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A SunCam online continuing education course

Stage Gate Project Management

by

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Course Outline:

Stage Gate Approaches
Front-End Planning
Gate Procedures
PMBOK Process Groups
Design-Build Stages
Agile and Product Development
PDRI
Cost Estimate Classes
Helpful References
Examination

Stage Gate Approaches

Engineering design is often performed in a series of steps called stages, phases, or tasks. For example, here is a simple three step approach:

Preliminary Study **>** Conceptual Design **>** Final Design

At the end of each step there is a deliverable (e.g., report, drawings, cost estimate). The deliverables are reviewed by stakeholders and key decisions are made before advancing to the next step. These pauses between steps are referred to as “gates” or “stage gates”.

Preliminary Study **>** Conceptual Design **>** Final Design

Gate 1	Gate 2
-Deliverables Review	-Deliverables Review
-Decision to Proceed	-Decision to Proceed

Benefits of a stage gate approach include:

1. Overall lower project cost and lifecycle cost
2. Gate reviews help avoid rework
3. Gate reviews drive the design towards success
4. Budget or schedule issues are identified early, allowing correction
5. Project can be stopped or changed early in planning stage
6. Stage gate procedures increase design efficiency
7. Gates can realign the design team to focus on achieving success criteria

Most projects involve some form of a stage gate process. Many organizations have developed a stage gate methodology that fits the needs of the organization. Project managers are generally tasked with ensuring the stage gate methodology is being followed for each project.

<u>Project Cost Influence</u>
The stage gate approach typically results in additional engineering effort early in the project. However, this extra engineering cost, typically 2 to 5% of the construction cost, is usually justified as it decreases construction cost and duration. According to a 2009 survey by Construction Industry Institute (CII), owners that put effort into front end planning with stage gates save 8% on average on improvement projects. That's after taking into account the additional engineering fees.

Making key decisions early allows a greater influence on the final cost and schedule for relatively less effort. Figure 1 depicts how design changes early in the project have the greatest potential to decrease the overall project cost and lifecycle cost of the improvements.

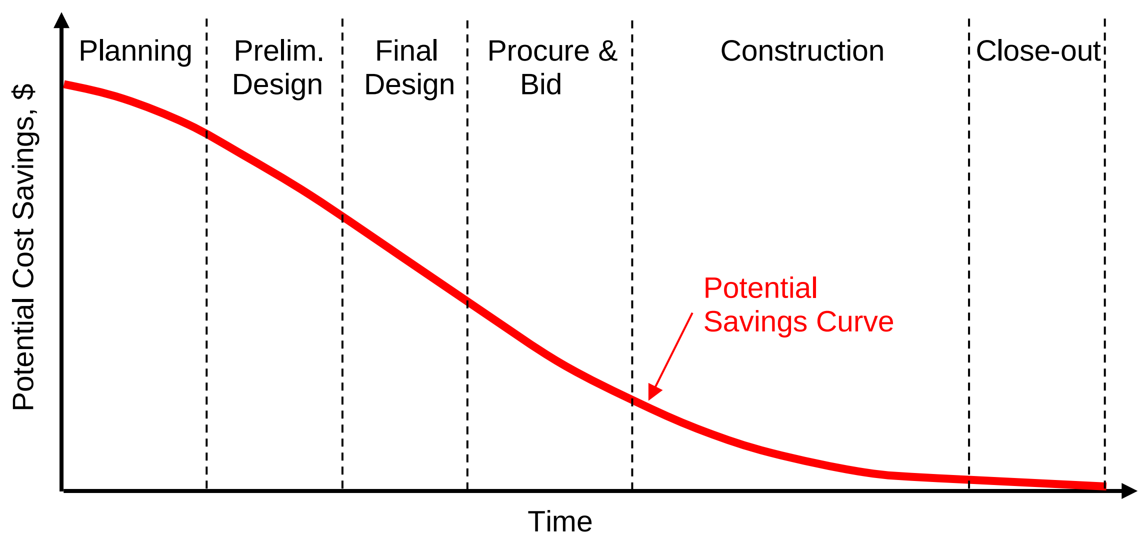


Figure 1 – Curve in red showing decreasing ability over time to lower the total project cost and lifecycle cost. Each dashed vertical line is a stage gate.
Source: Author

Cost of Changes

Adding features or other improvements is easiest done early in the planning process to avoid rework, efficiently integrate design elements, and obtain competitive pricing. Design changes during construction are much more expensive and extend the construction duration. Figure 2 depicts the increased cost of a design change over time.

