SECTION IV
MANAGEMENT, PLANNING, DESIGN, AND CONTROL

Handbook of Industrial Engineering: Technology and Operations Management, Third Edition.
Edited by Gavriel Salvendy

IV.A
Project Management

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CHAPTER 45

Project Management Cycle: Process Used to Manage Project (Steps to Go Through)

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1. INTRODUCTION

1.1. Projects and Processes

A project is an organized endeavor aimed at accomplishing a specific nonroutine or low-volume task (Shtub et al. 1994). Due to sheer size (number of man-hours required to perform the project) and specialization, teams perform most projects. In some projects the team members belong to the same organization, while in many other projects the work content of the project is divided among individuals from different organizations.

Coordination among individuals and organizations involved in a project is a complex task. To ensure success, integration of deliverables produced at different geographical locations by different individuals from different organizations at different times is required. Projects are typically performed under a time pressure, limited budgets, tight cash flow constraints, and uncertainty. Thus, a methodology is required to support the management of projects. Early efforts in developing such a methodology focused on tools. Tools for project scheduling such as the Gantt chart and the critical path method (CPM) were developed along with tools for resource allocation, project budgeting and project control (Shtub et al. 1994). The integration of different tools into a complete framework that supports project management efforts throughout the entire project life cycle (see Section 1.2 below) was achieved by the introduction of project-management processes.

A project-management process is a collection of tools and techniques that are used on a predefined set of inputs to produce a predefined set of outputs. Processes are connected to each other as the input to some of the project-management processes is created (is an output) by other processes. The collection of interrelated project-management processes forms a methodology that supports the management of projects throughout their life cycle, from the initiation of a new project to its (successful) end.

This chapter presents a collection of such interrelated processes. The proposed framework is based on the Project Management Body of Knowledge (PMBOK), developed by the Project Management Institute (PMI) (PMI 1996). The purpose of this chapter is to present the processes and the relationship between them. A detailed description of these processes is available in the PMBOK. PMI conducts a certification program based on the PMBOK. A Project Management Professional (PMP) certificate is earned by passing an exam and accumulating relevant experience in the project-management discipline.

1.2. The Project Life Cycle

Since this is a temporary effort designed to achieve a specific set of goals, it is convenient to define phases that the project goes through. The collection of these phases is defined as the project life cycle. Analogous to a living creature, a project is born (initiated), performed (lives), and terminated (dies), always following the same sequence. This simple life-cycle model of three phases is conceptually helpful in understanding the project-management processes because each process can be defined with respect to each phase. However, this simple life-cycle model is not detailed enough for implementation (in some projects each phase may span several months or years). Thus, more specific life-cycle models for families of similar projects were developed. A specific life-cycle model is a set of stages or phases that a family of projects goes through. The project's phases are performed in sequence or concurrently. The project life cycle defines the steps required to achieve the project goals as well as the content of each step. Thus, the literature on software projects is based on specific life-cycle models, such as the spiral model developed by Muench (1994), and the literature on construction projects is based on construction project life-cycle models, such as the one suggested by Morris (1981).

In the Morris (1981) model, a project is divided into four stages performed in sequence:

Stage I—feasibility. This stage terminates with a go/no-go decision for the project. It includes a formulation of the project, feasibility studies, strategy design, and strategy approval for the project.

Stage II—planning and design. This stage terminates with Major contracts Let. It includes base design, cost and schedule planning, contract definitions, and detailed planning of the project.

Stage III—production. This stage terminates with the installation substantially complete. It includes manufacturing, delivery, civil works, installation, and testing.

Stage IV—turnover and startup. This stage terminates with full operation of the facility. It includes final testing and maintenance.

Clearly this model does not fit R&D projects or software projects, while it may be very helpful for many construction projects.

