Changing How the World Builds

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

Steve Cabano, Pathfinder

RT 331, Assessing the Maturity and Accuracy of Front End Engineering Design to Support Phase Gate Approvals

RT 331 Objective

RT 331 was tasked with defining the appropriate two-dimensional criteria to evaluate not only the level of engineering **maturity** needed at Project Authorization, but also the **accuracy** of these engineering deliverables.

Front End Engineering Design Maturity and Accuracy Total Rating System (FEED MATRS) – “FEED Matters!”

24%

Cost Difference Between High Maturity High Accuracy and Low Maturity Low Accuracy Front End Engineering Design

Panelists

- Steve Cabano – Closing and Q&A
- Mark Balcezak
- G. Edward Gibson, Jr.
- Matthew (Zac) West
- Rob Garrison
- Eric Ochsner

RT 331, Assessing the Maturity and Accuracy of Front End Engineering Design to Support Phase Gate Approvals

Mark Balcezak (Chair), *Chevron*

Stephen L. Cabano, *Pathfinder, LLC.*

John C. Clarkin, *Honeywell UOP*

Mounir El Asmar, *Arizona State University*

John R. Fish, *Ford, Bacon & Davis, Inc. / S&B Engineers & Constructors, Ltd.*

Jose Francisco Riggio de Lima, *Construtora Norberto Odebrecht S.A.*

Rob Garrison, *Hargrove Engineering + Constructors*

G. Edward Gibson, Jr., *Arizona State University*

Thomas Hefferan, *Eli Lilly and Company*

Scott Maish, *Faithful+Gould*

Kevin Maloney, *Zachry Group*

Eric Ochsner, *Georgia Pacific Chemical, LLC.*

David Ramsey, *Arizona State University*

Jon Re, *Kiewit Energy USA*

Hans Ryham, *Occidental Oil & Gas*

Salvatore Scocca, *Technip USA, Inc.*

Anup Seshadri (Co-chair), *Emerson Automation Solutions*

Soundar R. Venkatakrishnan, *Huntsman Corporation*

Daniel Verner, *Irving Oil, Ltd.*

James Vicknair, *Eichleay Engineers*

Matthew Z. West, *U.S. Department of Energy*

Abdulrahman Yussef, *Arizona State University*

PAST MEMBERS

David Cobb, *Fluor Corporation*

Harvey Ivey, *Southern Company*

John A. Palmer, *Kiewit*

Samin Shokri, *Coreworx, Inc.*

Matthew Taylor, *Eli Lilly and Company*

Problem Statement

- There is Industry-wide confusion around the quality and completeness of the desired engineering deliverables at the end of front end planning
- Owners have differing guidelines around their engineering risk tolerance
- Contractors drive to different levels of completeness based on owner guidance
- CII's Project Definition Rating Index (PDRI) is a front end planning measurement tool that has been utilized for 22+ years to support full funding authorization

Projects often do not meet their cost/schedule commitments

Common Perceptions

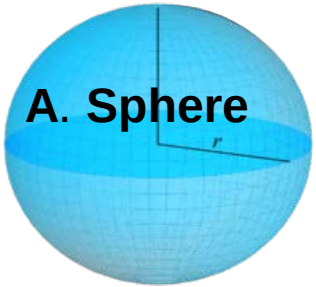
- A certain level of project scope definition is needed to get a high level of cost estimate confidence
- Engineering deliverables provide the foundation for scope definition
- Measuring completeness of front end engineering is important, but how (and by whom) were the documents developed?
- Both of these dimensions are critical

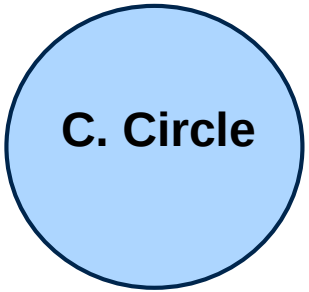
Adding Dimension/Perspective

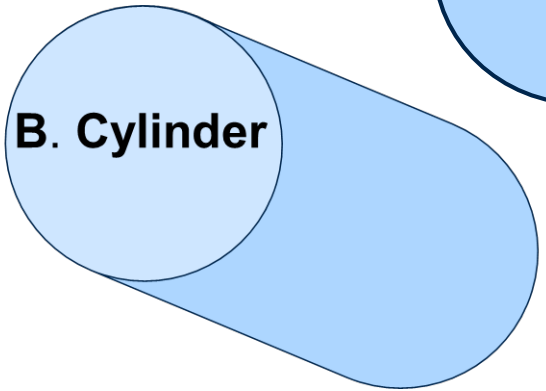
- Historically, the PDRI has provided an excellent measurement of the front end deliverables required to support a project
- One more dimension is needed to understand FEED

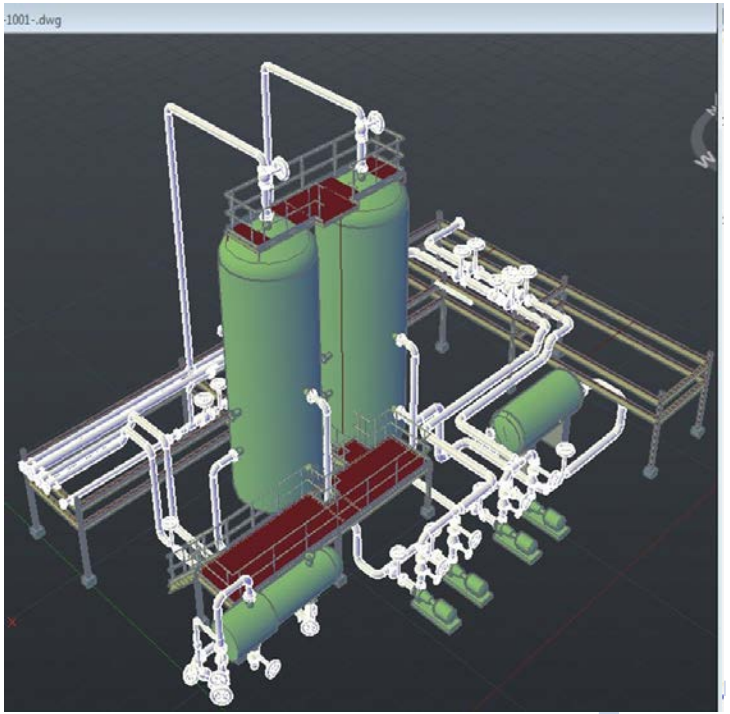
Adding Dimension/Perspective

- For instance: Another dimension provides clarity









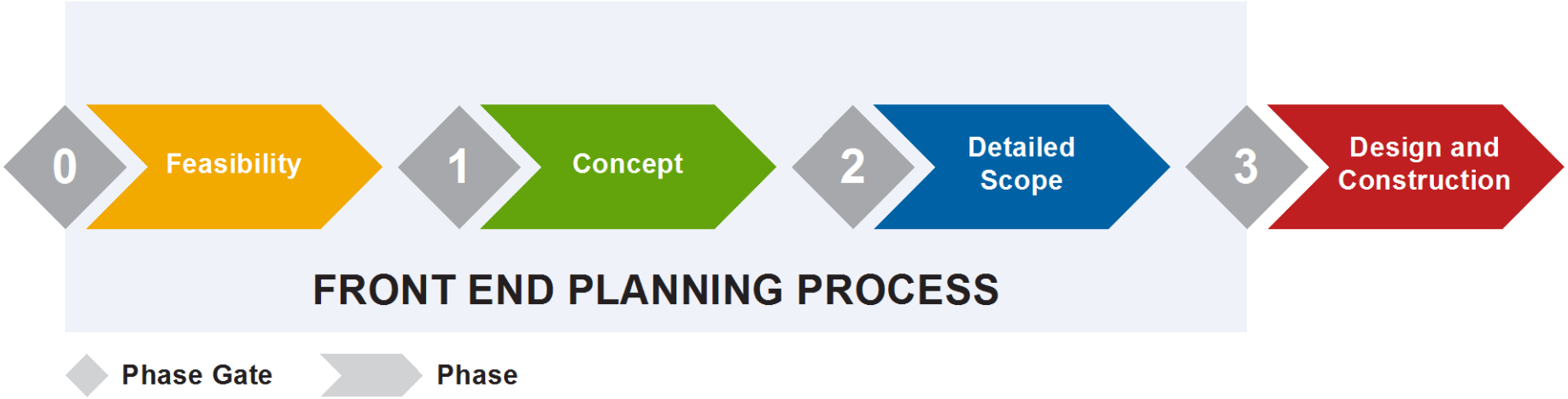
The Results

Front End Engineering Design Maturity and Accuracy Total Rating System (FEED MATRS) – “FEED Matters!”