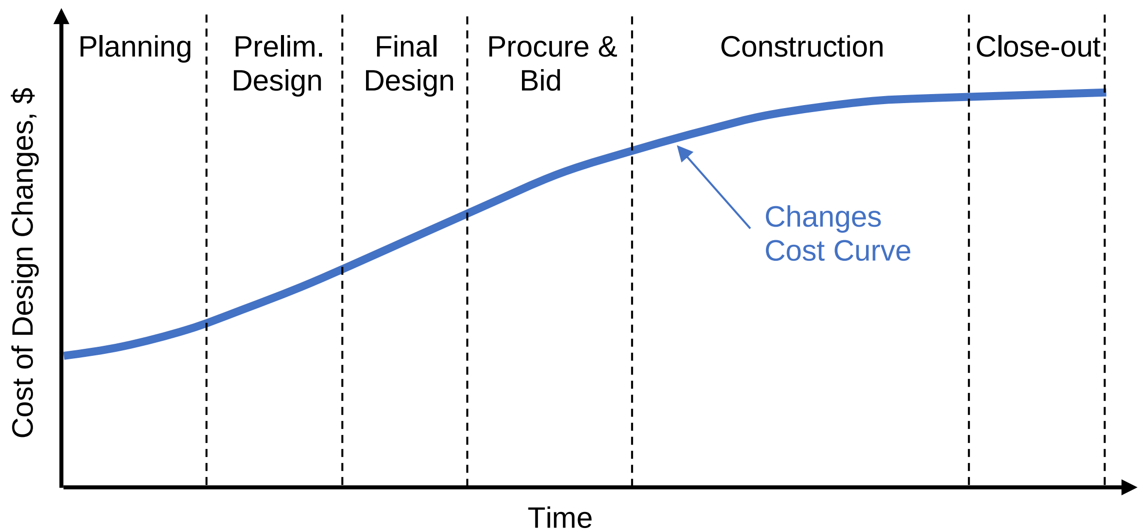
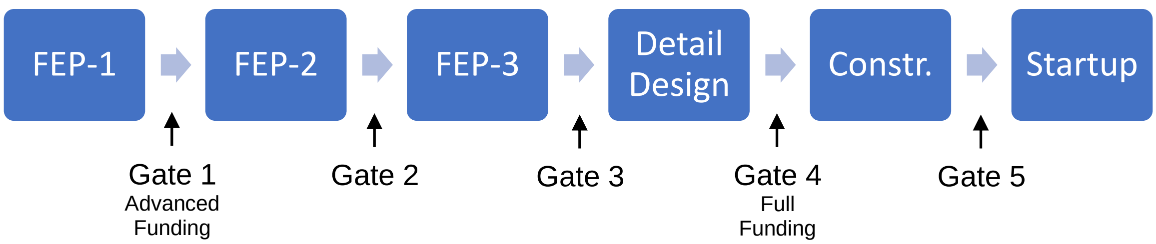


Figure 2 – Curve showing how a design change costs less earlier in the design process.
Source: Author

Front-End Planning

The most common stage gate methodology is Front-End Planning (FEP), also called Front-End Loading (FEL). FEP focuses on the early development of strategic information to confirm the business case for the project. The idea is to put more effort into planning so the end results will more closely align with success criteria.

The FEP workflow is as follows (a bidding stage may be added after Detail Design):



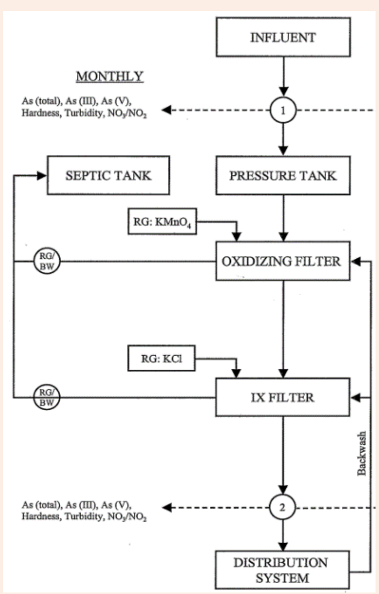
The FEP-1 stage leads to advanced funding. The Detailed Design (DD) stage leads to full funding. The first four engineering stages (FEP1 through DD) and typical gate procedures are described in detail in this course. FEP standards with additional details are published by the Construction Industry Institute (CII).

FEP-1 / FEL-1

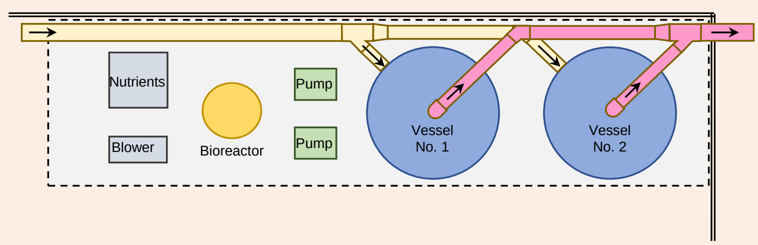
Known As	Inputs (if available)	Deliverables
• Feasibility • Assess • Business Planning • Rough Order of Magnitude • Ballpark • Study • Planning	• Business Objectives • Business Case • Regulatory Requirements • Previous Studies • Existing Drawings • Other Existing Information	• Scope Description • Business Case • Schematic Layout • Feasibility Report • Block Flow Diagram (BFD) • Project Timeframe • Major Equipment List • Alternatives Comparison • PDRI 1

- Percent of Engineering Fee: 2 to 5%
- Percent Complete of Construction Documents: 0 to 5%
- AACE Cost Estimate Class: 5

