

**Software Quality Improvement Policy  
and Software Quality Key Indicators  
(4-Ups Metrics): Member Company  
Requirements for Suppliers**

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# Software Quality Improvement Policy and Software Quality Key Indicators (4-Ups Metrics): Member Company Requirements for

**Suppliers**

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**Abstract:** This document presents the SEMATECH Member Companies Software Quality Improvement Policy, which includes a set of key indicators that semiconductor equipment suppliers are required to provide to SEMATECH member companies on request. It defines these key indicators, methods for collecting related data, formats for presenting the indicators to customers, and maximum acceptable “age” of the data. These requirements are designed to help suppliers continuously improve the reliability and the overall quality of software.

**Keywords:** Software Process Improvement, Software Reliability

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## **1 EXECUTIVE SUMMARY**

Software's role is critical to productivity and profitability in semiconductor wafer fabrication, assembly, and test operations. For many suppliers, software is now also a significant factor in their competitive position and overall business success. Recognizing this, SEMATECH member companies expect equipment and system suppliers to continuously improve the reliability and the overall quality of software.

This document presents the SEMATECH Member Companies Software Quality Improvement Policy, which sets forth expectations that SEMATECH member companies have established for supplier software quality, including a set of key indicators that semiconductor equipment suppliers are required to provide to their customers (SEMATECH member companies) on request. These indicators are of significant value to suppliers in improving software quality. This document defines the key indicators, methods for collecting related data, formats for presenting the indicators to customers, and maximum acceptable "age" of the data.

## **2 SEMATECH MEMBER COMPANIES SOFTWARE QUALITY IMPROVEMENT POLICY**

Software's role is critical to productivity and profitability in semiconductor wafer fabrication, assembly, and test operations. For many suppliers, software is now also a significant factor in their competitive position and overall business success. Recognizing this, SEMATECH member companies expect equipment and system suppliers to continuously improve the reliability and the overall quality of software by the following:

1. Establish an organizational commitment to improving software quality, driven by objective Process Assessment Findings from SSQA ratings and/or SEI maturity levels.
2. Institutionalize continuous improvement by adopting Software Quality Goals and Improvement Action Plans that achieve the goals, as evidenced by recognized metrics.
3. Establish and maintain a Problem and Corrective Action Reporting System that drives continuous improvement in equipment and system reliability.
4. Establish and maintain a Software Revision Control System to assure reproducibility of all delivered software and proper application of corrections and upgrades.
5. Charter staff and allocate budget to the work of continuously improving software quality, objectively validating the quality of software produced, and verifying the software process used.
6. Provide the following data as part of each major product release:
  - Software test plan and test report.
  - Release notes that include documentation for all changes and a list of all known problems in the delivered software, with a recommended procedure for recovery when the problem is encountered.
  - Compliance status with the Generic Equipment Model/Specific Equipment Model (GEM/SEM) and Semiconductor Equipment Communications Standard (SECS) interface standards.
7. Show compliance with this policy by using the following metrics:
  - Software defect trend (discovered, closed, and open)
  - Software reliability (mean wafers between interrupts [MWBI], mean time between failures [MTBF])
  - On-time delivery and release contents volatility (new features and defect fixes)
  - Software Process Maturity (SEI Levels 2-3 or SEMATECH SSQA Module 3)

A Supplier's Assessment Findings (Item 1), Quality Goals and Action Plan (Item 2), and data for all four metrics (Item 7) are to be provided upon request by any SEMATECH member company or by SEMATECH as part of a SEMATECH program.

### 3 SEMATECH SOFTWARE QUALITY INDICATORS (4-UPS METRICS)

#### 3.1 Purpose

SEMATECH's Software Quality Improvement Policy includes a set of key indicators that semiconductor equipment suppliers are required to provide to their customers (SEMATECH member companies) on request. These indicators are of significant value to suppliers in improving their software quality. The purpose of this section is to define the key indicators, methods for collecting the data, formats for presenting the indicators to customers, and the maximum acceptable "age" of the data presented.