With the integration of the ideas of project processes and the project life cycle, a methodology for project management emerges. The methodology is a collection of processes and a definition of

the part of each process that should be performed within each phase of the project life cycle. The responsibility to perform each process (or part of a process) can be allocated to specific individuals trained in the required tools and techniques. Furthermore, the information (input) required for each process can be delivered to the individuals responsible for the project, ensuring a well-coordinated flow of information and thus good communication between the project participants.

Templates or models of life cycles are useful for project management. When each phase is terminated with one or more completed documentable deliverables, the project-life cycle model is a simple yet very effective tool for monitoring and control of the project throughout its entire life cycle.

1.3. An Example of a Project Life Cycle

The Department of Defense uses a simple yet very popular life-cycle model for Defense acquisition (U.S. Department of Defense 1993):

Phase Number	Phase Description	Corresponding Milestone
	Determination of mission needs	Concept studies approval
0	Concept exploration and definition	Concept demonstration approval
1	Demonstration and validation	Development approval
2	Engineering and manufacturing development	Production approval
3	Production and deployment	Major modification approval as required
4	Operations and support	

2. PROJECT-MANAGEMENT PROCESSES

2.1. Definition of a Process

A process is a group of activities designed to transform a set of inputs into required outputs. There are three elements in the transformation of inputs into outputs:

1. Data and information
2. Decision making
3. Implementation and actions

A well-defined set of processes, supported by an appropriate information system (composed of a database and a model base) and implemented by a team trained in performing the processes is a cornerstone in the competitive edge of organizations.

2.2. Process Design

The design of a process is aimed at defining the following:

- Data required to support decisions, including:
  - The data sources
  - How the data should be collected
  - How the data should be stored
  - How the data should be retrieved
  - How the data should be presented as information to decision makers
- Models required to support decisions by transforming data into useful information, including:
  - Models that support routine decisions
  - Models that support ad hoc decisions
  - Models used for process control
- Data and models integration:
  - How data from the database is analyzed by the models
  - How information generated by the models is transferred and presented to decision makers

2.3. The PMBOK and Processes in the Project Life Cycle

A well-defined set of processes that applies to a large number of projects is discussed in the PMBOK (PMI 1996). Although some of the PMBOK processes may not apply to some projects, while other

PMBOK processes may need modifications in certain projects, the PMBOK is a well-accepted source of information and therefore the following definition of processes is based on the PMBOK.

The PMBOK classifies processes in two ways:

1. By sequence
   - Initiating processes
   - Planning processes
   - Executing processes
   - Controlling processes
   - Closing processes
2. By management function:
   - Processes in integration management
   - Processes in scope management
   - Processes in time management
   - Processes in cost management
   - Processes in quality management
   - Processes in human resource management
   - Processes in communication management
   - Processes in risk management
   - Processes in procurement management

The application of these processes in a specific organization requires customization, development of supporting tools, and training.

3. PROJECT INTEGRATION MANAGEMENT

3.1. Processes

Project integration management involves three processes:

1. Project plan development
2. Project plan execution
3. Overall change control

The purpose of these three processes is to ensure coordination among the various elements of the project. Coordination is achieved by getting inputs from other processes, integrating the information contained in these inputs, and providing integrated outputs to the decision makers and to other processes.

The project life-cycle model plays an important role in project integration management because project plan development is performed during the early phases of the project while project plan execution and project change control are performed during the other phases of the project. With a well-defined life-cycle model, it is possible to define the data, decision making, and activities required at each phase of the project life cycle and consequently train those responsible for performing the processes adequately.

3.2. Description

The project plan and its execution are the major outputs of this process. The plan is based on inputs from other planning processes (discussed later) such as scope planning, schedule development, resource planning, and cost estimating along with historical information and organizational policies. The project plan is continuously updated based on corrective actions triggered by approved change requests and analysis of performance measures.

Execution of the project plan produces work results—the deliverables of the project.

4. PROJECT SCOPE MANAGEMENT

4.1. Processes

Project scope management involves five processes:

1. Initiation
2. Scope planning

3. Scope definition
4. Scope verification
5. Scope change control

The purpose of these processes is to ensure that the project includes all work (and only that work) required for its successful completion.

