THE DESIGN-BUILDER'S GUIDE TO DESIGN MANAGEMENT:

A Playbook for the Industrial Sector

CHARLES PANKOW FOUNDATION

THE DESIGN-BUILDER'S GUIDE TO DESIGN MANAGEMENT: A PLAYBOOK FOR THE INDUSTRIAL SECTOR

July 2024

Authors

Dr. Bryan Franz, Associate Professor, University of Florida

Dr. Daniel Hall, Assistant Professor, Delft University of Technology

Managing Editor
Oksana Gieseman

Editor
Peter Hunsinger

Graphic Design and Layout
Alicia Hoermann

CHARLES PANKOW FOUNDATION

A GUIDE FROM
Charles Pankow Foundation
1390 Chain Bridge Rd #700
McLean, VA 22101
www.pankowfoundation.org
(360) 326-3767

Contents

CONTRIBUTORS TO THE INDUSTRIAL SECTOR PLAYBOOK

Subject Matter Experts

Allan VanHorn
SPID Administrator and SME
Motiva Enterprises, LLC

Brad Whitaker
Director of Construction Planning
Charles Pankow Builders, Ltd.

Mano Velayuthan
Senior Manager Design Engineering
Ontario Power Generation

Christina Trotter
Associate Project Engineer
Burns & McDonnell

Matt Dahlberg
Senior Design Manager
Haskell

Christine Angleton
Design Phase Executive
Mortenson

Catriona Winter
Senior Vice President
Clark Construction Group, LLC

Harry Gleich
Vice President of Engineering
Metromont Corporation

Paul Kelley
Senior Principal
Simpson Gumpertz & Heger

Greg Gidez
Director of Design Services
Hensel Phelps

EXECUTIVE SUMMARY

Design-build projects in the industrial sector encompass a variety of facility types, ranging from warehouses and distribution centers to manufacturing facilities, chemical processing plants, and oil refineries. Industrial facilities are built for functionality first. They involve heavy and specialized equipment and are often subject to environmental regulation and scrutiny.

This *Industrial Sector Playbook* offers guidance tailored to the characteristics of design-build project delivery in the industrial sector primarily for professionals who have been tasked with the role of design integration manager. This playbook is meant to be used in conjunction with *The Design-Builder's Guide to Design Management*. The guide aims to help owners, designers, and builders of design-build projects achieve greater success by understanding and fully leveraging the unique role of the design integration manager. To complement the guide, this playbook provides detailed information specific to the design integration manager's role in the industrial sector and describes how this individual interacts with project stakeholders across different project phases.

To succeed as a design integration manager in the industrial sector, it is crucial to recognize the key characteristics that differentiate this sector from others and to understand the diverse knowledge, skills, abilities, and other characteristics that the design integration manager needs to effectively guide a project from start to finish. This playbook addresses the competencies and qualifications that a design integration manager needs to successfully deliver a design-build project in the industrial sector and outlines the design integration manager's tasks, responsibilities, and involvement throughout all phases of industrial design-build projects.

Industrial design-build projects follow the structured front-end loading (FEL) process used in the delivery of large capital projects, which engages the design integration manager across five distinct phases:

- The **Proposal/Pre-award Phase** begins when the project owner initiates a competitive bidding or proposal process—whether for front-end engineering and design (FEED) services near the end of the second FEL phase or for project execution near the end of the third FEL phase—and ends when a contract award agreement is fully executed between the owner and the selected engineering firm or engineering, procurement, and construction (EPC) contractor.
- The **Front-End Engineering and Design Phase**, which corresponds to the third FEL phase, begins with the development of a preliminary conceptual design and ends with the development of a comprehensive issued for design (IFD) package.

“This playbook addresses the competencies and qualifications that a design integration manager needs to successfully deliver a design-build project in the industrial sector.”

- The **Project Initialization Phase** begins with validation of the project scope and ends when subcontracts are awarded to all partners and the project execution begins.
- The **Detailed Engineering and Design Phase** begins with validation of the FEED process and ends with the development of an issued for construction (IFC) package.
- The **Construction Phase** begins after the construction documents are prepared and ends with the completion of construction and handover of the end-product to the owner.

Each phase involves a set of key tasks and presents unique challenges and opportunities, and the design integration manager plays a critical role in ensuring seamless coordination and integration across all project phases. By understanding the responsibilities and tasks expected during each phase, the design integration manager can effectively navigate the complexities of industrial projects and contribute to their successful delivery.

To provide a clear overview of the industrial design-build process, establish a structured approach to project management, and facilitate efficient decision-making throughout a project's life cycle, the following table organizes the tasks by project phase and notes the frequency at which the design integration manager must perform them. The highlighted tasks, indicated by a factory icon, represent additional or alternative tasks specific to the industrial sector that are not included in *The Design-Builder's Guide to Design Management*.

Phase	Task	Frequency
Proposal/Pre-award	Review the owner's project announcement and identify the needed engineering departments and licensors of process equipment [when competing for FEED services contract] or the design, supplier, and trade contracting partners [when competing for EPC contract]*	Once
	Assign initial scopes of work to engineering departments and licensors [when competing for FEED services contract] or all partners [when competing for EPC contract] based on the owner's project announcement*	Once
	Coordinate with engineering departments and licensors [when competing for FEED services contract] or partners [when competing for EPC contract] to identify project-specific risks and create a risk register*	Every few days to weekly until proposal submission
	Develop a conceptual cost estimate for professional services	Once
	↗ Identify facility and process equipment with long lead times [when competing for EPC contract]	*Once*
	Develop a preliminary schedule for proposal and design deliverables	Every few weeks to monthly until proposal submission
	Verify that the design subcontracts to be issued to partners upon award meet the project requirements [when competing for EPC contract]	Once

** Phrasing has been modified slightly from The Design-Builder's Guide to Design Management to reflect the unique characteristics of the industrial sector*

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Phase	Task	Frequency
Front-End Engineering and Design	Confirm that the design aligns with the project budget	Weekly to every few weeks throughout design
	Set goals for meetings, then plan and organize effective meetings	Every few days to weekly throughout design
	Facilitate meetings with the authority having jurisdiction and regulatory bodies to discuss project-specific code and regulation compliance*	Every few weeks to monthly throughout design
	Mediate design questions and concerns between the project designer and the owner	Every few days to weekly throughout design
	Create and maintain a log of design changes and their associated costs	Every few days to weekly throughout design
	Oversee the progress of the design schedule	Weekly to every few weeks throughout design
	↗ Conduct continuous scope refinement	*Every few weeks to monthly throughout design*
Project Initialization	*↗ Validate assumptions and design deliverables from FEED study*	*Once*
	Manage and oversee the execution of the design subcontracts with partners	Once
	Identify and communicate key project expectations to all partners	Once
	Establish a communication plan with partners	Once
	Build a supportive team culture	Daily throughout the project
	Update and manage the project-specific risk register	Every few days to weekly throughout the project
	Refine the schedule for design deliverables	Every few weeks to monthly before design begins
	↗ Coordinate with partners to identify project constraints and create a constraint tracking plan	*Once*
Detailed Engineering and Design	Facilitate quality in the design process through design and constructability reviews with internal and external stakeholders	Every few weeks to monthly throughout design
	↗ Facilitate the development of a detailed 3D model of the facility design	*Every few weeks to monthly throughout design*
	Maintain morale and refocus the team	Every few days to weekly throughout the project
	Track and monitor the actual design costs	Every few days to weekly throughout design
	Monitor the procurement schedule with the construction team and coordinate deliverable deadlines with the design team	Every few weeks to monthly throughout design
Construction	Bridge design team and construction team efforts to maintain project alignment	Every few days to weekly until project close-out
	Document key design changes and communication with the authority having jurisdiction during construction	Every few weeks to monthly until project close-out
	↗ Coordinate project turnover with the owner's process equipment delivery and installation schedule	*Every few weeks until project close-out*
	Facilitate the project close-out documentation process	Every few weeks to monthly until project close-out

** Phrasing has been modified slightly from The Design-Builder's Guide to Design Management to reflect the unique characteristics of the industrial sector*

CHAPTER 1: CHARACTERISTICS OF THE INDUSTRIAL SECTOR

Several unique characteristics of the industrial sector impact design-build projects. These characteristics can affect how the design-build process unfolds and introduce new responsibilities and competencies for the design integration manager. Being aware of these characteristics will help prepare design integration managers to excel in their role on projects in the industrial sector.

Industrial design-build projects are characterized by the features described in the following sections.

Engineered System Complexity

While projects in all sectors can exhibit complexity in a variety of ways, industrial projects are nearly always complex in their design and execution. Factors contributing to this complexity include the following:

- **Specialized equipment and processes.** Industrial projects involve the design, implementation, and integration of specialized equipment and processes that are specific to the industrial activities being undertaken. This requires a deep understanding of the technology and engineering principles involved. In addition, specialized equipment has longer lead times than off-the-shelf alternatives, which can add complexity to the planning process. Coordinating with suppliers of this equipment and ensuring timely deliveries can be challenging. Commissioning industrial facilities and ensuring a smooth startup can also require detailed planning because of the interdependence of equipment and processes. In some cases, industrial projects may need to be integrated with existing facilities or operations, which requires careful planning to avoid disruptions and ensure a seamless transition.
- **Interdisciplinary collaboration.** Industrial projects require collaboration between multiple design disciplines, including mechanical engineering, electrical engineering, process engineering, automation, and many more. In addition, industrial projects typically involve various external stakeholders, including regulatory authorities, local communities, and environmental groups. Successfully coordinating and integrating these diverse interests is critical to delivering a functioning facility that meets or exceeds the owner's requirements.
- **Safety and risk management.** Industrial projects often deal with hazardous materials, high-risk processes, and heavy machinery. Ensuring the safety of workers and the surrounding environment is a critical and complex aspect of industrial projects. Industrial projects can also have significant environmental impacts, including air and water pollution, waste generation, and energy consumption. Compliance with environmental regulations and sustainability goals introduces additional complexity into the design process.

"While projects in all sectors can exhibit complexity in a variety of ways, industrial projects are nearly always complex in their design and execution."

Persistent Uncertainty

Industrial projects are often exposed to multiple sources of uncertainty, and uncertainty may persist from early design through construction. Sources of uncertainty can include the following:

- **Proprietary manufacturing processes.** Industrial owners may have their own proprietary manufacturing processes to safeguard their unique products and intellectual property from competitors. On industrial projects, detailed information about these processes is rarely shared with the design-builder, which may be provided with details only on a need-to-know basis and be expected to deliver the project without complete knowledge of how these processes will integrate with the completed facility. These proprietary processes often involve specialized equipment and methods that contribute to a competitive advantage in product quality and innovation. Procuring specialized equipment or materials for industrial projects can be time-consuming, and delays in the supply chain can affect project schedules and introduce uncertainty about equipment availability.
- **Regulatory changes.** The regulatory landscape for industrial projects can change during the project's execution, requiring adjustments to the original scope of the project plans or the engineering design to comply with new regulations. Additionally, obtaining the necessary permits and approvals for industrial projects can involve prolonged processes, and delays in these regulatory approvals can lead to uncertainty regarding the project schedule.
- **Technological advancements.** The industrial sector is constantly evolving, and new technologies may emerge during the project's life cycle. Late decisions about incorporating new technologies can result in drastic changes to the project's design.

