Chapter 7: Quality, Six Sigma, and New Product Development

Project Management in New Product Development by Bruce T. Barkley

Quality and Process Improvement

The purpose of this chapter is to link new product development to quality and process improvement. New products create new processes and new business risks, and therefore new product development initiatives open up opportunities for continuous improvement and associated Six Sigma projects.

Six Sigma is a measure of quality that drives an organization to achieve near perfection through a management-by-fact and data-driven process that defines a defect as anything outside customer specifications. A defect in Six Sigma terms is six standard deviations between the mean and nearest specification limit. In new product development this process is often called DMADC (define, measure, analyze, design, verify), an improvement program used to develop new products and new processes at Six Sigma levels. The objective is to target customer requirements—nothing more and nothing less. The company goal is to avoid wasteful and expensive rework and processes, and produce a product as close to specification as possible the first time.

One application of this quality concept is called integrated test management. New product processes require complete test coverage and tracking systems to ensure that issues associated with the product that are discovered in testing are evaluated and resolved. This requires traceability, the capacity to link every performance specification with a test and data point. The point is to ensure that new products meet stated requirements and functional standards set by customer need.

The focus of quality in new product development is to get the customer requirement right because it drives everything else. Quality is not the highest performance you can achieve; it is what the customer "requirements." Looking at new products this way, you see new product development from the customer's perspective and recognize that the risk is not only that the product will not meet customer requirements, but also that you will get the customer requirements wrong to begin with. As the major stakeholder and the project sponsor, the customer/client pays the price at the end of a project if these risks are not well managed.

Customer-Driven Risk Management

A customer-driven, new product project team is a team that responds to customers and manages customer satisfaction as a regular team function. Risk management is an overall obligation of the customer-driven project team. The team continually assesses risk at the project level as well as in each task of the project, not only in terms of time and cost, but also in terms of the technical feasibility. Again, the customer-driven lead team establishes the system for risk management. This risk management system influences the use of the other project management tools and techniques.

No new product project is without risk; that is the probability that a given process, task, subtask, work package, or level of effort cannot be accomplished as planned. Risk is not a question of time; it is often a question of feasibility. It pays in the development of the WBS to assign risk factors to each element of the WBS, separate from the assignments of schedules and milestones for the work. Risk factors can be assigned based on uncertainty, technological feasibility, availability of resources, or competition. Later, the elements with high risk factors are given close attention by the project manager, whether or not they are on the critical path itself. Special attention is given to customers, users, and clients.

One of the most effective ways to deal with risk is to develop customer-driven contingency plans, or parallel courses of action that come into play if the task cannot be accomplished as the customer sees it. In other words, if Six Sigma cannot be accomplished, alternatives are available. Contingency planning is based on "satisficing," as Herbert Simon called it (Hebert A. Simon: AI Pioneer Andresen S. IEEE Intelligent Systems & Their Applications 2001). Satisficing is finding solution that is most acceptable to all parties to the process.

Customer-driven contingency plans are carried out by the project manager, based on the level of risk assigned to a particular element of the project work breakdown structure. When testing a new technique or approach, for example, a manager might estimate a 15 percent chance of successfully

completing task 1 and satisfying the user because few new techniques work well the first time they are attempted. Similarly, there may be only a 10 percent chance of successfully completing task 2 because of the organization's previous experience with a similar problem. Hence, there is only a 1.5 percent probability of even reaching task 3 if its performance depends upon successful completion of the preceding tasks. After task 3 is completed, however, it may be implemented again and again, depending on how many problems have to be solved.

Illustration of New Product Risk Management—The Defense Risk Program

The Department of Defense (DoD) has for many years provided standard templates to contractors for reducing risk in system development. The DoD uses templates directed at the identification and establishment of critical engineering processes and their control methods. For each of the critical engineering processes a critical path template is provided. The template addresses the following areas for each critical engineering process:

- Area of risk
- Outline for reducing risk
- Timeline

Six Sigma Quality Template

Six Sigma quality is defined as an organized process of continuous improvement by private defense contractors and DoD activities aimed at developing, producing, and deploying superior material. The primary threat to reaching and sustaining this superiority is failure to manage with a purpose of constantly increasing intrinsic quality, economic value, and military worth of defense systems and equipments. Note the focus on management first, not technical risk. The Armed Forces and defense industrial entities may not attain a lasting competitive military posture and long-term competitive business stature without a total commitment to quality at the highest levels. Six Sigma is applicable to all functions concerned with the acquisition of defense material, supplies, facilities, and services. Being satisfied with suboptimum, short-term goals and objectives has adverse impacts on cost, schedule, and force effectiveness. A short-term approach leads to deterioration in the efficacy of specific products, the firms that produce them, and the industrial base overall. Major risk also is entailed with the inability to grasp and respond to the overriding importance attached to quality by the "customer" or user activities.

DoD Outline for Quality

- The organization has a "corporate-level" policy statement attaching the highest priority to the principles of total quality and Six Sigma. This policy statement defines quality in terms relevant to the individual enterprise or activity and its products or outputs.
- The corporate policy statement is supported by a quality implementation plan that sets enduring and long-range objectives lists, criteria for applying quality tools to new and on-going projects and programs, provides direction and guidance, and assigns responsibilities. Every employee at each level plays a functional role in implementing the plan.
- All personnel are given training in quality principles, practices, tools, and techniques. Importance is placed on self-initiated quality and Six Sigma effort.
- The quality effort begun in the conceptual phase of the acquisition cycle is vitally concerned with establishing a rapport between the producer and the user or customer and a recognition of the latter's stated performance requirements, mission profiles, system characteristics, and environmental factors. Those statements are translated into measurable design, manufacturing, and support parameters that are verified during demonstration and validation. Early new product activity is outlined in the Design Reference Mission Profile template and Design Requirements template. The Trade Studies template is used to identify potential characteristics which would accelerate design maturity while making the design more compatible with and less sensitive to variations in manufacturing and operational conditions.
- Design phase quality activity is described in the Design Process template. Key features enumerated include: design integration of life cycle factors concerned with production, operation, and support; availability of needed manufacturing technology; proof of manufacturing process; formation of design and design review teams with various functional area representation; and use of producibility engineering and planning to arrive at and transition a producible design to the shop floor without degradation in quality and performance. The Design Analysis template and Design Reviews template provide guidance in identifying and reducing the risk entailed in controlling critical design characteristics. Both hardware and software are emphasized (reference the Software Design template and Software Test

template). A high-quality design includes features to enhance conducting necessary test and inspection functions (reference the Design for Testing template).

- An integrated test plan of contractor development, qualification, and production acceptance testing and a test and evaluation master plan (TEMP) covering government-related testing are essential. The plans detail sufficient testing to prove conclusively the design, its operational suitability, and its potential for required growth and future utility. Test planning also makes efficient use of test articles, test facilities, and other resources. Failure reporting, field feedback, and problem disposition are vital mechanisms to obtaining a quality product.
- Manufacturing planning bears the same relationship to production success as test planning bears to a successful test program (reference the Manufacturing Plan template). The overall acquisition strategy includes a manufacturing strategy and a transition plan covering all production-related activities. Equal care and emphasis are placed on proof of manufacture as well as on proving the design itself. The Quality Manufacturing template highlights production planning, tooling, manufacturing methods, facilities, equipment, and personnel. Extreme importance is attached to subcontractor and vendor selection and qualification, including flow down in the use of quality principles. Special test equipment, computer-aided manufacturing, and other advanced equipments and statistical-based methods are used to check and control the manufacturing process.

Timeline

The *define, measure, analyze, design, verify* process is used throughout the product life cycle. Defense contractors and government activities concentrate on designing and building quality into their products at the outset. Successful new product developers are not content with the status quo or acceptable level of quality approach. Those developers respond to problems affecting product quality by changing the design and/or the process, not by increasing inspection levels. Reduction in variability of the detail design and the manufacturing process is a central concept, and is beneficial to lower cost as well as higher quality. Defect prevention is viewed as key to defect control. Astute contractors are constantly on the alert to identify and exploit new and proven managerial, engineering, and manufacturing disciplines and associated techniques, and are recognized as such.

DoD manuals stress the following, more traditional Total Quality Management (TQM) principles:

- Total commitment to quality
- Continuous improvement
- Involvement of many functions
- Long-term improvement effort
- Customer focus

TQM principles include company actions that:

- Produce a policy statement (vision/mission)
- Pursue a TQM environment
- Stress a TQM implementation plan
- Foster ownership
- Advocate training
- Include quality as an element of design
- Encourage measurements
- Include everything and everyone
- Nurture supplier and customer relationships
- Encourage cooperation and teamwork

New Product Portfolio Management

DoD policy first articulated the importance of project selection and portfolio management in the 1980s and has since refined the concept. The initial and most disruptive risk involved in program management lies in the inability to choose the right portfolio of new product projects in the first place. Fit and consistency with strategic plans, cash flow analysis and rate of return, and company competency ("can we make this product?"), lack of business analysis on markets, technical feasibility, and legal risk are key factors contributing to successful risk management.

Fit with company strategy. Alignment with strategy is a key risk challenge because projects that might otherwise be attractive might not be part of the company's plans for growth and competence. The weighted scoring model is one tool for assuring fit with strategy, but the risk here is in the inability to measure whether in fact a candidate project is going to help implement a company strategic goal.

Cash flow. Because profitability and rate of return are key to company growth, a project must be planned out over the long term to ensure net income growth. This means that candidate projects must be "fleshed out." The risk here is that cash flows are misestimated, and that key decisions and assumptions behind the decision are not made explicit.

Consistency with company competency. If the company does not have experience in a given area, it does not matter whether the project is consistent with strategy and cash flows are promising. Company capacity to perform is directly related to past experience and capacity; "sticking to the knitting" is still a major principle of success, and therefore a useful risk management concept.

