



# Fixed-Position Direct Radiation Environmental Monitoring Systems

## Market Survey Report

August 2019



**Homeland  
Security**

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## FOREWORD

The U.S. Department of Homeland Security (DHS) established the System Assessment and Validation for Emergency Responders (SAVER) Program to assist emergency responders making procurement decisions. The National Urban Security Technology Laboratory (NUSTL) located within the DHS Science and Technology Directorate (S&T) manages the SAVER Program, which conducts objective assessments and validations on commercially available equipment and systems and develops knowledge products that provide relevant equipment information to the emergency responder community. The SAVER Program mission includes:

- Conducting impartial, practitioner-relevant, operationally oriented assessments and validations of emergency response equipment.
- Providing information, in the form of knowledge products, that enables decision-makers and responders to better select, procure, use and maintain emergency response equipment.

SAVER Program knowledge products provide information on equipment that falls under the categories listed in the DHS Authorized Equipment List (AEL), focusing primarily on two main questions for the responder community: “What equipment is available?” and “How does it perform?” These knowledge products are shared nationally with the responder community, providing a life- and cost-saving asset to DHS, as well as to Federal, state and local responders.

NUSTL is responsible for all SAVER activities, including selecting and prioritizing program topics, developing SAVER knowledge products, coordinating with other organizations and ensuring flexibility and responsiveness to first responder requirements.

NUSTL provides expertise and analysis on a wide range of key subject areas, including chemical, biological, radiological, nuclear and explosive weapons detection; emergency response and recovery; and related equipment, instrumentation and technologies. For this report, NUSTL conducted a market survey of commercially available fixed-position direct radiation environmental monitoring systems at the request of the Fire Department of New York City (FDNY). These systems do not have a unique AEL reference number but may be considered a subset of the AEL reference number 07RD-04-SGND titled Standoff Radiation Detectors.

Visit NUSTL’s SAVER website at [www.dhs.gov/science-and-technology/SAVER](http://www.dhs.gov/science-and-technology/SAVER) for more information on the SAVER Program, or to view additional reports on radiation detection equipment and other technologies.

U.S. Department of Homeland Security



System Assessment and Validation for Emergency Responders



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## EXECUTIVE SUMMARY

Within minutes of an explosion in an urban area, emergency responders must assess the situation. This includes recognizing whether radioactive materials have been released—for example, in the case of a detonation of a radiological dispersal device (i.e., “dirty bomb”). Elevated radiation levels can be detected by specialized handheld or portable equipment deployed to the site, or if available, by fixed-position radiation sensors that continuously measure the radiation exposure rate (or dose rate) at a particular location. A network of radiation monitors spread throughout a city could provide localized radiation information that could guide emergency personnel response actions and public messaging for evacuation or shelter-in-place instructions. Some emergency responder agencies are considering establishing radiation sensor networks as part of their emergency preparedness planning.

To assist emergency responders interested in radiation monitoring networks, NUSTL’s SAVER program conducted a market survey of commercially available fixed-position direct radiation monitoring systems. Products included in this market survey report are capable of continuous, unattended outdoor operation and of providing real-time measurements of the external gamma radiation exposure rate ranging from natural background to emergency levels. They may also be capable of integrating with the RadResponder software platform as described in the U.S. Department of Homeland Security Science and Technology Directorate’s (S&T) *Radiological Dispersal Device Response Guidance: Planning for the First 100 Minutes*.

This market survey identified ten radiation monitors that may be used in a dispersed network to provide situational awareness of the radiation environment in the aftermath of a radioactive release. Three of the products can identify the specific radionuclides detected. Two products contain removable, handheld radiation instruments for both portable and fixed use. Prices for the radiation monitoring systems vary from under \$3,000 to over \$30,000; however, individual products differ in what options are included in the standard price. Most products have options for meteorological sensors, back-up batteries or alternate power supplies, and varying data transmission solutions. The products also have a variety of software systems for display, storage, and visualization of current and historical radiation exposure rate data. Five products are currently capable of automatic upload of exposure rate data to RadResponder.

Emergency responder agencies that consider purchasing fixed-position direct radiation monitoring systems should carefully research each product’s overall capabilities and limitations in relation to their agency’s operational needs. Agencies should also consider impacts associated with integrating equipment into their power and information technology infrastructure, data management and concepts of operations, and required maintenance.



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## 1.0 INTRODUCTION

Fixed-position direct radiation monitoring systems continuously measure the radiation exposure rate (or dose rate) at a particular location. Commonly called environmental monitors when used outdoors, or area monitors when used indoors, they track external exposure from radiation. This is distinct from monitoring potential ingestion pathways by collecting samples of air and water and analyzing them for radioactive material. Networks of environmental radiation monitors are used at the national level to detect and track global radiation releases and at the local level to monitor radiation in public areas surrounding nuclear power plants.

The Fire Department of New York City (FDNY) requested assistance in exploring the potential use of fixed-position direct radiation monitors as part of their emergency preparedness plans for consequence management after the detonation of a radiological dispersal device (RDD) in New York City (NYC). Fixed-position direct radiation monitors located at fire stations could be used to check for elevated radiation following an explosion anywhere in the city. RDD detonation response plan guidance relies on radiation surveys to map areas downwind out to a distance of 3 miles from the detonation site, and in outlying areas, in order to define hazard boundaries and establish safe evacuation routes. The radiation survey measurements are to be taken at a height of 3 feet from the ground for use in modelling codes that project doses to individuals from radioactive fallout on the ground. Determining whether or not radiation is present would guide response actions for emergency personnel and public messaging for evacuation or shelter-in-place instructions.

To provide FDNY and other localities with information on commercially available fixed-position direct radiation monitoring systems, NUSTL conducted a market survey under the System Assessment and Validation for Emergency Responders (SAVER) Program. This market survey report is based on information gathered from March 2018 through February 2019 from internet research, industry publications, consultations with subject matter experts, a government-issued Request for Information (RFI) that was posted on the Federal Business Opportunities website, and subsequent contact with equipment manufacturers and vendors. This report encompasses fixed-position direct radiation monitors with the following characteristics:

- Capable of real-time measurements of the external gamma radiation exposure rate, ranging from natural background levels (< 10 micro-roentgen per hour ( $\mu\text{R/h}$ )) to emergency levels ( $\geq 100$  milli-roentgen per hour (mR/h))
- Deployable such that the detector is located at a height of 3 feet (1 meter) from the ground
- Capable of continuous, unattended operation
- Measurement duration and/or recording frequency on the order of minutes to provide near real-time hourly exposure rate data
- Able to withstand outdoor weather conditions
- Potentially capable of automatic upload to, and integration with, the RadResponder<sup>i</sup> data management and visualization tool
- Does not include air particulate filters

Due diligence was performed to develop a report that is representative of products in the marketplace.

