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Rapid Product Development Metrics

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Concurrent engineering, or concurrent product development (CPD), is an improvement initiative that is focused on re-engineering the product development function for speed, efficiency, and quality.

To get off to a positive start in re-engineering initiatives such as CPD it is essential that opinions and politics be reduced to the smallest level possible during the initial stages of an improvement programme. Employees only have limited goodwill in conceptual discussions and arguments with members of a management team.

Anyone who has ever attempted to lead or participate in a major change initiative knows that if there is not agreement at the beginning of what is to be done, then there will be difficulty and lack of buy-in for the rest of the project.

The most effective way to gain consensus across all levels of the organization is to base analysis and recommendations on facts. A famous executive once said that "God is entitled to opinion, all others must bring facts and data". This is a good guideline to use for any major change initiative, including concurrent product development.

Agreeing on Needs

Before beginning the planning and implementation activities associated with concurrent engineering, the current "performance baseline" must be established. The baseline is a set of metrics, measures, and statistics that define the current performance of the product development function and capabilities.

The specific baseline metrics which are chosen should not only be meaningful to measuring today's environment, but should be applicable to measuring progress in an ongoing manner. The specific measures should be factual in nature, and quantitative whenever possible.

The number of different measures should be limited to a practical number. This may range from ten in some companies, to over 50 in other companies. A recommended number is somewhere in the middle, say around 25. The measures should be relatively easy to calculate and to remember.

There are five different categories of metrics that should be taken:

(1) *Organization-wide:* First, measures at a macro-level should measure the overall capability and throughput of product development capabilities at an aggregate level.

(2) *Project planning and start-up:* Measures should quantify approaches and limitations to defining plans for starting-up new product development efforts.

(3) *Team contract:* measures should exist to document the "contract" between management and the self-directed concurrent development teams regarding project goals and expectations.

(4) *Projects in-process:* Provisions should be made for measuring the progress of projects-in-process.

(5) *Accelerated metrics:* Measures should exist for measuring progress in the accelerated development environment of the future. In this last case, it many not be possible to apply these metrics to the current environment. The specific elements to be measured in future environments may not be tracked and/or recorded in traditional management and scheduling approaches.

Numerous metrics exist that facilitate and promote rapid development processes for each of these areas. This article will limit discussion to

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one or two metrics for each of these five areas. Where appropriate, case studies and industry surveys will be included to illustrate the use of the baseline metric in practice.

It is also important to note that the metrics discussed in this article are focused on the effectiveness and efficiency of "new product development processes," as opposed to a whole set of metrics that exist to measure "new product development technologies."

Organization-wide

The product development function in a company is much larger than the engineering department. It is actually composed of portions of several different business functions – marketing, engineering, manufacturing, field service, etc.

Staffing ratios: In manufacturing operations, capacity is measured either by machine capacity or by human capacity. In product development, capacity is measured solely by human capacities. As such, bottlenecks in product development largely occur because functions such as marketing, engineering, and manufacturing do not have the right amount of resources dedicated to new product development at the right times in the process.

In order to assure that a given company has minimized the chance of new product bottlenecks, the different resource requirements for the functions involved in new product development must be initially estimated and then actively managed in the future. An effective tool for accomplishing this task is named "staffing ratios". The ratio approach is important because it provides for scalability as an organization grows or shrinks over time.

By definition, the engineering department in a company has the primary responsibility for developing new products. The responsibility is certainly shared by other functions, but in reality only a subset of the personnel in other functions are actively involved in the process. The staffing ratios metric is always calculated by measuring the ratio of engineers to the "number of full-time equivalent or dedicated product development staff" in each of the other functions (see Figure 1).

Once a company determines its own ideal set of staffing ratios, it is now in a position to minimize the number of new product development bottlenecks. Several surveys are now available to assist companies in defining appropriate ratios. Highlights from one survey are included in this article (see Table I).

$$\frac{\text{Total engineers}}{\text{No. Dedicated to NPD}} = \text{Ratio}$$

Figure 1.
Staffing Ratios – Metric

There are several important things to keep in mind when using these surveys. First, what counts is "best-in-class" ratios and not "industry averages" when baselining a company. Comparing to averages has value, but new development process designs should be based on best-in-class. Second, specific competitive advantages or disadvantages that a company has must be incorporated into the thinking process. Functions with lower relative skill levels will require relatively more folks to accomplish the same results. Also, "monkey see-monkey do," is sometimes dangerous and will not result in the best answer for all companies. Use staffing ratio survey information as a guideline, and then apply the best judgement for a given situation in your own company.