Market analysis. If the market and future demand for a given project outcome or product/service are not well researched, the risk is that an efficient project may meet schedule, cost, and quality objectives, but produce a product that is not marketable. Therefore, the focus in risk planning must be in the adequacy of early business market analysis and research.

Technical feasibility. Because technical feasibility is key to new systems, if a project involves new, unproven technology, there is inherent risk in the project. Technical feasibility can be offset by embedded risk measures as described earlier in the product development process.

Legal risk. Legal and regulatory risk is attributable to changing government regulations and legal issues involved in liabilities for a given product. The risk here is that the company fails to understand and anticipate legal and regulatory constraints on a product or service.

Value of Customer-Driven, New Product Risk Management

Customer-driven risk management captures the critical importance of seeing risk in the eyes of the customer and client. A focus on customer risk can uncover uncertainties and risks in a project that are not apparent in an internally focused risk management process. For instance, in developing a software product, the customer focus may be grounded in compatibility or interface of systems, while the internal, project-oriented focus for software development might well be conformance with performance requirements without much attention to interface issues.

Risks in Customer Expectation, Need, and Requirements

Program and projects face customer risk is three areas, and each challenges the risk management process:

- Customer expectations
- Customer needs
- Customer requirements

Customer Expectations

Sometimes customers expect more than they specify in written specification documents. And expectations change from new information uncovered in the project itself. The risk associated with customer expectations reflects the inherent value of projects themselves; as products and service outcomes are produced and information is made available to the customer that uncovers new opportunity, customers sometimes change their minds.

Customer Needs

What the customer needs is not necessarily what the customer expects or requires. Needs suggest analytic data on customer needs; an objective view of needs underlies the project process, but needs are seldom differentiated from expectations and requirements.

Customer Requirements

Requirements are the actual specifications for the product or service outcome. Sometimes requirements are drawn up by project teams based on what is feasible rather that what is required. The risk here is that the requirements document does not adequately capture customer need.

Risk Lessons Learned and Project Risk Audit

There are two kinds of "post mortem" on a project, and both open up opportunities to look back at the risk management process to see what worked and what did not. This chapter addresses how to do a "risk lessons learned" review and a project risk audit, gives examples, and provides insights on corrective actions based on actual risk feedback from post-mortem sessions. Figure 7-1 shows the transitions from lessons learned to audit.

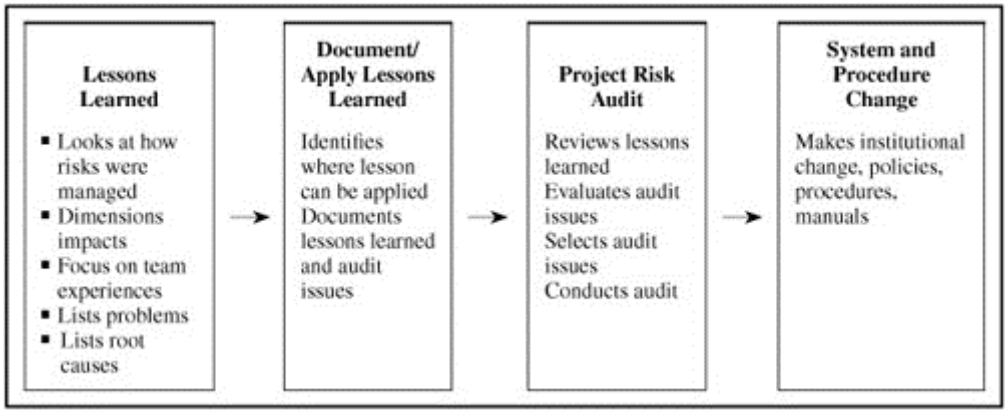

Figure 7-1: Transition from lessons learned to audit.

In Figure 7-1, lessons learned is the first step. This is the process of bringing the new product team together for an informal discussion of what went wrong and what went right in the project, and what the impacts were. Then the team identifies where such lessons can be applied in the risk management process, and identifies possible institutional or organizational problems associated with the lessons learned. Potential audit issues are identified; then an audit is conducted on those issues top management would like to earmark for policy, system, or organizational change.

The value of a timely post-mortem "lessons learned" review lies in the capturing of insights of the project team members and stakeholders and documented information on the project cycle, fresh from "combat." The process is like a military debriefing in the sense that it is well focused and tries to capture the intensity of feeling and information all at once. The implications for successful risk management in future projects are major because it is in those insights about what did and did not work that the organization and management team gain valuable information on future project risks and opportunities.

Project Audits

New product project audits are not the same as lessons learned. Project audits are performed by external teams (objective outsiders) who have not been part of the project process. The audit has been described as "the process of coming down off the mountain after the battle to kill the wounded." Such audits can be useful if they address issues that have already been identified by the project team. The purpose of an audit is to connect factors that contributed to project successes and failures based on documents and recorded information, and to match the project outcomes with project goals and objectives.

Performing a risk lessons learned review. A lesson learned project review should be conducted soon after project closeout, and should include all project team members, a member of top management, and stakeholder representatives. The focus should be on identifying what went right and what went wrong—and dimensioning what went wrong in terms of unanticipated or unmitigated risks and uncertainty. This can be accomplished by scheduling and facilitating the meeting around key risk issues or topics that help to capture the risks inherent in the project. The following is an example of an outcome report from a risk lessons learned session in a modern avionics instrument product development process.

Example of a lessons learned report. What went right (things that we want to recreate for future projects)

- This was a focused team with largely full time assignments
- Our team was autonomous: we drew the line with the customer for appropriate "windows" for changes, disruptions, etc.
- Little or no scope creep
- Resources (e.g., test equipment) allocated to resolve problems quickly
- Contingency plans in place when necessary
- Team defined its approach to documentation, etc., together, "as we went" (also noted as a weakness below)
- Communication within team was good
- Consistent high priority on this project from corporate: this was a high visibility, high priority project from the beginning, and we knew it

- Responsiveness of team members to each other very effective
- Project itself was not technically insurmountable; success was feasible
- Team able to separate what was controllable from what was not, e.g., flight test, and managed accordingly
- Team was highly proficient; good professional and technical skills
- Scheduling process handled resource issues somehow
- Program manager was open to change; flexible in responding to team issues
- Program manager used schedules as guides, but was very task and action oriented in meetings

What went wrong (things that we want to correct for future new product projects)

- Company process and procedure requirements, and differing interpretations of document requirements, sometimes acted as barriers to necessary work, and did not always facilitate successful completion of the project, e.g., software documents, reference documents, tables
- We sometimes described procedures *after* we completed them instead of before; documentation often followed verification rather than guiding it, e.g., STD checklist
- Confusion and uncertainty in the actual application of ISO, FAA certification procedures on the one hand, versus "actual" procedures that the team decided were necessary to get the product out on time
- Company changes (split) created resource issues; we had to "ad hoc" it in handling engineering change notices, assembly drawings, etc., because of resource problems created by the split and loss of staff
- Document numbering system created a lot of tension and uncertainty
- Training needs: staff involved in the project were not always trained to carry out procedures, e.g., staff loading the boxes did not have good guidance and training
- Ineffective version control on some documents and configurations
- Stress created by long hours was a problem; can't stretch people and expect them to stay on
- Schedules were not accurate in many cases, compared to the real work, e.g., the sequence of tests and dry runs
- Sometimes the team did not have the "big picture" on the project; sometimes the big picture helps to facilitate doing your job
- Wasted time in some meetings; meetings had agendas, but there were times when the team "blew off steam" and wasted a lot of time
- Some residual issues rooted in "military" versus "commercial" approach had an impact on the project, which came in the middle of the transition from military to commercial methods

Contingency Actions

In every new product lessons learned exercise, solutions and advances in process management are identified. For instance, here is a list of lessons learned follow-up actions from an electronic instrumentation company:

Issue #1: Document numbering system

Recommendation: Set aside time and develop a new document numbering scheme that reflects the way we want to do business

Issue #2: Big gap in documenting actual procedures and processes; problems in sequence and review of documents

Recommendation: Develop and document how we followed or created procedures for ISO audit (they will want to see how we followed our own procedures); review current processes for sequence and review of documents

Issue #3: No accountability for master charting function

Recommendation: Decide clear accountability for master chart function

Issue #4: Don't have the right tools to accomplish new product versions, process definition, and configuration control and documentation

Recommendation: Decide what the right tools are to facilitate documentation, and acquire them, e.g., *Framework* software replaces *Word, Agile software* used to conduct configuration management and control versions, and *Requisite Pro* software will be used to document requirements

Issue #5: Ineffective management of document and procedure revisions

Recommendation: Develop a referenced master list of documents and acronyms to assure effective revision management

Issue # 6: Some staff members don't follow established procedures and processes

Recommendation: Develop staff accountability for following established procedures and documentation requirements; follow up with consequences, if necessary

Issue #7: Inefficient acquisition of needed equipment

Recommendation: Plug required test equipment early into the scheduling process; anticipate asset issues before they happen

Issue #8: We don't capture observations, problems, and corrective actions along the way—lessons learned are lost

Recommendation: Establish a way to identify and capture project issues, processes, and corrective actions along the way

Issue #9: Conflicts in doing product development in a manufacturing environment; can't build the same thing twice

Recommendation: Establish a small prototype manufacturing unit in engineering to produce prototypes without leaning on product facilities already over-taxed with volume production requirements

Issue #10: There is a widely held view—that we need to turn around—that the company is good at identifying weaknesses, but does not follow up to fix them: there is a concern that issues such as those coming out of this session will not be addressed because of the press of time and work

Recommendation: Make presentation to top management to get personal commitments from key executives on corrective action to mitigate risks on future new product projects

A Postscript to Lessons Learned

Risk management is, in the end, a people-centered process, and it is in the key decisions that people make daily that the conditions for effective risk reduction and response are created. Because the lessons learned process focuses on the people who actually did the project work and gleans from them a realistic and practical perspective of risks as they played out in the project, the lessons learned process can be very valuable.

