5-2 DEVELOPMENT OF OPERATION NAVIGATION SYSTEM

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ABSTRACT

Bureau of Tokyo Sewerage has 13 wastewater treatment plants and 82 pumping stations.

In order to manage these facilities efficiently, collective operation in each treatment area is being promoted by making use of remote-control system.

Promotion of remote control system leads to concentration of facilities monitored or controlled from the master facility, and, therefore, increases tasks of each operator, enhancing possibility of his human error.

Also, due to pressing increase of age-limit retirees and strict restraint of employment, the number of operational staff is decreasing and, consequently, operational skills are being lost with veteran operators.

Automatic operation can save some load of operation, but it is limited in use because WWTP deals with uncontrollable materials, rainfall and sewerage.

As a solution to the problems, Operation Navigation System (ONS) was developed.

ONS, a computer system to make use of its performance and capacity, is a guidance system that has human-friendly interface and flexibility.

Developed ONS reduces operational tasks, functioning like car navigation. An operator can give operational instruction or action according to guidance message that is timely and pertinently shown on supervisory monitoring device.

The target of ONS is to establish safe and stable plant operation by inexperienced operational staff.

ONS uses data of the supervisory system to deduce the next action. The decision is shown as a guidance message or messages with other related information.

In contrast with automatic operation, which has restriction that it can be applied only to fixed operations, ONS can deal with operations that require operator’s judgment.

To evaluate ONS, prototype ONS was installed in the Morigasaki WWTP. The field test, which was done from July 2005 to March 2006, demonstrated practicality of the guidance message system. We confirmed good consistency between ONS guidance and actual operation. For operations of indefinite timing, additional data from operator works.

For ONS, operation know-how expressed in a form, such as document, manual, or flowchart is vital. ONS also asks for substantial improvement of operational data.

Preparing the documented know-how and improving operational data is the key to introduce ONS to our WWTP.

KEYWORDS

Human interface, WWTP operation, Operation guidance system, Logic table expression, Guidance message

1 INTRODUCTION

Bureau of Tokyo Sewerage, with 13 wastewater treatment plants and 82 pumping stations, contributes to the preservation of water quality in public water areas and the protection of Tokyo urban districts from rainfall inundation. (Fig.1)

In order to manage these facilities efficiently, collective operation in each treatment area is being promoted by making use of remote-control system. At present, 62 pumping stations and 1 wastewater treatment plant are remote-controlled from master pumping stations and wastewater treatment plants.

Promotion of remote control system increases the efficiency of operation, but leads to concentration of facilities monitored or controlled from the master facility, and, therefore, increases tasks of each operator, enhancing possibility of his human error.

Automatic operation can save some load of operation, but it is limited in use because it is applicable only to conditional operation that follows measured or processed value.

Also, due to pressing increase of age-limit retirees and strict restraint of employment, the number of operational staff is decreasing and, consequently, operational skills are being lost with veteran operators.

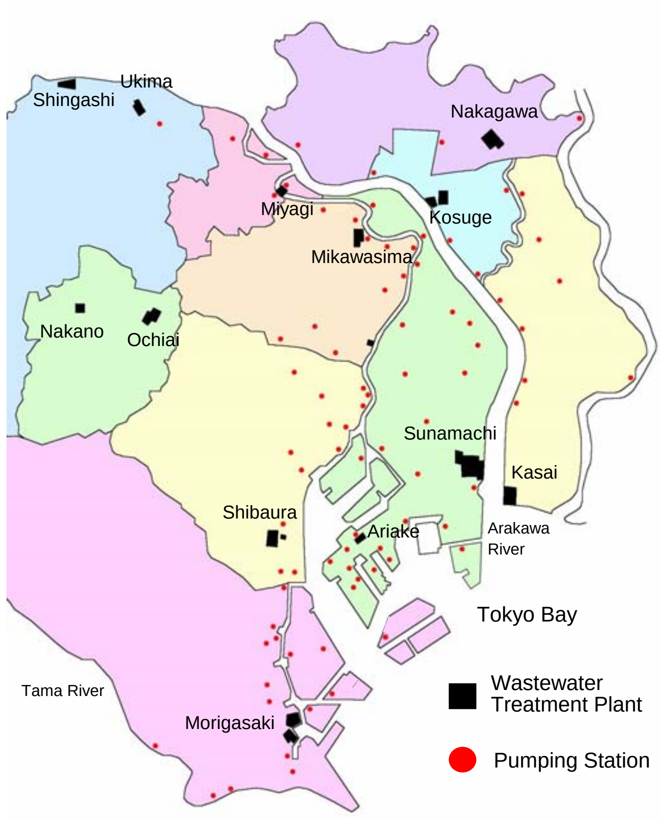

Fig.1 -Tokyo's WWTP & Pump stations

As a solution to the problems, Operation Navigation System (ONS) was developed.

2 Operation Navigation System (ONS)

2.1 Overview

WWTP operation can be said to be a sequential chain of plant status. Each status covers certain range of operation and, by balancing in the range, provides certain margin of time. An operator determines his next action in the present status by sensing tightness (or looseness) of the situation and considering margin allowed for him.

All operational actions can be classified by their object as follows.

(1)Regulation or adjustment

These actions are defined as tuning or control of each machine or system within the present plant status.

(2)Confirmation or justification

Actions such as checking the value of determinant factors on a supervisory panel, or CRTs are classified as verification of facts. These actions don't involve actual drive of a machine or a system.

(3)Status-transferring

When an operator determines that the situation is about to go beyond the present status, he takes some responsive actions to move the status into another appropriate one.

These actions are carried out:

-By automatic sequence

or -By manual setting or switching

Factors that trigger next actions are external or internal change of condition, occurrence of abnormality or trouble, or early sign of them.

Automatic sequence is surely ideal solution to reduce or remove some load of operation, but it is limited in application. It is not usable as far as operator's judgment is involved.

Actually, most of operational actions need some human judgment and are being done by operator's manual setting or switching.

This indicates that automation is surely the final goal of WWTP operation, but considering that actual operation largely depends on operator's professional judgment and is done through manual action, a computer-aided guidance system that suggests recommendation and commits final judgment to human operator is reasonable.

Developed ONS reduces operational tasks, functioning like car navigation. An operator can give operational instruction or action according to guidance message that is timely and pertinently shown on supervisory monitoring device.

ONS uses data of the supervisory system to deduce the next action. The decision is shown as a guidance message or messages with other related information.

In contrast with automatic operation, which has restriction that it can be applied only to fixed operations, ONS can deal with operations that require operator's judgment.

2.2 System function

Until now, experienced veteran staffs secure operational skill or knowledge.