For example, a baseline analysis that was conducted with a *Fortune 1000* manufacturer of automated test equipment resulted in identifying the existing/current ratios for three of their functions involved in new product development

Available survey information indicated that they needed a few more marketing professionals

Ratio of engineers to new product development staff function "X"	Marketing	Manufacturing engineering	Purchasing
Aerospace and defence	4.8	12.5	10.0
Automotive	8.5	5.0	6.0
Communications	11.6	11.8	20.0
Components	3.0	2.4	5.5
Computer	5.0	8.0	12.5
Electromechanical	6.3	6.0	10.0
Electronic subsystem	4.2	4.5	8.0
Heavy machinery	6.0	9.0	9.0
Instrumentation	7.5	4.8	6.1
Light assembly	2.8	2.5	3.3
Medical	3.8	4.0	13.4
Cross-industry	4.9	6.0	8.2

Source: "Survey of Product Development Practises", Management Round Table Inc. and Product Development Consulting, May 1991

Table I.
Staffing Ratios – Survey

dedicated to new product development. Their ratio was 10 engineers for every 1 marketing professional. The industry average was 7.5:1. The comparison was even more pronounced for manufacturing engineering. Their ratio was 8.5:1. The industry average was 4.8:1. Approximately 40 per cent more total resources were required for manufacturing engineering.

After examining the survey data, the manufacturer decided to try to get more specific information from its trade association. This is typical for first-time users of the staffing ratios analysis approach. Armed both with the survey information, and with the trade association information, the ATE manufacturer then went about developing appropriate ratios for their company.

Project Planning and Start-up

One of the basic principles of concurrent product development is to achieve "early cross-functional involvement". Numerous studies have shown that the product design becomes largely fixed in the very early stages of a new product development effort. Once the design becomes fixed, costs to change it increase dramatically.

Concurrency matrix: The concurrency matrix is a baselining tool that is used to determine the degree of early cross-functional involvement in new product development projects. It is typically applied too a set of representative development projects to analyze the specific performance of each project, and to calculate the organization-wide profile and averages. In ongoing projects, it is applied during the planning phases to assist in determining staffing skill requirements and levels. At major development milestones it is used as a "check-up" tool (see Figure 2).

The concurrency matrix must be constructed twice during the implementation of a CPD programme. Initially, during the baselining phase, it must be constructed using the current company development procedure. Then, once the forward-looking concurrent development process has been defined, it must again be constructed to utilize the forward framework.

During the baselining phase, the programme managers that were or are responsible for the representative portfolio of projects must get together to agree on common terms for the matrix so an apples-to-apples condition will exist to determine the concurrency matrix baseline. The programme managers must agree on two areas. First, the list of functions that are central to the development of new products in the company. Each of these functions becomes one row in the

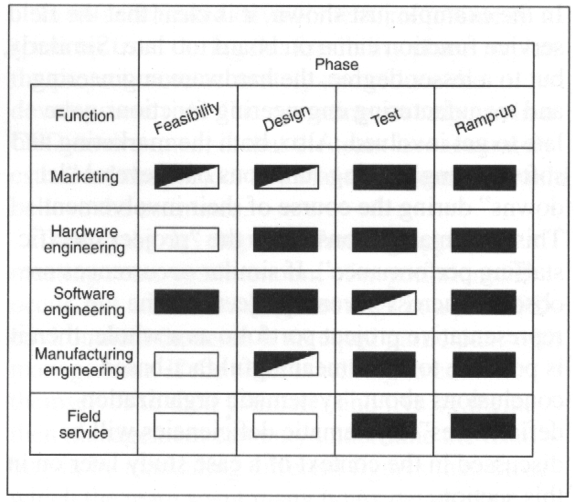

Figure 2.
Concurrency Matrix

matrix. Second, they must agree on the major phases that currently exist in the company's new product development process. Although most every manufacturer has a documented new product development process, there is typically a wide range of approaches in applying it. The programme managers must come to agreement on the four to seven major phases that apply across each of their projects. These phases become the columns of the matrix. With this information in hand, the matrix is constructed.