Project Audit

The project audit starts with the appointment of an auditor and audit team. The auditor is typically another project manager who assumes the role of auditor with some experience in project planning and control.

The audit, unlike the lessons learned session, is focused on an independent gathering of information and documents from the project, and reviewing them against the goals and objectives of the project and best practice criteria. This involves the question, "did the project produce what it intended to produce, and how effectively and efficiently?"

The project audit focuses on key aspects of the project, as follows:

- Business planning: Were the risks that actually occurred, and that impacted the project, identified adequately in the early business planning process?
- Follow-up response: Were those same risks monitored and controlled?
- Organization wide culture: Did top management support effective risk management as part of the project cycle?
- Project team: Did the project team members perform their roles as "risk managers" during the process and integrate risk into their daily work?

- Risk identification, assessment, and response: Was a systematic process used to identify, assess, and respond to risks?
- Key processes, decisions, and milestones: Were key risk-related processes, e.g., testing and reliability, quality assurance and control, decision trees, and product development integration milestones, actually followed?
- Resources: Did the project experience resource constraints, and were the constraints managed with buffers?
- Safety and reliability: Were the correct tests and reliability processes in place?
- Risk-based scheduling: Were project schedules adjusted using risk inputs and using the MS Project PERT analysis tool?
- Monitoring: Were risks followed in the project process and decisions made on risk mitigation and contingency that reduced risk?

The question of efficiency is reviewed through earned value and cost variance calculations. The issues would be, “did the project stay consistent with the schedule and budget; did the project manager make adequate adjustments based on variations from risk events; and did the project make its quality, schedule, and budget goals?”

Scheduling Contingencies and Improvements

Now we turn our attention to the importance of scheduling improvements, such as those uncovered in lessons learned exercises in new product development. With all of the emphasis on quality planning, quality assurance, and quality control in new product development, there is a tendency to forget that in project management it is the scheduled work—the tasks that are built into the work breakdown structure and made part of the baseline schedule—that actually gets done. If the quality functions and activities covered in this book are not actually scheduled, or if they are treated as “boilerplate” functions to be performed by the quality office, they will not be effective. Thus the reader is introduced early in the book to the scheduling process to emphasize the importance of scheduling in project quality management.

With the increasing availability of effective project management scheduling and resource management software, the scheduling process has become more useful as a project quality management tool. Software has enabled the integration of quality and resource planning as a single process because all tasks, including those specifically focused on quality such as failure assessment, can be scheduled into the baseline schedule. The purpose of this chapter is to orient the reader to the critical importance of *scheduling* as a practical quality tool and to point toward the useful and effective application of the quality tools covered in later chapters of the book.

Quality Tools and Techniques

It turns out that total quality management was a good idea, and one that has had profound impact on American industry. And the integration of project management and total quality made sense, evidenced by the Project Management Institute’s development of a separate section on project quality management. But there has not been much headway in putting these concepts into action in the project process. One reason is because project management is not seen as a planning tool; rather, it is seen as a scheduling and action-oriented tool. Quality plans do not get translated into project schedules as easily as product specifications.

Project managers typically see quality as an external aspect of the process because quality has been incorrectly “sold” in the workplace as something different from and external to the core product design and development process. Of course, we have found in experience that quality must be an integral part of the process, not an external force to be dealt with later when the quality office appears to inspect the products and audit procedures against ISO standards, and second-guess the process. Quality is what work is done, and the way that work is done and when, not how, the work is inspected. We have mistaken the measure for the process itself.

We also believe that quality is the key objective in new product project management, while cost and schedule are indicators. The theory is that the way to ensure successful integration of cost, schedule, and quality is to first satisfy quality requirements; cost and schedule will take care of themselves because achieving quality is less expensive than not achieving it. This means in practice that the project manager must first assume a mindset that places the qualitative aspects of the product out front. If quality tasks are scheduled first, not last in the process, they take on more significance. The project manager integrates quality by scheduling quality tasks and milestones to ensure that quality is built into the project process. In effect, we are saying that the classic triumvirate of cost, schedule, and quality is

not a triumvirate at all, but three sides of the same quality concept. Quality means customer satisfaction, and conformance to specifications with budget and time constraints. In a sense we can conclude that quality is the key effectiveness goal, with cost and schedule mere measures of efficiency.

Bridging the gap between customer requirements and scheduled work is no easy job. In writing the specification, the project manager points forward to the scheduling and monitoring phases, but is largely responding "out" to the customer's requirements. After specifications are clear, the project manager turns to the scheduling tool. But how can work definition and scheduling ensure that the work itself will achieve conformance to specifications? The answer lies in the scheduling process, which can now be integrated with work definition in one seamless process.

But, as indicated earlier, there are two quality objectives, quality as conformance and quality as customer satisfaction. Both must be achieved before the project can be considered successful. If quality as conformance can be measured and traced to specification, and then scheduled into actions, then conformance is ensured. But how does quality as customer satisfaction get translated into action? The answer requires some discussion of customer satisfaction.

"Quality as customer satisfaction" is relational rather than absolute and tends to get lost in the shuffle of *real* work. Therefore, the achievement of this aspect of quality must be planned, and scheduled, in a different way. Customer satisfaction is a function of four key forces:

1. *Expectation*, Documented project developments on user expectations and insights gained prior to or during the project
2. *Feelings* about the project manager and team, e.g., trust, reliability, loyalty, and other emotional responses to the project organization and team
3. *Feedback from stakeholders*, e.g., feedback the customer is getting from key stakeholders such as a standard setting association or government regulating agencies that would change their views of project progress
4. *Project performance*, e.g., schedule and cost variance, early indications of product and service quality that will give the customer a sense of confidence about progress or alternatively a sense of discomfort that will affect their satisfaction with the work

The issue becomes how to ensure that the soft objectives of customer relationship management are achieved while satisfying the customer's hard, product requirements. This is accomplished again through defining customer satisfaction into the work breakdown structure and schedule for the project. An illustration of this approach is the scheduling of a customer quality survey to be administered monthly to build a running account of customer reactions to the progress of the project work. Such a survey would be scheduled along with meetings to discuss the results as part of the original scheduled work.

The following are key quality tools in new product development. These tools are positioned in the product development process to ensure a quality product or service.

Quality Function Deployment (QFD)

QFD is applied in the design phase to translate customer requirements into project methodologies, e.g., design and specification. It is a translation of *what* to *how*. QFD is useful both as an agenda and a framework for discussion as well as a methodology. QFD suggests a way of thinking, an approach to asking questions of the customer, brokering answers to those questions to figure out how the customer's needs are going to be reflected in internal processes, designs, and production capabilities. QFD is a process, not simply a quantitative template for analysis, which assures that the project team is in dialogue with the customer and can assure that it can employ the appropriate systems and processes to produce what the customer wants. The QFD exercise should create standards or criteria for evaluating later the extent to which a project process has produced a product in the range of acceptability to the customer, e.g., that it conforms.

QFD is scheduled as a series of customer requirements activities in the initial concept phase and includes three summary tasks:

1. Obtain customer requirements in writing
2. Complete the QFD "house of quality" with the customer
3. Translate QFD results to product specifications.

Through these tasks, the project manager is ensured that the team can verify or trace the scheduled work directly back to the customer requirements.

Statistical Process Control (SPC)

SPC is used to identify processes that are out of control, or are varying unacceptably from the standard. Process stability is important in project quality management because it indicates that a product is performing within customer expectations and requirements, and within specifications. SPC is also a way to educate the customer on how it can be used to help them articulate requirements right up to "Six Sigma." It is a planning tool as well as a quality control tool.

In addition to including SPC in quality control downstream in the project, SPC can also be scheduled early in the concept phase as an activity performed with the customer. The scheduled task would include defining the customer's perception of key product tolerances and performance standards in terms of SPC.

Pareto Analysis

Pareto analysis is the analysis of frequency, and is another tool to confirm that the product or service is meeting customer expectations. Frequency measurements are made to confirm the statistical significance of occurrences in the project process that might affect quality. For instance, the number of schedule variations in a project schedule due to various root causes would be a good target for frequency analysis.

Pareto analysis can be scheduled into the project as a way to follow rework and errors in a product from design to assembly and testing. Frequencies of errors at each stage in the product development give the project manager a good way to identify key points in the design and development where errors occur, then display the results on a graph to show the relative frequency of errors at each point. Thus this kind of analysis should be scheduled at several intervals in the process.

Cost of Quality

The cost of quality accounts for quality control and audit costs, such as the *unnecessary* costs of correcting for bad decisions. Costs of appraisal, inspection, and rework involved in the design and production process are covered in a cost of quality analysis. As such, cost of quality is an important tool for the project manager to identify failures in quality assurance in the early processes of design that evolve into costs downstream in inspection and rework.

Cost of quality analysis is scheduled late in the project process to identify the costs of quality control and inspection. The task involves collecting the actual labor and equipment costs involved with such activities.

Quality Assurance (QA)

Quality assurance is the process of building quality into the project process—doing it right the first time—and is an important method of cost avoidance. But further, quality assurance is the integral aspect of project processes that create a safe and reliable product. For instance, the imposition of reliability testing in a product is a good indicator of the internalization of quality assurance into the design and production process. QA is not an external concept; it is the total integration of procedures and processes that test, validate, and verify the functionality of the product according to customer needs.

Quality assurance is scheduled early in the project in the form of a set of quality assurance tasks, e.g., design reviews that examine how initial design tasks were performed and whether those processes were consistent with professional design standards. New design software in the engineering field now provide for these tests and ensure that computer-aided design work is performed right the first time.

