

**An investigation on the software  
metrics to promote best practices for  
reliability improvement**

*Executive Summary*

April 2008

Japan Information Technology Services Industry  
Association

## 1. Background and purpose of the survey

With the increasing need to improve business efficiency and effectiveness, and the rapid development of information technology, information technology has become the foundation of society and business. As a result, failures in information systems could have a massive impact on society and business, and so it is a top priority for suppliers to create highly reliable information systems. However, it is difficult to monitor and control the reliability of information systems objectively; actually most suppliers go through a process of trial and error repeatedly.

To resolve this issue using software engineering, from a quantitative management viewpoint in particular, efforts are being made to secure and improve the reliability of information systems throughout the life cycle from development to maintenance and operation. In June 2006, the Ministry of Economy, Trade and Industry (METI) issued a “Guideline for improving the reliability of information systems” (IT Reliability Guideline)<sup>(1)</sup> and an associated “Reliability Evaluation Index (draft)”<sup>(2)</sup>.

This survey was undertaken in order to identify best practices for securing the reliability of information systems based on the activities of member companies and to present metrics system (metrics set), background of the scheme, practical usages and effects, in order to promote reliability improvement activities in the IT industry. As contrasted with the IT Reliability Guideline and Reliability Evaluation Index (draft) issued by METI, which focus on mainly what should be done, this survey examines what items should be measured, how they should be used and controlled, and the reason for doing so.

## 2. Survey results

We aggregated and presented management metrics of reliability used in development, maintenance and operation by member companies of the Information System Reliability Improvement Committee (Reliability Visualization Sub-committee). We summarized their effects and practical usages as a useful basis for quantitatively improving the reliability. We also mapped management metrics to IT Reliability Guideline in order to give suggestions for effective utilization of metrics for improving reliability according to the guideline.

### (1) Collection of cases of management metrics for reliability

We collected management metrics for development (7 examples), for maintenance (2 examples) and for operation (4 examples) from 8 member companies of JISA. Table 1 shows the companies and the number of metrics provided (by development, maintenance and operation).

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<sup>1</sup> <http://www.meti.go.jp/press/20060615002/20060615002.html>

<sup>2</sup> <http://sec.ipa.go.jp/download/200705ep.php> (free, but registration required)

Table 1 Collection of cases of management metrics for reliability (All of 13 examples)

Company	Number of Metrics		
	Development	Maintenance	Operation
NTT DATA CORPORATION	100 <case1>	—	13 <case11>
JASTECCo., Ltd.	192 <case2>	—	—
Daiwa Institute of Research Ltd.	29 <case3>	—	—
DTS CORPORATION	8 <case4>	—	1 <case13>
TOKIO MARINE NICHIDO SYSTEMS Co., Ltd.	206 <case5>	—	104 <case10>
Nomura Research Institute Ltd.	66 <case6>	23 <case8>	40 <case12>
Hitachi Software Engineering Co., Ltd.	54 <case7>	—	—
NS Solutions Corporation	—	62 <case9>	—
The Number of Case Studies	7 examples	2 examples	4 examples

Metrics sets are organized so that the organic relationship among individual metrics can be understood when referring individual metrics of each company. Furthermore, the characteristics of metrics sets and ways to use metrics (outline, analysis/utilization details, feedback details) are also explained.

(2) Background/purpose, viewpoint, effect of these efforts, and future efforts

We show the background/purpose (scheme) of the efforts, viewpoint for reliability (policy), utilization effect of metrics sets and future efforts for the reliability management metrics set for each company. You can use them to efficiently build effective management metrics for your organization by referring to the metrics set of (1).

Table 2 shows examples of the effect of using the management metrics set.

