METRICS — A PRACTICAL EXAMPLE

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X.1 Introduction

A measurements program translates corporate goals and objectives into action. It makes progress toward goals visible; allowing for clear communication, objective analysis and fact based decision making. Analyzing measurements information helps satisfactory results continue and identifies opportunities for improving results.

X.2 Why Measure?

Before measuring the new product development (NPD) process, it is important to decide why the measurements are being made. A measurement is one way to understand how well a process is working and what a process is doing. This includes the process design, the selection, qualification, and motivation of the people who carry out the work and the tools, materials and information systems that are used. As the underlying process is changed, the measured result may reflect that change. Changing a measured outcome requires a change in the design or operation of the underlying process.

Measurements can also identify problems or show progress towards goals. Making measurements visible and understood by the people who contribute to the result being measured can motivate change in an organization. Measurements provide the most useful basis for decision making.

X.3 Deciding What to Measure:

Selecting the measurements

Before deciding what to measure, ask yourself this question: “If the measurement goals are achieved, will you be satisfied?” This makes it clear that goals and objectives for the organization must be set before measurement planning can begin. Typical objectives might include increasing short or long term profit, market share, customer satisfaction, reliability, or effectiveness, decreasing cycle time, defects, re-work, costs or waste. How do you decide where to start and where to focus?

What gets measured gets done, so be careful what you choose to measure, you are liable to get it!

It is now well accepted that increasing market share increases long term profit, and increasing customer value increases market share [4,19]. How then do you increase customer value? Figure X.1 illustrates an example of elements that typically contribute to customer value. To establish an effective measurements program, understand this *customer value tree* in detail for your product in your markets.

Creating the Customer Value Tree Structure

Use figure X.1 as a starting point to create a detailed customer value tree specific to your products in your markets.

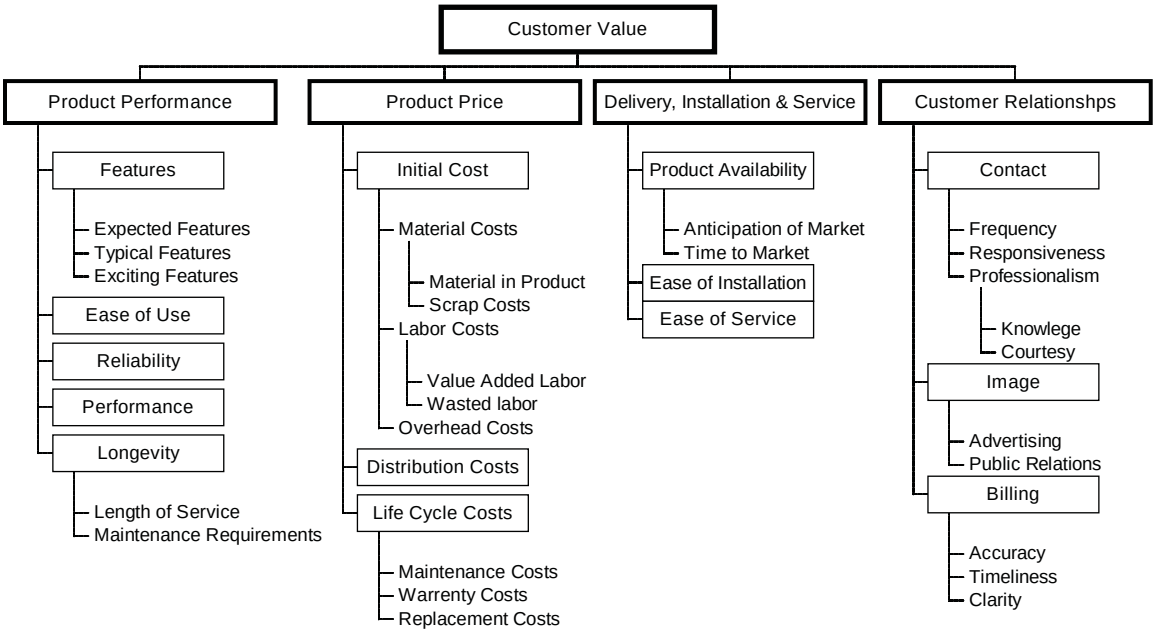


Figure X. 1

Decide first on the products and markets to be addressed by the tree. Then determine what your target customers value in choosing products and services. To do this, gather a team of experts, drawing from marketing, sales, service, engineering, product planning, manufacturing, finance and end customers to add elements (attributes of customer value) to the tree that are pertinent to your business. As each element is added to the tree ask:

- Does this element contribute to its “parent” element?
- Does the “parent” element require this element to be completely described?
- Is there anything else at this level that contributes to the “parent” element.

A completed tree may contain as many as several hundred elements.

Establishing Priorities

With the detailed tree structure completed, the next step is to identify the vital few attributes that will contribute the most to the overall customer value. The overall priority of each attribute is a combination of its importance and the gap that exists between the current performance and the performance goal. It can be established using the following relationships.

$$\text{Priority} = \text{Importance} \times \text{Performance Gap}$$

$$\text{Performance Gap} = \text{Desired Level of Performance} \div \text{Current Level of Performance}$$

The *importance* is the degree to which a change in this attribute will influence the customer perceived value of the product. It is often expressed as a percentage of the entire customer value. The *current level of performance* is how well your product is performing now with respect to that attribute. The *Desired level of Performance* reflects your business priorities and can be set by “shooting ahead of the competition” or by adopting improvement goals that each contributing unit commits to attain.

As an example, suppose that a survey has determined that customers attribute the following importance weights for your product in making purchase decisions:

- Product Performance 40%
- Product Price 30%

- Delivery, Installation & Service 20%
- Customer Relationships 10%

The research also shows that your products are priced the same as your competitors, but your product performance is not as good. Your product performance is rated a '3' and your competitors products performance is rated a '4,' each on a 5 point scale. Considering this analysis, you decide to maintain parity pricing, but to set a goal of '5' for product performance.