BFD



Schematic Layout



Alternatives Comparison

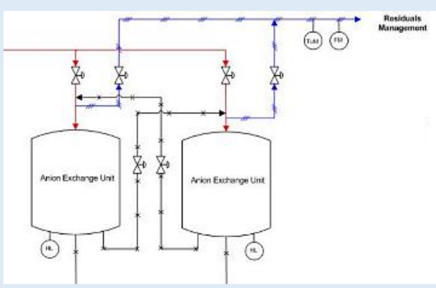
Table 4: Example Multi-criteria Scoring Table

Indicator	Weight Factor	Asphalt Shingle Normal. Index	Asphalt Shingle Weighted Index	Clay Tile Roof Normal. Index	Clay Tile Roof Weighted Index	Metal Roof Normal. Index	Metal Roof Weighted Index
Installation Time	10	1.0	10	0.4	4	0.6	6
Constr. Cost	30	1.0	30	0.2	6	0.3	9
Colors Available	10	0.2	2	0.1	1	1.0	10
Aesthetics	10	0.4	4	1.0	10	0.6	6
Life Span	20	0.3	6	1.0	20	0.8	16
Storm Resist.	20	0.7	14	0.8	16	1.0	20
Aggregated Index		-	66	-	57		**67**
Final Score (Normalized to 1)		-	0.99	-	0.85		**1.0**

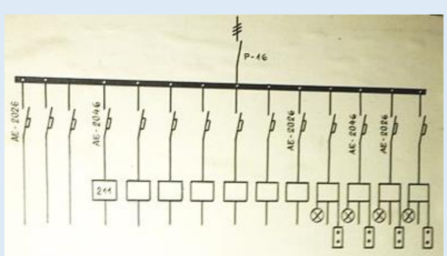
Figure 3: Example FEP-1 Deliverables
Source: Author

FEP-2 / FEL-2		
Known As	**Inputs (if available)**	**Deliverables (U = Updated from FEP-1)**
• Concept • Conceptual Design • Select • Preliminary • Pre-Design • Pre-FEED • Feasibility Design • Study (II)	• FEP-1 Deliverables • Safety Requirements • Client Specifications & Standards	• Updated FEP-1 Deliverables • Preliminary Design Report • Site Layout • Process Flow Diagram (PFD) • Power One-Line Diagram • Controls Architecture • Project Schedule • Drawing & Specification List • Geotechnical Report • Environmental Assessment • Topographical Survey • PDRI 2
• Percent of Engineering Fee: 5 to 10% • Percent Complete of Construction Documents: 5 to 30% • AACE Cost Estimate Class: 4		

PFD



One-Line



Site Layout

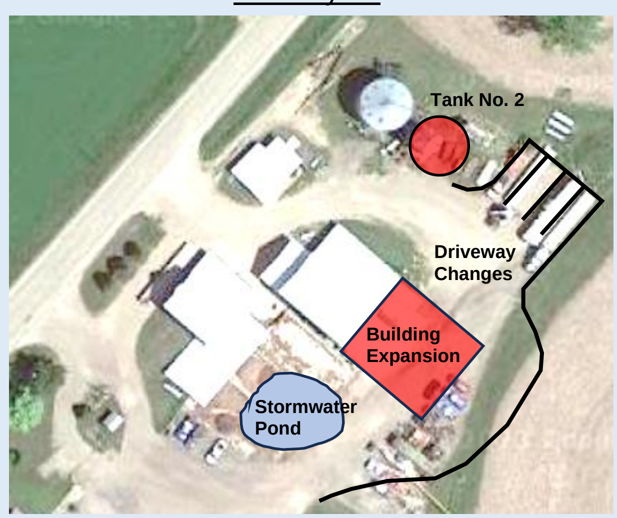


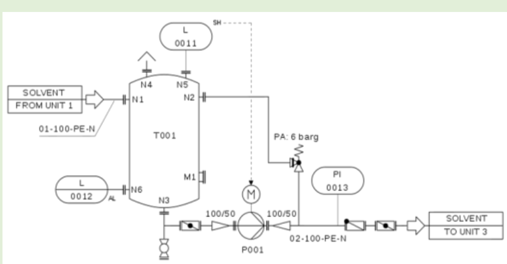
Figure 4: Example FEP-2 Deliverables

Source: commons.wikimedia.org/wiki/File:Soviet-era_one-line_diagram.jpg, Dmitry G, CC-BY-SA-3.0 (lower left)

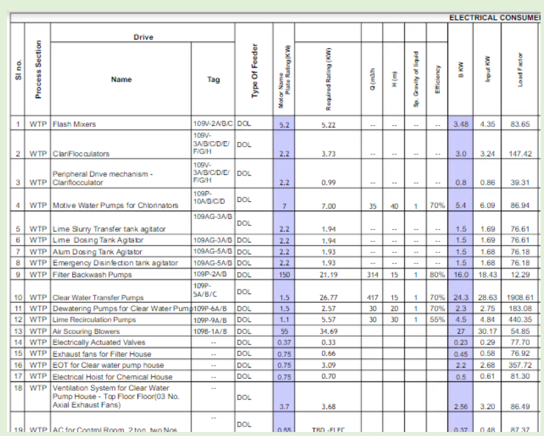
FEP-3 / FEL-3 Front-End Engineering Design (FEED)		
Known As	**Inputs (if available)**	**Deliverables (U = Updated from FEP-1)**
• Define • Budget • Basic Engineering • Detailed Scope • Front-End Engineering • Preliminary Design	• FEP-2 Deliverables • Existing Conditions & Data • Site Assessment Reports • Property Deeds & Easements • Utility Agreements & Bills • Detailed Regulatory Requirements • Reference Project Information	• Updated FEP-2 Deliverables • Issue for Design (IFD) Drawings and Specifications • P&IDs • Building Plans and Elevations • Foundation Plans • Equipment Arrangements • Equipment Specifications • 3D Model (Draft) • Motor List and Power Requirements • Controls Strategy • PDRI 3
• Percent of Engineering Fee: 10 to 20% • Percent Complete of Construction Documents: 10 to 60% • AACE Cost Estimate Class: 3		

