulations, and work flow diagrams) that are used effectively 3c. Clear priorities for cost, schedule, and required project features 3d. Significant input of construction knowledge into the FEED process 3e. Adequate process for coordination between key disciplines 3f. Alignment of FEED process with available project information, including the existence of peer reviews and a standard procedure for updating FEED 3g. Documentation of information used in preparing FEED 3h. Review and acceptance of FEED by appropriate parties
4. PROJECT RESOURCES 4a. Commitment of key personnel on the project team 4b. Calendar time allowed for preparing FEED management tools available including technology/software 4c. Local knowledge (e.g., institutional memory, understanding of laws and regulations, understanding of site history) and access to visit and evaluate the site 4d. Quality and level of detailed engineering data available 4e. Amount of funding allocated to perform FEED 4f. Availability of standards and procedures (e.g., design standards, standard operating procedures, and guidelines)

3

Benefits of FEED MATRS

FEED MATRS allows a project team to assess FEED maturity elements and accuracy factors related to FEED prior to detailed design and construction. The tool can identify gaps early, so they can be acted upon. The ability to identify these gaps makes the maturity and accuracy assessments a remarkably powerful method for the proactive management of front end planning. Moreover, FEED MATRS can be used as a method for benchmarking the project against its potential expected outcomes. Specific benefits of FEED MATRS include:

- **Consistency of FEED maturity** by establishing FEED maturity elements, adding detailed information on the maturity definition levels, and defining the interconnection between the FEED maturity elements
- **Improvement of FEED accuracy** by developing accuracy factors and their descriptions, and gauging the team environment in which a mature FEED can be developed
- **Improvement of project certainty** by showing a 24-percent cost performance difference and 12-percent change performance difference between projects with high maturity (>80) and high accuracy (>76) versus projects with low maturity (<80) and low accuracy (<76)

FEED MATRS centers around maturity and accuracy assessments, which combine into one metric. The results are plotted on a four-quadrant matrix where maturity and accuracy scores have been statistically correlated with performance outcomes based on collected project data. (The nature of these quadrants and the average performance outcomes are discussed in Chapter 6.) Projects that had higher maturity and accuracy scores performed significantly better than projects with low maturity and accuracy scores. (For details on the development of the tool, see Research Report 331-11.)

The FEED MATRS tool can be utilized in a variety of ways:

- As a **checklist** that a project team can use to determine the necessary steps for defining project scope, for both greenfield and R&R projects during the FEED process
- As a **checklist** to determine alignment issues and identify mitigation actions before performing risk analysis

- As input for, and complementary to, a **formal PDRI scoring session** (for more information about PDRI, see IR113-2)
- As a listing of **standardized scope definition terminology** for maturity and accuracy of FEED for large industrial projects
- As an industry standard for rating the completeness of the project definition package and to facilitate **risk assessment** and prediction of escalation potential for disputes
- As a means of **monitoring progress**—when used successively during all of FEP until the end of detailed scope (Phase 3)
- As a means to establish a **supportive team environment** prior to initiating FEED
- As a **forensic assessment** tool for evaluating success or failure of completed projects
- As a tool that promotes **communication and alignment** among owners, designers/engineers, and construction contractors by highlighting the maturity and accuracy of FEED
- As a means by which project team participants can **reconcile** differences, when used as a common basis for FEED evaluation
- As a means by which members of the project team can **identify FEED gaps and act upon them** before the project is negatively affected
- As a **training tool** for organizations and individuals (particularly those with less FEED experience) to understand the requirements of FEED of large industrial projects
- As a **benchmarking tool** for comparing FEED on current projects against performance of past projects, both within the organization and externally
- To support **FEED validation** moving into detailed design. (For more information on detailed design, see IR320-2.)

4

Guidelines for Using the Tool

This section outlines the guidelines and instructions for using FEED MATRS, including when to and who should use the tool. These guidelines should be reviewed before utilizing FEED MATRS to evaluate a project.

FEED MATRS was designed for use on large industrial projects. Table 4.1 lists criteria that generally define large industrial projects. Typically, total installed cost is greater than \$10 million and construction schedule is greater than nine months. Generally, a project's complexity is considered a major factor in determining whether it is considered small or large. (For more information on project complexity definitions, see IR314-2.) Table 4.2 provides a list of typical industrial project types that are suitable for evaluation using FEED MATRS.

Table 4.1. Industrial Project Criteria Selection Guide

Project Criteria	Scope
Total Installed Cost	>\$10 million
Construction Duration	>9 months
Number of Core Team Members	>10 core team members
Availability of Core Team Members	Combination of part-time and full-time to completely full-time

Table 4.2. Applicable Industrial Project Types for Maturity and Accuracy Assessments

Typical Industrial Projects		
• Oil/gas production facilities • Textile mills • Chemical plants • Pharmaceutical plants • Paper mills	• Steel/aluminum mills • Power plants • Steam heat/chilled water plants • Manufacturing facilities	• Food processing plants • Refineries • Water/wastewater treatment • Plant upgrade/retrofit

When to Use FEED MATRS

FEED MATRS should be used during the FEED process to ensure alignment, conformance to organizational procedures, and a continual focus on project priorities. The tool focuses on FEED activities during FEP and could be used both during and at the conclusion of FEED. Specific FEED MATRS application points are shown in Figure 4.1.