Earned Value

Earned value is a key project quality management tool when used effectively. Earned value measures whether the work performed on a project has been performed consistently with customer requirements as well as product specifications. Effective use of earned value for quality purposes requires that the project manager explicitly define earned value and percent complete reporting in terms of customer or user acceptance. In other words, when a task manager reports that a task is 50 percent complete, that must mean the work completed meets the quality specifications set out for the product or service as well as satisfy the customer. That inherent definition of earned value, backed up by a corporate culture that places primary priority on quality, then becomes the insurance policy against a high cost of quality.

Earned value is both a front-end function and a monitoring function. Earned value is scheduled into the front-end definition phase by describing key milestones in the project schedule where earned value assessment can be made. The scheduling process then accounts for these scheduled milestones in the baseline schedule.

Project Review

Project review is another quality tool because its purpose is to assess progress in terms of customer value, and provide data and information for a new product go or no-go decision. This requires a mindset that defines the program and project review process as a series of questions and answers that periodically pins down the quality of the work in progress. Quality questions must be asked before scheduling and cost questions. For instance, in earned value assessment during project review, the project team must struggle with the issue of whether the percent complete is an accurate representation of what the customer would say. Better still, the customer should be integrated into this decision so that they can probe earned value in terms of customer satisfaction. This process can be implemented easily by involving the customer in project review meetings, either in person or through virtual conferences that give the customer total access to the decisions process.

Project review is scheduled weekly or biweekly into the work, as well as at the end of each phase and at any other time when the customer or the project manager anticipates the need to assess progress and review key indicators of success. Again, if project review is not specifically scheduled as an activity in the baseline schedule, it is liable to be missed.

Documentation

Documentation is an essential project quality management tool because it disciplines the process and ensures that quality methods have been built into the design and production process. The project manager should see documentation in terms of a front-end process of driving work rather than as a back-end process that records what work has been done and how. In other words, documentation is a quality tool if it is used to define an early process (one that occurs in the concept and definition phases of a project) that has been proven to yield a quality product or service. If used to simply record what happened in a project or as boilerplate by an intervening and offline quality office, documentation has marginal quality benefits.

Documentation reviews are scheduled at each point in the project process where a document is to be internally approved or reviewed by the customer. Scheduling documentation reviews ensures that documentation is not delayed until the later phases of the project and treated as an afterthought.

Scheduling as Team Motivator

Team complacency is the enemy of quality; therefore, any strategy that addresses complacency will yield quality benefits in the project management process. The way project managers deal with complacency and maintain focus is to understand the tendency of the system to go to disorder and complacency unless regularly charged with new energy and purpose. If complacency is the enemy of quality, purpose and scheduling are the enemies of complacency. New purpose and energy are introduced to the system by focusing on the scheduled work and immersing the project team in the task interdependencies and interrelationships designed into the project process.

Quality has a unique structure and texture in each project—a project quality persona—that is built into the project. Quality must be structured into the work, and each project presents a different challenge in finding ways to do so. Tasks and subtasks that ensure quality should be made integral to the work breakdown structure and the schedule for the work. Scheduling quality into the work means addressing quality in the definition of summary tasks, subtasks, linkages, and work packages. For instance, for an electronic instrument project, the actual task of drawing an electronic version of the product is linked back to the baseline specification of the deliverable and to customer expectations. The drawing must meet specifications—and, conversely, specifications must be structured to allow alignment with drawings—before quality is actually structured into the task. If the potential gap between specifications and the drawing cannot be closed by a scheduled task, e.g., “Check Drawing Against Spec,” there is no linkage from the drawing to a functional requirement. This is the way scheduling is used to ensure project quality.

The advantage to using scheduling as a team motivating activity is that the schedule is a way to refocus individual work into the context of the team effort, to continually remind team members of the interdependencies in their work. Schedules projected on a screen for team review and discussion create the sense of a common purpose for the team. This motivates team members to see how their

work fits into the big picture. Customers respond positively to project schedules because they can fit key milestones and deliverables into their own calendars.

As a special note, there is wide variation in the extent to which project teams take the time to plan and schedule projects, especially across international lines. These differences are attributable to culture differences as well as style. European project firms, for instance, appear to place much more emphasis on front-end project planning, perhaps up to 40 percent of the project timeline, than American or Canadian project managers. American project managers minimize up-front planning and scheduling, and rely more on down-the-road change management strategies to deal with issues not addressed in the planning and scheduling process. We believe that this tendency to downplay project scheduling is being reversed by the competitive forces of the global economy. American project firms are giving more emphasis to planning and scheduling as a result.

Quality Must be Translated to Scheduled Tasks

While we emphasize the overwhelming importance of quality in the quality, cost, schedule triumvirate, quality is the most difficult of the three to pin down. The key integrating principle is that *customer involvement and quality assurance* are mutually supporting activities that increase the probability of producing customer satisfaction. There are fundamentally two basic ingredients to quality—conformance to specification or requirements and customer satisfaction—and one does not necessarily produce the other. Conformance to specification involves controlling the development of the deliverable so that it can be validated and verified, e.g., that it meets the specifications as stated and "works" in its systems environment, whatever that is. This is where the application of quality tools and techniques is important within the project process.

Customer satisfaction, on the other hand, is tied to customer expectations. While one would assume that customer satisfaction is related to conformance to customer specifications, that is not always the case. Typically customer satisfaction is related to conformance only to the degree that the customer's expectations, needs, and wants are reflected in the specification and that any fundamental changes in the customer's view are somehow reflected in the specifications through change orders and modifications to the project scope. In other words, while conformance is somewhat controllable in the sense that it can be quality assured and measured, customer satisfaction is not. Customer satisfaction is a feeling, a perception, and a disposition that is based on the continuing relationship or project firm and customer/sponsor. That is why it is important to keep an eye on customer expectations during the project tenure just as closely as the other eye is on conformance to specification.

Because the most useful measure of quality is earned value (whether a project is on planned cost and schedule), it is important for project managers to educate customers on earned value as an indicator of quality. We believe that customer satisfaction derives from continuous project involvement and education. Therefore, to the extent that earned value reports can be presented regularly to customers—and interpreted by the project firm—customer satisfaction can be regularly gauged. In the end, it is the quality of the product or service—its very features, functionality, performance, and capability to create value—that drives the customer's expectations.

There are several key points or windows in the project management and scheduling process when *quality as customer satisfaction* and *quality as conformance* can be expressed and integrated. It is in the project manager's interest to use these key windows explicitly for the purpose of assuring quality, and to share each schedule version with the customer to ensure that quality is translated into the real work breakdown structure and timeline. These key windows are:

1. Front-end customer process analysis
2. Concept development
3. Generation of alternative candidate projects
4. Scope of work
5. Scheduling
6. Budgeting and earned value planning
7. Quality assurance
8. Project metrics
9. Prototyping
10. Quality audit

We have learned that the project manager must find ways to practice quality at every turn and achieve *continuing closure* with the customer on all the aspects of scheduling quality work as the project takes

shape and progresses to the final deliverable. Quality is not the preserve of the quality office; it is integral to the project planning, scheduling, and controlling processes.

Project dynamics often work against achievement of quality objectives. *Without constant vigilance, the project system moves naturally away from the customer; the dynamics are in favor of isolated, narrow project tasking and insulation of the project team—and therefore of quality issues—from the customer*. That fragmentation occurs *naturally* unless managed, almost as a function of the system itself, because the project is a system seeking entropy or increasing disorder. Many a project has failed because there was a major gap in the dialogue between the customer and the project team on quality issues—attributable to the lack of scheduled tasks to close those gaps. So these windows become strategically important, if they are scheduled and monitored, as an insurance policy against the forces that isolate the customer from key quality issues and decisions.

Let's consider these windows and the tools and techniques associated with them, and see how they are scheduled so that they can contribute to project quality management.

Front-End Customer Process Analysis

Although there are always variations on the theme, projects typically go through five phases: concept, definition, production, operation and testing, and closeout. Prior to the concept phase, however, there is a key step that ensures an understanding of the customer's business processes, work setting, and market forces. That step is front-end customer process analysis, and it should be a scheduled summary task in every project schedule.

It is important to know the customer's business and organizational setting and key processes before a project relationship is created. This is because a project manager and team must understand the customer's markets and customer base *better than the customer does*. Customer expectations for a project deliverable come from the customer's own markets and opportunities and must be seen in the context of the customer's milieu. Value is created out of understanding and thinking ahead of the customer to anticipate wants, needs, expectations, and requirements and translating those needs into the project schedule. For instance, if during this initial window, a project sponsor is clearly expressing the need for a given product to create value in a given working environment or setting, the scheduled work includes a set of tasks that specifically verifies and validates the product prototype *in that specific environment*, early in the project process. The actual setting of this analysis with the customer includes continuous reviews of a draft project schedule projected on a screen in the customer's office. We favor direct translation of quality issues into a project schedule *as they come up* in this initial step. This process assumes that the project manager has acquired proficiency with project scheduling and presentation software to integrate analysis of customer needs with initial planning and scheduling of the project.

Even if a project has not yet been selected, it is good practice to schedule candidate projects out through a high-level scheduling process in order to give the customer a clear idea of expectant deliverables, milestones, quality issues, and cash flows. Cash flow analysis of alternative projects allows the customer to assess net present value of alternatives as one indicator of potential project value.

This is the point at which quality as customer satisfaction and quality as conformance begin to take shape. Customer satisfaction is grounded in a high confidence level that is derived from the customer's feeling that a project team can literally *walk in their shoes, that they know the customer's business milieu, are scheduling appropriate quality steps in response, and can help evaluate and select appropriate projects that promise value to the customer*.

This process analysis phase involves the use of process assessment, market analysis, discounting and net present value analysis, and scheduling tools. Strategic planning exposes the customer's broad business vision and strategies for long-term success. The customer's values and principles of practice are surfaced here. Process assessment is accomplished through strategic planning, process improvement techniques, stressing identification of key processes, and beginning to look for opportunities for improvement in the customer's work processes. Discounting is a quantitative approach to evaluating the financial viability of alternative projects, using net present value.