Time-Criticality

Industrial projects are often time-critical, in that the timing of their delivery needs to coincide with market demand expectations and the owner's business or operational objectives. For many industrial sector projects, the market demand for their output (e.g., products or services) can fluctuate rapidly. To capitalize on market opportunities and maximize sales revenue, industrial owners attempt to complete their projects quickly and bring their offerings to market ahead of competitors. In industries driven by technological advancements, completing projects quickly ensures that companies stay at the forefront of innovation and that their products and services are not outdated by the time projects are completed.

Early delivery incentives in industrial projects are designed to motivate design-builders to finish tasks ahead of schedule. This approach is vital in the industrial sector due to its focus on efficiency, cost-effectiveness, and on-time project completion.

CHAPTER 2: THE DESIGN-BUILD PROCESS IN THE INDUSTRIAL SECTOR

Industrial sector design-build projects follow a different progression of phases than outlined in *The Design-Builder's Guide to Design Management*. Project development in the industrial sector typically follows a phase gating process, known as front-end loading (FEL) or front-end planning (FEP). Phase gating provides the owner with a structured process to collect key strategic and project documentation that informs decisions regarding resource allocation and whether or not to move forward with a project. At each gate, the owner's organization reviews this documentation and makes a go or no-go decision, meaning that the project cannot advance unless it is approved at each gate. This process is essential to managing risk in large and complex industrial projects because it ensures that the project is well planned and fulfills the owner's objectives.

Design-Builders in the Industrial Sector

In the industrial sector, design-builders are commonly referred to as engineering, procurement, and construction (EPC) contractors. EPC contractors have in-house design and engineering departments, as well as the capability to provide construction and construction management services. For large-scale industrial projects, projects with an unusually high level of complexity, or projects requiring collaboration across sectors (e.g., water/wastewater), EPC contractors may form a joint venture with other designers, contractors, or vendors that have the needed expertise.

Phase Gating Approach to Project Development

A typical FEL process includes four phases. The first phase, FEL-1, occurs within the owner's organization and evaluates the business opportunity for the project, comparing several potential options to achieve the owner's objectives and ultimately developing a convincing business case. By the conclusion of this phase, the owner typically will have created an initial scope of work, including process flow diagrams, preliminary lists of major equipment, a conceptual plot plan, and a rough order of magnitude estimate (referred to as Class 5, typically ±50% accuracy) for the total installed cost (TIC). If there is a feasible path forward for the project, it advances to the second phase of the process, FEL-2.

"Project development in the industrial sector typically follows a phase gating process, known as front-end loading or front-end planning."

In FEL-2, which also occurs within the owner's organization, the owner's engineers or one or more hired consultants perform preliminary or conceptual engineering design services to create the issued for approval (IPA) package. During this phase, the owner further refines the project definition, creating a more detailed scope of work that includes an updated plot plan and major equipment list, environmental permitting requirements, refined process flow diagrams, and a more accurate estimate (Class 4, typically ±30%) for the TIC. During this phase, the owner also considers the procurement and execution strategy for the project. If the project is suitably well defined, it advances to the third phase of the project, FEL-3.

FEL-3 is the front-end engineering and design (FEED) phase of the process, also commonly referred to as basic engineering. During this phase, the owner hires an engineering firm or FEED EPC to further develop the preliminary design. Substantial engineering design is often needed during the early design phase of industrial projects to facilitate planning and costing. During this phase, the engineering firm or FEED EPC creates the issued for design (IFD) package, which contains the documentation necessary for the detailed engineering of the facility. This package typically includes a finalized project scope, a preliminary project schedule, piping and instrumentation diagrams (P&IDs), major equipment lists and data sheets, general layout drawings, a line list, a tie-in list, the basic engineering design data (BEDD), process safety requirements, and a detailed cost estimate (Class 3, typically ±15%) for the TIC. At the completion of this phase, the owner evaluates the results of the FEED process and all preceding phases before authorizing funding for the project. Upon successfully advancing beyond FEL-3, the project enters the execution stage, where detailed engineering design and construction will be performed by an EPC contractor.

The last phase of the process, FEL-4, involves the final approval of the IFC package, which permits construction to begin.

Levels of Estimates

While not as commonly used in the building construction sector, the five-level system of cost estimate classifications developed by the Association for the Advancement of Cost Engineering (AACE International) is used in the industrial sector to describe the accuracy of estimates. This system is articulated in *AACE International Recommended Practice No. 18R-97*. The levels are based on the project definition reflected in the deliverables and seek to align cost estimates with the phase gating process used in the industrial sector. Class 5 has the lowest level of accuracy, whereas Class 1 has the highest level. The design integration manager needs to be aware of this classification system and how each class of estimate is used in the project delivery process. A summary of the levels is shown below.

Class	Classification	Typical Use	Project Definition	Accuracy Range
Class 5	Order of Magnitude	Concept screening, FEL-1	0% to 2%	-50% to 100%
Class 4		Feasibility study, FEL-2	1% to 15%	-30% to 50%
Class 3	Budgetary	Budgeting, FEL-3	10% to 40%	-20% to 30%
Class 2	Definitive	Bidding; project controls; change management, FEL-4	30% to 75%	-15% to 20%
Class 1			65% to 100%	-10% to 15%

Levels of Estimates continued on following page

Levels of Estimates *(continued)*

AACE International has also mapped the estimate classes and maturity of project information against common engineering and design deliverables for industrial projects, as shown below.

Project Information	Estimate Classification				
	Class 5	Class 4	Class 3	Class 2	Class 1
General Project Data					
Project Scope Description	General	Preliminary	Defined	Defined	Defined
Plant Production/Facility Capacity	Assumed	Preliminary	Defined	Defined	Defined
Plant Location	General	Approximate	Specific	Specific	Specific
Soils and Hydrology	None	Preliminary	Defined	Defined	Defined
Integrated Project Plan	None	Preliminary	Defined	Defined	Defined
Project Master Schedule	None	Preliminary	Defined	Defined	Defined
Escalation Strategy	None	Preliminary	Defined	Defined	Defined
Work Breakdown Structure	None	Preliminary	Defined	Defined	Defined
Project Code of Accounts	None	Preliminary	Defined	Defined	Defined
Contracting Strategy	Assumed	Assumed	Preliminary	Defined	Defined
Engineering Deliverables					
Block Flow Diagrams	S/P	P/C	C	C	C
Plot Plans	—	S	P/C	C	C
Process Flow Diagrams (PDFs)	—	S/P	P/C	C	C
Utility Flow Diagrams (UFDs)	—	S/P	P/C	C	C
Piping and Instrument Diagrams (P&IDs)	—	S	P/C	C	C
Heat and Material Balances	—	S	P/C	C	C
Process Equipment List	—	S/P	P/C	C	C
Utility Equipment List	—	S/P	P/C	C	C
Electrical One-Line Drawings	—	S/P	P/C	C	C
Specifications and Datasheets	—	S	P/C	C	C
General Equipment Arrangement Drawings	—	S	P/C	C	C
Spare Parts Listings	—	—	S/P	P	C
Mechanical Discipline Drawings	—	—	S	P	P/C
Electrical Discipline Drawings	—	—	S	P	P/C
Instrumentation/Control System Discipline Drawings	—	—	S	P	P/C
Civil/Structural/Site Discipline Drawings	—	—	S	P	P/C

Source: AACE International Recommended Practice No. 18R-97

— (none): Development of the deliverable has not begun.

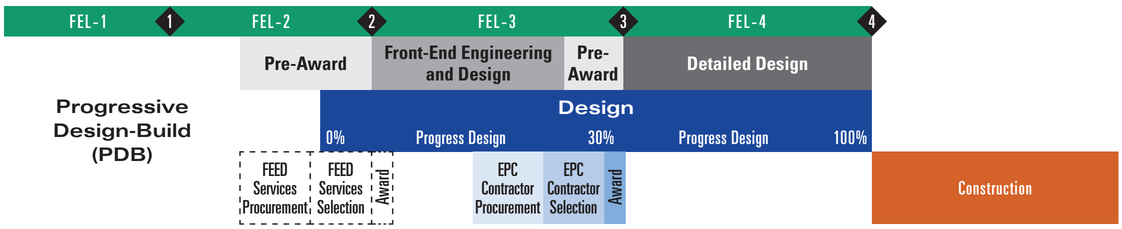
S (started): Work on the deliverable has begun. Development is typically limited to sketches, rough outlines, or similar levels of early completion.

P (preliminary): Work on the deliverable is advanced. Interim, cross-functional reviews have usually been conducted. Development may be near completion except for final reviews and approvals.

C (complete): The deliverable has been reviewed and approved as appropriate.

Phase Gating and the Design-Build Process

When applied in a design-build context, the phase gating process gives industrial project owners more flexibility than owners in other sectors to respond to changes in regulations, market demand, and price pressures. For example, the progressive design-build model in the building construction sector gives owners one opportunity to use an off ramp to exit from a project. In the industrial sector, however, each phase gate becomes a potential off ramp for the owner to select a different engineering firm or EPC contractor for the next phase or, in extreme cases, to either terminate the project or switch to an alternate project delivery method.



Phase gates in a progressive design-build delivery model

As a result, EPC contractors in the industrial sector are awarded projects in several ways:

1. **At the end of FEL-2, as a FEED EPC responsible for the basic engineering and design work and the IFD package.** Provided that the deliverables meet the owner's project objectives, EPC contractors that are contracted to provide FEED services and that are also capable and willing to develop the project further may be awarded the detailed design and construction contract without a second round of competition. Fast-tracked projects often use this method of award to retain a single EPC contractor across phases, which allows FEED services to be compressed and for detailed design and construction to overlap.
2. **At the end of FEL-3, as an EPC contractor responsible for developing the detailed design and constructing the facility.** Under this award method, the EPC contractor bases its proposal on the FEED deliverables completed previously by a different engineering firm or the FEED EPC. The awarded contract may be issued as a lump sum turnkey or negotiated price agreement or on a cost-reimbursable basis depending on the owner's desired involvement, the level of contingency required, the cost of risk transfer, and the market conditions at award.

For completeness, the guidance provided in this playbook addresses both types of EPC contractor involvement.