Table2 Examples of the effect of using the management metrics set

Effects on	Summary
Reliability	<ul style="list-style-type: none"> <li>· Decrease of failures case1</li> <li>· Surely improve reliability case6</li> <li>· In comparison with the state around 2000, failures decreased more than 90% case10</li> <li>· Human mistakes reduced to almost zero. case12</li> </ul>
Project Management	<ul style="list-style-type: none"> <li>· Understand important factors on the sources of bugs case10</li> <li>· Grasp quantitative effect on productivity by development activities case5</li> <li>· Recognize significant effects of detecting failures at earlier processes case3</li> <li>· Detect project risks earlier and decrease large-scale projects failures case7</li> </ul>

Effects on	Summary
Organization Management	<ul style="list-style-type: none"> <li>· Grasp characteristics of organizations by time serial analysis case1、 9</li> <li>· Implement change management and promote blanket contracts case2</li> <li>· Improve accountabilities for the policy of quantitative management case5</li> <li>· Able to explain the states of whole processes, and easy to correspond to inspection case10</li> <li>· Reduce labor costs for operation case12</li> </ul>

### (3) Mapping to the standard processes

We mapped the management metrics to the standard processes for IT industry. Management metrics for development and maintenance are mapped to the processes and activities of “Software Life Cycle Processes - Japan Common Frame 2007 (Japan Common Frame 2007)” (Table 3) and management metrics for operation are mapped in ITIL version 3 process (Table 4) <sup>(3)</sup>.

You can use it as a reference for selecting and using metrics such as what sort of metrics is measured in which process, and how it can be used.

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<sup>3</sup> (Note) The trends are analyzed based on the management metrics provided by each company as just one case example. So it does not mean the cases cover all the management of each company. Such metrics are not necessarily used pervasively throughout each company.

Table 3 Processes / activities of the Japan Common Frame 2007 vs. the management metrics for development and maintenance

View Point	Process/Activity	Development <Case No.>							Maintenance		
		<1>	<2>	<3>	<4>	<5>	<6>	<7>	<8>	<9>	
Contract· Agreement	1.1 Acquisition	○	○	○					○		
	1.2 Supply	○	○	○		○	○	○	(○)		
	1.3 Change Management of Contract		○	○		○					
Planning, Requirement Definition	1.4 Planning Process	○	○								
	1.5 Requirement Definition Process	○	○				○		(○)		
ITDevelopment	1.6 Development Process	1.6.1 Preparing for Starting Process				○	○	○	(○)		
		1.6.2 System Requirements Definition	○	○	○	○	○	○	○	(○)	
		1.6.3 System Architectural Design	○	○			○	○	○	(○)	
		1.6.4 Software Requirements Definition	○	○		○	○	○	○	(○)	
		1.6.5 Software Architectural Design	○	○	○	○	○	○	○	(○)	
		1.6.6 Software Detailed Design	○	○	○	○	○	○	○	(○)	
		1.6.7 Software Coding and Testing	○	○	○	○	○	○	○	(○)	
		1.6.8 Software Integration	○	○	○	○	○	○	○	(○)	
		1.6.9 Software Qualification Testing	○	○							
		1.6.10 System Integration	○	○	○	○	○	○	○	(○)	
		1.6.11 System Qualification Testing	○	○					○		
		1.6.12 Software Installation					○	○		(○)	
		1.6.13 Software Acceptance Test	○					○	○	(○)	
	1.8 Maintenance Process	1.8.1 Preparing for Starting Process								○	
		1.8.2 Problem grasp and revision analysis								○	○*
1.8.3 Enforcement of software revision									○		
1.8.4 Review and Acceptance									○		
1.8.5 Transition									○		
1.8.6 System, Software Retirement											
Organization	3.1 Management	○	○	○		○	○	○	○		
	3.4 Human Resource		○			○		○	○		