Scheduling is accomplished through project management software, using GANTT charts, resource assignments, and "what-if" analysis. Scheduling is both an art and a science, and proficiency in the use of scheduling software enables a project manager to continuously *center* the project on the key issues

and activities and to stimulate discussion. Because a schedule embodies quality, cost (resources), and time, the schedule is an integrating vehicle for the project manager. The process of customer relationship management involves the use of schedules to highlight current or future problems or opportunities and to place time and cost dimensions on them as well.

Concept Development

Following initial process analysis, the initial concept phase involves the flushing out of alternative project ideas and opportunities after full immersion in the customer's key processes and product/service mix. Here is the point where issues and needs are translated into conceptual solutions and potential project ideas. A conceptual solution is an idea that shapes a need into a working vision. For instance, a customer may see a particular product serving a particular need; the concept is a visual picture of that product actually serving a customer need.

The ideal setting for concept development is a collaborative process involving the customer and the project team, sharing information and collectively exploring potential projects and benefits. This is where new technologies are born, through the stimulation of project teams interacting with customer representatives to encourage out-of-the-box thinking.

Concept development draws on QFD tools, addressed earlier in this chapter. QFD translates needs and expectations to design concepts, which can be detailed later into product and service specifications. The key issue here is that concept development is a group activity conducted through brainstorming and other group techniques. Brainstorming provides a forum for identifying alternative ideas and concepts and prioritizing them so that the customer can make decisions to proceed with the best possible project concepts. Brainstorming is facilitated by the project team and starts with the information gained in process improvement and immersion in the customer's business.

Generation of Alternative Candidate Projects

The generation of alternatives is a delicate process of creating ideas and options from free flowing discussions in brainstorming sessions and from current projects. Since the majority of projects come from current ones, or are related to current project work, the customer-driven project management firm ensures that creative ideas are captured from current work to feed the pipeline. This is accomplished in program reviews, where new technology and marketing ideas are made a regular part of the agenda, and through closeout project team meetings, which glean lessons learned and new marketing concepts from team members.

Alternative projects are compared through a number of tools and techniques, including net present value and weighted scoring models. Net present value is the process of estimating cash flows over the life cycle of the project and calculating the net cash flow and net present value of candidate projects. The weighted scoring model scores candidate projects against a series of goals, gives weights to those goals, and then multiplies the weights by the scores to get a weighted score.

Scope of Work

The scope of work provides an effective window for emphasizing quality, but project scopes rarely include reference to quality management. In project quality management, the scope is written to include all quality and performance testing for the product or service, thus ensuring that the key quality aspects of the deliverable are visibly addressed in the scope.

The scope of work is used as a tool to confirm not only the work to be accomplished but also the approach to quality assurance and quality control. The scope template is typically included in the project plan and is associated with the project schedule. Key milestones from the schedule are referenced in the scope document.

Schedule

Project managers must schedule the scheduling task. The scheduling process may be the most useful way to promote project quality management because the task structure and scheduling of the project are the usually the most consistently used management tools. Scheduling is accomplished by first developing a work breakdown structure and then scheduling the tasks built into that structure. In project quality management, the top-level summary tasks not only include a quality assurance task that is decomposed to the same level as all other tasks, but it includes quality steps as an integral part of each task breakdown to the lowest level. This requires that the project manager specify in the company quality policy that all tasks will be defined in terms of quality to the extent feasible and appropriate.

The basic tool of scheduling is a project management software package. The scheduling tool is used to take the work breakdown structure and plan it out over time, identifying predecessors, durations, and resource assignments. Scheduling the scheduling task involves two key subtasks: developing a preliminary schedule with resource assignments and key linkages, and getting approval of the schedule from the customer, stakeholders, project firm leadership and the project team, and saving as a baseline schedule. While this may seem a mechanical process to some, the schedule becomes the key *contract* between the project team and the customer and thus the scheduling process is considered a major customer relationship management tool.

Budgeting and Earned Value

The concept of earned value is an important tool of quality if it is planned into the project correctly from the beginning. Earned value is an indicator of how much work that has been accomplished at any given time in the project has earned its value, that is, meets the dual test of quality, customer satisfaction, and conformance to specification. When a percent complete for a task is estimated by a task leader, the percent complete represents an assessment not of all the work accomplished but all the work accomplished that will be acceptable to the customer, e.g., quality work. The earned value is the dollar amount from the original budget that should have been spent for the work, which earned its value.

It is important that the project plan, scope of work, and schedule all reflect the earned value concept because if the project is not set up to relate percent complete to the original budget, then the dollar indicator of earned value will be difficult to estimate.

Earned value is a monitoring tool calculated automatically by any professional project management software if budget costs have been entered into the baseline schedule. If budget has not been entered into the schedule, earned value cannot be calculated. Earned value analysis is scheduled into the project review and monitoring process at key points in the project.

Quality Assurance

Quality assurance is the process of building quality into the definition, design, production, and testing of the product deliverable. Quality assurance procedures provide for testing, verifying, and validating work as its progresses, not later in project monitoring and appraisal. In effect, quality assurance builds quality into the deliverable so that quality practices are indistinguishable from all other design and production practices.

Quality assurance is implemented through a variety of statistical, testing, verifying, and validating procedures to ensure that work is done right the first time, that it meets necessary tolerances and standards, that it performs consistently against both the specification and the expectation of the customer, and that it works in the customer's work setting.

Project Metrics

Project plans and schedules typically include the application of a set of generic and tailored metrics or measures that are to be used to monitor progress and the final deliverable. Generic metrics include earned value, budget variance, and a wide variety of verification and validation measures. Tailored measures, however, include indicators that are unique to the deliverable.

Metrics are tailored to the unique performance requirements of the product. For instance, in the design of new electronic products, which require embedded software, a useful metric is a measure of software design life cycle, an accurate indicator for the whole product life cycle. This kind of metric is often regulated or standardized by an industry or professional trade association for that product or family of products. A good project quality manager will use these kinds of standards to discipline design and production work, which then can be marketed as regulatory compliant. Review of project metrics is scheduled into every project review meeting.

Prototyping

Prototyping is a useful approach to project quality management because prototyping often addresses the expectations—and the vision—that customers often have of the deliverable, but may not have expressed in requirements and specifications. Prototyping is the process of demonstrating an early model of the deliverable and how it will work without having made major investments in its design and development.

Prototyping can be accomplished through electronic and visual representations, computer screens, models of products, and graphics. Prototyping is scheduled into a typical project as an early summary

task with subtasks addressing prototype development, presentation, testing, and approval. Eventually, a prototype must be approved by the customer before proceeding, thus it is a key milestone that should be scheduled into the project.

Quality Audit

The quality audit is a post-mortem review of the project process to ensure that the experiences and documentation are captured and assessed for the purpose of improving future projects. While the quality audit is typically performed by the quality office, the quality engineer, or finance/administration office, the principles of project quality management would include the project team itself in the audit.

Auditing tools are document reviews, interviews, and internal control analyses that ensure that planned procedures and practices were followed and that the project accomplished what it set out to accomplish efficiently and effectively. Project audits must be scheduled during project closeout.

Transform Customer Expectations to Requirements

Customer expectations must be "teased" out and transformed into customer requirements for new products because projects cannot succeed in meeting vague and unexpressed expectations and undefined specifications that typically follow. The quality function deployment tool is useful in transforming expectations to specifications. But the essence of the process is the will and determination of the project manager to educate and be educated by the customer in the initial concept phase of the project.

After they are developed, customer requirements are typically embodied in a scope of work statement, or other documentation of the customer's performance and functional standards. Detailed system specifications—derived from customer standards—then serve as the basis for development of the prototype with the customer.

Follow a Defined Development Process and Work Breakdown Structure

Project management is a generic management system laid on a technical or product development process. If that development process is not defined in terms of the technology and language of the product or service, good project management practices will be wasted. This is both the strength and weakness of project management systems. Such systems focus on quality, resources, and time management, but sometimes these systems cannot alone carry a new product development project with a complex technical process. Projects must have strong subject matter experts doing the technical work. For instance, good, scrubbed project schedules are important, but they must be built around generic work breakdown structures tailored to the product or service being developed. A work breakdown structure for electronic instrument development is quite different from a work breakdown structure for a new telecommunications product. But the project manager is the facilitator of the process, pressing for a useful and workable WBS and keeping the customer involved through email and Internet pathways on progress in defining the product.

To the extent possible, scheduled work will be broken down into tasks, which are defined and specified. For instance, for a product development process, the basic structure of it is specified to four levels:

- Stage: These are generic development activities in the project management system, e.g., summary tasks in the schedule structure, including customer requirements, concept development, detailed design, prototype development, design validation, product transition, and manufacturing
- Project/Phase level: This is the next level of development, tailored to specific project phase features
- Systems: This is the product systems or functional systems level, defining how parts integrate with each other to produce product functionality
- Task: This is the operating component level, where work packages are put together and achieved through individual or small team activity serving as the basis for design reviews

Schedule Customer and Quality Early

This concept stresses the importance of building the customer and quality into the work breakdown structure and schedule. For instance, customer reviews are identified in the project schedule as separable milestones. Customers are brought into the development of the work breakdown structure through Internet exchanges and meetings in which the customer is educated on all the details of the WBS and the preliminary schedule.

Quality is integrated into the early development process. For instance, product quality and reliability testing are specified as product features, not as a separate testing process. Quality data on variances

and test outcomes are shared with the customer as with all project team members and stakeholders. ISO standards are written and scheduled not by separate quality staffs, but by product engineers who are actually doing the work. Documentation of product quality and safety is verified in a scheduled task to ensure that the product meets the specifications, and validated to ensure that the product works in the customer's operating environment.

