

# A METHOD TO SUPPORT THE TRANSFER AND UTILIZATION OF SKILLS OF SENIOR WORKERS IN MAINTENANCE TASK

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*This study aims to develop a support system that helps maintenance teams consisting of experienced senior workers and inexperienced junior workers to conduct maintenance tasks at remote sites. By taking advantage of IT, our support system facilitates communications, such as communication required for giving instructions and making reports, between maintenance headquarters and members at remote sites. Equipment having the aforementioned functions will be used for maintenance tasks at a toner plant in Japan, and its performance will be examined in light of the transmission of skills from experienced senior workers to junior workers.*

*Keywords: Maintenance task, Transfer and utilization of skill, Support system*

## **1 Introduction**

In recent times, Japan has witnessed a rapid increase in the number of serious accidents that occur due to incomplete maintenance tasks, such as accidents related to elevators and play equipment. This gives rise to serious concerns since issues relating to maintenance activity can worsen with a decrease in the number of skilled workers and an increase in the consignment maintenance business in the future. Moreover, the transfer and utilization of skills from experienced senior workers to junior workers is crucial as it can help Japan to cope with difficulties that the country may encounter in 2007, such as the retirement of people belonging to the baby boom generation, which now forms a part of risk assessment [1]. Hence, we develop a work support system wherein maintenance teams comprise experienced senior workers and inexperienced junior workers at a remote site in a large-scale plant, and an advanced and automated processing and assembly process. In particular, it is expected that senior workers will demonstrate and transfer skills upon obtaining information at a remote working site. However, this research has not yet been conducted [2]. This study will use equipment that has the functions requested through a field survey for maintenance tasks at a toner plant in Japan; its performance will be examined in light of the transmission of skills from experienced senior workers to junior workers.

## **2 Proposed method**

A field survey was conducted on workers to understand the current state of maintenance tasks in order to determine the types of functions that the support system must have. An analysis of the survey result helps in clarifying the functions expected from this system. Next, the support system with the requested functions is developed.

## 2.1 Field survey for determining the functions of a support system

### (1) Items of the questionnaire survey

Table 1 lists the items included in the questionnaire survey; the participants were instructed to rate the items using a 5-point scale, with 5 implying that the participant is “satisfied with the current state” and 1 suggesting that he considers the item to be “extremely inconvenient.”

### (2) Survey subject

This survey involved 14 workers with varying experience (in terms of the number of years) in the maintenance task carried out at a toner plant in Japan.

### (3) Survey results

The principal component analysis was conducted by using the survey results. The contribution rate of component 1 was 39.0%, and the rate of component 2 was 16.1%, with the total being 55.1%. Given that both components 1 and 2 integrated information equivalent to 50% or more, these components were considered.

The axis of component 1 shows the value of the coefficient concerning “instruction and report” on the maintenance work site to be large. According to junior workers’ rating, their satisfaction with this function is low. However, according to senior workers’ rating, their satisfaction with this function is high. Further, the axis of component 2 shows the value of the coefficient concerning “accuracy of task” on the maintenance work to be large. According to junior and senior workers’ rating, their satisfaction with this function is high. However, according to semi-experienced workers’ rating, their satisfaction with this function is low.

Therefore, as shown in Fig. 1, the survey results clarified the following two functions: instruction and report as well as accuracy of work.

Table 1: Questionnaire survey items

Headquarters	Oral communication with worker on site
	Time for headquarters to ascertain the state of the work site
	Time for maintenance task team to start relief activities
	Time to start maintenance task
	Discrepancies between the headquarter and team on site
	Usability of the system
	Reliability of the system
	Cost of maintaining for the system
	Possibility of complete oversight on site
	Usability of giving instructions
Maintenance task on site	Usability of hearing communication
	Possibility of misleading the team on site
	Transferability of experience
	Transferability of written knowledge
	Length of training period
Transfer of experience on site	Transferability of know-how
	Usability of giving instructions
	Usability of hearing communication
	Possibility of misleading the team on site
	Transferability of experience
	Transferability of written knowledge
	Length of training period
Transferability of know-how	

