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"PROJECT INTEGRATION"

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SUBJECT: PROJECT MANAGEMENT

"PROJECT INTEGRATION"

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TABLE OF CONTENTS

PROJECT INTEGRATION

INTRODUCTION

A New view of program, project, and business management, an integrative *wrap-around*, of sorts, of the current state of the art, builds on the Project Management Institute (PMI) "Project Integration Management" standard in the Project Management Body of Knowledge (PMBOK), and then goes farther into the complex dynamics and interdependencies of modern project organization. Thus it will be useful to all current and prospective PMI members in testing for the Project Management Professional (PMP) certification and keeping current. Traditional project management tools and techniques are framed in a series of integration models or metaphors. The integration model is a *forward-looking* concept, beginning with the individual and *building out* to project outcomes, technology, team, organization, business systems, customer and market segment, the overall business regime, and, finally, the global economy. Here the integration is defined at each level and builds toward a conceptual framework of *interconnection and purpose* that defines a successful project and program of projects.

Integration actually defines program management, that body of knowledge and practice dealing with multi project portfolios, project selection methods, and long-term, complex programs with multiphases. Thus, are designed to support program managers as they seek out their roles in the upper reaches of the organization, working to implement business strategy through successful, integrated projects.

INTEGRATION: CONCEPTS AND MODELS

What does integration look like? One way to answer this question quickly is to look at two ways to achieve cost control. The simplest way to control cost is to match actual spending to the spending plan, pure and simple. An accounting office might do control that way, lacking any other information or perspective. This is a classic mistake in cost control that does not integrate with work performance or value. The integrated cost control approach, on the other hand, involves looking at cost from the standpoint of work performed and quality/value achieved, not simply in terms of costs incurred. Integrated cost control is a *forward integration tool* that points toward completion of the work, keys on current progress, and matches costs to quality output. Forward cost control involves looking at the variance between the work performed in project execution against *what it should have cost to do that work.* It also looks at the value or quality of the deliverable at any given time to ensure that the customer is getting value for the dollar spent. In other words, a good indicator of whether you are forward integrating your cost control is whether invoices for work performed are paid. What does integration *feel like*? In other words this overused term has a significant meaning in many fields, perhaps beyond its literal translation. Asking what integration feels like is not as superficial as it may sound. To explore when we have it is to explore how to get it. The following indicators come to mind:

1. When there is complete integration, a project deliverable reflects in its performance and value to the customer and stakeholders all the project requirements and components outlined for it in the project plan and work

breakdown structure (WBS), along with horizontal and lateral coordination. Further, the design and performance of the product facilitates the customer's performance because it is integrated *into the customer's systems.*
2. When there is complete integration, all parties to a program and project— managers, team members, support people, suppliers, and customers—all are delighted with the project outcome and deliverables, and with their roles in its success.

3. When there is complete integration, all costs, schedule, quality, and risk factors, and changes along the way, are adequately reflected in the final outcome and due dates. The learning that occurs in a program or project is integrated into the product or service through *integrated* change controls.
4. When there is complete integration, the professional and technical project staffs, for instance, administrative staff, support people, software engineers, mechanical engineers, electrical engineers, and construction workers, who participated in defining specific components for a technical product deliverable, feel they have made a significant contribution and gained new working relationships with their colleagues.

5. When there is complete integration, there are no surprises and there has been an effective blending of cost, schedule, and quality considerations along the way in the project cycle; earned value has been maximized given project developments.

What significance does integration have for program and project managers in tomorrow's business settings?

Since the term integration is the key, let's explore what integration means. The concept of integration has many dimensions, individual, technological, organizational, interpersonal, and informational, but the core concept of integration is grounded in *connection and alignment.* But why will integration be more important in tomorrow's business organization? What makes integration key to organization and product performance? Integration means *completeness* and *closure*, bringing components of the "whole" together in an operating system. Components of a larger system, increasingly global in nature, are brought together to create performance; but what is the process of integration and how does it work generically? The answer lies in systems theory; a system is a series of parts working together with a common objective. Once the whole is defined, the analysis function breaks down the whole into its components for purposes of understanding, building, and managing the system. Integration then puts the "built components" of a system back together to create a performance model that is aligned, so that, all components work together as they were designed to. Projects must be internally and externally integrated; internal integration means that project work packages, deliverables, and systems are connected; external integration means that the project interfaces with customer systems and produces value for the customer and the market/industry as a whole. Repeated internal and external project integration produces economic development in the larger community and societal framework. The characteristics of integration that help to frame our understanding of program and project management and that underlie are as follows: [1]

Figure 1.1 Characteristics of integration

1. SYSTEMS DON'T INTEGRATE, PEOPLE DO. The individual and project team members, working with an external contingent of support people and stakeholders, are the beginning of integration. The way people who work in a project environment think about their roles, responsibilities, and tasks creates the conditions for integration. *Integration thinking* means that as people perform their functions; their behaviors reflect an awareness of impacts on other team members and on other product components, and most importantly on the customer's satisfaction with the outcome. *Integration support systems* connect key aspects of project performance, so that data are produced automatically on cost, schedule, and quality to allow informed decisions.

2. FORWARD INTEGRATION means that communication and connection is focused *forward* on producing deliverables and creating customer satisfaction, not necessarily to bring a project back to its original plan. Plans are estimates; real work performance serves as the basis for corrective action. Forward integration is a downstream concept in which work is performed to provide value downstream toward the deliverable; sequence means that integration occurs at the right moment in the process. This is a horizontal function, cutting across traditional functions to create synergy and cooperation.

3. TOP MANAGEMENT builds the culture and mechanisms for successful connection and integration, involving extensive coordination by a centralized program and project management function that works to avoid disconnected efforts throughout the enterprise.

4. Integration means integrity. There is a connection between integrity, e.g., producing what you promise and doing it in a professional and ethical way, and integration, making sure required connections occur at the right time. The outcome, product, or service has integrity because it is integrated.

4. ACCOUNTABILITY REQUIRES INTEGRATION; new requirements, including the Sarbanes-Oxley legislation, demand top management fiscal accountability, making financial and work performance integration imperative. The new requirement for internal accountability stresses internal control and checks and balances. Once seen as a low-level accounting and audit requirement, this new mandate now requires integration at every level of the organization, including programs and projects.

5. INTEGRATION BEGINS AT THE BUSINESS LEVEL. New forces require a new way of thinking about business itself, business strategy and operations, projects, and markets. These forces come about from developing changes in the landscape of business management, most notably at the global level; integration now occurs across geographical, economic, political, and system boundaries as never before.

6. THE "REGIME" OF BUSINESS, the whole business enterprise system, is also changing as more and more middle and small businesses surface and disappear with the tides of business fortune. How does a business organization, designed as it is to grow and profit through serving customers, assure that it plays in the regime of business fairly and with integrity? Such a business plays by the rules not just to avoid regulatory and government interference, but because *the business equates success with integrity.*[2]

VERTICAL AND HORIZONTAL INTEGRATION

There are two types of integration and they are both essential success factors, particularly in a multi project program environment. They are vertical and horizontal integration. Vertical integration looks *inside* and *up and down* into the business, program, project, and product/service components. This kind of integration targets the program, project, and product, and builds a product or service with integrity. It looks downstream in the project process to product performance and customer satisfaction. Horizontal integration looks *outside and around* to the external, the environmental, and the *organizational assets that support the project*. It focuses on outside forces that create risk and opportunity, market forces that will shape the product or service. Vertical integration is program integration; it proceeds down the project, going deep into the project processes and product configuration. It focuses on performance. Vertical integration is related to horizontal integration in the sense that a project that reflects outside factors and environmental scanning information is more to succeed in its performance because these factors can make or break a project.

ANALYSIS, SELECTION, AND SCHEDULING: PORTFOLIO INTEGRATION

Vertical and horizontal integration factors are reflected in the analysis, selection, and scheduling of projects and portfolio integration. Programs or product lines are "chunks" of business development that will help define a portfolio of projects to improve business performance. Once these programs are identified, we can identify five projects in each program as candidate projects to implement. In effect, you might be choosing three projects from a series of 15 projects for implementation. We use a variety of program management tools in selecting the three projects that will be planned and scheduled in detail.

THESE TOOLS INCLUDE:

1. *Cash flow analysis*. This tool requires you to forecast the first 5 years of cash flow for each project. Costs will come from a budget built up from a preliminary task list and schedule for the project, while revenues will come from your assessment of how the project deliverable or product will generate income or "value." A cash flow estimate can be identified for a project that does not produce a marketable product but adds value to the program portfolio. Simply allocate value each year to the benefits of the project to a user or customer in order to estimate the cash flow equivalent to the stream of project benefits.

2. *Net present value* (NPV). This tool requires taking the cash flow analysis you have prepared and calculate the net present value of each so that you can compare all the projects regardless of how many years their cash flow is projected.

3. *Risk assessment and management.* This tool requires identifying the high-level risks in each project and preparing a risk matrix, including task, task risk description, impact, probability, severity, and contingency plans.

4. *Weighted scoring model.* This tool allows scoring each project against the various strategic objectives of a company, to place weights on each strategic objective and multiply the scores by the weights to get a "weighted" score for each project. Performing this analysis for each project will be using the results to rank the projects in each program and to select three projects for detailed scheduling and budgeting using Microsoft Project. The selected projects may not be the ones most highly ranked in ordered listing, but they will be the three projects that must be implemented first, to enable the remaining projects to be implemented to integrate the program and business strategic objectives.

E-PROCUREMENT: EXAMPLE OF HORIZONTAL INTEGRATION

Project managers must look and work across the organization with supporting departments that are not directly invested in the project but those who support it. This includes working with procurement and acquisition services that are sometimes at odds with short-term project goals. This means project managers must be attuned to these questions and issues at the interface with the project:

1. e-Procurement and electronic data exchange with contractors and between businesses; new developments in Web-based supply management. Horizontal integration involves looking at the outside forces that will affect the project, working across an organization with supporting organizational assets. At the global level, this kind of integration involves looking at global supply chains, global economic and political factors, multinational corporate risks and opportunities, and the Internet. At the project level it involves looking at organizational assets that support the project such as e-Procurement and Web-based acquisition strategies.

2. Supply chain management and the Web, building partnerships with suppliers across an industry to achieve cheaper, better, faster procurement, which, however, sometimes conflicts with short-term project goals.

3. Supplier quality management, e.g., ISO requirements for vendors, qualifying suppliers to business with many project managers in a multi-project environment.

4. New product information and sourcing systems, the digitized catalog, sometimes restricting project managers to choose from suppliers they may not want to work with.[3]

PMBOK AND PROJECT PLANNING

The PMBOK standard on project integration management focuses on planning, execution, monitoring, and change control. This standard is the platform for all the other standards – providing the overall framework for subsequent concepts and tools. The PMBOK standard defines a *project management plan* as a plan to include *both* how the project will be *managed*, as well as how the *product or service itself will be produced*, for instance, technical characteristics, technical processes and stages, and product specifications as stated in the scope of work. PMBOK incorporates the scope of work in the plan, including technical and management/scheduling components.

PROJECT MANAGEMENT PLAN

The project integration management plan is a management document dealing with how resources are to be used, how project progress is to be monitored, how reporting will occur, and financial and funding issues relative to the project. The plan also includes the technical and product information necessary to produce the deliverable. This plan has the following elements:

1. Business plan and relevant strategic objectives
2. Project management process to be used
3. Program and product line framework
4. Documentation requirements
5. Reporting and monitoring approach
6. Cost benefit analyses, cost control, and finance issues
7. Conflict resolution approach
8. Stage-gate review requirements
9. Business and program/project organization
10. Roles and responsibilities
11. Project schedule and key milestones
12. Change control procedures
13. Team contact directory
14. Customer performance and technical requirements document
15. Project deliverable definitions
16. Generic WBS and data dictionary
17. Technical stage-gate process and phases
18. Design review requirements
19. Industry standards
20. Testing and user approval procedures
21. Regulatory and international technical constraints
22. Configuration management requirements for transition to production

Strategic Planning

The Eastern case deals with global strategic planning, integration of risk into the business planning process, and the articulation of the company's approach to implementing its strategic objectives. The integration message of this case is that integration starts very early in the business planning and portfolio development process and that projects that are generated out of an integrated process at the top tend to have higher probabilities of project success. This is because one of the key reasons for project failure has been the lack of top management support; integration at the business plan level assures more visibility of the project at the top of the organization and more opportunity to develop reliable sponsors in upper management.