They give guidance to inexperienced staff mostly through actual operation and, thus, by way of humans, technical know-how has been inherited to next generation.

As of April, 2006, the number of staffs who work for management of WWTP and pump station is approx. 1300 except headquarter members.

Among them, approx. 600 personnel are engaged specially in operation, and approx. 500 personnel are maintenance staff. Almost all of operational and maintenance staffs are of mechanical, electrical, or technical specialty.

Fig.2 shows number of personnel of those specialties by age. Shown in the figure, age-limit sixty awaits many veteran staffs. Into them, many operational staffs are included.

Also, short-term of personnel change or rotation, which is three years in average, blocks the time-taking on-the-job training.

The key to respond this pressing crisis is to establish a system that enables inexperienced staff to learn necessary operational skills in a short time and to accumulate and transfer plant-inherent operational know-how via non-human vessel.

ONS is a computer system to make use of its performance and capacity.

The target of ONS is to establish safe and stable plant operation by inexperienced operational staff.

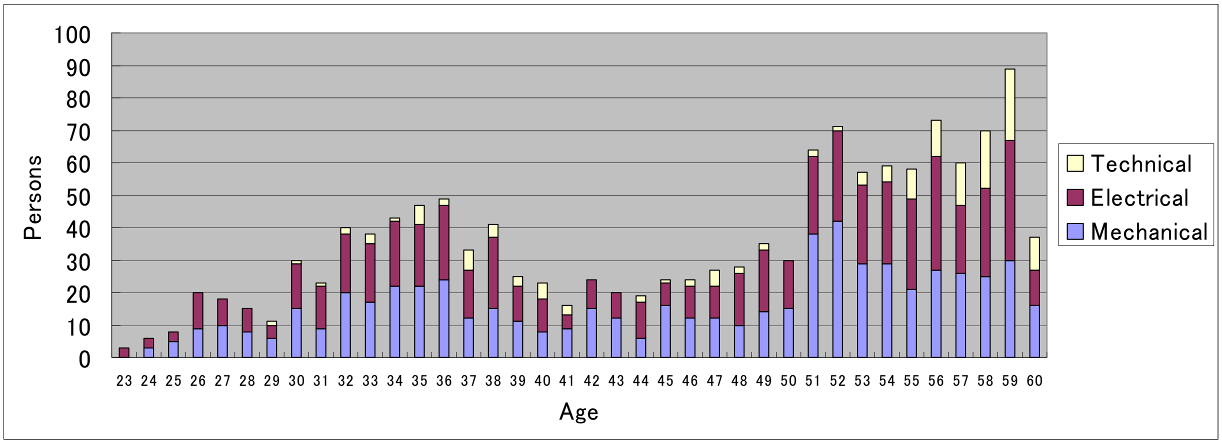

Fig.2 Sum of mechanical or electrical staff by age (as of 2006/April)

In the development of ONS, we put the priority on the interface of operator and computer. Firstly, we use existing supervisory CRT as the media by which ONS information is offered.

Also, the information given by ONS should be sufficient enough for an operator to act with confidence. The selected information is as follows.

(1) Guidance message

Message shows the object to act on and what to do as "Run Discharge-pump A." or "Set Valve B 30% open." Message appears when an AND-OR logic set of requirements is "true" and it disappears when the requirement logic gets "not true" after the action is completed. (Fig.3)

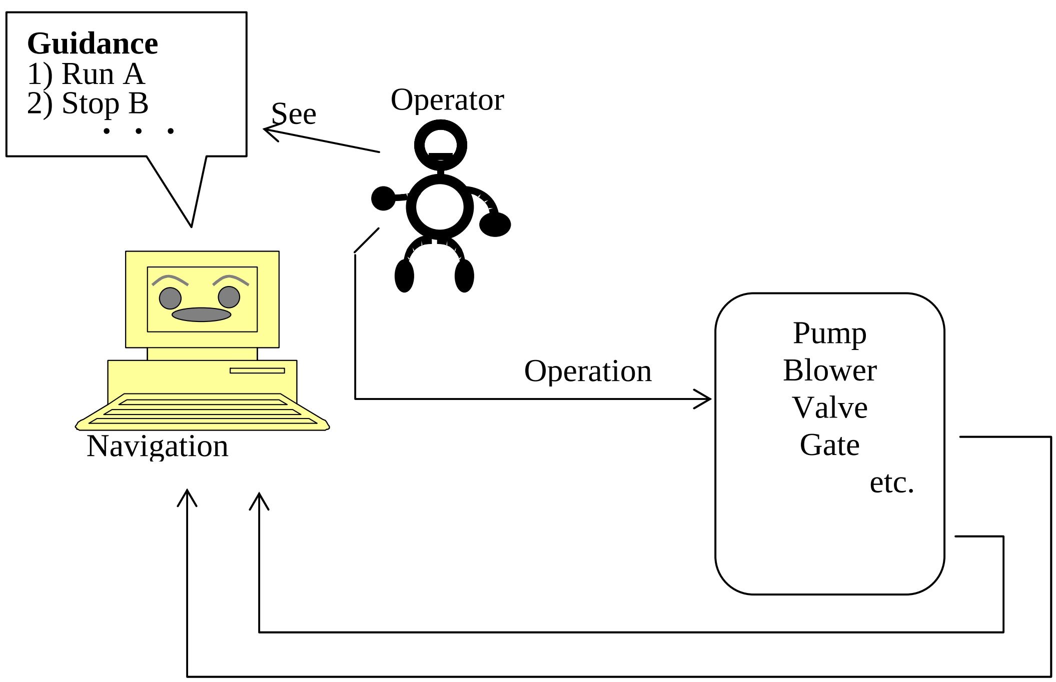

Fig.3 Operation guidance message

(2) Related data

Related information, which assists an operator to take the action or to confirm its correctness, is shown with guidance message.

In the case of "Run Discharge pump A.", a window for the 'run' order is popped up side by side with the message. After the order is done, some process values or states to follow the effect or to prepare for the next action are shown in a trend window.

Pop-up way of a window is selectable from automatically or on operator's request.

(3) Intensive expression

When there is no guidance message to display, an intensive overview window is shown on screen.

With hierarchically arranged data and symbolic expression, the intensive overview window enables an operator to monitor overall facilities simultaneously and notice change of the situation, or occurrence of emergency speedily.

The intensive data expression helps intuitive understanding.

(4) Interactive alteration

WWTP operation responds to various external or internal changes such as inflow fluctuation, capacity extension, or application change and so on. This explains why automatic operation of WWTP is difficult. As WWTP deals with uncontrollable materials, rainfall and sewerage, it is fundamentally unsuitable for automation.