Elevation

P&ID



Motor Load List



ELECTRICAL CONSUME

Sl no.	Process Section	Drive: Name	Drive: Tag	Type Of Feeder	Motor Name Plate Rating(KW)	Required Rating (KW)	Q (m3/h)	H (m)	Sp. Gravity of liquid	Efficiency	B KW	Input KW	Load Factor
1	WTP	Flash Mixers	109V-2A/B/C	DOL	5.2	5.22	--	--	--	--	3.48	4.35	83.65
2	WTP	ClariFlocculators	109V-3A/B/C/D/E/F/G/H	DOL	2.2	3.73	--	--	--	--	3.0	3.24	147.42
3	WTP	Peripheral Drive mechanism - Clariflocculator	109V-3A/B/C/D/E/F/G/H	DOL	2.2	0.99	--	--	--	--	0.8	0.86	39.31
4	WTP	Motive Water Pumps for Chlorinators	109P-10A/B/C/D	DOL	7	7.00	35	40	1	70%	5.4	6.09	86.94
5	WTP	Lime Slurry Transfer tank agitator	109AG-3A/B	DOL	2.2	1.94	--	--	--	--	1.5	1.69	76.61
6	WTP	Lime Dosing Tank Agitator	109AG-3A/B	DOL	2.2	1.94	--	--	--	--	1.5	1.69	76.61
7	WTP	Alum Dosing Tank Agitator	109AG-5A/B	DOL	2.2	1.93	--	--	--	--	1.5	1.68	76.18
8	WTP	Emergency Disinfection tank agitator	109AG-5A/B	DOL	2.2	1.93	--	--	--	--	1.5	1.68	76.18
9	WTP	Filter Backwash Pumps	109P-2A/B	DOL	150	21.19	314	15	1	80%	16.0	18.43	12.29
10	WTP	Clear Water Transfer Pumps	109P-5A/B/C	DOL	1.5	26.77	417	15	1	70%	24.3	28.63	1908.61
11	WTP	Dewatering Pumps for Clear Water Pump	109P-6A/B	DOL	1.5	2.57	30	20	1	70%	2.3	2.75	183.08
12	WTP	Lime Recirculation Pumps	109P-9A/B	DOL	1.1	5.57	30	30	1	55%	4.5	4.84	440.35
13	WTP	Air Scouring Blowers	109B-1A/B	DOL	55	34.69					27	30.17	54.85
14	WTP	Electrically Actuated Valves	--	DOL	0.37	0.33					0.23	0.29	77.70
15	WTP	Exhaust fans for Filter House	--	DOL	0.75	0.66					0.45	0.58	76.92
16	WTP	EOT for Clear water pump house	--	DOL	0.75	3.09					2.2	2.68	357.72
17	WTP	Electrical Hoist for Chemical House	--	DOL	0.75	0.70					0.5	0.61	81.30
18	WTP	Ventilation System for Clear Water Pump House - Top Floor Floor(03 No. Axial Exhaust Fans)	--	DOL	3.7	3.68					2.56	3.20	86.49
19	WTP	AC for Control Room, 2 ton, two Nos	--	DOL	0.55	TBD -ELEC					0.37	0.48	87.37

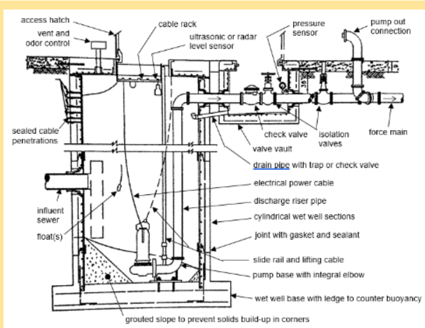
Figure 5: Example FEP-3 Deliverables
Source: commons.wikimedia.org/wiki/ File:Pump_with_tank_pid_en.svg, Con-struct, CC-BY-SA-3.0

FEP-4 / FEL-4
Detailed Design (DD)

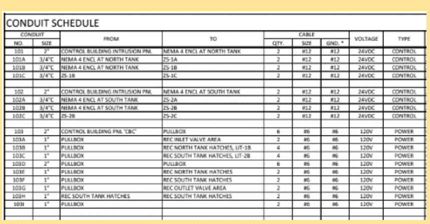
Known As	Inputs (if available)	Deliverables (U = Updated from FEP-1)
• Detail Design • Final Design • Detailed Engineering • Design • FEP-4 • FEL-4	• FEP-3 Deliverables • Existing Systems Information • Existing Tie-in Details • Lessons Learned from Reference Projects • Standard Operating Procedures • Project Requirements and Constraints	• Updated FEP-3 Deliverables • Issue for Construction (IFC) Drawings and Specifications • Detailed Equipment List • Pipe Schedule • Detailed Project Schedule • 3D Model (Final) • Controls Descriptions • Regulatory Approvals • Calculations Packages • I/O Lists • Wire & Conduit Schedules • Control Panel Layouts