Owner Involvement in the Procurement Process

To address both the uncertainty and time-criticality of industrial projects, the owner often assumes a proactive role in driving the procurement process. This involvement reduces the risk that specialized equipment and materials will not be ready and available on the jobsite when they are needed. The owner of an industrial project can take steps to ensure that specialized equipment and materials are ordered and delivered in a timely manner. The owner initiates procurement by outlining the project's goals and scope and including facility specifications and technologies that align with the desired outcomes. The owner also ensures the use of precise technical and quality benchmarks, overseeing quality control to verify compliance with industrial standards in procured materials and equipment.

The owner plays a pivotal role in identifying potential suppliers, contractors, and vendors that have the competence and capacity to fulfill the project's specialized needs. This involves conducting comprehensive market research, leveraging industry insights, and evaluating potential partners. Successful communication between the owner and suppliers is pivotal. The owner provides clear directives, addresses inquiries, and collaborates closely with suppliers to ensure project success.

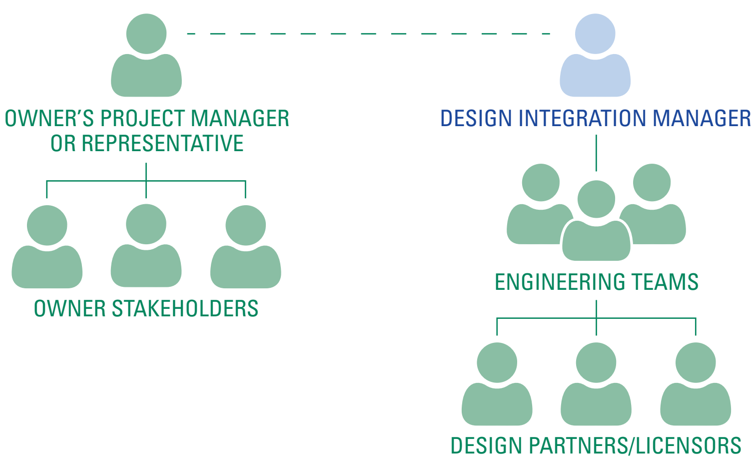
The owner may actively engage in contract negotiations with chosen suppliers or contractors to ensure that the terms, conditions, and pricing are favorable and aligned with the project's objectives. By collaborating with suppliers, the owner ensures that the procurement timeline synchronizes with the overarching project schedule and mitigates any delays that might affect project turnover. In some cases, the owner may purchase specialized equipment and materials directly from suppliers to furnish to the EPC contractor. In such cases, the EPC contractor is only responsible for installing the equipment and materials when they arrive onsite. This can allow the owner to order equipment with extremely long production and delivery times before selecting an EPC contractor.

CHAPTER 3: ROLE OF THE DESIGN INTEGRATION MANAGER IN THE INDUSTRIAL SECTOR

In the industrial sector, the design integration manager may go by titles such as engineering project manager, project engineering manager, or project construction manager. Regardless of title, however, the responsibilities are the same. The design integration manager must organize and manage the activities of many individuals—including the owner and the owner's representatives, engineering design teams, and construction teams—to conceptualize and develop the project design.

Organizational Structures of Industrial Sector Projects

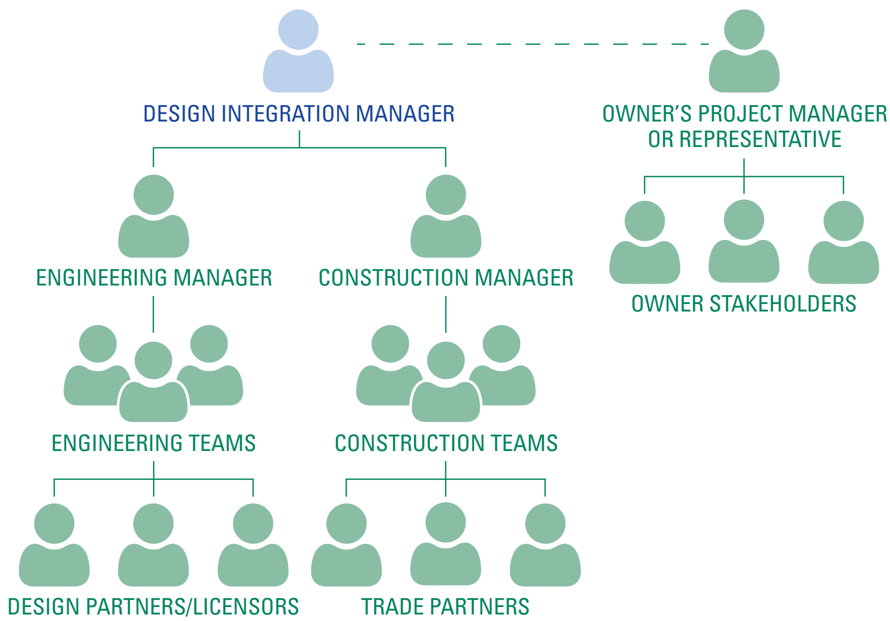
Within engineering, procurement, and construction (EPC) firms that have in-house design capabilities, the organization of the team will vary depending on services provided. If the EPC firm is engaged to provide front-end engineering and design (FEED) services, the design integration manager oversees one or more internal engineering teams or departments directly, with each typically specializing in an industrial process or facility system. Each engineering team may then hire external design partners or licensors with the specific engineering or proprietary system expertise needed for a given project.



Role of the design integration manager in a firm providing FEED services

> *"The design integration manager must organize and manage the activities of many individuals to conceptualize and develop the project design."*

If the EPC firm is engaged to provide detailed engineering and design services and perform construction phase work, the design integration manager oversees both an engineering manager and a construction manager. The engineering manager oversees one or more internal engineering teams or departments that operate in a structure like that described above. A similar organizational structure exists below the construction manager, who oversees one or more internal construction teams that subcontract portions of the construction scope to trade partners.



Role of the design integration manager in an EPC firm providing design and construction services

What the Design Integration Manager Needs to Be Successful

For a design integration manager to be successful in the industrial sector, several of the competencies listed in *The Design-Builder's Guide to Design Management* are especially important. For example, because of the significant amount of uncertainty that persists into later phases of industrial projects, knowledge of the sources of risk and risk management practices is critical. Knowledge of the technical and operational requirements of facilities is also important to manage complexity and resolve conflicts during the engineering design process.

This section outlines the knowledge, skills, abilities, and other characteristics that are especially important for the design integration manager in the industrial sector. Competencies unique to the industrial sector are indicated by a factory icon.

Key Recommended Knowledge in the Industrial Sector

Technical and operational requirements of various project types
Sources of risk and risk management practices
Industrial processes and production workflows
Environmental and health regulations
Process automation and control
Process inspection and testing procedures

Of the recommended knowledge documented in *The Design-Builder's Guide to Design Management*, the following is key in the industrial sector:

- Technical and operational requirements of various project types
- Sources of risk and risk management practices

The design integration manager is also expected to understand the industrial processes at the core of industrial projects. This understanding is needed not because the design integration manager is actively engaged in the design, but rather because it allows the design integration manager to effectively coordinate the interfaces between the design and engineering disciplines involved in the project. This introduces new knowledge competencies that should be obtained by the design integration manager prior to pursuing a design-build project in the industrial sector. Specifically, this knowledge includes the following:

- **Industrial processes and production workflows.** The design integration manager should have knowledge of the industrial processes, production workflows, manufacturing methodologies, and specialized equipment used in industrial facilities. These processes vary by project. For example, automotive manufacturing facilities often employ robotic assembly lines, whereas oil refineries use boilers, distillation towers, and process piping.
- **Environmental and health regulations.** The design integration manager should have knowledge of the regulations, safety standards, and environmental considerations that apply to different types of industrial projects, such as those involving chemical or automotive manufacturing or food processing. Organizations like the Occupational Safety and Health Association (OSHA), Environmental Protection Agency (EPA), and Food and Drug Administration (FDA) provide both general and specific regulations that must be met during the design and construction of industrial projects. For example, oil refinery projects are subject to the EPA's Petroleum Refinery Sector National Emissions Standards for Hazardous Air Pollutants (NESHAP).
- **Process automation and control.** The interconnectedness of industrial processes necessitates the use of complex automation technologies, process control systems, and instrumentation to ensure proper operation. Knowledge of the basic principles of process automation and control allows the design integration manager to coordinate informational needs across engineering disciplines.
- **Process inspection and testing procedures.** Because industrial projects are typically designed and constructed to meet specific performance targets, ensuring the quality and reliability of industrial products through rigorous testing and inspection processes is critical. Inspection and testing occur at various times throughout a project, so the design integration manager needs to be aware of when and how they are performed to support the facility turnover process.

Key Recommended Skills in the Industrial Sector

Leading a project team
Determining client and stakeholder expectations
Solving design problems
Hazard recognition
Data management and organization

Of the recommended skills documented in *The Design-Builder's Guide to Design Management*, the following are key in the industrial sector:

- Leading a project team
- Determining client and stakeholder expectations
- Solving design problems

When navigating industrial projects, the design integration manager is largely expected to have the same skills as those outlined in *The Design-Builder's Guide to Design Management*. However, because of the safety risks that may be encountered on industrial projects and the need to coordinate many design deliverables, the following additional skills may be useful:

- **Hazard recognition.** The design integration manager should develop a keen awareness of potential hazards in industrial environments and the ability to identify and address these hazards to ensure the safety of operators.
- **Data management and organization.** To ensure compliance with the owner's requirements regarding the storage of design data and 3D models, the design integration manager may need skills in navigating cloud computing platforms and managing metadata related to the design.

Key Recommended Abilities in the Industrial Sector

Engaging in continuous learning
Focusing on and remembering details
Working well under time pressure

While all of the abilities documented in *The Design-Builder's Guide to Design Management* are applicable to industrial projects, three stand out as being especially important:

- Engaging in continuous learning
- Focusing and remembering details
- Working well under time pressure

Key Recommended Other Characteristics in the Industrial Sector

Timely
Adaptable

Of the recommended other characteristics documented in *The Design-Builder's Guide to Design Management*, the following are key in the industrial sector:

- Timely
- Adaptable

CHAPTER 4: PROPOSAL/PRE-AWARD PHASE

Description of Phase

On industrial design-build projects, a proposal/pre-award phase can occur at two different times in the project delivery process depending on when the owner first engages with an engineering, procurement, and construction (EPC) contractor (see Chapter 2). The first proposal/pre-award phase occurs near the end of FEL-2. At this point, the owner releases a request for proposal (RFP) for front-end engineering and design (FEED) services to select an engineering firm or EPC contractor to develop the early project design and prepare the issued for design (IFD) package. The second proposal/pre-award phase occurs near the end of FEL-3. At this point, the owner issues another RFP to select an EPC contractor that will use the IFD package from the prior FEED study to develop the detailed design and execute the procurement, construction, and turnover of the facility. If the FEED services are performed by an EPC contractor that is willing and able to develop the project further, the owner may award the project execution work directly to that EPC contractor and bypass the second proposal/pre-award phase. Each proposal/pre-award phase begins when the owner initiates a procurement process, either for FEED or EPC services, and ends when a contract agreement is fully executed between the owner and EPC contractor.