#### 3.2 Definitions

**Software Product Indicators** (*software defect trend, software reliability*) measure the software in the supplier's product. The key indicators should present the status of the current release of the product in question. Historical data should be kept for several recent software releases to measure improvement. If the supplier manufactures more than one product, these indicators should be presented separately for each product (or product family, in the case of a group of very similar products).

*Software defect trend:* A measure of the number of post-release defects contained in the supplier's software. Key metrics are defects discovered and defects closed (fixed) during a specific time period, and defects remaining open at the end of the time period. The key indicator includes these three data items, measured monthly and plotted as a trend chart. A consistent defect severity classification scheme (such as that defined by IEEE 1044-1993) is to be implemented, and at least two sets of software defect data are to be tracked: *critical* and *serious* defects only, and all (total) defects.

*Software Reliability:* A measure of the ability of the software to perform to its specifications without failing for a certain number of wafers (MWBI) or period of time (MTBF). Software reliability is measured first by logging failures, and then using standard reliability methods (based on SEMI E10-96) to compute MWBI or MTBF. This is an opportunity for "partnering" between suppliers and their customers, as the most meaningful data can be measured best in a production (fab) environment, on tools that actually are processing wafers. The key indicator is to be calculated monthly, and plotted as a trend chart.

**Software Process Indicators** (*on-time delivery/release contents volatility and software process maturity*) measure the software organization and how it works, not the software contained in the supplier's product. If the supplier has more than one software product development organization (e.g., divisions, groups), each will be required to present these indicators separately.

*On-time delivery:* A measure of the time lag between the committed delivery date and the actual delivery date for a software release. The key indicator is the lead/lag time (days early/late) for several recent releases, plotted as a trend chart. A closely related measure is *release contents volatility*, one of the main root causes of late delivery. Key metrics are the number of new features and defect fixes actually included in the software release-vs.-planned and committed content, plotted as a trend chart for several recent releases.

*Software Process Maturity:* A measure of the ability of the software organization to develop quality software, on time, on budget, as defined by the SEI Capability Maturity Model (CMM) for Software or the SEMATECH SSQA Module 3–Software Quality. The key indicator for the SEI/CMM method is the organization’s satisfaction of the 13 SEI Level 2 and 3 Key Process Areas, as determined by an independent assessment. The key indicators for SSQA Module 3 are the scores for the 12 SSQA requirements, determined by a self-assessment and validated by a SEMATECH/member company assessment team.

*Maximum “age” of data:* Software defect trend and software reliability shall be tracked monthly. On-time delivery and release contents volatility shall be measured at the release date for each new software release. Software process maturity shall be based on assessment data that is not more than one year old.

### **3.3 Software Defect Trend**

The software organization is required to have a software defect tracking and closure system (whether manual or automated), and a system of classifying defects by severity level (such as that defined by IEEE 1044-1993).

#### **3.3.1 Software Defects Discovered**

Source: field engineering reports, software problem reports, customer trouble calls, test results.

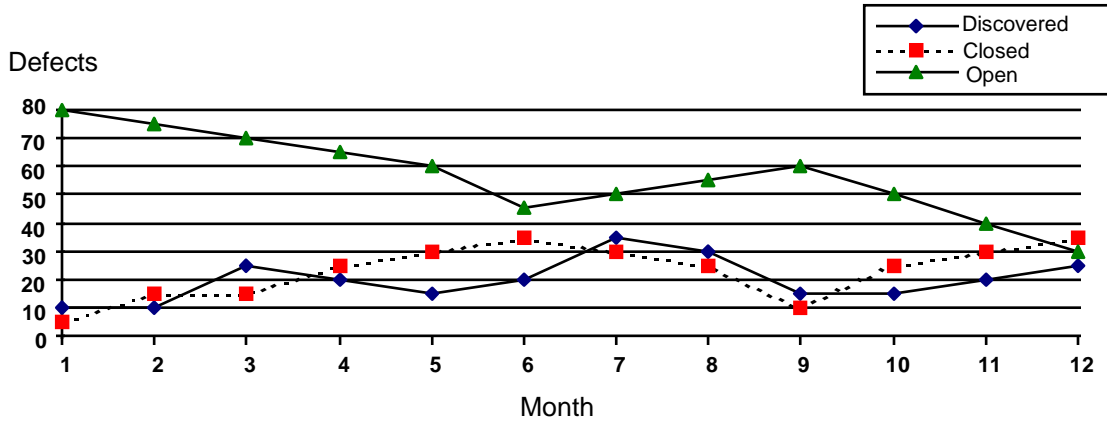
#### **3.3.2 Software Defects Closed (fixed)**

