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Your Product Development Process Demands Ongoing Improvement

Winners at new product development make every project a learning process. Here are 12 steps to reaching that level.

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OVERVIEW: *Although managers routinely review their product development projects to ensure that each is achieving its objectives, they seldom review the development process itself to identify and overcome its shortcomings. This article provides a I2-step process for capturing the learning from each project. The first step is selecting a name for the process that is preferably not the popular one, "postmortem." The last and most crucial step is converting the findings from each project into actual changes in the development process. This amounts to giving process change actions the same level of attention that development projects receive. Nine companies provide illustrations of the principles involved, showing that a well-tuned development process is a competitive advantage that repays the investment required to obtain it.*

Most firms today have an established process for developing new products. However, managers typically view the development process as a business system that must be in place to ensure the quality of their products and control the use of resources, rather than viewing it as a competitive strength. Thus, they are unwilling to invest in continually sharpening the process to provide a competitive edge as the environment shifts.

In my experience working with many different companies to accelerate or otherwise improve how they develop new products, I have found that each firm can be put into one of four levels of product development maturity, depending on the attention management pays to its development process:

1. An *ad hoc* process.

2. An established process that is used on most or all projects but is not reviewed itself.

3. Some projects are reviewed to learn about the process, but there is no effective, ongoing way of using the review to improve the process.

4. Each project is viewed as a learning experience, and formal channels exist for modifying the process as a result of this learning.

Many companies have moved from the first stage to the second; fewer have advanced to the third stage, and very few have reached the powerful fourth stage. This article presents a 12-step process for helping companies reach these higher levels of maturity, in which product development is regarded as a continuously adaptive process that learns from all past projects.

The mindset underlying the higher levels of maturity is that each development project has two deliverables: 1) The product that goes to market; 2) Improvements in the organization's development process. Any project that only produces an excellent product on time and within budget has only obtained half of the benefit. Leading companies invest in obtaining the second half.

Laying the Foundation

1. *Name your improvement process carefully.--This* first step is where many companies get off to a poor start. The most popular name is "postmortem," which suggests that something has died. Some companies place a lively twist on this situation by calling their process a postpartum.

Then there is the choice between "review" and "audit." Audit is an acceptable term in many companies, but it connotes unpleasant management heavy-handedness in others. The point is not that some terms are good and others are bad but that we should be particularly careful about the signals we send here, because any process that reviews project performance will get very close to evaluating individual performance too. Individuals will be unwilling to help the company improve if they suspect that their own career is at stake.

Senco Products (a Cincinnati, Ohio manufacturer of pneumatically powered hand tools) calls theirs a "process improvement review." Hewlett-Packard (Palo Alto, California) uses "retrospective analysis," and Farinon

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Division of Harris Corporation (a supplier of microwave products and systems in San Carlos, California) calls it "lessons learned." I will simply use "process review," but I suggest that readers choose a name that fits their culture and objectives.

2. *Piggyback on existing strengths.*--After choosing your name, borrow from the best of your management processes. Perhaps you are using continuous improvement in another part of your business and can adopt this as a model for starting development process reviews. Perhaps you have redesigned one of your other business processes and can use this as a model. Many companies are training their employees in meeting and process analysis skills that will contribute to understanding the development process and how to improve it.

3. *Pick a reviewing pattern.*--For process reviews to become routine, you will need a pattern for determining when they are to be conducted. There is no single answer here; it depends on objectives and company style. The most obvious pattern is simply to review each project as it is completed, as illustrated at the top of Figure 1. The major weakness of this approach is that it can take considerable time for a project to finish, and the learning is therefore delayed. Senco overcomes this problem by completing a minor review at the end of each phase and a more comprehensive review at project conclusion.

Another approach is to review the development process for all projects annually. This has two potential advantages. One is that several projects can be compared simultaneously for common issues, and the other is that an annual review can make it easier to obtain the senior management approval and attention crucial to making substantial changes.

