

Chapter 2

Project Delivery Systems (PDS)

2.1 Definition

A project delivery system is the comprehensive process by which a physical entity is designed and constructed. The comprehensive process includes (see pp. 6–20 in [1]):

- “Definition of scope and requirements of a project;
- Procedures, actions, and sequences of events;
- Contractual requirements, obligations, and responsibilities of the parties;
- Interrelationships among the participants;
- Mechanisms for managing time, cost, safety, and quality;
- Forms of agreement and documentation of activity;
- Actual execution of design and construction;
- Closeout of the project and start-up of the new facility.”

Loulakis, Michael C. (see p. 106 in [2]) agrees to the above-presented definition of Zimmermann, Josef and states: “Project delivery system is a process or means by which a construction project is comprehensively designed and constructed for an owner, including:

- Project scope definition
- Organization of designers, construction, and various consultants
- Sequencing of design and construction operations
- Execution of design and construction
- Closeout and start up.”

A project delivery system defines the way a construction project will be organized so that it is taken from the owner’s concept to the physical entity. The organization includes bringing together human and physical resources to accomplish planned objectives (see p. 194 in [3]) with the help of ideas, procedures, personnel, design, construction techniques, schedule and cost estimation, etc., which would lead to the successful completion of the project. This organization should match the owner’s design and construction capacities along with the specified requirements of

the project. The specified requirements include the factors like level of quality, time frame, and allocated costs. The organization thus should have the capacity to construct and fulfill these specified requirements. Organization of the project affects the efficiency and effectiveness in designing and building (see p. 35 in [4]).

Every project has its objectives and goals to be achieved; it is thus very important that each involving party should understand the goals, objectives, and obligations. The four prime criteria of the success of project delivery system are costs, quality, time, and safety, although the responsibilities to meet these criteria could be different for different systems (see pp. 6–20 in [1]). Project delivery systems define a common framework for the involved persons and organizations so that each one understands its duties and responsibilities so that they can work within the project in a coordinated manner. The responsibilities, authorities, and relationships are normally defined in the contract documents that provide the blueprint for the project delivery system (see p. 35 in [4]).

Note

The above-presented definition of Zimmermann, Josef and Loulakis, Michael C. considers project delivery systems as a comprehensive process of designing and constructing the project for the owner. Other literatures also denote project delivery system as designing and construction tasks (for instance, Glavinich, Thomas E.: Contractor's Guide to Green Building Construction, New Jersey, USA, 2008). But PPP is also a project delivery method, which includes finance, maintenance, and operation besides design and construction. Therefore, these definitions do not cover PPP. But Sanvido and Konchar [5] define a project delivery system as "the relationships, roles, and responsibilities of parties and the sequence of activities required to provide a facility." This definition could be interpreted in a manner that it includes financing, operation, and maintenance of the project (see p. 3 in [6]). Thus, for this book, the project delivery systems cover finance, design, construction, operation, management, and maintenance of the project.

2.2 Phases of Project Delivery

The project delivery starts after the real estate development. Within real estate development, scoping, feasibility study, and programming of the project are carried out. Zimmermann, Josef (see pp. 3–6 in [1]) has also adapted the phase of project delivery according to the Stanford University as presented in Fig. 2.1.

2.2.1 Schematic Design (SD)

It is a crucial phase where expectations are set. Budget and schedule are established; its primary objective is to be determined. The general scope, preliminary design, scale, and relationships among the components of the project, budget, and schedule are clearly defined (see p. 9.1 in [7]). The client specifies specifically about the

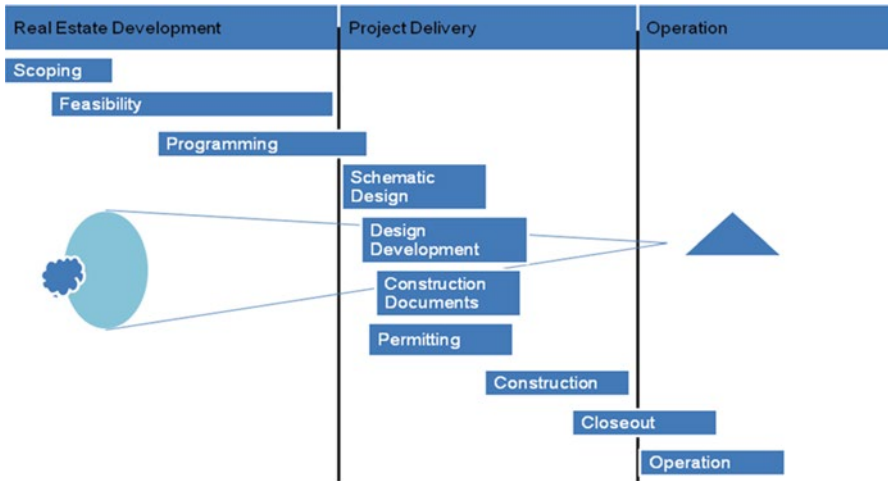


Fig. 2.1 Phases of project delivery (Based on [7]) (financing and maintenance aspects are missing)

requirements for the design option based on the programming phase. This phase should significantly be basic for the technicians and project managers to estimate budget and time schedules. It is regarded as the road map for all involved parties to define the outcomes. Josef Zimmermann (see pp. 3–8 in [1]) agrees to the fact that SD phase involves in setting the expectations, budget, and schedule.