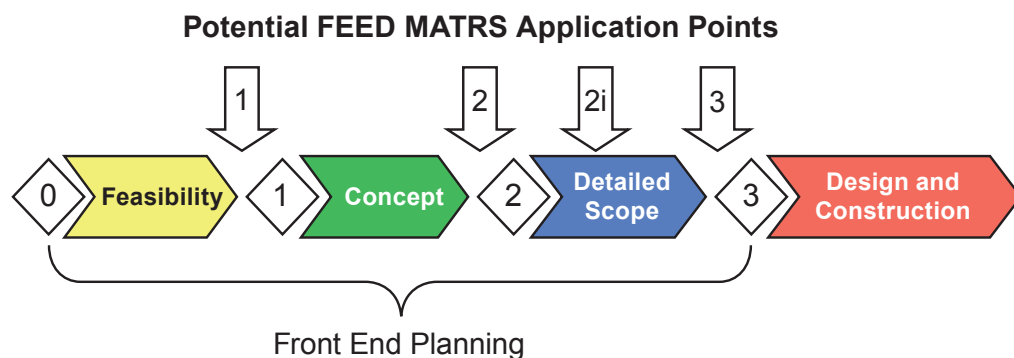


Figure 4.1. Potential FEED MATRS Application Points

Whatever the timing of a FEED MATRS assessment, the same checklist and descriptions should be used to conduct the evaluation in accordance with the following guidelines:

- **FEED MATRS 1 Review** – This is a high-level assessment of the project following feasibility prior to Phase Gate 1. It should be used to establish baseline values of maturity and accuracy before moving on to the next phase.
- **FEED MATRS 2 Review** – This is a high-level assessment of the project following the concept phase of the project. It should be used to develop updated values of maturity and accuracy before starting detailed scope.
- **FEED MATRS 2i Review** – This is an intermediate assessment of the project during detailed scope and typically should be held midway through this phase. It is done to assess the evolution of FEED activities and to determine how the engineering design effort is being defined.
- **FEED MATRS 3 Review** – This is typically the final assessment of the project, at the end of FEED prior to Phase Gate 3. A FEED MATRS 3 assessment should be conducted for all projects to establish final maturity and accuracy scores for the FEED.

The purpose of completing a FEED maturity and accuracy assessment is to help stakeholders ensure that they are progressing favorably in early project design before the beginning of detailed design. In order for the maturity and accuracy assessment to provide value, it should be conducted before detailed design commences. If the maturity and accuracy reviews are performed during detailed design, they may help with certain design elements; however, the assessment may not have the same impact it could have had if it had been completed during FEED. Recall that for large industrial projects, there is a PDRI–Industrial tool (IR113-2) that can help with the assessment of the entire project definition package, and it can be used in harmony with FEED MATRS.

FEED MATRS is intended to be used up to, and including, Phase Gate 3 in any of the following ways:

1. To assess maturity and accuracy at the beginning of FEED to inform the project team on needed management and engineering actions.
2. At the end of detailed scope (Phase Gate 3) as a stand-alone team exercise prior to a PDRI evaluation, in order to provide a more in-depth evaluation of FEED. (This could result in a more informed assessment of the 46 engineering elements during the PDRI evaluation.)
3. At the end of detailed scope (Phase Gate 3), used in conjunction with a team PDRI assessment to assist in a more rigorous evaluation of the 46 engineering elements.
4. As an audit tool by either internal or external parties looking at FEED engineering deliverables during any stage of FEP.
5. After FEP, or even post-project, as a post-mortem evaluation of maturity and accuracy of FEED (e.g., lessons learned).

For the first four items in this list, FEED MATRS can assist in the development of a gap list to provide the project team with a path forward to improve the FEED. The maturity and accuracy assessments of FEED MATRS can be completed at the same time by the same entity, or split into stand-alone maturity and accuracy assessments completed separately by different parties to inform decision-makers as needed.

Who Should Use FEED MATRS?

The maturity and accuracy assessment tools can be used by appropriate project stakeholders (owners, engineers, and contractors) to make informed project decisions. The tool may be used by a qualified facilitator (in-house or third-party) to assist the project team in the evaluation of FEED maturity and accuracy. (Guidance for facilitators is provided in Appendix G.) RT-331 recommends that the project team be well represented during an evaluation session that includes members of the design team from all relevant disciplines, project management, and project controls.

Owners can use FEED MATRS to establish a comfort level that, when reached, prompts them to move forward with detailed design for their projects. Moreover, designers, engineers, and contractors can use the tool to identify poorly defined FEED elements. FEED MATRS provides a common basis for FEED evaluation and a means for project participants to communicate and reconcile any differences they have. Owners can use these tools as a formal checklist of items to be defined and communicated, as well as factors that can affect FEED. FEED MATRS also provides an opportunity for owner and stakeholders—including operations and maintenance—to gain an understanding of the project.