To answer this, ONS, one of its features is flexibility, prepares interactive table-form alteration function for contents (1) and (2). Alteration can be done on-line without computer rebooting.

(5)Macro-operation function

The Macro-operation function is applied to a set of manual sequential operations which proved to be fixed. When a set of operations is always done sequentially and fixedly, and confirmation or judgment of operator for them can be omitted, this function works. By grouping them into one macro-group, these operations can be dealt with as one operation. Macro-operation runs automatically to its finish after "one action" of initial permission. (Fig.4)

Macro-operation function is ready for alteration or addition as (4). The function can substitute for automatic sequence and is applicable to broader operations in virtue of its flexibility.

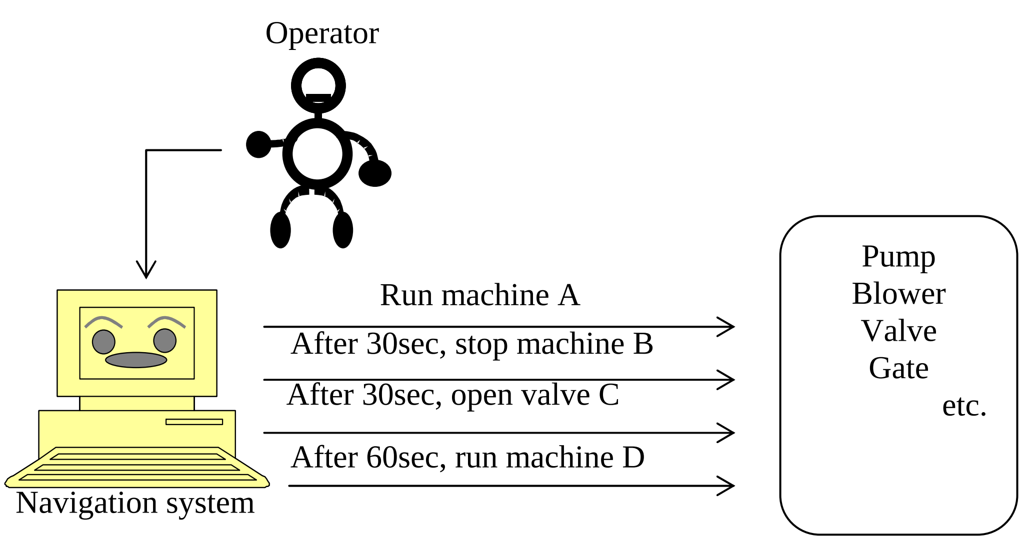

Fig.4 Macro-operation function

3 Human Interface

In studying human interface, we picked up a WWTP that has three remote-control pump stations as the model.

(1)Intensive data expression

Fig.6 shows an example of intensive data expression. Essential data, such as rainfall intensity, inflow, receiving electricity, pond level, pump state, stored fuel, are all arranged in a window, shown in symbolic expression like bar-graph or indication arrow. Colors show degree of caution.

When an event happened and operation is needed, the guidance message appears in red on the event message area. (Shown encircled in Fig.5) As the area is placed on upper part of the screen, the message arouses operator's attention effectively.

(2)Guidance message & Decision table

By clicking the message area, operation guidance window is shown. On the window, actions to respond to the event are listed. (Fig.6)

The operator proceeds with his operation sequentially according to the guidance. Selection of an action brings the related window on which the operation is carried out.

As described in 2.2, to confirm that the message is appropriate, the operator can look Decision table, by which AND-OR deduction logic is composed. In Decision table, difference of color tells plant status. Red is state-On and black is state-Off.

Example of Fig.6 is the start of primary treatment discharge from the east facility.

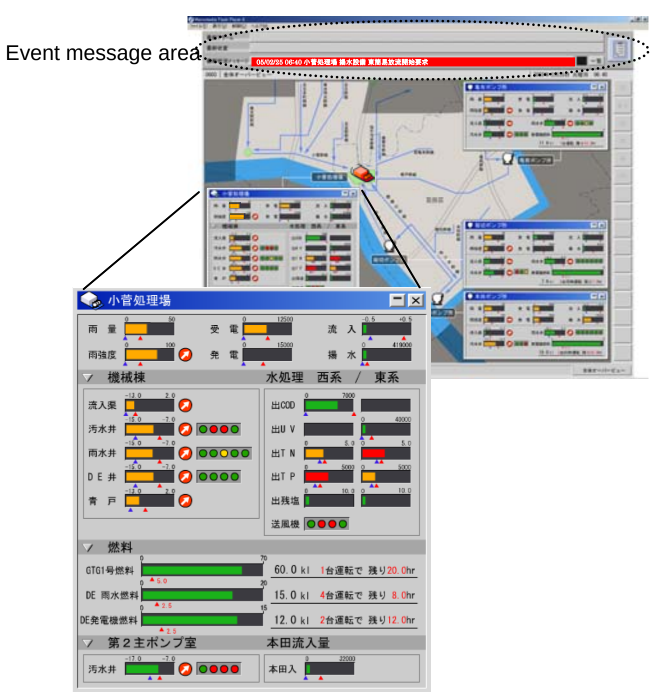

Fig.5 Intensive data expression

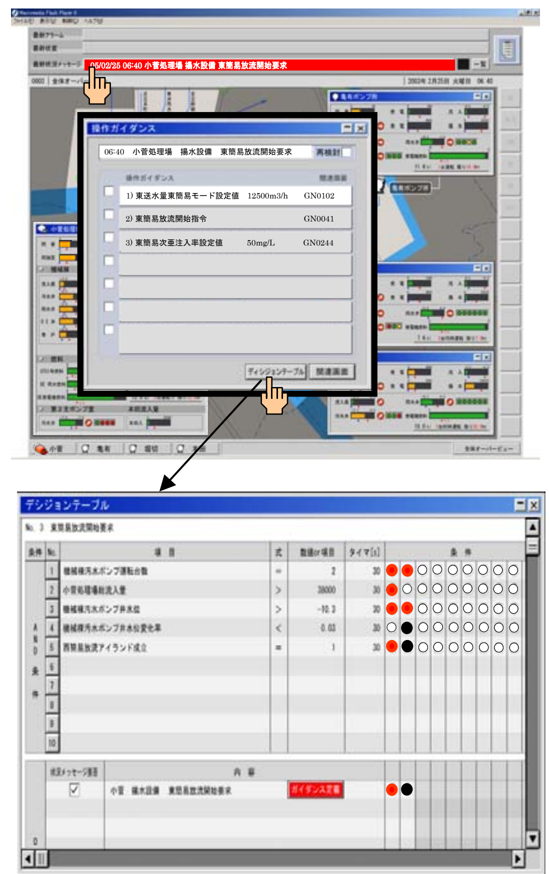

Fig.6 Guidance message (top) & Decision table (above)

In the operation, three actions, “Increase water to the east from xxx m^3/h to yyy m^3/h.”, “Drive the east facility gate sequence.”, “Set sodium-hypo injection rate at zzz mg/L”, are to be done. “The west line is discharging.” and “Inflow is still increasing” are requisite for the primary treatment discharge from the east facility. “Increase rate of water level is above the threshold.” can substitute for the inflow increase.