- Percent of Engineering Fee: 60 to 70%
- Percent Complete of Construction Documents: 60 to 100%
- AACE Cost Estimate Class: 1 or 2

Detail Drawing



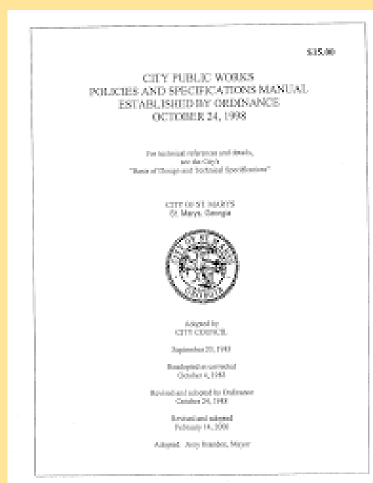
Conduit Schedule



CONDUIT SCHEDULE

CONDUIT		FROM	TO	CABLE			VOLTAGE	TYPE
NO.	SIZE			QTY.	SIZE	GND. *		
101	2"	CONTROL BUILDING INTRUSION PNL	NEMA 4 ENCL AT NORTH TANK	2	#12	#12	24VDC	CONTROL
101A	3/4"C	NEMA 4 ENCL AT NORTH TANK	ZS-1A	2	#12	#12	24VDC	CONTROL
101B	3/4"C	NEMA 4 ENCL AT NORTH TANK	ZS-1B	2	#12	#12	24VDC	CONTROL
101C	3/4"C	ZS-1B	ZS-1C	2	#12	#12	24VDC	CONTROL
102	2"	CONTROL BUILDING INTRUSION PNL	NEMA 4 ENCL AT SOUTH TANK	2	#12	#12	24VDC	CONTROL
102A	3/4"C	NEMA 4 ENCL AT SOUTH TANK	ZS-2A	2	#12	#12	24VDC	CONTROL
102B	3/4"C	NEMA 4 ENCL AT SOUTH TANK	ZS-2B	2	#12	#12	24VDC	CONTROL
102C	3/4"C	ZS-2B	ZS-2C	2	#12	#12	24VDC	CONTROL
103	2"	CONTROL BUILDING PNL 'CBC'	PULLBOX	6	#6	#6	120V	POWER
103A	1"	PULLBOX	REC INLET VALVE AREA	2	#6	#6	120V	POWER
103B	1"	PULLBOX	REC NORTH TANK HATCHES, LIT-1B	4	#6	#6	120V	POWER
103C	1"	PULLBOX	REC SOUTH TANK HATCHES, LIT-2B	4	#6	#6	120V	POWER
103D	2"	PULLBOX	PULLBOX	6	#6	#6	120V	POWER
103E	1"	PULLBOX	REC NORTH TANK HATCHES	2	#6	#6	120V	POWER
103F	1"	PULLBOX	REC SOUTH TANK HATCHES	2	#6	#6	120V	POWER
103G	1"	PULLBOX	REC OUTLET VALVE AREA	2	#6	#6	120V	POWER
103H	1"	REC SOUTH TANK HATCHES	REC SOUTH TANK HATCHES	2	#6	#6	120V	POWER
103I	1"	PULLBOX		2	#6	#6	120V	POWER

Specifications



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CITY PUBLIC WORKS
POLICIES AND SPECIFICATIONS MANUAL
ESTABLISHED BY ORDINANCE
OCTOBER 24, 1998

Figure 6: Example Detailed Design Deliverables

Gate Procedures

After each stage is a "gate" or "stage gate" where feedback is obtained from stakeholders and a decision is made whether to proceed to the next stage. The following are typical purposes/goals of each gate:

- Project alignment with business objectives
- Project status review
- Budget review
- Schedule review
- Stakeholder input
- Quality improvements
- Risk management
- Ability to stop or hold project
- Planning for next stage

It is helpful to follow a pre-determined process for each gate. Many organizations have developed stage gate standard procedures for capital improvement projects and product development. The below flow chart represents common steps for a gate.

Description of each step:

1. **Assemble Deliverables**: The deliverables (report, drawings, cost estimate, etc.) from the previous stage are gathered, confirmed as complete, and distributed to stakeholders.
2. **Assess KPIs**: The project manager calculates Key Performance Indicators (KPIs) such as budget, schedule, footprint, production output, efficiency, Project Definition Rating Index (PDRI), etc. KPIs vary by organization, project objectives, and leadership priorities.
3. **Present to Stakeholders**: The project manager presents the following to a group of stakeholders: project status, KPIs, summary of deliverables, risks, cost estimate, alternatives, and other important information.