In the following discussion, scope relates to the product scope (defined as the features and functions to be included in the product or service) and the project scope (defined as the work that must be done in order to deliver the product scope).

4.2. Description

The scope is defined based on a description of the needed product or service. Alternative products or services may exist. Based on appropriate selection criteria and a selection methodology, the best alternative is selected and a project charter is issued along with a nomination of a project manager. The project manager should evaluate different alternatives to produce the selected product or service and implement a methodology such as cost–benefit analysis to select the best alternative. Once an alternative is selected, a work breakdown structure (WBS) is developed. The WBS is a hierarchical presentation of the project scope in which the upper level is the whole project and at which the lowest-level work packages are defined. Each work package is assigned to a manager (organizational unit) responsible for its scope.

5. PROJECT TIME MANAGEMENT

5.1. Processes

Project Time Management involves five processes:

1. Activity definition
2. Activity sequencing
3. Activity duration estimating
4. Schedule development
5. Schedule control

The purpose of time management is to ensure timely completion of the project. The main output of time management is a schedule that defines what is to be done, when, and by whom. This schedule is used throughout the project execution to synchronize between people and organizations involved in the project and as a basis for control.

5.2. Description

Each work package in the WBS is decomposed into the activities required to complete its predefined scope. A list of activities is constructed and the time to complete each activity is estimated. Estimates can be deterministic (point estimates) or stochastic (distributions). Precedence relations among activities are defined, and a model such as a Gantt chart, activity on arc (AOA), or activity on nodes (AON) network is constructed (Shtub et al. 1994). An initial schedule is developed based on the model. This unconstrained schedule is a basis for estimating required resources and cash. Based on the constraint imposed by due dates, cash and resource availability, and resource requirements of other projects, a constrained schedule is developed. Further tuning of the schedule may be possible by changing the resource combination assigned to activities (these resource combinations are known as modes).

The schedule is implemented by the execution of activities. Due to uncertainty, a schedule control is required to detect deviations and decide how to react to such deviations and change requests. The schedule control system is based on performance measures such as actual completion of deliverables (milestones), actual starting time of activities, and actual finishing time of activities. Changes to the baseline schedule are required whenever a change in the project scope is implemented.

6. PROJECT COST MANAGEMENT

6.1. Processes

Project cost management involves four processes:

1. Resource planning
2. Cost estimating

3. Cost budgeting
4. Cost control

These processes are designed to provide an estimate of the cost required to complete the project scope, develop a budget based on management policies and strategy, and ensure that the project is completed within the approved budget.

6.2. Description

To complete the project activities, different resources are required. Labor, equipment, and information are examples of resources required to perform in-house activities, while money is required for outsourcing. The estimated amount of required resources as well as the timing of resource requirements are based on the activity list and the schedule. Resource allocation is performed at the lowest level of the WBS—the work package level—and requirements are aggregated to the project level and the whole-organization level. A comparison of resource requirements and resource availability is the basis of finite resource-allocation procedures (models) that assign available resources to projects and activities based on management's strategy and priorities. Resource planning results in a detailed plan specifying what resources are required for each work package. Applying the resource rates to the resource plan and adding overhead and outsourcing expenses allows a cost estimate of the project to be developed. The cost estimate is the basis for budgeting. Based on the schedule, cost estimates are time phased to allow for cash flow analysis. Furthermore, additional allocations are made, such as the management reserve required to buffer against uncertainty. The resulting budget is the baseline for project cost control.

Due to uncertainty, cost control is required to detect deviations and decide how to react to such deviations and change requests. The cost-control system is based on performance measures, such as actual cost of activities or deliverables (milestones) and actual cash flows. Changes to the baseline budget are required whenever a change in the project scope is implemented.