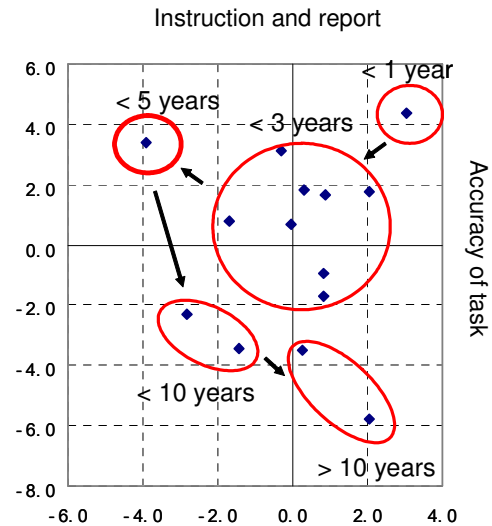


Fig. 1: Results of the questionnaire survey

## 2.2 Development of the support system to help in the maintenance task

### 2.2.1 Components of the support system

By taking advantage of IT, our support system aims to facilitate communications, such as communication required for giving instructions and making reports, between maintenance headquarters and members at remote sites. The constitution of the support system is shown in Fig. 2.

With respect to the “instruction and report” function ascertained from the field survey results, “position on site,” “live video image of the work site,” and “oral communication” will be added to the support system. Moreover, “live video image,” “oral communication,” and “work instruction” are added to the “accuracy of task” function.

The members of the maintenance task team are required to use the communication equipment that consists of a portable camera, a GPS receiver, and a wearable display (PDA).

Since this system can collect more information via live images and on-site positions as compared with one-way oral communication by using transceivers, the system ensures that on-site situations are transmitted to experienced senior workers at the headquarters. Therefore, the proposed system is expected to effectively support the transfer of skills from experienced senior workers to junior workers.

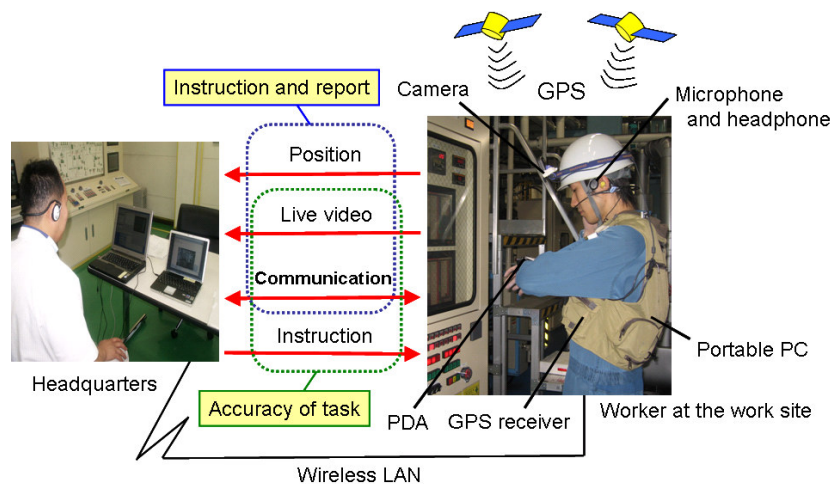


Fig. 2: Support system to help the maintenance task

### 2.2.2 Functions of the support system

The following are the functions of this support system.

#### (1) Indication of the location of a maintenance task team member

The support system indicates the current position of a maintenance task team member with a GPS receiver in a large-scale map of the entire area and a small-scale map of a specific area on the monitor at maintenance headquarters. Any position is indicated by the error margin accuracy within 10m.