4. **Feasibility Review**: Stakeholders review critical information to evaluate the feasibility of continuing with the project, including the following:
    a. Business need,
    b. Strategic fit,
    c. Cost estimate versus budget,
    d. Projected return on investment,
    e. Market conditions,
    f. Competition,
    g. Synergies, and
    h. Risks and mitigation strategies.
5. **Go / No Go Decision**: The governing group or individual (the gate keeper) makes a decision whether to continue with the project. Options includes:
    a. Go (continue to next stage)
    b. Conditional Go (continue with modifications or restrictions)
    c. Delay (stop work for a time period due to funding or other conditions)
    d. Hold (stop work and reassess in the future)
    e. Stop (stop work permanently and close project)
6. **Alternatives and Changes**: If project is to continue, make decisions on design alternatives and other options. Decide on changes to product requirements, design criteria, deliverables, budget, schedule, staff assignments, resources, risk mitigation, or other issues. Project manager documents and distributes decisions.

Sometimes, planning for the next stage is considered a last step in the gate (rather than being part of the next stage). This planning would include preparing the scope of work, confirming deliverables, creating a work breakdown structure, budget, schedule, quality plan, risk register, and planning resources such as staff, consultants, and contractors.

PMBOK Process Groups

The most widely accepted standard for project management principles is the Project Management Body of Knowledge (PMBOK) issued by the Project Management Institute, Inc. (PMI). Fundamental recommendations are provided which are widely accepted across a variety of project types and delivery types.

The PMBOK defines five process groups which apply to each stage/phase of a project and to the overall project itself:

1. **Initiating**: This involves making a vision for what the stage or overall project hopes to achieve. It defines the motivation for the project, the desired outcomes, and the overall scope of work. An initial budget is often set.

2. **Planning**: This includes defining milestones, creating a work breakdown structure, creating a detailed budget, scheduling, identifying risks, identifying staff, securing resources, quality management planning, and creating a project plan document.

3. **Executing**: This includes the actual work to complete deliverables. Here are examples for typical FEP stages:

    a. FEP-1: Prepare feasibility study
    b. FEP-2: Prepare preliminary design report
    c. FEP-3: Prepare preliminary drawings
    d. DD: Prepare final drawings
    e. Constr.: Order materials and install components
    f. Startup: Test new equipment

4. **Monitoring and Controlling**: The project manager tracks and reviews progress and performance. Changes are made to the project plan as needed to keep the project on track to meeting goals.

5. **Closing**: The stage or project is closed through a systematic process. At the close of each stage, the stage gate process is started. And after the last stage, the project itself is closed. Activities include confirming final quality acceptance, making final payments, closing contracts, archiving records, reviewing lessons learned, and having team celebrations.

Note that the above process groups are not meant to be sequential stages/phases of a project. Rather they apply to each stage. In the PMBOK, the overall project sequence is referred to as the "project life cycle". The five process groups are repeated for each stage of the project. Each stage of the overall project can be treated as its own project (or subproject) with the end being the stage gate.

The PMBOK defines ten "Knowledge Areas" for the project manager to manage, as shown in Figure 7. These knowledge areas apply to each stage of the project.

Figure 7: Project management "knowledge areas" per the PMBOK.
Source: Author

Example Problem 1

Project Manager (PM) Dale is planning for the FEP-3 (FEED) stage of a CapEx project for the expansion of a facility for the company Acme Corp in which he is employed. He plans to select a consultant to perform design services including producing plans and specifications. Help Dale determine whom should be responsible for the tasks in Table 1 below.

Table 1: Stage FEP-3 Tasks and Responsibilities for Problem 1

Process Group	Tasks	Responsibility	
		PM Dale, Acme Corp	Design Consultant
Initiating	Define Scope of Work		
	Set a Budget		
Planning	Create a Work Breakdown Structure		
	Identify Design Staff		
	Create a Project Plan		
Executing	Prepare Drawings		
	Prepare a Cost Estimate		
Monitoring & Controlling	Track KPIs		
	Approve Scope Changes		
Closing	Confirm quality of work is acceptable to Acme		
	Submit final invoice and lien waver		
	Pay final invoice		

Solution:
See Table 2 with recommended responsibilities between PM Dale and the Design Consultant. Note that both PM Dale and the Design Consultant have joint responsibility for some of the items. In these cases, PM Dale is responsible for the overall project while the Consultant is responsible for just the design aspects of the project. For example, the Design Consultant will create a Project Plan for managing just their design scope of work, while PM Dale will update the Project Plan for the overall CapEx project.

Table 2: Stage FEP-3 - Solution to Problem 1

Process Group	Tasks	Responsibility	
		PM Dale, Acme Corp	Design Consultant
Initiating	Define scope of work	X	
	Set a budget	X	
Planning	Prepare a proposal for the work		X
	Select a proposal and execute Contract	X	
	Create a work breakdown structure	X	X
	Assign design staff		X
	Create or update project plan	X	X
Executing	Prepare drawings		X
	Prepare a cost estimate		X
Monitoring & Controlling	Track KPIs	X	X
	Perform quality reviews	X	X
	Approve scope changes	X	
Closing	Confirm deliverables are acceptable	X	
	Submit final invoice and lien waver		X
	Pay final invoice	X	

Design-Build Approaches

There are several project delivery approaches available for capital improvement projects. The following are common approaches and their typical stages/phases. The stage flow diagrams have been simplified as follows:

- Business planning can be considered FEP-1/FEL-1,
- “Design stages” includes FEP-2 to FEP-4 (details vary by project),
- Long lead time equipment is often purchased in a design or bidding stage,
- Startup/commissioning phase is considered part of construction,
- A one-year warranty period/stage after startup is not shown.