2.2.2 *Design Development (DD)*

Schematic design describes the requirements and scope of the project, while design development refines the scope of previously prescribed in schematic design. The detailed design is developed, and each and every step to achieve the project is defined. Any change in the scope of the project would be possible in this phase because until this phase the participation of user groups is possible, but it should be handled and coordinated properly because it has a big impact on budget and schedule (see p. 10.1 in [7]). Josef Zimmermann (see pp. 3–9 in [1]) also agrees that DD is the last opportunity for any change in scope and design of the project.

2.2.3 *Construction Documents Phase*

This phase concludes the design phase, where drawings and specifications of the project are documented and the contract documents are finalized, which provide comprehensive, fully coordinated construction documents and specifications that the constructor should follow (see p. 11.1 in [7]). Within this phase, all documents required for the approval of the project should be obtained and prepared.

2.2.4 Permitting Phase

The permitting phase starts with the submission of all required documents necessary for the approval from the external authorities with jurisdiction for review of plan and code compliance. It is mostly time consuming and depends on the project's location, complexity, and phasing (see p. 12.1 in [7]).

2.2.5 Construction Phase

This is the most important phase which supplies the need of the client. The aim of the project is completed with the completion of construction. The objective of this phase is to build the project as prescribed in the contract documents meeting the allocated budget and planned time frame. Within the construction phase, the owner, architect, and contractor meet weekly to report and inform about the activities, track submittal status, budget and schedule, and solve the problem raised (see p. 13.1 in [7]). After the completion of construction phase, project closeout begins; in this phase, the constructed project is handed over to the owner for the occupancy.

2.2.6 Closeout Phase

After the completion of construction phase, project closeout begins; in this phase, the constructed project is handed over to the owner for the operation. The goal of this phase is to hand over the finished and inspected project to the owner.¹

2.2.7 Operation

After the closeout phase, the project is set into operation. PPP road projects are normally operated by the private partner for the contracting period whereby they collect the fee from the users through road tolls. With other project delivery systems, operation of the project is carried by the owner (for instance, with performance-based road management and maintenance contract and Funktionsbauvertrag).

2.2.8 Maintenance

Some project delivery methods include the maintenance work while some do not. Project delivery methods like Funktionsbauvertrag, PPP, and performance-based road management and maintenance contract include maintenance work for the contracting

¹Based on Stanford University: http://lbre.stanford.edu/sites/all/lbre-shared/files/docs_public/Vol2_1_All-web-1.pdf, p. 14.1.

period, while design-bid-build, for example, does not include maintenance work. These aspects will be elaborated in a later chapter.

2.2.9 Finance

Finance is the basic requirement of the project delivery. Project delivery methods like design-build, Funktionsbauvertrag, and PMMR are financed through the public fund. PPP, on the other hand, is normally financed by the private sector and is paid back as part of installments within the contract period (see p. 21 in [1]).

2.3 Key Players of Project Delivery Systems

Within a project, several people, organizations, and entities are involved. The stakeholders of the projects differ according to the nature of the project. According to the definition of project delivery systems, it is the comprehensive activity of the designing and construction of the physical entity. Thus, the key players are the owner, designer, and the constructor. A project, either public or a private, needs permission and final approval from the corresponding authority in order to start the construction work. Therefore, public authority is also regarded as a key player of project delivery systems.

2.3.1 The Owner

The client who needs and initiates a project is usually the owner of the project. The owner could be an individual, organization, or any other form of entity. The owner is the entity who holds one or more contracts with the designers and constructors and has the responsibility of essential payment to them. The owner bears all the construction costs. The knowledge of the owner on the design and construction aspects would be very crucial but not the prerequisite. Despite the experience and knowledge, the owner has great expectation from the designer and constructor in the project delivery (see p. 492 in [8]), because the designer and the constructor are hired by the owner as expert to design and build the project.

2.3.2 Designer/Engineer

The designer is the expert, who generates a design concept of the project. In case of building construction, an architect is the designer, while in case of road or bridge building, the civil engineer is the designer. The designer is responsible for designing the entity, documenting, and administering the contracts for the construction of the project. The designer generates documents that describe the design intent, and the contractors use these documents to build the projects (see p. 492 in [8]). Design

plays a vital role in the quality of the project because the construction is totally dependent on the design. The constructors build the project as prescribed in the design. ASCE Manual No. 73 (see p. 29 in [9]) states that the designer develops project concepts, plans, and design solution to fulfill the project objectives.

2.3.3 *Constructor*

The constructor is responsible to build the proposed project. Constructors can include a variety of subcontractors, suppliers, and fabricators, who design intent of the designer's documents in detail and agree at a prearranged point in the design phase to build the project in a certain amount and certain time frame (see p. 493 in [8]). The constructor should be careful to meet the specified standard as defined in the contract. ASCE Manual No. 73 (see p. 30 in [9]) agrees on the above tasks of constructor and states that the constructor executes the tasks to plan, manage, and properly construct the project according to the plans, specification, and other documents prepared by the designer.