In the Decision table, these two AND-logics are connected with one OR logic. Set-Timer is used to ensure “On” status of each requirement. When the status continues for the designated time, it is regarded as “On”. If timing gap or lack of some requirement is found, the contents of the table can be modified on-line. Message description is changed as well in the table.

(3)Macro-operation

Fig.7 is an example of Macro-operation. For a Macro-operation, by clicking the message area, registered Macro-operation windows appears.

After confirming the steps of the Macro, the operator gives permission for the Macro to proceed. He may keep watching the proceeding. The right window shows that the first step is going on. The window allows temporary-halt order or total cancellation from the operator.

(4) Interactive alteration function

ONS contents are expected to improve via frequent alteration. Therefore, in order to make the best use of ONS, the interface of registration function of Decision table and Macro operation must be human-friendly.

Fig.8 shows alteration of Decision table. By designating table and place, an alteration window is shown in the foreground. On the window, selection of point identification number, reset of threshold value can be done.

To register a Macro-operation, trace the set of operations in the same way as actual operation. The tracing operations never emit signals out of the computer system and a red frame surrounding the registration window tells that all operations on the window are invalid. Similarity between the interactive registration and actual operation can save additional training. (Fig.9)

Fig.7 Macro-operation

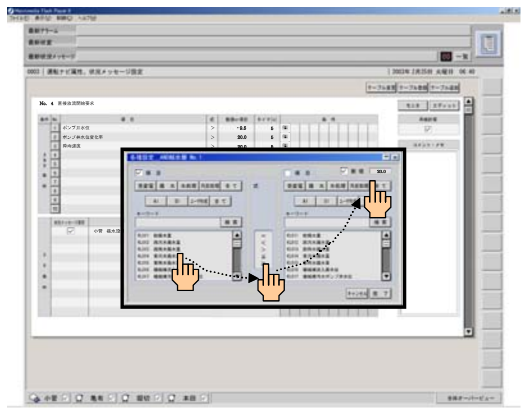

Fig.8 Alteration of Decision table

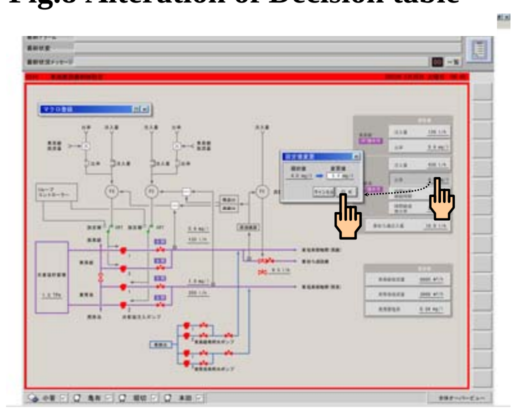

Fig.9 Macro-operation registration

4. **Evaluations of ONS**

4.1 Evaluation items

Morigasaki, facing Tokyo Bay in the south of Tokyo, is one of the largest WWTP in Japan, boasting total treatment capacity of 1,540,000m^3 per day. (West treatment facility: 480,000 m^3, East treatment facility: 1,060,000 m^3)

Inflow comes into Morigasaki through two main lines, Oomori line and Oota line. Inflow of Oomori line is distributed to West treatment and East treatment by pumps, but inflow of Oota line, which is sent from Higasi-Kojiya pump station, goes into East treatment directly. Thus, to keep East treatment stable, constant adjustment of water distribution by operation is necessary. But since Tokyo sewerage is mostly constructed on combined sewer system, inflow to WWTP is greatly influenced by rainfall.

Morigasaki operators are making great efforts to avoid or minimize combined sewer overflow (CSO), so they withstand as much as they can before starting primary treatment discharge or direct discharge.

To demonstrate that ONS is of practical use, prototype ONS (Proto-ONS) was installed in the Morigasaki WWTP. The field test, which was continued from July 2005 to March 2006, evaluated practicality of the guidance message system. To avoid operational mistake resulting from new interface, we introduced a new CRT of Proto ONS beside existing ones, and all orders from the CRT were invalid.

Proto-ONS uses data of the existing supervisory computer system covering operation from primary treatment discharge to direct discharge. By restricting ONS data to conventional ones, we tried to see whether additional data are needed for a practical ONS system, or, to grasp what information operators refer to in rainfall operation other than the data the existing computer system offers.

Operational chart, the fruit of long-time efforts by Morigasaki staffs, was the source of Proto-ONS. We converted the chart into Decision table through interpretation.

Evaluation of Proto-ONS was done by comparing ONS guidance with real operations, especially its timeliness and accuracy.

Evaluation items are as follows.

(a)Contents of guidance

(b) Timing of guidance indication

(c) Improvement of (a) and (b)

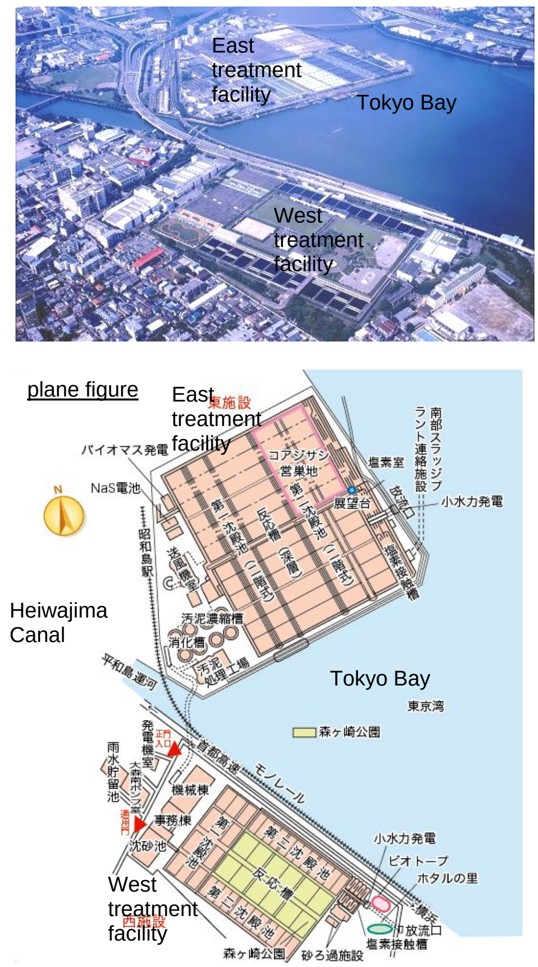

Fig.10 Morigasaki WWTP

4.2 Operation guidance (Example)

One example of operational guidance is shown here.