Design-Bid-Build (DBB)
This is the traditional method of executing a project. The competitive bid process often results in a lower cost than design-build. However, DBB projects typically last longer which increases risks for all parties.

Design-Build (DB)
Design-build is a project delivery approach in which a design-builder performs both design and construction services under a single contract. The contract is typically a guaranteed maximum price (GMP). The design-builder can be a single contractor or a partnership/team. It is sometimes called a “turnkey” approach because the design-builder does everything including turning on (starting up) the system. The DB approach is simple and fast.

Progressive Design-Build (PDB)

The PDB approach adds one or more intermediate stages to the DB process. The goal is to allow a preliminary design prior to establishing a GMP, which reduces risk for the design-builder and often reduces the overall project cost. Sometimes projects start as DB but if the GMP prices are overbudget, using a PDB approach combined with value engineering allows the project to proceed within budget.

Engineer-Procure-Construct (EPC)

The EPC approach is very similar to Design-Build, with a single contract to a contractor or joint venture team.

Key differences are as follows:

- With DB, the design-builder is typically given specifications or “bridging documents”. With EPC, the contractor is often given little more than performance requirements.
- With EPC, the contractor is often expected to take on additional risks for unknown conditions or unforeseen escalations.
- With EPC, there are often liquidated damages and/or consequential damages in the contract.
- With EPC, there are often initial operations and extensive warranty requirements, to ensure the system begins successfully.
- Due to the above, an EPC price is usually higher than DB.

Agile and Product Development

Agile is an approach that breaks the design process into iterative or repetitive stages. Agile is popular for software and product development projects, rather than capital improvement or construction projects. The goal is to regularly test the product and maximize flexibility for design improvements throughout the lifecycle of the project.

The process flow chart for Agile is more complicated that the FEP or DB approaches, which are "waterfall" approaches in which the project must move forward in a series of steps. In an Agile approach, the stages are called "sprints". At each gate, the project can go back to repeat a previous sprint.

Types of Agile methodologies are as follows:

- Scrum
  - Focuses on two-week sprints. There is a planning meeting before each sprint, and a retrospective meeting after each sprint.
- Extreme Programming (XP)
  - Focuses on regular customer interaction through frequent releases and short design cycles / sprints. Customer feedback is incorporated through each cycle.
- Dynamic System Development Method (DSDM)
  - Stages include pre-project, feasibility study, business study, functional model iteration, design and build iteration, implementation, post-project.
- Feature Driven Development Method (FDD)
  - Stages include domain object modeling, development by feature, component/class ownership, feature teams, inspections, configuration management, regular builds, visibility of progress and results.
- Crystal Method
  - A flexible approach that allows adjustment based on unique needs of people involved and their skills.
- Kanban
  - An illustrative approach which displays to the team the tasks "to do", "doing", and "done". Team meets and updates the display regularly.

PDRI

PDRI (Project Definition Rating Index) measures the level of scope definition for a project. Scope definition is recognized as an important factor in predicting project success. A scope definition should become more complete as the stages of the project advance. As the scope definition advances, project risk decreases. Therefore, PDRI is also a measure of the risk level of a project.

The PDRI approach was first developed by the Construction Industry Institute (CII). PDRI calculation templates are available on the CII website (see Helpful References):

- IR113-2, PDRI for Industrial Projects
- IR155-2, PDRI for Building Projects
- IR268-2, PDRI for Infrastructure Projects
- IR314-2 & a-2, PDRI for Small Projects

A PDRI assessment is performed by scoring different elements of scope definition, multiplying each by a weight factor (based on which elements are perceived as most important), and then summing for a total score. The elements (approx. 60 to 70) are grouped into sections and categories, as summarized in Table 3. Scoring in each section and category can be analyzed to determine which areas of the scope of work need further definition.

Table 3: Typical PDRI Sections and Categories

Section	Category	Maximum Score		
		Category	Section	Overall
1. Basis of Project	A. Business Strategy	214	413	1000
	B. Owner Philosophies	68		
	C. Project Requirements	131		
2. Basis of Design	D. Site Information	108	429	
	E. Building Programming	162		
	F. Design Parameters	122		
	G. Equipment	36		
3. Execution Approach	H. Procurement Strategy	25	158	
	J. Deliverables	11		
	K. Project Control	63		
	L. Project Execution Plan	60		

SECTION I - BASIS OF PROJECT DECISION									
CATEGORY	Definition Level								Max
Element	0	1	2	3	4	5	Level	**Score**	Score
A. BUSINESS STRATEGY (Maximum Score = 214)									
A1. Building Use	0	1	12	23	33	44	3	**23**	44
A2. Business Justification	0	1	8	14	21	27	3	**14**	27
A3. Business Plan	0	2	8	14	20	26	3	**14**	26
A4. Economic Analysis	0	2	6	11	16	21	3	**11**	21
A5. Facility Requirements	0	2	9	16	23	31	3	**16**	31
A6. Future Expansion/Alteration Considerations	0	1	7	12	17	22	3	**12**	22
A7. Site Selection Considerations	0	1	8	15	21	28	3	**15**	28
A8. Project Objectives Statement	0	1	4	8	11	15	3	**8**	15
CATEGORY A TOTAL								**113**	214

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

Figure 8: Example portion of a PDRI calculation table. In this case, the Level score (in red) is 3 of 5 in all 8 elements of the category “Business Strategy”. This results in a score of 113 of 214. Lower values mean greater definition level.