Product Performance Priority = 40% x (5/3) = 67%

Product Price Priority = 30% x (1) = 30%

So in this example it is more important to work on increasing product performance than to reduce price.

Use priority estimates to identify a manageable set of attributes to form the basis for the measurements plan. The number of attributes that are manageable by the organization will depend greatly on the maturity of the information systems available to the organization. If the data are collected manually, then only a handful of attributes will be manageable. If sophisticated automated data collection systems are in place, as many as several hundred attributes will soon be manageable. It is preferable to act on a few measurements than to be overwhelmed by too large a set. So start with a small set and use them as the basis for initial decision making.

It is better to affect change as a result of a acting on few well chosen metrics than to collect data and do nothing more than chart a large set of metrics.

Translating Customer Value Attributes into Metrics and Measurements

The customer value analysis may have identified reliability as critically important for your products, but how can it be measured? A translation is required between each customer value attribute and the actual measurement to be taken. Define this translation by consulting people who understand the products and how they are used by the customer. Measurement surrogates for "Reliability" might include:

- Mean time Between Failures (MTBF) or Mean time to Repair (MTTR)
- System Down Time
- Customer Reported Problems, Repair Service Call Rate or Warranty Repair Rates
- Surveys of customers' perceptions of product reliability.

The final choice of measurement will depend on how easily the information can be obtained, and most importantly, how accurately the indicator reflects the customer value.

The "Goal, Question, Metric" approach may be helpful here. Begin by stating your goal: "Increase reliability". Then ask some more specific questions related to that goal such as: "How often does product 'A' fail?" or "How often do customers complain about the reliability of product 'A'?" or "What behavior from the development team will lead to increased reliability?". Then use these questions to suggest specific metrics, such as: "Mean time between failures for product 'A'" or "customer reported problems with product 'A'" or "level of training of the development team on 'designing for high reliability' practices."

A good metric [8,12] must be accurate, informative and objective. It must be easily communicated and understood by those who need to act on it. It must provide an agreed basis for decision making at the intended organizational level.

It must apply to a broad range of applications to allow for useful comparisons of results. It must allow for uniform interpretation, be repeatable and independent of the observer — consistently applied by those who record and analyze it. The value it provides must be understood by the people who collect the data and the people who must act as a result of the data. It must reinforce desired behavior, reflect process performance, highlight opportunities for action, and be cost effective to collect, analyze, and report.

Creating a Measurements Plan

A measurement plan must specify what is measured, the source of the data, the frequency of data collection and reporting, and the party responsible for collecting and reporting the data. A simple example might look like this table:

Measurements Plan for the XYZ Product in the ABC Market:

Attribute	Measure	Data Source	Collection Interval	Collector
Reliability	Count of Repair Service Incidents	Service Department: Count of Service Tickets	Weekly	Smith
Reliability	Number of Designers completing “design for reliability” training	Team training records	Before beginning the “design” stage	Skinner
Performance	Top Speed	Engineering Lab Tests	Each new Release	Edison
Material Costs	Component costs + Procurement Costs + Inventory Costs	Procurement Department: Activity Based Costing System	Each new Release	Maddona
Product Availability	New Product Development Cycle Time	Program Manager for each new product or new release.	Each new Release	Whitney

Note - All data are reported by Jones on the 10th calendar day of each month.

When first creating the measurement plan, you may be forced to strike a balance between those measures that are important to the customer and the business, and those that you are able to collect and act on. At each stage in your measurements program, always choose the most important measures that are actionable by the organization. A measurement is important if it is tied to strategic corporate goals and is broad in scope. A measure is actionable if it is 1) defined, 2) the data can be collected, 3) the results can be assigned to a person or organization that can take action to improve the result, 4) the improvement team understands the data, 5) the data identifies performance gaps, 6) the data supports further analysis to identify the contributing causes of performance gaps.

Normalize metrics if your goal is to compare the efficiency of operations. Use the raw (unnormalized) metric if the goal is to improve the effectiveness of a result. For example, if the goal is to identify the most reliable product, then use a normalized metric such as Mean Time Between Failures. If the goal is to improve customer satisfaction, then use a raw metric such as the count of customer requested service incidents.

Aggregating measures increases their importance. Decomposing measures makes them more actionable. For example, reporting an aggregate number representing all repair service incidents for all products offered by the organization increases the scope of this measure and makes it very important. Such an aggregate measure, however, is typically not

actionable by any single group. To begin the analysis that will allow problems to be solved, the aggregate measure has to be broken down into components. For example, it can be reported by product type, or by service call type or by geographic region or any combination of factors until the information is granular enough to allow a small team to take specific action.

Aggregate (roll up) measurements to summarize trends, to increase the scope of the analysis and to identify the highest priority opportunities. These summary metrics help answer "what is happening?" Decompose (drill down) measurements to gain detailed understanding of the causes of measurements behavior and to take action. These low level metrics help answer "why is it happening?"

Rounding out the Measurements Plan

The measurement example shown above includes only "outcome" or "results" type measurements. While these are the most important, and bear directly on the product that the customer receives, they may not be directly actionable and they may not provide the earliest opportunity to prevent problems. It is important to supplement the list with "input" measures and "in-process" measures.