Ethics and Project Integration

There was a time when project accounting records, costs, and expenses of business projects were *beneath the eye level* of top business management. That time is past. The integration of projects into a corporate portfolio has implications for corporate ethics and accountability. As the recent Enron case indicates, the source of Enron's problems in accountability and abuse of reporting accounting were grounded in part in the lack of an integrated project accounting system. Enron was a classic multi-project corporate environment. As such, top management had direct and continuous contact with the many natural gas project investments and projects in the company; in fact, they created many of these projects in their negotiations with their many potential customers, for instance, utilities, manufacturing plants, communities, and the like. Some top managers were paid bonuses based on profits *attributable to individual projects they generated.* The new Sarbanes-Oxley legislation and regulation now requires that business officers sign-off on business and financial reporting and assure that internal controls are in place to track all business expenditures to make sure that they are legitimate. In project-oriented companies such as Enron, this means that now actual costs must be integrated into project planning and management. Project integration is associated with both program and project management.

Integration Model

The integration model that follows (Fig. 1.1) captures the essential factors requiring a new level of integration in program and project management.

People - People integrate, not systems, so people are trained to coordinate and interact with program and project participants, forming a true interdisciplinary team.

Projects - Projects become more cross-functional as project work is defined in terms of coordination and integration of work.

Technology - Complex products are managed at the interface, placing more emphasis on product and service integration.

Financial, schedule, risk, and quality combined - Through earned value and integrative tools, program and project progress is seen in terms of the combined impacts on financial, schedule, risk response, and quality issues.

Program management applications - Integration defines the program manager's role; working between top management and project managers; program managers integrate projects with company plans and strategies, and work with enterprise-wide resource management systems.

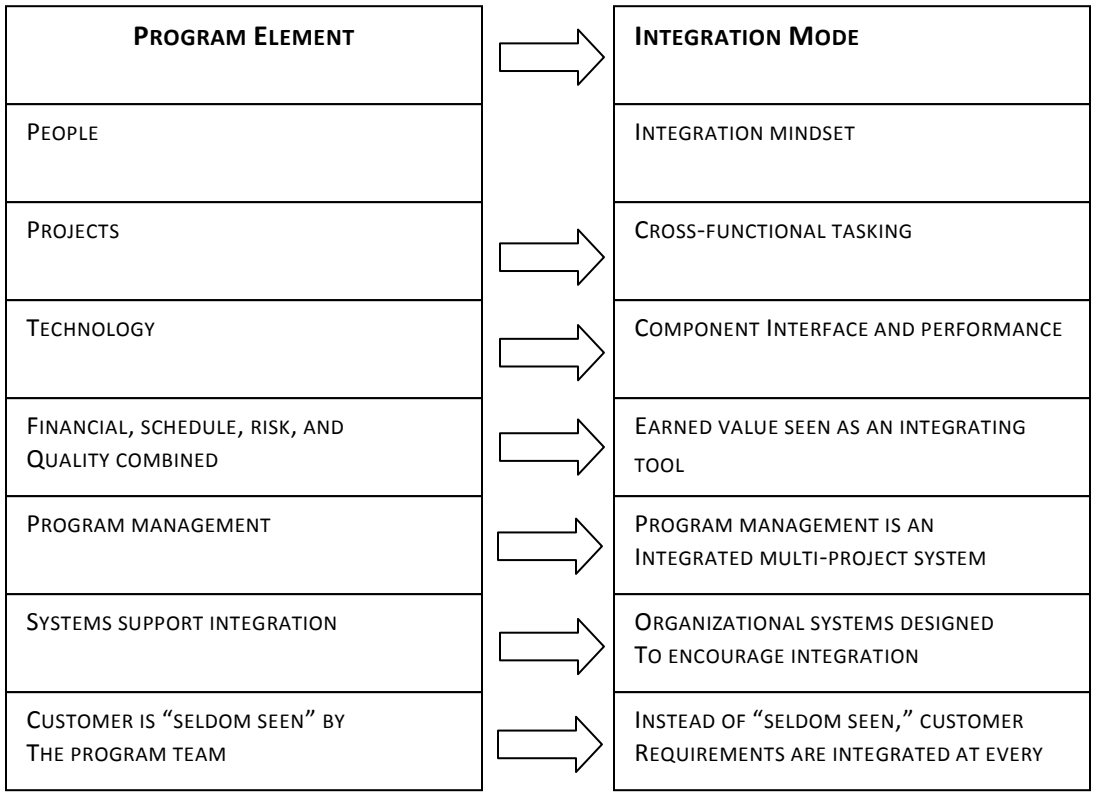

Figure 1.2 Program and project management integration

Systems support integration - Organizational and information technology systems are designed to interface with each other and to encourage integration.

Customer is "seen" by the program team - All programs and project activity is performed with the customer in full view, integrating the work with customer's expectations.[4]

PROJECT INTEGRATION MANAGEMENT: ORGANIZATIONAL ISSUES

The model for successful project integration management starts with the organizational reform, with the key steps shown in Fig. 1.2.

PREPARE THE ORGANIZATION

As will be seen in the analysis of PMI PMBOK requirements for integration, the concept of organizational and technical coordination starts with a key business process focused on organizational integration.

Figure 1.3 Key steps for project integration management

The process of putting things together and recognizing the interdependencies of the project process is the first priority. It starts with preparing a culture and supporting mechanism for working together for a shared outcome and deliverable, and designing systems to integrate rather than diffuse organizational performance. Preparing the organization starts with a corporate and enterprise policy on integration, backed up by top managers who *walk the talk* that brings people and system together, and treats the outcome as a shared vision.

DEVELOP SYSTEMS OF INTEGRATION

Systems of integration include business processes such as design reviews, project earned value analysis, configuration management, software compatibility, and interdisciplinary assignments. The more the organization provides mechanisms that in their very existence further integration, the more successful the integration process will be.

DEVELOP INTEGRATION SKILLS

Integration skills start with a mindset that one's project tasks fit into a larger whole, and that the success of the project and the enterprise itself is dependent on the collective success and efficiency involved in producing the product or service.

RECOGNIZE INTEGRATION SUCCESS

What you recognize and measure is usually what you get, therefore the success of integration in planning and project management begins in what the company measures and rewards. Measurement of integration success can be accomplished using various indicators of integration:

1. Duration of integration tasks, looking for faster integration turnarounds
2. Conflict intensity during integration
3. Lessons learned.[5]

INTEGRATE WITH THE CUSTOMER

The final integration is the alignment with customer expectations and systems, leading to "perfect storm" of timing and performance with the customer's processes. This integration can be accomplished by keeping the customer involved and engaged throughout the project life cycle. The Project Management Institute (PMI) standard for project integration has fundamentally changed from its early form—a narrow focus on project-only issues—to a broader treatment, published in 2005, of project integration from an organization-wide, global view. Project integration is now a project management knowledge area that includes the processes and activities needed to identify, define, combine, unify, and coordinate the various processes and project management activities within the project management groups, such as, initiating, planning, executing, monitoring, controlling, and closing. In the project management context, integration includes the characteristics of unification, consolidation, articulation, and integrative actions that are crucial to project completion, successfully meeting customer and other stakeholder requirements, and managing expectations.

Integration, in the context of managing a project, is making choices about where to concentrate resources and effort on any given day, anticipating potential issues, dealing with these issues before they become critical, and coordinating work for the overall good of the project. The integration effort also involves making trade-offs among competing objectives and alternatives.

What this means in simple terms is that integration has become the essential pulling together of project and organizational systems and processes for a multi-project, portfolio approach to project management. Integration is essentially the major function of program management, running several projects simultaneously and using all the support systems of the organization. Integration brings together all of the PMBOK processes, including cost management, time management, and risk management. These processes interact to provide opportunities for tradeoffs between schedule, cost, and performance of the deliverable. The deliverable should reflect the benefits of integration – the most cost-effective product possible, within resource and time constraints, that meets or exceeds customer expectations. Most experienced project practitioners know that there is no single way to manage a project. They apply project management knowledge, skills, and processes in different orders and degrees of rigor to achieve the desired project performance. However, the perception that a particular process is not required, e.g. cost, does not mean that it should not be addressed. The project manager and project team must address every process, and the level of implementation for each process must be determined for each specific project. Some integrative activities performed by the project management team include:

- Analyze and understand the scope. This includes the project and product requirements, criteria, assumptions, constraints, and other influences related to a project, and how each will be managed or addressed within the project.
- Document specific tradeoffs inherent in product requirements.
- Understand how to take the identified information and transform it into a project management plan using the planning process group described in the Project Management Body of Knowledge (PMBOK) guide.
- Prepare the work breakdown structure (WBS).

- Take appropriate action to have the project performed in accordance with the project management plan, the planned set of integrated processes, and the planned scope.

- Measure and monitor project status, processes, and products.

- Analyze project risks. PMBOK assumes separate "process groups," linked at various points, or "gates," in the project. The planning process group provides the executive process group with a documented project management plan early in the project and then facilitates updates to the project management plan if changes occur as the project progresses. Integration is primarily concerned with effectively integrating the processes among the project management process groups that are required to accomplish project objectives within an organization's defined procedures. Figure 1.3 provides an overview of the major project management integrative processes. Figure 1.3 provides a process flow diagram of those processes and their inputs, outputs, and other related knowledge area processes. The integrative project management processes include the following steps:

a. Develop project charter - Developing the project charter that formally authorizes a project or a project phase.
b. Develop preliminary project scope statement - Developing the preliminary project scope statement that provides high-level scope narrative.
c. Develop project management plan - Documenting the actions necessary to define, prepare, integrate, and coordinate all subsidiary plans into a project management plan.
d. Direct and manage project execution - Executing the work defined in the project management plan to achieve the project's requirements defined in the project scope statement.
e. Monitor and control project work - Monitoring and controlling the processes used to initiate, plan, execute, and close a project to meet performance objectives defined in the project management plan.
f. Integrated change control - Reviewing all change requests, approving changes, and controlling changes to the deliverables and organizational process assets.
g. Close project - Finalizing all activities across all the project management process groups to formally close the project or a project phase.[6]

DEVELOP PROJECT CHARTER

The project charter is the document that formally authorizes a project. The project charter provides the project manager with the authority to apply organizational resources to project activities. A project manager is identified and assigned as early in the project as is feasible.

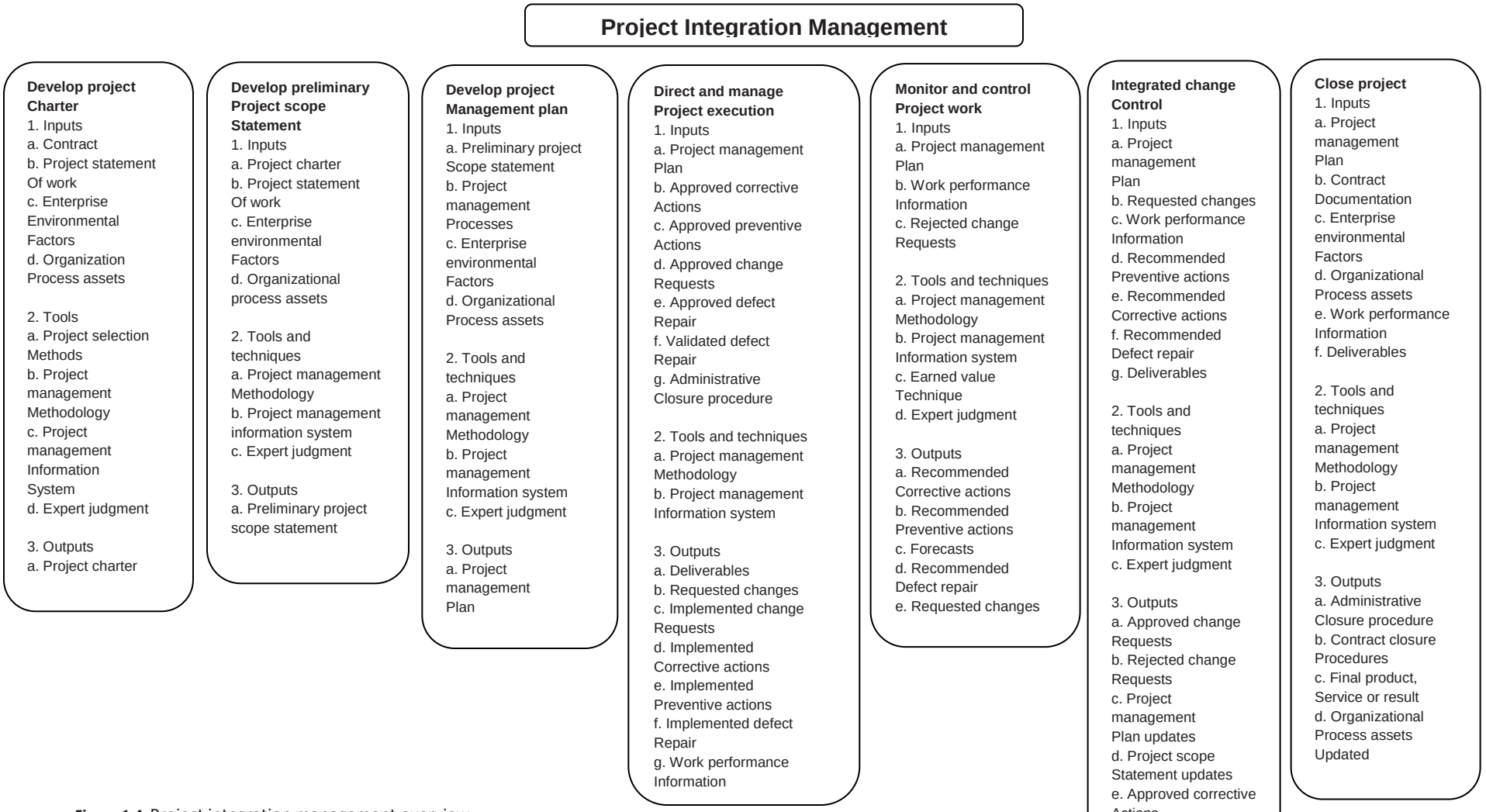

Figure 1.4. Project integration management overview.