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<sup>i</sup> RadResponder is a software platform to collect, map, and manage radiological data during an emergency. See Section 2.3.1.





## 2.0 FIXED-POSITION DIRECT RADIATION MONITORING SYSTEMS OVERVIEW

In the first minutes after an explosion or fire in an urban area, emergency responders have the difficult tasks of evaluating the scene, conducting life-saving operations, issuing protective actions, and more. In the case of a terrorist attack that releases radioactive material, such as the detonation of an RDD or an improvised nuclear device, the complexity of the response increases greatly. Since radiation is not visible or perceptible to the human senses, its presence must be recognized through an alert from a radiation detector. Local response agencies and municipalities are putting plans and equipment in place to recognize and respond to an incident involving the release of radioactive material.

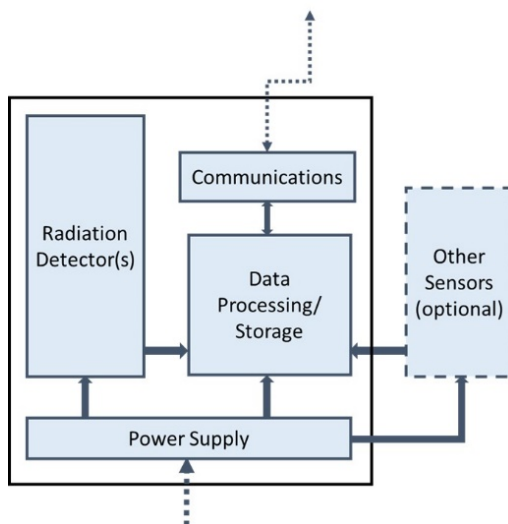
### 2.1 CURRENT TECHNOLOGY

Many law enforcement and response agencies now equip their personnel with a variety of handheld, body-worn, or transportable radiation detection equipment for use in interdiction and consequence management missions<sup>ii</sup>. This equipment may include personal radiation detectors (PRDs), radionuclide identification devices, handheld radiation survey meters, electronic dosimeters, and standoff radiation detectors [1] [2] [3] [4] [5] [6] [7]. In contrast to those instruments, fixed-position direct radiation monitors are installed in select locations (such as at a fire station or in proximity to critical infrastructure) to continuously monitor surrounding radiation levels in that environment. Fixed position radiation monitors provide a measure of the external gamma radiation in units of exposure rate (roentgen per hour (R/h)) or dose rate (roentgen equivalent man per hour (rem/h) or sievert per hour (Sv/h)).

The primary hardware components of a fixed-position direct radiation monitoring system are shown in Figure 1-1. In addition to the radiation detector, it includes a power supply, data processing and storage unit, communications module, and protective (weatherproof) housing. (A user interface provides control of the device using an external computer.) Some systems include temperature, humidity, or other weather sensors—because the natural radiation background varies with temperature and precipitation, and radioactive material released would be affected by wind and rain, weather data can aid analysis of environmental radiation measurements. For example, rainfall can cause the natural radiation background to increase by 30 percent due to washout of atmospheric radon progeny present in the air from the natural exhalation of radon from the soil [8]. Similarly, atmospheric mixing due to diurnal temperature oscillations also causes small variations in the radiation background. In an urban setting, the wind speed and direction may vary locally due to urban canyon effects, which could result in unexpected RDD fallout patterns.

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<sup>ii</sup> Some handheld or body-worn devices can potentially be used as a distributed sensor network for awareness of radiation levels. For example, see the Defense Advanced Research Projects Agency (DARPA) Sigma+ program for a radiation (and other threat) interdiction program (<https://www.darpa.mil/program/sigma-plus>).



**Figure 2-1 Block Diagram of Main Hardware Components**

The rectangular outline enclosing the labelled components represents the protective (weatherproof) housing for the radiation detection components; weather sensors, if used, would be mounted externally. The dashed arrows denote wired connections, optional in some products, to input external line power (bottom) and to transmit and receive communications (top).

### 2.1.1 RADIATION DETECTORS

The two types of radiation detectors used in environmental monitoring systems are gas-filled or scintillation detectors. In gas-filled radiation detectors, i.e., the Geiger-Mueller (GM) tube and the pressurized ionization chamber (PIC), a cylinder or sphere filled with air or an inert gas is maintained between high-voltage electrodes. Radiation is detected as it ionizes the gas and generates a corresponding measurable electric current. High pressure ionization chambers (HPICs) contain gas at several atmospheres of pressure for increased sensitivity. A scintillation radiation detector consists of a solid crystal material, such as sodium iodide (NaI), cesium iodide (CsI), Cerium (III) bromide (CeBr<sub>3</sub>), or Lanthanum (III) bromide (LaBr<sub>3</sub>), which emits a light pulse when it absorbs radiation. In order to operate over a wide range of exposure rates from natural background<sup>iii</sup> conditions through emergency levels<sup>iv</sup>, some systems use multiple detectors such as two GM tubes or a scintillator and a GM tube.

The radiation detector measures the electric current or number of counts for a set time interval (e.g., 1 minute) and reports the hourly exposure rate (R/h); in most systems the measurement duration (also referred to as measurement cycle) and/or the data transmission cycle may be set by the user. (Shorter measurement and transmission cycles consume more power and may affect battery life. Some products have an option to automatically switch to a faster measurement cycle if the exposure rate reaches a specified threshold.) Wired or wireless communication channels may be used to change radiation monitoring system settings.

<sup>iii</sup> The background radiation exposure rate from natural sources varies with geography and precipitation—for the purposes of this report it is approximated as less than 10 µR/h.