We take “Primary treatment discharge from East facility”.

Either of three conditions should be satisfied to start the Primary treatment discharge from East facility.

Those are:
“Oomori Minami reservoir being stored” and “Oomori inflow canal level is over –7.0m T.P. (i.e. Tokyo Bay Peil)”
or “Higashi Kojiya #4 pump is standby” and “More than four pumps in Morigasaki and Higashi Kojiya are sending to East facility.”
or “Higashi Kojiya #4 pump is in service” and “More than five pumps in Morigasaki and Higashi Kojiya are sending to East facility.”
Since Higashi Kojiya #4 pump is smaller in capacity, almost half of other pumps, it changes the maximum total number of pumps that are permitted to send water to East facility.
When either of them is satisfied, operation guidance messages shown below are presented.
-Start auto-control of East facility primary treatment discharge gate 1-1 to 2-2.
-Set East facility primary treatment discharge sodium-hypo injection rate 15mg/L or injection volume 5,000L/hour.
-Confirm East facility primary treatment discharge sodium-hypo injection pump auto-control on.
-Increase East facility miscellaneous water pump from one to two (for diluting sodium-hypo).
-Inform sludge treatment staff of the increase of East facility miscellaneous water pump
-Inform water quality management section staff of the start of the Primary treatment discharge from East facility.
-Discharge foam-off equipment service in, if foaming is seen on ITV.
-Set East facility secondary treatment discharge sodium-hypo injection rate 2mg/L.
-Halt East primary sedimentation tank scum skimmer.
-Halt East secondary sedimentation tank scum skimmer.
Some of the guidance messages are carried out on CRT screen; some are done by other means.
In this example, many tasks must be done speedily and precisely. Therefore, clearly, additional information is necessary for an inexperienced operator to fulfill each of them. ONS can solve this demand by offering related information with selection of the message, though we didn’t include them into Proto-ONS.

4.3 Method of evaluation

We evaluated effectiveness of operational guidance message system in operation of primary treatment discharge to direct discharge.
The methods are:
(1) Compare the operation guidance of Proto-ONS with actual operation in the scene of primary treatment discharge to direct discharge. Gap of time between the two occurrences is focal point.
(2) Analyze the timing gap resulting from difference in plant conditions or other operational conditions to see factors and consider counter plan.

These (1) & (2) are done by using operational history data stored in the supervisory system and the guidance history in Proto-ONS.
The period of data collection was from July to November, the rainy season in Japan.
Rainfalls during the period are shown in Table.1. In total, we collected data of twenty-four rainfalls.

Table.1 Rainfalls from July to November in 2005

No.	Date	Precipitation (mm)	Intensity (Max. mm/h)	Duration (hour)	Type (see notes)	Remarks
1	3rd&4th, Jul.	66.4	19.4	20	C	
2	5th&4th, Jul.	44.9	50.7	13	E	
3	9th&10th, Jul.	32.4	62.3	4.7	B	
4	25th&27th, Jul.	73.4	68.8	23.6	D	Typhoon#7
5	12th&13th, Aug.	6.9	30.9	7	A	
6	13th&14th, Aug	4.0	18.9	5	A	
7	23rd&24th, Aug.	110.9	100.0	12	D	Typhoon#11
8	25th&26th, Aug.	72.4	64.2	27	D	Typhoon#11
9	30th, Aug.	6.5	58.2	0.5	A	
10	4th&5th, Nov.	47.8	100.0	6	D	Typhoon#14
11	5th&6th, Nov.	16.0	24.4	20	C	
12	7th, Nov.	4.9	30.9	1.5	A	
13	11th, Nov.	9.5	45.3	1	A	
14	4th&6th, Oct.	17.8	6.9	36	C	
15	7th&8th, Oct.	19.0	51.7	9	B	
16	9th, Oct	4.5	15.0	6	A	
17	10th, Oct.	15.4	26.4	7	B	
18	10th&11th, Oct.	6.6	3.8	15	A	
19	15th&16th, Oct.	25.9	23.3	8	B	
20	16th, Oct.	2.5	3.9	5	A	
21	17th&19th, Oct.	51.3	12.3	44	C	
22	27th, Oct.	8.0	5.8	5	A	
23	6th&7th, Nov.	29.4	28.3	14	E	
24	12th, Nov.	6.5	5.3	7	A	

(Notes)
Rainfall type (P: precipitation, I: intensity, D: duration)
A: light (P: less than 10mm)
B: heavy but short-time (P: more than 10mm, I: more than 20mm, D: less than 12hours)
C: light and long-time (P: more than 10mm, I: less than 20mm, D: more than 12hours)
D: heavy (P: more than 50mm, I: more than 20mm or typhoon)
E: medium (rains other than A to D)

4.4 Result of analysis

(1) Gap of time between guidance and actual operation

Fig.11 shows the ratio by gap of time for “Primary treatment discharge from East facility”. In the figure, plus (+) means that actual operation was done later than guidance.

When the gap is within plus or minus 5min, we can say that guidance timing is almost consistent with the actual operation

As for primary treatment discharge from East facility, good consistency was observed. As described before, operators tend to delay primary treatment discharge to the limit. That explains why some operation was done later than guidance.