Source: completion of module and regression testing by supplier software engineering organization.

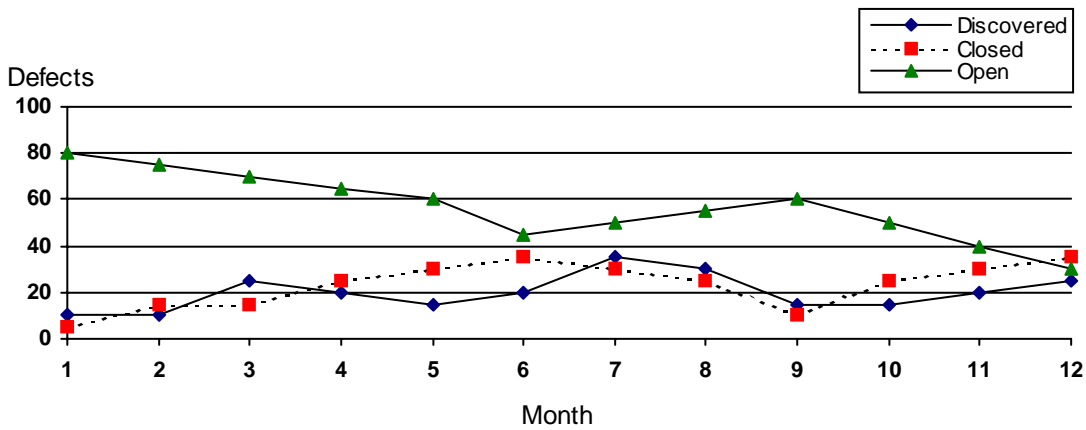
#### **3.3.3 Software Defects Open (discovered but not yet fixed)**

Formula: open defects at start of period + newly discovered defects - defects closed during the time period.

The defect trend data is to be measured monthly, and presented as shown in Figure 1 (for critical and serious defects only) and Figure 2 (for *all* defects).



**Figure 1 Software Defect Trend (Critical and Serious Defects Only)**



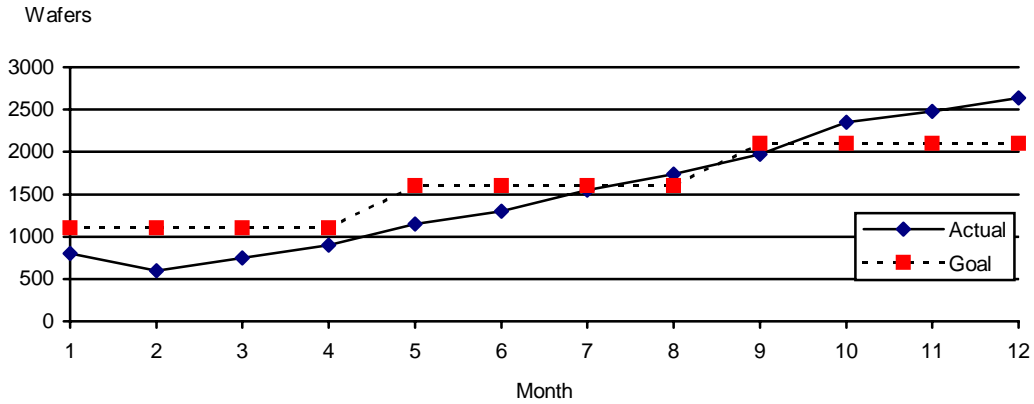
**Figure 2 Software Defect Trend (All Defects)**

### 3.4 Software Reliability

Suppliers are required to establish a software reliability goal, track their performance against that goal, and present both goal and actual on a trend chart. The test environment should closely approximate a production environment. Data may be collected at either the supplier’s site or at customer sites. This is an ideal opportunity for “partnering” between suppliers and their customers to measure reliability.