(○) : the same metrics as those of development

\*See Table 4

Table 4 ITIL version 3 processes vs. the management metrics for operation

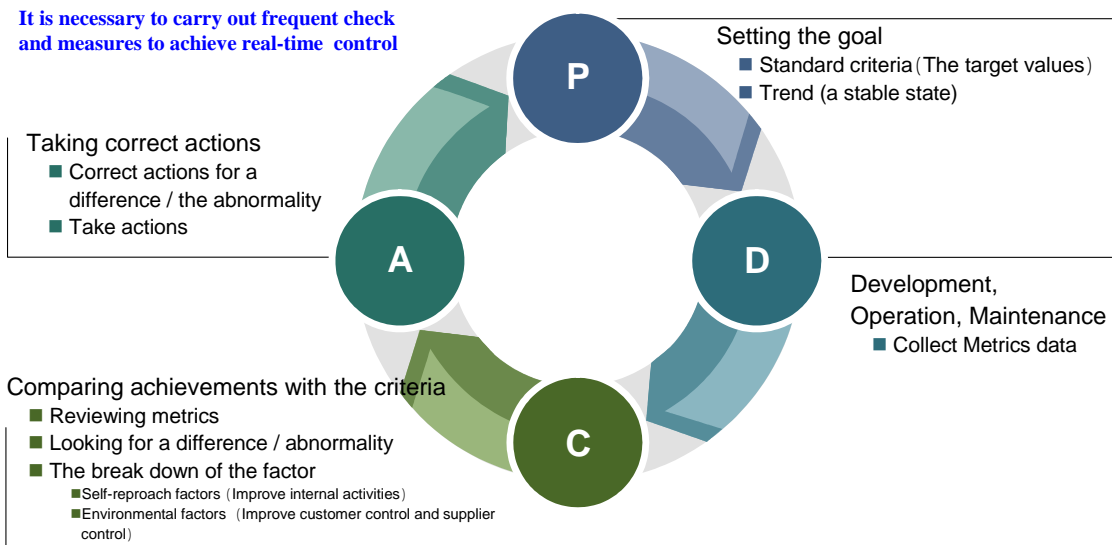
ITIL v3 SERVICE LIFECYCLE		Maintenance	Operation		
Core	Processes	<9.>	<10.>	<11.>	<12.>
SERVICE STRATEGY	Financial Management		○		
	Demand Management				
	Service Portfolio Management				
SERVICE DESIGN	Service Catalogue Management				
	Service Level Management		○	○	
	Capacity Management		○		
	Availability Management		○		
	ITservice Continuity Management		○		
	Information Security Management			○	○
	Supplier Management		○		
SERVICE TRANSITION	Change Management		○		○
	Service Asset and Configuration Management		○		○
	Knowledge Management				
	Transition Planning and Support		○		
	Release and Deployment Management		○		○
	Service Validation and Testing				
	Evaluation	○	○		
SERVICE OPERATION	Event Management		○		
	Incident Management	○	○		○
	Request Fulfillment	○	○	○	
	Access Management				
	Problem Management	○	○		○
	Service Desk		○		○
	Technical Management		○		○
	Application Management				
IT Operations Management		○		○	
CONTINUAL SERVICE IMPROVEMENT	The Seven-step Improvement Process	○	○	○	○
	Service Measurement	○	○	○	○
	Service Reporting	○	○	○	○

**(4) Analysis of progress in the management metrics effort**

As a general overview of the survey results, we indicate points for using the management metrics and for encouraging usage, together with deployment and steps for using the management metrics for securing and improving reliability.

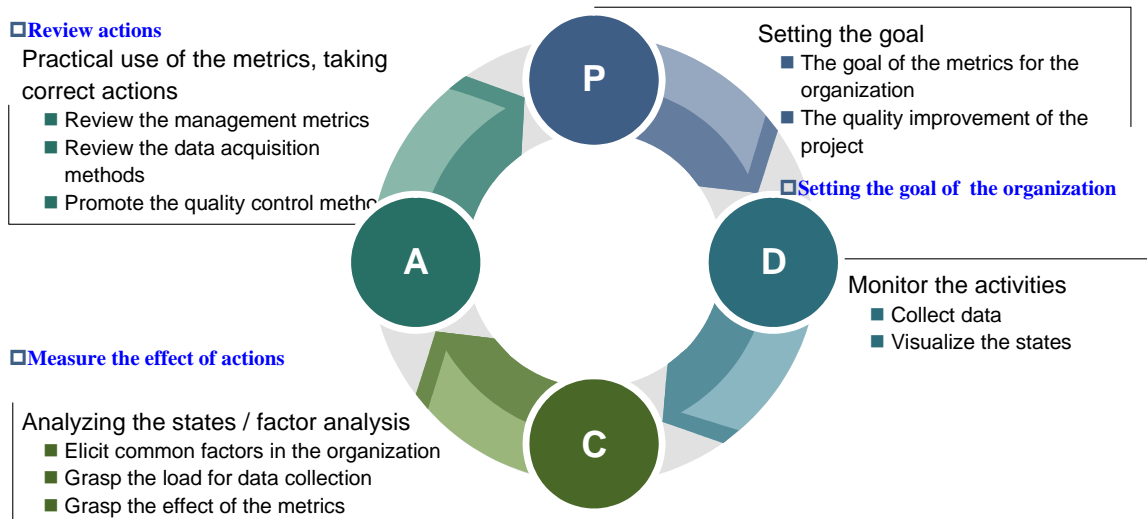
You can use these points to review past activities or as a reference for work in the next step.