Communication is essential to ensure the FEP team is proceeding to meet the expectations and requirements of the owner stakeholders. During the FEED MATRS assessment, every attempt should be made to involve as many key project stakeholders as possible in the assessment session, to ensure that the team is making the correct evaluation, based on the right assumptions. Engineers and contractors may become involved in projects at various points during FEED and can use the maturity and accuracy assessment tools to organize their work.

FEED MATRS can also be used as an alignment tool to understand and participate in the development of the owner's business objectives and drivers, facilitating the FEP team's understanding of the elements defined in Section I – Basis of Project Decision. As FEED progresses, FEED MATRS helps project participants clarify requirements and ensure the right input from key owner stakeholders representing specific engineering design areas, such as project scope, manufacturing objectives, site information, process/mechanical, and infrastructure. FEED MATRS can also help support coordination and project execution planning within the owner organization.

Contractors are often given a request for proposal (RFP) on a project that has had all or a portion of the project scope defined by the owner, or the owner has utilized a third-party engineering firm to develop the scope definition package. In such instances, the contractor could use FEED MATRS for risk analysis to determine the degree of FEED definition and identify any potential weaknesses or areas of concern before responding to the RFP. Contractors may also use FEED MATRS to determine whether the work within their control is adequately defined. Many contractors spend a portion of the project development effort performing design, procurement, and constructability reviews prior to starting work in the field; FEED MATRS can aid in their assessment.

Other Important Guidance When Using FEED MATRS

1. For large projects that involve several units or work packages, FEED MATRS can be used independently for each element. In cases that combine the FEED packages for multiple units, care should be taken to review the scope interfaces, as these could result in gaps and eventually lead to poor or incomplete definition.
2. For projects that are critical for capturing business opportunities, a FEED MATRS assessment can be used to help determine risks that affect contingency, or engineering allowance requirements, as well as pre-funding requests.
3. FEED MATRS is best used during FEP through detailed scope (Phase Gate 3). This tool has limited applicability after Phase Gate 3, and especially after early detailed design.
4. Additional deliverables are part of the Project Definition Package. (See the definition of FEED in Chapter 1.) This tool is not intended to be the only evaluation used for the whole project definition package. FEED MATRS focuses on engineering deliverables and the factors that influence them. There are 24 additional elements to consider beyond the engineering deliverables portion of FEED, and they are included in the PDRI tool.
5. FEED MATRS is intended for use on large industrial projects. This tool should not be applied to infrastructure and building projects' FEED. Using this tool for small industrial projects may result in inconsistencies with correlating maturity and accuracy to project performance outcomes.

5

Instructions for Assessing a Project

Experienced individuals involved in front end planning should use the project score sheets shown in Appendices A and C to assess a project:

- Appendix A provides the unweighted and weighted **maturity element score sheets** that enable a front end planning team to quantify the level of FEED maturity on a zero to 100-point scale, with higher scores being better or more mature. The unweighted version should be used during a team scoring process, to prevent bias in choosing the level of definition and to guard against “targeting” a specific score. The team leader or facilitator can then easily score the project while the session is being held.
- Appendix C contains the unweighted and weighted **accuracy factors score sheets** that allow a front end planning team to quantify the level of FEED accuracy on a zero to 100-point scale, with higher scores being better or more accurate. Similar to the maturity score sheet, the unweighted version should be used in a team scoring process, to prevent bias in choosing the level of definition or in “targeting” a specific score.

An Excel-based tool has been developed to automate the scoring. The tool automatically calculates the scores of individual elements and factors, multiplies them by the appropriate weighting factors, and delivers a score between zero and 100. Moreover, the tool illustrates the final score on the maturity-accuracy matrix, which correlates with expected performance.

Assessing a Maturity Element

To assess an element, the user should first refer to the unweighted score sheet in Appendix A, and then read its corresponding element description in Appendix B. Some elements contain a list of items to be considered as their definition levels are evaluated. These lists may be used as checklists. Additional issues may be applicable for renovation projects. All elements have six pre-assigned scores, one for each of the six possible definition levels.

The maturity assessment tool consists of three main sections, and each section consists of several categories. The categories are further broken down into 46 maturity elements. (The elements are described individually in Appendix B.) Elements are rated numerically from 0 to 5, where 0 represents

Not Applicable, 1 means *Complete Definition*, and 5 signifies *Incomplete or Poor Definition* (i.e., not yet started), as indicated in the legend at the bottom of each score sheet. Each applicable element should receive a rating of 1, 2, 3, 4, or 5, depending on the team's assessment. Those elements deemed not applicable for the project under consideration should receive a 0, so as not to affect the final maturity score. All maturity element assessments contribute to the final maturity score for the project.

