DEVELOPMENT AND CURRENT STATUS OF A CARBORNE GAMMA-RAY SURVEY SYSTEM, KURAMA-II

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Abstract

A carborne gamma-ray survey system, named KURAMA (Kyoto University RAdiation MApping system), was developed as a response to the nuclear accident at TEPCO Fukushima Daiichi Nuclear Power Plant in 2011. A CompactRIO-based system KURAMA-II has been developed as the successor of KURAMA, and served for various activities on the radiation monitoring in Eastern Japan. We continue developing KURAMA-II as a tool not only for the current monitoring activities, but also for the immediate responses in nuclear incidents in future. The current status and on-going developments of KURAMA-II will be introduced along with the recent status of the east Japan.

INTRODUCTION

The magnitude-9 earthquake in Eastern Japan and the following massive tsunami caused a serious nuclear disaster of Fukushima Daiichi nuclear power plant. Serious contamination was caused by radioactive isotopes in Fukushima and surrounding prefectures. KURAMA [1] was developed to overcome the difficulties in radiation surveys and to establish air dose-rate maps during and after the present incident. KURAMA enabled operations of a large number of in-vehicle units for large-scale surveys owing to its high flexibility in the configuration of data-processing hubs or monitoring cars. KURAMA has been successfully applied to various activities in the radiation measurements and the compilation of radiation maps in Fukushima and surrounding areas.

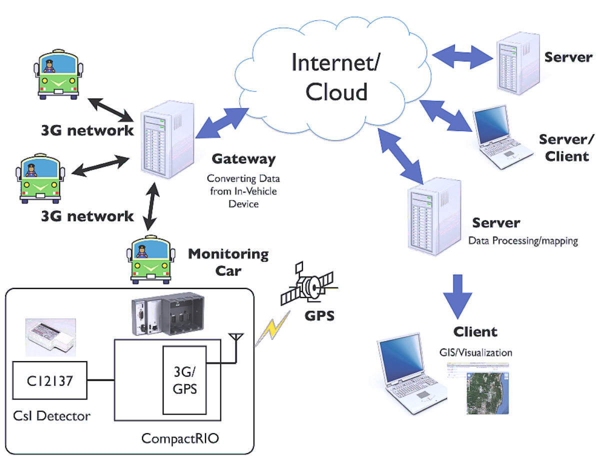

Figure 1: System outline of KURAMA-II.

As the situation becomes stabilized, the main interest in measurements moves to the tracking of the radioactive materials that have already been released into the environment surrounding the residential areas. Such monitorings can be realized efficiently if vehicles that periodically move around the residential areas, such as local buses, delivery vans or postal motorcycles, have compact and full-automated KURAMAs onboard. KURAMA-II [2] is designed for such purposes, characterized by its compactness, autonomous operation, and additional functions such as the measurement of pulse height spectrum. In this paper, the system outline of KURAMA-II as well as the results of continuous monitoring using KURAMA-II will be introduced.

SYSTEM OUTLINE OF KURAMA-II

Long term (in the order of tens of years) and detailed surveillances of radiation are required in the residential areas exposed to the radioactive materials by the nuclear accident. Such monitoring can be realized by implementing radiation monitoring units into moving vehicles in residential areas such as local buses, delivery vans or postal motorcycles. KURAMA-II is developed for such usages.

System outline of KURAMA-II is shown in Fig. 1. KURAMA-II stands on the architecture of KURAMA, but the in-vehicle part is totally re-designed for the autonomous, continuous operations in vehicles [3]. The platform is replaced from a conventional laptop PC to a CompactRIO controller of National Instruments to obtain better toughness, stability and compactness. The radiation detection part is replaced from the conventional NaI survey meter to a Hamamatsu C12137 [4], a CsI detector characterized as its compactness, high efficiency, direct ADC output and USB bus power operation. The mobile network and GPS functions are handled by a Gxxx module for CompactRIO by

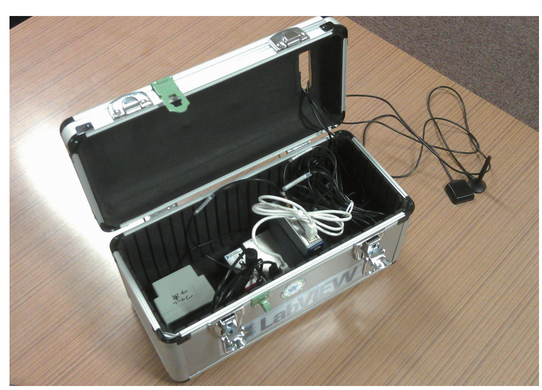

Figure 2: In-vehicle unit of KURAMA-II. A CsI detector and a CompactRIO controller are compactly placed in a tool box with the size of 34.5 cm ×17.5 cm ×19.5 cm.