Panelists

- Steve Cabano
- **Mark Balcezak – Definitions**
- G. Edward Gibson, Jr.
- Matthew (Zac) West
- Rob Garrison
- Eric Ochsner

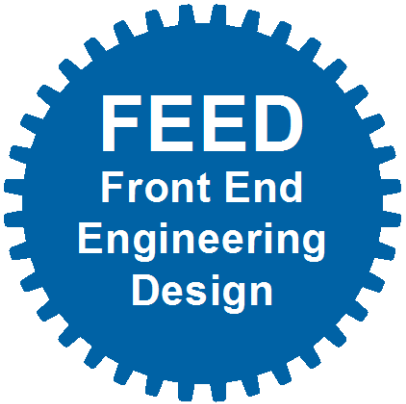
Front End Planning & FEED



- Front End Engineering Design (FEED) is part of Phase 3 “Detailed Scope”

FEED Definition

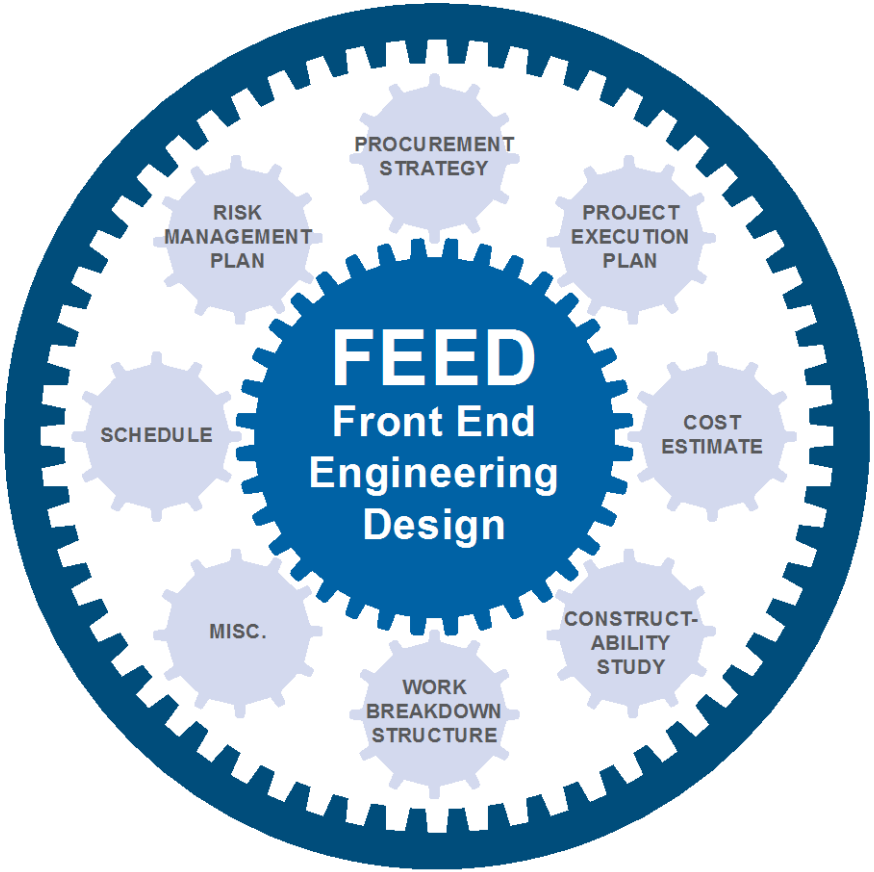
A component of the Front End Planning (FEP) process performed during Detailed Scope (Phase 3), consisting of the engineering documents, outputs, and deliverables for the chosen scope of work.



FEED is Integrated with All Activities in Phase 3

Project Definition Package

- FEED
- Cost Estimate
- Schedule
- Project Execution Plan
- Procurement Strategy
- Risk Management Plan
- Constructability Study
- Other

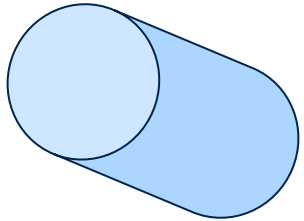


PROJECT DEFINITION PACKAGE

FEED Maturity & Accuracy Definitions

MATURITY

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



ACCURACY

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).

Objective Evaluation of Engineering Maturity

SECTION	DEFINITION LEVEL					
	N/A	Best		Medium		Worst
CATEGORY	**0**	**1**	**2**	**3**	**4**	**5**
Element Element Description	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 addressed 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 & Revamp R&R Description		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 no 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.	

Objective Evaluation of Engineering Accuracy

HIGH PERFORMING	MEETS MOST	MEETS SOME	NEEDS IMPROVEMENT	NOT ACCEPTABLE
Rating a factor High Performing 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 Meets Most indicates that the factor's criteria are consistently met and understood with minor deficiencies.	Rating a factor Meets Some indicates that the factor's criteria are partially met and without improvement, project success could be in jeopardy.	Rating a factor Needs Improvement 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 Not Acceptable 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.

Top 9 Industrial Project *MATURITY* Elements

RANK	PDRI ELEMENT	ELEMENT DESCRIPTION
1	B1	Products
2	B5	Capacities
3	C1	Technology
4	C2	Processes
5	G1	Process Flow Sheets
6	G3	Piping and Instrumentation Diagrams (P&ID's)
7	D3	Site Characteristics Available vs. Required
8	G2	Heat and Materials Balances
9	D2	Project Design Criteria

Top 5 Industrial Project *ACCURACY* Factors

RANK	FACTOR	FACTOR DESCRIPTION
1	2a	Technical capability and relevant training/certification of the execution team
2	1a	Leadership team's previous experience planning, designing, and executing a project of similar size, scope, and/or location including FEED
3	1b	Stakeholders are appropriately represented on the project leadership team
4	2b	Contractor/Engineer's team experience with the location, with similar projects, and with the FEED process
5	4a	Commitment of key personnel on the project team

Panelists

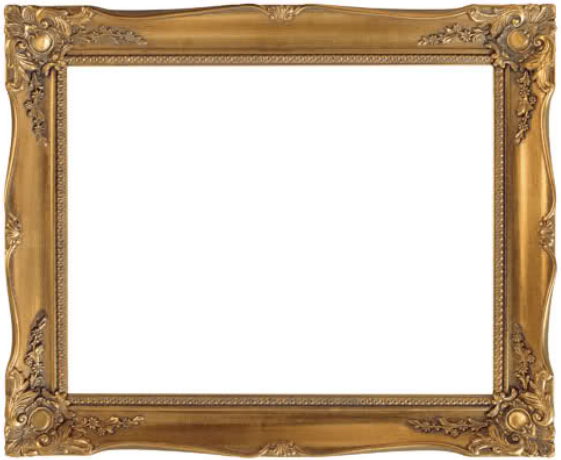
- Steve Cabano
- Mark Balcezak
- **G. Edward Gibson, Jr. – Research**
- Matthew (Zac) West
- Rob Garrison
- Eric Ochsner

Summary of Research Engagement

- Industry Survey
  - 80 responses from 33 organizations
- 4 Workshops
  - 48 participants from 31 organizations
- 33 completed projects and 11 in-process projects
  - More than $13.9 billion total
  - Data from across the US, Canada, and eight other countries

Industry Survey

- No widely accepted definition of FEED
- 80 total respondents
- 81 percent agreed with our definition
- Few evaluated FEED maturity and accuracy
- Survey provided path forward



FEED MATRS Development

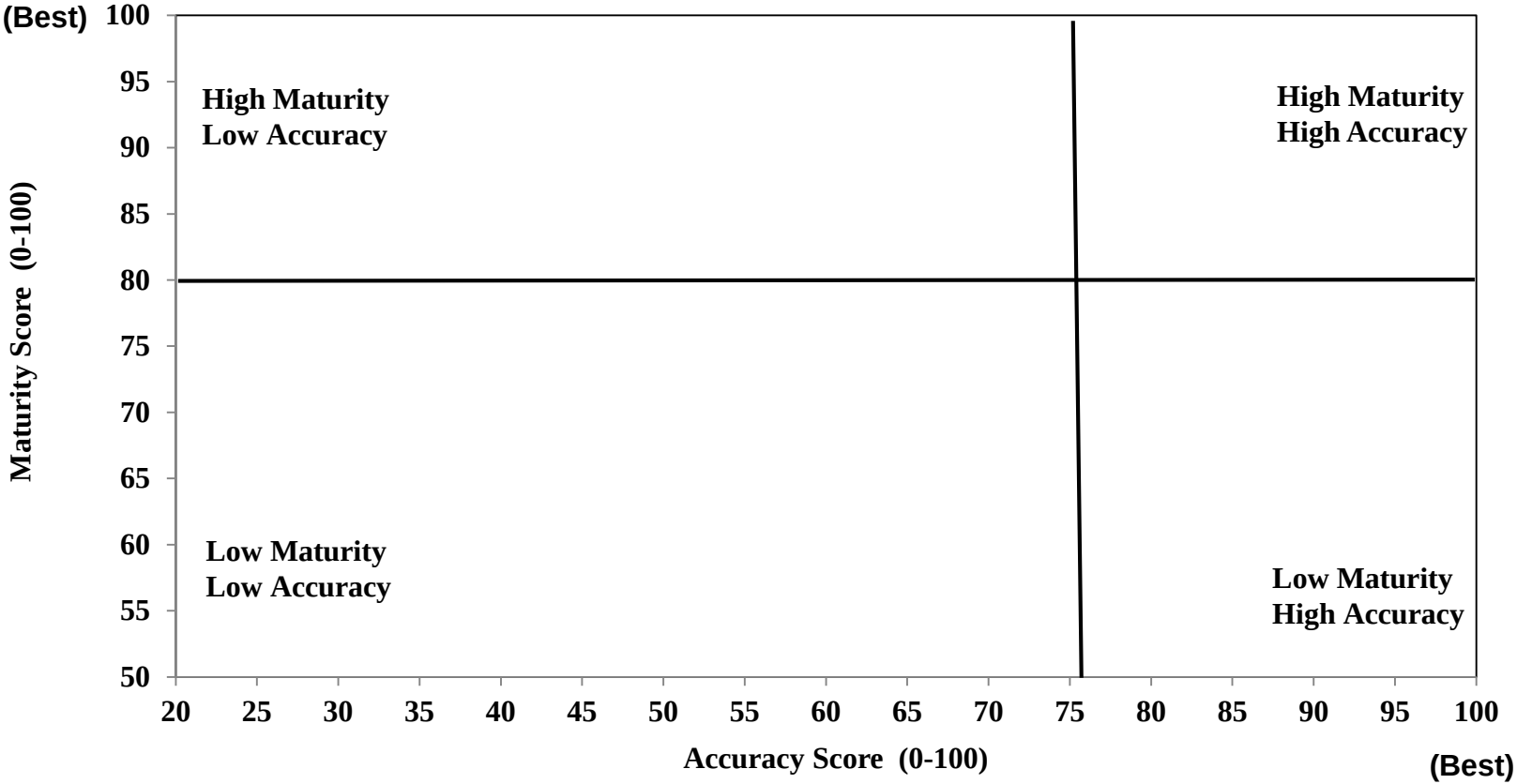
- Strong foundation
  - Maturity: PDRI – Industrial
  - Accuracy: past CII research and additional literature
- RT 331 sub-teams
  - Maturity element definition level descriptions and accuracy descriptions
  - Feedback from sub-teams' organizations
- Developed working draft for data collection workshops
- 46 engineering elements, 27 accuracy factors