The RFPs issued by industrial owners to engineering firms and EPC contractors include several documents in addition to those listed in *The Design-Builder's Guide to Design Management*. These documents may include requirements for confidentiality or nondisclosure pertaining to the information contained in the RFP, design deliverables, project turnover procedures, document management systems, and server-based information databases to support building information modeling (BIM) and digital twin modeling applications. Most importantly, however, the owner provides the basic engineering design data (BEDD) for the project at its current stage of development.

"On industrial design-build projects, a proposal/pre-award phase can occur at two different times in the project delivery process depending on when the owner first engages with an engineering, procurement, and construction contractor."

Basic Engineering Design Data

Provided by the owner during both of the proposal/pre-award phases, the basic engineering design data (BEDD) serves as the initial basis of design and is used by engineering firms and EPC contractors to understand the project scope and create estimates. The content of the BEDD, which is often revised in later project phases as more information becomes available, is tightly controlled via a formal change management process. According to Practice PEEPJ004 developed by Process Industry Practices (PIP), anticipated for release by the end of 2024, the content of the BEDD describes the facility requirements and performance criteria, which typically include the following:

- **Site information**, such as location, site plan, and climate data
- **Site design criteria** for the structure, facility, and equipment across the site, such as thresholds for wind and seismic loading, soil and geological conditions, groundwater level, and frost line depth
- **Process utility information**, including underground utility maps and the minimum, maximum, and design conditions for utility systems such as steam, water, fuel, compressed air, and bulk gases
- **Communications**, such as telephone, radio, and internet services
- **Logistics and modes of transportation**, such as roadways, rail, pipeline, barge, and air freight
- **Emergency response systems**, such as fire alarms, emergency generators, plant intercoms, and community notification systems
- **Engineering and design tools**, such as BIM, process simulation software, and instrumentation tools
- **Numbering procedures** to ensure that the entire scope of the facility is consistently numbered and that documentation can easily be referenced by personnel and any regulatory bodies performing reviews and inspections
- **Design philosophies for the project**, such as the equipment design life, corrosion allowances, cleaning requirements, and level of automation
- **Site-specific design procedures**, which may provide guidance on fouling factors, acceptable ranges for velocity and pressure drops in process and utility piping, isolation requirements, and design margins
- **Environmental health and safety regulations** relevant to the project
- **Building requirements**, which list any special requirements for onsite buildings such as control rooms, warehouses, offices, and laboratories
- **Applicable specifications, codes, and standards** to be followed at the facility
- **Units of measure**, either US customary or metric, to be used for consistency in the facility

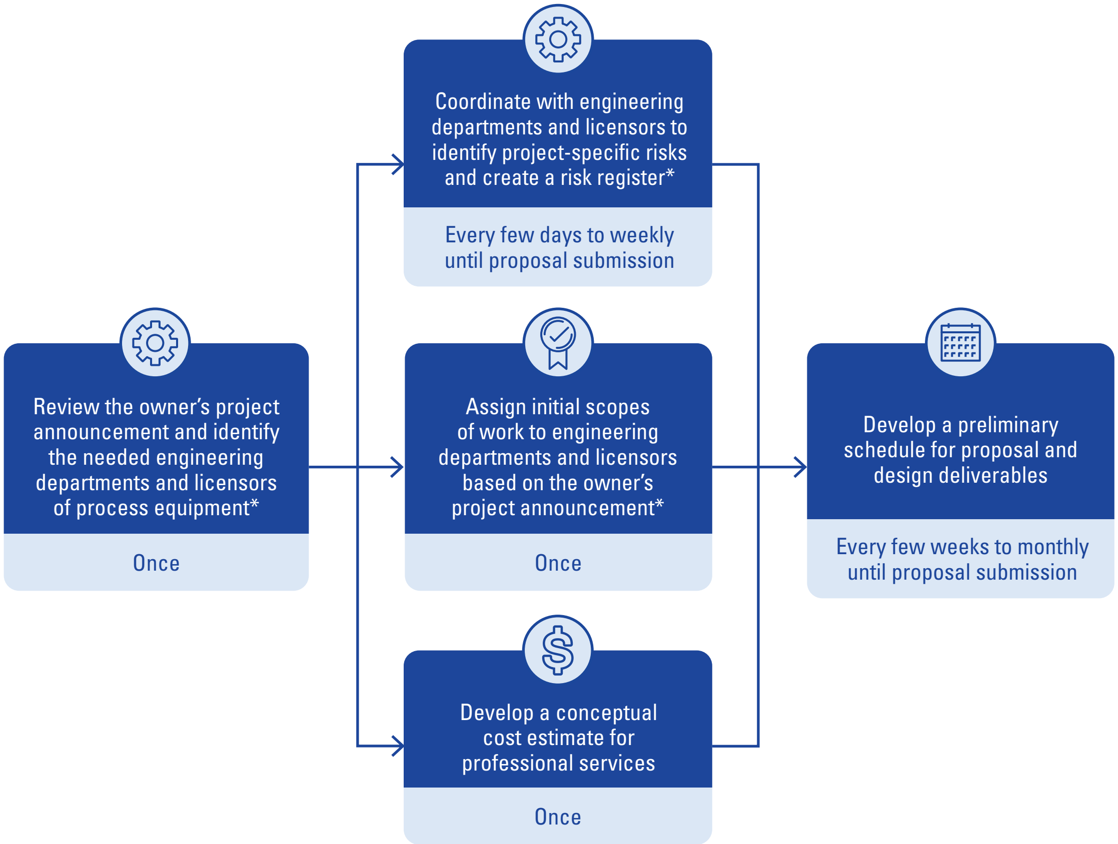
The cost estimates prepared during each of the proposal/pre-award phases for industrial projects are highly dependent on the maturity of the project information prepared earlier in the phase gating process. The design integration manager needs to ensure that the estimates prepared for design and construction services provide the appropriate level of detail and accuracy in light of the level of project definition provided in the owner's project announcement and supporting documentation, such as the BEDD. In addition, unlike design-builders in other market sectors, EPC contractors on industrial projects are often expected to provide a performance guarantee for the completed facility. During each of the proposal/pre-award phases, the EPC contractor may prepare multiple proposals for different scenarios to achieve the performance requirements outlined in the BEDD.

The Role of the Design Integration Manager

During each of the proposal/pre-award phases, the design integration manager performs tasks similar to those outlined in *The Design-Builder's Guide to Design Management*. However, since these phases are more deliverable focused on industrial projects, there is less emphasis on teaming and more effort directed towards coordinating the proposal process.

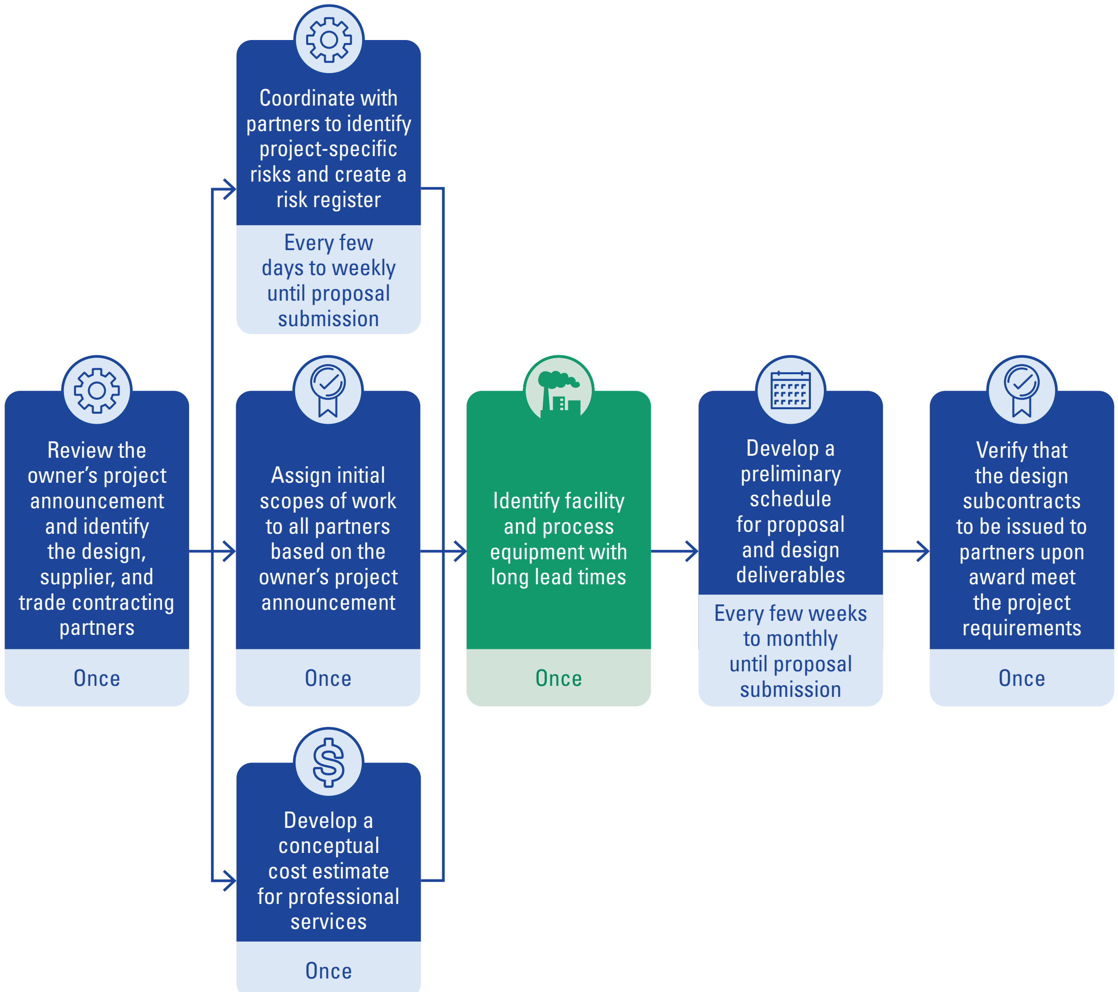
As described in *The Design-Builder's Guide to Design Management*, negotiating a teaming agreement between the design-builder and its design, supplier, and trade contractor partners is a key initial step in the proposal/pre-award phase of building construction projects. However, teaming agreements are not common among EPC contractors in the industrial sector. Because of the need for specialty process equipment, owners in some cases may dictate specific designers, suppliers, or technology licensors that the EPC contractor must select if awarded the contract. In other cases, the EPC contractor may have the necessary in-house engineering expertise and therefore may not need to subcontract with any design partners outside of the firm.

For these reasons, there is less of a need to engage and secure external design and trade partners during either of the proposal/pre-award phases on industrial projects, especially during the proposal/pre-award phase for FEED services. However, the design integration manager needs to understand whether a given industrial process is being provided externally (e.g., by the owner or its vendors) or internally (e.g., by the EPC contractor) in order to engage the right partners during each of the proposal/pre-award phases.