The PDRI scoring is inverted, so a low score means the scope is better defined. Zero is the best score while 1000 is the worst. A goal of front-end planning is to reduce the PDRI to an acceptable level. A PDRI score of 200 or less is often considered sufficient to proceed with final design and construction of a project. Table 4 lists typical PDRI ranges at the end of each FEP stage.

Table 4: Typical PDRI Ranges by FEP Stage				
	FEP-1	FEP-2	FEP-3	FEP-4 / DD
Min.	500	400	200	100
Max.	800	600	450	250

Often PDRI scoring is required at design stage gates. The PDRI results can indicate which areas should be further developed in the next stage.

<u>Example Problem 2</u>

Project Manager Tom performed a PDRI assessment of a project with the results in Table 5. Based on the percentages, which section and category should Tom focus on developing? In which FEP stage does the project fit?

Table 5: PDRI Scores for Example Problem 2

Section	Category	Category Score			Section Score		
		Project	Max	%	Project	Max	%
1. Basis of Project	A. Business Strategy	93	214	43	164	413	40
	B. Owner Philosophies	28	68	41			
	C. Project Requirement	43	131	33			
2. Basis of Design	D. Site Information	55	108	51	146	429	34
	E. Building Program.	36	162	22			
	F. Design Parameters	43	122	35			
	G. Equipment	12	36	33			
3. Execution Approach	H. Proc. Strategy	9	25	36	58	158	37
	J. Deliverables	2	11	18			
	K. Project Control	21	63	33			
	L. Project Exec. Plan	26	60	43			
	Total	368	1000	37	368	1000	37

Solution:

For PDRI scoring, a higher number means poorer project definition, so the category with the highest score is the one Tom should focus on most. The highest percentage is in "**basis of project**" section and the "**site information**" category, so Tom should focus on developing those further.

With a total score of 368, the project would typically be in the **FEP-3** stage (200 to 450).

Cost Estimate Classes

Accuracy Range

The overall accuracy of construction cost estimates increases as the design develops and design stages progress. For guidance on accuracy ranges, the Association of Advancement for Cost Engineering (AACE) developed a recognized standard entitled "Cost Estimate Classification System". The standard defined five (5) classes of estimates, with one (1) being the most detailed take-off before bidding or procurement. Table 6 summarizes the AACE accuracy ranges at the end of each FEP stage.

Table 6: AACE Cost Estimate Classes

Estimate Class	Percent Complete	Typical Stage	Accuracy Range, %		Contingency, %	
			Low	High	Low	High
5	0 to 2%	FEP-1	-20 to -50	30 to 100	20	50
4	1 to 15%	FEP-2	-15 to -30	20 to 50	20	30
3	10 to 40%	FEP-3	-10 to -20	10 to 30	15	25
2	30 to 75%	DD	-5 to -15	5 to 20	10	20
1	65 to 100%	DD/Bid	-3 to -10	3 to 15	5	10

Contingency

Construction cost estimates include a contingency dollar amount to account for unknowns and risks. Contingency is usually a percent of the overall construction cost estimate. As the project advances, contingency decreases, as shown in Table 6.

Example costs covered by contingency are as follows:

- Undefined design details,
- Unforeseen site conditions like buried utilities or contaminated soils,
- Addressing regulatory comments and unknowns,
- Alternatives not yet selected,
- Minor scope and material changes,
- Cost estimate inaccuracies and omissions, and
- Market changes.

Costs typically NOT covered by contingency are as follows:

- Contractor overhead, profit, general conditions, taxes (separate line items)
- Escalation to mid-point of construction (separate line item)
- Major scope changes,
- Extraordinary events such as pandemics and natural disasters,
- Significant or global supply chain issues and events,
- Unforeseen legal issues and fees, and
- Unforeseen public relations efforts.

Example Problem 3

Engineer Michele has estimated a construction cost of $3.5M for a project that is 50% complete. She needs to add a contingency value and present a low and high range for the cost. Help Michele by using the AACE values in Table 6 with the high-end contingency value and the greatest accuracy range for the appropriate class.

Solution:

A project at 50% complete would be at Estimate Class 2. Per Table 6, the high-end contingency is 20% and the largest accuracy range would be -15% to 20%. The calculations are as follows (values rounded):

Contingency = $3.5M * 20% = **$0.7M**

Cost Estimate = $3.5M + $0.7M = $4.2M

Cost Range Low = $4.2M - ($4.2M * 15%) = **$3.6M**

Cost Range High = $4.2M + ($4.2M * 20%) = **$5.0M**

Helpful References

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