During the course of constructing the matrix it is typically useful to define one to three activities that occur in each box of the matrix. Again, the programme managers should do this together. This chart should be limited to a single piece of paper. There are literally thousands of activities that functions perform during each phase of development. The challenge here is for programme managers to agree on one to three of them for every "function-phase" box in the concurrency matrix.

This one-page concurrency matrix framework becomes the standard by which all representative projects are baselined. Each programme manager now applies the tool to their individual projects. Once the concurrency of each project has been calculated, it is possible to derive the concurrency of the company as a whole.

The concurrency matrix results in a great deal of information about the new product process in a company. Three areas are discussed here.

- Project-specific staffing performance.
- Numerical calculation of "per cent concurrent".
- Systemic organization deficiencies.

In the example just shown, it is clear that the field service function came on board too late. Similarly, but to a lesser degree, the hardware engineering and manufacturing engineering functions were late to get involved. Also, both the marketing and software engineering functions had several "let downs" during the course of their involvement. This information constitutes the "project specific staffing performance". If similar occurrences are observed across several projects, or the representative project portfolio as a whole, then it is possible to draw meaningful fact-based conclusions about "systematic organization deficiencies". Systematic deficiencies will be discussed in the context of a case study later on in this section.

Using the concurrency matrix it is also possible to determine a "numerical calculation of per cent concurrent". The example shown here indicates that this new product development team was 70 per cent concurrent. The mathematics is straightforward. There are 20 boxes in the matrix. Each box is worth two points by definition. When the activities of a box are completely performed in the specified time period, then two points are awarded and the box is fully blackened. If a portion of the activities are performed, and/or they are performed late, then either a half-box or a blank box is awarded. Half-boxes are worth one point, blank boxes are zero points. In all, this product development team accumulated 28 of a possible 40 points. Dividing 28 by 40 yields 70 per cent concurrent.

Finally, the ability of the concurrency matrix to identify "systematic organization deficiencies" is notable. One case study involved an instrument manufacturer that developed relatively complex instruments. A company elected to apply the matrix to ten programmes. Four of the ten concurrency matrices are shown in Figure 3. Their results are similar to the other six projects.

Projects 1 and 2 were already completed and in the marketplace for several years. Project 1 was a tremendous success. Project 2 was barely acceptable. Projects 3 and 4 were still in process. It was generally believed that Project 3 would be a bomb and that Project 4 would be quite successful.

In summary, systems engineering always had gaps in the early phases when their direction and input is absolutely essential to architecting and planning the project. The marketing function was always late in getting on board. In several cases the project was half over before marketing became seriously involved. Software and SQA had gaps on three of the four projects. Electrical engineering had the best overall performance,

