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REGULAR ARTICLE

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SAFER – A way to achieve affordable large-scale radiological survey network

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Abstract. Safer is a low cost, low power connected radiological beacon, deployed as a network of sensors around cities and industrial sites, it creates an early warning system and enhance situational awareness, post-action assessment, and decision-making. Working continuously, it collects data in real time in order to protect workers, first responders and population.

1 Use cases

Having a low cost, low power geolocated connected radiological sensors allow for cost-effective deployment and multiple new use cases:

- large-scale deployment of radiological sensors around cities (train station, stadium...) for RN threats population protection, this topic has been covered by multiple articles [1–4].
- Simplify recurrent measurement in industrial sites, like environmental measurement at site fences or hot spot measurement inside nuclear facilities.

Our innovation answers the following problems:

- enhance workers, first responders and population protection by decreasing radiation exposure.
- Optimize radioprotection costs by avoiding manual measurement.
- Increase the safety level of nuclear facilities by easily adding real time radiation measurement at different places.

2 Innovation

Safer innovative electronic allows for ultra-low power radiation measurement which results in new disruptive approach to radiation measurement and radioprotection. Safer is using state-of-the-art low-cost Geiger-Müller tube simplifying user adoption and allowing large sensor network deployment.

Safer embeds multiple wireless long-range and secured communication systems in order to adapt the different industrial use cases but also to emergency response.

Fig. 1. Safer.

Capable to work for up to 10 years continuously on a small single-cell battery. Safer is a place and forget device that is easy to deploy and maintain as it doesn't require any cable or complex configuration.

Inside nuclear facilities it measures in real time recurrent hot spot without exposing radioprotection services personnel to radiation. Safer is a mobile solution that could be adapted to any measurement situation, deploying a Safer is as simple as making the first measurement (see Fig. 1).

3 Technical achievements

We developed an ultra-low power high voltage (HV) supply and signal processing electronic in order to use low-cost Geiger-Müller RN detection technology. Our complete sensor, with its data transmission system consume less than 20 µA at 9 VDC with continuous measurement. It could measure for up to 10 years on a single cell battery.

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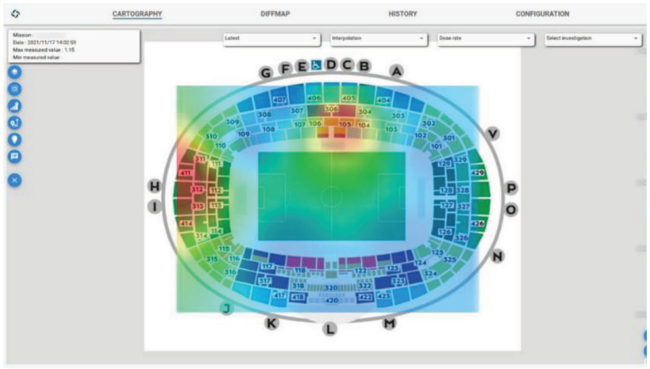

Fig. 2. Radiological heat map example with 11 sensors.

Our radiological sensor is calibrated in lab and run a blank measurement upon installation in order to be able to detect even low levels of radiation increase and alert on any suspicious event, our detection limit is less than 100 nSv/h. We understand that false alarms are problematic, that is why we use continuous measurement and sensor network correlation in order to reject false positive measurement.

Safer is geolocated using GNSS or manually in its fixed position configuration, data is sent over 4G/5G or LoRa to a local or cloud-based information systems. LoRa communication allows data collection in a local bubble in case of major crisis where communication has either been denied or infrastructure are compromised. We use LoRa frequency sniffing in order to shift to a free frequency when enemies are trying to use denial of service attack on our communication system. Safer is made to be a resilient device, it doesn't rely on any fixed infrastructure or power grid. As an alternative, Safer also embedded Bluetooth Low Energy long-range communication (up to 100 meters) for communication with workers or first responders on the field. All our communications are secured using state-of-the-art RSA and AES encryption.

Using multiple measurement points, our software is capable of displaying a heat map of the area in order to quickly identify hazardous areas. We use a combination of kriging [5,6], inverse distance weighted (IDW) [7,8] and retro projection algorithms in order to provide a digested and simple to understand information to end users.

Using this interpolated matrix, we are then able to use path optimization algorithms (A*) to optimize evacuation and intervention paths (see Fig. 2).

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Conflicts of interest

The authors declare that they have no competing interests to report.

Data availability statement

This article has no associated data generated and/or analyzed/data associated with this article cannot be disclosed due to legal/ethical/other reason.

Author contribution statement

M.A. BALLIER is responsible for SAFER project administration, is an active SAFER developer, and lead the writing and editing of this manuscript. M.P.A. ROBIN is an active SAFER developer, and reviewed and provided edits for this manuscript.

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