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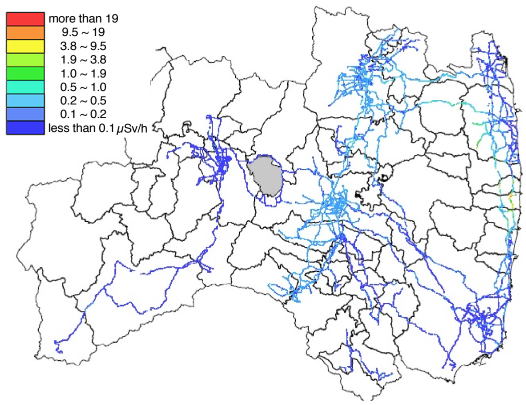

Figure 3: The result of continuous monitoring by local buses etc. in Fukushima as of the fourth week of September 2016. This kind of maps are released both in picture and in data files (csv and kmz) through the web on weekly-basis.

SEA. All components of the in-vehicle unit are placed in a small tool box for the better handling (Fig. 2).

The software for KURAMA-II is basically the same code as that of original KURAMA, with additional developments for newly introduced C12137 detector and Gxxx module, for the start up and initialize sequences fautonomous operation, and for a RESTful-based file transfer protocol.

All the data collected by in-vehicle units are shared over Dropbox, a cloud storage service. The gateway server is prepared as the interface between in-vehicle units and Dropbox because it does not currently support CompactRIO. A feasibility study of ownCloud with the implementation of data transfer protocol of KURAMA-II is on the way as the alternative cloud storage for KURAMA-II system, not only to eliminate the gateway server, but also to obtain more flexibility in the cooperative operations with other databases, such as GIS servers.

OPERATIONS OF KURAMA-II IN EASTERN JAPAN

Continuous Monitoring by Local Buses

One of the major application of KURAMA-II is the continuous monitoring in residential areas by local buses. A series of field tests on local buses started in December 2011 have finally evolved into the official project organized by Fukushima prefectural government under the collaboration of Kyoto University and JAEA [5]. As of October 2016, more than fifty KURAMA-II units are continuously operated throughout Fukushima prefecture. In-vehicle units are deployed not only to local buses, but also to official vehicles operated by Fukushima prefectural government for purposes other than radiation monitoring. In the case of local buses, the bus routes in each operation areas are completed over three to five days typically, based on the transportation plan determined by its respective bus operator. The air dose rate at 1 m above on the road is determined by multiplying the shielding factor of bus body determined by the comparison with the results of periodical carborne surveys by Japanese

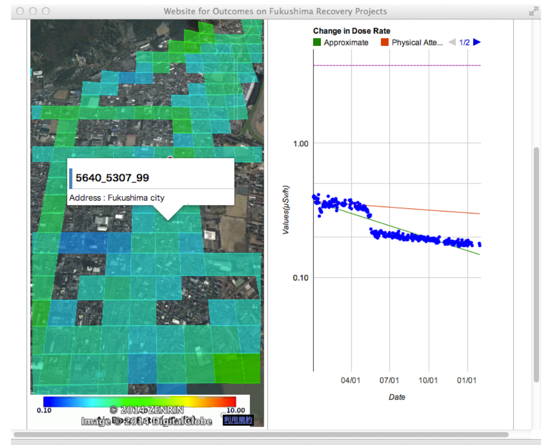

Figure 4: Typical example of the decontamination effect observed through monitoring by KURAMA-II on a local bus. In this figure, a drastic reduction of air dose rate along with the decontamination was observed.

government. The results from this project is released to the public from the web site on a weekly basis (Fig. 3). The changes of radiations in residential areas are successfully observed (Fig. 4).