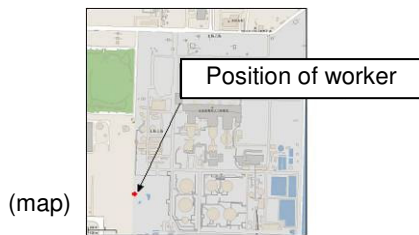
#### (2) Receipt of images sent by a maintenance task team member

The headquarters receive real-time images of that which is simultaneously viewed by a maintenance task team member. The maintenance task team members wear a

helmet equipped with a small camera. The images recorded by this camera are transmitted through wireless LAN and displayed on the monitor at the headquarters.

(3) Instructions to maintenance task team members

Depending on the status of the maintenance task, the headquarters provide work instructions to the maintenance task team members. Work instructions are chosen or newly indicated on the PC at the headquarters. The work instructions (in texts and figures) are shown on a wearable display (PDA). The instructions include letters and illustrations and are transmitted to the PDA of each member.



(map)

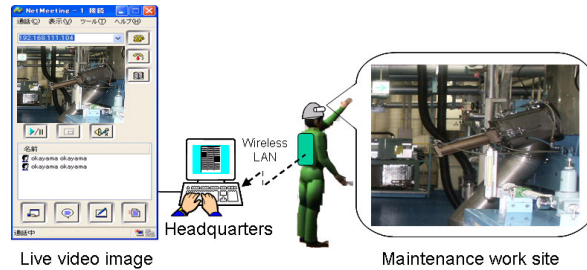


Fig. 3: Indication of the location of a member at the work site

Fig. 4: Receipt of images sent from the work site

(4) Automatic documentation of communication history during the maintenance task

Conversations exchanged between maintenance task team members and maintenance headquarters are automatically converted into written texts, as shown in Fig. 6. Each sentence is recorded along with the specific time at which it is spoken. This conversation is the output from time to time and is distributed to each of the related agencies.

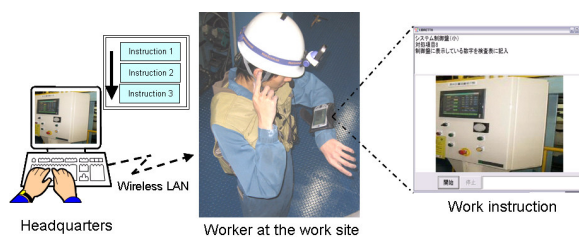


Fig. 5: Instructions to the members at the work site

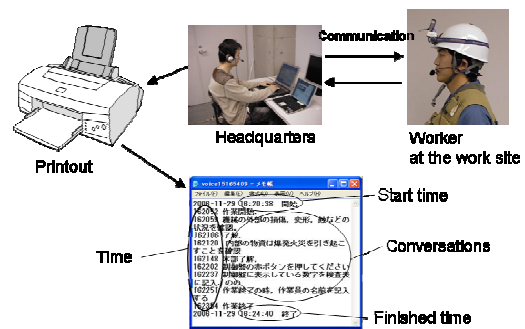


Fig. 6: Automatic documentation of the communication history

2.2.3 Details of the equipment related to the support system

The following is the constitution of the present support system.

(1) Portable camera: It transmits images of the maintenance task site; headphones are used for communications between maintenance headquarters and members at the work site. Together with the images indicated by the PDA, the headphones can be

used to transmit information such as names of facilities, properties of substances found inside the facilities, and handling cautions.

- (2) GPS receiver: It measures the position of a maintenance team member in real time. It is also used to indicate the location of a maintenance task team member on the map of the working area, which is displayed on the monitors at maintenance headquarters.
- (3) Wearable display (PDA): A PDA displays work instructions that are transmitted by maintenance headquarters. It differs from a head mount display (HMD) that always exists in worker's view because it is possible to use it only if necessary. Moreover, there is no individual variation in the recognition of contents on the display by eyesight and the experience in the size of the screen and the point of use.
- (4) Access point of wireless LAN: The network for this system is constructed by using wireless LAN between a PC at the headquarters and a PC at maintenance work sites.
- (5) PC at maintenance headquarters: The PC at the headquarters displays images received from the maintenance work site and indicates the locations of maintenance task team members, providing instructions on work details. It can also convert oral communication. The CPU of such a PC is generally Intel Celeron M (1.30 GHz).
- (6) Portable PC at the maintenance work site: The PC at the work site has control over on-site devices. It can also display instructions related to work details and can convert oral communication. The CPU of such a PC is usually Intel Pentium M (1.10 GHz).