7. PROJECT QUALITY MANAGEMENT

7.1. Processes

Project quality management involves three processes:

1. Quality planning
2. Quality assurance
3. Quality control

The purpose of these processes is to ensure that the project will satisfy the needs for which it was undertaken. These needs are multidimensional—Garvin (1987) suggests that quality has eight dimensions or performance measures:

1. *Performance:* This dimension refers to the product or service's primary characteristics, such as the acceleration, cruising speed, and comfort of an automobile or the sound and picture clarity of a TV set. The understanding of performance required by the customer and the design of the service or product to achieve the required performance level are key factors in quality-based competition.
2. *Features:* This is a secondary aspect of performance—the characteristics that supplement the basic functioning. Garvin (1987) defines features as ''the bells and whistles'' of the product or service. The flexibility a customer has to select desired options from a large list of such options contributes to the quality of the product or service.
3. *Reliability:* This performance measure reflects the probability of a product malfunctioning or failing within a specified time period. It reflects on both the cost of maintenance and on downtime of the product.
4. *Conformance:* This is the degree to which the product or service design and operating characteristics meet established standards.
5. *Durability:* This is a measure of the economic and technical service duration of a product. It relates to the amount of use one can get from a product before it has to be replaced due to technical or economical considerations.
6. *Serviceability:* This measure reflects the speed, courtesy, competence, and ease of repair should the product fail. The reliability of a product and its serviceability complement each other. A

reliable product that rarely fails, and on those occasions fast and inexpensive service is available, has a lower downtime and better serves its owner.

7. *Aesthetics:* This is a subjective performance measure related to how the product feels, tastes, looks, or smells. It reflects individual preferences.
8. *Perceived quality:* This is another subjective measure related to the reputation of product or a service. This reputation may be based on past experience and partial information, but in many cases the customer's decisions are based on perceived quality because exact information about the other performance measures listed above is not readily available.

7.2. Description

Quality planning starts with the definition of standards or performance levels for each of the dimensions of quality. Based on the scope of the project, quality policy, standards, and regulations, a quality management plan is developed. The plan describes ''the organizational structure, responsibilities, procedures, processes, and resources needed to implement quality management'' (ISO 9000), that is, how the project management team will implement its quality policy to achieve the required quality levels. Checklists and metrics or operational definitions are also developed for each performance measure so that actual results and performance can be evaluated against specified requirements.

To provide confidence that the project will achieve the required quality level, a quality assurance process is implemented. By continuously reviewing (or auditing) the actual implementation of the plan developed during quality planning, quality assurance systematically seeks to increase the effectiveness and efficiency of the project and its results.

Actual results are monitored and controlled. This quality-control process provides input to quality assurance as well as a firm basis for acceptance (or rejection) decisions.

8. PROJECT HUMAN RESOURCE MANAGEMENT

8.1. Processes

Project human resource management involves three processes:

1. Organizational planning
2. Staff acquisition
3. Team development

These processes deal with the management of human resources during the project life cycle. The processes are aimed at making the most effective use of people involved with the project. The temporary nature of project organizations, the multidisciplinary teams required in many projects, and the participation of people from different organizations in the same project require special attention to team building, motivation, leadership, and communication in order to succeed.

8.2. Description

The work content of the project is allocated to the performing organizations by integrating the work breakdown structure (WBS) with the organizational breakdown structure (OBS) of the project. At the lowest level, these two hierarchical structures define work packages—specific work content assigned to specific organizational units. The managers of work packages are responsible for managing the building blocks of the projects. Each work package is an elementary project with a specific scope, schedule, budget, and quality requirements. Organizational planning activities are required to ensure that the total work content of the project is assigned and performed by the work packages and integration of the deliverables produced by the work packages into the final product results is possible according to the project plans. The organizational plan defines roles and responsibilities as well as staffing requirements and the OBS of the project.

