

Plant Operation Diagnoses by Comparative Effectiveness Analysis Focusing on System Effectiveness

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Industrial automation (IA) systems and products used in plants are fundamental infrastructure for realizing ideal plant operation. Yokogawa's Comparative Effectiveness Analysis helps customers achieve this by identifying new challenges for improving operations through the automatic acquisition and calculation of various effectiveness indexes of system utilization, and the comparisons with past data, data of other in-house plants and even data of competitors' plants. The first system supported is CENTUM series integrated production control system considering ease of acquiring necessary data. This paper outlines the service for the CENTUM series and the results for 2009 and 2010.

INTRODUCTION

Industrial automation (IA) systems and products, which utilize measurement, control and information technologies, are used across the world as fundamental infrastructure for achieving safe, stable and highly efficient plant operation. In order to keep the systems and products effective throughout the plant lifecycle, customers need to periodically check their effectiveness and take prompt action if any problem is identified.

Such a task is becoming more difficult to carry out with their own employees alone because of shortages of human resources caused by retirement and organizational reengineering. Tedious works for data acquisition and analysis to evaluate the effectiveness also discourage such a task. To meet these market needs, Yokogawa has developed and launched the new service Comparative Effectiveness Analysis ⁽¹⁾. This paper describes the functions and features of the Comparative Effectiveness Analysis, its procedure, and general trends identified from analysis of the results.

COMPARATIVE EFFECTIVENESS ANALYSIS

The Comparative Effectiveness Analysis helps to achieve ideal plant operation by identifying new challenges for operational improvements through comparison of the various

indexes that show how much an IA system is made use of, i.e., effectiveness indexes, with past data, data of the customer's other plants, and data of competitors' plants. Required data for calculating indexes are automatically acquired by a dedicated program. This service is the most fundamental of the Opportunity Identification Services to identify specific operational issues in Yokogawa's VigilantPlant Services.

The outcome of the service is a comparative analysis report, which is delivered by Yokogawa every six months in case of a yearly contract. The report can also be obtained under a monthly trial contract.

As of March 2011, the service is available only for the CENTUM CS (R2.05 or later) and CENTUM CS 3000 (R3.03 or later) integrated production control systems, considering the number of systems in operation. The service will be made available to other systems in the future.

Effectiveness Index

Table 1 shows examples of the effectiveness indexes for the CENTUM CS 3000. Various effectiveness indexes are provided. For securing safety (Safety Excellence), there are indexes regarding alarms and operators' responses to alarms, changes of parameters including alarm settings and alarm suppression settings, and transactions to the human machine interface (HMI) such as graphic display and trend chart display. For optimizing production (Production Excellence), effectiveness indexes on control functions (PID control and advanced control) and manual interventions are available. For optimizing the total cost of ownership (TCO) of the

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system (Lifecycle Excellence), indexes on RASIS (reliability, availability, serviceability, integrity and security) are provided.

The effectiveness indexes include those that are difficult to calculate except by the system suppliers; for example, the frequency of switching screens, the number of ignored alarms for which no acknowledgement was made within 5 minutes to clear it, and control bus loads. More unique indexes are going to be added.

Outline of Data Acquisition and Effectiveness Index

Calculation

Figure 1 shows an example system configuration. In case the target system is the CENTUM CS 3000 with V net control bus, the comparative analysis reporting tool (CART), which automatically acquires raw data and calculates the indexes, is installed on the PC connected to the human interface station (HIS) operator console via Ethernet.

The PC communicates with the HIS only when data acquisition is requested for the effectiveness index calculation. The communications load on the HIS is quite low because the data to be acquired, such as event log, operation log and internal command execution results, are all small in quantity. When alarm-related indexes are calculated, suppressed alarms are excluded from the calculation to keep data integrity between sites. Data processing is carefully designed not to disturb control performance based on Yokogawa’s many years of experience as an IA supplier. For example, when control-related indexes are calculated, process data acquisition is not performed so as to minimize the communications load with the system; instead, the standard alarm & event log is used.

The effectiveness indexes are automatically calculated to reduce the processing burden on users. The effectiveness index

files are archived for half a year and then sent to Yokogawa, which in turn provides comparative analysis reports.

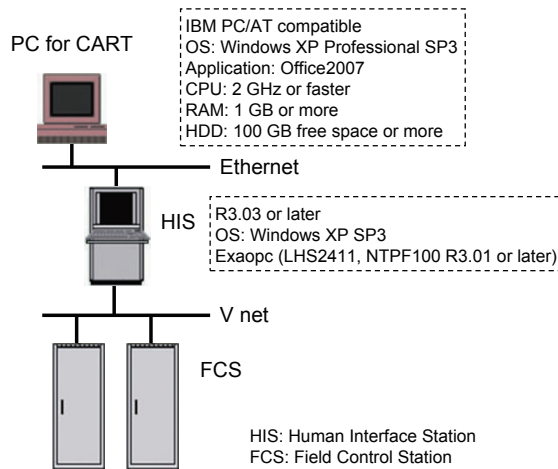


Figure 1 System configuration example

Comparative Analysis Using Effectiveness Indexes

Effectiveness indexes automatically calculated by the CART are gathered from plants around the world to Yokogawa and incorporated into the population for comparative analysis. Three methods are available for evaluating specific effectiveness indexes.