** Phrasing has been modified slightly from* The Design-Builder's Guide to Design Management *to reflect the unique characteristics of the industrial sector*

Workflow of the design integration manager's tasks during the proposal/pre-award phase for FEED services



Workflow of the design integration manager's tasks during the proposal/pre-award phase for EPC services

Additional Task: Identify Facility and Process Equipment with Long Lead Times

Once

In this task, the design integration manager reviews the owner's project announcement with internal and external engineering partners to identify facility and process equipment that may experience extended production or delivery times. This information is critical in making decisions related to the early release and procurement of equipment. Completing this task requires the design integration manager to be familiar with the industrial processes specific to the project and the utility requirements for their operation.

Knowledge	Skills	Abilities	Other Characteristics
• Industrial processes and production workflows • Technical and operational requirements of various project types • Contractual terms and conditions	• Delegating responsibilities and work to the right people • Managing time	• Focusing on and remembering details • Collaborating with partners • Establishing and maintaining relationships	• Timely • Patient

Lead time describes the amount of time between placement of an order for a material, component, or piece of equipment and its delivery to the construction site. For items with long lead times, this period is extended. The extended delivery period may be the result of challenges faced by the supplier, such as order backlogs, slow manufacturing processes, or labor strikes, or disruptions in the broader supply chain, such as national or global shortages, disruptive weather events, or long shipping times. Regardless of the reason, long lead times can delay the installation of critical equipment on industrial projects and potentially result in late turnover of the facility. Some specialized equipment can have lead times exceeding one year.

The design integration manager needs to be aware of items with long lead times and ensure that they are ordered well in advance of when they are needed. Depending on lead times and other considerations, procurement may begin as soon as items are approved by the owner. While early material or equipment purchases can expose an EPC contractor to the risk of design changes and cancellation charges, the risk is often outweighed by the time and cost savings resulting from early purchases.

To get started, the design integration manager should work with in-house engineering departments to create a list of items with potentially long lead times. The items on this list may come from information included in the owner's project announcement, such as an initial equipment list or the BEDD, or from lessons learned on previous projects. Examples of items with long lead times on industrial projects include the following:

- Mechanical and electrical facility equipment, including transformers, switchgears, boilers, and chillers
- Specialized process equipment
- Custom-made parts or components

Talking directly with vendors, suppliers, and licensors of items on this list can provide a clearer picture of fabrication and delivery times as well as the shop drawings or submittals that must be produced before fabrication can take place. While a detailed project schedule may not be prepared during the proposal/pre-award phase, the design integration manager should incorporate these items into any milestone schedules.

CHAPTER 5: FRONT-END ENGINEERING AND DESIGN PHASE

Description of Phase

The front-end engineering and design (FEED) phase is analogous to the early design phase described in *The Design-Builder's Guide to Design Management*. For large industrial projects, owners often split the design and construction delivery process into two stages. In the first stage, referred to as FEED, an engineering firm or a FEED engineering, procurement, and construction (EPC) firm sets the design parameters and breaks down the scope into basic engineering packages for budgeting and planning purposes. These engineering packages often include process design packages (PDPs), which should be sufficiently developed to a level that allows the owner to competitively award the project to an EPC contractor for the second stage: execution of the detailed engineering and design phase and the construction phase.

The FEED phase begins after the contract for FEED services is awarded and ends with the creation of an issued for design (IFD) package that satisfies the owner's requirements. These requirements vary from project to project and from owner to owner, and the resulting FEED deliverables can be developed to a greater or lesser extent. The duration of the FEED phase is typically less than one year.

At the completion of the FEED phase, the design integration manager will have coordinated the delivery of several key design deliverables within the IFD package.

Key design deliverables within the IFD package

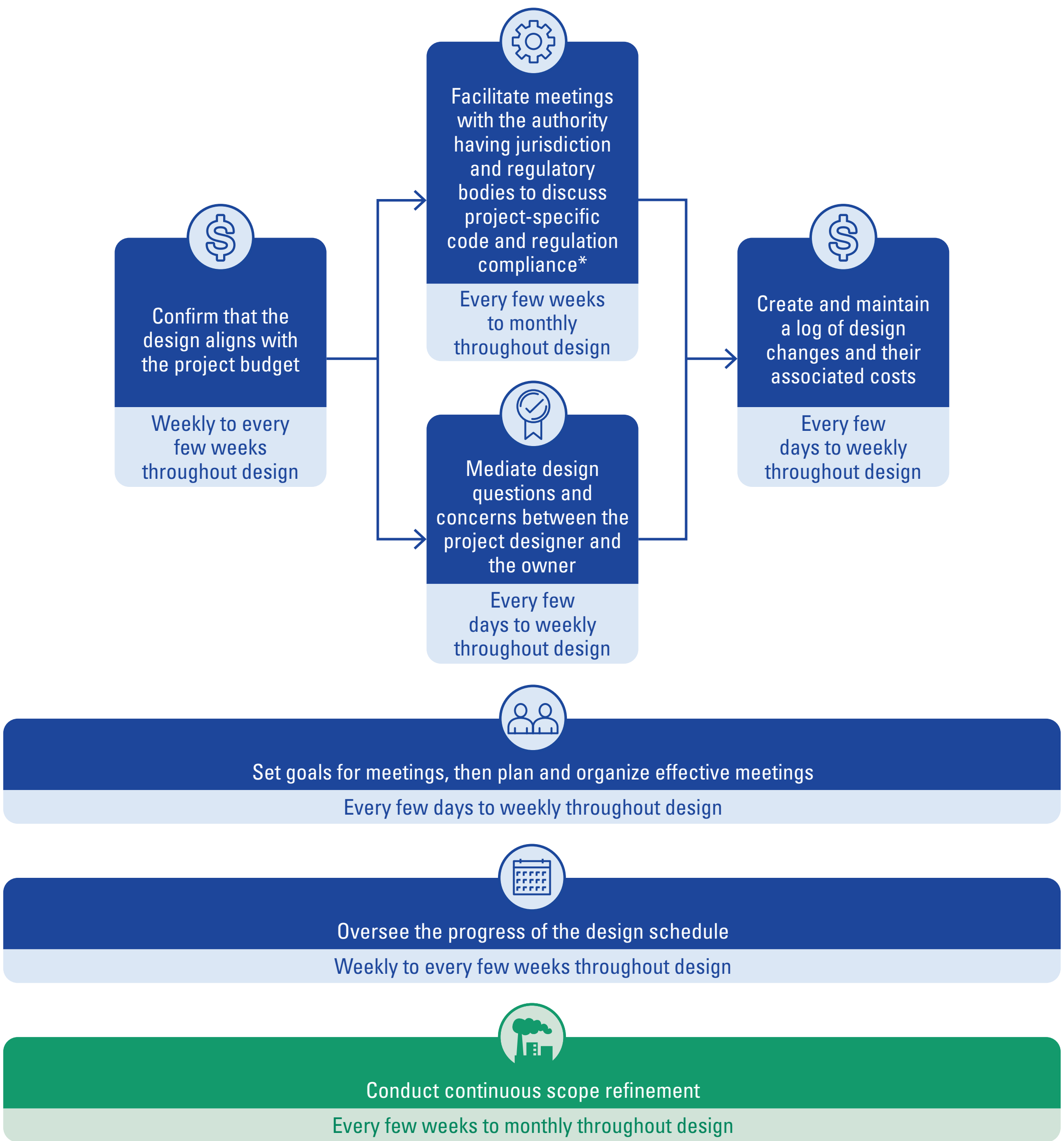
Design Deliverables	Stage of Development
Block flow diagrams	Complete
Process flow diagrams	Complete
Piping and instrument diagrams (P&IDs)	Preliminary
Plot plan	Preliminary
3D model/piping plans	Preliminary
Process equipment list and specifications	Complete for items with long lead times, preliminary for other equipment
Instrument index	Preliminary
Block diagrams	Preliminary
Piping line list	Preliminary
Piping material take-off	Preliminary

> *"In this phase, an engineering firm or a FEED engineering, procurement, and construction firm sets the design parameters and breaks down the scope into basic engineering packages for budgeting and planning purposes."*

The Role of the Design Integration Manager

During the FEED phase, the design integration manager performs tasks similar to those described in *The Design-Builder's Guide to Design Management* for the early design phase, apart from an additional ongoing task.

Because industrial projects are large and complex, structured efforts are needed to ensure that projects remain on track to optimally meet their objectives. To achieve this, the design integration manager leads a continuous scope refinement effort that examines all facets of the project, including the facility, industrial processes, and technologies, in search of opportunities for improvement. Decisions made during this effort are thoroughly documented and incorporated into the resulting FEED deliverables.



** Phrasing has been modified slightly from* The Design-Builder's Guide to Design Management *to reflect the unique characteristics of the industrial sector*

Workflow of the design integration manager's tasks during the FEED phase

Additional Task: Conduct Continuous Scope Refinement

Every few weeks to monthly throughout design

In this task, the design integration manager works with the owner and the owner's consultants to identify opportunities for project improvement and ensures that all changes are incorporated into the FEED deliverables.

Knowledge	Skills	Abilities	Other Characteristics
• Industrial processes and production workflows • Environmental and health regulations • Process automation and control	• Determining client and stakeholder expectations • Leading a project team • Hazard recognition	• Engaging in continuous learning	• Respectful • Adaptable

Given the high degree of uncertainty on industrial projects, the EPC contractor or engineering firm engages in continuous scope refinement during the FEED phase, when engineers are most able to influence the final characteristics of the project without significantly impacting its cost. Inadequate or incomplete scoping during the FEED phase can have downstream consequences in the form of costly redesign, turnover delay, and poor system performance. Therefore, the goal of scope refinement is to best align the project's design with the owner's objectives without causing the scope to expand beyond what was approved at prior phase gates.

This task is often led by an owner's consultant, who initiates value improving practices (VIPs) in collaboration with the EPC contractor or engineering firm. The design integration manager works with this consultant in coordinating the efforts of the engineering team and external partners, who bring their expertise to the process.

Value Improving Practices

Value improving practices (VIPs) are intentional, targeted practices to facilitate improvements in the cost, schedule, operability, safety, and reliability outcomes of industrial projects. In most cases, VIPs are initiated during the FEED phase by an outside consultant hired by the owner but are applied to the entire project scope and are not intended to improve one outcome at the expense of another. Some examples of VIPs include the following:

- Process simplification
- Facility optimization
- Technology selection
- Design-to-capacity
- Energy optimization
- Predictive maintenance

While VIPs are primarily intended to align design parameters with project objectives, VIPs may also be used to conduct operability and maintainability reviews, constructability reviews, and design effectiveness reviews. The design integration manager, if involved in the FEED phase, should coordinate with the consultant leading the VIP efforts to ensure that documentation from each VIP is incorporated into the FEED deliverables.