Customer-Driven Teamwork

Project teams are established with the objective of including the customer in all team deliberations and building an environment of high performance teamwork with the customer. The customer is seen as a team member, not simply a sponsor. To the extent possible, staff will be assigned tasks that are consistent with their backgrounds and expressed professional interests. In product development firms, project teams are composed of engineering, software, and technical professionals who are suited to the work they are expected to perform. Team staff members will be trained as necessary to enable them to perform assigned tasks. Team support functions are scheduled.

Define and Communicate the Scope of Work and Assignments Clearly

Product requirements and job assignments, including assignments to the customer for design clarification, customer data, and other necessary inputs to the project, are defined and communicated to the program team clearly. This will allow staff to understand how their work contributes to product development, and prepare for work assignments with necessary training and development.

Project management software resource reports are shared weekly with project team staff *including the customer* to indicate how tasks are assigned, to whom, and to identify key milestones. While this practice of sharing resource and schedule information with the customer as a matter of doing business creates a bond with the customer that ensures trust and reliability in the relationship, some customers may have difficulty with this level of involvement. For this reason, the project manager must make a strong pitch in the initial phases of the project that the only way to truly integrate the work with the voice of the customer is to place the voice of the customer in every discussion involving the project. This will require some education and advocacy, but customers quickly see the value of such an arrangement and learn when to play a passive role and when to interject themselves in key decisions in which they have a stake.

Collaboration Across the Organization

Collaboration among project managers, department managers, and the customer- driven team is the essential ingredient to the success of customer-driven project management. This arrangement encourages constant, professional communication and information exchange among project, departments and system managers in the process so that there is both individual team member accountability and collective ownership of schedules and requirements. In addition, an interesting dynamic occurs when the customer is involved; project team and department managers pay particular attention to customer reactions to project issues and gain valuable insights, which help them with other customers and other products.

Work Will be Quality and Schedule Driven

Since the heart of project management is the scheduling process, maximum emphasis will be placed on preparing tight program schedules that incorporate all the work necessary for program success. Program schedules will be planned and "scrubbed" in a collaborative process that ensures that all necessary work is included and all durations and resources are tightly planned and estimated. Schedule baselines will be established and work initiated only after schedules have been tightened through this process.

Ensure Timely Procurement of Product Components

Project managers pay special attention in early scheduling of activities that involve customers, suppliers, and stakeholders. These activities include procurement actions, testing actions, and technology challenges. Hardware specifications, parts, test equipment, and supply items will be included in schedules, and appropriate lead times established. Procurement actions are taken in a timely way to avoid schedule delays attributable to lack of inventory, but also to bring suppliers and vendors into the scheduling and planning process so they can share ownership on the timing and quality of the deliverables.

Change Is Managed

Customer-driven firms administer a formal engineering or product change notice process and a documented configuration management process that ensures that requirements and product component changes are managed and controlled. A systematic change management process will be

maintained through sound documentation and configuration management in these organizations. For the customer, this ensures that orders and reorders can be made online with a minimum of assistance from the project firm. The more the customer knows the parts list and numbering system of a product, the more the customer feels a part of the process and interfaces with it seamlessly. Thus configuration management is an important customer strategy as well as a key internal control on inventory and procurement.

Program Progress Will be Tracked and Periodically Reviewed

Project reviews involve the customer as well as other key stakeholders. Project managers track program progress using software schedules showing "baselines and actuals," prepare weekly presentations and earned value reports, and prepare for weekly program reviews conducted by the customer with the assistance of the project manager. This kind of customer role is essential if the key issues are to be addressed in project reviews. Typically, proprietary information is not surfaced in these meetings to ensure no sensitivity in the agenda or discussions.

Involve the Customer in Designing the Management Support System

A project management support system is an institutional set of supports, processes, and resources to ensure successful projects. Such a system involves a consistent approach and set of tools and techniques for planning and implementing programs in close association with the customer. When implemented across the division, such a project management system provides an organization wide program management culture that places emphasis first on product quality and timeliness. Such priority is confirmed with customer involvement. Formats for planning, information exchange, and project review are governed by distinct work breakdown structures and project phases, reporting requirements, and schedule, cost, and quality controls. Project managers are trained and developed in a consistent way—both in technical project techniques and team leadership, as well as customer interface—and manage their programs using standard project management software and Internet tools. Program teams are established as formal groups with charters in writing, and with performance guidelines and criteria for evaluating team members. A project management guide is used to communicate policies, procedures, and support systems, and the system is continuously reviewed. A common project management language governs communication on programs.

Quality as Driver

Quality must be built into the deliverable, not stamped on during inspection. That means that the deliverable specifications are defined in terms of quality and subject to classic quality testing and measurement during the development stage of the project. As is evidenced in the following chapters, customer involvement is the best quality assurance mechanism because it combines two critical forces in the determination of quality: the quality tools and metrics deployed in the project are appropriate to the customer's needs for quality as stated by the customer; and the development of the deliverable reflects the customer's changing views of a quality product and/or service as the customer sees it now. This is a difficult lesson for project managers to learn—quality is not a static concept, even though it might be served by a series of static processes and procedures. Quality is the combination of quality processes and customer learning, challenging the project manager to balance the application of quality standards to the appropriate user view of what is important. This requires that the customer be educated by the project team on the appropriate quality testing and standards for the customer's planned application. This suggests the relative nature of quality in the context of the wide variety of quality objectives or features for a given deliverable.

This relativistic view of quality does not diminish the importance of reducing and eliminating waste and keeping the cost of quality under control. Whatever the quality standard, the project must continually strive to improve processes and reduce rework as a basic proposition. But the project manager must exercise discretion in the actual application of quality measures and standards simply because there will be a limit to concepts, say of six sigma, to project deliverables that do not require it.

Reviewing Program Progress and Resolving Conflicts

The project manager conducts weekly review meetings with the program team to ensure a unified and informed effort. Sometimes these meetings generate substantial changes. Such change inevitably brings tension and conflict, particularly if its source for some reason is the customer. To dispel this tension, the project manager provides for a weekly agenda of discussions with the customer on anticipated changes and strategies to deal with them. This includes discussions of risks and risk mitigation strategies focused on the customer's perspective of risk. As project requirements change, the project manager ensures that the plan, schedule, and configuration management documents are kept current and distributed.

The project manager resolves resource and program schedule conflicts if possible within the team. In the event of issues and resource conflicts that cannot be resolved by the project manager, the customer, or the departments, the project manager is responsible for raising issues to a joint team of executives involving the customer for resolution.

Project Planning

The project manager has the primary responsibility for creating a project plan and a schedule using project management software and composed of tasks and milestones down to the fourth level in the WBS hierarchy, tailoring the actual work breakdown structure to the unique needs of the project. The plan is created with support from the customer, team members, and department managers. The project manager is required to keep the program schedule current, track progress, and incorporate changes as required, and for sharing updated schedules and earned value reports with the customer through the Internet.

The project manager utilizes project management software to produce and update schedules and resource reports, and is expected to be proficient in the use of such software for control and presentation purposes.

The project plan must include, as a minimum:

- An overview of customer requirements, program scope of work, and program objectives
- Specifications derived from customer requirements
- Schedules, including major schedule tasks and milestones
- Resource assignments, linked to the central resource pool file to allow analysis of overall resource impacts
- Identification of test equipment and components needed for the program (special test software, special test sets, fixtures, jigs, cables, and so on)
- Identification of any special tests required for the program
- Procurement requirements for development efforts
- Manufacturing requirements for development efforts
- Outside integration (A/C, customer lab, and so on)
- An estimate of other direct materials required for the project, including materials for test assets, test equipment, outside facilities, travel, and any other pertinent costs
- Risk assessment and risk mitigation plans

The project manager has the primary responsibility to create and maintain a detailed schedule that meets the needs of the customer, team members, and department managers. The schedule must contain, as a minimum:

- Summary tasks, task structure, and key milestones that correspond to all major program objectives contained in the plan
- All product or service development activities and tasks required to execute a given project, including systems design, detailed design, certification, test equipment, reliability, safety, design reviews, manufacturing, procurement, test assets, and so on
- Tasks detailed to the lowest practical level; activities and tasks should generally be built four levels down
- Resources assigned to activities and tasks and leveled to reflect a realistic workload
- A central resource pool which indicates the combined effect on the workforce of all active project schedules

Departmental Manager Roles

In a customer-driven organization, department managers for functions such as systems engineering, mechanical design, electrical design, and software certification are responsible for building and maintaining the resource and technical capacity of their departments to support of the product development process. Here are some key functions of these managers.

- The department's organizational structure and reporting relationships, roles, and performance expectations are communicated
- Performance evaluation; all staff receive annual performance evaluations reflecting department and program manager feedback
- Hiring, training, and career development plans; the department's technical capacity to perform is a function of its people and their ability to keep up in their fields; technical training is an integral part of the department manager's job
- Development of a department budget, which is used to guide and schedule implementation of the department's program; the budget includes labor and equipment acquisition

- Preparation of a staffing plan that projects future resource requirements
- In a matrix organization, department managers assist project managers in bringing program schedules to baseline, determining resource requirements, and supporting delivery of program products

Project Team Roles

Each project team member is responsible for understanding their assigned tasks, their interdependencies with other tasks, and for general support to overall team performance. The primary given is the team member's technical competence; the primary value-added is the team member's dedication to the project team's objectives and the project deliverable. Team members are accountable for keeping technically proficient and performing their assigned tasks in a timely way, consistent with the schedule. Team members collaborate with each other and the project manager, promptly attend team meetings, and report to their project managers and department managers on technical and schedule issues.