- Comparison with mean values of the population
- Comparison with the bottom of the first quartile of the population
- Comparison with the industry’s standards or guidelines (only for alarms at the moment)

Table 1 Examples of the effectiveness indexes

System effectiveness			Effectiveness index
Viewpoint	Category	Item	
Safety Excellence	The 2nd and 3rd independent protection layers of the IEC 61511, ANSI/ISA-84.00.01 (2)	Alarm	No. of alarms/10 min./operator No. of repeated alarms/day/operator No. of long-standing alarms/day/operator No. of neglected alarms/day/operator
		Parameter changes	No. of changes in alarm settings/day No. of changes in alarm suppression settings/day No. of changes in PID parameters/day
		HMI	No. of displays opened/day/operator
Production Excellence	Level 2 of the functional enterprise-control model of the IEC 62264.03/ISA-95 (3)	Control	Time APC (advanced process control) in control Time PID in automatic control (AUTO mode) Time loop without deviation alarms Time loop output at limit Repeated works in PID and MLD tags No. of manual interventions/day/operator No. of loops (analog outputs)/operator
Lifecycle Excellence	Reliability Availability Serviceability Integrity Security	Mean time between failures	No. of critical or medium system alarms/month/control station
		System availability	Time without critical system alarms/control station
		Mean time to recovery	Time to recovery from critical system alarm/control station
		Control bus load	Maximum control bus load
		Security	No. of unauthorized log-ons No. of connections to unidentified communication port No. of USB device connections No. of security patches applied/operator console

The effectiveness indexes can be compared with those of competitors, which is difficult for customers to do by themselves. This is made possible by Yokogawa's advantage of having many systems installed around the world and being able to serve as an organizer. When a customer has a multi-year contract for the service, comparison of operations at different times for the same plant can be visualized using the archived database.

Table 2 shows an example of the comparative analysis report delivered to customers. The report shows a comparative analysis of effectiveness indexes and rankings of tags that have largely contributed to those indexes. As both areas and tags to be improved are clearly indicated, the report is most beneficial for plant operational improvement.

Table 2 Contents of comparative analysis report

No.	Item	Description
1	Summary	Comprehensive evaluation covering all the areas, intended for the top management of a plant
2	Alarm effectiveness	Comparative analysis of process alarms. Alarm rankings, type of alarms, alarms per shift and various comparison charts are included.
3	MOC effectiveness	Comparative analysis of parameter changes by operators. Lists of worst 10 tags for change management and a list of worst 10 tags that require a review for control configuration are included.
4	HMI effectiveness	Comparative analysis of display changes of the operator console. Rankings of frequently opened displays are included.
5	Automatic control effectiveness	Comparative analysis of effective use of PID controllers. Tags with a low rate of automatic control are identified.
6	Manual intervention effectiveness	Comparative analysis of manual interventions by operators. The number of loops handled by each operator is benchmarked for a reference to study consolidating control rooms or expanding the control area by one operator.
7	RASIS	Analysis of reliability, availability, serviceability, integrity and security relating to CENTUM. Effectiveness of the current security measures for the system and availability of each component can be monitored.
8	Appendix	Customer information, excluded periods, etc.

Service Procedure

Figure 2 shows the service procedure of the Comparative Effectiveness Analysis. The VigilantPlant Services provide not only opportunities for identifying improvements but also various solution services to solve the issues.

As shown in Figure 3, once the Comparative Effectiveness Analysis has identified issues, the Solution Implementation Services can be used to provide solutions. Thus, the maximum benefits will be delivered to customers.

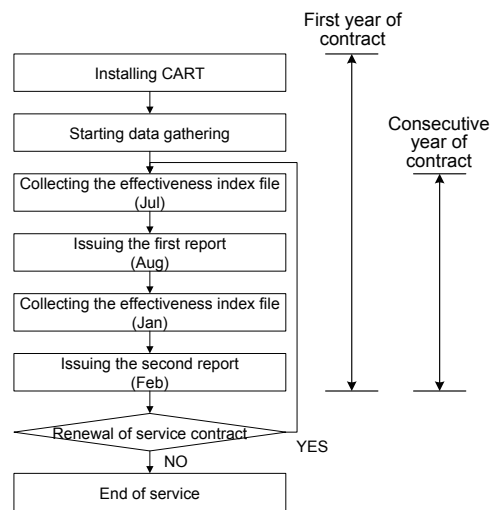


Figure 2 Procedure of Comparative Effectiveness Analysis

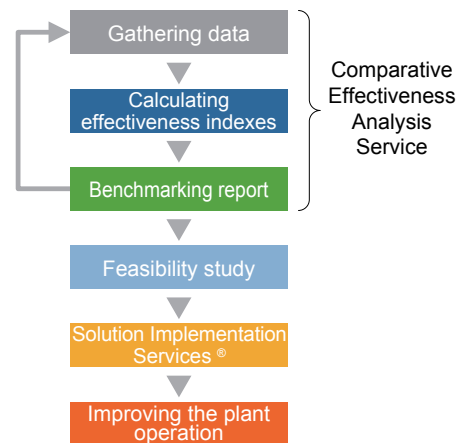


Figure 3 From Comparative Effectiveness Analysis to Solution Implementation Services