DEVELOP PROJECT MANAGEMENT PLAN

The develop project management plan process includes the actions necessary to define, integrate, and coordinate all subsidiary plans into a project management plan. The project management plan content will vary depending upon the application area and complexity of the project. This process results in a project management plan that is updated and revised through the integrated change control process. The project management plan defines how the project is executed, monitored, controlled, and closed. The project management plan documents the collection of outputs of the planning processes of the planning process group and includes:

- The project management processes selected by the project management team.
- The level of implementation of each selected process.
- The descriptions of the tools and techniques to be used for accomplishing those processes
- How the selected processes will be used to manage the specific project, including the dependencies, interactions among those processes, and the essential inputs and outputs
- How work will be executed to accomplish the project objectives
- How changes will be monitored and controlled
- How configuration management will be performed
- How integrity of the performance measurement baselines will be maintained and used
- The need and techniques for communication among stakeholders
- The selected project life cycle and, for multiphase projects, the associated project phases
- Key management reviews for content, extent, and timing to facilitate addressing open issues and pending decisions. [7]

Figure 1.5. *PMI Knowledge Areas[8]*

The project management plan can be composed of one or more subsidiary plans and other components. Each of the subsidiary plans and components is detailed to the extent required by the specific project. These subsidiary plans include, but are not limited to:

- Project scope management plan
- Schedule management plan
- Cost management plan
- Quality management plan
- Process improvement plan
- Staffing management plan
- Communication management plan
- Risk management plan
- Procurement management plan
- Milestone list
- Resource calendar
- Schedule baseline
- Cost baseline
- Quality baseline
- Risk register

DIRECT AND MANAGE PROJECT EXECUTION

The direct and manage project execution process requires the project manager and the project team to perform multiple actions to execute the project management plan to accomplish the work defined in the project scope statement. Some of these actions are:

Figure 1.6. Manage Project Execution

The project manager, along with the project management team, directs the performance of the planning project activities, and manages various technical and organizational interfaces that exist within the project. The direct and manage project execution process is directly affected most by the project application area. Deliverables are produced as outputs from the processes performed to accomplish the project work planned and scheduled in the project management plan. Work performance information about the completion status of the deliverables, and what has been accomplished, is collected as part of project execution and is fed into the performance reporting process. Although the products, services, or results of the project are frequently in the form of tangible deliverables such as buildings, and roads, intangible deliverables, such as training, can also be provided. Direct and manage project execution also requires implementation of:

- Approved corrective actions that will bring anticipated project performance into compliance with the project management plan
- Approved preventive actions to reduce the probability of potential negative consequences
- Approved defect repair requests to correct product defects found by the quality process

MONITOR AND CONTROL PROJECT WORK

The monitor and control project work process is performed to monitor project processes associated with initiating, planning, executing, and closing. Corrective or preventive actions are taken to control the project performance. Monitoring is an aspect of project management performed throughout the project. Monitoring includes collecting, measuring, and disseminating performance information, and assessing measurements and trends to effect process improvements. Continuous monitoring gives the project management team insight into the health of the project and identifies those areas that can require special attention. The monitor and control project work process is concerned with:

- Comparing actual project performance against the project management plan,
- Assessing performance to determine whether any corrective or preventive actions are indicated and then recommending those actions as necessary,
- Analyzing tracking and monitoring project risks to make sure that the risks are identified, their status reported, and that appropriate risk response plans are being executed,
- Maintaining accurate and timely information base concerning the project's products and their associated documentation through project completion,
- Providing information to support status reporting, progress measurement, and forecasting and
- Monitoring implementation of approved changes as and when they occur

CLOSE PROJECT

The close project process involves performing the project closure portion of the project management plan. In multiphase projects, the close project process closes out the portion of the project scope and associated activities applicable to a given phase. This process includes finalizing all activities completed across all project management process groups to formally close the project or a project phase, and transfer the completed or cancelled project as appropriate. The close project process also establishes the procedures to coordinate activities needed to verify and

document the project deliverables, to coordinate and interact to formalize acceptance of those deliverables by the customer or sponsor, and to investigate and document the reasons for actions taken if a project is terminated before completion. Two procedures are developed to establish the interactions necessary to perform the closure activities across the entire project or for a project phase:

- ***Administrative closure procedure*** - This procedure details all the activities, interactions, and related roles and responsibilities of the project team members and other stakeholders involved in executing the administrative closure procedure for the project. Performing the administrative closure process also includes integrated activities needed to collect project records, analyze project success or failure, gather lessons learned, and archive project information for future use by the organization.

- ***Contract closure procedure*** - Includes all activities and interactions needed to settle and close any contract agreement established for the project, as well as define those related activities supporting the formal administrative closure of the project. This procedure involves both product verification (all work completed satisfactorily and correctly) and administrative closure (updating of contract records to reflect final results and archiving that information for future use). The contract terms and conditions can also prescribe specifications for contract closure that must be part of this procedure. Early termination of a contract is a special case of contract closure that could involve, for example, the inability to deliver the product, a budget overrun, or lack of required resources. This procedure is an input to the close contract process. [9]

QUALITY AND PROJECT INTEGRATION

Quality and integration are inextricably linked. In the case of new product development and other projects that face technical issues, project integration management takes on a special meaning, one focused on integrating product components into quality systems and products in a highly technical environment. In the end, however, technical integration does not occur without team integration, without trusting relationships among different project team members and functional departments.

This contains the following integrating tools and techniques:

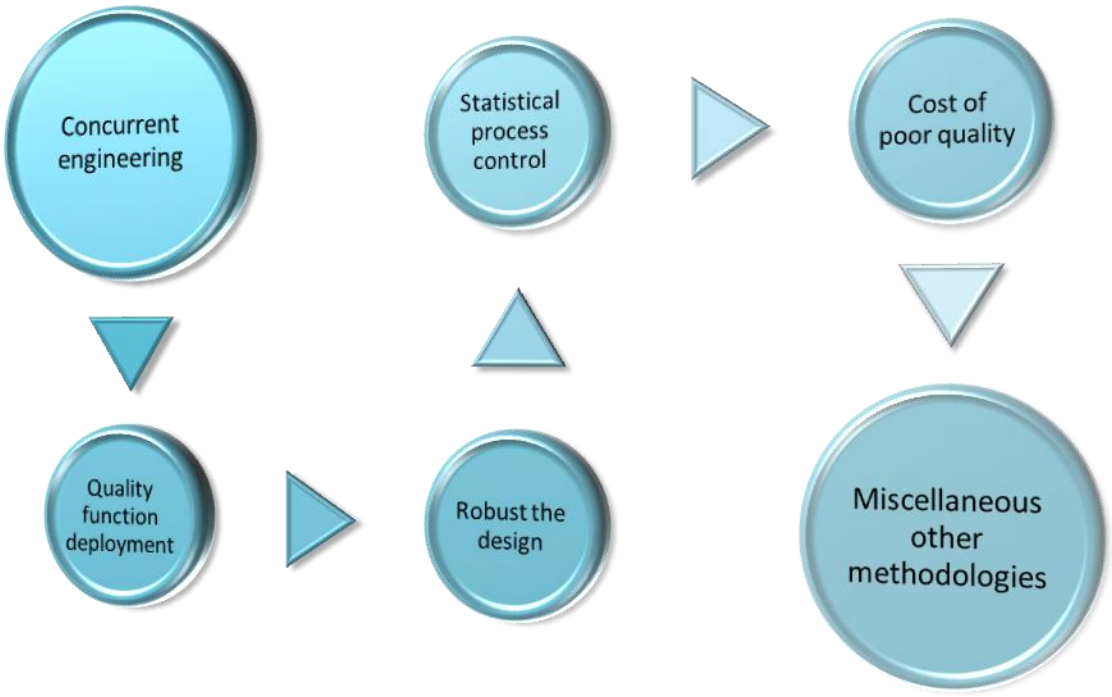

Figure 1.7.Integration Tools and Techniques

System integration focuses on the design of system components, first by work breakdown from the top down, then designing and building components from the bottom up. A configuration management system is typically used to document the product breakdown as it is designed for testing and manufacture. The system can be as complicated as an F-16 or a car, or as simple as a flight control surface or a car door. The system improvement tools and techniques can be used for any system—a system, subsystem, or a part. In fact, some of the tools, like statistical process control (SPC) and quality function deployment (QFD), have been used successfully for the continuous improvement of entire organizational systems. The integration tools and techniques describes specific application in the product design, process design, and production processes. However, these tools and techniques can be used to improve any system in the organization. They are applicable for improving whole systems, subsystems, or parts.

CONCURRENT ENGINEERING

Concurrent engineering (CE) is a philosophy and set of guiding principles where product design and process design are developed concurrently, with some product design and process development overlapping. This includes production and support planning. Unlike sequential engineering, concurrent engineering involves parallel work and dynamic integration. Software, electrical, and mechanical engineers are in constant contact on integration issues as they design and build prototypes. Concurrent engineering requires an integrative management and cultural environment, matrix teams, and an improvement system focusing on customer satisfaction as the final "arbiter" of quality. The concurrent engineering philosophy emphasizes on customer focus. It advocates an organization-wide, systematic approach using a disciplined methodology. It stresses the never-ending improvements of product, processes, production, and support. It involves the concurrent, simultaneous, or overlapping accomplishment of the phases of the project. For instance, the concept and design phases are accomplished concurrently with a design-build approach. The design and development phases are performed simultaneously. The development and production phases are done with some overlapping activities. In most cases of concurrent engineering, all the phases contain some overlapping activities. Concurrent engineering requires upper management's active leadership and support to be successful. It focuses on robust design that decreases loss. It aims at reducing cost and time, while improving quality and productivity. It uses the latest engineering planning initiatives, including automation. Concurrent engineering forges a new reliance on multifunctional teams using tools and techniques such as quality function deployment, design of experiments, Taguchi approach, and statistical process control. If concurrent engineering is a systematic approach to the integrated, concurrent design of products and their related processes, including manufacture and support, then project integration management involves the "scrubbing" of project schedules in order to maximize concurrency and integration. This means that project schedules are characterized by overlapping task dependencies. This approach is intended to cause the developers, from the outset, to consider all elements of the product life cycle from conception, through disposal, including quality, cost, schedule, and user requirements.

CONCURRENT ENGINEERING STEPS

The concurrent engineering steps are as follows:

- Establish a multifunctional team. Ensure representation from all required disciplines. The team should include representatives from such functions as systems/design engineering, reliability and maintainability engineering, test engineering, manufacturing engineering, production engineering, purchasing, manufacturing test and assembly, logistics engineering, supportability engineering, marketing, finance and accounting.
- Use a systematic disciplined approach. Select a specific approach using appropriate tools and techniques.
- Determine customer requirements. Be sure to communicate with customers.
- Develop product design, process design, and the planning of production and support processes together.

QUALITY FUNCTION DEPLOYMENT

Quality function deployment (QFD) is a disciplined approach for integrating customer requirements, the voice of the customer, into product development requirements, in effect, integrating customer requirements with scope of work. Too often, scopes of work and functional requirements are not integrated with customer

expectations, thus successful completion of functional requirements on time and within budget can be unsatisfactory to the customer. QFD is a tool for making plans visible and then determining the impact of the plans. QFD involves all activities of everyone at all stages from development through production, with a customer focus. The four phases of QFD are *product planning, parts deployment, process planning, and production planning*. During phase 1, customer requirements are transformed into design requirements. In phase 2, design requirements are converted into a system (part) or concept design. Phase 3 examines candidate processes and selects one. Phase 4 looks at making capable production processes.