2.3.4 *Public Authorities*

For the public projects, public authorities are the clients and are responsible for the financing, permission, and inspection, but for the private construction, public authorities are responsible for the permission and inspection. The public authority grants permission after inspection on different prescribed aspects such as environment and procedures (see p. 493 in [8]).

2.3.5 *Responsibilities of Different Actors of Project Delivery Systems*

2.3.5.1 *Owner*

The responsibilities of the owner include the need identification of the project, which is one of the important aspects of any project. Why the project is needed and its goals and objectives should be well identified by the owner. Besides need identification, the owner is responsible to program the project means, he is responsible to make the arrangements of the project, and he sets the criteria and quality level of design (see p. 507 in [8]). Finance arrangement, designing contracts, site allocation, project planning, research (to make the projects successful which includes market research and price research), designing the project to translate the needs and objectives in form of drawings, arrangement of construction contract documents, signing the contract documents, starting the project, and maintenance are other activities that should be carried by the owner (see pp. 6–21 in [1]).

The responsibilities of the owner, however, are not identical for every project delivery system. For example, preliminary designing and maintenance are the tasks of the owner with design-bid-build, but they are performed by the contractor with performance-based contract for road management and maintenance and Funktionsbauvertrag (for details, see Chap. 3). The selection of the appropriate project delivery system is a challenging responsibility of the owner which affects the quality of the project (see p. 23 in [9]).

2.3.5.2 Designer/Engineer

The designer is mainly responsible to present the needs and requirements of the owner in form of drawings or other structures. In order to design, a designer who is normally an architect or an engineer needs to clearly understand why the project is needed and how the needs could be realized. A designer is responsible for programming the project, designing the site and projects, planning the projects' various phases, research (which includes new technology for designing and searching cost-effective method for designing), finalizing the design and administrating the construction contract documents, and giving suggestions during the construction phases (see pp. 6–21 in [1]).

The responsibilities of the designer differ, however, depending upon the types of delivery system (see p. 492 in [8]). For instance, with design-build, the contractor is responsible for designing and building tasks, whereas with design-bid-build, the designer and constructor are different. Therefore, the designer's responsibility ends with the design of the entity in case of design-bid-build.

2.3.5.3 Constructor

The main responsibility of the constructor is to bring the purpose of the project into reality as a physical entity. The constructor is responsible to procure the project, sign construction contract documents, hire the workers, start the construction, inspect during construction to ensure the level of quality, and complete the construction per design and, in some cases, the maintenance works (see pp. 6–21 in [1]).

The responsibilities of contractor differ with the types of the project delivery method. For instance, the contractor is responsible for the maintenance with Funktionsbauvertrag, whereas the maintenance is not the responsibility with design-bid-build.

2.3.5.4 Public Authority

In case of public projects like road construction, the public authority is the owner. In this case, the authority is responsible for the financial burden. The other aspects such as environmental aspects and aesthetical aspects which may be affected by the

project are revised by the public authority. If such aspects are under the defined standard values, the authority grants the permission of construction. Inspection is also the responsibility of the authority to ensure if the construction is as per defined (see pp. 6–21 in [1]).

The role of public authority differs with the type of projects. For the private projects, public authority is only responsible for the inspection regarding law, environmental aspects, aesthetical values, etc., and permitting to construct. But with public projects, public authority performs inspection, permitting, and financing tasks.

2.4 Key Factors Affecting Project Delivery Choice

Traditionally, the construction cost was the main criteria affecting the selection of the project delivery method. Normally, the contractor with the lowest bid price was selected, but nowadays, the other variables along with the bid price may affect the choice of project delivery methods. The other variables are construction costs, schedule, quality, risks, and owner capabilities (see p. 493 in [8]). Thus, before deciding on the particular delivery method, various criteria are considered as stated above.

2.4.1 Construction Costs

The owner has the obligation of all project costs. The construction cost is frequently the main concern of design and construction (see p. 493 in [8]). Construction costs depend on the magnitude of the project, but in general construction costs are very high and the owner has limited funds. To meet the defined budget is important, and it is the high priority of each and every member of the project team.

2.4.2 Schedule

“Time is of the essence, is the key factor of the agreement and may be an overriding criterion for completion. The project time available is generally established by the owner in the schedule developed during project conception” (see p. 3.5 in [10]). The delay in the delivery project may add extra costs on the total costs. Mostly the project is defined by the date of completion. The project includes the time frame within which the project has to be completed. Fulfilling the precise schedule would be the most essential consideration in determining how and when a project would be constructed. Delay would add extra costs to the owner. Meeting the schedule is crucial, especially when the interest rate is very high and capital for building is scarce because a small delay raises the costs of construction (see p. 494 in [8]). ASCE Manual No. 73 agrees that owner benefits from completion of a project as soon as possible (see p. 31 in [9]).

2.4.3 *Building Quality*

“The demand for particular standards of performance in system, finishes, enclosure, or other building elements is directly related to decision about schedule and construction costs” (see p. 494 in [8]). The standard is prescribed in the contracts which should be achieved by the constructor. The designer normally presents a clear level of quantity, budget, and program; thus, change in one of these parameters may lead to the change in others. Sometimes the owner may accept the project with lower quality if the construction cost is lower or the completion of project is before scheduled time frame. Projects with a long life span should assure the quality in order to save maintenance costs (see p. 494 in [8]).