Periodical Surveys by Japanese Government

The Nuclear Regulation Authority (NSR) in Japan conducts the periodic carborne surveys in Eastern Japan since 2011 [6, 7]. This project has been taken over to Nuclear Regulation Authority (NSR) because of the reorganization of atomic energy administration in Japan. In this project,

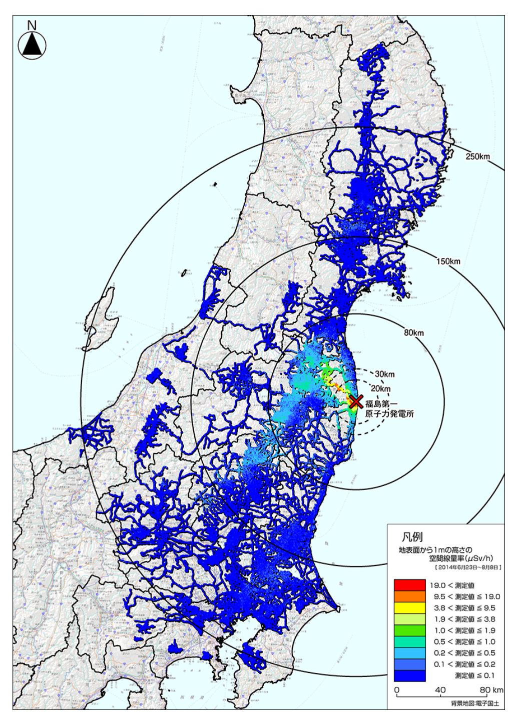

Figure 5: A typical map of air dose rates on roads measured by KURAMA-II from June to August 2014 [7].

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around one hundred KURAMA-II are deployed to the local municipalities in Eastern Japan twice a year, and the staff members in each municipality drive around their own municipalities with in-vehicle units (see Fig. 5). The summarized data is released through the websites [8, 9] as well as served for various analyses including the evaluation of ecological half-lives of radioactive cesium in environment and the long-term predictions of air dose rates in Fukushima [10] (Fig. 6).

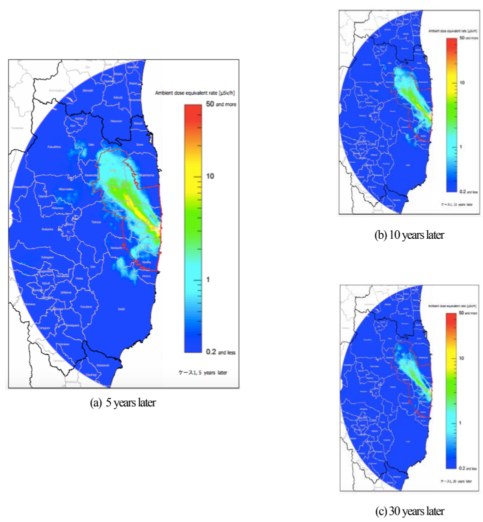

Figure 6: Prediction of air dose rate in the area within 80 km from the Fukushima Daiichi Nuclear Power Plant [10]. The parameters used for these predictions are determined by using the data of carborne surveys by KURAMA-II.

ON-GOING DEVELOPMENT

One important lesson we learned from the experience in the Fukushima accident is that the quality of data in a monitoring activity under emergency situation can be easily and severely suffered by human errors. For example, almost half of data was suffered by human errors in one of the large-scale monitoring activities performed by several hundreds of scientists, who were considered to be the specialists on this kind of activities. Efforts and costs to recover such errors sometimes become sufficient to terminate the activity itself.

Such human errors can be eliminated by implementing an autonomous data-handling function like KURAMA-II to any measurement devices used in emergency situations. We are working for KURAMA-mini, a survey meter with KURAMA-II function, as an device for such purpose. Feasibility studies on the monitoring scheme with KURAMA-mini in emergency situations are on on the way (Fig. 7).

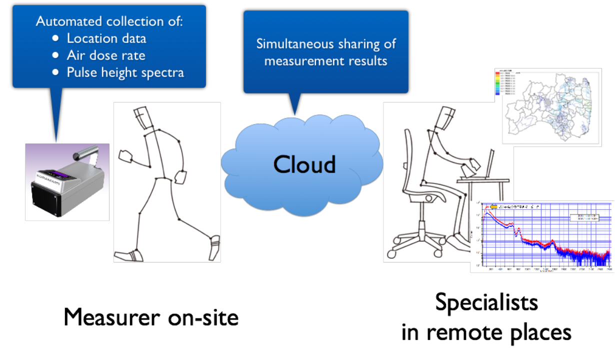

Figure 7: Expected usage of KURAMA-mini in emergency situations. Measurer just go to the site with KURAMA-mini, and the data autonomously collected by KURAMA-mini is shared with specialists in remote sites for proper analysis or decision making etc.

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