ROBUST DESIGN

Robust design means designing a product having minimal quality losses. There are several methodologies associated with robust design. The major ones are traditional design of experiments (DOE) and the Taguchi approach. Traditional design of experiments is an experimental tool used to establish both parametric relationships and a product/process model in the early (applied research) stages of the design process. However, traditional design of experiments can be very costly, particularly, when it is desired to examine many parameters and their integrative effects. Traditional DOE examines various causes of performance for their contribution to variation, with a focus on arriving at the most influential causes of variation. Traditional design of experiments may be a useful tool in the preliminary design stage for modeling, parameter determination, research, and establishing a general understanding of product phenomena. A major approach to robust design is the Taguchi approach. The Taguchi approach focuses on quality optimization. "Quality optimization" is based on Dr. Taguchi's definition of quality. Taguchi (2004), in his book *Introduction to Quality Engineering*, states that any failure to satisfy the customer is a loss. Loss is determined by variation of performance from optimum target values. Loss, therefore, in the form of variability from best target values, is the enemy of quality. The goal is to minimize variation by designing a system (product, process, or part) having the best combination of factors, i.e., centering on the optimum target values with minimal variability. By focusing on the bull's-eye, the product, process, or part is insensitive to those normally uncontrollable "noise" factors that contribute to poor product performance and business failures. The Taguchi approach is not simply "just another form of design of experiments." It is a major part of the successful total quality management (TQM) philosophy.

ROBUST DESIGN PHASES

Product or process designs have three phases:

Systems (part) or concept design - This phase arrives at the design architecture (size, shape, materials, number of parts, and the like) by looking at the best available technology. Gate reviews focus on design and performance against customer and functional requirements.

Parameter (or robust) design - This stage focuses on making the product performance (or process output) insensitive to variation by moving toward the best target values of quality characteristics.

Tolerance design - This stage focuses on setting tight tolerances to reduce variation in performance. Because it is the phase most responsible for adding costs, it is essential to reduce the need for setting tight tolerances by successfully producing robust products and processes in the parameter design phase.

STATISTICAL PROCESS CONTROL

Statistical process control (SPC) is a statistical tool for monitoring and controlling a process. SPC monitors the variation in a process with the aim to produce the product at its best target values. The major elements of SPC is a process chart consisting of data plots, upper control limit (UCL), lower control limit (LCL), and the mean for the process. Variation is the result of both common and special/assignable causes. Common causes produce normal variation in an established process. Special/assignable causes are abnormal causes of variation in the process.

Statistical process control steps

There are four steps in SPC:

1. Measure the process. Ensure that data collection is thorough, complete, and accurate.
2. Bring the process under statistical control. Eliminate special/assignable causes.
3. Monitor the process. Keep the process under statistical control.
4. Improve the process toward best target value.[10]

COST OF POOR QUALITY

Cost of quality is a system, providing managers with cost details often hidden from them. Cost of quality includes both the cost of conformance and the cost of nonconformance to quality requirements. Cost of conformance consists of all the costs associated with maintaining acceptable quality. The cost of nonconformance or the "cost of poor quality" is the total cost incurred as a result of failure to achieve quality. Historically, organizations looked at all costs of quality. Today, many excellent organizations are concentrating strictly on the nonconformance costs. This highlights the waste, or losses, due to deviation from best target values. Once these costs are determined, they can be reduced or eliminated through application of the continuous improvement philosophy. Typically, the cost of nonconformance includes items such as inspection, warranty, litigation, scrap and rejects, rework, testing, retesting, change orders, errors, lengthy cycle times, inventory, and customer complaints. Cost of quality can often be traced to lack of early integration of system parts and functions. When the deliverable is planned in parts, with little interaction between project team members, quality usually suffers and the cost of inspection, testing, integration, and rework increases.[11]

MISCELLANEOUS OTHER METHODOLOGIES

Just-in-Time

Just-in-time (JIT) is a method of having the right material just in time to be used in an operation—the integration of inventory and manufacturing. JIT reduces inventory and allows immediate correction of defects. This methodology is used for reducing waste, decreasing costs, and preventing errors.

Total Production Maintenance

Total production maintenance (TPM) is a system for involving the total organization in maintenance activities. TPM involves focusing specifically on equipment maintenance. TPM emphasizes involvement of everyone and

everything, continuous improvement, training, optimum life cycle cost, prevention of defects, and quality design. This methodology is effective for improving all production maintenance activities.

Manufacturing Resource Planning

Manufacturing resource planning (MRPII) is an overall system for planning and controlling a manufacturing company's operations. MRPII is used as a management tool to monitor and control manufacturing operations.

Computer-aided design,
Computer-aided engineering and
Computer-aided manufacturing

Computer-aided design, computer-aided engineering, and computer-aided manufacturing (CAD/CAE/CAM) are automated systems for assisting in the design, engineering, and manufacturing processes. CAD/CAE/CAM are used to improve systems and processes, enhance product and process design, reduce time, and eliminate losses.

Computer integrated manufacturing

Computer integrated manufacturing (CIM) is the integration of computer-aided design and computer-aided manufacturing (CAD/CAM) for all the design and manufacturing processes. The CIM methods improve on the CAD/CAM weapon system by eliminating redundancy.

Computer systems

Computer systems include a wide range of items such as hardware, software, firmware, robotics, expert systems, and artificial intelligence. Computer systems are a major integrating methodology.

Total integrated logistics

Total integrated logistics (TIL) is the integration of all the logistic elements involved in the inputs of the organization, all the processes within the organization, and the outputs of the organization to ensure total customer supportability at an optimum life cycle cost. This method aims at total customer satisfaction by supporting the operations of the organization and the customer. TIL can be a major differentiator.

System development/improvement
Methodologies within the
Department of Defense DoD

There are many methodologies that are used specifically by the Department of Defense (DoD) that have application in the commercial world. Many of the CDPM tools and techniques described in this book can be originally attributed to the DoD or government agencies. The methodologies mentioned in this section are in addition to the tools and techniques described in other parts of this book. Some examples of the more specific DoD TQM methodologies include computer aided acquisition and logistics support (CALS), in-plant quality evaluation program (IQUE), reliability and maintainability (R&M 2000), and value engineering (VE). This is not an all-inclusive list. The DoD has many TQM methodologies being used in all its agencies to continuously improve its processes, focusing on customer satisfaction.

Computer-aided acquisition and logistics support

The CALS program is a strategy to institute within DoD an industry and integrated "system of systems" to create, transmit, and use technical information in digital form to design, manufacture, and support weapon systems and equipment, and apply communication and computer technology to acquisition and support of major weapon systems and information systems. CALS focuses on integrating automation between the DoD contractor and the

DoD. This is a program to acquire, manage, access, and distribute weapon systems information more efficiently. This includes all acquisition, design, manufacturing, and logistics information. CALS focuses on an increase in reliability, maintainability, and availability through integration of automation systems. In addition, CALS seeks improvement of the productivity, quality, and timeliness of logistics support while again reducing costs.

In-plant quality evaluation

The in-plant quality evaluation (IQUE) program changes the method by which in-plant government people evaluate contractor controls over product quality. The IQUE program changes some of the traditional methods of evaluation with a TQM approach. The IQUE approach focuses on measuring and continuously improving processes with the aim toward quality (customer satisfaction). It concentrates on the "what" versus the "how." The government provides the "what" and the contractor determines the "how." IQUE implements a cooperative team concept between government and contractors.

R&M 2000

The reliability and maintainability (R&M) 2000 approach is geared to increasing combat capability while reducing costs through R&M practices. It stresses improvements in R&M to increase combat availability and reduce logistics support requirements. The R&M 2000 principles build on the TQM approach. R&M 2000 stresses the need for management involvement (leadership), requirements (vision/mission, involvement of everyone and everything focused on customer satisfaction), preservation (continuous improvement of processes and years of commitment and support), design and growth (training and ownership), and motivation (rewards and recognition).

Value engineering

Value engineering (VE) is an organized effort directed at analyzing the function of systems, equipment, facilities, services, and supplies for the purpose of achieving essential functions at the lowest life cycle cost consistent with performance, reliability, maintainability, interchangeability, product quality, and safety. This definition comes from DoD Directive 4245.8. This specific DoD weapon system for Total Quality Management (TQM) again stresses the need to improve quality and productivity of DoD and DoD contractors while reducing cost.

Integrating quality into project
Management through customer-driven
Project management

Customer-driven project management's foundation is in the integration of the project management and TQM approaches. Customer-driven management merges the proven methodologies, tools, and techniques of project management and TQM under a single customer-driven management approach. Customer-driven project management expands the boundaries of both TQM and project management by using the customer (customer's voice) to drive an organization to complete a project focusing on total customer satisfaction. Historically, a project manager's primary purpose was to use the organization's resources to meet the objectives set by the organization's management. Production was normally the most important objective of the organization. This naturally places management's emphasis on completing projects emphasizing internal operations. They focused on the management functions of planning, organizing, staffing, coordinating, directing, and controlling. In most organizations, directing and controlling were the primary functions of management. This traditional management approach stresses strong task-oriented management, especially at the top of the organization, to meet organizational goals. Often, these goals are driven by schedule and cost rather than quality. This process requires the customer to use the organization's resources to achieve customer satisfaction. The customer must take the initiative to work with project teams in integrating customer requirements. The customer-driven project leader's

purpose is to optimize the use of all resources through the use of people in customer-driven teams to meet objectives set by the customer.

Total customer satisfaction is the most important objective of an *integrating project organization*. This places management's emphasis on internal operations focusing on the customer. This requires a greater concentration on all the management functions. In addition, this makes leadership essential to guide the teams. In customer-driven project management, strong people-oriented leadership and effective task-oriented management throughout the organization are both necessary to satisfy the customer. In traditional organizations, production was usually more important than people. People were viewed as just another resource. They were just "slotted" into job functions as part of the organizing and staffing function of management. In the day-to-day operations of the project, the human resource like all other resources was to be minimized to maximize profit. In fact, as most organizations concentrated on the directing and controlling functions of management, they viewed people as just another commodity to be controlled by structuring, eliminating, and specializing. In customer-integrated project management, people are the most important resource. People are the primary means to add value to a deliverable that is necessary when striving for total customer satisfaction. People are used on customer-driven teams, where they can best contribute. People not only need to perform the process, they are expected to continuously improve it. People are viewed as a valuable asset adding value to the product. This people resource must be developed by coaching, facilitating, training, and supporting. These basic changes to traditional and project management, that form the foundation of customer-driven project management, evolved from a wide range of earlier management practices, manufacturing productivity enhancement, quality improvement efforts, and project management methodologies. Customer-driven project management uses the concepts that provide an organization the means to meet the many challenges of today, while ultimately moving the organization toward the future. [12]

History of Project Integration Management And Quality

Integrated project management has its roots in the experience of managing complex technological and system developments during World War II. During WWII, traditional management approaches proved deficient in integrating the many aspects of the development and production of complex weapon systems. After WWII, the need to manage large and complex undertakings increased the interest in project management approaches. This was fostered by successful efforts, such as the Manhattan project. In the early 1950s, project management started to evolve into a more systematic approach to completing programs. Project management became necessary as industries took on specific jobs, usually defense related or civil engineering-related. These programs were typically for the management of major space, weapons, and construction projects through the stages of design, development, manufacturing, testing, and production. In the 1960s, project management began to be implemented in many organizations besides defense, space, and construction industries. Project management became essential in the computer industry. By the 1970s, project management was recognized as an established management approach for many organizations involved in government, education, and private endeavors. Today, project management has continued to progress into a management approach—essential to producing many deliverables. Further, project management software helps perform many of the project management tasks. As it evolved from the management of complex projects, project management, usually involved the management of defined, non routine activities aimed at distinct time, financial, and performance goals for a system development project. Through the years, project management has been refined through the application of a wide range of industrial and service organizations. The most well-known use of project management is within the DoD industries to develop weapon systems. Weapon systems such as the B-2 aircraft, with its state-of-the art design, would not be possible without highly sophisticated project management techniques. Modern construction projects could not be built without using project management. Today, computer companies, the movie studios, small businesses, and even the music industry uses project management. The basic project management techniques have remained fairly standard over the years. However, the greatest impact on project management has been with the use of technology. Technology, especially automation and telecommunications, has allowed project management techniques to expand in breadth and scope.

What is integrated project management?

Integrated project management is the coordinated management of an activity that has a defined start and finish. Because project management is usually viewed with a definite finish, the focus of project management is on completing the project as scheduled. The objective in project management is to complete the project before or on time, at or below cost, and within technical performance specifications. Project management can be called program management, product management, and construction management to relate to the major areas where it is used. Program management is usually the term used in the DoD. Product management is the term used to manage a product in a commercial industry. Construction management is used in a building industry.

THE UNIQUENESS OF PROJECT MANAGEMENT

Project management is unique because of the following:

- It has a defined specification, deliverable, and end point.
- It borrows and integrates resources.

Each of these unique factors presents its challenges to an organization. First, since the focus of project management is on completing the project at its defined end, there is always a focus on the time element. This frequently results in a constant battle between the three basic competing elements of project management: time, cost, and performance. Balancing these three parameters while striving to complete the project requires constant attention to ensure that the priority is not on just getting the deliverable out of the door. This constant consideration for time, cost, and performance trade-offs requires developing positive internal coalitions. It also makes the relationship with the customer critical to success.