2.4.4 *Client Capabilities*

The internal capabilities of the client and the client organization could affect the role of client, designer, and contractors significantly (see p. 494 in [8]). Client capabilities and experiences are not the requirements but would certainly affect the efficiency of the construction. The professional expertise and knowledge of the client is assumed as the key to the successful use of the project delivery systems (see p. 3.34 in [10]).

2.4.5 *Project Scope*

Before the starting of the project, project scope is defined, but the scope is not completely understood or permanently fixed during the course of the project. Scopes are generally defined during design, detail design, and construction phases. The external factors have effect on the scope of delivery system, like change in the price of the material or construction law. The delivery model should to the highest extent recognize the degree to which project could be or couldn't be modified (see p. 494 in [8]).

2.4.6 *Risks*

Risk is the factor which needs proper management during construction. It should be handled properly to overcome the cost overrun. All project participants should make their best effort to manage and reduce the risks as the project unfolds. The key to reduce risk is to understand the project requirements by all the participants. (Associated risks with the different types of delivery systems are elaborated under respective headings.)

In contrast to Demkin, Joseph A. (Bernstein, Phillip G., FAIA, RIBA, LEED AP), the ASCE Manual No. 73 (see p. 16 in [9]) argues that the project financing has become one of the more significant factors in selecting an appropriate project delivery system.

Different literatures have presented their views on factors that affect the choice of the project delivery method, which are as follows:

Demkin, Joseph A (Bernstein, Phillip G., FAIA, RIBA, LEED AP) (see p. 493 in [8]) in the chapter Project Delivery Methods clearly stated construction costs, schedule, quality, risks, and owner capabilities are the factors that affect the choice of the project delivery method, but it is not clearly presented how these factors lead to the choice of the particular delivery method.

Molenaar, Keith R. and Yakowenko, Gerald (see p. 4 in [11]) argued that choosing the appropriate delivery method requires an adequate understanding of each delivery method, contracting approaches, as well as the ability to understand the advantages and disadvantages of the different delivery methods. They further pointed out the understanding of various contracting approaches and the potential of the management team decisions could be advantageous on deciding the particular delivery method. The selection of the particular method should depend on the project-specific decision processes, on the types of projects, project risks, human resource available, and the objectives of the project.

Ozdemir, Levent (see p. 184 in [12]) argued that there is no single project delivery method that fits in the entire situation and points out the set of goals of the project as a basic for selecting the particular method. The owner's goals can be achieved efficiently if the constructor is motivated, so the focus should be given to that particular method that motivates the contractor to achieve the goals. Factors like the plans and specifications or statements of works, the extent to which the owner is ready to accept the risks, the ability of the owner to manage and monitor the construction works, costs, specified quality, and completion schedule are considered in choosing the particular type of project delivery method. Construction costs, schedule, quality, risks, and owner capabilities are not only the factors affecting the choice of project delivery methods, but financing, project-specific decision processes on the types of project, project risk, human resource available, and the objectives of the project are also the affecting factors.

2.4.7 Conclusion

From the literature analysis, it is difficult to point out the selection criteria of the particular project delivery method. There is not any rule or principle that helps in choosing the particular delivery method. According to Usher, Thomas E. and Davenport, Philip (see p. 58 in [13]), it is difficult to choose the appropriate delivery method for particular project because of the presence of large number of delivery methods. Every delivery method has its unique features, characteristics, procedure, advantages, and disadvantages. Therefore, a good knowledge and comparison of

these criteria would be helpful in finding the particular delivery method for the particular projects. Comparison of these criteria with the needs of the project would be another method to choose the particular delivery methods.

2.5 Project Delivery Systems in Road Infrastructure

Sections 2.1, 2.2, 2.3, and 2.4 dealt with the general concept of the project delivery systems. This chapter aims to present the concept of project delivery systems for road infrastructure. “Since 1990, a number of transportation agencies (as owners, sponsors, or contracting agencies of highway projects) have been experimenting with a wide variety of innovative project delivery strategies aimed at lowering the costs and time to produce highway construction and rehabilitation projects, while maintaining or improving project quality” [14]. There are several methods of project delivery like design-build, design-bid-build, PPP, construction management at risks, and Funktionsbauvertrag. Every delivery method is not suitable for every project. For instance, Funktionsbauvertrag and performance-based road management and maintenance contract are delivery methods developed to deliver the road projects; therefore, they are not suitable for building construction or power generation projects with present concepts, procedures, and functional requirements. Funktionsbauvertrag could be used in delivery of other projects including road projects by developing requirements and procedures for each project type. But performance-based road management and maintenance contract does not include construction but includes rehabilitation or renovation and maintenance aspects, so it could be developed for other project delivery including road projects excluding construction aspect. In this case, well-defined requirements and procedures are to be defined for each type of projects.