The bottom diagram in Figure 1 illustrates a standing committee charged with continually upgrading the development process. The committee meets for perhaps a couple of hours every week and monitors every project regularly. This suggests a substantial commitment to improving the development process, and improvement can be rapid,with such continual attention. Potential weaknesses are that the product developers may view the committee as "fluff," or it may have little authority to make major changes. Clearly, the committee must be well linked to senior management in order to benefit from the time devoted by the committee.

Figure 1 does not cover all of the possibilities. For example, Forma Scientific (a Marietta, Ohio producer of cell culture incubators and other laboratory equipment) set up a new product development team, not to improve the process but to actually build it. That is, rather than establish a development process in the abstract in advance, Forma's new product process development team interacted with the product development teams to develop its process as it developed the products.

Any prqject that only produces an excellent product on time and within budget has only obtained half the benefit.

To select a pattern for your process review process, consider your objectives and your current situation. Typical considerations include:

- The effort you are willing to commit to reviewing projects and implementing process changes.
- How much you are willing to burden development teams with this task.
- How and when decisions on significant process changes are made in the company.
- How strongly you are wedded to project phase milestones, which will influence the review points.
- How you are going to compare across projects to generalize conclusions.
- How quickly you would like to correct specific weaknesses in your process.
- The relative importance of development time, product cost, development expense, and product quality in your business.

To achieve your specific objectives, a mix or hybrid may be appropriate. For example, Senco combines a standing quarterly review with the reviews of individual projects mentioned earlier. Says Senco's product development manager, Scott Allspaw: "Until we develop the habit of ongoing process improvement, we're meeting quarterly to ensure a continuous upgrading of our product development efforts."

The development team at Baker Oil Tools (a manufacturer of downhole safety valves in Broken Arrow, Oklahoma) is authorized to make minor process changes and try alternatives stemming from the team's weekly development process meetings. Then, at major project milestones, the project team meets with a senior management committee to recommend broader improvements.

Managers are familiar with development, design or project reviews in which accomplishments regarding time, cost and design quality are compared against plan and variances are noted. Such reviews are sufficient for managing projects but are inadequate to reach our goal here-learning from projects. To learn, we must go further, asking:

- How did this occur?