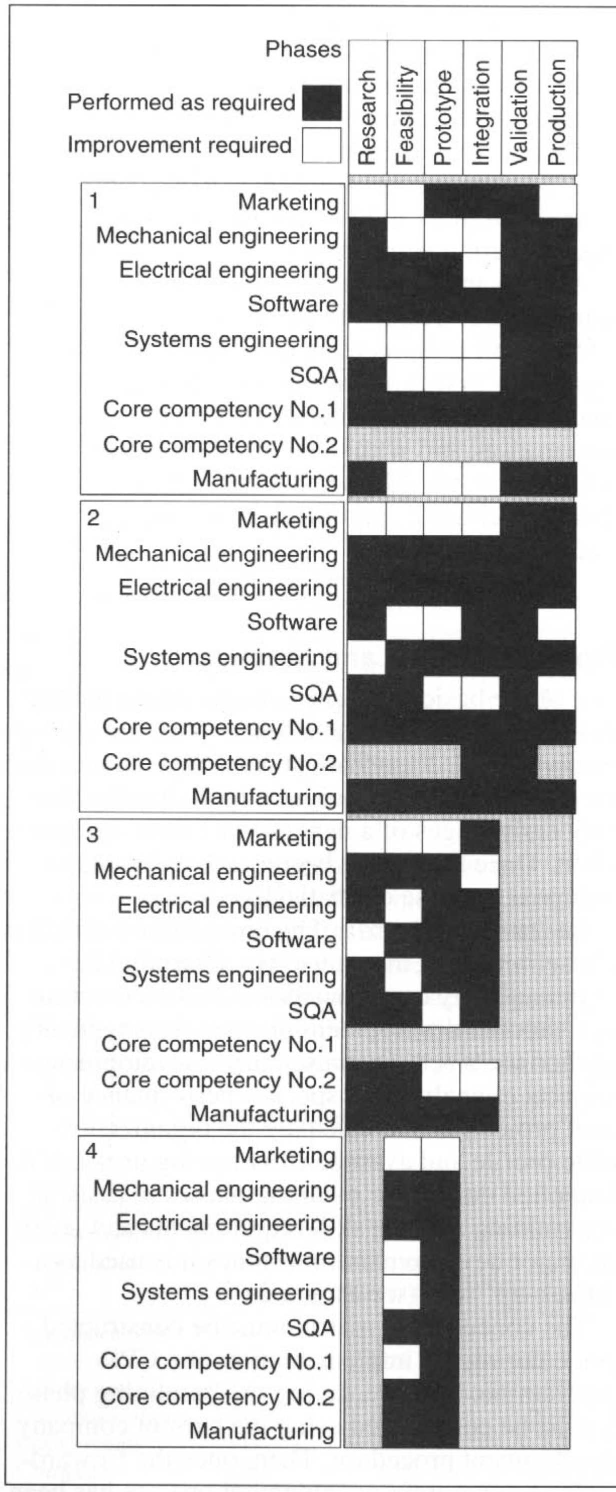

Figure 3.
Concurrency Matrix – Case

followed by a rough tie between mechanical engineering and manufacturing. These facts were first discussed with the programme managers and then with executive management.

The concurrency matrix baseline provided benefits immediately to the company. Even though the company had just begun to determine the overall CPD needs, and was still many months from implementing a programme, it was possible to make immediate corrections based on these systematic deficiencies across current projects.

The marketing function, which was really a sales-oriented function, was further refined to define a category of product planners that would be dedicated to assisting engineering and manufacturing from the early phases of product definition throughout development of the final project.

The issue in systems engineering was that no one person really owned the function. An appropriate manager was assigned to define the requirements for a more formal systems engineering function. During the process, company management realized that this really was a core competency for complex instruments that they had completely overlooked in their company.

The situation with software and SQA was determined to be important, but unavoidable to date. The presence of software in their product had increased dramatically over the past few years. This was true of every company in their industry and in many other industries. The problem was probably not unique to them. Nevertheless, the company needed to come to grips with the problem and the concurrency matrix baseline provided the jump start.

Improvements were initiated fairly quickly in all of these areas by executive management, and readily adopted by the programme managers and programme team members. The systematic and fact-based analytical approach which all the key players participated in created an environment for immediate consensus. Everyone felt great about taking some quick decisive actions so early in the project. There was little "wiggle room" for the power brokers and politicians. Everyone had to agree. The CPD programme gained momentum from this point forward.

Team Contract

Of central importance in an ongoing CPD environment, but of relatively little importance during the needs assessment and baselining activities, are the "team contract" metrics.

Team contract metrics are the "heart" of accelerated development processes. They result from the team's own estimates of the resource and time requirements necessary to complete the project. These are the measures that the team is willing to live by during the development process, and be measured by upon conclusion of the project.

In an accelerated environment, more time is spent up front during the feasibility phase to plan the project more accurately and reduce the development risk. The operating assumption in a CPD environment is that the team has accurately estimated the project and that management should believe the estimates.

During the development funding approval meeting some small amount of negotiation will occur, but unlike funding meetings in a pre-CPD environment the team is an equal participant with management. If the team is willing to commit themselves to their estimates and live by them, then management can only undermine the team's buy-in by mandating different figures than those which the team spent many hours developing together. There must be a "trust" between management and the team regarding development estimates and time frames in accelerated environments.

Therefore, both the team and the management commit themselves, in a two way agreement made during the development funding meeting, to specific goals. These mutual goals typically include overall time to market, product cost, and market size estimates. A "representative team contract" may include several other goals as well (Figure 4).

Specific ranges are negotiated around each of the goals. As long as the team is operating within the ranges negotiated with management, they will be free to execute the project virtually independent from external interference. If the team stays on course, the only management reviews will be those which occur at the major phase transition points or milestones during the development process. If the team's actual