Project delivery systems is a broad concept comprising all possible delivery methods for all possible types of projects, but project delivery systems in road infrastructure include only the delivery methods that are being used in the road delivery. The road is a public infrastructure and a basic requirement of mobility. Therefore, there is a big investment in the transport infrastructures, particularly with roads all over the world because of its social and economic importance. Various forms of project delivery systems have been widely used all over the world for the construction of roads and highways. Project delivery systems have evolved over time; in the past, the master planner used to design, engineer, and construct the entity. The master builder had control of the design and construction of the project, but the change in technology and increasing complications in construction demanded for the specialization of design and construction (see pp. 6–21 in [1]). Thus, the designer was responsible for designing and the constructor for construction. This idea led to the traditional idea of design-bid-build. With this concept, the communication between designer and constructor is realized to be limited. The communication and interaction occurred only during the end phase of designing and during the construction which resulted in inefficient design, increased errors and disputes, higher costs, and

longer schedules. To overcome these disadvantages in the 1970s and 1980s, a third party was brought to assist designers and constructors during designing and constructing. This third party is often called as agency construction managers, but it was not responsible for cost or schedule. In the late 1980s and 1990s, the concept contractor was developed with bounded contracts and was responsible for the work, costs, and schedule; after that, the concept of the construction manager/general contractor or construction manager at risk developed (see pp. 6–22 in [1]).

2.5.1 Forms of Project Delivery Systems in Road Infrastructure

Today, there are choices among various approaches and forms of project delivery systems, in an effort to make construction more efficient (see p. 6 in [15]). Different project delivery systems make use of various kinds of estimation (conceptual, preliminary, and details) at different stages as the project progresses depending on the scope of work (set of expectation of the owner) prescribed at the particular stage (see p. 5 in [16]). Each owner and constructor chooses and implements the particular form of the project delivery system depending on the nature of the project. Whatever form of delivery method is selected, the success depends on the teamwork, how well they are contractually connected to each other, and how well they communicate to accomplish the tasks (see p. 58 in [13]).

Some frequently used forms of road project delivery systems depending upon the practice are described below:

2.5.1.1 Design-Bid-Build

A Comparison of the aspects of project delivery system of Sect. 2.1 with design-bid-build is presented in Table 2.1.

Hence, design-bid-build includes all these aspects of project delivery systems; therefore, it is a project delivery method.

Forms of Design-Bid-Build

Design-bid-build is widely used and well-established project delivery systems (see p. 1 in [17]). The design phase normally accounts for 5–10 % of the total project costs, while the construction accounts remaining 90–95 % of the total project costs (see p. 1 in [17]). Exploratory Study on Responsibility, Liability, and Accountability for Risks in Construction (see p. 20 in [18]) also agrees that in a construction project, design process generally accounts for 5–10 % of the total project costs. The construction phase is costly and time consuming because through this phase the owner realizes his desire in form of physical entity. This data would be very helpful

Table 2.1 Comparison of the aspects of project delivery systems with the aspects of design-bid-build

Aspects of project delivery system	Aspects of design-bid-build
Project scope definition	The owner provides complete plans and specification and set the project for bidding, which is the project scope (see Sect. 2.5.1.1.1)
Organization of designers, constructors, and various consultants	Figures 2.3 and 2.4 present that design-bid-build is an organization of designers, constructors, and various subconsultants. For the design purpose, a designer is hired and a constructor for constructions and consultants for suggestions during the design and construction phase
Sequencing of design and construction operations	With design-bid-build, designer and the constructor are separate entity. Therefore, the owners select the contractor after design phase is completed. The contractor is selected and enters into agreement with the owner to construct the facility as specified. ^a Hence, design and construction are carried out in sequence
Execution of design and construction	Under design-bid-build, the owner contracts separately with a designer and a contractor to execute the design and construction of the project ^a
Closeout and start-up ^b	The owner manages all contracts throughout the construction period up to the completion of the construction and then takes the possession of the project on substantial completion ^a

^a See pp. 6–26 in [1]

^bHow closeout and start-up are regulated is not described in detail in this book because they are not well described in available literatures. This subject may be interesting for the future research

when the contractor is responsible for both designing and construction tasks and if the payment is on lump sum based. In such case, the constructor knows how much costs to allocate for designing and how much for the construction.

Design-Bid-Build: General Contractor

“Design-Bid-Build is a traditional procurement approach of a project. The contracting agency provides the completed plans and specifications and procures the construction services based on the lowest bid, in sequential order” (see p. 26 in [19]). The design team completes the design, and then the owner contracts the general contractor to build the project depending upon the specified design; with design-bid-build, the general contractor is generally selected depending upon the low price based on the competitive process (see p. 36 in [4]). With this delivery system, the owner deals separately with the designer and the general contractor for the completion of the project. The first step would be to get the designs from the designer in detail. After the completion of the design, the owner typically bids out the project in order to select or open list of qualified contractors (see p. 37 in [4]). After the completion of bidding, the suitable contractor is selected, and the owner and the

