

# Maintenance Support System Development for Maintenance Personnel in Nuclear Power Plants

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## 1. Introduction

As plants or factories get old, the number of maintenance activities increases, and so does the necessity of maintenance itself. Industries have adopted the latest technologies such as RFID, wireless sensor networking, and augmented reality to develop systems which increase human performances as well as productivity. Due to safety related concerns, nuclear power industries have been reluctant to use these fancy technologies. However, from the economics point of view, it is necessary to take advantages of novel technologies. This empirical study considers not only ergonomics view, but also the economics view when building maintenance support systems.

This paper introduces brief features of five sub-systems which were built to reduce human errors and advantages when each system successfully reduces those human errors.

## 2. Ubiquitous maintenance support systems

This system consists of five sub-systems; automatic inventory system, location system, wireless sensor network system, video distinguishment system, and augmented reality manual system.

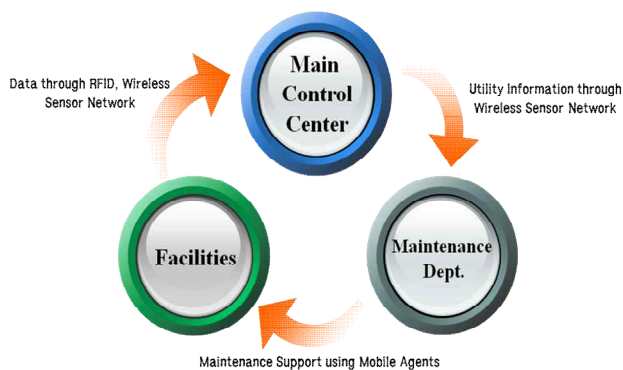


Fig. 1. Overview of ubiquitous maintenance support systems

### 2.1 Radio Frequency Identification (RFID)

RFID is the pervasive technology in many industries such as logistics and transportation. Smart inventory and smart tool box concept were developed for moveable asset management [1]. Automatic inventory system is based on 900 MHz band which has merit, such as: 1)

wide range coverage; 2) rapid data transmission; 3) robustness; 4) multiple tag reading. This system reduces human work load through processing automatic warehousing of goods and indicating the exact positions of the goods on the mobile agent so that maintenance personnel can reduce time to search repair parts. This system also alarms people - when the number of certain parts is under the desired stock - to check inventories in advance to prevent delays of maintenance procedure due to the late delivery or the short of needed parts.

### 2.2 Real Time Location System (RTLS)

RTLS is the system that traces moving objects and tells tracers the whereabouts of them. Our system uses wireless LAN based on IEEE 802.11b; 2.4 GHz band. Wireless LAN based RTLS has four advantages, such as: 1) convenience to construct; 2) wireless; 3) wide-coverage; 4) rapid transmission [2]. The purpose of the system is to increase a number of communication channels between supervisors and maintenance personnel through tag tracking, map tracking and instant text message communication. The former two features will help maintenance personnel find others when they need a support, and they have more chance to cooperate. The last feature was added to ensure and crosscheck obscure situations and tasks. This system helps novices solve knowledge based problems and release them from mistakes caused by stressful decision making situations through online devices as if they are under the experienced workers' or engineers' supervision.

### 2.3 Ubiquitous Sensor Network (USN)

Wireless sensor network has been an issue for a long time because of its unknown or unidentified effects on electronic devices in nuclear power plants (NPPs). However, a real time monitoring and control system is needed for ensuring the safety of NPPs [3]. This system was developed given that the frequency neither trips nor affects any electronic devices. The system transmits the signal through the ZigBee protocol that uses 2.4 GHz band. This ubiquitous sensor network system can not only reduce implementation costs, such as laying cables and saving space, or repair costs, but also enable maintenance personnel to monitor facilities with real-time data using mobile agents thus enhance personnel's capability of diagnosing conditions of machines.

### 2.4 Video Distinguishment

## REFERENCES

Video cameras are used for various purposes in industries, for example, surveillance. NPPs have numerous checking points thus it is impossible to check all the points and to diagnose situations always the same because operators have different experiences, physical and psychological status. In conjunction with this matter, video distinguishment system using Support Vector Machines (SVMs) was developed. SVMs have been introduced as an effective method for solving classification problems with many successful applications such as face detection, data mining, etc [4]. This system aims firstly at dropping operators work load to diagnose the status of facilities and secondly at reducing the number of fault diagnoses caused by heavy-work-loaded human operators. Cameras can cover 'hard-to-reach but important' points, increasing the plant's reliability.

### 2.5 Augmented Reality (AR)

AR was first developed more than a decade ago. Although we have seen much progress in the basic enabling technologies, displays, trackers and AR systems in general need to become more accurate, lighter, cheaper, and less power consuming [5]. However, we believe AR has a great potentiality to solve one of the human cognitive problems: short-term memory limit; therefore, we built AR manual system especially for novices. The system is based on Infrared Tracking for accurate object imposing. Manuals were designed based on Cognitive Load Theory and aimed at improving learning effects of the users. It means 'the more the AR manual is used, the less the usage frequency of the AR manual becomes.'

## 3. Conclusions

Nuclear power industry has put enormous efforts to run its plants safely and cost effectively. Undoubtedly, improving maintenance efficiency is a big part of their efforts. In this paper, the proto type of the ubiquitous maintenance support system, the system that focused on human factors as well as economic matters, was introduced. The system consists of five different sub-systems and each of them was evaluated separately. Although the further work is clear to integrate five sub-systems and to evaluate the human performances of the integrated system, the proto type of each support system has been proved to reduce human errors. We thus expect that this proto type maintenance support system has laid foundations for further research of more practical maintenance support system implementation. Even the safety - when using such radio frequency devices - is still unconvincing to some plant managers, we are positive that this study will help them break their passive tendencies of adopting advantageous technologies.

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