<sup>iv</sup> For this report, exposure rates greater than 10 mR/h are considered emergency levels, consistent with the National Council on Radiation Protection and Measurements' [14] recommendations for radiation control perimeters during an emergency that define a “cold zone” where the exposure rate is ≤ 10 mR/h, a “hot zone” at > 10 mR/h, and a “dangerous-radiation zone” at ≥ 10 R/h.

### **2.1.2 DATA TRANSMISSION**

Radiation measurement data is stored in an internal memory and transmitted via wired or wireless communications to the user's computer or mobile device for analysis or display. A radiation monitor may use redundant modes of communication to ensure data receipt if one mode fails. Multiple monitoring station locations may be networked for centralized alert notifications, data access, and to enable mapping and spatial analysis. Standard wired connections include RS-232 or universal serial bus (USB) cables to connect directly to a computer and Ethernet cable or digital subscriber line (DSL) for networked computer access.


Wireless communication uses electromagnetic waves to send signals between devices, each with an appropriate transmitter and receiver for either short range or longer range communications, depending on the application and radiation monitor's location. Different types of wireless technologies use different parts of the electromagnetic spectrum, and include infrared (IR), Bluetooth (BT), Wi-Fi, radio-frequency (RF), cellular, or satellite. IR and BT communication is typically used for short distances on the order of a few meters. For example, IR may be used for manual/interactive data downloads; BT may be used to send data to a nearby smart phone. Wi-Fi is used in local area networking where a component called an access point (often combined with a router) connects other devices wirelessly to a wired network. The Wi-Fi devices must be within the spatial range (about 20 meters) of the access point. In this context, RF refers to data transmission among devices with appropriate antennas and transceivers tuned to the same frequencies, similar to walkie-talkies. This type of radio network operates in specific frequency allocations regulated by the Federal Communications Commission. Cellular data transmission is the wireless connection to the internet through cellular towers within a coverage area; users maintain a subscription account with a commercial provider. Satellite data systems transmit and receive data from one device to another through an orbiting satellite using specialized hardware integrated into the monitoring station. This could be useful in areas with no cellular coverage or when a redundant communications method is desired. Data airtime charges may be based on a subscription or data usage.

### **2.1.3 POWER SUPPLY**

Power is supplied by an internal battery or by connection to an external direct current (DC) or alternating current (AC) power supply. In some systems the external line power charges an internal battery pack to run the device, and if external power is lost, the remaining charge on the battery can continue to run the system temporarily as backup. External power may connect through a dedicated cable or be provided through the communications cable as power over USB or power over Ethernet (PoE).

### **2.1.4 ENVIRONMENTAL ENCLOSURES**

System components must be enclosed in weatherproof housing to be deployed outdoors. Enclosures are rated according to the National Electrical Manufacturers Association (NEMA), or according to International Electrotechnical Commission's (IEC's) international (ingress) protection (IP) ratings. NEMA and IP ratings classify the degree of protection that the enclosure provides to the internal components and are included in the manufacturer's instrument specifications.



For example, a NEMA type 3 enclosure is weather resistant and intended for outdoor use. In the 2-digit IP ratings, the first digit specifies the level of protection from solids and the second digit indicates protection against liquids: higher numbers indicate more protection, for example IP65 indicates protection from dust and low pressure water jets from any direction.

### 2.1.5 DATA ANALYSIS

In addition to the hardware, data handling software is an important element of fixed radiation monitoring systems. In order to follow dynamic conditions during an emergency response, a user may need to view the exposure rate in real time, compare data from different locations, and review past measurements. Software for the user interface may be provided for the system on a compact disc or through internet download. Available features may include desktop-only or web-based access, an interactive data display, mapping, temporal or spatial analysis, and alarm or fault notifications. Some systems also offer options for mobile device applications. Radiation level alarms and alerts may be displayed at the user interface and systems may also have audible or other alert capabilities. Some systems may integrate data output to the RadResponder network described in section 2.3.1.

## 2.2 PRODUCT DESIGN VARIATIONS

While all of the products included here have the hardware components described in section 2.1, two variations in the detector component are significant and may be considered subcategories.

**Spectroscopic Systems:** In solid crystal detectors, the size of the scintillation pulse may be used to determine the incident gamma energy to identify the radioactive material. While radionuclide identification is not required for the RDD response applications addressed in this report, environmental monitors having identification capability are included here if they also measure the exposure or dose rate.

**Perimeter Systems with Removable Handheld Instruments:** Within nuclear facilities, indoor area monitoring networks used for radiation safety may extend to outdoor areas of the facility or its perimeter by use of weatherproof enclosures. Most nuclear facility monitors are designed for high radiation areas and do not measure low, natural background radiation levels applicable to this report. However, a few systems use handheld instruments that can be removed from the enclosure to conduct radiation surveys—such handheld instruments may be capable of measuring low radiation levels. Weatherproof perimeter monitors capable of measuring natural background radiation levels are included here.