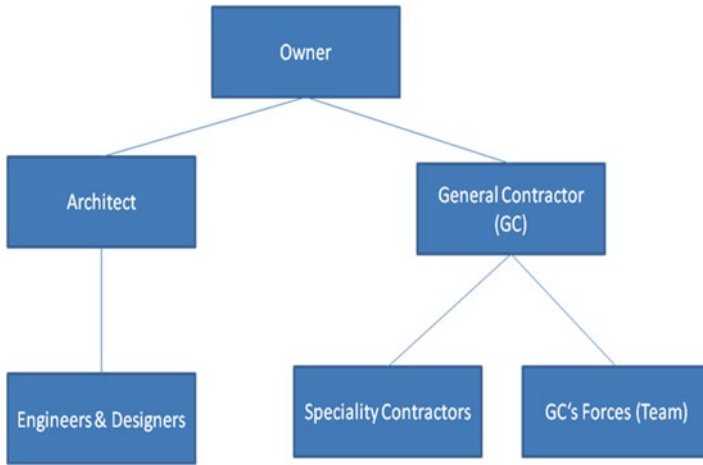


Fig. 2.2 Design-bid-build project delivery system (see p. 37 in [4])

contractor enter into an agreement; the contractor is normally called a general contractor, who is responsible to build the project as specified in the agreement. The general contractor then selects the subcontractors and enters into the contracts for the construction of the project. For example, supplier could be subcontractors.

Design-bid-build has three comprehensive phases:

1. Design: During design phase, the owner prepares detailed project plans and specifications in hiring designers and engineers.
2. Bid: After the completion of designing, the project is set for bidding; the owner invites the construction entity and normally awards to the lowest responsible company.
3. Construction: Building process starts after the selection of the constructors and completion of all contracting documents (Fig. 2.2).

The contractor is not involved during the design phase, which is seen as a disadvantage of this form. Making changes to the design that would reduce the construction costs and wastes and the increase project efficiency after occupancy is difficult to achieve since the owner cannot use the contractor's knowledge in performing value analysis and constructability review in the design phase as well as in cost estimating and scheduling (see p. 37 in [4]).

The general contracts can be a unit price, a lump sum, cost-plus fee agreements, or a guaranteed maximum price (GMP).

Unit Price

Unit price contracts are the contracts where the payment to the contractor is dependent upon the amount of inputs like number of working hours, amount of concrete used, or amount of bitumen used.

Table 2.2 Cost-plus fee contract

Actual costs	Fee as % of costs	Contract amount
1,000,000	50,000	1,050,000

Lump-Sum Contract

With lump-sum contracts, in return for an agreed fixed price as a single payment for the total amount, the contractors provide everything necessary to ensure that the completed project is up to the standard specified and in required level of performance and is completed within the specified time (see p. 1 in [20]). Once the contract is agreed on and signed, the owner is responsible for the payment of the agreed sum regardless of the actual costs beard by the contractors; the constructor would also be paid the agreed price regardless of the actual market price. Thus, the negotiation process mostly takes place before completion of contract documents which would allow discussion among general contractors, designers, and the owner on the issues like safety, schedule, quality, and price (see pp. 6–25 in [1]).

Cost-Plus Fee Agreements

“Under cost-plus-fee contracts, the owner reimburses the contractor for all actual cost associated with the work plus a fixed fee or percentage of cost” (see p. 3 in [21]). Zimmermann, Josef (see pp. 6–25 in [1]) argues plus fee may be a fixed fee, a percentage fee, a multiple of direct costs of labor, materials, and other reimbursable. This type of contract is suitable in the case of uncertainty, when it is difficult to define the scope of the project accurately or the construction needs to be started before full pans or construction needs to be completed than the stipulated time (see pp. 6–25 in [1]).

An example of cost-plus fee contract with 5 % of fee (all costs are presented in \$) is shown in Table 2.2.

The contractor receives \$1,050,000.

A Guaranteed Maximum Price (GMP)

“GMP is frequently used because it allows owner to gain the protection of the maximum cost of the construction while retaining the potential for saving. It is basically a cost plus fee contract with a cap on it” (see p. 19 in [22]). Jackson, Barbara J (see p. 104 in [21]) argues that it is the agreed sum beyond which the owner is not obliged to compensate the contractor. Thus, the owner is protected by GMP but receives benefit of any realized savings. It allows flexibility in the future prospective and could be negotiated based on the design documents with drawings, costs, time frame, and specifications.

An example of GMP (all costs are presented in \$) is shown in Table 2.3.

Design-Bid-Build: Multiple Prime

“Multiple prime is a variation on the traditional approach in which the owner directly retains trade contractors to perform discrete portions of the work” (see p. 9 in [23]). With this, the owner contracts separately with one or more designers and contractors in the project delivery process. Design could be performed by one or more prime

Table 2.3 GMP contract

GMP contract amount	Actual costs plus fee	Contractor impact	Owner impact
1,000,000	1,030,000	Contractor suffers 30,000 loss	No impact. The contract price remains same
1,000,000	999,000	No impact	Owner receives 1,000 savings

Based on Jackson, Barbara J [20], p. 104

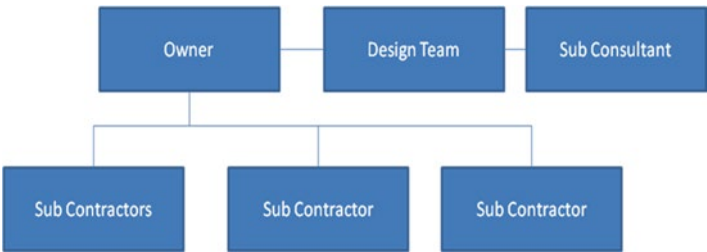


Fig. 2.3 Multiple prime (see pp. 6–23 in [1])