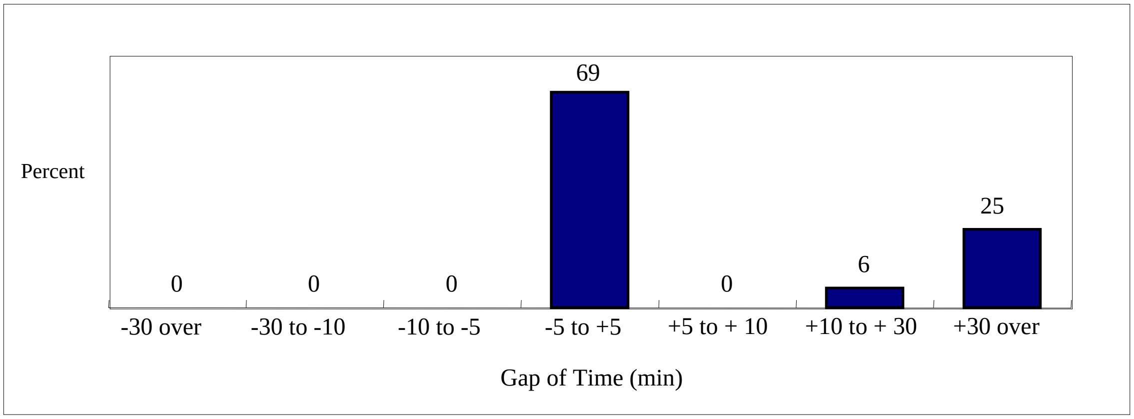

Fig.11 Gap of time for Primary treatment discharge from East facility

Fig.12 shows the ratio by gap of time for "Main transformer additional in-service". The condition for addition of main-trans is "more than five pumps of Oomori line in operation".

Unlike the East Primary treatment discharge, the transformer operation was not very consistent. Morigasaki receives electricity through two lines. To save energy cost, normally one transformer is in service. With the increase of electricity demand to drive pumps, another transformer is put in service. The result shows that though the timing of the operation is defined, it greatly depends on operator's discretion.

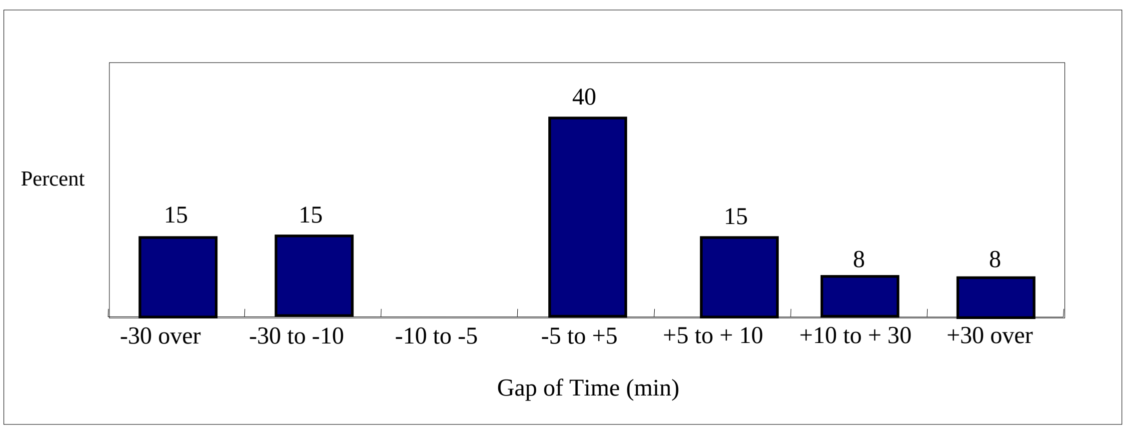

Fig.12 Gap of time for main transformer in service

By classifying operations according to the time gap, we can assume that the operational chart, our source for ONS, is a norm. Each operation has its own margin depending on urgency. Operator passes final judgment for the operation based on his professional knowledge. Skillful operator decides the optimum timing from his experience taking difference in plant conditions or other operational conditions into consideration.

(2) Analysis of operator's judgment

As for operations of different timing from guidance, we analyzed the reason. We can classify them into three categories.

(a) Fine adjustment

Fine adjustment is permitted for operators.
-Operation that has span of time (ex. Do within ten to twenty minutes)
-Operation that has some conditional range (ex. Start at level –7.7m to –8.0mT.P.)
-Overlapping of operations
These operations should be entrusted to operators' judgment.
ONS can cover these operations by offering guidance message at the earliest timing within the given span or range.
(b) Difficult to define in ONS
Some conditions are difficult to define. Also, some are unclear in their end.
Examples:
"Just after rainfall start"
"End of rainfall"
"In case rainfall is expected to come."
"Intense rainfall had come."
"Rainfall is weakening"
Since these conditions have some ambiguity, we cannot define them clearly in ONS.
To compensate for the lack of their clarity, we propose that operator define them on the spot. When operator decides now is "Just after start of rainfall", he enters "On" for the condition. We call this additional function "Dialogue selection function". (Fig.13)

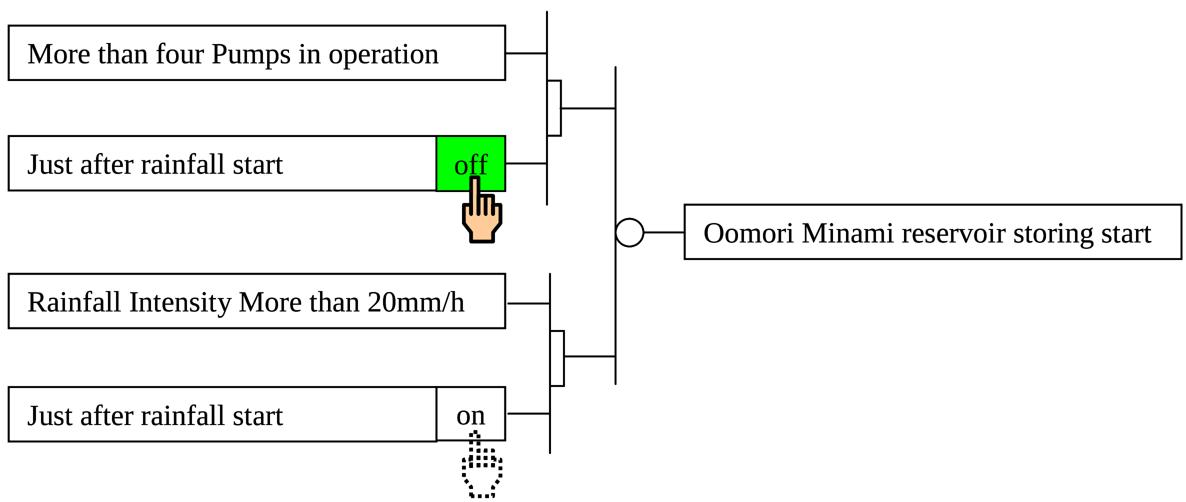

Fig.13 Dialogue selection function

(c) Experiential operation
Some operations are experiential, not expressed definitely on the operational chart
Operator often uses the effect of an operation as a condition for the next operation.
When the effect varies, some variations are not described on the operational chart.
For example,
-After starting a pump, pond water level kept increasing instead of decreasing. Therefore, operator added another pump into operation.
Similarly,
-After starting a pump, pond water level kept the same level for more than 20 minutes instead of decreasing or increasing. Therefore, operator added another pump into operation.