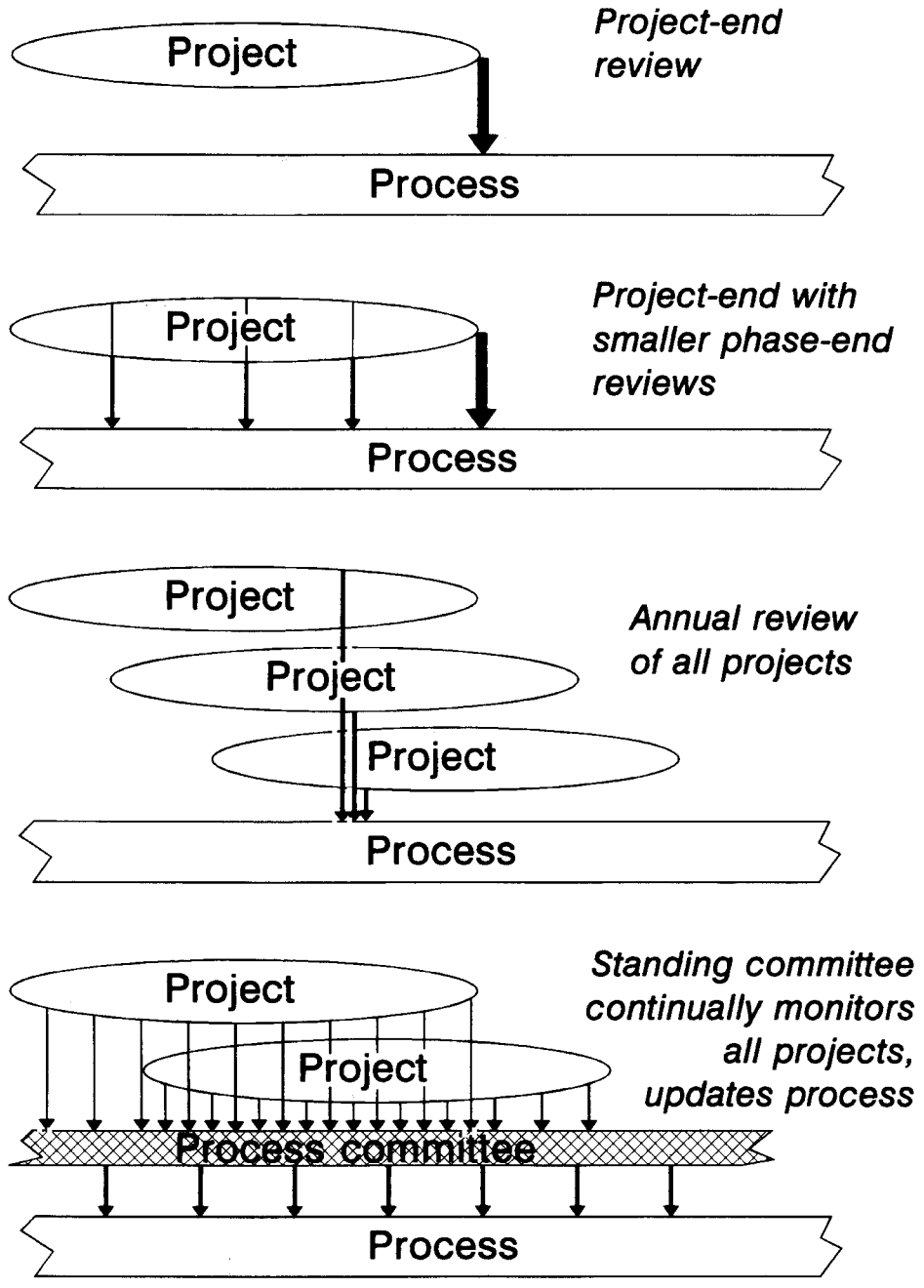

Figure 1.—From top to bottom, four of the many possible patterns for timing process reviews.

- How often does it occur?
- What could be done to prevent recurrence?
- Who will work on fixing the process?
- How will we know when it is fixed?

Conducting Reviews

4. *Assign a reviewer*.--After you know how you will be reviewing your process, consider who the reviewer will be. This is not an issue with relatively informal development team self-reviews, but it is critical for broader-based or more intensive reviews. Basically, the reviewer(s) must have an independent viewpoint, without a vested interest in the project under review. In addition, the reviewer should be able to engender real sharing and learning about the process, rather than an attitude of "auditing" it for mistakes. Three types of individuals may qualify:

- Product developers currently assigned to other projects.
- Those from "neutral" departments, such as corporate quality or human resources.
- Outsiders, such as consultants, facilitators, retirees, or benchmarking partners.

Reviewers should also be familiar with your products, processes and product development in general, so that they can place suggestions in context and spot a gem or red herring when they see it. In this regard, an outside product development expert or an employee who has recently transferred from a competitor can add value to the process by drawing from other experiences.

5. *Constuctively balance positive and negutive findings*.--Strive for balance in conducting the review. Some companies tend to concentrate on the pleasant experiences and avoid conflict or failures. Consequently, there is the temptation at all levels to make the project look good, as though the people were writing a press release on it. The only problem with this is that it distracts us from what we are about, which is learning from our mistakes.

On the other hand negative feedback that "poisons the well" is especially destructive. We must take time to understand what we did well and the reasons for the success, and to reinforce what we need to continue doing.