Workshops

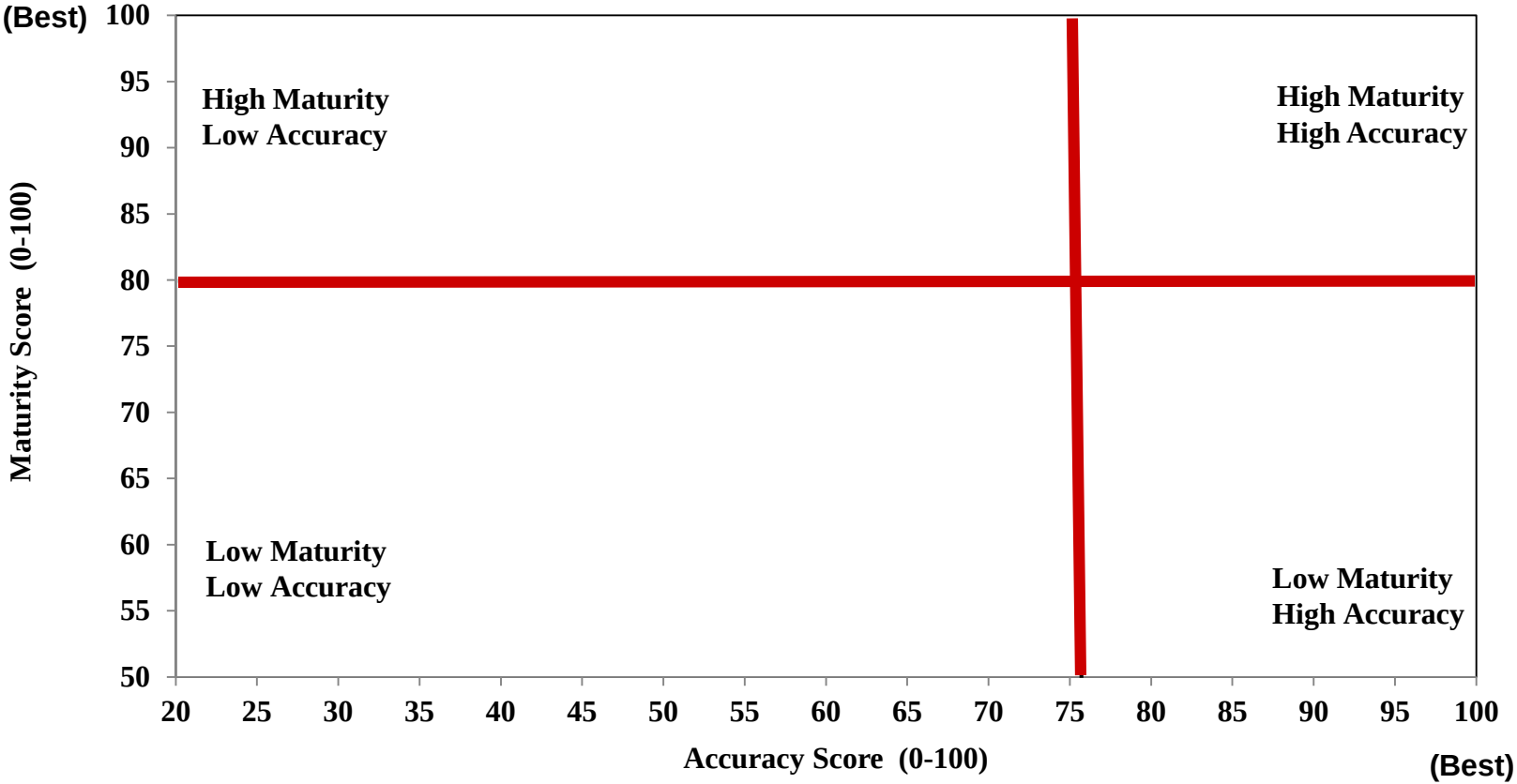
- Purposive (expert) charrettes
- Large industrial projects focus
- Owner and contractor experts provided input to tool, as well as project data
- Geographically dispersed
- Participants had >10 years large industrial project experience with specific emphasis on FEED