Second, the borrowing and integration of resources from functional departments constantly creates the potential for conflict between functional resources and project resources. Collaborative unions between functional managers and project managers are essential to resolve issues relating to the dual responsibilities of project team members. [13]

TIME, COST, AND PERFORMANCE TRADE-OFFS

Traditionally, there are three factors that are keys to the success of integrated project management, time, cost, and performance. Each of these factors is fundamental to successful project management because they represent three of the most important project management characteristics as follows:

- Completion of the project within allocated resources. This is the cost factor of project management
- Completion of the project within allocated schedule. This is the time factor of project management
- Completion of the project within explicit criteria, standards, and specifications. This is the performance factor of project management. This is also sometimes called the quality factor.

These factors are not considered equal in every project. In some projects, it may be critical to have the product on time. For instance, a weapon system may be required to perform a certain military mission or a computer program may be required to build the rest of the computer system or a new registration system must be ready for students. In other projects, cost might be critical. For example, only a specific amount of funds is allotted to the project. In this case, a fence or limit may be put on the budget of a project. In some cases, quality may be the most important characteristic and resources are essentially unlimited. Traditionally, the project management organization focuses on planning and controlling time and cost, while assuming its functional departments will ensure quality through a focus on specifications.

INTEGRATED MATRIX ORGANIZATION

Project management requires integration of function and project delivery. Success relies on the technical expertise in each one of the many functions at varying times during the project. This requires a matrix organization to share

resources between functional management and project management. This use of a matrix organizational structure for project management presents a major management challenge. To comprehend this challenge, the differences between the traditional organizational structure and the matrix organization must be known. In a traditional organization, the organizational structure is based on functional organizations. For example, on the chart engineering, production, marketing, and support are functional organizations. These functional organizations perform all the activities in the organization within their specific areas. This type of organization depends on each separate function performing within its specialty. There is little emphasis placed on cross-functional coordination or on communication with the customer. Each functional organization is responsible for the technical capabilities of its processes and people. In a matrix organization, the project managers use resources (people, equipment, and material) from the functional organizations. This requires using the same resources in both functional management and project management. It also means the distribution of resources among various projects. In a matrix organization, responsibility, authority, and resources flow vertically through the functional organization and they flow horizontally from the project manager. Project managers influence the "what," "when," and "how much." These are the essential elements of the project. Functional managers direct the "how." The "hows" are the processes in the organization. In today's organizations, the functional managers are the overall process owners. They decide on how the process will operate. Project management requires a full appreciation of the complexity of behavior in organizations. It also recognizes that successful work in an organization is not guaranteed, or even facilitated, by a traditional organization structure. Project work concentrates on pulling diverse activities together into short-term projects. It emphasizes communication and coordination of effort among functional departments such as planning, engineering, production, and marketing. Project management stresses functional departments focusing on distinct short-term outputs and products while performing their traditional continuous long-term operations. Project management facilitates successful negotiation of scarce time and resources. This strengthens the organization's ability to share responsibility and accountability throughout the organization. Rather than encouraging isolated work in each departmental setting, the project management approach encourages people to aim their functional expertise toward the organization goal (the project). This ensures that the organization can produce products and services on time, within budget, and performance standards, meeting and satisfying the needs of the customer. [14]

PROJECT MANAGEMENT PRINCIPLES

The principles of integrated project management target the successful completion of the project. The emphasis is on the project, production, technology, control, responsibility, cost, schedule, and performance parameters, matrix and team organization, and customer satisfaction.

The project management principles are:

- Provide a project focus.
- Reward production.
- Involve functional organizations.
- Nurture rapid technological change.
- Control and plan all activities.
- Include authority and resources with responsibility.
- Provide time, cost, and quality objectives.
- Let functional organizations perform processes.

- Encourage teamwork and cooperation.
- Satisfy the customer.

INTEGRATED PROJECT MANAGEMENT CYCLES

Project management involves a cycle of processes. These cycles for defining, designing, developing, and delivering a deliverable vary according to organization.

The classical project management approach and DoD cycles provide two examples of most widely used project management cycles. The classic project management cycle has been described by many authors. For instance, David I. Cleland (2002) in *Project Management, Strategic Design, and Implementation* discusses a generic project management life cycle including conceptual, definition, production, operation, and divestment. This approach is also detailed by Harold Kerzner (2003) in *Project Management*. The five phases generally involve the following functions:

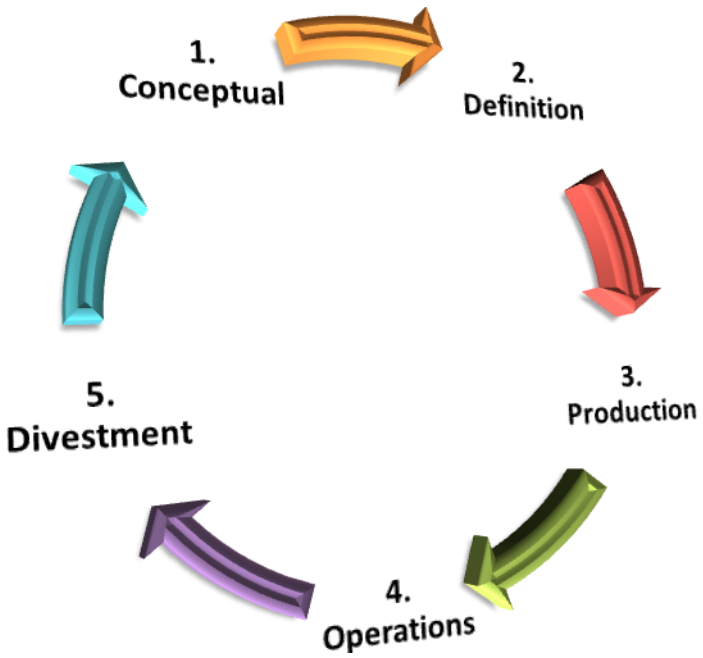

Figure.1.8. *Integrated project management cycles.*

1. CONCEPTUAL. This is the phase in which objectives and goals are set and specifications determined. It is in this phase that projects are outlined and modeled to assure that the project deliverable is understood. Often the assumption is that the customer—the sponsoring agency or firm has already determined the priority and need for

the project deliverable, and that the basic role of the project team is to deliver it within schedule and budget. Traditional project management does not make much room for involvement of the project team with the customer in selecting the project, much less assuring that it results from a quality improvement process performance within the customer's organization and environment.

2. DEFINITION. This is the process of defining the project deliverable in terms of a work breakdown structure (WBS), a budget and schedule, and a critical path network. This is where the WBS provides an organizational and hierarchical look at the project, showing basic interdependencies and interrelationships with the project task structure. A scope of work, budget, and schedule is drawn up in this phase, and the project team is developed around the tasks.

3. PRODUCTION. It is in this phase that the project deliverable is actually produced or "prototyped," so that testing and measuring can proceed. Production involves lining up all the required resources and integrating them according to their interdependencies as shown in the WBS.

4. OPERATIONS. Here the project deliverable is installed, tested, and measured in operation, with the customer or user. Operations assure that the project deliverable, whether a system, product, or a new service, conforms with the original specifications.

5. DIVESTMENT. Divestment involves documenting the project and closing it down. Here the team members are typically selected for other project teams and the project books are closed. [15]

Within the DoD, the project management cycle is described as the seven phase acquisition cycle. The seven phase acquisition cycle as described in James V. Jones's Integrated Logistics Support Handbook (2004) includes:

- Preconcept
- Concept
- Demonstration and validation
- Full-scale development
- Production
- Deployment and operations
- Disposal

The preconcept phase begins the acquisition cycle. In this phase the need is identified through an analysis of missions and/or systems. This triggers the identification of operational deficiencies, operational needs, system or equipment development, modifications, and improvements.

The concept phase involves developing alternative approaches to satisfying the need identified during the preconcept phase. During the concept phase, all possible alternatives are analyzed to determine the alternative or alternatives best capable of satisfying the need.

During the demonstration and validation phase, the alternative or alternatives developed during the concept phase are evaluated to determine feasibility to actually accomplish the requirement. The demonstration

and validation phase has two purposes: (1) demonstrate that the concept can actually work, and (2) validate that the alternative can meet the need defined earlier.

Once an alternative passes the demonstration and validation phase, full-scale development begins. During full-scale development the deliverable is designed.

The production phase involves the actual development and/or manufacturing of the deliverable.

The deployment and operation phase begins after the item is delivered to the customer. During this phase the customer assumes ownership with the support of the supplier.

Eventually the item may need to be replaced. This is when the disposal phase begins for the old item. The disposal phase involves removing the item from inventory.

Whichever traditional project management cycle is used, the thrust is the same, producing a deliverable. The deliverable is essentially already identified by the sponsor or customer. This project management approach is based on traditional quality control. Its innovation was the matrix team that integrated internal functions to complete a project. [16]

GENERATING COMMITMENT AND PURPOSE IN THE INTEGRATED PROJECT TEAM

The essence of project success in most organizations lies not in teamwork, per se, but in individual performance focused on integration, inspired by the team and by the customer. Like any joint effort, it is the combined effect of individuals with common purpose that produces success; it is too easy to describe this simply as teamwork. It is in fact individual effort and integrity that produces success. Individual proficiency and integrity as well as teamwork are needed, but in a mix unique to each enterprise and created by the project manager to match the project situation. Again, keying off some of Tom Peters' ideas, we stress the new dimension that individuals with unique perspectives—not team-dominated, consensus-driven groups—can bring to the field to accept a new "rainbow" team. We deal with "brand you" concepts in a project environment. We hold that individual creativity sparks most successful projects, and most breakthroughs occur not as a result of teams brainstorming, but of individuals simply thinking through implications and impacts in the context of their own experiences. People are the key to success in customer-driven project management. People make are the ones who perform and improve the project. Customer-driven project management aims to maximize the potential of the human resources in an organization. This is accomplished by fostering both individual and team contributions to the organization. Customer-driven project management relies on individuals working smart and taking pride in their work accomplishing the project mission. In addition, these individual's contributions are multiplied through customer-driven teams. People involvement tools and techniques include: individual involvement, teamwork, communication especially listening, focus setting, meetings, brainstorming, and presentation.

INTEGRATION AND INDIVIDUAL INVOLVEMENT

Individual involvement concerns each person's contributions to the organization. In customer-driven project management, individuals work to continually perform their work and improve the processes in the organization, focusing on total customer satisfaction.

Each individual is unique and valuable. This diversity is a distinct advantage in today's economic environment to the organization that learns to use this to improve their competitive position. People have a variety of attitudes, beliefs, perceptions, behaviors, opinions, and ideas. These are potential sources of creativity. Innovation can be gained from different competencies, abilities, knowledge, and skills of the work force. Each person's culture, background, and personality fosters an individuality that can be used for the good of the organization. Creativity, innovation, and individuality can be the edge needed for growth. Therefore in a customer-driven project management organization, individual differences are valued as an important resource. Although each person is different, people generally want some of the same basic things. They want to be safe and secure, trusted, and appreciated, need to belong, feel important, have pride in work, be involved and have advancement and personal growth opportunities. The organization that provides a work environment where all of these wants can be achieved by the individual will be rewarded with high individual productivity. In an integrated project management environment, the goal is the actual empowerment of everyone in the organization. Empowerment means all individuals in the organization have the authority to do what is necessary to perform and improve their work. Empowerment does not just happen. The organization cannot simply announce that the people are empowered and expect it to work. Typically, empowerment comes in stages. First, people must trust the organization. Typically, most organizations have developed many adversarial relationships over the years. This has led to mistrust between management and workers, organizations, and unions, and one department or function and another department or function. These barriers must be removed before an individual will become involved in any extraordinary effort. Restoring trust may take some time depending on the organization. This can only be accomplished by the actions of management working through structure activities. These activities should foster honest and open communication, leading to some specific actions that build the trust. Once trust is restored, people will start becoming involved in assuming more ownership in their work. At this point, the resources must be available to allow the person to take pride in work. When pride in the work is the norm, people can be completely empowered to provide total customer satisfaction. With the added emphasis on human resources, people must work smarter to perform and improve their work, with a focus on customer satisfaction. People have always known best how to do things right, and do them better. However, neither the organization nor the people knew how to tap this resource for the benefit of the organization, the individual, and the customer. The organization must be transformed to provide an environment where individuals can maximize their potential. At the same time people must be trained in a systematic process that provides them the capability to influence their work. When this is accomplished, individual involvement can reach its maximum potential.

Individual involvement is fostered by the following:

- Instill pride of workmanship.
- Nurture individual self-esteem.
- Develop an atmosphere of trust and encouragement.
- Involve everyone.
- Visualize a common purpose.
- Improve everything.

- Demand effective and open communications.
- Use rewards and recognition.
- Allow creativity and innovation.
- Lead by example.