Keeping the Program on Track

As the development program is underway, it is the responsibility of the program team to keep the schedule, feature content and costs consistent with the current plan. One very powerful way to illustrate the plan is with a "return map."[6] as shown in figure X.2

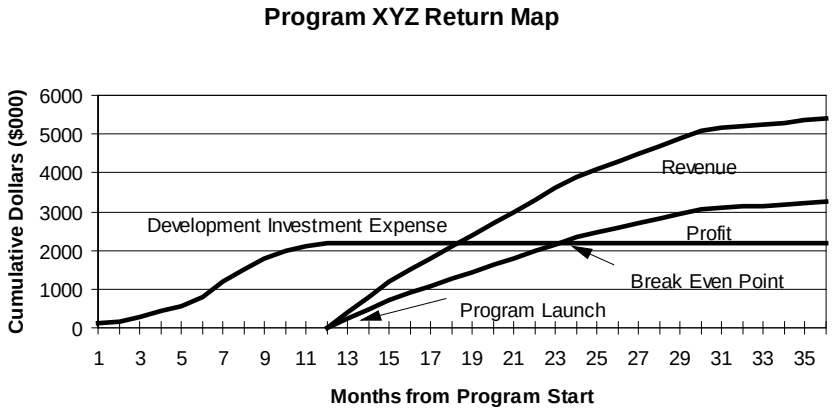


Figure X. 2

This one page summary of the program can be used initially as a plan, and again throughout the life of the program to track development expense, schedule outlook, sales revenue (including sales price and volume forecasts), profit and profit margin (including unit cost) and break even time. To track schedule outlook more closely, use a "slip chart" or "bullseye" chart like the one in figure X.3

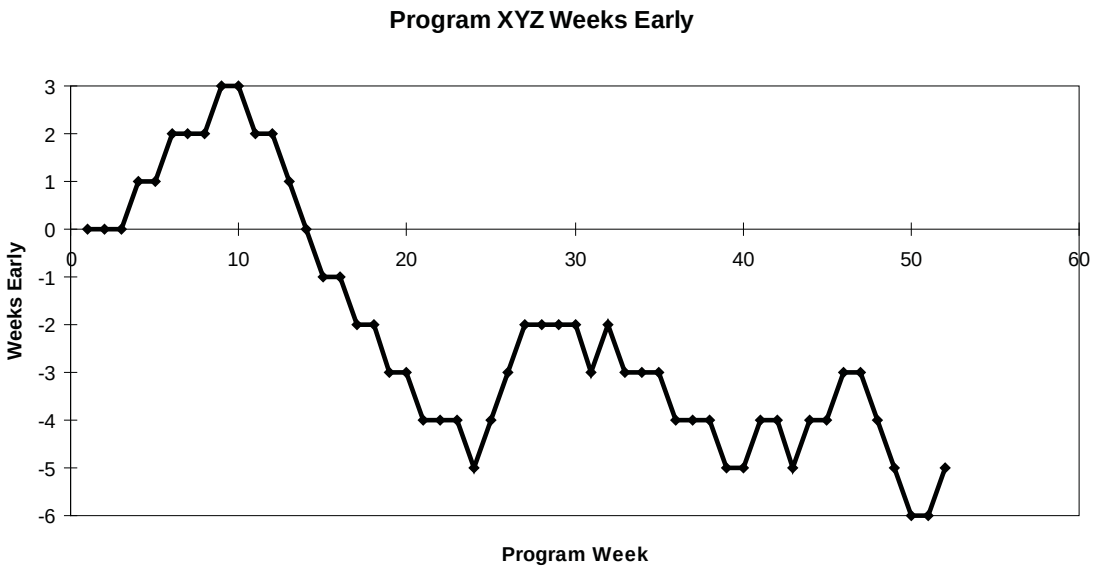


Figure X. 3

A data point is added to this chart at each weekly program status meeting. It shows at a glance how the actual program is progressing with respect to the current plan and can be used to focus discussions on improving the NPD work. Similar charts can be used to track product cost outlook, sales volume outlook, feature content and any other parameter key to achieving the plan described by the return map.

Learning from Existing Products

Other input or in-process measures can be derived by a drill down and analysis of the outcome measurement results from existing products. For example, suppose a particular product was requiring a large number of repair service calls. The analysis might uncover a particular component of the product that is failing, causing a large fraction of the repair calls. To reduce the number of service incidents it may be most economical to subject this component to a more rigorous incoming inspection process. On a different product, it might be found that the large number of service calls are required because the service staff lack specific skills needed to install and repair the device. In this case it may be best to measure the number of staff that have completed in-depth training on this product or to plan for training the service staff on the new product.

Other Candidate Measures

To be complete, a measurements plan will contain some number of measurements directed toward direct financial contribution, employee satisfaction, growth, innovation, learning, process control and other topics. A list is provided in Appendix X.A [10, 11, 13, 16, 18, 5] to stimulate your thinking

In addition to choosing the topics of each metric, the scope of the measurement (firm-wide, department-wide, product-line-wide, product-wide, product-instance-only, sub-component only or process-wide), the timeframe (past results, current performance, future outlook) and the audience (executives, middle managers (e.g. project managers, engineering managers), specific work groups or individuals, shareholders, current customers, future customers, suppliers or others) must be decided.

The level of quality system maturity of an organization influences the best practices that are most effective. [3] Similarly the quality system maturity will heavily influence the metrics that are most valuable. For an organization just beginning to use process management and metrics, it is best to focus on measurements of activity, inputs, conformance, deployment and process control. For a more mature organization, integrated

measures of results with goals leading to breakthroughs in performance are appropriate

While there are too many options to be able to make a recommendation for any particular project or organization, here are a few metrics that can provide rich information and powerful results:

- NPD cycle time - time to develop new products (overall and by stage or sub-process), time to react to the market.
- New product schedule, market size and unit cost prediction accuracy
- Defect Removal efficiency [7] - The number of defects found in the present development stage as a fraction of all defects found in the entire product life cycle.
- Percent (revenue, profit, model numbers) from new (e.g. newer than 3 years old) products
- Economic value add [15]
- Customer value add ratio
- Market share
- Product service activity rates
- Break even time for new products, derived from the Return Map [6]
- Lost customers

Select the vital few metrics that best help to deploy your corporate strategy. Always use the most important metrics that are actionable at this time.