Proto-ONS logic wasn't able to respond to those continuous countermeasure operations.
To solve this inaction of ONS-logic, we propose a chain of Decision table. By making the effect of one operation as a condition of another one, continuous follow-up is possible. A solution is shown in Fig.14 and Fig.15 for the examples of pump operation.

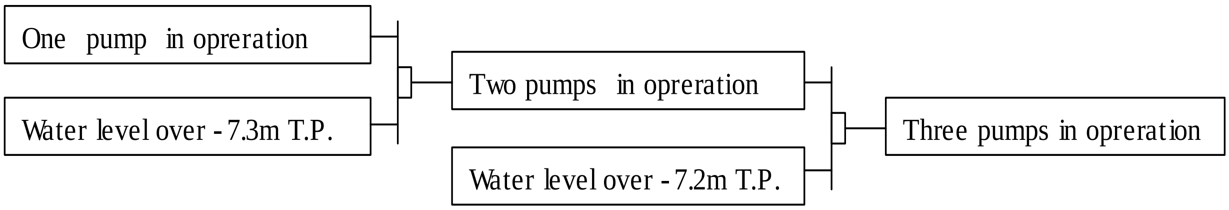

Fig.14 A chain of guidance logic for pump operation Example 1

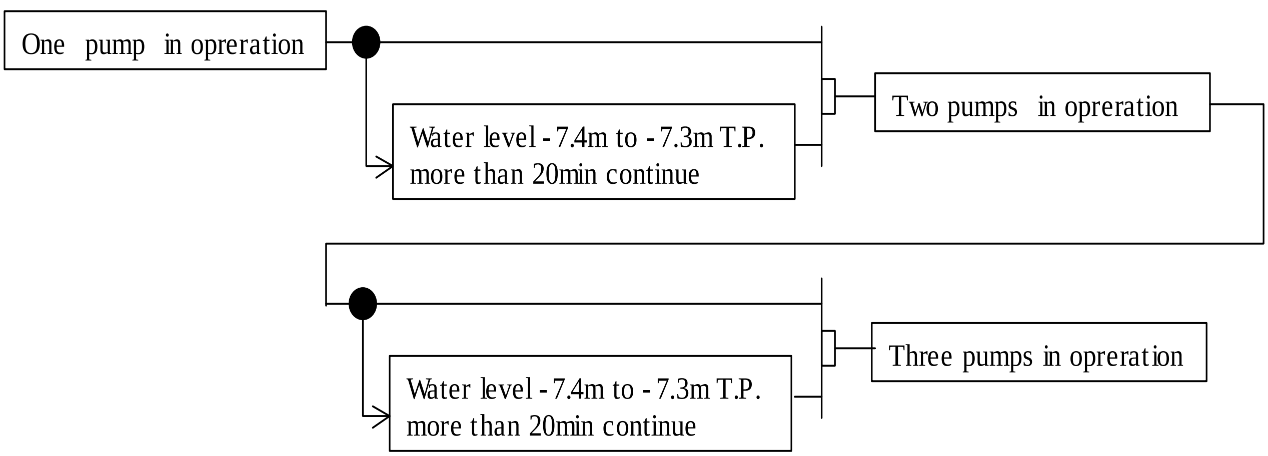

Fig.15 A chain of guidance logic for pump operation Example 2

4.5 Evaluation summary

The analysis is summarized below.

(1) ONS has real-time response for principle operations.

Morigasaki has fixed operational rules for response to rainfall inflow.
Those are operations such as "draw rainfall inflow into reservoir", "start primary treatment discharge", "start direct discharge", and "restrict inflow".

The timing of those operations is decided physically in relation to the capacity of pumps, treatment facility, and receiving electricity.

ONS has real-time response for the operations of definite timing.

(2) With additional data from operator, ONS can cover operations of indefinite timing.

For operations conditions of which have some span or range, the exact timing to carry out is committed to operator. ONS can cover these operations by offering guidance message at the earliest timing within the span or range.

For operations that include indefinite condition, dialogue selection function through which operator add his judgment to ONS is effective.

5 Conclusions

Bureau of Tokyo Sewerage need to respond to the drastic change of working environment such as intensive control of facilities, loss of skillful veteran operators.

As a solution, Operation Navigation System (ONS) was developed.

Since WWTP deals with uncontrollable materials, rainfall and sewerage, automatic operation has its limit for application. ONS is a guidance system that makes use of the power of computer and can keep on improving.

Logic AND-OR form is selected as the form of knowledge of ONS. This selection is reasonable because most of our operational decision is deduced using a combination of plant data.

In the development of ONS, we put the priority on the human-interface. Since flexibility is also essential, ONS has on-line alteration or registration function.

To demonstrate that ONS is of practical use, prototype ONS was installed in the Morigasaki WWTP. The field test, which was continued from July 2005 to March 2006, evaluated practicality of the guidance message system.

Through the field test, we confirmed good consistency between ONS guidance and actual operation. For operations of indefinite timing, additional data from operator works.

For ONS, operation know-how expressed in a form, such as document, manual, or flowchart is vital. However, as our staffs have learned their skill in actual operation, most of their knowledge hasn't been stored into non-human media.

Also, ONS asks for substantial improvement of operational data.

One of the reason we selected Morigasaki as the test-field is that it has the operational chart for rainfall inflow that can be interpreted into ONS logic. To introduce ONS to WWTP, preparing the documented know-how and improving operational data are our pressing first task

5-2 DEVELOPMENT OF OPERATION NAVIGATION SYSTEM

Bureau of Sewerage, Tokyo Metropolitan Government

Hideo OHASHI
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1 Introduction

Bureau of Tokyo Sewerage, with 13 wastewater treatment plants and 79 pumping stations, contributes to the preservation of water quality in public water areas and the protection of Tokyo urban districts from rainfall inundation.

In order to manage these facilities efficiently, collective operation in each treatment area is being promoted by making use of remote-control system.

At present, 57 pumping stations and 1 wastewater treatment plant are remote-controlled from master pumping stations and wastewater treatment plants.

Promotion of remote control system leads to concentration of facilities monitored or controlled from the master facility, and, therefore, increases tasks of each operator, enhancing possibility of his human error.

Automatic operation can save some load of operation, but it is limited in use because it is applicable only to conditional operation that follows measured or processed value.

Also, due to pressing increase of age-limit retirees and strict restraint of employment, the number of operational staff is decreasing and, consequently, operational skills are being lost with veteran operators.

As a solution to the problems, Operation Navigation System (ONS) was developed.