Individual involvement steps

- Establish a people-centered environment.
- Provide development opportunities.
- Provide experiences with expected behavior.
- Reward and recognize appropriate behavior. [17]

TEAMS

A team is a group of people working together for a common goal. Teams should not be confused with groups. A team shares responsibility, authority, and resources to achieve their collective mission. They feel empowered to do whatever is necessary within their defined boundaries. Action through cooperation is practiced both within the team and when acquiring support. Problem solving and decision making are natural activities. Effective, open, and full communication, especially listening, is prolific. The leader and the members possess a positive "can do" attitude even during difficult times. Team members motivate, respect, and support each other. Team members manage conflict. Team members build self-esteem and motivate other team members. They all contribute their technical competence in their specialty as well as all other skills. They acquire many skills to accomplish the mission and build and maintain teamwork. Effective teams realize diversity, individuality, and creativity are their greatest advantages. Individual and team contributions are rewarded and recognized appropriately. The team takes ownership and pride in their performance. Everyone is totally committed to cost, schedule, and quality standards of excellence with total customer satisfaction being the primary focus of all team activities.

TYPES OF TEAMS

Teams can be either functional or multifunctional. A functional team consists of members from the same discipline or organization. For example, an engineering functional team would be a team in which all the members work in the engineering department. A multifunctional team would have members from engineering, manufacturing, marketing, and other fields as appropriate.

TEAMWORK

Teamwork is the technique where the individual team members work together to achieve a common goal. This involves cooperative relationships, open communications, group problem-solving and consensus decision-making. Teamwork can only be effective in an environment of honesty, trust, open communications, individual involvement, pride of workmanship, and commitment. Specifically, effective teamwork involves the following:

- Trust
- Effective communication, especially listening
- Positive "can do" attitude

- Motivation to perform and improve
- "We" mentality
- Ownership of work with pride
- Respect and consideration for others
- Remaining focused on total customer satisfaction

BENEFITS OF TEAMWORK

Teamwork provides the responsive workforce required to survive in today's environment. Cooperation toward a common goal is essential for success. Some of the benefits of teamwork include:

- Better decisions and motivation
- Everyone can participate
- Nurtures improved working relationships
- Encourages rewards in work itself
- Freer contribution of information
- Increased communication
- Thrusts an organization toward common focus
- Supports an organization-wide perspective

PRINCIPLES OF TEAMWORK

In order to build and maintain teamwork, the team must obey some principles.
The key principles of teamwork involve the following:

- Keep focused on the mission; not on the person
- Encourage open communication and active listening
- Yearn for constructive relationships

In addition to these key principles, there are basic principles that every team must observe to build and maintain teamwork over the long term. The team must be continuously developing and maintaining teamwork. The individual team members and the team must receive appropriate rewards and recognition to maintain interest in teamwork. Further, all members must be involved in team activities to maximize the true potential of the team. Team members must have enough self-esteem to actively contribute. Communication is essential in any team activity. In addition, the strength of the team lies in the individuality of each of the team members. Constructive cooperative relationships are critical, both within and outside the team—between team members and with customers, suppliers, and other teams. All the members, especially the team leader must set the example. Team members can develop the behavior necessary to work as a team through observation. Ideas are the power of the team. All team members must be encouraged to continually contribute toward innovative and creative ideas. Above all, focus on the mission—not the person. It is not personal. Teamwork demands an unrelenting devotion to a common purpose. The basic principles of teamwork can be summarized as follows:

- Pursue team environment.

- Reward and recognize the individual and the team.
- Involve all team members.
- Nurture the self-esteem of all team members.
- Communicate freely and openly.
- Include individuality.
- Pursue constructive relationships.
- Lead by example.
- Encourage all team members' ideas.
- Stay focused on the mission.

BUILDING TEAMWORK

Team building requires continual diagnosing and improving the effectiveness of the team. In order to build the cohesiveness and effectiveness of the team, it is important to pay particular attention to the mission, roles and responsibilities, group dynamics, and interpersonal relationships within the team. The following are essential to build teamwork:

- Identify the team mission.
- Establish team roles and responsibilities.
- Understand team dynamics.
- Manage conflict.
- Provide motivation.
- Build individual self-esteem.
- Develop the team.

IDENTIFY THE TEAM MISSION

The mission is the intended result. It provides the focus for all team activities. It gives the expected outcome(s) of the project. The mission provides an indication of the magnitude of the project. It should state the boundaries of the project to include specific process(es). It is important for the mission to define the authority of the team. Further, the team's resources to accomplish the mission must be identified. Normally, the mission originates from outside the team. It comes in general terms from variety of sources, i.e., management, customer. This general mission must be negotiated and clarified by the team. The mission must be written in a mission statement. The clarification of the mission should be the first outcome-related activity of the team. The mission statement must be understood, clear and achievable. The team must reach consensus on a mission statement before doing any other team activity. Teamwork requires unrelenting devotion to a common purpose for success. The mission provides the common purpose.

ESTABLISH ROLES AND RESPONSIBILITIES

Roles and responsibilities are the specific contributions expected from each team member to accomplish the mission. These contributions can include any formal or informal offerings; each team member brings to the team. Formal contributions include the expected roles and responsibilities of a specific discipline, function, or

organization. Informal offering are the contributions a team member can add as a result of personal strengths. Each team must develop their own unique roles and responsibilities based on the requirements of the mission and the capabilities of the team members. Roles and responsibilities must be defined in a "living document" developed by the team. Each team member must have distinct responsibilities with corresponding accountability. The roles and responsibilities change as the team develops and the project progresses. Developing the initial roles and responsibilities should be the next team activity after agreeing to the mission statement. The roles and responsibilities should include:

- Results—expected outcome(s) from each team member
- Ownership including the amount of control
- Limits of resources—funds, equipment, and people
- Empowerment with amount of authority
- Standards focusing on customer satisfaction

The roles and responsibilities should include the expected outcomes from each team member. These should be stated in terms relating to the contribution to the mission. If possible, it should be stated in terms of metrics. In the initial stage of a project it may not be possible to include specific measurement, but performance measurements must be included as soon as possible. This lets team members know exactly what they need to do. Another part of roles and responsibilities involves ownership. The roles and responsibilities must state which processes each team member owns. This provides each team member a statement of what they do. Critical to performance of roles and responsibilities is the amount of resources available. Again, this should be detailed. This provides each team member a statement of what is available to do it. Empowerment involves having the responsibility, authority and resources to do whatever is required to satisfy the customer and achieve the mission within defined boundaries. The key to empowerment is defined boundaries. Each team member must know the boundaries. These boundaries will change as the team develops and the project progresses. In the beginning of a project, team members usually do not have the capability to be fully empowered. As they are trained and gain new experience, the team can assume more empowerment. Eventually the team can be fully empowered. This is when the maximum potential of the team can be realized through the creativity and innovation of the team members. This provides each team member a statement of what they can do. Standards are an essential part of roles and responsibilities. These are the accepted norms for all team members focusing on customer satisfaction. Standards must be a clear definition of what is acceptable under all situations. This provides each team member a statement of what they all should do.

SPECIFIC TEAM ROLES AND RESPONSIBILITIES

The team consists of a team leader, team members, and sometimes a team facilitator. Each of these team players has a specific role. The team leader guides the team to mission accomplishment. The team members contribute toward achieving the mission. The team facilitator assists the team with focus, teamwork, methodology, tools, and techniques.

The team leader and team members' roles depend on the category of team. The first category of team is the traditional directive organization with a manager. The role of the manager in this team is to get the task accomplished. The role of the team member is to strictly perform the directed job. The second category of team is a participative organization. A leader guides the team to a common goal through a process involving all team members. The team members provide their expertise and cooperation. The third category of team is a collective self-led organization. In this team, ownership is shared by all team members. A team facilitator creates and

maintains teamwork. The fourth category is an empowered organization. In an empowered organization, teams have the total responsibility, authority, and resources to perform and improve their process (es). In this category of team organization, a coach and/or resource person advises the teams.

UNDERSTAND TEAM DYNAMICS

Each must understand that although they are unique, all teams normally go through four distinct stages before they are truly performing as a team. The four stages of team development are *ORIENTATION, DISSATISFACTION, RESOLUTION, AND PRODUCTION*. Each team must go through all four stages of team development before they reach synergy. There is no short-cut. The duration and intensity of each stage varies with each team. It is important to maintain the focus and a positive attitude throughout all the stages; the team will achieve its mission. A general description of each of the stages of team development follows:

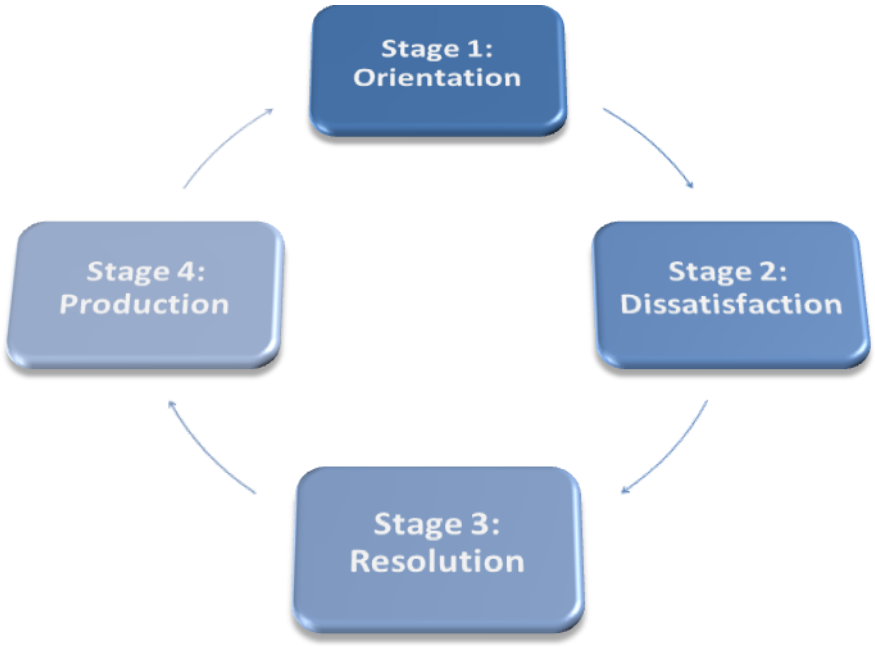

Figure 1.9. *Stages of Team Development*

STAGE 1: ORIENTATION. During the first stage, the team is becoming acquainted to each other and teamwork. Members are building rapport, honesty, trust, and open communication. They are trying to determine what it takes to fit in. The team members usually have great enthusiasm for the project. However, they do not know how to work as a team to accomplish it. During this stage, the team is deciding: what they need to accomplish and who needs to accomplish it.

STAGE 2: DISSATISFACTION. Stage 2 is characterized by being overwhelmed by the information and task. Sometimes power struggles, emotions, and egos become evident. This stage is the most difficult to overcome. Some teams never progress past this stage. If this happens, they should be disbanded. To move forward to the next stage, the team must find some small success as a group. Once the team understands they can perform as a team, the team usually progresses to the next stage.

STAGE 3: RESOLUTION. During Stage 3, the team moves toward the mission. In this stage, customer contact and measurements can help the team members to start assisting each other and focus on the mission. This is the first stage where the team is actually working as a team. Here the team knows how to operate as a team.

STAGE 4: PRODUCTION. Finally, in Stage 4 the team becomes effective. The team members work together to achieve the mission. [18]

RISK AND PROJECT INTEGRATION

The integration of risk into project planning is a major challenge. Risk management planning is ineffective unless made an integral part of the project cycle. Successful integration of risk requires a proactive approach. The following is a risk integration checklist suggesting key points of interface with project decisions in the following categories: business culture, business strategy, project selection, project plan, formal risk management planning, project manual, product/ technical process development, customer risk tolerance, and lessons learned.