CHAPTER 6: PROJECT INITIALIZATION PHASE

Description of Phase

The project initialization phase for industrial projects is analogous to the post-award phase described in *The Design-Builder's Guide to Design Management* for building construction projects. For projects in both sectors, this phase sets the tone and pace for the project going forward. However, the phase can be substantially shorter for industrial projects, lasting anywhere from a few days to a month.

Additionally, two tasks performed during this phase have a different scope on industrial projects than on building construction projects:

- **Establish a communication plan with partners.** On industrial projects, the communication plan is often derived from a responsible, accountable, consulted, and informed (RACI) matrix, which describes the four types of responsibility found on a project. Developed by the owner or by the engineering, procurement, and construction (EPC) contractor, a RACI matrix assigns each role, department, or individual working on the project a responsibility type for each specific activity, task, or deliverable. For example, under the task "Update and manage the project-specific risk register," the design integration manager may be assigned as the responsible party for developing and completing the work, with the EPC contractor's various engineering teams assigned as consulted parties to provide opinions and input on the task and the owner assigned as an informed party to be kept in the communication loop throughout the task. Because of the complexity inherent in industrial process design, the design integration manager should determine whether RACI matrices are available from the owner or need to be created prior to establishing the communication plan.
- **Refine the schedule for design deliverables.** Design deliverables on industrial projects tend to be scheduled according to a "push" (rather than "pull") planning system because of the importance placed on the early procurement of equipment. The objective of a pull planning system is to improve efficiency by delivering materials and equipment exactly when they are needed for installation, thereby avoiding the cost of storage or the risk of damage to installed work. However, if the equipment arrives later than expected due to production or shipping delays, there are few buffers in a pull planning system to avoid subsequent turnover delays. Because time to market is critical on industrial projects, a push planning system, in which materials and equipment are delivered as soon as they are ready (rather than when they are needed), is preferred to reduce the exposure of the project to turnover delays. For the design integration manager, this means aligning the schedule for design deliverables with material and equipment lead times such that the EPC contractor's engineering teams prioritize design work that involves items with longer lead times. This may mean that some design deliverables are scheduled and developed out of sequence.

"The project initialization phase sets the tone and pace for the project going forward."

The Role of the Design Integration Manager

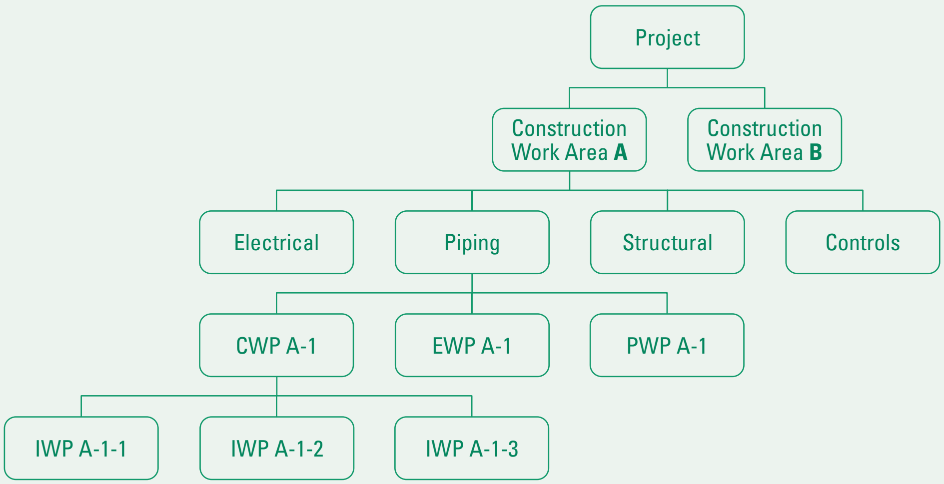
During the project initialization phase, the design integration manager performs tasks similar to those described in *The Design-Builder's Guide to Design Management* for the post-award phase. However, the project initialization phase features two additional tasks, one to replace the initial task and one to conclude the phase.

Because the owner's request for proposal (RFP) tends to be performance based on industrial projects, there is little for the design integration manager to reconcile between the owner's "ask" and the EPC contractor's "offer." By submitting a proposal, the EPC contractor commits to achieving the performance requirements for the project as established by the owner. Therefore, the design integration manager instead begins the project initialization phase by validating the assumptions and design deliverables created during the proposal/pre-award phase for front-end engineering and design (FEED) services. This task is as important as its counterpart in *The Design-Builder's Guide to Design Management* because the EPC contractor is expected to continue and expand on the initial design. The EPC contractor is liable for all engineering design work after the contract award and for the subsequent performance of the project, and therefore identifying errors and poor or outdated assumptions from previous deliverables is a key first step for project initialization.

An additional task for the design integration manager during the project initialization phase is to begin constraint tracking for the project. Constraint tracking attempts to identify necessary information or decisions that may delay the design if not provided in a timely manner. When an industrial project uses a structured work packaging process such as advanced work packaging (AWP), constraint tracking is critical to ensuring the reliable flow of information between the engineering and construction disciplines. Constraint tracking begins in the project initialization phase and continues throughout the project.

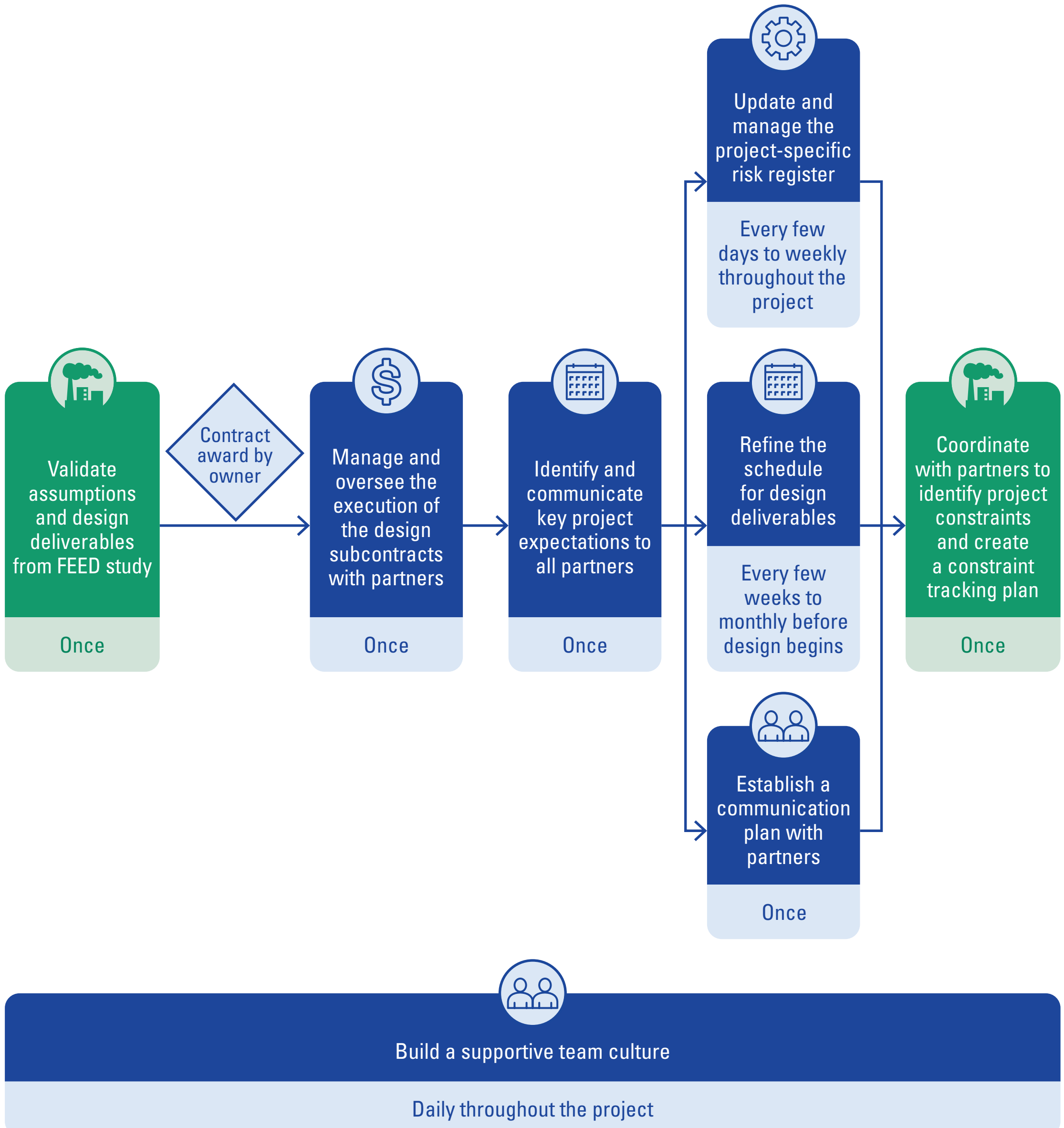
Advanced Work Packaging

According to the Construction Industry Institute (CII), advanced work packaging (AWP) is a construction-driven process that adopts the philosophy of "beginning with the end in mind." This process depends on collaboration between the construction and engineering disciplines during the FEED, detailed engineering and design, and construction phases. Collaboration ensures that the project is designed in a manner that creates a constraint-fee work environment in the field by breaking down the scope into construction work packages (CWPs) that are fed with the appropriate sequence of engineering work packages (EWPs). The EWPs are then used to create procurement work packages (PWPs) to track the purchasing of materials and equipment, while the CWPs inform the development of installation work packages (IWPs) to break the work into weekly plans for site operations. On industrial projects using AWP practices, the boundaries between the CWPs and EWPs may be defined during the proposal/pre-award phase for FEED services. However, the design integration manager has an important role in managing the interfaces between the CWPs from the construction management team and the EWPs from the engineering team because the boundaries may not be as clearly defined in practice.



Example hierarchy of work packages and their relationship to one another

On large projects, the EPC contractor may assign a dedicated AWP manager to oversee the work packaging process. On smaller projects, the design integration manager may perform that role. Additional information on AWP can be found in the CII's Best Practices program.



Workflow of the design integration manager's tasks during the project initialization phase

Additional Task: Validate Assumptions and Design Deliverables from FEED Study

Once

If the EPC contractor selected for the detailed engineering and design phase is different than the firm selected to provide FEED services, the design integration manager must lead a validation effort of the previous engineering firm's work. In this task, the design integration manager works with partners to verify the accuracy of the assumptions and basic engineering work from the earlier FEED study.