#### 3.4.1 Mean Wafers Between Interrupts (MWBI)

MWBI (the number of wafers processed between software failures) is the preferred software reliability key indicator for wafer processing tools, because it measures software reliability while the supplier’s equipment is actually processing wafers (not while the equipment is in an idle state or down for maintenance or another reason). To calculate MWBI, suppliers must log the number of wafers processed between software failures and compute the average monthly.

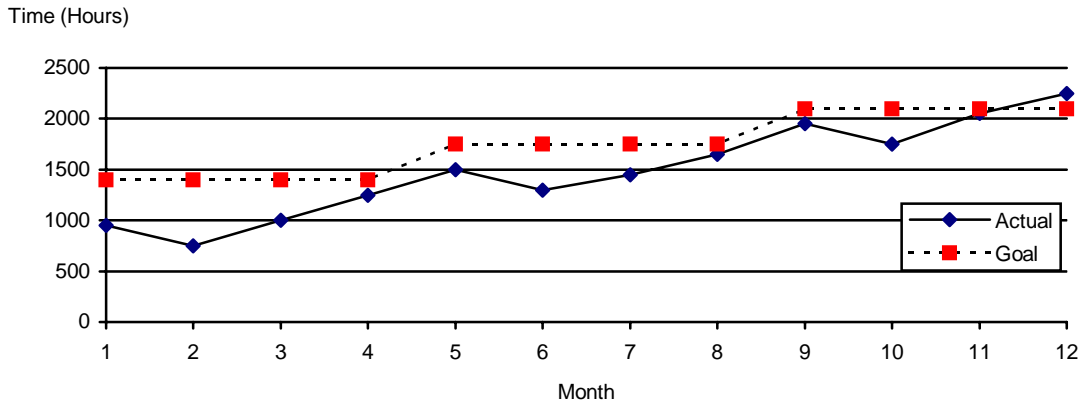


**Figure 3 Software Reliability (MWBI)**

**3.4.2 Mean Time Between Failures (MTBF)**

Software MTBF (the time duration between software failures) is the preferred software reliability indicator for tools that do not process wafers and tools that process wafers in batches (where MWBI would be confusing), and is acceptable for any tools.

In order to compute software MTBF, suppliers must log each software failure, and compute MTBF monthly, using a standard reliability methodology (based on SEMI E10-96).



**Figure 4 Software Reliability (MTBF)**

**3.5 On-Time Delivery (and Release Contents Volatility)**

The software organization is required to have an effective project planning and tracking system capable of recording plan-vs.-actual performance against the committed schedule and the planned and actual contents (new features and defect fixes) for each software release. Following are key indicators to be measured.

### 3.5.1 On-Time Delivery

This is the number of days early (+) or late (-) for several recent software releases, measured at the release date.

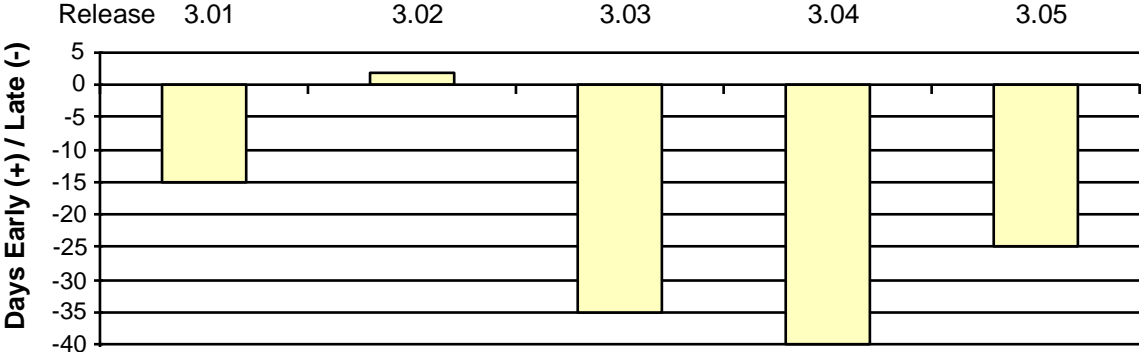


Figure 5 On-Time Delivery (Days Early/Late)

### 3.5.2 Release Contents Volatility

Release contents are new features and defect fixes, planned-vs.-actual, measured at the release date.