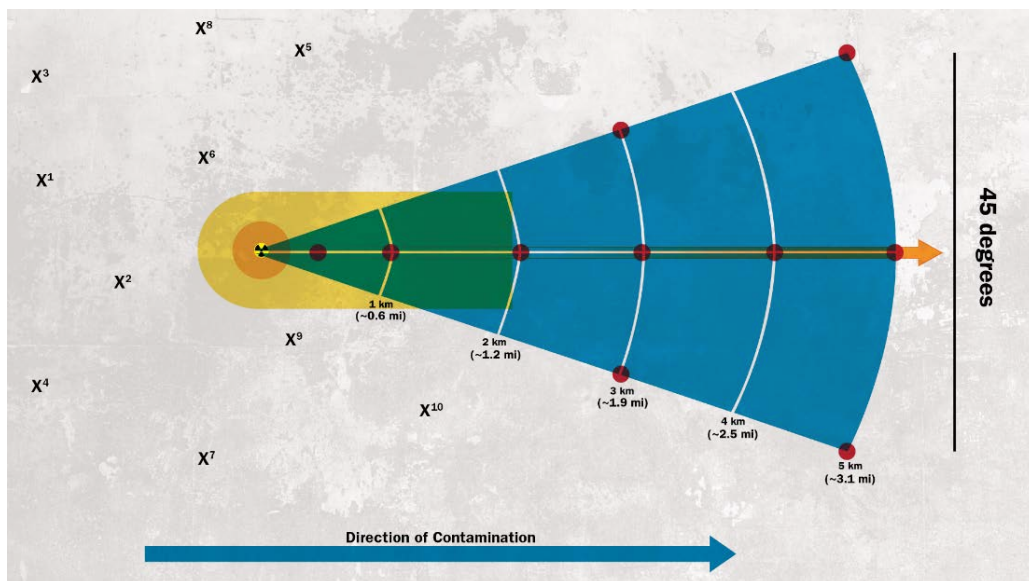
## 2.3 EMERGENCY RESPONSE APPLICATION

The primary application of interest for potential FDNY use of a fixed-position radiation monitoring system is to provide readily available, wide-area, ground-level radiation survey data consistent with their RDD emergency response plan. Emergency response is based on exposure rate measurements taken at a height of 3 feet (1 meter) from the ground to determine the potential exposure from radioactive fallout, called “groundshine.” A fixed-position system would provide real time measurements indicating the extent of the dispersal of radioactive fallout, or lack thereof, as well as confirmation of locations where radiation is not present in outlying areas. This information is critical for public messaging to identify hazard areas and provide shelter-in-place or evacuation instructions.

Under the RDD response plan guidance [9], it is recommended that handheld radiation detection instruments would be used by emergency responders to map the radiation levels near the site of a detonation. Downwind, determined by the direction of contamination, and in outlying areas, fixed radiation monitoring stations could be used to supplement handheld field measurements and provide timely data to characterize the incident and inform appropriate response actions.

The U.S. Department of Homeland Security Science and Technology Directorate’s (S&T) *Radiological Dispersal Device Response Guidance: Planning for the First 100 Minutes*<sup>v</sup> was published in November 2017. Among other operational missions, it describes missions and tactics to measure and map radiation levels in order to define hazard boundaries to establish safe evacuation routes and make health and public safety decisions. Radiation surveys are to be conducted using handheld instruments in the vicinity of the detonation site and in the nearfield at distances ranging from approximately 65 feet (20 meters) to 0.5 miles (1 kilometer) away from the detonation.

If elevated levels<sup>vi</sup> are detected at a distance of about 0.5 miles (1 kilometer) away, additional measurements are needed to determine the extent of the dispersal. As illustrated in Figure 2-2, a 10-point monitoring plan is recommended for the area in the direction of highest contamination out to about 3.1 miles (5 kilometers) from the detonation site. Additional measurements are to be made in outlying areas to confirm that radiation is not present.




**Figure 2-2 RDD Response Guidance for Radiation Survey Measurement Locations**  
*From “RDD Response Guidance: Planning for the First 100 Minutes”*

Dots in the blue shaded sector show measurement locations for conducting a 10-point radiation survey in the direction of contamination from the detonation point of an RDD (marked with the radiation trefoil within the orange circle at the left). The X’s denote additional scattered locations to collect measurements in areas outlying the incident. Data from fixed-point radiation detection locations throughout the jurisdiction and surrounding areas could be used for some of these measurements.

<sup>v</sup> Available at <https://www.dhs.gov/publication/st-frg-rdd-response-guidance-planning-first-100-minutes>

<sup>vi</sup> The RDD guidance document notes that in order to be able to identify elevated radiation levels after a detonation it is critical for local agencies to document and understand background radiation levels in their jurisdiction and how the natural background radiation reads on the specific instruments used by responders. As a baseline, the presence of dispersed radioactive material downwind may be indicated by a reading of approximately twice background.





For RDD response, it is recommended that all measurement data be uploaded to the RadResponder application and later incorporated into operational models by the National Atmospheric Release Advisory Center (NARAC). The exposure rate measurements are to be taken at a height of 3 feet (1 meter) from the ground in order to correlate with NARAC models that project dose to individuals in the area from radioactive fallout on the ground. The latitude and longitude of the measurement location is a vital parameter for the NARAC models; therefore, downwind and in outlying areas, ground-level, fixed-position radiation monitoring stations could be used to provide key data to characterize the incident and inform appropriate response actions. Rooftop-mounted systems would not correlate with this application<sup>vii</sup>.

### 2.3.1 INTEGRATION WITH RADRESPONDER

RadResponder is a software platform that provides a networked approach to collect, map, and manage radiological data during an emergency. It was developed by the Federal Emergency Management Agency, the U.S. Department of Energy National Nuclear Security Administration, and the U.S. Environmental Protection Agency (EPA). RadResponder is provided free to all federal, state, local, tribal, and territorial response organizations. RadResponder can be accessed on smartphones and tablets (iOS, Android, Windows) and via the web (<https://www.radresponder.net/>).

During an emergency, users enter radiological measurement data into RadResponder manually using either a mobile app or a computer connected to the internet. RadResponder can also accept data sent directly from an instrument, thereby avoiding potential human transcription errors, if the manufacturer has configured the equipment to do so. RadResponder can currently support the direct upload of continuous exposure rate data from fixed radiation monitoring systems<sup>viii</sup>. The RadResponder network will store the exposure rate data for up to one year, and can be set up with an alert feature that will send an e-mail, text, or push notification if the exposure rate exceeds a threshold value set by the user.

It is up to the manufacturers of radiation detection instrumentation to configure their systems for integration with the RadResponder network using the appropriate data format and authentication protocols<sup>ix</sup>. RadResponder does not specify or provide recommendations on the exposure rate averaging time or upload frequency, but it can accept data updates up to once per second. To integrate with the RadResponder Standard Fixed Monitoring Data Application Programming Interface (API), manufacturers must submit fixed monitoring data in JavaScript Object Notation (JSON) or Extensible Markup Language (XML) format. Applications must be registered to authenticate, and authentication is done via the authorization framework OAuth2. Location is required, and may be submitted as a street address or latitude and longitude coordinates in decimal format. Developers can register their application and find complete documentation of the API endpoints at <https://developer.radresponder.net> after logging in with an approved RadResponder API Client Manager account. The RadResponder website provides a list of equipment that is integrated with RadResponder, as reported by the manufacturers<sup>x</sup>.

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<sup>vii</sup> S. Musolino, Brookhaven National Laboratory, *private communication*, August 13, 2018.

<sup>viii</sup> Direct upload of radiation *spectrum* data to RadResponder from fixed monitoring systems is not currently supported.