2 Characteristics of ONS

(1)Overview

ONS reduces operational tasks, functioning like car navigation.

Operator can give operational instruction according to guidance messages timely and pertinently shown on supervisory monitoring device.

ONS indicates the guidance messages by logical deduction using information of the supervisory system.

In contrast with automatic operation, which has a restriction that it can be applied only to fixed operations, ONS can deal with operations that require operator's judgment.

(2)Functions

(a)Operation guidance

Operation guidance indicates operational decisions based on the logic constructed on “Decision Table” using plant input signals. Logics on the Decision Table can be modified easily so as to correspond with operator’s decision. The flexibility is effective in reflecting knowledge or know-how of skilled and experienced operator. Fig.1 shows ONS functioning as an agent for a skilled operator.

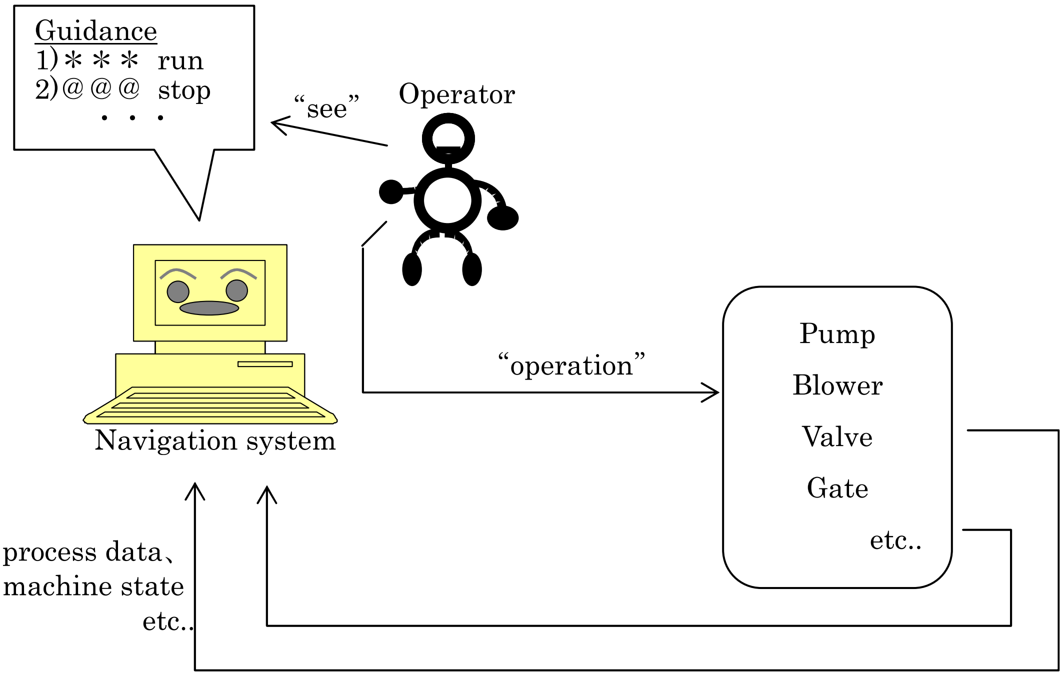


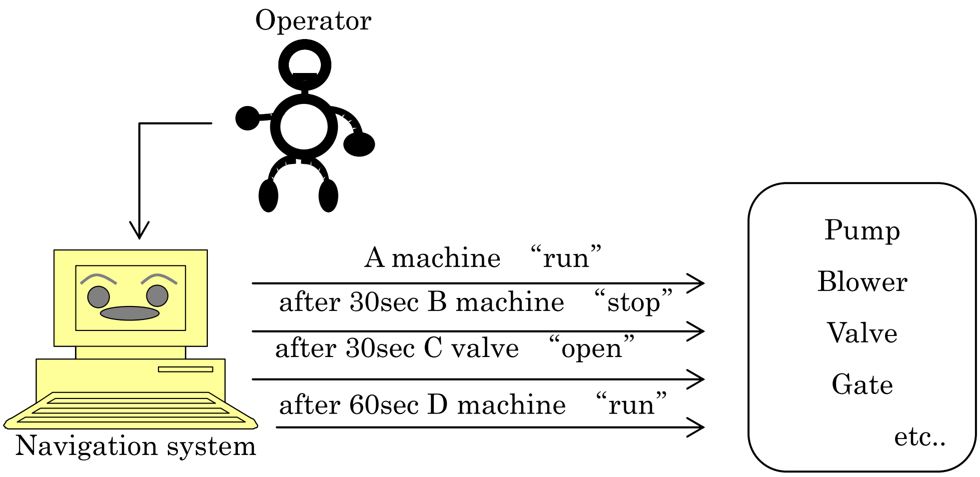
Fig.1 Operation guidance function

(b)Macro-operation function

By registering a set of sequential operations as ‘one action’, the operations run automatically with initial permission of operator.

Macro-operation function can convert multiple operations to one automatic operation.

The function is applicable to a set of manual sequential operations which proved to be fixed. Fig.2 shows automatic operation using Macro-operation function.



※A,B,C,D : various equipments machines

Fig.2 Macro-operation function

(c) Rationalized indication

In order for an operator to grasp the situation speedily even in emergency, indication data of facilities are hierarchically arranged on a display.

Also, symbolic indications to assist intuitive understanding are introduced.

(3)Effects

(a) To reduce operation tasks by guidance and rationalized indication

(b) To guide inexperienced operator with guidance appropriate to plant conditions

(c) To respond promptly in case of emergency

3 Evaluations of ONS

Guidance function of ONS is now under evaluation through a field test on Morigasaki wastewater treatment plant. The period of the test is from July 2005 to March 2006.

(1) Performance verification by prototype system

(a) Design and coding of Decision Table and Guidance consistent with pumping operation flow

(b) Installation of a proto ONS system by connecting to the supervisory system

(c) Running the proto system using input signals of the supervisory system

(2) Evaluation of guidance function

Based on comparison with real operations, ONS are evaluated.

Evaluation items are;

(a) Contents of guidance

(b) Timing of guidance indication

(c) Improvement of (a) and (b)

(d) Human interface

At present, the field-test shows good coincidence of guidance contents and timing with actual operation taken by operators.

4 Conclusions

In the background of concentration of operational tasks due to promotion of remote-control and impending loss of technical skills accompanied with retirement of many veteran technical staff, we have developed a navigation system ONS that stores operational knowledge, which can be modified, and shows directions timely.

ONS, being effective in wastewater treatment process and pumping discharge, is being evaluated in a field test.

After reflecting the result of the evaluation to improve ONS, we are planning to introduce ONS to real plants.