WORKSHOPS	**4**
PARTICIPANTS	**48**
AVERAGE EXPERIENCE	**17 years**
ORGANIZATIONS	**31**
OWNER	**14**
CONTRACTOR	**17**

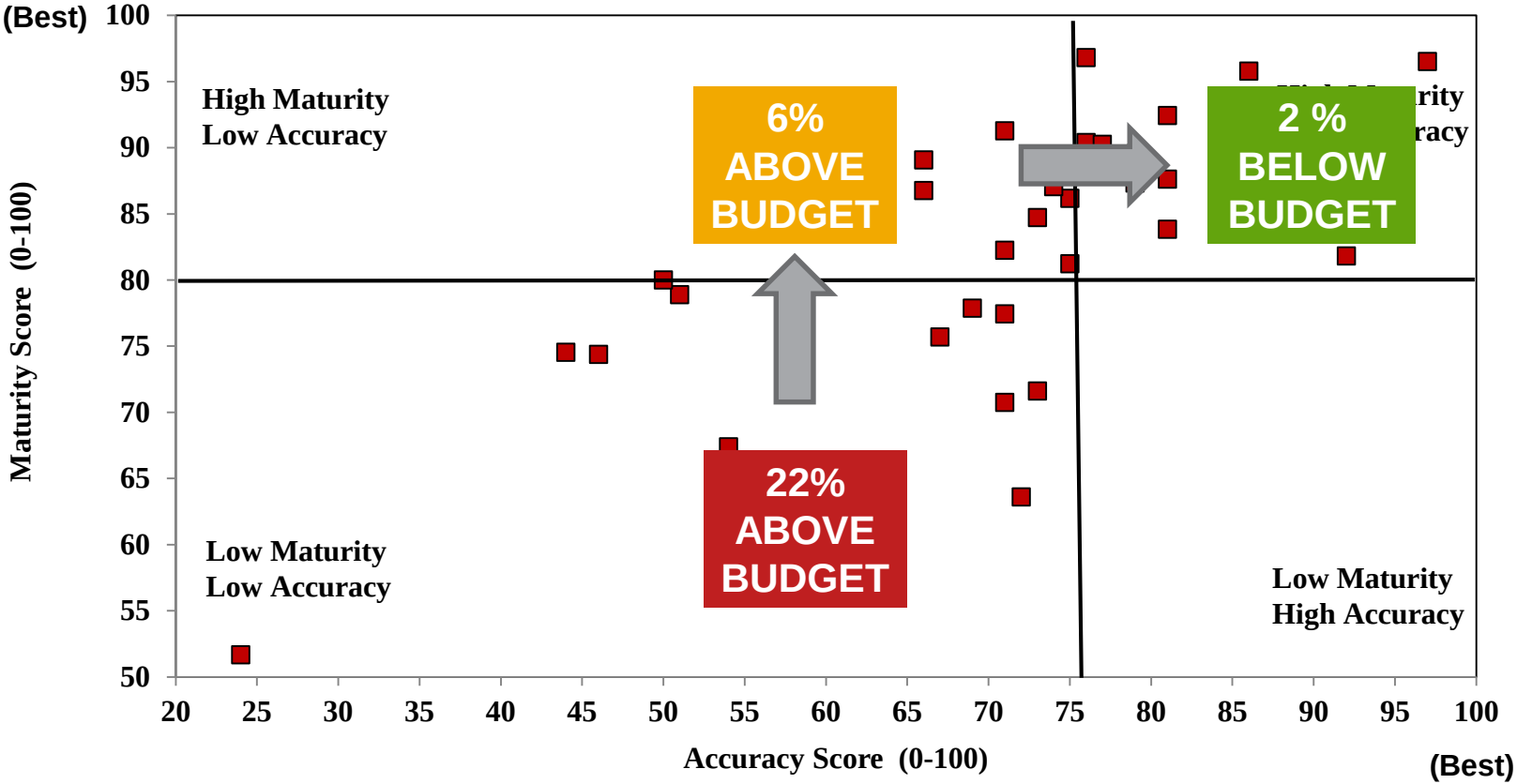
Maturity and Accuracy Matrix



Maturity and Accuracy Matrix



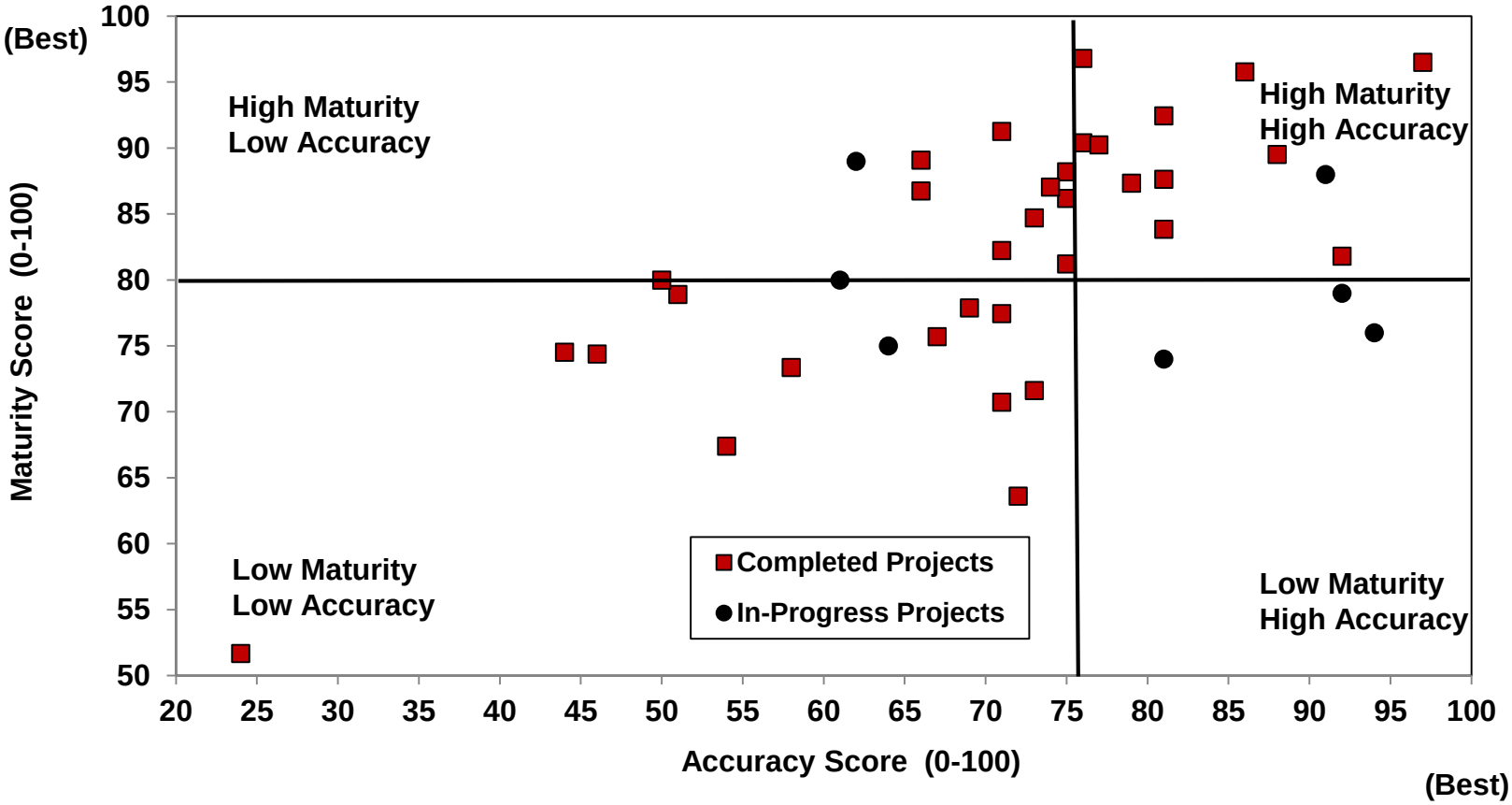
Research Results



In-Progress Projects

- Eleven total:
  - 5 chemical plants, 2 refinery, 1 pipeline, 1 storage facility, 1 mine project, 1 biotech
- Over $5.1 billion
- Team's input; facilitated by RT 331 team members
- Gaps identified
- Added value to these projects
- Tool found to be complete and valid
- Assessment takes about 4 hours

Completed and In-Progress Projects



FEED MATRS: Project Distribution

Participating Organizations – RT 331 Organizations, Workshops, Survey, and Testing of In-Progress Projects

CONTRACTORS (30)

- 2.9 Inc. #
- AECOM #
- Altran US Corp. #
- CH2M *
- Day & Zimmerman *
- Eichleay Engineers Inc.
- Emerson Automation Solutions #
- Faithful+Gould #
- Fluor *#
- Fluor Canada, Ltd. #
- Ford, Bacon & Davis, Inc.
- Hargrove Engineers + Constructors *#•
- IHI E&C International Corporation *
- Kiewit Energy U.S.
- Lauren Engineers & Constructors *
- Merrick & Co. #
- Mott MacDonald #
- Odebrecht #•
- Pathfinder, LLC. *#
- Parsons *
- PTAG Inc. *
- Quality Execution, Inc. *
- Revay & Associates, Ltd. #
- S&B Engineers and Constructors #
- SBM Offshore *
- Supreme Steel *
- Technip #
- Undisclosed #
- Yates Construction *
- Zachry Group *#

OWNERS (32)

- AstraZeneca*
- Cargill #
- Chevron*#•
- Conoco Phillips*
- U.S. Department of Energy •
- DuPont #
- Eastman Chemical Company*
- Eli Lilly and Company*#•
- Eskom Holdings SOC Ltd.*
- Gatwick Airport Ltd.*
- General Motors*
- Georgia Pacific*•
- GlaxoSmithKline #
- Honeywell International Inc.
- Huntsman Corporation*#•
- Husky Energy #
- Irving Oil Limited
- INEOS Olefins & Polymers USA #
- Infineum, USA LP #
- Johnson & Johnson #
- Koch Ag & Energy Solutions*
- NASA*
- Nova Chemicals, Ltd. #
- Occidental Petroleum*
- Petronas*
- SABIC*
- SCHREIBER*
- Shell Canada, Ltd.*
- Statoil ASA*
- Tennessee Valley Authority*
- Tesoro Companies, Inc. #
- TransCanada Pipelines #•

* = Survey
# = Workshops
• = In-Progress Testing

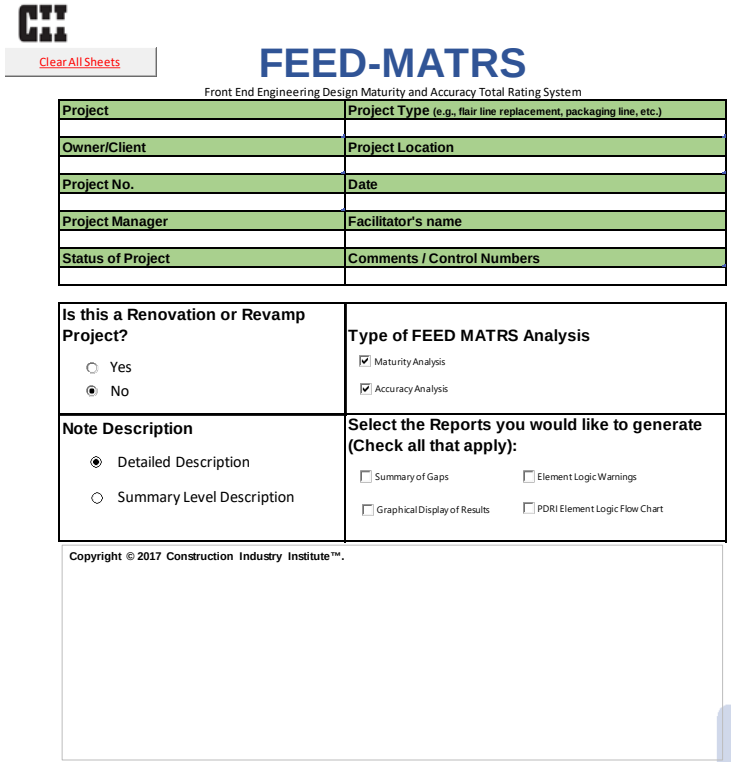

FEED MATRS
Maturity and Accuracy Quadrants
Data Analysis
Large Industrial Projects
HMHA
LMLA
Sub Teams
Accuracy Score
t-test
Maturity
Normality Test
Literature Review
R-sq.
Multiple Linear Regression
Sensitivity Analysis
Financial Performance
Linear Regression
PDRI-Industrial
Accuracy
FEED
Survey
Standard Deviation
Mann-Whitney-Wilcoxon Test
Cost Change
In Progress Projects
Proven
Tested
$10 Billion
Sample
Kruskal-Wallis
Workshops
p-value
Inputs
Median
ANOVA
Schedule Change
Outputs
27 Accuracy Factors
Customer Satisfaction
Maturity Score
33 Completed Projects
HMLA
46 Maturity Elements
Change Performance
Generalized Linear Modeling

Panelists

- Steve Cabano
- Mark Balcezak
- G. Edward Gibson, Jr.
- **Matthew (Zac) West – Tool**
- Rob Garrison
- Eric Ochsner

FEED MATRS - Excel Based Tool

- Similar design to other CII tools, such as Project Definition Rating Index (PDRI)
- Both Excel-based and paper-based versions
- Ready to use now
- Use at any phase of front end planning
- Separate Maturity and Accuracy components



Clear All Sheets

FEED-MATRS

Front End Engineering Design Maturity and Accuracy Total Rating System

Project	Project Type (e.g., flair line replacement, packaging line, etc.)
Owner/Client	Project Location
Project No.	Date
Project Manager	Facilitator's name
Status of Project	Comments / Control Numbers

Is this a Renovation or Revamp Project?	Type of FEED MATRS Analysis
○ Yes ◉ No	☑ Maturity Analysis ☑ Accuracy Analysis
Note Description	**Select the Reports you would like to generate (Check all that apply):**
◉ Detailed Description ○ Summary Level Description	☐ Summary of Gaps ☐ Element Logic Warnings ☐ Graphical Display of Results ☐ PDRI Element Logic Flow Chart

FEED MATRS

Clear All Sheets

Front End Engineering Design Maturity and Accuracy Total Rating System (Final Draft)

Project	Project Type (e.g., flair line replacement, packaging line, etc.)
Owner/Client	Project Location
Project No.	Date
Project Manager	Facilitator's name
Status of Project	Comments / Control Numbers

Is this a Renovation or Revamp Project?