### **3 Operational test and results**

Two operational tests were performed at a toner plant with a developed system, and a practical possibility of this system was investigated.

#### *3.1 Operational test*

Two operational tests of the support system were performed at a toner plant in Japan. As an operational test, a normal maintenance task was carried out with our support system. The toner plant has three floors. The same questionnaire was administered before and after the operational test to 14 workers who normally work at the plant.

#### *3.2 Results of the questionnaire*

The average of each item was calculated from the questionnaire results, as shown in Fig. 7. The effectiveness of this system was confirmed in the item of 86.9% or more as compared with a past device.

### **4 Conclusion**

This study developed a support system with the objective of helping maintenance teams that consist of experienced senior workers and inexperienced junior workers to conduct maintenance tasks at remote sites. By taking advantage of IT, our support system could facilitate communications, such as communication required for giving instructions and making reports, between maintenance headquarters and members at remote sites. Equipment with such functions was used for maintenance tasks at a toner plant in Japan, and its performance was examined in light of the transmission of skills from experienced senior workers to junior workers.

Through this study, we aim to improve the reliability and functions of the support system in the future so that it may be introduced for maintenance task in companies.

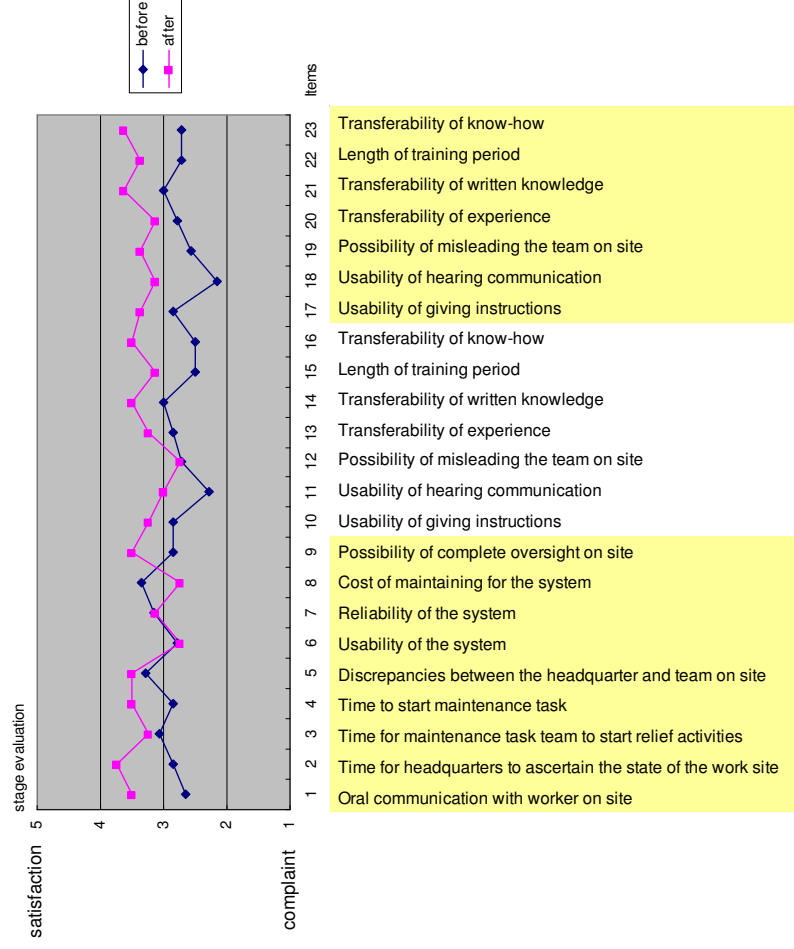


Fig. 7: Questionnaire and results

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