At Convex Computer (a Richardson, Texas-based producer of supercomputers and scalable servers) the review is structured to cover both successes, called the "gold buckets," and mistakes, called the "brown buckets" because of their dirtier nature. Reviews are structured to cover the brown buckets first in order to get people talking, then to close with the gold buckets to help people leave the review with a positive feeling.

Our objective is to learn how to do the-job better, faster or more effectively.

6. *Focus on an improved process*.--One problem with calling the reviews "audits" is that an audit suggests the purpose is to ensure that all rules were followed, whereas our objective is to learn how to do the job better, faster or more effectively. In fact, effectiveness may be enhanced by not following all steps every time, and a good review will uncover non-value-added activities that might be eliminated. Thus, "audit" suggests that the process is sacred, missing the whole point that our job instead is to streamline the process. An audit may stifle the very creativity we are trying to foster in learning about the process. For example, Fluke Corporation (an Everett, Washington producer of electronic test instruments) does conduct true process audits to inspect for conformance to process criteria, but they are careful to keep these audits totally independent of their process reviews.

Just as "audit" sends the wrong message as to what we are about, tying a process review to the company's reward system corrupts the objective and inhibits the free flow of information. You may wish to recognize a development team's accomplishments, but this should have nothing to do with learning about how the process might be improved. Specifically, maintain a clear separation between process reviews and personal performance appraisals.

As you modify your development process, remember that control systems, such as development procedures, tend to grow naturally with time. Consequently, maintain a conscious effort to eliminate as much from the process as you add to it. Otherwise, the process will grow imperceptibly slower and more bureaucratic as it is "improved."

Collecting Information

Process reviews are beneficial to the extent that they produce data supporting process change. Accordingly, reviewers collect two types of mutually supportive information about the project: qualitative information, in the form of participant interviews, and quantitative information, usually as metrics.

7. *Interview key participants*.--In selecting interviewees, consider four types of participants:

- Project participants (team members), who will have an inside view of the process's strengths and weaknesses.
- Those in supporting roles, who contribute to the product's development but are not considered members of

the development team, including buyers, industrial engineers and cost accountants; to them, this project is just one of many they must service.

- Internal customers of the development team's efforts, usually production and sales; these people are in a good position to judge the quality of the development work, because they will have to deal with the resulting problems.

- The process beneficiary, who is the executive (usually of sales or marketing) who most directly benefits from having a timely, successful new product; this individual should have the clearest picture of the corporate value of an improved development process.

My normal approach is to interview the process beneficiary first to get the big picture as to how well the project and the product satisfied broader organizational objectives. This provides guidance on where emphasis should be placed for the remainder of the review. The next step is to work with the development team as a group to capture where this project advanced the development process and where the team encountered difficulties with the process. Finally, I interview selected internal customers and those in supporting roles to understand strengths and weaknesses from their posititon in the organization; their opinion on a certain point may vary from that of the development team.

8. *Back up the interviews with data*.--These interviews provide a great deal of relatively soft information. Quantitative measures, or metrics, can be used to focus on specific questions that have arisen in the interviews or to measure specific variables that relate to the firm's success. For example, manufacturing may observe that there were too many design changes late in the development cycle, so we collect data on engineering change notices issued by project phase and relate them to other comparable projects. This is a process of hypothesis testing, firming up the verbal data.

Generalizing on a practice often used in software development, Fluke Corporation monitors several types of defects, such as the number of parts changed per week, changes in specifications, and project plan changes. Fluke has also found complexity to be a revealing parameter, so they measure percent reuse of parts, percent reuse of integrated circuit design and the number of manufacturing processes used for the product.

Baker Oil Tools measures Suggested Dimensional Changes (from manufacturing), numerical control programming changes, and changes in manufacturing methods as indicators of how well their development process is working.

Randy Englund a project manager at Hewlett-Packard points out that metrics should be used to reinforce desired behavior. "People should know what they can do differently to change how the data reflect their

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performance," he says. "For example, a report could show progress on software defect resolution."