Role of a Project Management Office (PMO)

The role of the project management office is to promote best practices and consistency in project management. The office provides administrative support to project managers and departments with scheduling, resource planning, and reporting services and activities. A key role is the analysis of all resource impacts to identify and resolve conflicts. In addition, the support office prepares management guidelines, provides training, and develops project evaluation metrics. In addition, the office implements standard methodology through project management guidelines, implements tracking software, supports project review, and distributes all project reports and meeting minutes to the customer and the team. The office assists with estimating costs, manages the project documentation process, and produces resource usage reports to all effected staff. The project management office helps management review alignment of the project with customer strategies as well as project firm strategies, and helps plan for project process improvement initiatives and future resource needs.

Scheduling

Good scheduling is at the heart of the customer-driven project management process. Schedules created in appropriate software are scaled to the project effort, linked to a central resource pool file, and posted on a network including the customer. Schedules constitute the basis for program development, tracking, and review, and project review meetings involve projections of schedules on standup screens to encourage group discussion and understanding. Customers are involved directly in schedule reviews or through conference calls participate actively. A good scheduling process provides adequate time to ensure that the work breakdown is comprehensive, that scheduled task durations and predecessors are as accurate as possible, that key linkages are made, and that resources, once assigned, are actually available and committed to the program when they are needed.

Scheduling and associated resource planning are accomplished collaboratively by the project manager, working closely with department managers and the project team. Communication and sharing of schedule and resource information, check points, approvals, and feedback are managed on the network to the extent feasible, with meetings and review of hardcopy schedules or action lists as necessary.

The project manager carries out the following basic scheduling procedures with support from the program planner:

- Ensures that customer requirements, expectations, and reviews for product functionality are clearly represented at four levels
- Establishes project team "sign off" of the schedule before base lining
- Develops the top-level work breakdown structure to serve as the basis for scheduling, using current WBS templates or creating them in consultation with the customer and key departments
- Prepares a top-level schedule showing basic task structure, durations, start and finish dates, linkages and predecessors, and links the schedule to the central resource pool
- Integrates top-level tasks into a more detailed schedule
- "Scrubs" the schedule, involving four steps:
    - Drafts an initial schedule, with a work breakdown structure to the fourth level, and makes resource assignments for all tasks
    - Works with department managers to assign resources and resolve conflicts
    - Links the schedule into the central resource pool to identify resource issues

    - Manages meetings with department managers and customers to work out final schedule structure, task definition, linkages, and resource assignments
- Enters hourly, fixed, and equipment costs and produces a project budget that is shared with the customer
- Gets sign-offs from all department managers before proceeding to schedule baseline
- Saves the project baseline as the key point of departure for the work
- Kicks off project with team meeting; hands out hardcopy schedules and individual task assignments
- On a weekly basis, collects and enters actual performance data from team members on: (a) percent completion, (b) actual hours spent on tasks (from time sheets), (c) actual start and finish dates, (d) actual durations, (e) remaining durations, and (f) actual ODC costs, and updates schedule on the network
- Prepares summary presentation reports, tables, and narratives on earned value, estimate to complete, and estimate at completion and submits them to the customer and management, along with schedule updates with all tasks updated and conflicts resolved
- With the assistance of the project management office, analyzes resource usage from central resource pool file and identifies conflicts, issues, and problems for current and future projects

Base lining the Schedule: A Quality Management Action

Establishing the baseline schedule is a significant quality action in the project management process, signifying the official kick-off of the work and indicating a strong commitment to the quality objectives, quality procedures built into the schedule, and to the schedule and resource plans themselves. The baseline is the point of departure for monitoring and tracking the process. When a project is base lined, the project schedule is complete. The following are some rules of thumb for base lining:

1. The purpose is to get to a baseline schedule that captures all the work to be done, particularly quality procedures as summary tasks. This includes key documentation and procurement tasks. The baseline schedule does not change unless the basic scope changes. After agreement is reached, the project manager confirms the baseline by saving it and making it available on the network *as the baseline*. There is no uncertainty where the baseline is and how to access it.
2. The baseline schedule is the agreed upon, scrubbed schedule for the project, linked to the resource pool. The baseline shows all interdependencies, linkages; and resource requirements; includes all tasks necessary to get the work done; and shows impacts on parallel programs and resources. All procurements and test equipment are covered in the schedule.
3. The baseline schedule is resource-leveled—the schedule can be implemented with current, available resources. Assigned staff and the customer are aware of the commitments and have "signed-on" to complete their tasks to meet the schedule milestones.
4. Getting to the schedule baseline involves collaboration between the project manager and all departments and staff involved in planning and implementing the schedule, as well as the customer. A baseline meeting is held to arrive at final agreement on schedule and resources committed before the baseline is saved to the network. The project manager facilitates the meeting, and all department managers attend and come prepared to commit their resources to the final, agreed upon baseline schedule.

Schedules on a Network

Managing schedules in a network environment involves ground rules for access and change, and for preserving the project manager's control of the baseline schedule. The following are the steps involved:

1. All base lined and planned schedules are housed on a server that can be accessed by the customer and the team. Separate folders will be located within this directory for each schedule. There are no dates in the file name. The central resource pool file will continue to be named "Central Resources," and will be housed in the same directory. Archive versions of schedules will be housed in a separate folder.
2. The project management department controls access to schedule files. Customers have "write" access to the schedules. Department managers, systems engineers, and other engineering and manufacturing staff have "read" access to program schedules.
3. The project management department is responsible for maintaining and updating program schedules on the network. The project manager will then save the schedule as a baseline schedule. Once base lined, the schedule will be placed in an administrative directory. The baseline schedule will be the only version of that schedule housed on the network and will serve as the source of "planned versus actual" tracking information.

4. In preparation for the weekly project review and weekly report, the project manager will update the schedule in consultation with department managers and the program team. To update the schedule, the manager will update percent complete for all tasks, and update all start and finish dates as appropriate. All updates will be made to the network schedule version.
5. Department managers will be responsible for maintaining their own department schedules and resource pool files, and assisting project managers in updating program schedules. Project managers and department managers will share schedules through email or hardcopy until updates are agreed upon.

Resource Planning

Customers are interested in resources, resource planning, and scheduling for projects they sponsor. They want to know who is working on their deliverable because staffing is a major quality issue. Because scheduling is essentially the process of planning for use of personnel and equipment resources, schedules and their resource files are of direct interest to customers. Good project management requires that there be a process to plan for future resources, to allocate current and projected resources to schedules, and to make shifts in resource management as required. The process must provide for a central resource pool to identify impacts of project schedules and ensure the efficient utilization of the workforce. The resource pool information on the network is shared with management staff and all team members to allow each team member to evaluate the scheduled work assigned and to provide guidance on task definition, durations, start and finish dates, and interdependencies.

Resource conflicts are identified through the resource pool. The project manager and program planner are responsible for identifying conflicts and root causes and involving the team in resolving issues. Corrective actions are taken by the program manager in consultation with the customer.

Long-Term Staff Planning

Involvement of the customer in long-term planning can help to build longer-term relationships with the customer. Long-term staff planning begins with some understanding of what the current workforce is doing, e.g., its current capacity. Standards are then developed that relate current capacity to performance standards. The process involves relating staffing levels and/or staffing mixes to standards for work and output. For instance, such a standard might define what a given level and mix of software certification engineers can produce, based on past history, e.g., five engineers are supporting three concurrent product development projects with an average turnaround on software certification documents of three weeks.

These standards are used to estimate what various alternative staffing levels might produce in the way of more capacity to produce certification documents sooner or produce more such documents in a given period of time. The issue in this case would be to see what new staffing levels would be required to put out twice as many software documents in the same three weeks.

The more immediate workforce decisions are made on the basis of schedule conflicts created by current scheduling impacts on the current workforce. Whenever a current conflict is created by current and planned schedules, program managers are expected to collaborate to resolve such issues or bring them to management.

Good workforce planning involves the staff themselves in the planning process. Providing team members with information on assignments helps to give them ownership on key project issues such as task interdependence and resolving resource conflicts. It also allows them to assist in estimating levels of hiring necessary to raise the capacity to improve performance to various levels to meet future demand. To provide access, program managers provide information from the central resource pool to all staff, reflecting assignments for all scheduled programs to team members. If staff confirms that these resource plans accurately reflect the work actually going on and anticipated, that would tell the manager that he or she is on the right path in the scheduling process. Positive staff reaction to getting this information would tell the manager that staff needs more information on expectations and assignments than they are getting.

Preparing Staffing Policy and Plans

This section defines the process for meeting staffing requirements through the development of staffing plans. Staffing plans are part of the project planning process to prepare for future customer and program requirements.

The objective is to initiate a planning process to prepare and implement staffing plans based on forecasted programs and workload requirements. Staffing plans are produced through a process of accounting for current staff activity, then forecasting program and staffing needs.

It is the responsibility of department managers to periodically review staffing and resource requirements for their departments, and to develop staffing plans to meet future program requirements. Based on these plans, department managers are jointly responsible for acquiring the necessary staff resources and building their capacity to meet projected needs.

The planning process involves six steps:

1. Determine department staffing levels and assignments
2. Develop staffing/workload standards
3. Forecast future requirements
4. Develop department staffing requirements
5. Develop department staffing pattern
6. Prepare staffing plan

Step 1—Determine Staffing Levels and Assignments

This step describes and documents current department staffing levels and staffing mixes, and relates current staffing levels to current assignments. The purpose of this step is to describe the current department workforce, functions, and assignments. One source of information for this review is the ID resource pool that reflects all program assignments from active program schedules.

The report from this step is shown in Table 7-1.

Table 7-1: Sample Staffing Report

Department role/function				
Software department	Position	Current staffing level	Task summary	Job assignment
Software certification	Software certification engineer	3	Support program management	Requirements definition
				Software code development
				Software documentation

Step 2—Develop Staffing Standards

Staffing standards help compare staffing levels with performance goals. This step involves developing staffing standards that relate staffing levels and mixes of technical expertise to specific workloads or performance goals. Standards compare staffing with particular product development workloads, schedules, activities, documents, and other outputs. This allows the department manager to forecast what kind of staffing increases are necessary to meet future needs for timely product development. Functional areas, workload factors, and standards should be tailored to the department's functions, but should relate performance, e.g., meeting a functional requirement within a given schedule requirement, to staffing levels.