Learning from a Repeatable Process

One of the difficulties in predicting performance and improving the NPD process is that program development takes a long time to carry out. Furthermore, the NPD process seem to change each time a new program is developed. This makes it difficult to use measurements of other programs to help manage the present program.

The increased use of the ISO 9001 standard [1] and adoption of best practice make it typical for the NPD process to be both defined and repeatable. A defined and repeatable process allows measures from other programs to help manage the current program. Also many measures can be analyzed in the *process* domain as well as in the *product* domain. For example, it may be possible to determine in which stage of the NPD process the most product defects are introduced (or not detected). To do so, assign each repair service incident, regardless of what product it occurs on, to NPD Stages as follows:

- Assign it to the stage in which the product problem was introduced (e.g., the specification stage or the design stage)
- Assigned it again to the stage that had the last opportunity to detect the problem (e.g., the system testing stage or the customer validation stage)

Such an analysis can uncover deficiencies in the processes used in that stage, pertinent to all products that are developed using that process.

X.4 Establishing the Measurements Program

To make it effective, integrate the measurements plan into the organization. Because both measurement plans and organization structures are often hierarchies, a simple mapping from each aggregated measurement to the organization responsible for taking action on the results can often be made.

Defining Each Metric

The goal in defining each metric is to communicate to the organization both its definition and its importance. Choose a

short descriptive name for the measurement. Describe the importance and intent of the measurement, mapping it back to customer value whenever possible, and describing the reasons it was chosen. Provide a clear and accurate mathematical definition of the metric, specifying what it includes and what it excludes. Finally, assign and communicate the responsibilities for defining, collecting, reporting, analyzing and acting on the data. Exhibit X.1 provides an example.

Name: Requests for Repair Service

Importance: Surveys of our target customers have shown them to consider "Product Reliability" to be very important when choosing and using products like our ABC line. When asked to define "Product Reliability" customers use phrases like "The product never breaks," "it works when I need it," "It never needs service" and "I want to install it and forget it." Studies have shown that our product reliability is inferior when compared to our competitors, especially Rockworx, the industry leader in reliability. A count of customer requests for service calls is a good translation of this customer need into something our organization can measure within our existing systems and act on for both current and future products.

Definition: A raw count of customer requests for repair service of any of our products worldwide, aggregated and reported on a calendar month basis. This includes requests for product repair or replacement including incidents where the problem was resolved over the phone. It excludes requests for initial product installation.

Responsibilities: Ed Jordan, of the Quality Office, is responsible for the definition of this metric.

Exhibit X. 1

Setting Goals for Measurement Results

To maintain current performance or to improve beyond the current performance requires that goals be set for each measured quantity. In setting goals be sure to consider each of the following factors:

- Is the measurement being taken to improve performance? If so an improvement goal must be set. Otherwise, if the measurement is taken to maintain the current level of performance, it is satisfactory to set a conservative "alarm threshold" below which no action is required.
- What is the current level of performance? If it is satisfactory, then only modest improvement goal needs to be set. If current performance is poor, then set aggressive improvement goals. Consider your performance relative to the competition's performance or other relevant benchmarks when making these decisions. Keep in mind that the competition will continue to improve and a breakthrough can occur at any time.
- How difficult will it be to achieve an improvement? If large gains are possible, it makes sense to achieve them. If it is very difficult to make progress, then a more modest goal can be set.
- What resources are available to achieve the goal? Setting a goal that requires more resources than have been made available to address the improvement will only frustrate the people in the organization.
- What goal are the people who must do the work willing to support? If the goal is set out of reach or the metric is not seen as relevant to the business, then the people in the organization become disconnected from the goal. When this happens, no one is working to achieve the goal and failure is assured.

Thresholds and goals have different definitions and purposes. A threshold establishes a performance standard and is used for process control; keeping the process working as well today as it worked yesterday. If a measurement crosses an established threshold, then some specifically prescribed fix in the process operation must take place to restore the process operation to the acceptable level it has maintained in the past. A goal is used for process improvement; making the process work better today than it has in the past. A plan for achieving the goal is carried out, with the purpose of changing the process operation to be able to achieve the stated goal. A comprehensive measurements plan will include both thresholds and goals.

Responsibility for goal setting has to be shared between the top executives responsible for overall organizational performance and the people at all levels of the organization who must do the work required to meet the goals that are set. During these negotiations (often called “catchball”) it is important to understand and respect the difficulties each group faces in meeting or not meeting a suggested target.

Take care to communicate not only the goal, but why and how it was set. Exhibit X.2 provides an example:

Goal for the Requests for Repair Service Metric: Considering the importance of product reliability to our customers, and our lagging position on reliability with respect to our competition, we have set an aggressive improvement goal for this metric. The managers of service, installation, manufacturing and engineering, with the support of the people in their departments, have agreed to achieve an improvement of 20% over last year’s average performance. The goal for this year is to receive no more than 4529 service requests in total, across the corporation. This goal has been further allocated to individual products according to the following table . . . Note that some highly reliable products need only maintain the same level of performance they achieved last year. Other less reliable products must meet aggressive improvement targets. Also note that products planned for introduction later this year will be expected to have a reliability substantially better than our current average. Staffing, expense and capital equipment budgets include items needed by each department to carry out these improvement plans.

Exhibit X. 2

Collecting the Data

The definition of the metric starts to specify how it is collected. What remains is to clarify who collects the information, what systems they use, and who receives the data. Whenever possible, look for a place in the organization where the required information comes together. These “data funnels” occur where a large number of operations within the organization come together in a single place. For the “Requests for Repair Service” metric a natural data funnel is the repair service call dispatch center. They may already have an automated information system that collects this information. If not, each operator can be trained to keep a stroke count or other log of calls for repair service. This log may need to include information such as the product model number and the nature of the requested repair to allow for further analysis.