Knowledge	Skills	Abilities	Other Characteristics
• Industrial processes and production workflows • Environmental and health regulations	• Solving design problems • Determine client and stakeholder expectations • Reading and understanding design drawings	• Working well under time pressure • Devising innovative solutions	• Timely • Adaptable • Decisive

The basic engineering deliverables created during the FEED study are used by the EPC contractor as a bridge to the detailed engineering and design phase. Downstream consequences arising from defects such as poor design assumptions and errors and omissions in the FEED deliverables pose a significant risk to owners because these defects can be difficult and expensive to resolve later in the project. As a result, industrial owners often transfer this risk to the EPC contractor. The EPC contractor, however, should not accept this risk without first carrying out a thorough evaluation of the FEED deliverables. Skipping this task could be costly—after the contract award, EPC contractors rarely have any recourse against the engineering firm that created the FEED deliverables if a defect is discovered.

When evaluating the FEED deliverables, the design integration manager should pay close attention to the following:

- Ensuring that the design meets all applicable design standards and codes
- Verifying that all assumptions are based on information provided in the basic engineering design data (BEDD), applicable design standards, or other criteria
- Verifying the complete integration of design disciplines or components across systems
- Confirming that utility packages are appropriately sized
- Confirming the design solutions proposed from value improving packages (VIPs)

This task can require significant effort from the EPC contractor and may require many basic design activities, such as process simulations and calculations, to be redone within a short time period. In addition, sometimes the FEED deliverables are incomplete, with several design details either vague or missing. The design integration manager is responsible for coordinating this process and ensuring that any additional requirements identified during the validation are recognized and added to the project scope prior to the contract award.

Additional Task: Coordinate with Partners to Identify Project Constraints and Create a Constraint Tracking Plan

Once

In this task, the design integration manager directs partners to identify potential project constraints that will be encountered during the FEED or detailed engineering and design phases and establishes a constraint tracking procedure.

Knowledge	Skills	Abilities	Other Characteristics
• Industrial processes and production workflows • Construction work sequencing • The design process and stages of design • Project roles and the work responsibilities commonly associated with each role	• Conveying a message in written form • Conveying information verbally • Delegating responsibilities and work to the right people • Organizing and leading effective meetings	• Collaborating with partners • Collecting, analyzing, and interpreting information	• Assertive • Accountable • Empathetic

Constraints are different from risks. A risk is the possibility that an event may occur and result in negative consequences to the project, such as cost overruns or schedule delays. Conversely, a constraint is a limitation or restriction on the progress of work that will occur with certainty if not addressed. When applied to design, managing constraints means identifying instances where information and decisions are needed to move the design forward and ensuring that these are received in a timely manner. Structured constraint tracking provides transparency to the design and engineering process. The design integration manager should lead the engineering team and external partners in identifying and managing constraints, starting with the FEED phase and extending through the detailed engineering and design phase.

CHAPTER 7: DETAILED ENGINEERING AND DESIGN PHASE

Description of Phase

The detailed engineering and design phase is the beginning of the execution stage of industrial projects. The phase begins when the engineering, procurement, and construction (EPC) contractor is awarded the project execution work and ends with the finalization of the issued for construction (IFC) package. In this phase, the EPC contractor uses the validated deliverables from the front-end engineering and design (FEED) phase to perform the detailed engineering and design work for the project.

Within the detailed engineering and design phase, three critical reviews are typically performed leading up to the IFC package. Referred to as 30-60-90 reviews, these reviews are performed at 30%, 60%, and 90% completion of the engineering design. Like projects in the building construction sector, industrial projects undergo constructability reviews throughout the design process. However, because of additional safety, regulatory, and performance expectations, industrial projects are subject to further specialized reviews, including operability and maintenance reviews, hazard and operability (HAZOP)/hazard identification (HAZID) reviews, and value improving practice (VIP) reviews. The owner may coordinate with the EPC contractor to define quantifiable progress or maturity metrics for each design deliverable. These metrics may be as subjective or objective as the owner and EPC contractor deem acceptable for managing project risk.

At the completion of the detailed engineering and design phase, the design integration manager will have coordinated the delivery of several key design deliverables within the IFC package.

"At the completion of the detailed engineering and design phase, the design integration manager will have coordinated the delivery of several key design deliverables within the IFC package."

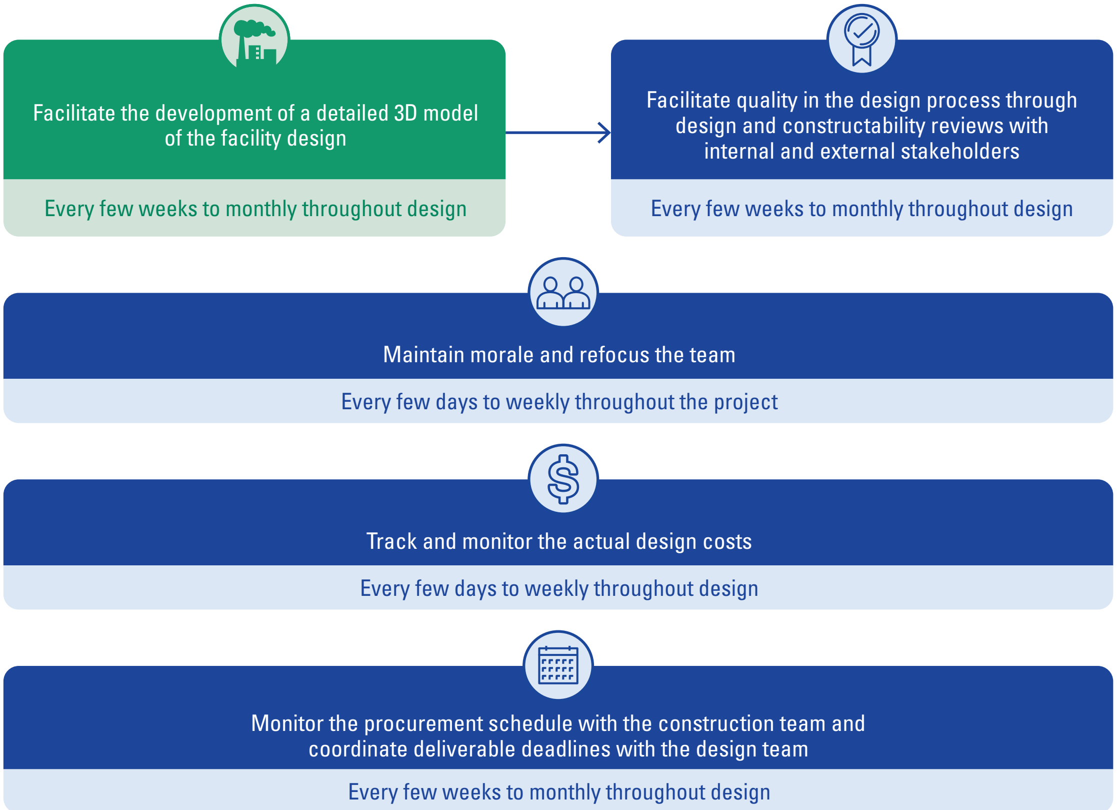
Key design deliverables within the IFC package

Design Deliverables	Stage of Development
Block flow diagrams	Complete
Process flow diagrams	Complete
Piping and instrument diagrams (P&IDs)	Complete
Plot plan	Complete
3D model/piping plans	Finalized
Process equipment list	Finalized
Instrument index	Finalized
Block diagrams	Finalized
Piping line list	Finalized
Piping material take-off	Finalized
Commissioning and startup	Finalized
Construction work packages	Finalized
Vendor model and skid details	Finalized
Operation manuals	Finalized
System and subsystem walkdowns	Finalized

The Role of the Design Integration Manager

Due to the substantial time commitment required to procure items on industrial projects, the design integration manager plays a prominent role in the task "Monitor the procurement schedule with the construction team and coordinate deliverable deadlines with the design team." While items with long lead times are identified in earlier phases, the process of obtaining quotes for these and other items from suppliers, negotiating terms and conditions, and issuing purchase orders may extend into the detailed engineering and design phase. In addition, the responsibilities of the EPC contractor do not end once orders are placed. Downpayments, follow-up calls to verify proof of progress, and inspections of fully assembled equipment may be required. Logistical considerations such as freight deliveries and the loading and unloading of equipment on site must also be planned and coordinated with the construction schedule. Therefore, the design integration manager verifies the lead times for facility and process equipment early and often.

Because the basis of design for industrial projects is well defined in the owner's basic engineering design data (BEDD) and the subsequent FEED study, the design integration manager does not need to document the final basis of design during the detailed engineering and design phase. Instead, the design integration manager is responsible for a new task to facilitate the development of a 3D model of the facility design. This model serves as a single source of truth on the project, ensuring that information is consistent and coordinated across engineering disciplines.



Workflow of the design integration manager's tasks during the detailed engineering and design phase

Additional Task: Facilitate the Development of a Detailed 3D Model of the Facility Design

Every few weeks to monthly throughout design

In this task, the design integration manager facilitates information flow between engineering teams and external partners and ensures that 3D models and the data associated with those models are accurate and reliable.

Knowledge	Skills	Abilities	Other Characteristics
• Project roles and the work responsibilities commonly associated with each role • Document management procedures • Capabilities of design and drafting software	• Data management and organization • Delegating responsibilities and work to the right people • Organizing information and record keeping	• Collaborating with partners • Collecting, analyzing, and interpreting information	• Accountable • Timely

Because of the complexity and frequency of changes inherent in industrial process design, information management is critical. Using outdated or incomplete information during design can lead to poor coordination and rework. Similarly, when each engineering team or external partner uses its own platform for design, the result is a variety of file formats and versions spread across multiple locations. One solution to these challenges is a data-centric design philosophy. This philosophy attempts to ensure that all engineering teams and external partners are aligned with respect to the detailed design. Alignment is achieved using a common data environment that all parties can access at any time. The information added to this common data environment becomes the source of truth for the project, on which engineers can rely during design.

The design integration manager must keep in mind two considerations when facilitating the development of detailed 3D models. First, the owner may require that the EPC contractor create 3D models on the owner's servers using the owner's preferred platform. The EPC contractor can decide whether to use the owner's platform throughout the project or to use an in-house platform until then end of the project, at which point the EPC contractor can then either convert its models for compatibility with the owner's platform or hire a consultant to recreate the models on the owner's platform. There are advantages and disadvantages to both options, which the design integration manager can assist in navigating.

Second, not all vendors or licensors have the capacity to perform the 3D modeling required by the owner or incorporate information in a digital format. In these cases, the EPC contractor needs to replicate the content from the vendor or licensor in an appropriate format to satisfy the owner's requirements. The liability of the content will remain with the vendor or licensor, but the EPC contractor bears the additional cost of remodeling or redrawing the content. The design integration manager coordinates this process to ensure that vendor and licensor data are incorporated into the owner's platform.

Data-Centric Design

Data-centric design is a design philosophy that places engineering data rather than specific applications at the center of the design process. A key aspect of this philosophy is the storage of data in a centralized project information database from which these data can be referenced by other applications or documents as needed. This philosophy enables the use of collaborative design tools that allow multiple engineering disciplines to work within a common design environment for both schematic and physical design. The use of data-centric design can improve the efficiency and accuracy of engineering applications such as modeling, 4D or 5D scheduling, clash detection, and the creation of data-driven P&IDs because updates are made to and distributed through the centralized database.