<sup>ix</sup> Details on RadResponder described here were provided by M. Powers and Z. Green, developers at Chainbridge Technologies, *private communications*, January 2019.

<sup>x</sup> The list of integrated equipment provided at <https://www.radresponder.net/#about/equipment> may not reflect all the latest enhancements. For more information, contact RadResponder at [support@radresponder.net](mailto:support@radresponder.net).

It is recommended that agencies interested in this capability verify the implementation of this feature with the manufacturer or vendor and test the equipment before purchasing.

RadResponder recently released a new feature that enables users to mark exposure rate readings as “background,” and in 2019 it is hosting a nationwide drill for users to upload background survey information during a five-day period in order to create regional/jurisdictional maps to serve as a basis for making comparisons and observations.

## 2.4 ROUTINE MONITORING APPLICATIONS

Fixed-positon direct radiation monitoring networks are in use at the national, state, and local levels. Individual nuclear facilities conduct environmental radiation monitoring as part of their radiation control programs, and other entities may conduct environmental radiation monitoring for research and education purposes.

**National:** The EPA operates a nationwide environmental radiation monitoring network called RadNet that includes 130 locations in 50 states with monitoring stations deployed at ground level and on rooftops. While most of the locations collect samples of air, precipitation, and drinking water, in 2016 the EPA started upgrading monitoring locations to also measure the exposure rate using a GM detector<sup>xi</sup>. Currently, 39 RadNet locations measure the exposure rate, and their near real-time measurement data can be viewed at the RadNet website<sup>xii</sup>. (See <https://www.epa.gov/radnet>.) Additionally, at least one internet community posts a regularly updated map of radiation measurements from about 50 locations across the United States based on data from a variety of instruments uploaded by volunteer members of the public<sup>xiii</sup>.

**State:** Six state agencies<sup>xiv</sup> operate environmental monitoring networks in the emergency planning zone around nuclear power plants to verify compliance with regulations for public radiation dose limits and emergency preparedness. The largest state power plant radiation monitoring program in the United States is the Illinois Emergency Management Agency’s (IEMA) Gamma Detection Network (GDN), which consists of 16 HPICs placed radially at a distance of approximately 2 to 5 miles from each of Illinois’ six operating nuclear power stations<sup>xv</sup>.

For each nuclear power plant, the HPIC network data is displayed together on an analytical display developed for use by IEMA health physicists [10] [11].

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<sup>xi</sup> The RadNet stations use a custom-built GM tube with a measurement range of approximately 2  $\mu$ R/h to 200 mR/h, and continuous measurement cycle of 1 hour. (EPA also has 40 environmental monitoring systems for temporary deployment which use the Bertin Instruments GammaTracer to measure exposure rate.) D. Askren, U.S. EPA National Analytical Radiation Environmental Laboratory, private communications, April 2019.

<sup>xii</sup> In addition, the RadResponder platform now displays the exposure rate data posted at the EPA RadNet website.

<sup>xiii</sup> A company called Mineralab LLC operates a website where interested individuals with various models of radiation detectors can participate by purchasing software and connecting their detector by cable to a personal computer to automatically transmit radiation count rate data for display on a map that is updated every minute. The data is not corrected for variations in detector sensitivity, and an alert threshold is defined at 100 counts per minute (CPM) or 2.5 times a station’s baseline reading. This website suggests that municipal fire department could use their software to monitor a network of environmental radiation detectors. <http://radiationnetwork.com/>

<sup>xiv</sup> The states are New Jersey, Illinois, Alabama, Delaware, Massachusetts, and Vermont. S. Garry, U.S. NRC, private communication, August 2018.

<sup>xv</sup> Illinois has the most commercial nuclear power generation in the United States, with eleven operating reactors at six nuclear power stations. The Illinois GDN uses GE Reuter-Stokes HPICs situated near ground level as part of a remote monitoring system that includes gaseous effluent radioactivity monitors located at the reactor stacks.



The New Jersey Department of Environmental Protection (NJDEP) has operated the Continuous Radiological Environmental Surveillance Telemetry (CREST) system since the late 1980s. It consists of HPICs mounted at a height of 22 feet on telephone poles at 32 monitoring locations around two nuclear power stations<sup>xvi</sup>. Minute-by-minute radiation and meteorological information is transmitted via cellular communications to a centralized data system and also shared to RadResponder<sup>xvii</sup>.

The State of Connecticut Department of Energy and Environmental Protection is currently testing the use of a radiation monitoring system to measure radiation near the operating nuclear power station in that state. It uses a GM detector with output integrated with RadResponder. Monitoring stations will be deployed in a network of eight locations around the facility, to be located at elevated locations approximately 20 to 30 feet in the air such as attached to buildings<sup>xviii</sup>. Additionally, the Community Environmental Monitoring Program (CEMP) is a network of monitoring stations in areas surrounding and downwind of the Nevada National Security Site in Nevada, Utah, and California. The CEMP is a joint effort between the Department of Energy's National Nuclear Security Administration Nevada Field Office and the Desert Research Institute of the Nevada System of Higher Education<sup>xix</sup> and is managed by local citizens.

**Local:** Municipal-level fixed position radiation monitoring systems may be used by law enforcement or emergency management agencies. For example, the NYC Police Department operates the Radiological Emergency Management System (REMS), which consists of monitoring stations based on NaI detectors positioned on the rooftops of buildings around NYC. Since the REMS system is rooftop-mounted, the data is not directly applicable to FDNY RDD emergency response plans. However, the NYPD experience in deploying REMS provides valuable lessons learned that could be applied to the use of ground-based monitoring networks [12].

**Nuclear Facilities:** Direct radiation monitoring is a component of environmental and safety programs at nuclear power plants around the United States, which are licensed and regulated by the U.S. Nuclear Regulatory Commission (NRC). While the NRC does not require real-time direct exposure rate monitoring<sup>xx</sup>, approximately five NRC licensees do use fixed environmental radiation monitoring systems<sup>xxi</sup> for real-time measurements. Such power plants may provide responder access to radiation monitoring data at their emergency operations facilities.

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<sup>xvi</sup> NJDEP uses the GE Reuter-Stokes RSDetection HPIC. A. Pfaff, *Nuclear Emergency Preparedness, Bureau of Nuclear Engineering, New Jersey Department of Environmental Protection, private communication June 2019.*


<sup>xvii</sup> The CREST minute and hourly average data are uploaded to the RadResponder network using standard data protocols established for the Environmental Information Exchange Network, an Internet-based system sponsored by the EPA to facilitate data sharing between State and Federal partners. See <https://www.epa.gov/exchangenetwork>.