Reporting The Measurement

To effect change, the measurements data must be reported to the people who have to act on it. Furthermore, they must be able to clearly understand the data, including its current level, recent trends, the goal for the measure and whether an improvement is indicated by an increase or decrease in this measurement. Begin by deciding who must understand the results. If it is a small group, then the data is easily shared. If it is a larger group, consider choosing some combination of the following methods:

- Use mail, group meetings, bulletin boards, the company newsletter, staff meeting discussions, E-mail messages to communicate results,
- Have the people responsible for achieving the results report out at a “town meeting,”
- Keep the data in a shared electronic database that interested people can interrogate at will,
- Post the results using an hyperlinked set of Internet World Wide Web pages (behind a corporate firewall that provides security for the information). Use a separate page for each measurement, maintained by those responsible for the results.

Use easily read graphs to display the data. Use a run chart showing the recent trend history, the goal, and an arrow labeled “good” pointing either up or down to show the direction of improvement. Include the definition of the metric along with

names and organization of the various people who are responsible for collecting, reporting, analyzing and acting on the information shown. See figure X.4 for an example.

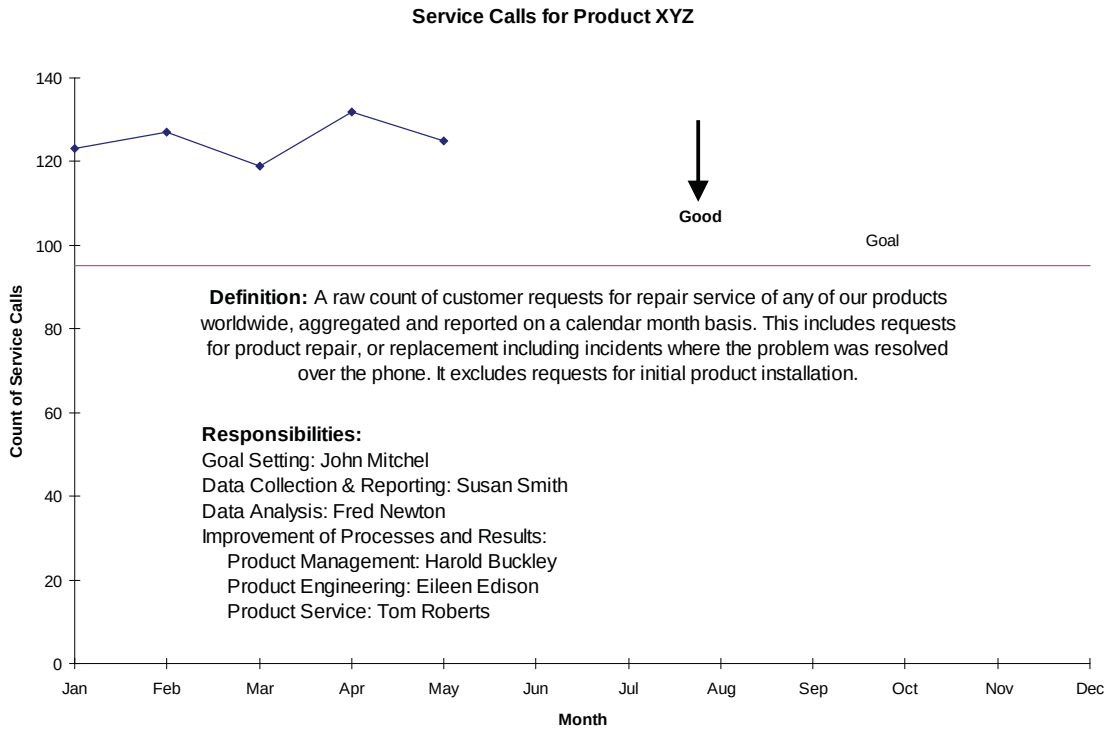


Figure X. 4

To show the current performance of a product along many dimensions, use a “radar chart.” See figure X.5 for an example.