INDUSTRY TRENDS REVEALED BY COMPARATIVE EFFECTIVENESS ANALYSIS

We conducted the Comparative Effectiveness Analysis on more than 100 systems from 2009 to 2010. Many of the customers received the results with surprise.

■ Alarm

The mean value of the number of alarms per 10 minutes per operator is just over two. This is more than double the number recommended for safe operation in the alarm management guideline, EEMUA (4) No. 191. Some three-quarters of the customers scored one or higher in this index. This indicates that there is much room for improvement concerning alarm management.

If more alarms are activated than the operators can handle, this may lead to oversight of critical alarms and consequent hazards. One customer succeeded in reducing nuisance alarms by 90% at a plant where alarms had been excessively announced by introducing the Alarm Rationalization, one of

Yokogawa's Solution Implementation Services. Reduction of alarms not only eliminates a potential hazard factor but also improves operators' efficiency.

■ Management of Change

Regarding changes in alarm settings (upper/lower limits, upper-upper/lower-lower limits), one-third of the customers scored zero or almost zero. This means they did not change those settings during the term. On the other hand, another one-third made more than 10 changes a day. Actually, changes have been recorded even for customers where the settings were not allowed to be changed. This information is quite valuable to reestablish an alarm management system for such customers who change the upper-upper or lower-lower limit settings. Some organizational reengineering might be required for change management of an alarm system including controlling tentative changes.

Interestingly, the mean value of this index for Japanese customers is about 1.4 times that of overseas customers. This suggests that Japanese operators manipulate a plant carefully so as not to announce any alarm by changing alarm settings frequently.

■ HMI

The frequency of switching operation and monitoring screens on the HIS is once every two minutes on average. It seems that plants are not operating stably and operators switch screens rather frequently. At some plants, operators switch more than once a minute on average.

Frequent screen switching may be due to inefficient display designs. For instance, the displays may have been designed as copies of obsolete ones or may not satisfy ergonomic usability requirements. Proper design of HMI for operation and monitoring is vital for safe plant operation with prompt judgment of the situation and effective intervention. If the frequency of screen changes is high, the HMI needs to be redesigned.

■ Automatic Control

The rate of time that PID loops are in automatic control is approximately 70% on average. In other words, these loops are operated in manual mode during about 30% of the whole operation time.

In a plant lacking a control engineer, operators or instrumentation maintenance engineers are often responsible for tuning the PID control function blocks. Thus, loops that are difficult to control tend to be manually operated. Such customers, whose automatic control index value is low, often ask us for overall tuning and/or re-tuning of PID control loops.

■ Manual Intervention

The number of manual interventions is 1.2 times in 10 minutes on average. The average for Japanese customers is about 1.5, which is 50% more than that for overseas customers. The fact that both the number of changes in alarm settings and the number of manual interventions are high for Japanese

customers suggests that plant operations in Japan depend on the skills of operators more greatly than in overseas plants. Considering the particular situation in Japan that operational expertise will be lost with the retirement of experienced operators, there is an urgent need to systematize the operation know-how and pass on the expertise to younger generations.

A close study of the indexes relating to manual interventions often highlights opportunities leading to large economic improvements. Yokogawa offers a service for reducing manual interventions using the Best Practice Pilot, one of the Solution Implementation Services.

CONCLUSION

Detailed analysis of various data accumulated in the operator console visualizes the behaviors of the operators. Such analysis sometimes reveals unnecessary actions by operators, for instance, switching screens too frequently. In most cases, however, the analysis shows that operators are struggling to keep their plant safe and to run it close to the optimal point under difficult conditions, such as alarm flooding and too much or too little information on the display because of improper design of the operating system. This valuable information has been unearthed by this service.

Most companies are working towards the same goal: increasing operators' productivity and maximizing profits while ensuring safe operation. However, the statistics of indexes show significant differences among the plants.

We will make these services available for our new CENTUM VP system in the near future. We will establish a user consortium involving a wider range of customers to obtain broad knowledge and opinions for new operational indexes. We are also considering data acquisition from competitors' systems. We hope to be able to report in the future that the average performance of Yokogawa's system users is superior to that of competitors' system users by fully utilizing this service.

As the utility of such a benchmarking system increases according to the number of participants, we hope that many customers will join the consortium.

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