Action	What?	Why?	When?	Output?	Who?
		Business culture			
Create risk management policy	Create business intent to manage risk	Confirm that it is important and back it up	Part of business plan; underlies project process	Policy statement on how the business will handle risk	Executive and program management level
Assess organization awareness	Find out how aware workforce is on risk and risk response impacts	Survey workforce	Every six months	Workforce awareness of risk management report	HR/project team
Deliver training program	Design training around practice planning tools; use to introduce business risk	Workforce will implement if they understand tools	Every year with refresher	Certification	All PM, teams, and technical personnel
Reward effective risk management	Provide rewards for good risk management effort and effectiveness	Incentives motivation	During project	Compensation reward	Project managers and team members
Risk component of business plan	Provide for a risk section in the business plan and communicate it	SWOT analysis; threats = risks Translate to product line risk exposure	Annual update of business strategic and business plan	Risk-based business plan; integrate with financial and profitability analysis	Executives and program managements

Strategic objectives	State objectives in terms of risk	Measurable strategy goals	Part of plan; communicate to workforce	Set of 10 long term objectives	Executives and program managers
Project selection					
Do risk assessment of candidate projects	In developing business portfolio of projects, use risk as one criterion for project selection	Use PMBOK process; broad Brush risk assessment	Each time project portfolio pipeline is updated	Rank order projects using composite risk, alignment, cost and revenue Assess men	Program managers and functional managers
Weigh risk against revenues and alignment	Demonstrate that risk has been embedded in business and financial analysis	Trade off risk with opportunity for profitability and taking advantage of business core competence	Each time pipeline is updated	Analysis, data, and documentation	Project management office, project team, business planning staff
Project plan					
Requirements	State customer requirements in terms of customer risks	Risk that customer requirements do not reflect risk, or misunderstanding customer perspective and expectations on project risks	During initial concept phase, part of project plan	Requirements document stating customer requirements and risks	Project manager, functional manager, and customer
Work breakdown structure (WBS)	Include risk contingencies from risk matrix in WBS work activity	Because there is inherent risk in missing major parts of the deliverable in initial planning; WBS assures coverage of major “chunks” of work	During development of the deliverable, the “work” should include initial contingencies identified in risk assessment	WBS in organization chart form and outline in MS Project	Project manager

Action	What?	Why?	When?	Output?	Who?
		Project plan			
Task list	Include risk tasks and contingencies in baseline schedule	Task list should include all anticipated contingency actions if risk events occur	After WBS is prepared, do task list and link; there is inherent risk that linkages will be too "hard;" allow for "soft" linkage	Task list in MS Project Gantt chart or spreadsheet	Project management office and/or project manager
Network diagram	Show risk in network diagram with three scenarios, expected, pessimistic, and optimistic	Arrow diagram shows critical and noncritical paths; risks inherent in focusing on critical path when resource constraints in noncritical tasks may serve as bottleneck—theory of constraints	During translation of WBS to Gantt chart, prepared to show dependencies and paths	Arrow diagram in MS Project or other software	Project management office template, or project manager
Calendar-based diagram	Relate network to time to begin to see schedule impacts and milestones	Histogram using arrows and calendar	During translation of WBS to Gantt chart	Graphics software or document	Project manager
Risk-based schedule	Do risk-based schedule using MS Project PERT analysis tool	MS Project Gantt chart showing calculated risk based duration after weights and three scenarios are entered	During initial scheduling, then any time risk is identified and contingency prepared	MS Project schedule file showing calculated durations for high risk tasks	Project management office or project manager

Risk management process					
Risk identification	Using input from business plan, identify and rank project tasks in terms of risk	Using data, information and past experience, rank summary tasks in WBS using risk matrix	During business planning, project and portfolio selection, and project WBS scheduling	Risk matrix	Project management office or project manager
Risk assessment	Assess risks using risk matrix format	Complete risk definition, impact (schedule, cost, quality, business growth); make probability estimate (25%, 50%, 75% probability), severity on project outcome, and contingency	During business planning, project selection, and project planning and control	Risk matrix updated monthly	Project manager
Risk response	Prepare contingency actions and include in baseline schedule	Response is planning through definitive contingency plans and tasks which are embedded in project schedule as regular tasks, triggered if risk event occurs	During project planning, responses and contingencies are designed to address specific risks and recorded; this is where the team anticipates what might happen to slow or delay the project, what can be done to prevent it or address it, and schedules contingency tasks into the Project	Risk contingency actions	Project manager

Risk management process					
Risk matrix	Prepare risk matrix as basis for scheduling	The risk matrix is the basic checklist item for risk throughout the process; it is the guide for action	During project planning a basic risk matrix file is established and appears with all project planning and project review documents	Risk matrix following prescribed format	Project manager and team or task managers
Decision tree	Do decision tree analysis to expected value of optional decisions	This is the way project managers anticipate decisions they will have to make based on risk, and what alternative paths and expected values will follow each decision path	During project planning, decision tree analysis is applied to high risk tasks	Decision tree diagram with expected values calculated	Project manager

Integrate risk into project manual					
Basic project manual	Assure that risk is not treated separately, but seen as part of the way projects are planned and controlled	Because risk should not be treated separately from project management process; manual captures how risk is integrated into process	Business establishes a system of basic project manuals as part of "projectizing" the organization	Online and hardcopy manual including basic project planning and risk management tools and templates	Project management office (PMO
Provide software tools	Train and provide software analysis tools in manual	Much of the risk analysis can be done through spreadsheets and decision tree analysis software; workforce needs to know how to use	Business establishes a support system of risk management application software and trains appropriate staff	Software library	IT and project managers

Action	What?	Why?	When?	Output?	Who?
		Product/technical process development			
Define product/ technical development process in generic WBS	Assure that business has defined the core, product development, and technical processes which it uses to produce products and services, such as engineering, construction, system development, standardizing where possible	Because project risk management cannot be successful unless both technical and product development/ testing requirements are conducted to control risk, and management impacts, such as schedule and Cost.	Business establishes a generic WBS of technical processes; these are recorded and updated so that all project WBS and schedule information, and risk data, are taken from the generic model and tailored	WBS file	Functional managers
Project codes	Provide for coding actions in WBS so that costs can be captured	Because once you have identified all tasks and risk contingencies, you will want to capture costs against those codes to build a history of risk management	When generic WBS is set up, codes are added at the appropriate level to capture costs	Coding system integrated with time sheets and accounting system	Accounting, project management
		Identify customer risk tolerance			
Assess customer perspective on business and project risk and how much risk customer is willing to assume	Solicit customer input on customer risks and uncertainties	Because customer may have different and valuable insight on business and project risks that have been part of the customer expectations but not reflected in real planning	When requirements are being written	Customer risk analysis	Customer representative and functional and project managers, jointly

Action	What?	Why?	When?	Output?	Who?
		Lessons learned			
Risk audit	Do a project risk audit following selected projects to evaluate success in anticipating and managing risk	Because insights and documents that can lead to better risk management in the future will be lost unless a risk audit team builds a history of the project, how risk decisions were made, and how effective risk management was	At project close-out	Risk audit report to project manager	Project management office, audit staff, project and functional managers
Lessons learned meeting and report	Prepare and communicate short report on what project team members and customers learned in the project that would reduce risks	Because the best lessons and insights are going to be lost unless someone facilitates a lessons learned session and report	At close-out	Lessons learned report, referencing systems, decisions, risk, outcomes, but no names	Project manager

EARNED VALUE: A RISK INTEGRATION INDICATOR

The earned value management system (EVMS) is a method used to *plan, schedule, and monitor cost and schedule* performance. Earned value systems are used to ensure that risk of schedule and cost variance is monitored.

EVMS:

- Measures work progress to the plan, identifying potential risk impacts
- Integrates cost, schedule, and technical performance
- Leads to root cause analysis to identify risk causes
- Aids in making informed decisions on corrective action to mitigate risk

THE RISK OF "UNACCOUNTABILITY"

Here we discuss some organizational and management tools that facilitate risk integration: responsibility assignment matrix (RAM), the organization structure, and the cost account manager.

The RAM is the document that integrates the organizational structure and the WBS into a usable matrix for assigning work responsibilities within any given organization working on the program. The RAM may be referred to as a single point verification of authority for a given organization to expend effort on an assigned program task. Without the RAM, there is risk of performance breakdowns because of unclear accountability. The cost account manager (CAM) concept stresses accountability for work performance and cost control at the work package level. The CAM and the support team are responsible for planning, managing, and tracking technical, schedule, and cost performance for one or more control accounts. Risk impacts are cost overruns and cost variance.

The CAM:

- Participates in the identification of scope
- Is responsible for schedule and budget development
- Reports status cost and schedule performance
- Explains and documents variances to the plan
- Develops work-around and recovery plans
- Reviews and updates estimate at completion (EAC)
- Supports internal and customer reviews
- Responsible for maintenance of EVMS reports
- Identifies, tracks, and mitigates technical, schedule, and cost risk
- Is responsible for budgeted cost of work scheduled (BCWS), budgeted cost of work
- performed (BCWP), and actual cost of work performed (ACWP) of control account

PROJECT MANAGER INTEGRATION ROLES

The project manager is responsible for integration of risk into the project decision making process. The project manager:

- Integrates project work scope, schedule, and cost objectives
- Provides for an objective assessment of accomplishments against the prospect of risk impacts
- Summarizes risk data to higher levels (roll-ups) for management, critical path analysis, and decision making
- Enables analysis of significant variances from the plan forecast impacts
- Project managers use vertical and horizontal traceability to verify integration.
- Vertical traceability occurs when all sub element tasks that support a summary element start and complete on time.
- Horizontal traceability occurs when a stated milestone or event from one schedule is identified and coordinated with another schedule. This is also referred to as project interface management, for instance, the mitigation of risk through coordination of similar milestones across projects.

INTEGRATION ISSUES IN BUDGETING

UNDISTRIBUTED BUDGET. Budget that has been authorized by a contract but as a result of an incomplete related task has not been released to the contract team for use.

MANAGEMENT RESERVE. Stated amount of the authorized project budget that is being held in reserve by the project/program office for contingencies and unknown unknowns. Sometimes referred to as the buffer in critical chain management, it is a "tap" on the project budget that the project manager uses to offset risks and resource bottlenecks.

WORK PACKAGE. Time phased and budgeted tasks that are assigned to a specific work group, team or other entity to be accomplished. Typically the work package contains the lowest level of identifiable and budgeted tasks within a given project.

PLANNING PACKAGE. Planning package represents tasks that have not been planned in detail and is typically a holding package for budget that is yet to be identified in discrete tasks.

ROLLING WAVE. Technique for providing a plan of action and discrete budgeting and scheduling once a better definition of how to accomplish the effort is known. Typically the rolling wave is accomplished in six-month modules.

WHY INTEGRATE RISK?

Risk management is an organized systematic decision-making process that efficiently identifies risks, assesses or analyzes risks, and effectively reduces or eliminates risks to achieve program goals. Risk assessment should not be a separate process but rather an integrated part of the project planning and management process.

The purpose of risk management:

- Spans all phases of the project
- Provides an iterative process
- Is not an option or a project add-on
- Should be developed to the specific project

Integrating question. The key risk issue is "what could go wrong in the project and how can contingencies, e.g., mitigation actions be developed and integrated into the schedule so that should the risk occur, the actions to offset the risk are an integrated part of the project plan and schedule?"

RISK MANAGEMENT PLANNING. The process of setting up the organization to do risk management as an integral part of the project planning process.

RISK IDENTIFICATION. Risks are identified during development of the WBS, in the definition of tasks in a generic WBS "data dictionary."

RISK ANALYSIS. Assessing the qualitative and quantitative characteristics of the risk occurs during the planning process.

RISK PLANNING/MITIGATION. Contingencies to deal with risks are integrated into the WBS task structure and corrective actions scheduled into the program and project.

Risk tracking. Earned value indicators are used to monitor risks, e.g., those risks identified in planning that will have schedule impacts are monitored when negative schedule variance indicates their impacts.

INTEGRATION AND SENSITIVITY ANALYSIS

Sensitivity analysis is the process of looking at what variables—project tasks, costs, materials, fixed costs, are most likely to affect project outcomes such as on-time delivery or cost control. Sensitivity analysis is integrated into project scheduling by identifying key variables in the project and their impact on costs and schedules. It can be useful to use MS Project to model a trial and error process, making changes in task durations to quantify impacts on project due dates.

MONTE CARLO RISK ANALYSIS: QUANTITATIVE RISK INTEGRATION

Here is a listing of expectations from Monte Carlo analysis.

- How likely is any date, but particularly the critical path method date or any imposed date, to occur given the current plan?
- Which activities contribute the most to schedule overrun risk in the project?
- What is the exposure to risk, which is the same as asking, "How much schedule contingency do I need to drive the risk to an acceptable level?"

Four distinct steps in a Monte Carlo analysis are required in order to gain the benefit of a network:

- Create a solid network.
- Apply most likely optimistic and pessimistic durations for activities.
- Run the Monte Carlo simulation.
- Interpret results.

SPECIAL CHALLENGES OF INTEGRATING RISK INTO A SOFTWARE PROJECT

Integration of risk takes on a special meaning in the case of software development projects simply because the performance record for software projects is not good. Software presents particular integration obstacles in designing and testing.

The risk in software development is that failures turn up too late to resolve. Risk integration in software development requires that testing and verification be integrated in the design phase. This means that software engineers must be trained to iterate their designs early into the customer platform and "setting." Further, unless software engineers document their designs and communicate them early, software integration typically fails.

Third party intervention is sometimes necessary to “force” integration issues early. Text cases using customer requirements are used in such cases. In addition, change impact analysis is used to evaluate integration impacts of code and design changes.

A good integration plan includes a scheduled integration phase with gate reviews at particular milestones, including design, coding, and testing. In addition, the project team is made aware of the need to communicate across functional areas to make sure that software engineers, certification engineers, quality assurance engineers, electrical engineers, and mechanical engineers are all talking during software development.