Users should choose only one definition level (i.e., 0, 1, 2, 3, 4, or 5) for each element, based on their perception of how well it has been addressed. The suggested method for making this determination is through open discussion among the project team members until they reach a consensus decision. In considering the completeness of each maturity element, the FEP team should consider the possible impact of this element on project performance. The team must have an adequate understanding of the issues with each element and the work required to achieve complete definition. On certain issues, it is important to defer to the most knowledgeable team member (for example, structural design issues should be deferred to a structural engineer), while at the same time respecting the concerns of other team members. As the discussion unfolds, it is critical to capture action items or "gaps." Appendix H provides an example of an action item (gap) list.

For maturity elements that are completely defined, no further work is needed during FEED. For elements with minor deficiencies, no further work is needed during FEED development, and the issue will not adversely affect project performance; however, the project team will need to track and address the minor issues identified as the project proceeds into detailed design. For those elements that are assessed as having some problems or major deficiencies, or are incomplete, the team will have to perform further mitigation during FEED before the end of the detailed scope phase (Phase Gate 3).

Once users have chosen the appropriate definition level for each of the 46 elements, they select the value of the score that corresponds to that level on the paper maturity score sheet. Alternatively, the maturity and accuracy assessment Excel-based spreadsheet can be used to capture each score. Regardless, it is important to assess each element.

All of the element scores within a category should be added together to produce a score for that category. Then, the scores for all categories in a section should be summed to arrive at a section score. The three section scores should then be combined to determine the total score. Finally, the maturity score normalization formula will transform the raw total score into a FEED maturity score in the zero to 100 range. (The maturity and accuracy assessment Excel spreadsheet performs these steps automatically.)

Assessing an Accuracy Factor

To assess an accuracy factor, the user should first refer to the unweighted score sheet in Appendix C, and then read its corresponding description in Appendix D. Some factors contain a list of items to be considered as their rating levels are evaluated, and these lists may be used as checklists. All factors have five pre-assigned scores: one for each of the five possible rating levels.

As noted earlier, the accuracy assessment tool consists of four main types of accuracy factors. A total of 27 accuracy factors have been shown to affect the outcome of FEED. (These factors are described individually in Appendix D.) Factors are rated from *Not Acceptable* to *High Performing*. Each factor that is rated *High Performing* is considered to fully defined, and that factor's criteria have been met within the context of its respective accuracy type. Each factor that is rated *Not Acceptable* indicates that that factor's criteria are below expectations and current performance is unacceptable. Each accuracy factor should receive a rating that reflects its assessment. The ratings for all four accuracy factor types result in the final accuracy score for the project.

Users should choose only one rating level (i.e., *High Performing*, *Meets Most*, *Meets Some*, *Needs Improvement*, or *Not Acceptable*) for a factor, based on their perception of how well it has been addressed. The suggested methods for making this determination are either through open discussion among the project team members, through interviews and dialogues with key project team participants, or through comparison of project and executive teams' opinions. In considering the rating of each accuracy factor, the assessor(s) should consider the possible impact of this factor on project performance. The assessor(s) must have an adequate understanding of each accuracy factor and the actions required to improve it.

Examples of Maturity and Accuracy Assessments

Maturity Assessment

Consider for example that you are a member of a front end planning team responsible for developing the FEED deliverables for a new chemical plant. Your team has identified major milestones throughout the front end planning process, including when you plan to use the FEED MATRS tool to evaluate the current level of FEED maturity and accuracy. Assume that at the time of this evaluation, the FEED development is complete (end of Phase 3).

Your responsibility is to evaluate how well the project infrastructure requirements have been identified and defined to date. This information is covered in Category J of the FEED MATRS as shown below and consists of three elements: “Water Treatment Requirements,” “Loading/Unloading/Storage Facilities Requirements,” and “Transportation Requirements.” It is recommended to use the unweighted assessment sheet when evaluating a project in a team setting.

CATEGORY Element	Definition Level						Score
	0	1	2	3	4	5	
J. INFRASTRUCTURE							
J1. Water Treatment Requirements							
J2. Loading/Unloading/Storage Facilities Requirements							
J3. Transportation Requirements							
CATEGORY J TOTAL							

Definition Levels

N/A = Not Applicable 2 = Minor Deficiencies 4 = Major Deficiencies
 1 = Complete Definition 3 = Some Deficiencies 5 = Incomplete or Poor Definition

To fill out Category J, Infrastructure, follow these steps:

Step 1: Read the description for each element in Appendix B. Scan the bold first sentence for each of the five definition levels and bracket the two bold sentences that most closely relate to your project’s status. Then read the detailed statement under each bold sentence and select the one that more closely defines your project.

Step 2: Collect all data or input that you may need to properly evaluate and select the definition level for each element in this category. This may require obtaining input from other individuals involved in the FEED development effort.