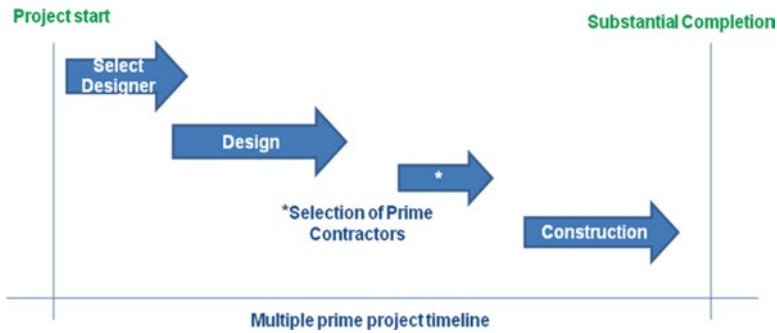


Fig. 2.4 Multiple prime project timeline (see pp. 6–23 in [1])

designers, and the construction is carried through various coordinated but separate prime contracts with multiple constructors (Fig. 2.3; see pp. 6–23 in [1]).

The sequence and the events of the organization are shown in Figs. 2.4 and 2.5. The contractor is normally selected by low bid process. The owner directly contracts with designer and subcontractors.

2.5.1.2 Construction Management at Risk

Comparing the aspects of project delivery system of Sect. 2.1 with the aspects of management at risk, see Table 2.4.

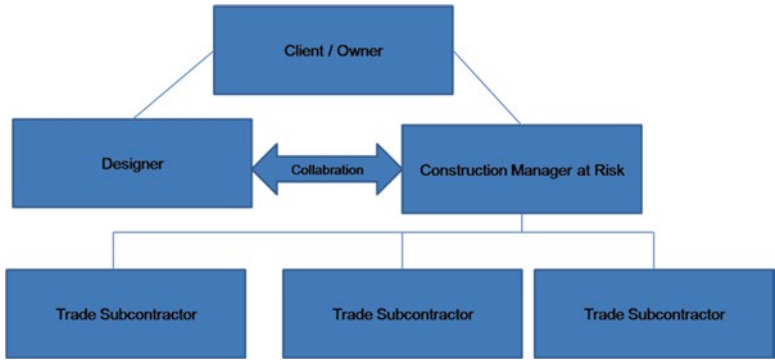


Fig. 2.5 Construction manager at risk (see p. 4 in [24])

Table 2.4 Comparison of the aspects of project delivery systems with the aspects of management at risk

Aspects of project delivery system	Aspects of management at risk
Project scope definition	The owner forms the team comprising designers, constructors, and him to determine the scope of the project before designing and constructing (see p. 52 in [25]) This means project requirements, estimated costs, and time frame of delivery are clearly defined in the contract
Organization of designers, constructors, and various consultants	Figure 2.6 shows the involvement of a designer, constructors, and subcontractors within construction management at risk. The designer involves the specialty subconsultant during the design phase (see pp. 6–26 in [1])
Sequencing of design and construction operations	The owner hires the designer and construction manager simultaneously and completes the designing and then hires subcontractors. The owner then selects a contractor to execute construction management services and construction of the project (see pp. 6–26 in [1]). Thus, this method follows sequential order of design and construction
Execution of design and construction	The designing and construction are executed by the help of the designer and the team of construction managers at risks and other subcontractors (see Fig. 2.6)
Closeout and start-up	After the completion of construction, the inspection phase starts. The owner takes possession of the project after substantial completion (see pp. 6–26 in [1]). The project contracts are also closed with the required signature of owner and contractor

Therefore, the construction manager at risk fulfills the criteria to be project delivery method.

Construction management at risk is a project delivery system where the construction manager is involved from the beginning of the project as the owner’s advisor and as the construction manager contracts and coordinates the specialty contractors and subcontractors (see p. 32 in [4]). It is a team-based contract where team building

Table 2.5 Comparison of the aspects of project delivery systems with the aspects of design-build

Aspects of project delivery system	Aspects of design-build
Project scope definition	Once the owner understands the needs and requirements of the project, he contracts with a single entity to perform both design and construction tasks under single design-build contract (see pp. 6–26 in [1])
Organization of designers, constructors, and various consultants	Figure 3.1 clearly presents the organization of designer and constructor in design-build delivery method. Some selected special works are performed by the specialty consultant during design and construction phases (see pp. 6–26 in [1])
Sequencing of design and construction operations	Design and construction are performed by a single entity. Since designer and constructor are carried out by a single entity, sometime they could be executed simultaneously (see below the explanation of design-build)
Execution of design and construction	A single entity carries out design and construction works ^b
Closeout and start-up	After the successful completion of the project, the owner takes possession of the facility (see p. 39 in [4])

among the owner, designer, and the construction manager starts from the beginning of the project’s conceptual design till the final construction and the operation of the project. The process is based on teamwork, and every player inputs his/her approaches throughout the project delivery. This method of delivery is flexible in the implementation of late changes in the design process without impacting construction schedules and final delivery dates (see p. 2 in [26]).

The construction manager performs the task according to the specified plan for a fee and reimbursable costs. The construction manager contacts the subcontractors and specialists for the construction procedures after the completion of designing.