Errors detected in integration are often difficult to address. Thus, a parallel verification process is managed to identify errors early in design, usually by another software engineer acting as a quality assurance reviewer. The purpose of verification activities is to detect and report errors that may have been introduced during the software development process. Verification activities consist of developing requirements-based test cases and procedures; executing test cases and procedures; and reviewing and analyzing requirements-based testing, structural coverage analysis, and formal qualification testing. The software engineer may serve the role of a certification engineer, generating test procedures and running tests when independence is not required.

Finally, verification should include requirements-based test cases and procedures, carried out by third party “certification” engineers. This ensures an objective integration process later in the project cycle. [19]

TOOLS IN BUILDING AN INTEGRATED PROJECT MANAGEMENT SYSTEM

In building a company or agency system to support project integration, there are 10 targets for process improvement. These are organization-wide or enterprise wide project management systems, program portfolio system development, integrated resource management systems, information technology, technical product development including a stage-gateway review system, interface management system, project portfolio management, project monitoring and corrective action, change control, and program evaluation.

ORGANIZATION-WIDE PROJECT MANAGEMENT SYSTEM

▪ *Integrated project management culture.* Leaders develop their organizations to accomplish integration through systems and communication. This system involves the development of a culture of defining and capturing work in terms of projects, e.g., all work of the organization outside recurring production work is considered project work with a customer and deliverables. All training and development, and incentive systems are built to encourage work to be accomplished through formal projects and plans and schedules that integrate cost, time, and quality

▪ *Generic work breakdown structure (WBS).* A generic WBS is a task outline in sequence but not linked. The purpose of the generic WBS is to integrate the work, which is project coded to capture costs and task performance history, with the scheduling of any task the company takes on in any project. The generic WBS defines each task in a *data dictionary*, or task definition that covers what the task expectation is and what its deliverable is, to improve the estimation of task duration and integrating task linkages.

Here is an example of a generic task definition for a safety and testing activity associated with new product development.

1. *Functional hazard analysis (FHA).* The functional hazard assessment (FHA) is designed to assess the severity of the effects of foreseeable functional failures of the product. The FHA categorizes the functions, possible failure modes of the functions, and associated effects; provides a classification of the severity of the failure mode; and provides justifications and assumptions for each failure classification to support the chosen failure mode severity classification.

2. *Built-in-test assessment.* Safety engineering of continuous built-in test for adequacy against safety criteria.

3. *Failure modes and effects analysis (FMEA).* The FMEA categorizes the functional block and provides a functional description; lists associated failure modes; and provides the failure rate, describes the internal and external effects of such a failure, and provides the expected detection method of the failure mode.

▪ *Scheduling system.* A scheduling system places all work in a project schedule software, such as MS Project or Primavera, assigns resources and estimates costs, in order to control the work. Integration of all the work of the company is accomplished through scheduling, which is seen as a process of *committing resources to work in scheduled "windows."*

▪ *Resource assignment.* Resources are assigned to projects and tasks so that the workforce is integrated into the work that is authorized and sponsored by the company. Projects are seen as investments in the business plan; therefore, there is a major impetus to capture the work being performed in a resource assignment system.

▪ *Task linkages and interdependency.* Projects are consolidated and tasks are linked to stress the interdependency of project work. No piece of work in the company is left *unconnected*, to ensure integration.

▪ *Matrix team structure.* The matrix structure ensures integration because functional departments and project teams are intermingled in every aspect of the company's work, from projects to process development and improvement. Project teams are staffed by functional departments in charge of the quality of work and the development of technical systems. Project managers manage assigned team members toward project deliverables and earned value.

▪ *Work authorization system.* Again in order to assure that work that goes on is project work, all work is authorized and directed by the project manager. Work is approved is through the baseline schedule, which defines the authorized work sequence.

▪ *Guidelines for project management plan.* The project management plan is defined in a company policy statement to guide the definition and control of the work. Therefore, the plan must include control points—Stage-Gateway reviews, which ensure that management authorizes advancement from one phase or stage to another. Reporting and monitoring strategies, including the use of earned value to integrate cost, schedule, and quality performance, should be made explicit.

Enterprise-wide management should also address accountability, particularly in view of the recent legislative and regulatory requirements of the Sarbanes-Oxley Act. This requirement which facilitates compliance with internal control and accounting standards is no longer optional for project managers. Compliance with Sarbanes-Oxley therefore is not a choice but a requirement, and the plan should state standards for estimating costs, tracking the costs and relating costs to work performed, and the integrity of the closeout procedure and invoices to customers for work performed. [20]

PROGRAM/PORTFOLIO PLANNING AND DEVELOPMENT SYSTEM

▪ *Business planning system and strategic objectives.* The integrated company has a business and strategic planning process that produces a statement of strategic objectives to serve as a guide for all planning and budgeting. Such a system helps to shape the project portfolio and assures that the company invests in projects that are integrated with the direction of the business and its ownership.

▪ *Decision process.* Some kind of decision process supports integration because open decisions, if prolonged, can lead to waste and ineffective work. Decision trees are used to assess the commercial value of various decision paths involved in defining the task structure and sequence in approved projects.

▪ *Budgeting system.* A capital rationing system, or some way to allocate company resources in line with the priority of relative strategic objectives is part of integration. Once budgets are identified to carry out business plans, projects are planned and prioritized in the portfolio system, then costs are estimated. Finally, projects are funded according to their relative merit against business plans and available budget.

▪ *Risk management system*. Some kind of risk management planning system that identifies and assesses risks, and generates risk contingency plans, is necessary in an integrated project management system. The risk matrix is the format for developing risk information that is used in scheduling and controlling the work.

▪ *Program definition.* Programs are sets of projects with similarities in process, product, and customer base. Definition of longer term *product lines* will help to clarify the boundaries of a given program over time.

▪ *Portfolio pipeline system.* A pipeline of approved projects is maintained so that as funds and resources become available, projects are quickly initiated. Project plans and schedules are produced for projects in the pipeline so that when authorized they can proceed quickly.

RESOURCE MANAGEMENT SYSTEM

There needs to be a way to manage resources in an integrated project management organization simply because there is value in targeting all resources and equipment on the right project work. A resource pool can be established using MS Project that records all assignments in order to keep a running view of how people and equipment are being utilized.

▪ *Workforce planning.* A workforce planning system integrates the hiring and training of personnel with the needs of the program portfolio of projects. In other words, people, equipment, and systems are brought into the company to fill needs that are made explicit in the project resource allocation pool that reflects both current and planned work. Measures such as *person month needs* by project are used to predict resource needs.

▪ *Staffing planning.* A staffing system allocates staff to the priority project needs in order to fully integrate the core competence of the workforce with the priority needs of key projects. Staff is focused on assignments that are visible and reviewed regularly.

- Financial and accounting control is assured in a project management system that captures all project costs, both direct and indirect, and assures internal controls on project costs and equipment inventories.

- *Earned value.* Reports on work progress and costs are used to calculate earned value so that the company knows how each project is doing in terms of schedule and cost.

- *Industry standards.* Industrial cost and work standards are used to control the estimated duration of scheduled tasks, e.g., using a trade association to schedule an industry wide activity on which there are available and tested work and industrial standards.

PROGRAM INFORMATION TECHNOLOGY SYSTEM

A program information system that documents all project work in consolidated schedules and resource pools assures that work is staffed, planned, and monitored in a uniform way. This allows comparison of project progress and supports decisions on where to focus resources.

- *Network system.* All program and project information, such as schedules, resource pools, project review and gate review data, and configuration management documents, are kept on a company intranet to allow wide ranging visibility.

- *Accessibility to key information.* Accessibility to information is controlled and focused on need to know criteria. However, customers are regularly informed on program and project progress through, for instance MS Project Central Web-based reporting systems that allow review of schedules without parent software.

- *Reliability planning.* In reliability planning, failure mode effects and functional hazard assessments, along with risk matrix documents, help to consistently design and test the reliability of product performance to conform with customer requirements and specifications.

- *Workforce training.* Workforce training is designed to meet project needs as evidenced in work performance feedback reviews and lessons learned exercises with project teams in close out.

PRODUCT/SERVICE DEVELOPMENT PROCESS

Integrated project management cannot be accomplished without integrated product development processes with strong stage-gate milestones.

- *Gate decisions.* Project management is a process of managing time, cost, and quality, but the underlying strength of any project integration process is a strong, phased development process with clear controls on entry to the next stage. Gate reviews are documented and generic work breakdown structures and data dictionaries are developed for all product and service development activities.

- *Technology support and testing.* Technical support that meets industry standards assures that product integration and testing is verifiable. Designs are tested against specifications, specifications are tested against scope of work, and scope of work can be traced to customer requirements and expectations.

INTERFACE MANAGEMENT

▪ *Matrix organization.* Interfaces procurement between functional departments, such as accounting, engineering, testing, and the project management department are assured through strong interface management. Separate departments and functions are brought together constantly through information and reporting systems and face-to-face review meetings at key milestones and gates.

▪ *Program review meeting formats.* Review meetings are controlled by generic meeting agendas and data and information support from a professional project management office (PMO) or staff. This way review information is objective and consistent.

▪ *Procurement interface.* Because of the importance of contract and outsourced work, contractor personnel and processes are integrated with sponsor company personnel and processes. Common scheduling and reporting systems are developed.

▪ *Financial, accounting, and internal control interface.* New impetus for strong accounting and accountability reporting now requires that project managers capture costs and be able to trace costs to work performed and equipment purchased.

▪ *Marketing and sales interface.* Integration of marketing, sales, and project work is accomplished by assigning marketing and sales personnel to project teams. They attend and give input to the teams on customer developments and learn what they can and cannot commit to customers and when.

▪ *HR interface.* The interface with HR is important to integrate personnel and HR policies and procedures with project work and priorities. Performance reviews are left flexible, yet are important in assigning resources to future projects.

PORTFOLIO MANAGEMENT

▪ *Top management visibility of programs and projects.* The whole set of projects in a multiple project system are managed consistently in an integrated project management system. All projects are monitored using common earned value and other measurement systems, e.g., balanced scorecard.

▪ *Uniform project management system.* A uniform approach to projects in the portfolio is assured through a professional project management staff and PMO support system.

▪ *Pipeline Management*

▪ *Generation of projects.* A systematic way of generating projects through brainstorming, budgeting processes, and business planning.

▪ *Evaluation of projects.* A way of reviewing portfolio projects using net present value and cash flows, weighted scoring models to score projects against business objectives, and risk management.

▪ *Selection of projects* - Projects are selected using a uniform set of criteria.

PROGRAM MONITORING AND CONTROL SYSTEM

▪ *Project management office (PMO).* Monitoring is based on earned value reporting and quality is assured by a task planning system that relates %complete to defined milestones in the baseline schedule, all supported by a PMO.

▪ *Corrective action/risk management process.* Contingencies and corrective actions are based on remaining work, and are forward oriented. Contingencies are embedded in schedules to assure that should risks occur, contingencies have already been scheduled and budgeted.

▪ *Escalation system for decisions.* Conflicts and differences within project process are reviewed regularly by top management to assure that decisions are not delayed.

CHANGE MANAGEMENT SYSTEM

▪ *Change order system.* All changes to a scope of work are submitted by project team members or the sponsor/customer to assure that changes are reviewed and managed.

▪ *Change impact system.* Change impact statements are prepared for all substantial changes, with risk, schedule, cost, and quality impacts specified.

PROGRAM EVALUATION SYSTEM

▪ *Document lessons learned.* Close out includes lessons learned meeting and documentation of outcomes. The PMO is made responsible to assuring that lessons learned are integrated into future projects.

▪ *Financial auditing system.* A financial and program audit system is managed to assure accountability and internal control of all assets. [21]

LIMITATIONS OF INTEGRATION SYSTEMS

Again, systems don't integrate projects, people do. Even if the organization is able to design and install compatible systems to help integrate projects, they will not work if the people who manage the work don't use them. For instance, configuration management as an integrating function in product development between design and production cannot be effective if the configuration manager does not see both ends of that spectrum. Project manager who is obsessed with schedule and on time delivery at any price, and who does not care about costs simply because top management or the customer has not focused on costs, *will not succeed for the business as a whole.* The lesson is this: individual project success should not be at the expense of the business itself. To assure that this does not happen, company leadership must continuously work toward an integrative vision and process at all levels of the organization — they must daily walk the integrative talk. [22]

CONCLUSION

In practice, of course, there is no clear definition of how to integrate project processes, activities, and knowledge. The project manager's role is made both challenging—and rewarding—by the skill gained while attempting to manage the project to facilitate and monitor efforts for success. In fact, a case can be made that integration is the capstone skill for excellent project managers—the skill that, more than any other, reflects the project management role.

It is also clear that the various activities that the project manager performs are not individual one-time events. Rather, they are overlapping integrated processes which occur at varying levels throughout the project. The project manager must be proficient in the knowledge areas; however the project manager's experience really shows when he/she can skillfully integrate those knowledge areas to effectively deliver the project's desired results.

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