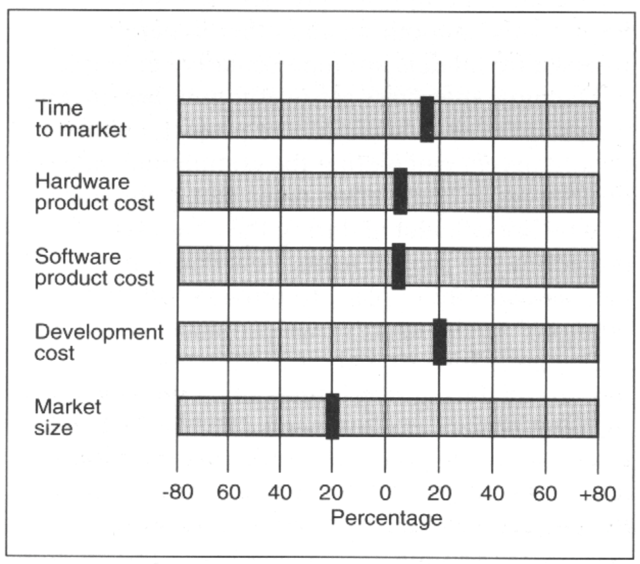

Figure 4.
Team Contract Metrics

performance goes outside the negotiated ranges, then management reserves the right to conduct a project review.

The negotiated ranges will differ for each project. In some cases, time to market will be the critical factor for success. In other cases it may be the product cost and planned profit margin. The negotiated range around the most critical items will necessarily be smaller than less important goals.

Projects-in-process

The representative baseline tools discussed in this section both focus on time to market.

Static time to market: Static measures are fairly intuitive and obvious measures. Many companies have significant experience with this metric and it is important that they become more experienced in the future.

Applying static measures in several ways to a representative portfolio of projects will yield new information in each different analysis. With a single set of static data, several measurements are possible. For example, it is possible to calculate overall schedule forecast accuracy, examine the variation in predicted and actual phase times across projects, and identify the places where the development processes typically breaks down all with the same set of data.

Dynamic time to market: This section will concentrate on dynamic measures as they are rarely used by companies, even though the technologies behind them are simple. The dynamic method discussed here is a take-off on simple regression. More advanced approaches utilize tools similar to those used by most marketing functions to "predict the future". Exponential smoothing and other dynamic forecasting models are representative examples.

Dynamic measures are useful both for tracking the progress of a development project, and for quantitatively calculating the completion date of a project. Most completion dates that companies rely on are calculated during the course of a project by the project team. Few checking mechanisms are in place to provide "second opinions" to the team's own estimates.

Dynamic time to market is an extremely easy tool to use during baselining activities, and in ongoing project environments (Figure 5). Every time a schedule prediction is made by the team during the course of a project, the date is plotted on the graph against the date that the prediction was made. As time passes, and several predictions are plotted, it is possible to extrapolate the data to estimate a prediction date. The tool inherently

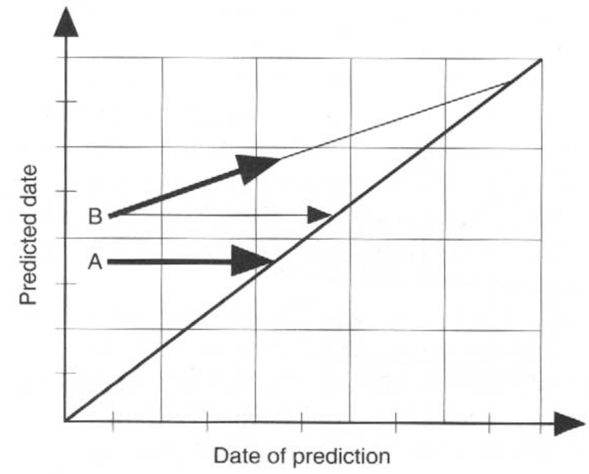

Figure 5.
Dynamic Time to Market

incorporates the ongoing forecast error, whether it be positive or negative, into the extrapolation.

In this example, Project A is clearly on track. Regardless of the date of prediction, the predicted date remains the same. A project that is on schedule will always proceed directly horizontally towards the diagonal line. Project B, on the other hand, is off-track. Projects that are slipping will start trending upward and asymptotically to the diagonal line.

The "second opinion" of time to market is calculated by extrapolating the actual project line to intersect the diagonal line. At the intersection, "run a perpendicular" to the "predicted date" axis. This date will provide a sound "second opinion".

An application of dynamic time to market to four different projects provides some interesting results (Figure 6). First, the graphical presentation clearly indicates projects that are slipping.