It is essential to set a goal for which the management metrics is to be used. The states of projects are monitored in order to achieve the goal. If there are deviations from the goal, the PDCA (Plan, Do, Check, Act) cycle are performed to correct the deviations. The management metrics is used to monitor the state of deviations quantitatively. The PDCA cycle has two loops: one for improving reliability of the project (Figure 1 (a)) and one for improving reliability as an organizational effort (Figure 1(b)). The points of each PDCA cycle are summarized below.



**The break down of the factor is necessary for detailed analysis and improvement action**

(a) PDCA cycle for improving reliability of the project



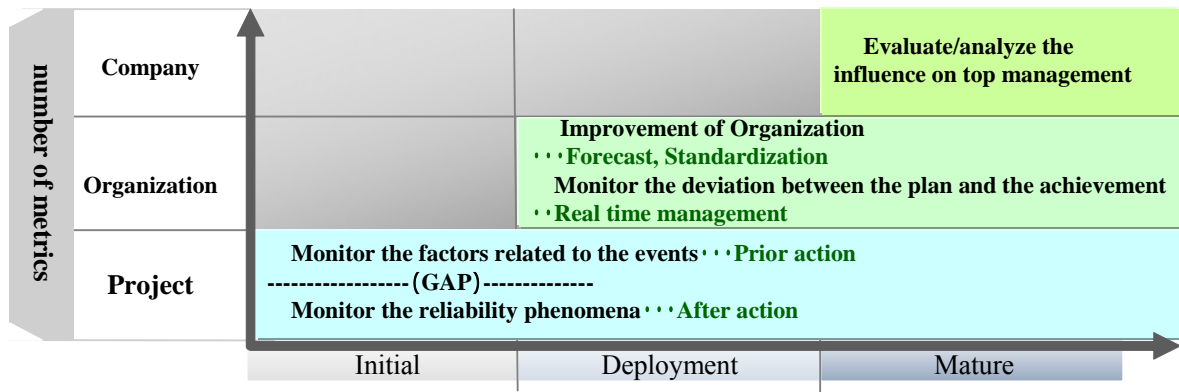
**Quality Control Sections, Project Management Sections**

(b) PDCA cycle for improving reliability as an organizational effort

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Figure 1 PDCA cycle for the practical use of software metrics

We also organized steps up to establishment of these PDCA cycles (Figure 2). At a project level, there is ① a step to monitor the reliability phenomena (incidents including problems), ② a step to monitor the factors related to the events; and at an organizational level, there is ③ a step to monitor the deviation between the plan and the achievement and to control reliability in real-time, ④ a step to improve the organization, and finally ⑤ a step to evaluate/analyze the influence on top management. The development of these steps is summarized below.



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Figure 2 Development of usage of management metrics

To ensure the management metrics takes root in the organization as shown here, not only is the understanding and enthusiasm of the top / senior management necessary but also is the involvement of staffs in the field. The management metrics can help improve negotiation with customers and partner companies. Important points to encourage the use are identified and proposed based on information on each company's efforts (Table 5).

