A Development of Radioactive material tracking and location control system

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1. Introduction

As the whole industry fields such as construction, chemistry, machine, medicine including nuclear-related field have extended the range of radioactive material uses, it is tendency that domestic uses of radioactive material have been increased in quantity and number. In addition, as the transportation, transfer and use of radioactive material have been frequent, its loss, robbery, and carelessness of handling may cause not only employees in charge but the public to worry about damage of explosion and put an obstacle to increase trust in nuclear-related industry. At present, though the transportation, use and storage of radioactive material conform to the institution & standard of the atomic energy law, if we tracking radioactive material in real time, we can take immediate actions to prevent its loss, robbery.

As our research institute developed a terminal that control location and tracking real time location for gamma-ray projector used in transporting, transferring, and using nondestructive test, we take a good look at utilities by using GPS-Cell ID bases location control.

2. System and Design

2.1 Positioning System

Currently, the possible ways that tracking and control location by using communication-infra on a national scale are Cell ID, E-OTD, OTDOA, A-GPS and Hybrid based on mobile phone services. The best systems through GPS(SPS) used at the pentagon in terms of positioning precision, expansion, and cost, are A-GPS, Hybrid system.

Basic principle of GPS as follows. After measuring signal of satellite and distance between receiver and satellite, a location of receiver is determined by the Eq.1.

$$\sqrt{(x_p - x_n)^2 + (y_p - y_n)^2 + (z_p - z_n)^2} = (\Delta t - E)c \quad (1)$$

Δt = observation value of arrival time between receiver and satellite, c = the velocity of light, E = time difference between receiver and satellite, x_n, y_n, z_n = n-th satellite location, x_p, y_p, z_p = location of receiver which can be determined by measuring four satellite signal.

2.2 Design

There are two systems which receive location positioning result from control system by GPS.

A-GPS system for commercial use (name: gpsOne; network based positioning) a system that receive GPS receiver positioning result from CDMA netework.

We designed and manufactured a location tracking terminal like Fig. 1 from GPS-CDMA system which is more relatively inexpensive (include network infra cost) than A-GPS system.

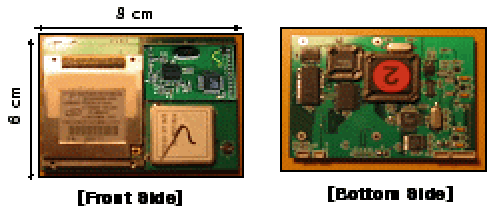

Fig. 1 Developed Positioning & Tracking Module

Manufactured location tracking terminal consists of GPS receiver receiving signal to position current location, CDMA module sending positioned signal through communication network to control system,

RF module that can position with radio-wave direction detector location where location tracking terminal is in emergency or radio-wave shadow zone, and MCU that controls each module.

2.3 Location Control System

The degree of precision for GPS positioning method is known as not exceeding a several tens meter. But because of GPS characteristics it is impossible for us to position inside building or car. For this reason, the necessity of improvement or supplement of GPS positioning method comes to the fore. Recently, as an alternative measure to the GPS impossible area, Hybrid system mixed with Cell ID is made a subject of discussion. Here, we build our control system after sending GPS positioning results to control system, and receiving Cell ID location information from a telecommunication industry's help.

2.4 Management Software

Management software consists of one program designed to provide mapping, reporting and administrative functions from one computer. As each tracking unit is validated in the system it can begin to collect data in the field(Fig.2.). The data is then processed into the database making the routes available on the map.

Fig. 2. Management Software

3. Result and Consideration

3.1 GPS and Cell-ID positioning precision analysis

There are two major errors in GPS(SPS). One is structural error such as satellite time error, satellite location error, atmosphere error, receiver noise error, radio-wave multiple-course-error, SA code error. The other is geometrical error by satellite arrangement. Generally speaking, it generates an error equivalent to ~50m, except for SA code deviation (deliberate deviation of the US Pentagon). This study has analyzed GPS deviation by mounting the location tracking terminal developed in Fig. 1 on the gamma ray projector transporting radioactive material for non-destructive testing as seen in Fig. 3.

Fig. 3. Installed positioning & tracking module in Gamma-ray Projector

After receiving data on location for 30 minutes via mobile communication means, we indicated results as seen in Fig. 4 and found that location deviation was 49.12m.

Cell ID determination has been known to show 100m to several tens of kilometers with based on mobile station-based GPS services. Therefore, this study has used extra data on determination when it was impossible to make GPS determination.

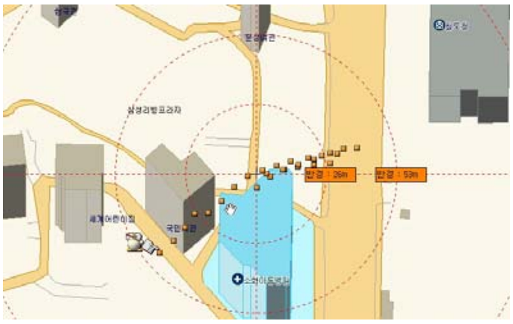

Fig. 4. An analysis of GPS positioning results

3.2 A solution of Radio-wave shadow zones

The non-destructive testing device applying GPS system requires closed and sealed transport means. For this reason, we used additionally Cell ID type. In addition, a secondary tracking method is needed to cope with such an emergency as theft of radioactive material. Through the secondary method, Cell ID method, we could detect and track the location with the radio-wave direction detector and recover the radioactive material by operating remotely the RF module built in the location-tracking terminal.

4. Conclusion

After developing the location tracking terminal for real-time monitoring and tracking of radioactive material and applying it to the fields in which these materials are transported and moved, we found the results as follow.

1. GPS determination method was suitable to identify and tracking radioactive material but it was almost impossible at the radio-wave shadow zones.
2. We could identify and tracking radioactive material at the radio-wave shadow zones by using Cell ID determination and RF module.
3. The mixed system of GPS, Cell ID, and RF module was proved to be effective in identification and tracking when radioactive material are transported, used, or stored.

5. Acknowledgement

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