Step 3: Select the definition level for each element as described below:

Element J1: **Most of the water treatment requirements have been documented. Stakeholders have reviewed and commented on draft documents.**

In this example, most water treatment facilities for the project have been defined and documented. Overall balances and system hydraulics are complete, with only minor adjustments anticipated. The water management and waste water treatment design basis is under review; however, the design basis has not been approved. **Definition Level = 2.**

Element J2: Your team decides that this element is *not applicable* to your particular project. **Definition Level = 0.**

Element J3: Work has not been started on this particular element. **Definition Level = 5.**

CATEGORY Element	Definition Level						Score
	0	1	2	3	4	5	
J. INFRASTRUCTURE							
J1. Water Treatment Requirements			X				
J2. Loading/Unloading/Storage Facilities Requirements	X						
J3. Transportation Requirements						X	
CATEGORY J TOTAL							

Definition Levels

N/A = Not Applicable 2 = Minor Deficiencies 4 = Major Deficiencies
 1 = Complete Definition 3 = Some Deficiencies 5 = Incomplete or Poor Definition

Be sure to capture action items and comments as the discussion progresses, for reference in Step 6. This list is referred to as a “gap” list because it identifies which issues need to be addressed to move the project forward and it identifies any gaps in the planning activities.

Step 4: For each element, circle the score that corresponds to its level of definition. If the team feels that any or all of the elements were not applicable for this project, they would have had a definition level of “0” and been zeroed out. The weighted score sheet is given below. Circle the chosen definition levels for the assessed element.

CATEGORY Element	Definition Level						Score
	0	1	2	3	4	5	
J. INFRASTRUCTURE (Maximum Score = 25)							
J1. Water Treatment Requirements	0	1	3	5	7	10	
J2. Loading/Unloading/Storage Facilities Requirements	0	1	3	5	7	10	
J3. Transportation Requirements	0	1	2	3	4	5	
CATEGORY J TOTAL							

Definition Levels

N/A = Not Applicable 2 = Minor Deficiencies 4 = Major Deficiencies
 1 = Complete Definition 3 = Some Deficiencies 5 = Incomplete or Poor Definition

Step 5: Add the element scores to obtain a category score. Repeat this process for each element in the FEED MATRS tool. In this example, the category has a total score of 8. Add category scores to obtain section scores. Add section scores to obtain a raw maturity score. Input the raw maturity score into the normalization equation at the end of Appendix A to obtain a normalized maturity score on a zero to 100-point scale.

CATEGORY Element	Definition Level						Score
	0	1	2	3	4	5	
J. INFRASTRUCTURE (Maximum Score = 25)							
J1. Water Treatment Requirements	0	1	3	5	7	10	3
J2. Loading/Unloading/Storage Facilities Requirements	0	1	3	5	7	10	0
J3. Transportation Requirements	0	1	2	3	4	5	5
CATEGORY J TOTAL							8

Definition Levels

N/A = Not Applicable 2 = Minor Deficiencies 4 = Major Deficiencies
 1 = Complete Definition 3 = Some Deficiencies 5 = Incomplete or Poor Definition

Step 6: Take Action. In this example, Category J has a total score of 8 (out of 25 total points) and probably needs more work, particularly for Element J3. Use the gap list to identify which issues need additional attention.

Accuracy Assessment

For the accuracy assessment, members of the project team evaluate the environment in which an accurate FEED can be developed. Once again, at the timing of this evaluation the FEED development is complete (end of Phase 3).

The first task of the accuracy assessment is to help evaluate the project leadership team and how it performed during FEED. This information is covered in the accuracy type “Project Leadership Team,” as shown in the diagram below.

1. Project Leadership Team <i>The project leadership team is composed of individuals who represent the interests of their respective stakeholders (e.g., owner, engineer, contractor) and are adept in the relevant subject matter, in order to contribute to the decision-making process that leads to favorable project outcomes.</i>						
Factors for Review	High Performing	Meets Most	Meets Some	Needs Improvement	Not Acceptable	Raw Score
1a. Leadership team's previous experience planning, designing, and executing a project of similar size, scope, and/or location including FEED	6	5	3	2	0	
1b. Stakeholders are appropriately represented on the project leadership team	6	5	3	2	0	
1c. Project leadership is defined, effective, and accountable	5	4	3	1	0	
1d. Leadership team and organizational culture foster trust, honesty, and shared values	5	3	2	1	0	
1e. Project leadership team's attitude is able to adequately manage change	2	1	1	0	0	
1f. Key personnel turnover (e.g., how long key personnel stay with the leadership team)	1	1	1	0	0	
Project Leadership Team Maximum Score = 25						Project Leadership Team Total Score

To assess Project Leadership Team, follow these steps:

Step 1: Read the description for each factor in Appendix C. Each factor has a specific description associated with it that should be considered when your team evaluates its rating.

Step 2: Collect all the input you may need to properly evaluate and select the rating level for each factor in this accuracy type. This may require obtaining input from other individuals involved in the FEED development effort.