Based on the organizational plan, staff assignment is performed. Availability of staff is compared to the requirements and gaps identified. These gaps are filled by staff-acquisition activities. The assignment of available staff to the project and the acquisition of new staff result in the creation of a project team that may be a combination of employees assigned full-time to the project, full-time employees assigned part-time to the project, and part-timers.

The assignment of staff to the project is the first step in the team-development process. To succeed in achieving the project goals, a team spirit is needed. The transformation of a group of people assigned to a project into a high-performance team requires leadership, communication skills, and negotiation skills as well as the ability to motivate people, coach and mentor them, and deal with conflicts in a professional yet effective way.

9. PROJECT COMMUNICATIONS MANAGEMENT

9.1. Processes

Project communications management involves four processes:

1. Communications Planning
2. Information Distribution
3. Performance reporting
4. Administrative closure

These processes are required to ensure ''timely and appropriate generation, collection, dissemination, storage, and ultimate disposition of project information'' (PMI 1996). The processes are tightly linked with organizational planning. The communication within the project team, with stakeholders, and with the external environment can take many forms, including formal and informal communication, written or verbal communication, and planned or ad hoc communication. The decision regarding communication channels, the information that should be distributed, and the best form of communication for each type of information is crucial in supporting teamwork and coordination.

9.2. Description

Communications planning is the process of selecting the communication channels, the modes of communication and the contents of the communication among project participants, stakeholders, and the environment. Taking into account the information needs, the available technology, and constraints on the availability and distribution of information, the communications-management plan specifies the frequency and the methods by which information is collected, stored, retrieved, transmitted, and presented to the parties involved in the project. Based on the plan, data-collection as well as data-storage and retrieval systems can be implemented and used throughout the project life cycle. The project communication system, which supports the transmission and presentation of information, should be designed and established early on to facilitate the transfer of information.

Information distribution is based on the communication-management plan. It is the process of implementing the plan throughout the project life cycle to ensure proper and timely information to the parties involved. In addition to the timely distribution of information, historical records are kept to enable analysis of the project records to support organizational and individual learning. Information related to performances of the project is important. Performance reporting provides stakeholders with information on the actual status of the project, current accomplishments, and forecasts of future project status and progress. Performance reporting is essential for project control because deviations between plans and actual progress trigger control actions.

To facilitate an orderly closure of each phase and of the entire project, information on actual performance levels of the project phases and product is collected and compared to the project plan and product specifications. This verification process ensures an ordered formal acceptance of the project products by the stakeholders and provides a means for record keeping that supports organizational learning.

10. PROJECT RISK MANAGEMENT

10.1. Processes

Project risk management involves four processes:

1. Risk identification
2. Risk quantification
3. Risk response development
4. Risk response control

These processes are designed to evaluate the possible risk events that might influence the project and integrate proper measures to handle uncertainty in the project-planning monitoring and control activities.

10.2. Description

A risk event is a discrete random occurrence that (if occurring) affects the project. Risk events are identified based on the difficulty to achieve the required project outcome (the characteristics of the product or service), constraints on schedules and budgets, and the availability of resources. The environment in which the project is performed is also a potential source of risk. Historical information

is an important input in the risk-identification process—knowledge gaps are a common source of risk in projects. Risks are generated by different sources, such as technology—an effort to develop, use, or integrate new technologies in a project creates a knowledge gap and consequently risks. External risks such as new laws or a strike in government agencies may generate project risks. Internal sources within the project or its stakeholders may also do so. The probability of risk events and the magnitude of their affect on the project success are estimated during the risk-quantification process. This process is aimed at an effort to rank risks in order of the probability of occurrence and the level of impact on the project. Thus, a high risk is an event that is highly probable and may cause substantial damage to the project.