Table 5 Points for making the management metrics take root in the organization and for using the metrics to negotiate with external partners

Points	Concept
[Common knowledge]	
• "small start"	It is better not to add metrics without good reason. Note that there will be difficulties till the metrics management gains its own momentum.
•Review management metrics	Necessary metrics will vary according to the age. If ways to develop information systems are changed, management metrics must also be changed.
•Conduct trend analysis	Trend analysis reveals the state of the organization.
•Recognize differences in the needs for metrics depending on positions	Comprehensive metrics for assessing overall risks or problems is useful for senior management, while metrics for monitoring progress and problems is useful for project leaders.
•Utilize metrics that are easy to adopt and understand	When the metrics is difficult to collect or its merits are unknown, even if collection of data is ordered in a top-down manner, it will not take root in the organization. The key is to start from data that is easy to measure. Note that it is difficult to seek cooperation from the field without positive feedback.
•Incorporate metrics in the business processes	It is important to incorporate activities to collect and analyze metrics data in the business processes. If they are not related to daily tasks, they will not take root. On the contrary, if they are related, they will be naturally used.
•Reduce daily burden to collect data	Regarding collection of metrics data, it is preferable to organize a system where data is collected and reported simultaneously when the daily activities are recorded, without forcing staff in the field to carry out tasks only for the sake of collection. Unifying with existing progress control is an effective way.
•Notes on feedback	It is important to know how field people themselves use the numeric figures of metrics, and to consider matters together with people, not to blame them just based on numbers. Reliability will not be improved by forcing people into a corner.
•Evaluate and praise activities related to management metrics	Set priority not only on delivering results but also on ensuring that reliability improvement activities are surely performed. Knowledge should be shared by spotlighting those people who do the work properly and asking them to make a presentation on effective ways to tackle problems, etc.



●Company wide efforts	It is important to carry out reliability improvement activities step by step throughout the company, using companywide training.
[Points on using the metrics during development and operation]	
●Monitor the bugs	It is important not only to monitor problems after starting operation but also to monitor bugs during development.
●Review and inspection	In order to monitor the state of the system during development, review and inspection are highly necessary.
●Monitor troubles by factors	It is better not only to monitor the number of problems as a whole but also to classify them by cause. This will allow effective countermeasures such as giving priority to frequent problems.
●Points in analyzing the causes of troubles	It is better to use the same factor classification over a long period for analyzing the causes of problems. This enables you to monitor the state and trend for each cause. It is also effective to use fractionated factor classification depending on the situation.
●Change control	Problems are often caused when changing requirements, etc. Therefore, it is important to use metrics in change control.
●Metrics in the upper phase processes	The people in the field must understand the importance of controlling the upper phase processes and carrying out analysis and countermeasures using quantitative metrics.
[Points on using the metrics during discussions with customers and partner companies]	
●Share the purpose and the definition	It is possible to use collected data in project management and understand each other by sharing the purpose and the definition of the metrics with a customer or partner companies.
●Agreement on the metrics to be used	It is desirable to show what metrics are used for management and to reach an agreement as a contract. It is also important to confirm it again at the kick-off meeting at the start of the project.
●Report, check and discuss on the metrics at regular meetings	Through regular reporting, checking and discussion on the metrics at meetings with the customer or partner companies, risks can be discovered and minimized and the state of achieving the goal can be shared. It is more effective when top and senior management participates in the meeting.
●Change control (repeated)	Problems are often caused when changing requirements, etc. Therefore, change control using metrics is important.
●Quantitative effect of change control	Predicted values fluctuate according to the project environment and when they are estimated. Therefore, the most reliable predicted value as of the analysis should be obtained and used, so that the true change amount can be monitored. And the responsibilities for changes can be clarified among stakeholders and charges for making changes can be imposed. Of course, the change control ways must be agreed upon among stakeholders beforehand.
●Metrics in the upper phase processes (repeated)	Staff in the field must understand the importance of controlling the upper phase processes and carrying out analysis and countermeasures using metrics.