The key to the successful implementation of data-centric design is the use of metadata. Metadata summarize basic information about the various types of engineering data used on a project in order to facilitate the process of finding and working with data. For example, the metadata associated with a given object within a model may describe the object's class (e.g., equipment, piping, or instrumentation), family (e.g., vessel, heat transfer, or mechanical), and additional properties (e.g., construction status, supplied by, and designed by). The use of consistent metadata enables information to be shared across platforms with minimal interoperability issues. Standards such as ISO 15926 provide specific guidance on integrating data into different applications, sharing and exchanging data between applications, and handing over data at project close-out.

CHAPTER 8: CONSTRUCTION PHASE

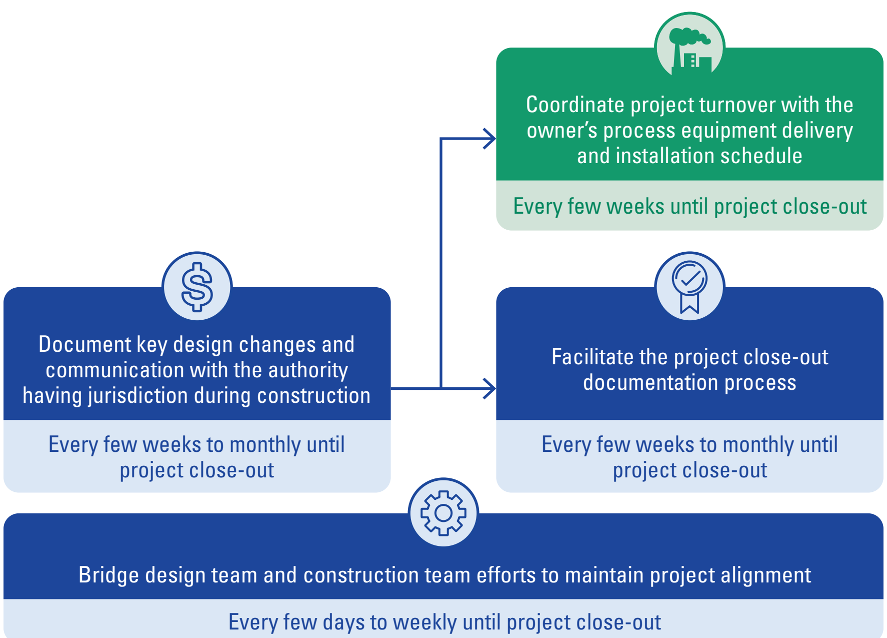
Description of Phase

The construction phase formally begins upon approval of the issued for construction (IFC) package produced during the detailed engineering and design phase and concludes when the facility and process equipment is turned over to the owner. From the perspective of the design integration manager, the construction phase of an industrial project typically mirrors that of projects in other sectors. While some regulations and documentation requirements specific to the industrial sector may need to be followed, the core aspects of construction management, such as planning, scheduling, budgeting, quality control, and stakeholder coordination, remain consistent.

However, because industrial projects are performance based, industrial facilities and process equipment require more extensive commissioning, startup, and performance testing activities than comparable facilities in building construction projects. In practice, this means that each system and subsystem in an industrial project may have a separate and distinct turnover to the owner. As a result, the turnover process may last from several weeks to several months, depending on the complexity of the project.

The Role of the Design Integration Manager

The tasks of the design integration manager during the construction phase align with those in _The Design-Builder's Guide to Design Management_, apart from the addition of one new task.



Workflow of the design integration manager's tasks during the construction phase

"Because industrial projects are performance based, industrial facilities and process equipment require more extensive commissioning, startup, and performance testing activities than comparable facilities in building construction projects."

Additional Task: Coordinate Project Turnover with the Owner's Process Equipment Delivery and Installation Schedule

Every few weeks until project close-out

In this task, the design integration manager works with the engineering and construction teams to identify the various systems that will be turned over to the owner separately so that the owner can plan the delivery and installation of process equipment with suppliers and consultants.

Knowledge	Skills	Abilities	Other Characteristics
• Process automation and control • Process inspection and testing procedures	• Hazard recognition	• Working well under time pressure	• Timely • Accountable

On industrial projects, turnover is performed piecewise by system. As a result, the turnover process can take anywhere from several weeks to several months to complete. A key challenge in this process is the complexity of industrial facilities and processes, which makes it difficult to determine where one system ends and another begins. While the scheduling of inspections and the remediation of punch list items for each system is typically the responsibility of the construction team, the design integration manager has an important role in clearly defining the boundaries of the systems being turned over.

For this task, the design integration manager delineates all systems early in the construction phase, clearly specifying which piping, equipment, and other components belong to each system and identifying which systems can be approved (via a walkdown) and turned over together. This information feeds into turnover schedules that will ultimately assist the owner in planning the occupancy of the facility.

GLOSSARY

A

Advanced Work Packaging (AWP)
According to the Construction Industry Institute (CII), a construction-driven planning and collaboration framework for industrial projects that is focused on creating a constraint-free work environment. Under AWP, engineering deliverables are broken down into smaller pieces of work (packages) that are directly aligned with the path of construction. AWP typically begins during the front-end engineering and design (FEED) phase and continues through the detailed engineering and design phase and the construction phase.

B

Basic Engineering Design Data (BEDD)
The set of fundamental information, specifications, and parameters developed for an industrial project by the owner or an engineering consulting firm. The BEDD serves as the initial basis of design and is used by engineering, procurement, and construction (EPC) contractors to understand the project scope and create estimates.

C

Construction Work Package (CWP)
Used in work packaging, a construction deliverable that adds construction planning information, such as construction equipment requirements, estimated manhours, and planned start and finish dates, to an engineering work package (EWP).

D

Data-Centric Design
A design philosophy in which engineering data are stored in a centralized project information database from which they can be referenced by other applications or documents as needed. This philosophy enables the use of collaborative design tools that allow multiple engineering disciplines to work within a common design environment for both schematic and physical design.

E

Engineering, Procurement, and Construction (EPC)
A project delivery method used on large-scale and complex industrial projects in which a single contractor is hired to deliver a complete facility and perform all of the necessary design, engineering, and construction work. EPC is often referred to as a turnkey delivery method because all responsibility for the performance of the project is placed on the contractor and the facility is considered ready to use at turnover. EPC is analogous to design-build delivery in the building construction sector.

Engineering Work Package (EWP)
Used in work packaging, an engineering deliverable that contains the necessary engineering and vendor data, drawings, and technical specifications for a construction team to build a specific scope of work. EWPs are used to develop construction work packages (CWPs).

EPC Contractor
An EPC firm contracted to perform the execution stage of an industrial project, including detailed engineering and design, procurement of all physical materials and equipment, purchasing of vendor and licensor services, construction of the capital facility, and commissioning, startup, and turnover of industrial processes and systems.

F

FEED EPC
An EPC firm contracted to perform the basic engineering services during the FEED phase of an industrial project. Depending on the owner, the FEED EPC may then be selected directly as the EPC contractor for the execution stage of the project or may be asked to recompete for the work in a second proposal phase near the completion of the FEED phase.

Front-End Engineering and Design (FEED)
The third phase in the phase gating process for industrial projects, following feasibility evaluation and conceptual design but preceding detailed engineering and design. FEED is often considered to be synonymous with basic engineering. The purpose of the FEED phase is to develop the project definition to a level at which the owner is comfortable with the risk in the execution stage of the project. As a result, FEED focuses on defining the technical requirements, evaluating alternative design options, and creating more accurate cost estimates for the project. FEED services may be performed by an engineering firm or by an engineering, procurement, and construction (EPC) contractor.

Front-End Loading (FEL)
Also known as front-end planning (FEP), a structured approach to the planning and early design phases in the life cycle of an industrial project. The FEL process typically uses phase gates to direct the project through a series of well-defined milestones before the project receives approval and funding to proceed to later phases of work. This process is designed to ensure that all critical decisions and preparations are made at the beginning of the project, which can reduce the risk of cost overruns and turnover delays during the execution stage.

Front-End Planning (FEP)
See Front-End Loading (FEL).

H

Hazard and Operability (HAZOP)
A systematic study of planned processes or operations in an industrial project to identify hazards to personnel, equipment, and the environment as well as issues that could negatively affect the operation of the facility.

I

Installation Work Package (IWP)
Used in work packaging, a discipline-specific subset of the scope of work from a construction work package (CWP) that describes one to three weeks of work activities for use by a construction foreman. IWPs often include task lists, manhour allocations, specialty tool and equipment requirements, bills of materials, and any technical documents or drawings relevant to the work.

Issued for Approval (IFA)
Any document issued to an authority for approval.

Issued for Construction (IFC)
Documents issued to begin construction after the design is complete.

Issued for Design (IFD)
Documents issued for further design or engineering work.

O

Owner/Operator
The party that owns the facility wherein the specified industrial process will be used.

P

Phase Gate
A milestone in the front-end loading (FEL) process at which the owner decides whether the project is ready to proceed to the next phase. Industrial projects typically feature four phase gates: at the end of the feasibility phase (FEL-1), at the end of the conceptual design phase (FEL-2), at the end of the FEED phase (FEL-3), and at the end of the detailed engineering and design phase (FEL-4).

Procurement Work Package (PWP)
Used in work packaging, a procurement deliverable that defines all required vendor data, materials, and equipment needed for an engineering work package (EWP). PWPs are used in tracking and logistics to tag purchase orders, track shipping, and maintain transparency of the procurement process.

R

Responsible, Accountable, Consulted, and Informed (RACI)
A project management tool, typically presented as a matrix, that describes the role of various parties in completing tasks or deliverables for the project. Also known as a linear responsibility chart.

S

Stage Gate
See Phase Gate.

Supplier
The party responsible for manufacturing and/or furnishing the specified equipment or materials.

V

Value Improving Practices (VIPs)
Intentional, targeted practices to facilitate improvements in the cost, schedule, operability, safety, and reliability outcomes of industrial projects. In most cases, VIPs are initiated during the front-end engineering and design (FEED) phase by an outside consultant hired by the owner but are applied to the entire project scope and are not intended to improve one outcome at the expense of another.

W

Work Packaging
See Advanced Work Packaging (AWP).

Sitting at the intersection of multiple parties in a design-build project, the design integration manager must organize and manage the activities of many individuals to conceptualize and develop the project design.

In industrial design-build projects, the role of the design integration manager spans five distinct phases:

- PROPOSAL/PRE-AWARD PHASE
- FRONT-END ENGINEERING AND DESIGN PHASE
- PROJECT INITIALIZATION PHASE
- DETAILED ENGINEERING AND DESIGN PHASE
- CONSTRUCTION PHASE

CHARLES PANKOW FOUNDATION

pankowfoundation.org
(360) 326-3767