Based on the magnitude of risk associated with each risk event, a risk response is developed. Several responses are used in project management, including:

- *Risk elimination:* In some projects it is possible to eliminate some risks altogether by using a different technology, a different supplier, etc.
- *Risk reduction:* If risk elimination is too expensive or impossible, risk reduction may be used by reducing the probability of a risk event or its impact or both. A typical example is redundancy in R&D projects when two mutually exclusive technologies are developed in parallel to reduce the risk that a failure in development will harm the project. Although only one of the alternative technologies will be used, the redundancy reduces the probability of a failure.
- *Risk sharing:* It is possible in some projects to share risks (and benefits) with some stakeholders such as suppliers, subcontractors, partners, or even the client. Another form of risk sharing is with an insurance company.
- *Risk absorption:* If a decision is made to absorb the risk, buffers in the form of management reserve or extra time in the schedule can be used. In addition, contingency plans may be appropriate tools to help in coping with the consequences of risk events.

Since information is collected throughout the life cycle of a project, additional information is used to continuously update the risk-management plan. Risk-response control is a continuous effort to identify new sources of risk, update the estimates regarding probabilities and impacts of risk events, and activate the risk-management plan when needed. Constantly monitoring the project progress in an effort to update the risk-management plan and activate it when necessary can reduce the impact of uncertainty and increase the probability of successful project completion.

11. PROJECT PROCUREMENT MANAGEMENT

11.1. Processes

Project procurement management involves six processes:

1. Procurement planning
2. Solicitation planning
3. Solicitation
4. Source selection
5. Contract administration
6. Contract closeout

These processes are required to acquire goods and services from outside the performing organization (from consultants, subcontractors, suppliers, etc.). The decision to acquire such goods and services (the make or buy decision) has a short-term or tactical level (project-related) impact as well as a long-term or strategic level (organization-related) impact. At the strategic level, core competencies should rarely be outsourced even when outsourcing can reduce the project cost, shorten its duration, reduce its risk, or provide higher quality. At the tactical level, outsourcing can elevate resource shortages, help in closing knowledge gaps, and increase the probability of project success.

Management of the outsourcing process from supplier selection to contract closeout is an important part of the management of many projects.

11.2. Description

The decision on what parts in the project scope and product scope to purchase from outside the performing organization, how to do it, and when to do it is critical to the success of most projects. This is not only because significant parts of many project budgets are candidates for outsourcing, but because the level of uncertainty and consequently the risk involved in outsourcing are quite different from the levels of uncertainty and risk of activities performed in-house. In order to gain a

competitive advantage from outsourcing, well-defined planning, execution, and control of outsourcing processes supported by data and models (tools) are needed.

The first step in the process is to consider what parts of the project scope and product scope to outsource. These are decisions regarding sources of capacity and know-how that can help the project in achieving its goal. A conflict may exist between the goals of the project and other goals of the stakeholders. For example, subcontracting may help a potential future competitor develop know-how and capabilities. This was the case with IBM when it outsourced the development of the Disk Operating System (DOS) for the IBM PC to Microsoft and the development of the CPU to Intel. The analysis should take into account the cost, quality, speed, risk, and flexibility of in-house vs. outsourcing. Outsourcing decisions should also take into account the long-term or strategic factors discussed earlier.

Once a decision is made to outsource, a solicitation process is required. Solicitation planning deals with the exact definition of the goods or services required, estimates of the cost and time required, and preparation of a list of potential sources. During solicitation planning, a decision model can be developed, such as a list of required attributes with a relative weight for each attribute and a scale for measuring the attributes of the alternatives. A simple scoring model, as well as more sophisticated decision support models prepared at the solicitation-planning phase, can help in reaching consensus among stakeholders and making the process more objective.

Solicitation can take many forms: a request for proposal (RFP) advertised and open to all potential sources is one extreme, while a direct approach to a single preferred (or only) source is another extreme—with many variations in between, such as the use of electronic commerce. The main output of the solicitation process is one or more proposals for the goods or services required. A well-planned solicitation-planning process followed by a well-managed solicitation process is required to make the next step, source selection, efficient and effective.