9. *Measure progress with ongoing metrics*.--Although this use of metrics has the advantage of being responsive and adaptive, it provides little continuity with which to judge progress from project to project. Thus, other metrics are needed to provide an ongoing measure of performance relative to corporate goals. These may include cycle time for the entire development process or for critical phases or activities, such as prototyping cycles.

Cost and effectiveness measures are other common possibilities. Such broad metrics may not be powerful diagnostic tools, but they monitor how well the development process is achieving its objectives. Consequently, these trend metrics should be:

- Relatively permanent, as their value increases with the number of projects they can be used to compare.

- Well aligned with process objectives, to avoid misguiding people; for example, it would seem appropriate to track how well the project met its expense budget, but project economics analyses seldom suggest that project expense is a strong driver of new product profitability (*1*).

Convex Computer uses the metric of manufacturing scrap dollars over the product introduction period to compare projects and monitor where improvements occur. This has the advantage of being "bottom line" oriented and it is already tracked by the financial systems. Note that this measure aims at exposing root causes of the scrap: design process weaknesses early in the cycle and unanticipated redesign effort during the production startup phase, both of which lead to development expense overruns and schedule slippage.

Eastman Chemical (1993 Malcolm Baldrige National Quality Award winner, which manufactures chemicals, plastics and fibers in Kingsport, Tennessee) tracks net present value of their research projects as they pass various gates of Eastman's innovation process. This ensures that they are concentrating effectively on those projects that add value to the company's bottom line.

Meyer provides additional guidance on measures, focusing particularly on ones that help a development team to monitor itself (*2*). One of his points is that, to

Software Development: A Rich Source of Metrics Ideas

Although many managers are drawn to the concept of using metrics, they find it difficult to specify useful metrics. I have found it helpful to borrow heavily from what software developers have learned about constructing metrics.

Software is a valuable starting place, both because it lends itself to quantification and because it has shown itself to be notoriously difficult to manage, thus drawing considerable remedial attention. Grady and Caswell, for example, explain how the software development process is measured at Hewlett-Packard (3,4). A pair of their charts below illustrates how metrics can help orient developers toward the reuse of existing code-r existing mechanical or electrical components, or existing chemical compounds, as the case may be.

Although it may appear obvious that reused product components reduce development labor and decrease risk dramatically, developers who pride themselves in inventing often need powerful evidence to adopt such changes in style. Leading software companies have learned how to use such metrics effectively to improve their product development.--**P.G.S.**