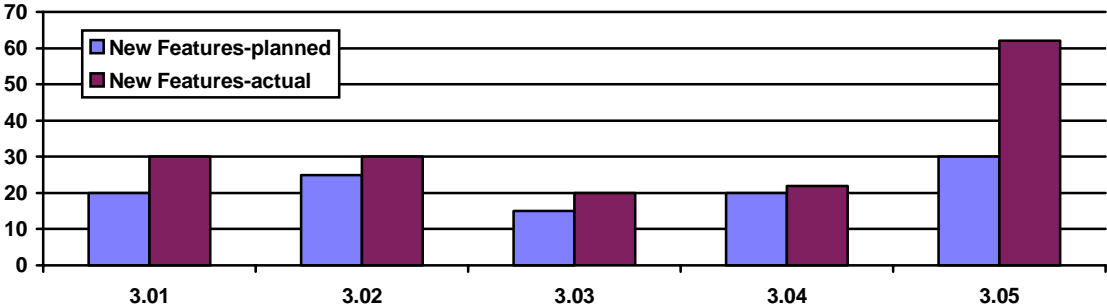


Figure 6 Release Contents Volatility (New Features)

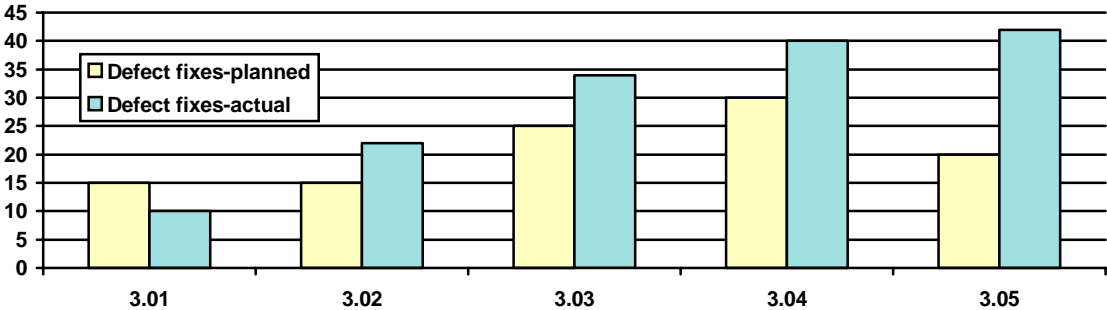


Figure 7 Release Contents Volatility (Defect Fixes)

### 3.6 Software Process Maturity

#### 3.6.1 Software Engineering Institute/Capability Maturity Model (SEI/CMM)

The SEI/CMM<sup>1</sup> for Software defines five Levels of software process maturity. These key indicators include only SEI Levels 2 and 3 (Levels 4 and 5 are outside the scope of this document). Each level has several Key Process Areas (KPAs) that must be satisfied to reach that level. To achieve SEI Level 2, all of the Level 2 KPAs must be fully satisfied.

Each Key Process Area has a set of goals and activities associated with it which must be satisfied, and is assessed on five factors:

Commitment to perform	Establishing organizational policies and management sponsorship.
Ability to perform	Having appropriate resources, organizational structures, and training.
Activities performed	Establishing plans, performing work, tracking, and taking corrective action.
Measurement and analysis	Measuring the process and analyzing the measurements.
Verifying implementation	Conducting reviews and audits by management and quality assurance.