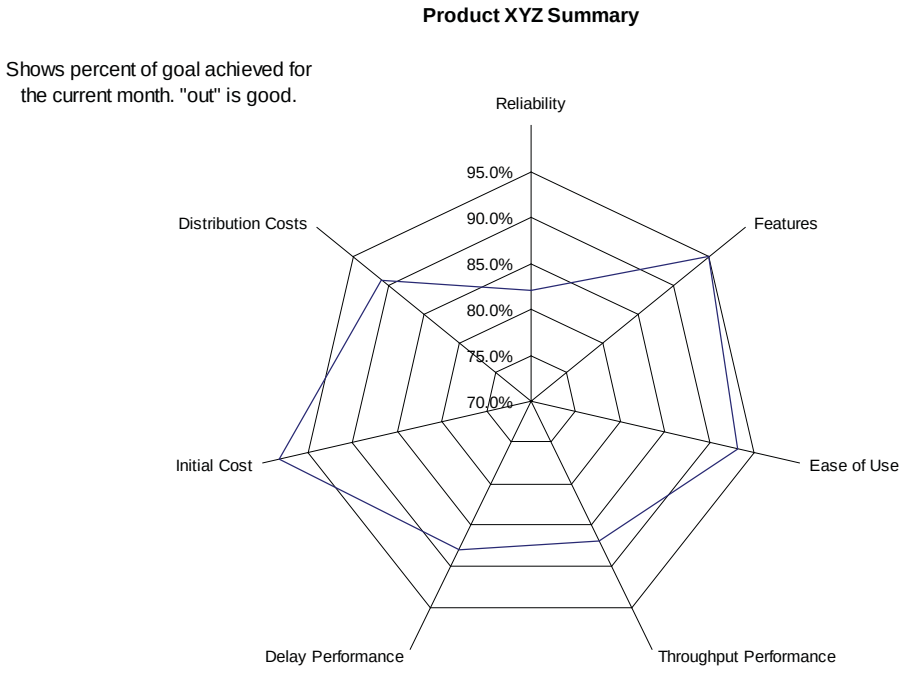


Figure X. 5

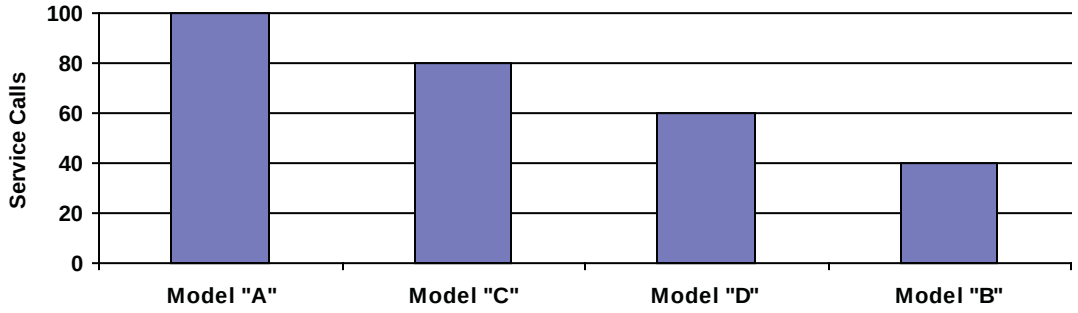
To assess the clarity of the presentation, ask a new or inexperienced employee to explain the chart to you. If they have any trouble, improve the presentation of the data.

Analyzing the Data

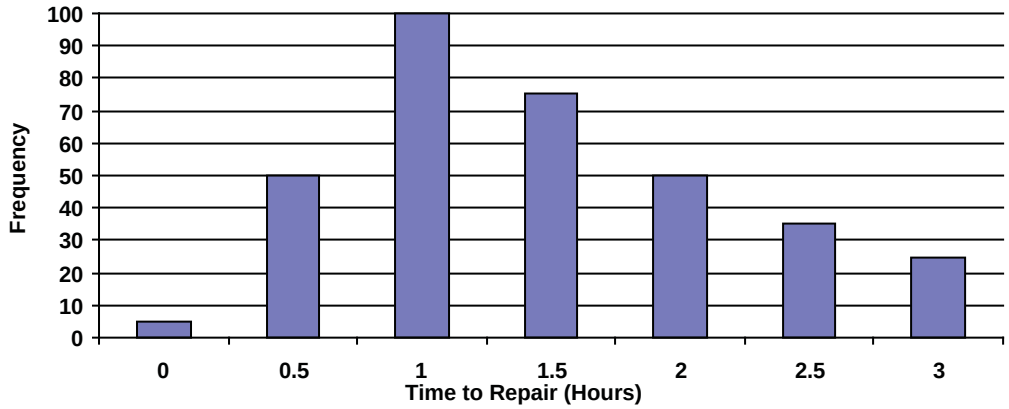
The data must be analyzed before they can be acted on intelligently. Begin by stratifying the data into rational subsets. Next identify the largest performance gap, and finally determine the causes of that gap. Here are the details.

Stratification

For discrete (counted) data, such as a count of requests for repair service, create a Pareto [2] chart. The categories used to create the Pareto might be model number, geographic region, service call type or some other dimension that aggregates data according to some similar characteristic. The result may look like this:



For continuous (measured) data, such as mean time to repair, use a histogram [9] to identify outliners; items that are significantly (e.g., one or two standard deviations) beyond the mean. The result may look like this:



Identify the largest performance gap

Address the largest opportunity for improvement first. In the first example above, begin by investigating the repair call requests for Model “A”. In the second example, investigate the calls that have a repair time of more than 2.5 hours. At this stage it is best to turn the analysis over to a team who is expert in the operation of Model “A”. This team of subject matter experts may need a facilitator skilled in the use of cause-effect diagrams to conduct an efficient and complete analysis.

Enumerate the causes for the Performance Gap

Use a fish bone (also called Cause-Effect [14] diagram or Ishikawa diagram) to enumerate the suspected causes of the performance gap. Refer to the example shown in figure X.6.

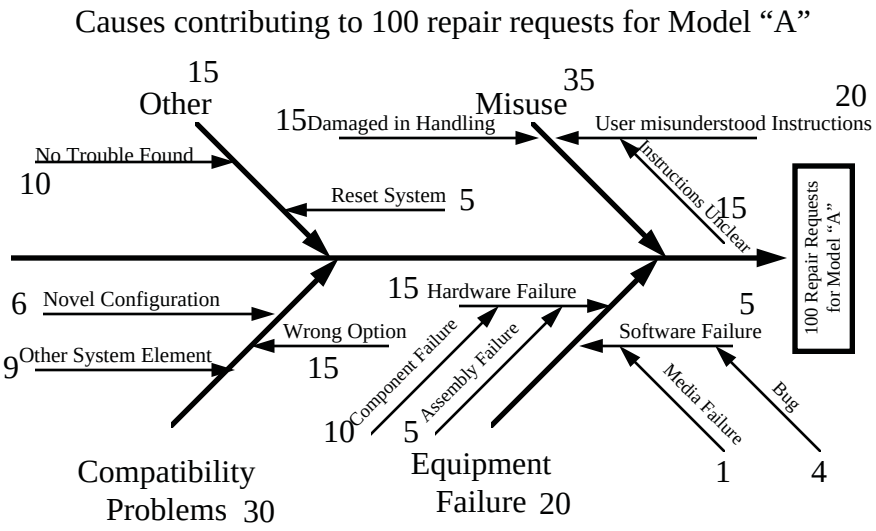


Figure X. 6

Begin by stating the performance gap to be analyzed (Model "A" had 100 service calls) at the head of the fish. Then list major causes contributing to the repair requests, each on a major "bone". The major causes in this example are "Other", "Misuse", "Compatibility Problems" and "Equipment failure." For each of these major causes, add "bones" showing their contributing causes. For example, both "hardware failure" and "software failures" contributed to equipment failures. Continue the analysis to the limit of the team's understanding.