Table 7-2 shows a recommended sample format.

Table 7-2: Recommended Staffing Standards Format

Staffing level	Functional area	Workload factor	Task duration	Standard
3 Software certification engineers	Software certification documentation	Concurrently prepare all software certification documentation requirements for three program phases	45 days	Meet certification documentation requirements in 45 days for three programs concurrently, with three engineers

Step 3—Forecast Future Requirements

This step identifies future program and project requirements for the department, e.g., what workload the department is likely to be required to do in the future, and forecasts the appropriate staffing level and mix to meet those requirements. Future requirement information will be obtained from program planning forecasts and other information on future project demands, as well as analysis of current assignments and durations.

Step 4—Develop Department Staffing Requirements

This step involves developing a department staffing pattern, which defines the level and mix of staff required to meet current and future needs, and placing them into a department organization chart. The staffing pattern identifies core positions, e.g., positions that are essential to carrying out the department's role and function, as well as support and junior/training positions as required.

Step 5—Develop Department Staffing Patterns

This step produces a plan to acquire the levels and mix of staff necessary to meet future department staffing needs. This step determines various sources of the expertise needed, various employment arrangements, e.g., employee, contractor, etc., and outlines a hiring and/or internal career development approach.

Step 6—Prepare Staffing Plan

A department staffing plan includes the results of previous steps. It includes current staffing levels and mix, and assignments; staffing/workload standards; a forecast of future program requirements; future department staffing requirements; a department staffing pattern; and a staffing implementation plan.

Program Review

The manager of projects or program manager holds weekly program review meetings to discuss broad program issues; detailed technical, resource, and schedule problems; project team performance; and risks. Customers are invited to attend. Project managers are responsible for preparing for these reviews and anticipating key agenda items. Department managers attend program review meetings as appropriate.

The project manager is required to track the progress of the program on an on-going basis and update the program schedule on a weekly basis. The program plan is updated as changes in plans warrant. Project managers are required to hold periodic reviews with the program team in preparation for reporting and to support task assignments and feedback, either as a single meeting with all functions represented, or as a series of meetings with major functional areas represented at each meeting. The project managers are required to report progress to customers and management at a minimum of biweekly intervals.

Problems that significantly impact cost, schedule, or product performance must be identified, investigated, and reported to management so that decisions can be made on a fully informed and timely basis. As part of the program tracking and reporting, it is the program manager's responsibility to identify those problem areas, and to assume responsibility for resolving them.

A good tracking system and weekly program review meetings are keys to the success of the project management system. The manager follows up on program reviews, and the program planner is responsible for maintaining program review agendas and documenting action follow-up. In support of program review, the project management office:

- Flags current and new issues for the week
- Distributes assignments to staff and gathers feedback
- Identifies conflicts and facilitates resolution

- Provides weekly hardcopy updates of all schedules before program review meetings with summaries of variance between planned and actual, by schedule (text and graphics); problem areas with a plan for correcting the problems; risk management issues report; 12-month lead time resource assignment reports; labor utilization and earned value; ETC (estimated time to complete); and EAC (estimated budget at completion)

Development of Customer-Driven Program Manager Competencies

Project managers must be more than administrators of their schedules. To build and improve the program management capacity of the organization, project managers are trained and developed, emphasizing key competencies. Training in project management approaches, tools, and techniques is provided to all such managers, as well as team facilitator training, and project management software training. A typical training and development program consists of workshops on:

- Customer interface, which covers an understanding of the business value of customer relations, the particular customer processes and key markets, key contact points, negotiation and presentation skills, and communication
- The project management organization, which covers the matrix relationships in the organization, roles, functions, and responsibilities
- Program planning, which covers the planning process, planning outputs, and the structure of the project plan, e.g., objectives, scope of work, schedule, and budgeting
- Scheduling and resource management, which covers proficiency in project management software, task linkages, resource planning, and tracking practices
- Budgeting, which covers budgeting techniques, standard labor and overhead costs, fixed costs, and accounting codes for capturing project costs
- Staffing skills, which covers workforce and staff planning approaches, staffing patterns, job definitions, and hiring and interviewing
- Team facilitation, which covers team and group facilitation skills, including how to enable the customer and the team to interact productively

Agile Project Management

Gary Chin, in Agile Project Management: How to Succeed in the Face of Changing Project Requirements (AMACOM 2004), challenges traditional project management in his discussion of keeping the process flexible. His admonitions are especially applicable to quality issues in new product development.

Here are the salient points in Chin's book:

1. Estimates of resources and work versus commitment. While classic project management focuses on resources and time, agile project management focuses more on team commitment and key milestones. Less attention is paid to tight resource allocations, and more to ensuring that team members do whatever they need to do to get the whole project completed.

2. The project manager takes an external perspective, not internal, and sees business risks. Program and project managers are seen not simply as "task masters" over schedules and budgets, but rather representatives of the business, extensions of the business in the project environment. The external perspective places the project and program manager both in the world of translating, communicating, and negotiating with project sponsors, sensing market and global changes affecting the project deliverable, and adjusting to change.

3. Achievements versus activities. The emphasis is on achievement of the project objectives, with less attention on strict enforcement of work activities and tasks. In other words, team members are empowered to change the way work is conceived and done in the agile environment. This gives team members the challenge of owning the key deliverables and outcomes of the project and shifting job tasks and redefining and reinventing work processes to get the job done faster and better.

4. Shorten the time horizons. Because of the changes in project variables and competitive forces, the time horizon for planning becomes shorter and more focused. The 80-hour rule becomes the approach, while longer-term planning and milestones are left more vague and undetermined. The assumption here is that project risk is increased if a project locks into a structured approach over the long term and cannot adjust when necessary. The focus is on "cost to complete" and remaining work, looking ahead to redefine and redirect the project work given the situation at any given project review point.

5. Technical skills versus adaptability. Agile project management requires a stronger concentration on adaptability than technical skills. Team members are recruited and developed not simply to perform technical work, but to be able to adjust and play a variety of roles across many technical interfaces, e.g., electrical engineers are expected to understand software engineering; mechanical engineers work with electrical and software engineers in "seamless" teams to integrate products and get them to market.
6. Variances in external forces versus variance in plans. More attention to external influences, e.g., the price and quality of contract supplies, changes in market demand and customer requirements, and less attention to variance in plans, schedule, and cost. This does not mean that earned value and variance are no longer useful; rather, that short-term shifts and variances are seen as indicators of the future rather than strict guidelines.
7. Achieving business results versus managing schedule, scope, and resources. Program and project managers are encouraged to look at business results, e.g., cash flow projections for marketing the project deliverable, profitability and cost reduction, and sponsor satisfaction. Team members are delegated more responsibility to manage day-to-day work schedules and variances with their eyes on the project outcome.
8. Achievement-based networks rather than Gantt charts. Track network diagrams and "project paths and interdependencies," rather than standard Gantt chart schedules. Achievements are seen as key "gateways" or milestones that must be reached.
9. Look at decisions rather than activities. More emphasis on decisions made in a project and less on activities per se. This trend has more project managers looking at decision *trees* and key options at various project crossroads, rather than assuming project tasks are settled and pose no decision challenges. In other words, if a project manager must make a decision to deal with a future risk and there are important implications for taking one or another decision path, those decision paths are mapped into the schedule and team members contribute to the decision-making process. Chin's "Project Data Sheet" helps to integrated network diagram and decision milestones into project planning.
10. Successful product versus successful project; more emphasis on the outcomes and products of the project than the project itself. Projects that meet schedule and cost goals but do not produce marketable and profitable deliverables are not considered successful projects.
11. Integrating the project and the business. Rather than seeing projects as separate from the business, agile project managers *consider themselves the business*. In practice this means that project managers are aware of business considerations, e.g., market share, product cost and pricing, competition, quality, and customer satisfaction, and reflect them in project decisions.
12. Build contingencies into schedules and plans. This approach gives more priority to looking at key risk decisions and options and building contingencies into the baseline schedule rather than keeping them outside the project circle until needed.
13. Alternative pathways to deliverable versus shortest path. Program and project managers encourage team members and support staff, including the project management office, to identify shorter pathways to task and project outcomes, loosening up the work breakdown structure and schedule and "authorizing" different ways of accomplishing the work.
14. Expect versus discourage change. Project changes are encouraged as the project team and the customer learn from the project, and change management practices and procedures take on more significance. The built-in bias against change is transformed into a "learning environment" that adjusts to change and new insights especially in new product development.
15. Reinventing project boundaries versus enforcing them. Boundaries between functional managers and project managers are blurred as team members cross technical and project boundaries to get the job done, e.g., professional engineers help technicians understand and complete testing requirements; purchasing agents spend time with team members to understand supply and equipment needs and issues to allow them to serve the project team more effectively.
16. Risk-based infrastructure for the agile company. The agile project management company builds a supporting culture for risk-based scheduling and decision making. Support systems encourage tight short-term management but provide for analysis of future options in project reviews.

17. Balance innovation and process. Barriers to innovation and creativity are removed in the project planning and execution process; premium is placed on finding better ways to get the work done and to redefining the work with “work around” and “out of the box” thinking.
18. Emphasis on the execution stage versus emphasis on the planning stage. Risk and uncertainty encourage more focus on execution, corrective action, and agility, less on long-term planning. Rather than spending 20 percent of the project life cycle on planning and getting to a baseline, work is initiated with skeletal scheduling (5 percent) and cost information. More emphasis is placed on midstream adjustments and realignments of tasks to new forces that surface during project execution.