<sup>xviii</sup> Connecticut uses the Canberra EcoGamma-g radiation monitor. Additional deployments would be in the emergency planning zone at state and local facilities having emergency power and data access. J. Semancik, *Director, Connecticut Department of Energy and Environmental Protection, Radiation Division, Bureau of Air Management, private communication, February 2019.*

<sup>xix</sup> The CEMP uses pressurized ionization chambers for exposure rate measurements. See <https://cemp.dri.edu/cemp/>

<sup>xx</sup> The NRC requires licensees to conduct continuous, but not real time, direct radiation monitoring at the site boundary and offsite using passive, integrating environmental dosimeters which accumulate the radiation dose and are checked quarterly. The environmental dosimeters are located at the site boundary, 5 miles away, and at the nearest population center. The NRC also requires monitoring of effluent releases into the air and water. Annual measurement reports are posted at the NRC website and serve to verify that the NRC licensee is in compliance with public radiation dose limits.

<sup>xxi</sup> The nuclear power plants that conduct real-time direct radiation monitoring are Susquehanna, Diablo Canyon, Son Onofre, Arkansas Nuclear, and Indian Point. S. Garry, *U.S. NRC, private communication, August 2018.*




**Other:** The University of Michigan has developed a prototype radiation and weather monitoring station with the goal of providing publicly accessible radiation data and educational materials—the system uses an HPIC mounted on the roof of a two-story building [13].

## 2.5 CONSIDERATIONS

Agencies considering implementing a network of fixed-position direct radiation monitoring systems will have additional considerations beyond the choice of radiation monitor. These include:

- **Data management:** Continuously operating sensors can generate significant amounts of data. An agency using radiation monitors should plan for how data will be stored, transmitted, displayed and evaluated.
- **Redundant and secure power and communications:** Depending on the scale of an emergency or incident, it is possible that power and communications may be affected. For example, if cellular networks are overwhelmed by phone users, this communication pathway may become ineffective for data transmission by a radiation system. Further, as data may be used to guide decision-making, data security and authentication may be important for many agencies.
- **Computer security:** Any device that will be integrated into an agency’s information technology (IT) network will require vetting and approval. It is important to involve the agency’s IT department prior to device procurement to address security requirements and obtain approvals for network connections.
- **Concept of operations:** Plans must be established to monitor, evaluate, and respond to sensor information and alarms. A radiation monitoring station placed at 3 feet above ground level in proximity to vehicle and pedestrian traffic will detect elevated radiation from the routine use of radioactive material, such as people who have undergone a medical radiation treatment or the movement of vehicles containing legitimate radiological cargo. Experience from the NYC REMS network shows that monitoring stations initially positioned near ground level received nuisance alarms primarily from medical patients treated with a radioisotope. Careful consideration of placement, measurement cycle time, and alarm threshold settings can minimize nuisance alarms; however, an agency must consider how they will respond to potential alarms that are not due to an RDD incident. Additionally, spatial variations in the radiation background due to natural radionuclides in nearby building materials may be a factor to consider in setting station-specific alarm thresholds.
- **Interdiction vs. consequence management:** Although this market survey report focuses on the use of radiation detection equipment for post-incident situational awareness, fixed radiation sensors could potentially reveal the illicit movement of a radioactive source, requiring a different concept of operations not addressed here.
- **Maintenance and calibration:** As with any equipment, fixed-position direct radiation monitoring systems may require periodic maintenance, and the radiation detector may also require periodic recalibration.

## 2.6 STANDARDS/REGULATIONS



Some commercially available fixed-position direct radiation monitoring systems cite compliance with the IEC standards listed here.

*IEC 60532: Radiation protection instrumentation—Installed dose rate meters, warning assemblies and monitors—X and gamma radiation of energy between 50 keV and 7 MeV<sup>xxii</sup>.* This standard applies to monitors that are used to prevent or mitigate a minor radioactive release, or minor degradation of fuel, within the nuclear power plants/nuclear facility design basis, and to warn personnel or to ensure their safety during or following incidents that involve or result in release of radioactivity in the nuclear power plants/nuclear facility, or risk of radiation exposure.

*IEC 60846-1: (2009) Radiation protection instrumentation –Ambient and/or directional dose equivalent (rate) meters and/or monitors for beta, X, and gamma radiation—Part 1: Portable workplace and environmental meters and monitors.* This standard applies to design requirements and performance characteristics of monitors and meters for the measurement of ambient dose equivalent (rate) and directional dose equivalent (rate).

*IEC 60846-2: (2015) Radiation protection instrumentation—Ambient and/or directional dose equivalent (rate) meters and/or monitors for beta, X, and gamma radiation—Part 2: High range beta and photon dose and dose rate portable instruments for emergency radiation protection purposes.* This specifies design requirements and performance characteristics of portable or transportable meters for the measurement of ambient dose equivalent (rate) and directional dose equivalent (rate) during emergency situations.

Radiation monitoring systems that utilize removable, portable radiation detection instruments may cite other standards related to the handheld component.

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<sup>xxii</sup> The abbreviation “keV” is 1,000 electron volts and “MeV” is 1,000,000 electron volts.



## 3.0 PRODUCT INFORMATION

This section provides information on ten fixed-position direct radiation monitoring products. Table 3-1 summarizes their key specifications while additional information and photos are provided in sections 3.1 through 3.9. The products are sorted into three categories, as reflected in sections of Table 3-1: monitoring systems with non-removable detectors that report external gamma radiation exposure rate are shown in the top section, systems based on removable handheld radiation instruments are in the middle section, and products with radionuclide identification capability are shown in the bottom section. Product information presented in this section was obtained directly from manufacturers, vendors, and their websites. The information has not been independently verified by the SAVER Program.

The product information in Table 3-1 is defined as follows, listed in column order:

**Product:** The manufacturer and the name of the product.

**Price:** Approximate manufacturer suggested retail price for one unit, in U.S. dollars; quantity discounts are typically available. Where noted, the General Services Administration (GSA) price from GSA Advantage is quoted. “NI” means no information was available about price.