Now "weigh the bones" by allocating the full gap (100 repair requests) across all of the bones. In this example 35 requests were due to "misuse" and of those 20 were due to the user misunderstanding instructions.

The team now chooses a few causes to prevent. Choose causes that have high weights or are easy to remedy. In this example the team has chosen to prevent "unclear instructions" (because of its high weight and relative ease of remedy) and also "Component Failures" because 8 of the 10 were due to a single component that has been recently eliminated from similar product designs.

Acting on the Measurement

Having identified the few causes that represent the best opportunity for improvement, the team identifies remedies that will prevent their occurrence in the future.

The team that is best able to collect and report the data may be different from the team that is best able to analyze the data and take action to improve based on that analysis. It is usually best to assign improvement responsibilities to those who carryout the process.

Continuing with the example, to remedy the unclear instructions, the improvement team has decided to interview 10 of the 15 users who misread the instructions. Considering their findings they will re-write the unclear sections of the instructions and distribute a revised version of the instruction manual. The team has agreed to complete all of this work in the next 6 weeks. To remedy the component failure, the design will be changed to use a more reliable alternative part. The team has

agreed to have the new part in production 4 weeks from today.

Analysis precedes action. Analysis without action is wasteful because no change occurs and no result is accomplished. Action without analysis (often called "tampering") is wasteful because the action is unlikely to be responsive to the underlying cause of the problem.

Avoiding the Trouble Spots

Designing and deploying a measurements program is a difficult task. You can expect difficulties at each stage. Here are some tips that may make the job easier.

Improve the Process, the Results will follow

Be clear that the goal is improved processes resulting in better value to the customer. The measurements are only a tool and no measurement is without its harmful side effects. Deal quickly and decisively with any attempt to improve the measured result without improving the underlying processes or adding value. For example, efforts to make it more difficult for customers to report problems may show an improvement in this reliability measurement. Such deliberate efforts are nothing short of sabotage and should be dealt with as such. Clarify or re-define any measurements that are having significant adverse effects.

Data and Reporting Integrity

Because the data will be used as the basis for decision making, insist on honest and accurate data collection and reporting. At the same time, allow the team to estimate information they do not yet know. For example, in allocating weights on a fish bone diagram the team may have to rely on its collective judgment rather than on hard data. Encourage this when it speeds progress. Remind the teams that they should clearly identify any estimates they have made.

Motivating Positive Behavior

Being clear about what gets measured sends a strong signal throughout the organization defining what executive management views as important. At the same time, basing decisions on measurements data shifts the center of power and control in the organization. Measurements empowers people at all levels in the organization by giving them the information they need to make decisions based on facts. Imagine how the director of service operations might *really* feel about the goal to reduce service calls? What effect will a smaller service organization have on his or her career goals? How does each person react when measurements are reported that highlight problems in their area of responsibility? Are they truly pleased to see problems identified and solved, or are they defensive about the performance of their work group?

Problems must be identified before they can be solved. Encourage reporting the defects, don't shoot the messenger, especially when the message contains bad news.

To overcome these problems first the executives, then the middle managers, and finally everyone must lead a cultural change in both word and action. They must hold steadfastly to the goal of improved customer value and long term business results. They must encourage reports of problems, especially when opportunities for improvement are clearly identified. They must establish meaningful incentives based on measurement goals that are sufficient to overcome local discomfort with the changes taking place. The organization must learn over months and years from its experience in managing the business by the metrics.

Trial New Metrics

Before basing critical decisions on a newly defined metric, consider using it first during a trial period. This trial period

provides an opportunity to examine several alternative definitions of the metric and determine which definition gives the most useful information. The stability of the metric from one measurement period to the next can be examined. A history of the metrics values can be obtained to provide a baseline reference for analyzing data in the future. Finally, people who may be skeptical about the usefulness of the metric will have an opportunity to observe its behavior before it is used to run the business. This is analogous to the "Demonstration Sports" included with each running of the Olympic games.

Correlate Measurements Results with Goals Achievement

Measurements at best can only be surrogates for the attainment of the true goals of the organization. To evaluate the effectiveness of the measurements program, examine the correlation between the measurements results and the goal attainment. As the reliability measurements improve, does a requisite improvement in customer satisfaction, market share, profitability and growth occur? If they do, they you have an excellent and effective measurements program. If they do not, then the current measurement set may not be an accurate surrogate for the goals you set out to achieve. Investigate to determine where the analysis has broken down. Revise the measurements plan to better reflect the goals.

Reviewing, Evaluating and Improving the Measurements program

As the organization's quality system and information systems mature, the organization will be able to take action on increasingly important metrics. The annual planning cycle is a good time to revisit the overall measurements plan and to move to a more important set of measures. At that time the measurements set can be aligned with the latest corporate goals. The nature of the current performance gaps can be reassessed. Measures originally introduced to identify process improvements can now be used to sustain process control. Measures that will allow for still greater process improvements can be introduced. Opportunities to transform the NPD process may be identified by looking across measurements that identify chronic and systematic process problems. Also, the resources needed to carry out the measurements plan, including implementing improvements identified by analyzing the measurements can be planned for at this time.

X.5 Summary

A complete measurements program consists of an annual planning cycle and a more frequent periodic measurements information review cycle including the major tasks shown here in exhibit X.3.

Exhibit X. 3

Glossary

Economic Value Add - The value added to or subtracted from shareholder value during the period of time being measured. The EVA formula is:
EVA = (Return on Invested Capital - Cost of Capital) x Average Invested Capital

Metric - The definition of a class of measurements.