Second, the most recent predicted launch date may or may not be an accurate prediction of the actual launch date. Current predictions become modified by past history in this tool. For example, look at the third data point for project "2". In the middle of 1985, project was predicted to complete approximately one-year later in the middle of 1986. Using extrapolation based only the first three data points, the project would be forecasted sometime during the middle of 1987. This is one whole year longer than the team's prediction at the time. In the final analysis, the project was completed in the latter part of 1988. The application of the dynamic time to market tool yielded a more accurate forecast of completion than the current estimate of the team at the time.

Next, examine project "3". Management should have begun asking tough questions when the second data point was plotted. Once the third data

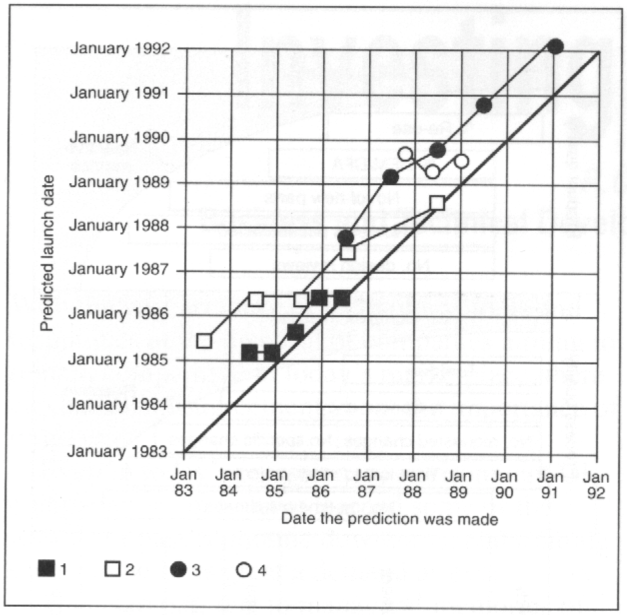

Figure 6.
Dynamic Time to Market Case

point had been plotted indicating the unacceptable and ongoing slip rate, company management should have become involved in redefining the project scope and goals. It is not always the team's problem that projects slip. In many cases the task handed to the team is too great, the resources given to the team may be too few, and numerous other reasons exist. Sometimes teams need help.

Problem projects are quite easy to identify, with or without this analytical tool. Dynamic time to market at the very least provides a framework for identifying problem projects and for getting a "second-opinion" on the most realistic prediction of actual development time and launch dates.

Accelerated Metrics

For a good many industries, the entire development cycle in the future will be under one year, most likely on the order of four to eight months.

In this redefined business environment, it will be necessary to make assessments of products and projects virtually days into their development cycle. What today is considered unmeasurable, will be totally measurable. Product development will undergo in the 1990s what manufacturing and materials functions experienced in the 1980s.

The companies which see in to the future now and begin to prepare for it will be those which are best positioned to succeed.

Goldense Group, Inc. is among the first companies in the US to develop and apply advanced metrics frameworks for the future.

Some of our forward-looking concepts, which are applicable in selected environments today, focus on measurements taken early-on in the "soft stages" of development projects.

GGI refers to these metrics as process-oriented concurrency metrics or "POCMs," pronounced "poke-ems." The translation is literal and direct. Numerous simple measures will need to be made early-on in the development environments of the future (Figure 7). Management and teams will measure project progress at a much greater level of granularity and much more frequently than practices of today.

POCMs may take a few moments to absorb. Their simplicity is disarming and few companies would consider measuring these items as primary measures in traditional environments. They even fly in the face of values that many managers hold as their "deemed rights" in the 1990s. This strained condition will exist for several years to come, until many companies have fully internalized the implications of accelerated development cycles and realized the full brunt of foreign competition.

POCMs are proactive metrics. The information they yield allows for actions on projects-in-process today, not the next development cycle. Popular measures such as engineering change orders are totally reactive. All learning is hindsight and can be put into practice only on future projects or redesigns.