Step 3: Select the rating level for each factor as described below:

Factor 1a: Your team decides that the leadership team has extensive experience planning, designing and executing a project of similar size, scope, and location including FEED. **Rating Level = High Performing.**

Factor 1b: Your team decides that most of the stakeholders are appropriately represented on the project leadership team. **Rating Level = Meets Most.**

Factor 1c: Your team decides that the project leadership is not defined, effective, and accountable. **Rating Level = Needs Improvement.**

Factor 1d: Your team decides that the leadership team and organizational culture somewhat foster trust, honesty, and shared values. **Rating Level = Meets Some.**

Factor 1e: Your team decides that the project leadership team's attitude is very good at managing change. **Rating Level = High Performing.**

Factor 1f: Your team determines that key personnel turnover on this project has been extensive and problematic. **Rating Level = Not Acceptable.**

1. Project Leadership Team <i>The project leadership team is composed of individuals who represent the interests of their respective stakeholders (e.g., owner, engineer, contractor) and are adept in the relevant subject matter, in order to contribute to the decision-making process that leads to favorable project outcomes.</i>						
Factors for Review	High Performing	Meets Most	Meets Some	Needs Improvement	Not Acceptable	Raw Score
1a. Leadership team's previous experience planning, designing, and executing a project of similar size, scope, and/or location including FEED	X					
1b. Stakeholders are appropriately represented on the project leadership team		X				
1c. Project leadership is defined, effective, and accountable				X		
1d. Leadership team and organizational culture foster trust, honesty, and shared values			X			
1e. Project leadership team's attitude is able to adequately manage change	X					
1f. Key personnel turnover (e.g., how long key personnel stay with the leadership team)					X	
Project Leadership Team Maximum Score = 25						Project Leadership Team Total Score

Be sure to capture action items and comments as the discussion progresses for reference in Step 6. This list is referred to as a "gap list," in that it identifies which issues need to be addressed to move the project forward and identifies gaps in the planning activities.

Step 4: For each factor, circle the score that corresponds to its rating level. The weighted score sheet is given below. Circle the chosen rating level for each assessed factor.

1. Project Leadership Team						
<i>The project leadership team is composed of individuals who represent the interests of their respective stakeholders (e.g., owner, engineer, contractor) and are adept in the relevant subject matter, in order to contribute to the decision-making process that leads to favorable project outcomes.</i>						
Factors for Review	High Performing	Meets Most	Meets Some	Needs Improvement	Not Acceptable	Raw Score
1a. Leadership team's previous experience planning, designing, and executing a project of similar size, scope, and/or location including FEED	6	5	3	2	0	
1b. Stakeholders are appropriately represented on the project leadership team	6	5	3	2	0	
1c. Project leadership is defined, effective, and accountable	5	4	3	1	0	
1d. Leadership team and organizational culture foster trust, honesty, and shared values	5	3	2	1	0	
1e. Project leadership team's attitude is able to adequately manage change	2	1	1	0	0	
1f. Key personnel turnover (e.g., how long key personnel stay with the leadership team)	1	1	1	0	0	
Project Leadership Team Maximum Score = 25						Project Leadership Team Total Score

Step 5: Add the factor scores to obtain an accuracy type score. Repeat this process for each accuracy factor in the FEED MATRS tool. In this example, this type has a total score of 16 out of 25. Add accuracy type scores to obtain the total accuracy score on a scale of zero to 100.

1. Project Leadership Team						
<i>The project leadership team is composed of individuals who represent the interests of their respective stakeholders (e.g., owner, engineer, contractor) and are adept in the relevant subject matter, in order to contribute to the decision-making process that leads to favorable project outcomes.</i>						
Factors for Review	High Performing	Meets Most	Meets Some	Needs Improvement	Not Acceptable	Raw Score
1a. Leadership team's previous experience planning, designing, and executing a project of similar size, scope, and/or location including FEED	6	5	3	2	0	6
1b. Stakeholders are appropriately represented on the project leadership team	6	5	3	2	0	5
1c. Project leadership is defined, effective, and accountable	5	4	3	1	0	1
1d. Leadership team and organizational culture foster trust, honesty, and shared values	5	3	2	1	0	2
1e. Project leadership team's attitude is able to adequately manage change	2	1	1	0	0	2
1f. Key personnel turnover (e.g., how long key personnel stay with the leadership team)	1	1	1	0	0	0
Project Leadership Team Maximum Score = 25						Project Leadership Team Total Score

Step 6: Take action. In this example, Project Leadership Team has a total score of 16 (out of 25 total points) and probably needs more work, particularly for factors 1c and 1f. Use the gap list to identify issues that need additional attention. Since this is at the end of Phase 3,

the decision-makers should be concerned about accuracy from a project leadership perspective, although perhaps little could be done. At this point, the decision-makers need to reassess the path forward (for instance, accept the risk, add contingency, or stop and re-evaluate).

Implementation across an Organization

Previous experience indicates that many successful organizations require a PDRI assessment as part of their project approval process. FEED MATRS should serve a similar role. Projects with a maturity score of 80 or higher and an accuracy score of 76 or higher before moving to detailed design were found to perform better. Organization-specific procedures that require the use of FEED MATRS prior to a project's authorization to proceed with the detailed design phase may be helpful.