Measurement - Numbers obtained according to a metric definition

Customer Value Add Ratio - The ratio of WWPF for your products to WWPF for your competitors products. A ratio above 100% indicates superior value compared with your competitors.

Data - measurements taken at the source of a process operation

Information - Knowledge and insight, often gained by examining measurements.

Pareto Chart - A bar graph, sorted in descending order. It is used to identify the largest opportunity for improvement; distinguishing the “vital few” causes from the “useful many” causes.

Waste - Any activity which utilizes equipment, materials, parts, space, employee time, etc. beyond the minimum amount required for value-added operations to insure manufacturability. These activities could include waiting, accumulating semi-processed parts, reloading, passing materials from one hand to the other, etc. Shigeo Shingo identified seven basic categories of waste which a business should strive to eliminate: overproduction, waiting for machines, transportation time, process time, excess inventory, excess motion, and defects. [17]

Worth What Paid For (WWPF) - The quantitative evaluation by a person in your customer segment of the question: “Considering the products and services that your vendor offers, are they worth what you paid for them?”

Appendix X.A

A Gallery of Candidate Metrics

Financial Performance

- Short term revenue, profit, growth
- Long term revenue, profit, growth
- Return on investment, Economic Value Add, Break Even Time
- Development Cost, Product Cost, Service Cost, Warranty Cost
- Financial risk

Customer Satisfaction

- Customer Satisfaction Survey
- Product Functionality, Usability, Reliability, Performance, Serviceability, ergonomics and aesthetics
- Timeliness of product availability

- Product return rates, customer complaint levels
- Capture and loss of new customers, contracts and markets. Customer Loyalty

Employee Satisfaction

- Satisfaction Survey, by Employee Group or Job Classification
- Recruitment Rates, Turnover rates, employee complaints and suggestions.

Growth, Innovation and Learning

- Revenue, profit, growth from new products
- Growth in Market Share, revenue, profitability
- Patents, copyrights, licenses, proprietary products
- Learning, teaching, innovation activity levels and results
- Rate of progress in cycle time reduction, defect reduction, cost reduction, process capability prediction and customer satisfaction.

Process Capability Prediction

- Accuracy of cost, development schedule, manufacturing schedule, product reliability, product performance and sales forecasts
- Variation from program to program and Quarter to Quarter.

Productivity and Resource Consumption

- Indicators of effective use of staffing, materials, energy, capital and equipment.
- Waste creation levels
- Expense to revenue ratios by function and by product.
- Staffing levels, task volumes, equipment usage

Process Control

- Manufacturing yields, scrap rates, line rejects, defects, re-work levels, cycle times, order intervals, inventory levels, inventory turns and assets.
- Design change activity rates.
- Sales order cycle time, on-time delivery and defects.
- Supplier performance
- Speed of customer call answer and response
- Billing speed, accuracy and problem resolution
- Service call response times, effectiveness
- Financial reporting accuracy, timeliness, usability
- Advertising activity levels and response rates.
- Information systems availability, capacity and response times
- Safety, absenteeism, turnover, sickness and accident rates

References

1 Beaumont, Leland R. *ISO 9001, The Standard Interpretation*, Middletown NJ:ISO Easy, January, 1995.

2 Burr, John T. *The Tools of Quality Part VI: Pareto Charts*, Quality Progress magazine, November 1990, pp 59-62.

3 Ernst & Young, *International Quality Study, Best Practices Report*, American Society for Quality Control.

4 Gale, Bradley T. *Managing Customer Value, Creating Quality & Service that Customers can See*. New York: The Free Press, 1994.

5 Griffin, Abbie. *Developing Products and Services: How do you know how well you've done?*, Talk presented at the Second Annual Program on Improving the New Product Development Process: Lessons From Experts, Houston, 1995.

6 House, Charles H., Price, Raymond L. *The Return Map: Tracking Product Teams*, Harvard Business Review, (January-February, 1991)

7 Jones, Capers. *Applied Software Measurement, Assuring Productivity and Quality*, McGraw-Hill, Inc. New York, 1991

8 Juran, Joseph M. *Juran on Planning for Quality*, New York: The Free Press, 1988.

9 Juran Institute, *The Tools of Quality Part IV: Histograms*, Quality Progress magazine, September 1990, pp 75-78

10 Kaplan, Robert S., Norton, David P. *The Balanced Scorecard — Measures That Drive Performance*, Harvard Business Review, (January-February 1992)

11 Kaplan, Robert S., Norton, David P. *Putting the Balanced Scorecard to Work*, Harvard Business Review,(September-October 1993)

12 Möller, K. H., Paulish, D. J. *Software Metrics, A Practitioner's Guide to Improved Product Development*, Piscataway, NJ: IEEE Press, 1993.

13 Rosenau, Milton D. *International Benchmarking Clearinghouse Benchmarking Consortuim Study, New Product Development final report*, American Productivity & Quality Center, 1995

14 Sarazen, J. Stephen *The Tools of Quality Part II: Cause-and-Effect Diagrams*, Quality Progress magazine, July 1990, pp 59-

15 Tully, Shawn. *The Real Key to Creating Wealth*, FORTUNE, September 20, 1993, pp 38-50.

16 United States Department of Commerce, Technology Administration, National Institute of Standards and Technology, *Malcolm Baldrige National Quality Award, 1995 Award Criteria*.

17 Utah State University. *Shingo Prize for Excellence in Manufacturing, 1995-1996 Application Guidelines*, Utah State University, College of Business, 1995.

18 Walrad, C., Moses, E. *Measurement: The Key to application development quality*, IBM System Journal, Vol 32, No 3, 1993. pp 445-460

19 Whiteley, Richard C. *The Customer Driven Company, Moving from Talk to Action*, Reading Massachusetts: Addison-Wesley, 1991