**Detector(s):** The type of gamma radiation sensor(s) used— cesium iodide (CsI), sodium iodide (NaI), Cerium (III) bromide (CeBr<sub>3</sub>), Lanthanum (III) bromide (LaBr<sub>3</sub>), Geiger-Mueller, (GM), or high pressure ionization chamber (HPIC). The “+” symbol indicates that one type of detector is paired with another.

**Exposure Rate Minimum and Maximum:** The exposure rate range that the product is capable of measuring. For products with dual detectors, the range spans both detectors. Since different products may display various radiation units, the range is expressed here in units of R/h to simplify product comparisons<sup>xxiii</sup>. Micro-roentgens per hour ( $\mu\text{R/h}$ ) is  $10^{-6}$  roentgens per hour, and milli-roentgens per hour ( $\text{mR/h}$ ) is  $10^{-3}$  roentgens per hour.


**Data Cycle:** The length of time over which the detector measures each exposure rate value, followed by the time elapsed between transmitting data to the central database. User-configurable intervals are indicated by a range. Where only one set of values is provided, the instrument specifications do not distinguish between data measurement and transmission cycles.

**External Power:** If the product requires an external power source (i.e., does not primarily operate on the charge of an internal battery), the required power, voltage and type of current is listed. Power is listed in watts (W), voltage in volts (V), and type of current as alternating current (AC) or direct current (DC). Where noted, external power is provided through the data communication cable (PoE or USB).

**Battery Life:** The expected battery life for devices powered by battery only. For some products, an internal backup battery is continuously charged by a cable connection to a main power line as indicated in the left adjacent column: for these products, the battery backup time in case of an external power line failure is denoted in parentheses. Expected battery life may be dependent on data cycle settings.

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<sup>xxiii</sup> Where appropriate, ranges that the manufacturer or vendor specified in dose rate have been converted to exposure rate by using the approximation  $1 \text{ R} \approx 1 \text{ rad} \approx 1 \text{ rem}$ . Specifications provided in Sv or Gy were first multiplied by 100 to convert to rem or rad, respectively.



**Solar Power:** A check mark indicates products with the option for solar power, a dash indicates this feature is not included as an option.

**Temperature Range:** The external temperature range at which the device functions.

**Enclosure:** Alpha-numeric NEMA ratings for electrical enclosures or numeric IP ratings for protection from dust and liquid ingress.

A NEMA code of 4 means the enclosure provides protection against windblown dust and rain, splashing and hose directed water, and is undamaged by ice forming on the enclosure; a following X indicates additional corrosion protection from salt water

The IP ratings are specified as a two-digit numerical code, where the first digit indicates protection from solids and the second digit indicates protection from liquids. A first digit of 6 means dustproof. For the second digit: 5 = protection from low pressure water jets from any direction; 6 = protection from high pressure water jets; 7 = protection from temporary water submersion to a depth of up to 1 meter; 8 = protection from continuous submersion in water to depth beyond 1 meter.

Where more than one NEMA rating or IP rating is listed, different options are available.

**Wired Data:** Type of cable used for real time hard-wire data export from the device. This includes Ethernet, USB, RS-232, RS-485, or DSL.

**Wireless Data:** The transmission method integrated into the monitor for real time wireless data communication. Long range wireless transmission methods are RF, Wi-Fi, cellular, and satellite. The shorter range methods are shown in parenthesis, where “(BT)” pairs to a nearby smart phone and “(IR)” is used for interactive data downloads. Note that for most products the various modules for communications must be specified as options.

**Weather Sensors:** Additional sensors available for monitoring weather parameters are indicated as “T” for external air temperature, “R” for rain accumulation, and “W” for wind speed and direction. A dash indicates that no additional sensors are offered.

**Size and Weight:** The dimensions of each product are rounded to the nearest inch. Two dimensions are provided for cylindrical shaped devices and three dimensions are provided for rectangular shaped devices. The weight is rounded to the nearest 0.1 pound and includes batteries. NI means that no information on size and weight was available.

**RadResponder:** A “✓” indicates that the product is currently available with an application that can upload measurement data to the RadResponder software platform. A “(✓)” indicates that the manufacturer is currently working on or is planning to add integration with RadResponder. A dash indicates that the manufacturer is not currently planning to integrate the output with RadResponder.

Information in the table is based on data gathered from vendors and their websites from March 2018 to February 2019.

Table 3-1 Product Comparison Matrix for Fixed-Position Direct Radiation Monitoring Systems