##### (5) Mapping to the IT Reliability Guideline of METI

With regard to the IT Reliability Guideline of METI, we map the management metrics of each company to the items of the guideline. This makes it possible for organizations to select and use the metrics that are effective for improving reliability complying with the guideline of METI.

In practice, management metrics collected from each company are mapped for ①Items related to overall planning/development and maintenance/operation (chapter III of the guideline), ② Items related to technology (chapter IV), ③ Items related to personnel/organization (chapter V) and ④ Items related to commercial practices/contract/legal factors (chapter VI). See Table 6.

Table 6 IT Reliability Guideline of METI vs. the management metrics

Chapter	Section	metrics
III. Planning, development, maintenance, operation	(1) Project Planning	53
	(2) Development processes	268
	(3) Maintenance and Operation Processes	159
	(4) Recovery from System Failures	77
	(5) System Lifecycle Processes (general important notices)	182
IV. Technology	(1) Development methods and tools	10
	(2) Technology use and important notices regarding reliability and safety improvement	12
V. Personnel, Organization	(1) Education and Human Resources	31
	(2) Organization Development	39
VI. Business Practices, Contracts, regal issues	(1) Clarification of the important matters in the contracts	3
	(2) Clarification of roles and the responsibilities during development	N/A

### 3. How to use the survey results

To understand how to use this report, it is crucial that each management metrics is not seen alone but as an organic part of an entire set of management metrics. It is important to understand that the management metrics of each company are not just a group of individual metrics, but they are inter-related organically and consequently they can effectively serve as management metrics. Therefore, no matter states you are in regarding metrics, it is preferable to refer to the whole management metrics set for each cases mentioned in “Collection of cases of management metrics” (Chapter 4 of the “survey report”), to consider the cases of each company associated with the metrics, and to choose the ones necessary for your own organization. Table 7 shows how to use the results of this survey by state of organization.

Table 7 Usage method by type of organization

State of organization	Usage method
Organizations which has already deployed them enough	Sufficient knowledge is accumulated, so it is possible to confirm the appropriateness of the current activities or obtain hints by directly referring to the cases in “Collection of cases of management metrics (Chap 4)” or referring to “Analysis of progress in the management metrics effort (Chap 7)”.
Organizations which have already started using them, but are still struggling to deploy them	A starting point is to refer to cases similar to the situation of your own organization from “Background/purpose, viewpoint, effect of these efforts, and future efforts (Chap 5)” and reviewing the activities of your own organization by referring to “Mapping to the standard processes (Chap 6)”. Finally, all cases in “Collection of cases of management metrics (Chap 4)” should be referred to find hints for improvements.
Organizations which intend to start making use of reliability management metrics just from now on	“Analysis of progress in the management metrics effort (Chap 7)” can be referred to in order to determine the step to start at, and the cases similar to your own organization can be checked with “Background/purpose, viewpoint and effect of these efforts and future efforts (Chap 5)” and your own plan can be drawn up.
Organizations which consider to incorporate “IT Reliability Guideline“ issued by METI	“Mapping to the IT Reliability Guideline of METI (Chap 8)” can be referred to in order to consider how the management metrics can be used for the items in the IT Reliability Guideline and Reliability Evaluation Index (draft) for which countermeasures need to be set up at your own organization. The cases in “Collection of cases of management metrics (Chap 4)” can be checked and referred to in order to devise countermeasures.

#### 4. Conclusion

We collected management metrics for development (7 examples), for maintenance (2 examples) and for operation (4 examples) from 8 member companies of JISA, and surveyed their analysis/practical usages, effects of usage, scheme of metrics, and future direction. We believe this report is the world's first such summary and presentation of detailed management metrics.

We include the collected management metrics sets of each company as cases (best practice) of each company, and show the mapping to the Japan Common Frame 2007, ITIL version 3, and IT Reliability Guideline of METI. Moreover, we clarify and indicate the points for using management metrics and encouraging usage, together with steps for deploying and using management metrics for ensuring and improving reliability. We have organized management metrics from various viewpoints in order to encourage their use.