Rapid metrics consist largely of measures taken well before product design is complete and released to manufacturing. There are literally hundreds of measures that can be made in these early phases of development. The metrics with the

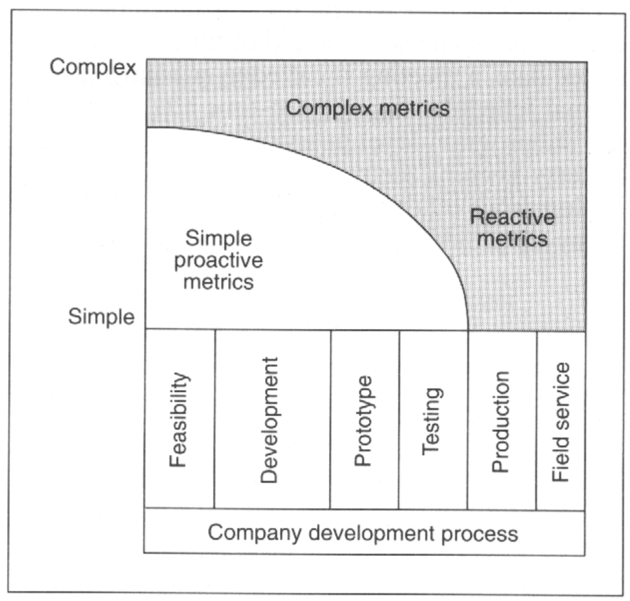

Figure 7.
POCMs Framework

most predictive capabilities for any given company should be chosen.

POCMs should be focused two ways. First, there should be metrics that measure only the softest aspects of new product development process quality. Second, there should be metrics of the quality of the product being designed that are driven by the quality of the development process. This is why the term "process-oriented" is used. While both process and product measures are taken, the "driver" for the metric lies in the overall quality of the human activities during the development process (Figure 8).

Early adopters of GGI's rapid metrics have found poke-ems serve to keep both teams and management honest during the "development contract". They are valid additional measures of project performance.

For instance, a relevant POCM metric is "core-team turnover". Few will argue that turning-over key core team members does not affect the project duration and outcome. Typically, it is the management group that causes turn-over and resource-shifts that affect the project plan. Measurements in this area will help reduce the number of times that a team "thrashes" during the development project as critical resources are shifted to other projects and/or are yanked for short periods of time.

Conversely, "number of milestones completed on-time" and "number of design reviews completed on-time" are valid measures of team-controllable metrics.

Keeping a simple count of "on-time hits and misses" of key project activities is a valid indicator of the future. Almost every project team that is late on major and minor milestones still promises that they will hit the scheduled plan date. Then, some short period of time before the actual date, a meeting is called to announce a formal schedule slippage. On-time hits and misses on "subprogram-level milestones" are an effective honesty-keeping metric for teams.

Numerous other examples exist. POCMs help to rev-up project speed by focusing collective team attention on some of the finer but significant aspects of the programme plan. They are typically managed within the team, but are visible in management information systems.

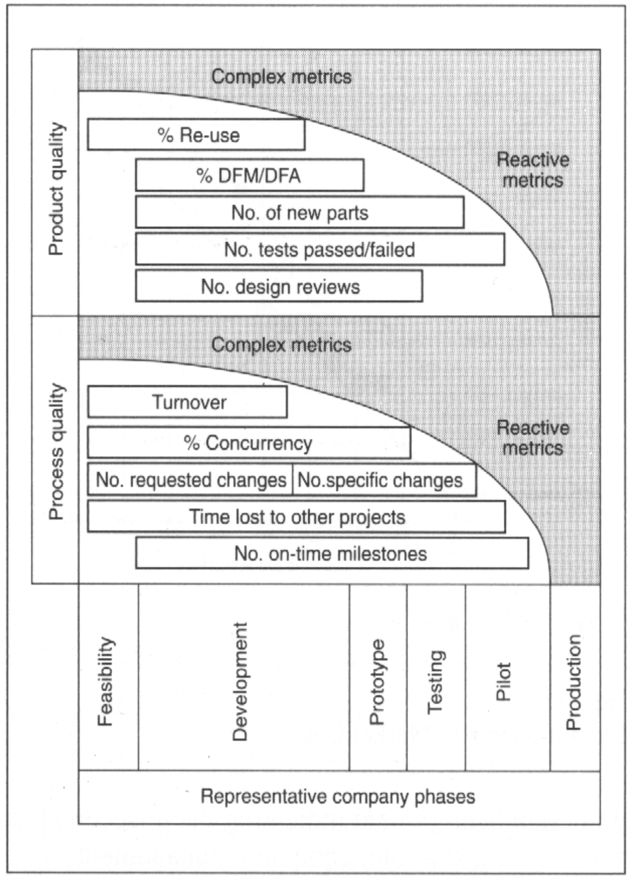

Figure 8.
POCMs Examples

In conclusion, rapid process-oriented concurrency metrics (POCMs) will be required for the accelerated development environments of the twenty-first century.

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