#### Software Engineering Institute Capability Maturity Model for Software SEI/CMM Level 2 & 3 Key Process Area Profile

3	"Defined" Key Process Areas
	Peer reviews
	Intergroup coordination
	Software product engineering
	Integrated software management
	Training program
	Organization process definition
	Organization process focus

2	"Repeatable" Key Process Areas
	Software configuration management
	Software quality assurance
	Software subcontract management
	Software project tracking & oversight
	Software project planning
	Requirements management

	fully satisfied
	partially satisfied
	not satisfied
	not applicable
	not rated

**Figure 8 Process Maturity: SEI/CMM Levels 2 and 3**

The software organization is required to perform an assessment of its software engineering practices (the assessment to be performed by a qualified SEI assessor) and document the results using the SEI/CMM method at least once a year. The results shall be presented as an achievement of SEI Levels 2 or 3, and/or the satisfaction of the SEI Level 2 and 3 Key Process Areas as shown in Figure 8.

<sup>1</sup> Software Engineering Institute Capability Maturity Model for Software, Version 1.1 (see Section 0, References)

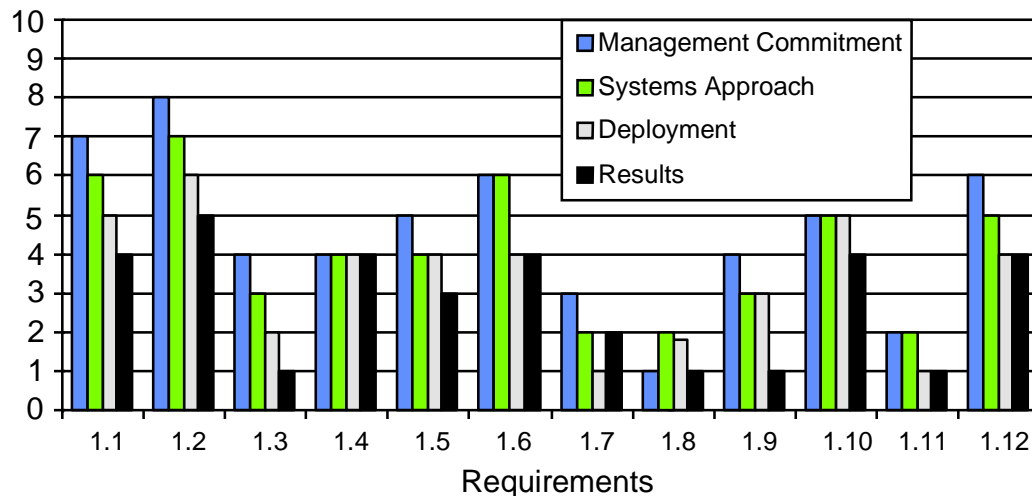
### 3.6.2 SEMATECH SSQA Module 3 (Software Quality)

SEMATECH Standardized Supplier Quality Assessment (SSQA)<sup>2</sup> Module 3 defines 12 requirements for software quality:

- |   |  |
|---|--|
| 1.1 Documented process                          | 1.7 Independent testing of software          |
| 1.2 Software project planning and control       | 1.8 Software quality goals                   |
| 1.3 Software development system                 | 1.9 Software quality organization            |
| 1.4 Documented requirements                     | 1.10 Continuous software quality improvement |
| 1.5 Configuration management and change control | 1.11 Software capability improvement         |
| 1.6 Software development security               | 1.12 Software subcontractors                 |

Each requirement is scored on a scale of 0–10 on each of four factors, using the SSQA scoring matrix<sup>2</sup>:

Management Commitment	Is management committed to this requirement being satisfied?
Systems Approach	Is there a systematic approach in place that defines the process?
Deployment	Is the process deployed and being used throughout the organization?
Results	Are there measurable results that can be attributed to the process?



**Figure 9 Process Maturity: SSQA Module 3**

The software organization is required to perform a self-assessment of its practices (validated by a SEMATECH/member company assessment team) and document the results using the SSQA method at least once a year. The results shall be presented as the scores for each of the 12 SSQA requirements as shown in Figure 9.