- ○ Yes
- ◉ No

Type of FEED MATRS Analysis

- ☐ Maturity Analysis
- ☐ Accuracy Analysis

Note Description

- ◉ Detailed Description
- ○ Summary Level Description

Select the Reports you would like to generate (Check all that apply):

- ☐ Summary of Gaps
- ☐ Element Logic Warnings
- ☐ Graphical Display of Result and Summary
- ☐ PDRI Element Flow Logic

Zoom selection for Maturity Facilitation Sheets (Type a value between 10-400)	Zoom selection for Accuracy Facilitation Sheets (Type a value between 10-400)
80	80

Zoom selection for Main Workbook pages (Type a value between 10-400)

100

Getting Started

Note: Enable Macros

Project Data

Maturity and Accuracy

Level of Note Detail / Renovations

Reports

Zoom

Maturity Section of the Tool

Hide Element Scores | Show Element Scores | Clear Sheet

CATEGORY Element	Maturity Definition Level / Weights								Minimum Score	Maturity Score	Maximum Score	Normalized Score	
FEED Maturity (Use Hyperlinks below to start facilitation mode)	0	1	2	3	4	5	*Make your selection in this Column using the Drop Down List or Type 0-5*	Comments	52	170	724	174	Higher is Better Target = > 80% — 77%
Section I - Basis of Project Decision									*18*	*90*	*324*	**Project:**	
A. MANUFACTURING OBJECTIVES CRITERIA									*3*	***10***	*45*	0	
A.1 Reliability Philosophy		1					1		1	1	20	**Project Manager:**	
A2. Maintenance Philosophy				5			3		1	5	9	0	
A3. Operating Philosophy			4				2		1	4	16	**Facilitator:**	
B. BUSINESS OBJECTIVES									4	**20**	119	0	
B1. Products		1					1		1	1	56	**Status of Project:**	
B5. Capacities			11				2		2	11	55	0	
B6. Future Expansion Considerations	0						0		0	0	0	**Date:**	
B7. Expected Project Life Cycle						8	5		1	8	8	August 1, 2017	
C. BASIC DATA RESEARCH & DEVELOPMENT									4	**47**	94		
C1. Technology					39		4		2	39	54		
C2. Processes			8				2		2	8	40		

ELEMENTS

Maturity Section of the Tool

Hide Element Scores | Show Element Scores | Clear Sheet

CATEGORY Element	Maturity Definition Level / Weights							Comments	Minimum Score	Maturity Score	Maximum Score	Normalized Score		
FEED Maturity (Use Hyperlinks below to start facilitation mode)	0	1	2	3	4	5	Make your selection in this Column using the Drop Down List or Type 0-5		52	170	724	174	Higher is Better Target = > 80%	77%
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A. MANUFACTURING OBJECTIVES CRITERIA									*3*	***10***	*45*	0		
A.1 Reliability Philosophy		1					1		1	1	20	**Project Manager:**		
A2. Maintenance Philosophy			5				5		1	5	9	0		
A3. Operating Philosophy				4			4		1	4	16	**Facilitator:**		
B. BUSINESS OBJECTIVES									4	**20**	119	0		
B1. Products		1					1		1	1	56	**Status of Project:**		
B5. Capacities			11				2		2	11	55	0		
B6. Future Expansion Considerations	0						0		0	0	0	**Date:**		
B7. Expected Project Life Cycle						8	5		1	8	8	August 1, 2017		
C. BASIC DATA RESEARCH & DEVELOPMENT									4	**47**	94			
C1. Technology					39		4		2	39	54			
C2. Processes			8				2		2	8	40			

ASSESSMENT

Maturity Section of the Tool

Hide Element Scores | Show Element Scores | Clear Sheet

CATEGORY Element	Maturity Definition Level / Weights								Minimum Score	Maturity Score	Maximum Score	Normalized Score	
FEED Maturity (Use Hyperlinks below to start facilitation mode)	0	1	2	3	4	5	Make your selection in this Column using the Drop Down List or Type 0-5	Comments	52	170	724	174	Higher is Better Target = > 80% — 77%
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A. MANUFACTURING OBJECTIVES CRITERIA									*3*	*10*	*40*		
A.1 Reliability Philosophy		1					1		1	1	20	Project Manager:	
A2. Maintenance Philosophy				5			3		1	5	9		0
A3. Operating Philosophy			4				2		1	4	11		
B. BUSINESS OBJECTIVES									4	**20**	119		0
B1. Products		1					1		1	1	5		
B5. Capacities			11				2		2	11	55		0
B6. Future Expansion Considerations	0						0		0	0	0	Date:	
B7. Expected Project Life Cycle						8	5		1	8	8	August 1, 2017	
C. BASIC DATA RESEARCH & DEVELOPMENT									4	47	94		
C1. Technology					39		4		2	39	54		
C2. Processes			8				2		2	8	40		

WEIGHTED ASSESSMENT & SUMMARY

Section II -- BASIS OF DESIGN	Definition Level					
	N/A	BEST		MEDIUM		WORST
G. PROCESS/MECHANICAL	**0**	**1**	**2**	**3**	**4**	**5**
G8. Plot Plan The plot plan will show the location of new work in relation to adjoining units or facilities. It should include items such as: • Plant grid system with coordinates • Unit limits • Gates, fences and/or barriers • Lighting requirements • Off-site facilities • Tank farms • Roads & access ways • Roads • Rail facilities • Green space • Buildings • Major pipe racks • Laydown areas • Construction/fabrication areas • Other *Comments on Issues:* *Construction knowledge and input are typically taken into account when considering the completeness of this element. Additionally, a siting reviewis typically included to ensure compliance with client requirements. Moreover, elevation drawings and regulatory requirements are typically incorporated into the plot plan when considering the completeness of this element.*	Not Required for Project	**The plot plan is complete and approved by key stakeholders (i.e., operations) as a basis for detailed design.**	**Most of the plot plan is complete and issued for PHA.**	**Some of the plot plan is prepared with holds and deficiencies.**	**Plot plan development has started with some initial thoughts applied to this effort.**	N
		The layout and spacing was rev haz rec inc cor sys is c pro pro cor gates and fencing are documented and approved. Equipment spacing is per project specifications and dimensions are sourced from vendor supplied information, if available.	The plot plan is mostly	Some units and major	General areas are outlined for	
** Additional items to consider for Renovation & Revamp projects • Establish project specific vertical and horizontal reference points for all participants		All project specific vertical and horizontal reference points for all participants have been verified, documented, and approved.	Most of the project specific vertical and horizontal reference points for all participants have been verified and documented, but not yet approved.	Some of the project specific vertical and horizontal reference points have been documented.	Little or no effort has been done to establish the project specific vertical and horizontal reference points.	

ELEMENT DESCRIPTION
Provides Scope of the Element – A list of things to consider for this element

Comment:

1

To Element G9

To Element G7

Return to Score Sheet

Section II -- BASIS OF DESIGN	Definition Level					
	N/A	BEST		MEDIUM		WORST
G. PROCESS/MECHANICAL	**0**	**1**	**2**	**3**	**4**	**5**
G8. Plot Plan The plot plan will show the location of new work in relation to adjoining units or facilities. It should include items such as: • Plant grid system with coordinates • Unit limits • Gates, fences and/or barriers • Lighting requirements • Off-site facilities • Tank farms • Roads & access ways • Roads • Rail facilities • Green space • Buildings • Major pipe racks • Laydown areas • Construction/fabrication areas • Other *Comments on Issues:* *Construction knowledge and input are typically taken into account when considering the completeness of this element. Additionally, a siting reviewis typically included to ensure compliance with client requirements. Moreover, elevation drawings and regulatory requirements are typically incorporated into the plot plan when considering the completeness of this element.*		**The plot plan is complete and approved by key stakeholders (i.e., operations) as a basis for detailed design.**	**Most of the plot plan is complete and issued for PHA.**	**Some of the plot plan is prepared with holds and deficiencies.**	**Plot plan development has started with some initial thoughts applied to this effort.**	
	Not Required for this Project	The layout and spacing was reviewed in the process hazards analysis (PHA) and recommendations were [illegible] roads and rail lines, fire protection systems, construction, laydown areas, gates and fencing are documented and approved. Equipment spacing is per project specifications and dimensions are sourced from vendor supplied information, if available.	The plot plan is mostly consistent with [illegible] fencing are documented. There may be minor holds.	Some units and major process equipment are identified. Some pipe racks, buildings, utilities, off-sites [illegible]	General areas are outlined for process, utilities and off-site facilities. Plant grid system and surveying has not been [illegible] and little or nothing has been documented.	**Not yet started**
** Additional items to consider for Renovation & Revamp projects • Establish project specific vertical and horizontal reference points for all participants		All project specific vertical and horizontal reference points for all participants have been verified, documented, and approved.	Most of the project specific vertical and horizontal reference points for all participants have been verified and documented, but not yet approved.	Some of the project specific vertical and horizontal reference points have been documented.	Little or no effort has been done to establish the project specific vertical and horizontal reference points.	

Summary of Completeness and Status for Each Definition Level

Comment:

1

To Element G9

To Element G7

Return to Score Sheet

Section II -- BASIS OF DESIGN	Definition Level					
	N/A	BEST		MEDIUM		WORST
G. PROCESS/MECHANICAL	**0**	**1**	**2**	**3**	**4**	**5**
G8. Plot Plan The plot plan will show the location of new work in relation to adjoining units or facilities. It should include items such as: • Plant grid system with coordinates • Unit limits • Gates, fences and/or barriers • Lighting requirements • Off-site facilities • Tank farms • Roads & access ways • Roads • Rail facilities • Green space • Buildings • Major pipe racks • Laydown areas • Construction/fabrication areas • Other *Comments on Issues:* *Construction knowledge and input are typically taken into account when considering the completeness of this element. Additionally, a siting reviewis typically included to ensure compliance with client requirements. Moreover, elevation drawings and regulatory requirements are typically incorporated into the plot plan when considering the completeness of this element.*	Not Required for this Project	**The plot plan is complete and approved by key stakeholders (i.e., operations) as a basis for detailed design.**	**Most of the plot plan is complete and issued for PHA.**	**Some of the plot plan is prepared with holds and deficiencies.**	**Plot plan development has started with some initial thoughts applied to this effort.**	
** Additional items to consider for Renovation & Revamp projects • Establish project specific vertical and horizontal reference points for all participants		All project sp... horizontal ref... all participan... verified, docu... approved.				