Source selection is required whenever more than one adequate source is available. If a proper selection model is developed during the solicitation-planning process and all the data required for the model are collected from the potential suppliers during the solicitation process, source selection is easy, efficient, and effective. Based on the evaluation criteria and organizational policies, proposals are evaluated and ranked. Negotiations with the highest-ranked suppliers can take place to get the best and final offer, and the process is terminated when a contract is signed. If, however, solicitation planning and the solicitation process do not yield a clear set of criteria and a selection model, source selection may become a difficult and time-consuming process; it may not end with the best supplier selected or the best possible contract signed. It is difficult to compare proposals that are not structured according to clear RFP requirements; in many cases important information is missing in the proposals.

Throughout the life cycle of a project, contracts are managed as part of the execution and change control efforts. Work results are submitted and evaluated, payments are made, and, when necessary, change requests are issued. When these are approved, changes are made to the contracts. Contract management is equivalent to the management of a work package performed in-house, and therefore similar tools are required during the contract-administration process.

Contract closeout is the closing process that signifies formal acceptance and closure. Based on the original contract and all the approved changes, the goods or services provided are evaluated and, if accepted, payment is made and the contract closed. Information collected during this process is important for future projects and supplier selection because effective management is based on such information.

12. THE LEARNING ORGANIZATION: CONTINUOUS IMPROVEMENT IN PROJECT MANAGEMENT

12.1. Individual Learning and Organizational Learning

Excellence in project management is based on the ability of individuals to initiate, plan, execute, control, and terminate the project scope and product scope successfully. The ability of individuals to master product- and project-related processes is the foundation on which organizational learning is built. Individual learning can take many forms, including the learning of verbal knowledge, intellectual skills, cognitive strategies, and attitudes. The learning mechanism can also take many forms, including learning by imitation of other people or learning by repetition of a process.

The ability of groups to improve performances by learning is also very important. Katzenbach and Smith (1993) explain how important it is to combine individual learning with team building.

A project team must combine these two learning processes in order to succeed. As it is important for each individual to learn and master his part in the product scope and in the project scope, it is equally important for the group to learn how to work as a team. Team building and organizational learning are important in the project environment. Establishing clear processes in which the input to each process is well defined and the individuals responsible for the process master the tools and techniques required to do the process right and to produce the desired output enables excellence in project management to be achieved.

12.2. Workflow and Process Design as the Basis of Learning

Successful project management requires successful planning, execution, and control of project scope and the product scope. The one-time, nonrepetitive nature of projects makes uncertainty a major factor affecting a project's success. In addition, the ability to learn by repetition is limited because most projects are unique. A key to project-management success is the exploitation of the repetitive parts of project scope. Identifying repetitive processes (repetitiveness within the project as well as repetitiveness between projects) and building an environment that supports learning and data collection enhances competitiveness in project management.

A key tool in building a learning–supporting environment is the design and implementation of a workflow-management system–a system that defines, manages, supports, and executes information-processing and decision-making processes. Each of the processes discussed in this chapter should be studied, defined, and implemented within the workflow management system. The definition includes the trigger (which initiates the process) of the process, inputs to the process, the participants in the process, the activities performed and required data processing, models used, the order or sequence of processing, and finally, process termination conditions and the process results or deliverables. The workflow-management system employs a workflow-enactment system or workflow-process engines that can create, manage, and execute multiple process instances.

By identifying the repetitive processes shared by many projects performed by an organization, it is possible to implement a workflow system that supports and even automates the repetitive processes. Automation means that the routing of each process is defined along with the input information, processing, and output information. Thus, although the product scope may vary substantially from project to project, the execution of the project scope is supported by an automatic workflow system that reduces the level of uncertainty (processes are clearly defined and the flow of information required to support these processes is automatic) and enables learning. The well-structured process can be taught to new employees or learned by repetition. In projects performed by the organization, the same processes are repeated, the same formats are used to present information, and the same models support decision making.

Definition of processes and the support of these processes by a workflow-management system are key to the success of organizations dealing repeatedly with projects.

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