<sup>2</sup> The SEMATECH SSQA Workbook and Scoring Matrix are available to SEMATECH and SEMI/SEMATECH member companies. Call (512) 356-7028 for ordering information.

### 3.7 Presenting The 4-Ups Metrics to Customers: An Example

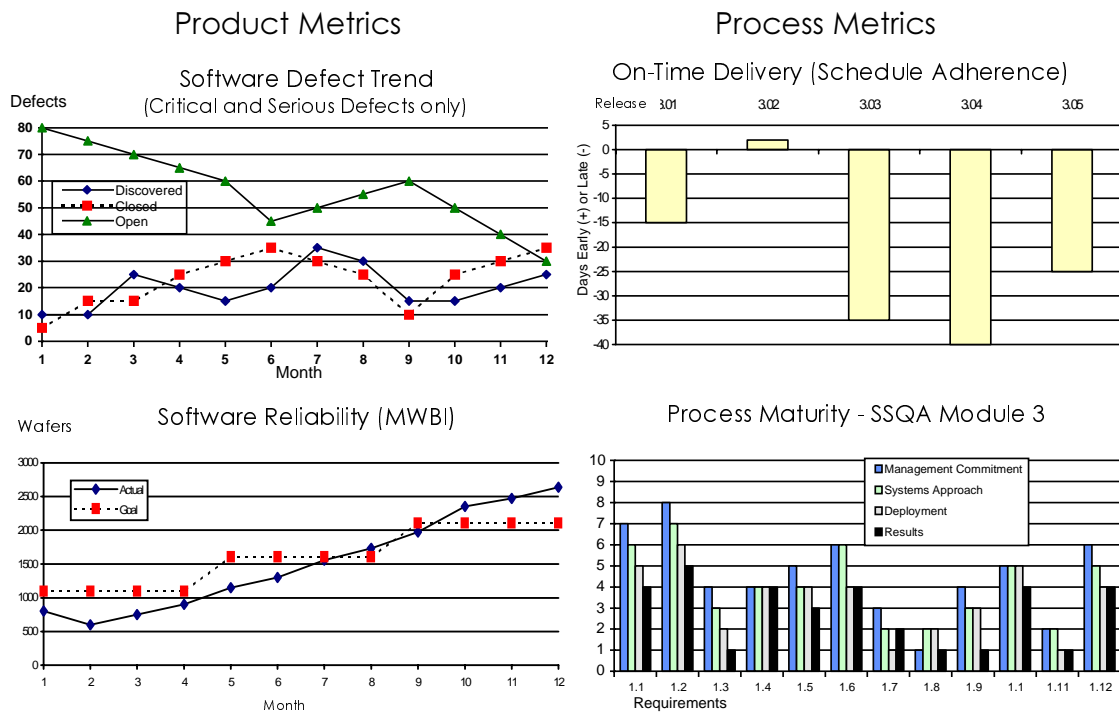
The 4-Ups Software Quality Metrics have been defined with three goals in mind:

1. Simplicity—SEMATECH member companies do not want to burden suppliers with complex metrics
2. Consistency—establish a common set of metrics and presentation formats for use by all suppliers
3. Brevity—the fast pace of this industry dictates a presentation format that may grasped quickly

Q: Why call them “4-Ups”?

A: “4-Ups” means “4 sets of metrics (charts) on one page.” The goal is to have a set of metrics that can be summarized on one presentation foil. Several SEMATECH member companies use this format at all internal management reviews, and are accustomed to it. They want to be able to see “at a glance” whether suppliers are making progress on software quality key indicators.

Figure 10 is an example of how the 4-Ups may be presented to customers.



**Figure 10 4-Ups Presentation Format Example**

In the event that some of the data is not available (e.g., software reliability), another of the 4-Ups metrics (e.g., release contents volatility) may be substituted.

Q: Figures 1-9 present nine (not four) metrics. What if a member company asks for all of them?

A: The actual format to be used is to be decided between each supplier and their customers. For example: in the event of a detailed software quality review, member companies may request that each of the metrics be presented separately, along with the underlying data.

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