Definitio

N/A BEST

0	1	2	
	The plot plan is complete and approved by key stakeholders (i.e., operations) as a basis for detailed design.	**Most of the plot plan is complete and issued for PHA.**	**S p o**
	The layout and spacing was reviewed in the process hazards analysis (PHA) and recommendations were	The plot plan is mostly consistent with the plant grid system and most required surveying is complete. Most	S p i b

Comment:

1

To Element G9

To Element G7

Return to Score Sheet

Section II -- BASIS OF DESIGN	Definition Level					
	N/A	BEST		MEDIUM		WORST
G. PROCESS/MECHANICAL	**0**	**1**	**2**	**3**	**4**	**5**
G8. Plot Plan The plot plan will show the location of new work in relation to adjoining units or facilities. It should include items such as: • Plant grid system with coordinates • Unit limits • Gates, fences and/or barriers • Lighting requirements • Off-site facilities • Tank farms • Roads & access ways • Roads • Rail facilities • Green space • Buildings • Major pipe racks • Laydown areas • Construction/fabrication areas • Other *Comments on Issues:* *Construction knowledge and input are typically taken into account when considering the completeness of this element. Additionally, a siting reviewis typically included to ensure compliance with client requirements. Moreover, elevation drawings and regulatory requirements are typically incorporated into the plot plan when considering the completeness of this element.*	Not Required for this Project	**The plot plan is complete and approved by key stakeholders (i.e., operations) as a basis for detailed design.** The layout and spacing was reviewed in the process hazards analysis (PHA) and recommendations were incorporated. The plot plan is consistent with the plant grid system and required surveying is complete. All units, major process equipment, pipe racks, buildings, utilities, off-site facilities, tank farms, roads and rail lines, fire protection systems, construction, laydown areas, gates and fencing are documented and approved.	**Most of the plot plan is complete and issued for PHA.** The plot plan is mostly consistent with the plant grid system and most required surveying is complete. Most units, major process equipment, pipe racks, buildings, utilities, off-site facilities, tank farms, roads and rail lines, fire protection systems, construction and laydown areas, gate and fencing are documented. There may be minor holds.	**Some of the plot plan is prepared with holds and deficiencies.** Some units and major process equipment are identified. Some pipe racks, buildings, utilities, off-sites, tank farms, roads and rail lines, fire protection systems, construction and laydown areas, gates and fencing are identified.	**Plot plan development has started with some initial thoughts applied to this effort.** General areas are outlined for process, utilities and off-site facilities. Plant grid system and surveying has not been conducted. A dialog has started with plant operations, utility and safety departments. Little or no meeting time or design/ consulting hours have been expended on this topic and little or nothing has been documented.	Not yet started
** Additional items to consider for Renovation & Revamp projects • Establish project specific vertical and horizontal reference points for all participants		All project specific vertical and horizontal reference points for all participants have been verified, documented, and approved.	Most of the project specific vertical and horizontal reference points for all participants have been verified and documented, but not yet approved.	Some of the project specific vertical and horizontal reference points have been documented.	Little or no effort has been done to establish the project specific vertical and horizontal reference points.	

Renovation and Revamp Definition

Comment:

1

To Element G9

To Element G7

Return to Score Sheet

Section II -- BASIS OF DESIGN	Definition Level					
	N/A	BEST		MEDIUM		WORST
G. PROCESS/MECHANICAL	**0**	**1**	**2**	**3**	**4**	**5**
G8. Plot Plan The plot plan will show the location of new work in relation to adjoining units or facilities. It should include items such as: • Plant grid system with coordinates • Unit limits • Gates, fences and/or barriers • Lighting requirements • Off-site facilities • Tank farms • Roads & access ways • Roads • Rail facilities • Green space • Buildings • Major pipe racks • Laydown areas • Construction/fabrication areas • Other *Comments on Issues:* *Construction knowledge and input are typically taken into account when considering the completeness of this element. Additionally, a siting reviewis typically included to ensure compliance with client requirements. Moreover, elevation drawings and regulatory requirements are typically incorporated into the plot plan when considering the completeness of this element.*	Not Required for this Project	**The plot plan is complete and approved by key stakeholders (i.e., operations) as a basis for detailed design.** The layout and spacing was reviewed in the process hazards analysis (PHA) and recommendations were incorporated. The plot plan is consistent with the plant grid system and required surveying is complete. All units, major process equipment, pipe racks, buildings, utilities, off-site facilities, tank farms, roads and rail lines, fire protection systems, construction, laydown areas, gates and fencing are documented and approved. Equipment spacing is per project specifications and dimensions are sourced from vendor supplied information, if available.	**Most of the plot plan is complete and issued for PHA.** The plot plan is mostly consistent with the plant grid system and most required surveying is complete. Most units, major process equipment, pipe racks, buildings, utilities, off-site facilities, tank farms, roads and rail lines, fire protection systems, construction and laydown areas, gate and fencing are documented. There may be minor holds.	**Some of the plot plan is prepared with holds and deficiencies.** Some units and major process equipment are identified. Some pipe racks, buildings, utilities, off-sites, tank farms, roads and rail lines, fire protection systems, construction and laydown areas, gates and fencing are identified.	**Plot plan development has started with some initial thoughts applied to this effort.** General areas are outlined for process, utilities and off-site facilities. Plant grid system and surveying has not been conducted. A dialog has started with plant operations, utility and safety departments. Little or no meeting time or design/ consulting hours have been expended on this topic and little or nothing has been documented.	Not yet started

Assessment Scoring, Commenting, and Navigation

Comment:

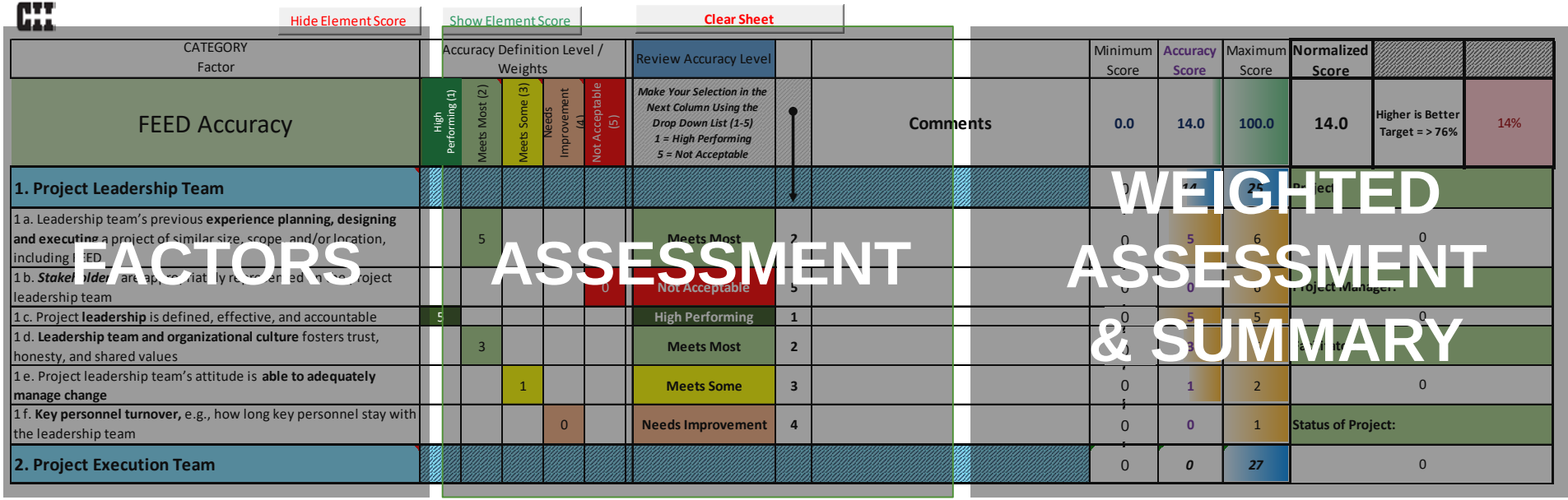
1

To Element G9

To Element G7

Return to Score Sheet

Accuracy Section of the Tool



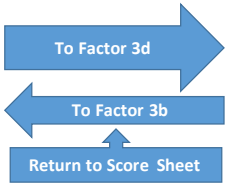
Hide Element Score | Show Element Score | Clear Sheet

CATEGORY Factor	Accuracy Definition Level / Weights					Review Accuracy Level		Comments	Minimum Score	Accuracy Score	Maximum Score	Normalized Score		
FEED Accuracy	High Performing (1)	Meets Most (2)	Meets Some (3)	Needs Improvement (4)	Not Acceptable (5)	*Make Your Selection in the Next Column Using the Drop Down List (1-5) 1 = High Performing 5 = Not Acceptable*			0.0	14.0	100.0	14.0	Higher is Better Target = > 76%	14%
1. Project Leadership Team											25			
1 a. Leadership team's previous **experience planning, designing and executing** a project of similar size, scope, and/or location, including FEED		5				Meets Most	2		0	5	6		0	
1 b. ***Stakeholder*** participation, **clearly** defined **roles** of project leadership team					0	Not Acceptable	5		0	0	0	Project Manager:		
1 c. Project **leadership** is defined, effective, and accountable	5					High Performing	1		0	5	5		0	
1 d. **Leadership team and organizational culture** fosters trust, honesty, and shared values		3				Meets Most	2		0	3	4			
1 e. Project leadership team's attitude is **able to adequately manage change**			1			Meets Some	3		0	1	2		0	
1 f. **Key personnel turnover,** e.g., how long key personnel stay with the leadership team				0		Needs Improvement	4		0	0	1	Status of Project:		
2. Project Execution Team									0	*0*	*27*		0	

FEED ACCURACY					
	BEST		MEDIUM		WORST
3. PROJECT MANAGEMENT PROCESS The project management process is the availability and application of standardized tools and methods to adequately implement clear requirements for the FEED process.	**High Performing**	**Meets Most**	**Meets Some**	**Needs Improvement**	**Not Acceptable**
3c. Priority between cost, schedule, and required project features is clear Setting priorities enables the project team to determine which project aspect is most essential (e.g., cost, schedule, required features). These priorities support scope definition, decision-making, risk management, plan optimization, negotiating project changes, and integrated change control.	**Indicates the factor's criteria are fully met with in the context of their respective category, e.g., project leadership, execution, management, or project resources.**	**Indicates that the factor's criteria are consistently met and understood with minor deficiencies.**	**Indicates that the factor's criteria are partially met ans without improvements, project success could be in jeopardy.**	**Indicates that the factor's criteria are not consistent in meeting project expectations and without improvement, the project is at risk. Substaintial action to meet expectations is required.**	**Indicates that the factor's criteria are consistently below expectations and current performance is unacceptable. Project success can not be achieved in this current state and actions are required to improve.**

Comment:

Select



Accuracy Facilitation Sheet Similar to Maturity

Accuracy Facilitation

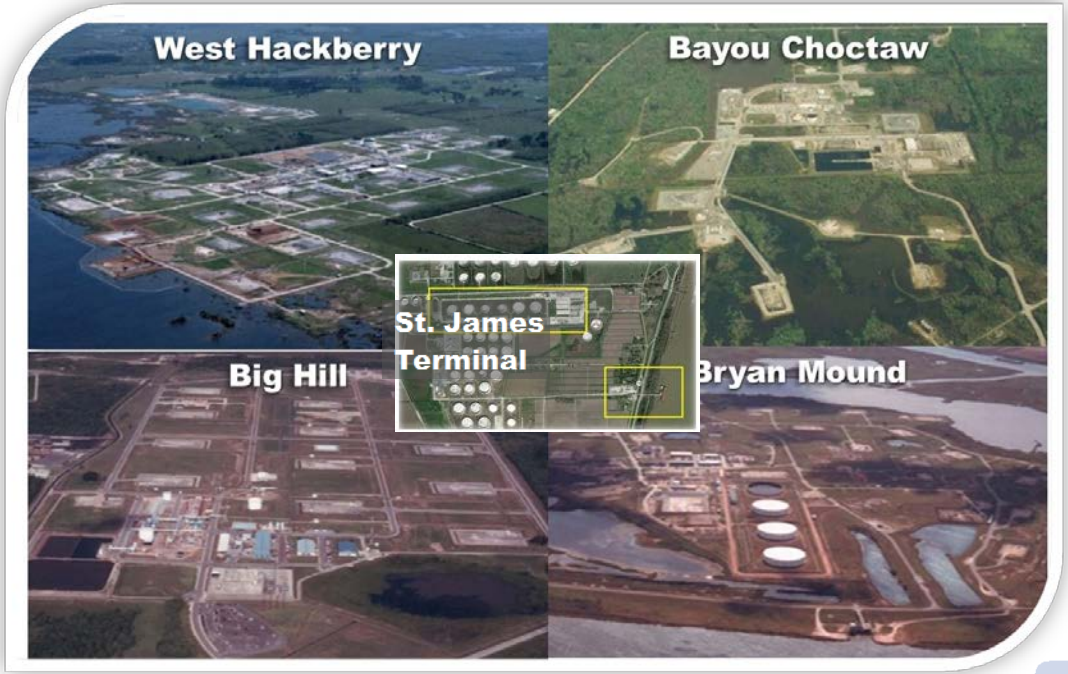
FEED ACCURACY	BEST		MEDIUM		WORST
1. PROJECT LEADERSHIP TEAM The project leadership team is comprised of individuals each representing the interests of their respective stakeholders (e.g., owner, engineer, contractor, etc.) and are adept in the relevant subject matter in order to contribute to the decision making process that leads to favorable project outcomes.	**High Performing**	**Meets Most**	**Meets Some**	**Needs Improvement**	**Not Acceptable**
1a. Leadership team's previous **experience planning, designing and executing** a project similar size, scope, and/or location, including FE Previous experience increases the familiarity of the leader team with the project planning, design, and execution processes. Repetition plays a major role in both organizati learning (lessons learned) and in the creation of routines a capabilities in general.					
Comment:					

FEED ACCURACY	BEST	
1. PROJECT LEADERSHIP TEAM The project leadership team is comprised of individuals each representing the interests of their respective stakeholders (e.g., owner, engineer, contractor, etc.) and are adept in the relevant subject matter in order to contribute to the decision making process that leads to favorable project outcomes.	**High Performing**	**Meets Most**
1a. Leadership team's previous **experience planning, designing and executing** a project of similar size, scope, and/or location, including FEED. Previous experience increases the familiarity of the leadership team with the project planning, design, and execution processes. Repetition plays a major role in both organizational learning (lessons learned) and in the creation of routines and capabilities in general.	**Indicates the factor's criteria are fully met with in the context of their respective category, e.g., project leadership, execution, management, or project resources.**	**Indicates that the factor's criteria are consistently met and understood with minor deficiencies.**

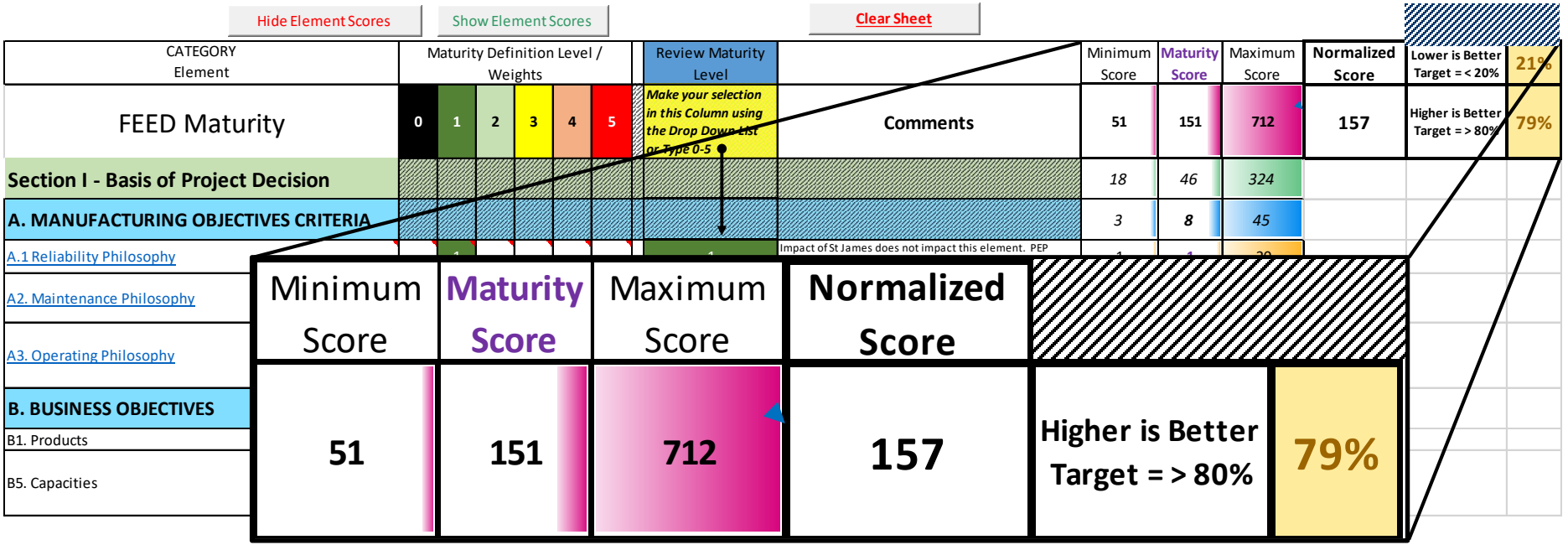
Example – Department of Energy's Strategic Petroleum Reserve Life Extension Phase 2

$1.4 billion program with 5 projects to renovate and repair above ground infrastructure:

- Degas plant
- Heat exchangers
- 176 miles of pipeline
- Pumps/motors/valves
- Controls
- Security
- Vapor recovery units



SPR LE2 – Maturity Slide



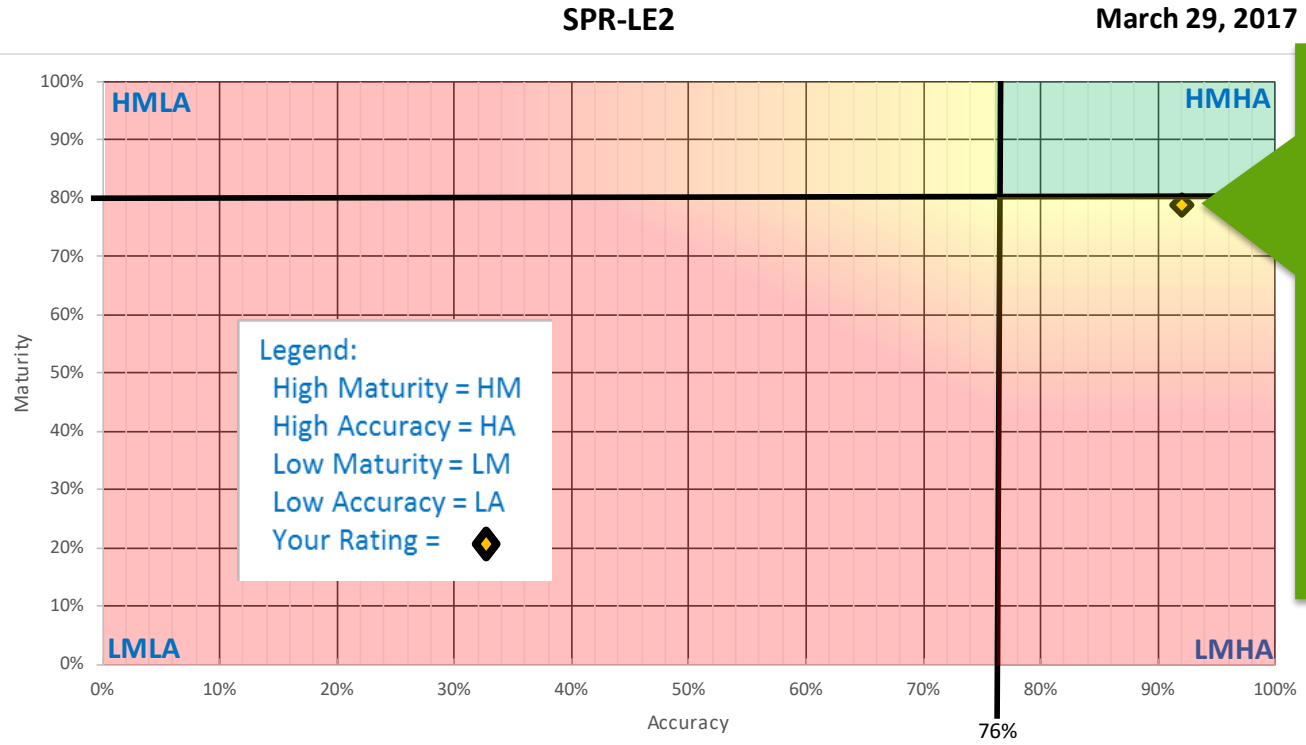
SPR LE2 – Accuracy Slide

CATEGORY Element	Accuracy Definition Level / Weights					Review Accuracy Level		Minimum Score	Accuracy Score	Maximum Score	Normalized Score		
FEED Accuracy	High Performing	Meets Most	Meets Some	Needs Improvement	Not Acceptable	*Make your selection in this Column using the Drop Down List*	**Comments**	0.0	92.0	100.0	92.0	Higher is Better Target = > 76%	92%
1. Project Leadership Team								*0*	*23*	*25*			
1 a. Leadership team's previous **experience planning, designing and executing** a project of similar size, scope, and/or location, including FEED		5				**Meets Most**			5	6			
1 b. ***Stakeholders*** are appropriately repre leadership team													
1 c. Project **leadership** is defined, effecti													
1 d. **Leadership team and organizational** honesty, and shared values													
1 e. Project leadership team's attitude is **manage change**													
1 f. **Key personnel turnover,** e.g., how lo the leadership team													
2. Project Exectution Team													
2 a. **Technical capability and relevant trai** execution team													
2 b. **Contractor/Engineer's team experie** similar projects, and with the FEED proce													