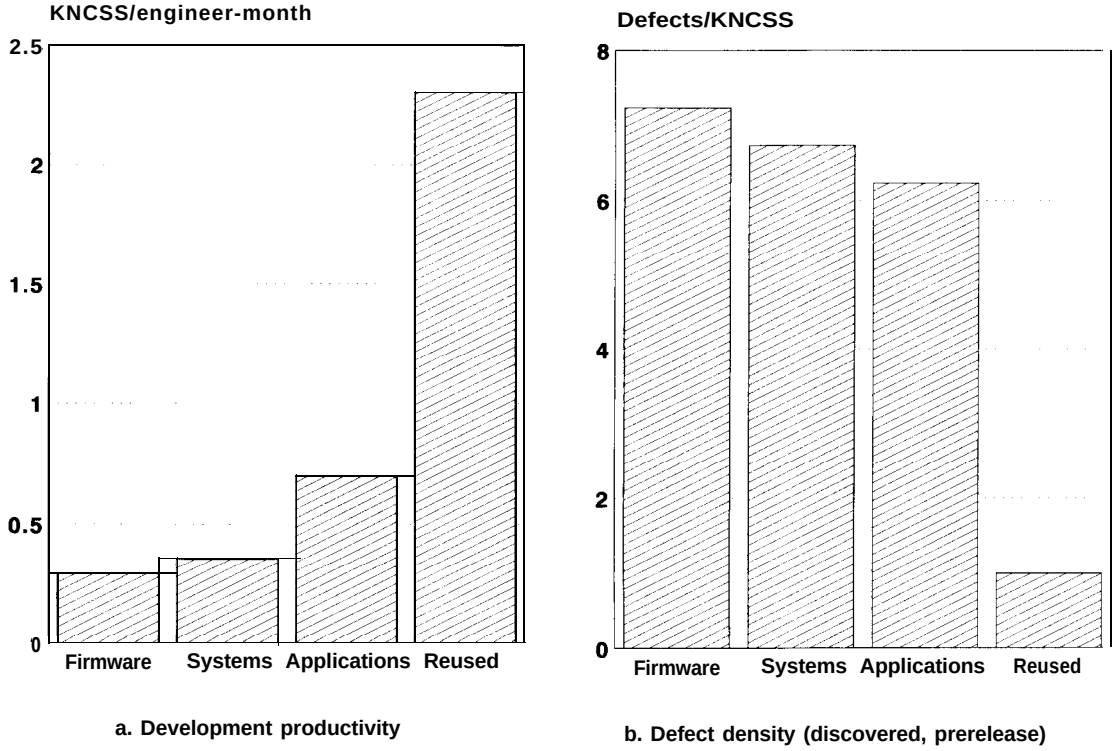

Figure 2.--Hewlett-Packard divided its sofware development projects into the four categories represented by the fourbars, demonstrating that projects making considerable use of existing code carried considerable advantuge in both productivity and defect reduction. KNCSS = Thousand lines of non-comment source stutements. (From Grady/Caswell, Software Metrics: Establishing a Company-Wide Program, *copyright 1987, pp. 111-112. Reprinted by permission of Prentice-Hall, Inc., Englewood Cliffs, New Jersey.)*

maintain focus, the number of metrics must be limited to fewer than 15. (See "Software Development: A Rich Source of Metrics Ideas," this page.)

Closing the All-Important Feedback Loop

The only reason we conduct process reviews is to improve the process. While this may seem obvious, this final step fails to occur in all too many cases. Analyzing and discussing improvement opportunities is far easier than committing to actually improve.

10. *Establish a closure mechanism.*--In order to benefit from the effort expended on the review, you need a leak-proof system to convert findings into action. Those with the authority and resources to make changes in the process must initiate and monitor the change process. Although some changes can be handled relatively informally at a low level, others will require a massive effort led from the top of the company.

AT&T's Global Business Communications Systems (GBCS---Middletown, New Jersey) analyzes their

process using several quality tools, such as affinity analysis, to identify candidate process improvements. Then, they charter quality improvement teams to develop and deploy process improvements. To ensure that the improvement concepts are incorporated into the GBCS process, they schedule activities, allocate budgets, assign staffing, and act on the results of their quality improvement teams in the same way as they handle development projects.

Although each firm will have its own style for guaranteeing closure, fundamentally it comes down to the tools of effective management: accountable individuals or teams, due dates and available resources.

The resource issue cannot be overemphasized. Conducting effective reviews will divert resources from activities, such as product development, with more immediate payoff, and taking action on certain findings will usually demand even more resources. Thus, an improved development process must be viewed as a strategic investment, just like a new laboratory. How much you are willing to invest depends on how quickly you wish to improve. Viewing the benefits as being free is a prescription for failure.

Each company should design its own change management system in accordance with its culture and style, its needs, its position on the learning curve, and the resources it is willing to invest. In most cases, a process manager is an important ingredient of a successful system. This manager-who actually may range from one person working part time to a group of dozens in a large company-consolidates, updates and preserves the list of improvement options, and monitors both the review process and the current action projects. Generally, process managers do not decide which improvement actions are undertaken or actually work on the improvement actions themselves.

Here are a few examples of how organizations have applied these principles to actually change the way they do business:

- Harris-Farinon has learned that for certain components with specific development needs, such as application-specific integrated circuits (ASICs) or microwave power amplifiers, they can improve supplier responsiveness by tailoring subprocesses to their suppliers' individual process needs rather than imposing a Farinon process.