The construction manager normally guarantees the maximum price of the project and project time frame to the owner; any saving under guaranteed maximum price could be shared by the owner and contractor or could be on hold by the owner (see pp. 6–26 in [1]). With this system, the owner chooses the designer and construction manager simultaneously to get the design completed, and then the construction manager builds the project with one or more subcontractors. After completion of the project, it is handed over to the owner.

2.5.1.3 Design-Build

Comparing the aspects of project delivery system of Sect. 2.1 with the aspects of design-build, see Table 2.5.

The design-build fulfills the criteria of project delivery systems; therefore, it is a project delivery method.

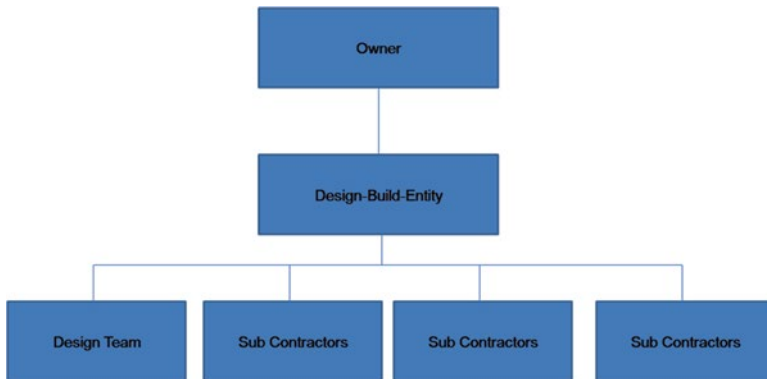


Fig. 2.6 Design-build (see pp. 6–26 in [1])

Design-build is one of the project delivery systems that has been used in road projects as a project delivery system since 1990 with the aim of lowering the costs and time frame [14]. Today, about one-half of all state transportation agencies employ design-build in some form or other in the USA (see p. 110 in [27]). Design-build is a type of contract where a single entity is responsible for designing and constructing a project. With design-build, only one entity or organization is responsible for designing and constructing, and the owner has only one contract for the total delivery of the project; the contract includes both design and construction contracts (see p. 39 in [4]). The design-builder is responsible to design the project based on the performance specifications of the owner, the selection of materials, and methods of construction and coordination of the activities required for the final delivery of the project (see p. 143 in [28]). Although design-build is based on the performance specification, it doesn't fulfill the required criteria to be a performance-based contract.²

As shown in Fig. 2.6, the owner needs to administer only one contract for the design and construction. The responsible entity is responsible for both tasks designing and building; thus, the owner needs not to put himself/herself in between the designer and constructors. If there is a failure in the performance criteria, it is the responsibility of the single entity. Whether there is a failure in construction or design, the owner needs not to resolve the issue; rather the single entity is responsible for both failures. The only period that the owner should face responsibility is if there is a change in the agreed-upon project criteria or if the entity suffers with the conditions beyond the control that is not foreseen at the beginning of the project (see p. 40 in [4]).

After the financial arrangement, the owner advertises for the constructors or engineering firm for the entire designing and construction. The selection of the entity is not necessarily in the basic of the lowest bid. The selection is based on the following aspects (see p. 2 in [29]):

² See Sect. 3.2.

- “Past performance (both the architectural and or engineering and contractor and major subcontractors);
- Technical approach;
- Technical qualifications (specialized experience);
- Capability to perform;
- Other appropriate factors, such as insurance and bonding; and
- Bid amount.”

Note: Design-build is considered as the most recent evolution of project delivery systems (see pp. 6–26 in [1]). Therefore, the selection criteria as described above may have been included with it.

With this method, the project gets involvement of design expertise during the construction phase. Since the constructor and designer work together, this may result in lower costs and lower time frame. The owner has to deal only with the single entity, but the concept of specialization is not applicable here, and the check and balance is also not applicable because of the presence of only one entity for the execution of design and construction tasks.

There are several other project delivery systems that evolved especially for the road project delivery with performance-based criteria like public-private partnership (PPP), performance-based contracts for road maintenance and management, and Funktionsbauvertrag in Germany which would be discussed in detail in the following chapter.

*Key Learning of the Chapter*³

1. Several literatures defined PDS as a comprehensive process of designing and construction of a project for the owner. But it is not true for other PDS like PPP or Funktionsbauvertrag. Therefore, for this book, the project delivery systems cover finance, design, construction, operation, management, and maintenance.
2. Main players of PDS are owner, designer/architect, constructor, and public authority.
3. The phases of PDS are schematic design, design development, construction document, permitting, and construction.
4. Construction costs, schedule, building quality, project scope, risks, and client capabilities are the key factors affecting project delivery choice.
5. There are not any formula, method, and principle that help in finding out the suitable project delivery method.
6. Good knowledge of each project delivery method regarding features, characteristics, procedures, advantages and disadvantages, and the experiences of each player are helpful in selecting appropriate project delivery method.
7. Commonly used project delivery methods in road projects are design-bid-build, design-build, and construction management at risk.

³Based on this chapter, the respective references are presented at the end of this chapter.

8. The general contracts can be unit price, lump sum, cost-plus fee agreements, or a guaranteed maximum price (GMP).
9. About one-half of all state transport agencies in the USA employ design-build for road projects.

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