There is some risk in putting too much focus on scoring. Placing too much emphasis on the scores can lead to the use of the tool as a perfunctory administrative exercise rather than a beneficial project evaluation or risk assessment tool. The gap list and team alignment developed as part of the effort may prove more important than the numbers generated.

Another helpful practice for implementation across an organization is to designate a champion. This individual is an enthusiastic supporter and advocate of CII FEP applications. He or she gains knowledge about the tool and fosters its widespread application by staying in contact with other organizations that use the tool.

Training for successful FEED MATRS implementation is another helpful practice, and several facilitators should be trained within an organization. The number of facilitators that are needed will vary depending on the size of the organization and the number of projects that require approval. The objective is to ensure that every project has access to a trained facilitator in a timely manner. The facilitator should not be a stakeholder of the project team. In many organizations, project managers are trained as facilitators for their peers' projects.

In addition to developing a cadre of facilitators, organizations may want to ensure that users understand the PDRI tool, which is one of the foundations of FEED MATRS. In many cases, this can be accomplished with just-in-time

training. At the outset of each session, the facilitator should brief the participants on the purpose of the maturity and accuracy assessment process and explain their respective roles in making the session a success.

As FEED MATRS is implemented across the organization, its use should be monitored. The maturity element and accuracy factor descriptions within these tools may be modified to meet certain business development goals or to address proprietary concerns on a project-by-project basis. While a maturity target of 80 or higher and an accuracy target of 76 or higher are preferable from a project performance standpoint, at some point above these targets, FEED may reach a point of diminishing returns where organizations should look to balance FEED costs with overall project downstream costs and risks.

6

The Meaning of Maturity and Accuracy Scores

As part of FEED MATRS development, the tool was tested on 33 completed industrial projects (worth a total of \$8.83 billion), each of which represented a typical industrial project. These included several project types, such as chemical plants, refineries, pharmaceutical manufacturing facilities, food manufacturing plants, power plants, pipelines, and compression facilities. (The full list of projects is included in Research Report 331-11.)

A high maturity score (>80) represents a FEED that is well defined and, in general, corresponds to an increased probability for project success. Lower scores indicate that certain elements within the FEED lack adequate definition.

Similarly, a high accuracy score (>76) represents a FEED where the accuracy factors related to the project leadership team, execution team, project management processes, and project resources are all aligned. Similarly, lower scores indicate that there are signs of misalignment and potential risk in the quality of FEED.

Table 6.1 shows the results of RT-331's comparison of project performance across the sampled projects. These data show the mean performance for the projects versus the execution estimate for design and construction, and the absolute value of changes as a percentage of total project cost at Phase Gate 3.

Table 6.1. Project Performance Based on Maturity and Accuracy Scores

Performance	Maturity and Accuracy Scores		
	High Maturity High Accuracy M>80, A>76	High Maturity Low Accuracy M>80, A<76	Low Maturity Low Accuracy M<80, A<76
Cost (N=32)	2% below budget (N=11)	6% above budget (N=9)	22% above budget (N=12)
Change Orders (N=31)	4% of budget (N=12)	9% of budget (N=8)	16% of budget (N=11)

(N = Sample of Completed Projects)

Projects in the High Maturity High Accuracy (HMHA) quadrant outperformed projects in the other two quadrants by a significant margin in terms of cost and changes. (Note that schedule performance showed no significant differences across any of the established quadrants.)

FEED MATRS was also tested on 11 projects worth a total of \$5.1 billion in expenditures during real-time planning exercises. In general, the feedback from these users was extremely positive. The tool performed well in identifying critical risk issues during the front end planning process, and it spurred important conversations about elements that the project teams had not yet considered. FEED MATRS also indicated to management which changes could be made to the project teams to improve accuracy. As one user stated: “The FEED MATRS tool is simple and effective – it not only helped to assess the quality and adequacy of the technical documentation required, but also provided an opportunity to check the organization’s readiness before making a capital investment decision. Both our project execution team and project leadership were quick to see the value and decided to use it going forward in our projects.”

Analyzing Maturity Scores – What to Look for

An organization may wish to determine a comfort level (range of maturity scores) at which it is willing to move into the detailed design phase, depending on the nature of its business, its internal scope definition practices, and project requirements.

The maturity assessment component of FEED MATRS is of little value unless the user uses its analysis to take action to identify and mitigate risk for the project. At times, project teams are pressured to develop a preliminary engineering design in a short period of time. To streamline the process, the team could focus on the top nine maturity elements. (This is in accordance with the Pareto principle, that a large portion of effects can be attributed to 20 percent of the causes). Therefore, Table 6.2 shows the top 20 percent of maturity elements, or the top nine of the 46 total elements. These elements comprise approximately 47 percent of the maturity total score. (See Appendix C for descriptions of the top nine elements.)