- Through process reviews, Convex Computer learned that technical risk assessments and planning early in the project were considered to be obstacles by the engineers. Yet, the same process reviews also demonstrated the need for such risk management. Consequently, resistance to risk management abated, which has led to early identification of latent problems and has been a key to reducing development cycle time by 50 percent while also reducing scrap costs.

The only reason we conduct process reviews is to improve the process.

- Through its process reviews, Baker Oil Tools has discovered the need for cross-functional job titles that reflect concurrent design of products and their associated manufacturing processes. For example, a senior tool engineer is now called a senior product development technologist.

Institutionalizing the Process

Companies that do well at learning from and improving their development processes do not regard process improvement as a one-time activity or a luxury reserved for times when they can afford it. Instead they seek to make it a way of life, a normal part of business activity. Their first step is to appoint a permanent process manager and assign basic resources for reviews and improvement actions.

11. *Review every project.*--Do not review an occasional project that proceeded especially well or poorly, but expect to learn from every project (above a certain threshold in size). There are practical reasons for this. Most companies do not have a large-enough sample of projects to see patterns clearly; they need all of the reviews they can get.

More subtly, selecting certain projects for review makes them special. They turn out to be congratulatory exercises for the participants--or worse, witch hunts--which erodes the learning and suggests to the participants that both they and the process are on trial. Selective reviews weaken the desired habit, which is that reviews are an expected and normal part of every project.

12. *Align the process with corporate objectives.*--*As* with most cultural changes, a key part of building the review-is-normal environment is ascertaining that it is supported by corporate expectations and rewards. For example, those who participate in the process should be given time to participate and compensated adequately for their involvement. At a practical level, consider providing a charge number for those participating in process improvement, so that the time is not viewed as being stolen from other activities. Also, cultivate intrinsic motivators, such as the satisfaction that comes from knowing one is making an important contribution to the company.

At Eastman Chemical, top management demonstrates its interest in improving its innovation process by regularly setting aside time to review project learnings. Also, the firm has changed its Quality Management Process to

explicitly state that "checking and acting" are parts of a systematic management process.

In my final example, process improvement activities at AT&T's GBCS have evolved from what was viewed as "extra work" that got in the way of getting the job done, to what has become an integral part of product realization. It is now a way of life and no longer questioned.

The Payback

In working with dozens of companies to accelerate their development cycles, I have found that the ones that are winning with new products are those that are investing in their development process. The benefits they derive from these investments occur in several areas:

- Faster product development, as opportunities are found to adapt the development process to the specific needs of a project and to overlap activities.
- Higher-value products, because the link between the customer and the feature set is shortened and strengthened over time.
- Lower-cost products, as manufacturability decisions are made ever earlier in the product design phase.
- More products per dollar, because extraneous, non-value-adding activities are rooted out of the process.
- More responsiveness to turbulence in markets, technologies and the regulatory environment, due to a process that is built to continually adapt to change.

Acknowledgment

I wish to thank all of the companies named in this article, which have so graciously provided examples of how they actually apply the concepts covered here. In each case they have approved their material and it is reproduced here with their permission.

References

1. Smith, Preston G., and Donald G. Reinertsen. *Developing Products in Hulf the Time.* (New York: Van Nostrand Reinhold, 1995).
2. Meyer, Christopher. "How the Right Measures Help Teams Excel," *Harvard Business Review, 72, 3,* pp. 95-103, 1994.
3. Grady, Robert B., and Deborah L. Caswell. *Software Metrics.* (Englewood Cliffs, New Jersey: Prentice-Hall. 1987).
4. Grady, Robert B. *Practical Software Metrics for Project Management and Process Improvement* (Englewood Cliffs, New Jersey: Prentice-Hall, 1992).