Minimum Score	Accuracy Score	Maximum Score	Normalized Score		
0.0	92.0	100.0	92.0	Higher is Better Target = > 76%	92%

SPR LE2 Maturity-Accuracy Matrix “Tool Output”

FEED MATRS



SPR LE2 is just inside Low Maturity with High Accuracy

Late addition of scope pulled down maturity

Project team identified and established a corrective action plan

SPR-LE2 Summary of Gaps

Assessment Gaps (Maturity - Default Set to Definition Levels 3, 4, and 5; Accurary - Default Set to Definition Levels "Meets Some", "Needs Improvement", and "Not Acceptable"; Print on Legal

FILTER - Use this filter option to adjust to your needs

Generate Report

Generate Report resets Default Filters

For Project Team Use

Maturity

Element	Level	Comment	Minimu	Scor	Maximu	Action	Action Owner
D3. Site Characteristics Available vs. Required	3	The St. James Terminal has areas of concern as open actions. The ability to meet delivery rates are still under review to include the need for off-site capabilities. Storage concerns are under review.	2	16	29		
G3. Piping & Instrumentation Drawings	3	The St. James VRU P&ID and PHA are not completed. The P&IDs for the Degas at BC is not completed. These are at 70%. P&IDs to be improved by A/E going into detailed design.	2	15	31		
G9. Mechanical Equipment List	3	List under development now.	1	9	18		
G10. Line List	3	Will be addressed in detailed design.	1	4	8		

Higher Scores are worse and require more assessment and understanding of Risk and Uncertainty

Accuracy (1 - Proj ... sses, 4 - Project Resources)

				Sco	Maximu	Action	Action Owner
3 c. Priority between cost, schedule, and required project features is clear		for additional work during the analysis of alternatives		2.0	4.0		
4 e. Amount of funding allocated to perform FEED	Meets Some	Funding delays pushed the project to the right 6 months and added costs upfront.	0.0	2.0	4.0		

- Maturity & Accuracy Gaps
- User Adjustable Filter

Panelists

- Steve Cabano
- Mark Balcezak
- G. Edward Gibson, Jr.
- Matthew (Zac) West
- **Rob Garrison – Testimonial**
- Eric Ochsner

Testimonials

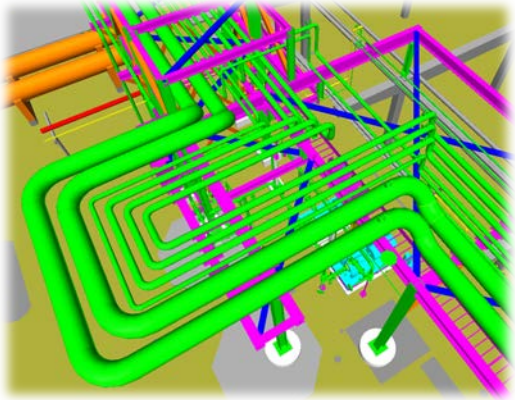
- FEED MATRS session conducted for in-progress projects:
  - Air system upgrade project, petrochemical facility (TIC ~ $10MM)
  - Crude oil transfer and storage upgrade project, Strategic Petroleum Reserves (TIC ~ $1.4B)

Testimonials (Continued)

- Facilitation Observations:
  - Summary definition level description was helpful
  - Having reviewed and approved deliverables was a differentiator in element definition level selection
  - Accuracy session was well received and open and honest feedback was given
  - Scoring system and quadrant plot were very intuitive

Testimonials (Continued)

- Project Takeaways:
  - Projects did not have the same level of FEED completion
  - Preliminary stress of critical lines not performed
  - Specialty items list not started
  - Funding disruptions during FEED was consistent



Panelists

- Steve Cabano
- Mark Balcezak
- G. Edward Gibson, Jr.
- Matthew (Zac) West
- Rob Garrison
- **Eric Ochsner – Testimonial**

Ways to Create Value

1) Better definitions of maturity elements allowed the teams to evaluate their progress during FEED development
2) Doing Accuracy Evaluations early in the FEED process could allow us to create a better environment for teams to be successful.

Testimonials – Using Maturity Definitions

- Project – Structural Steel Replacement and Repair

SITUATION	MATURITY SCORE
Initial Score (Project Team)	82%
Revised Score with Definitions (Project Team)	70%
Final Score (Project Team and Stakeholders)	71%

Testimonials – Using Early Accuracy Assessment

- Project – Facility Separation, Argentina
- Accuracy assessment done at the start of FEP 3 – Score 74%

1A	Leadership team's previous experience planning, designing and executing a project of similar size, scope, and/or location, including FEED
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

Panelists

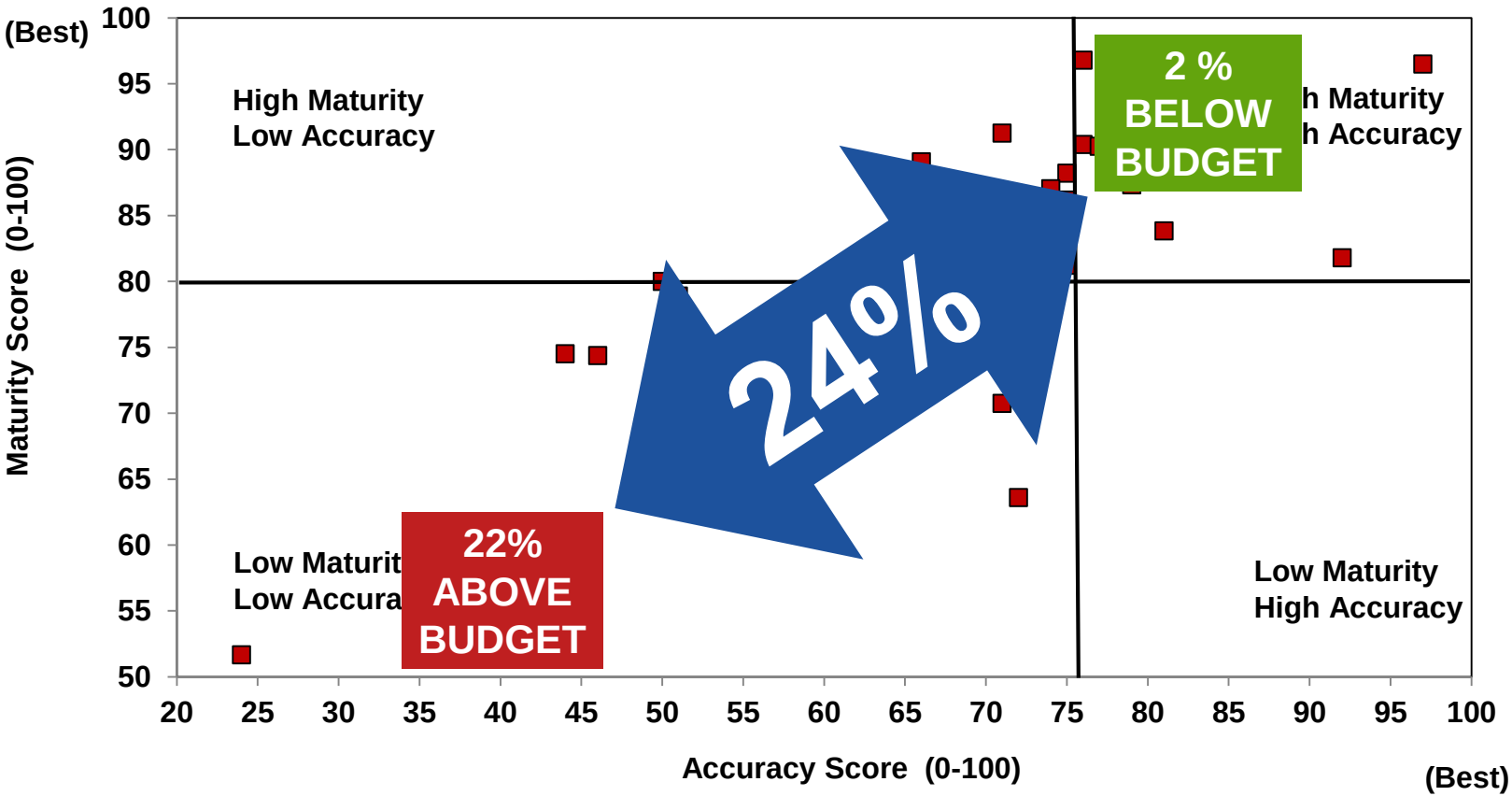
- **Steve Cabano – Closing and Q&A**
- Mark Balcezak
- G. Edward Gibson, Jr.
- Matthew (Zac) West
- Rob Garrison
- Eric Ochsner

In Summary

The team has provided:

- A tested definition for FEED
- Detailed criteria for the required “Engineering” deliverables
- Added “Accuracy” measurement
- Developed FEED MATRS tool

In Summary – Where Do You Want To Be?



Questions – Q & A Ground Rules

- Please use the microphone
- Indicate your name and company affiliation
- Direct your question to a specific panel member, if appropriate

https://tinyurl.com/RT331FEED

Changing How the World Builds

Q&A