Project teams can use maturity scores in a number of ways, including the following:

- Maturity scores can be compared over time to identify trends in FEED development as benchmarks.
- Different types of industrial projects can be compared to determine threshold maturity scores for each type and to identify critical success factors from the comparisons. The maturity score can also be used to compare projects for different clients or different-sized projects for the same client.
- Maturity scores can isolate scope definition gaps at the section, category, or element level. For example, if any element has a definition level of 3, 4, or 5, the project team should further define this element or develop a risk mitigation strategy for it. This provides an effective method of risk analysis, since each element, category, and section is weighted relative to the others in terms of potential risk exposure. Identifying the project's gaps is critical as the project team progresses toward execution, and it should provide "path-forward" action items.

Table 6.2. The Nine Highest-ranking Maturity Elements

Rank	Element	Definition Level 5 Weight
1	B1. Products	56
2	B5. Capacities	55
3	C1. Technology	54
4	C2. Processes	40
5	G1. Process Flow Sheets	36
6	G3. Piping and Instrumentation Diagrams (P&IDs)	31
7	D3. Site Characteristics Available vs. Required	29
8	G2. Heat and Material Balances	23
9	D2. Project Design Criteria	22
	Total	346

Project teams can determine and evaluate a project's maturity definition level by using the normalized maturity score. For example, the maturity scoring scheme has a range of 100 total points (i.e., 0 to 100). If a project's maturity score was 40 out of 100 points, then 40 percent of the maturity definition has yet to be achieved. (See Appendix A for the maturity score normalization formula.)

Analyzing Accuracy Scores – What to Look for

The accuracy assessment component of FEED MATRS is of little value unless the user uses its analysis to take action to improve the accuracy environment of the FEED process. Table 6.3 (once again, in accordance with the Pareto principle) represents the top five accuracy factors that project teams may want to focus on to best improve their accuracy score. These five factors represent 31 percent of the accuracy total score.

Table 6.3. The Five Highest-ranking Accuracy Factors

Rank	Factor Description	“High Performing” Weight
1	2a. Technical capability and relevant training/certification of the execution team	7
2	1a. Leadership team’s previous experience planning, designing, and executing a project of similar size, scope, and/or location including FEED	6
3	1b. Stakeholders are appropriately represented on the project leadership team	6
4	2b. Contractor/engineer’s team experience with the location, with similar projects, and with the FEED process	6
5	4a. Commitment of key personnel on the project execution team	6
	Total	31

Project teams can use accuracy scores in a number of ways, including the following:

- As a benchmark
- To assess gaps in the leadership team, execution team, project management processes, and project resource allocation related to the FEED process. For example, if any factor has a rating of *Meets Some*, *Needs Improvement*, or *Not Acceptable*, the project team should further define this factor or develop a risk mitigation strategy for it. This provides an effective method of risk analysis, since the importance of each factor is weighted relative to the others. Identifying the project’s gaps is critical as the project team progresses toward execution, and it should provide “path-forward” action items.

FEED MATRS Scores and How They Can Inform Organizations

Keeping a corporate or organizational database of FEED MATRS scores may be desirable. As more projects are scored with FEED MATRS and completed, the ability to predict the probability of success on future projects should improve. Organizations may come to depend on FEED MATRS as a gauge for deciding whether to proceed to detailed design. Another possible use for FEED MATRS is as an external benchmark for measurement against the FEED practices of other industry leaders.

There is also a relationship between FEED maturity and classes of estimates. AACE International (AACEi) is an association for cost professionals. Its cost estimating publications are widely referenced globally. The AACEi requires a well-defined Project Definition Package (or FEED Package) to produce an AACEi Class 3 cost estimate.

AACEi (2016) Recommended Practice No. 18R-97 defines cost-estimate classifications. AACEi RP 18R-97 points to Class 3 as the estimate prepared just prior to the final investment decision. AACEi states, “Class 3 estimates are generally prepared to form the basis for budget authorization, appropriation, and/or funding.” Financing or authorization usually occurs at the end of the third phase of front end planning, which coincides with the completion of FEED.

AACEi RP 18R-97 requires a level of engineering and design for a Class 3 cost estimate that is similar to what the processing industry requires for FEED. In fact, the industry survey RT-331 completed as part of this research project found that, on average, FEED represents 30% of engineering and design complete, which is within the Class 3 cost estimate range. AACEi RP 18R-97 states that the “level of Project Definition [is] expressed as a percent of full definition. For the process industries, this correlates with the percent of engineering and design complete.” AACEi further states that a Class 3 cost estimate requires 10 to 40% project definition; again, FEED fits comfortably within this range.

Moreover, AACEi (2011) transactions document EST. 604, *Document Project Readiness by Estimate Class Using PDRI*, correlates the CII PDRI score to the AACEi estimate classification. The authors state that a PDRI score for a well-defined FEED package is 200 points or lower, and that that score should be achieved at engineering freeze date for authorization for expenditure (generally Class 3) estimate material take-off. The authors of EST. 604 state that the