Product	Price	Detector(s)	Exposure Rate		Data Cycle	External Power	Battery Life	Solar Power	Temperature Range	Enclosure	Wired Data	Wireless Data	Weather Sensors	Size Weight	Rad Responder
			Min	Max											
<b>EXPOSURE RATE SYSTEMS WITH BUILT IN DETECTORS</b>															
Bertin Instruments <b>GammaTRACER XL2-2</b>	\$4,964 <sup>§</sup>	2 GM	1 µR/h	1,000 R/h	1 min – 2 h 1 min – 24 h	none	5- 10 y	✓	-4 to 122°F*	IP68	RS-232 RS-485 Ethernet	RF cellular satellite	T R W	3x23 4.4 - 6.6 lbs	✓
Bertin Instruments <b>GammaTRACER XL2 -3</b>	NI	3 GM	1 µR/h	1,000 R/h	1 min – 2 h 1 min – 24 h	none	5-10 y	✓	-4 to 122°F*	IP68	RS-232 RS-485 Ethernet	RF cellular satellite	T R W	3x23 4.4 - 6.6 lbs	✓
GE <b>Reuter Stokes RSDetection</b>	\$11,933	HPIC	0.1 µR/h	100 R/h	seconds – days	12 V DC	(48 h)	–	-40 to 131°F	IP66	RS-232 Ethernet USB	–	T R W	20x14x17 27 lbs	–
D-tect Systems <b>Rad-DX</b>	\$2,595	CsI	1 µR/h	100 mR/h	1s – 15 s 1 s – 10 s	120 V AC	(3 h)	–	-4 to 122°F	IP65	Ethernet USB	Wi-fi	–	6x6x2 0.5 lbs	(✓)
Mirion Technologies <b>EcoGamma-g</b>	\$3,737	GM	1 µR/h	1,000 R/h	1 min 1 s – 4.25 min	PoE 1.25 W USB 0.5 W	–	–	-40 to 140°F	IP67	Ethernet USB	–	T	3x18 2.4 lbs	✓
<b>EXPOSURE RATE SYSTEMS WITH REMOVABLE HANDHELD INSTRUMENTS</b>															
Mirion Technologies <b>RDS-31 Perimeter Area Monitor</b>	\$8,500	GM	1 µR/h	10 R/h	transmit at ≥ 2 sec	120 V AC DC power option	5 days	✓	-13°F to 140°F	4X IP65	Ethernet	RF cellular satellite	T	NI	(✓)
Thermo Fisher Scientific <b>RadEyeArea Monitor with PRDER</b>	\$4,210	Nal	1 µR/h	10 R/h	seconds – hours	120 V AC	(800 h)	–	-4 to 122°F	IP65	RS-232	(IR)	–	11x5x4 4.3 lbs	✓
<b>SPECTROSCOPIC SYSTEMS</b>															
Bertin Instruments <b>SpectroTRACER</b>	\$15,036 <sup>§</sup> NI \$23,034 <sup>§</sup>	2 GM + NaI 2 GM + CeBr <sub>3</sub> 2 GM + LaBr <sub>3</sub>	0.1 µR/h	100 R/h	1 min – 2 h 1 min – 24 h	24 V DC 2.5 W	option for 1-10 days	✓	-4 to 122°F -22 to 142°F	IP68 IP65	Ethernet DSL	RF Wi-fi cellular satellite	T R W	7x22 14 lbs	✓
RSI <b>RS-252D</b>	\$25,000	GM + NaI	0.1 µR/h	10 R/h	1 sec – 1 hour	115 V AC (12 V DC option)	–	–	-40 to 122°F	IP66	Ethernet	Wi-fi cellular (BT)	–	9x9x18 < 25 lbs	(✓)
Thermo Scientific <b>RadHalo FM</b>	\$24,420 to \$34,000	GM + NaI	1 µR/h	1,000 R/h	seconds – hours	110 V AC	(60 h)	✓	-22° to 122°F	IP68	Ethernet USB	RF Wi-fi cellular satellite	–	24x24x8 50 lbs	(✓)
Key: NI means that no information is available on this feature ✓ indicates that the system is equipped with corresponding feature; (✓) means that feature to be available in future – indicates that the feature not available * extended temperature range to 140°F is available § indicates price from GSA Advantage															

### 3.1 BERTIN INSTRUMENTS GAMMATRACER

The GammaTRACER detectors are housed in an aluminum cylinder: the XL2-2 model contains two GM tubes, and the XL2-3 contains a third, redundant low-dose-rate detector for increased precision at low levels and to serve as back-up if needed. Both models are capable of measuring exposure rates from 1  $\mu$ R/h to 1,000 R/h.

The GammaTRACER allows the user to select from measurement cycle options of 1, 2, 5, 10, 15, 30, 60, or 120 minutes and data transmission cycle options from 1 minute to 24 hours. Both the measurement and transmission cycles can be set to automatically switch to another cycle depending on the dose rate. Data is recorded and stored internally, up to 10,000 datasets for up to 800 days, depending on the measurement cycle. As shown in Table 3-1, data may be transmitted via Ethernet cable, radio, satellite, or cellular transmission, and redundant configurations of wireless modules are possible, such as cellular + satellite or cellular + radio. The optional radio module uses Bertin's SkyLINK and ShortLINK data transmission and receiver systems for communication at distances up to 62 miles (100 kilometers), depending on site conditions. GammaTRACER output is configured for automatic upload to RadResponder.

Data can be secured and saved in a central server and integrated into internal systems, or accessed via a web browser using web-based central data management. The associated software, called Data EXPERT, is a professional database with communication, data visualization, and analysis capabilities. Data can be accessed and configured via WebVIEW using any standard browser.

The GammaTRACER has built-in humidity and temperature sensors. All models are hermitically sealed with an IP68 rating. Other features that are optionally available are Global Positioning System (GPS) acquisition, sensors for rain, wind, and weather, a solar panel power supply, and a seismic qualified version. The GammaTRACER is designed with a battery pack that allows continuous operation for up to 10 years, depending on the data transmission mode. An optional built-in solar panel allows indefinite operation at a 10-minute measurement cycle and transmission cycle.

The manufacturer recommends a yearly calibration check, which can be conducted by the user on-site using the Gammacheck calibration tool.



*Image courtesy of Bertin Instruments*

### 3.2 GENERAL ELECTRIC RSDetection

The RSDetection environmental radiation monitor, formerly called the Reuter Stokes, has a 10-inch diameter, stainless steel, spherical high pressure ionization chamber filled with 25 atmospheres of argon gas housed in a weatherproof polycarbonate case. It is capable of measuring exposure rates from 0.1  $\mu\text{R}/\text{h}$  to 100 R/h and it is sensitive to gamma radiation energies from 60 keV to 8 MeV. A light emitting diode (LED) on the unit base indicates the current operational status.



*Image courtesy of Reuter-Stokes Baker Hughes, a General Electric Company*

The data recording interval is configurable from seconds to days. Time-stamped exposure rate data is stored internally in its 1 gigabyte (GB) memory. Data may be transmitted via a serial connection or through a router or network. The serial connection uses a dedicated RS-232 port or USB-B port to connect directly to a computer. Alternatively, an RJ-45 connector or RS-S131-EN Ethernet cable network connection is made through a router to the computer and to the Ethernet network. The cables are weatherproof on one end—the user must weatherproof the other end via a NEMA box or other enclosure.

The RSDetection configuration utility is used to control the firmware installed on the monitoring system. It is used to configure the recording interval, set alarm parameters (e.g., alarm threshold values), and conditions for sending notifications. Alarms are logged to the internal database that can be retrieved at any time using the configuration utility or user-developed software to receive and decode XML-based format. The software can be used to plot measurements in real time, or a history of measurements between specified dates or to view an event log. A network connection is required for updating the firmware.

An external 12-V DC power supply is required to operate the unit and charge the internal battery. The power consumption is typically 4 watts, and the battery automatically powers the unit for about 48 hours if external power is removed. The internal battery should be replaced approximately every 5 years. The product includes options for a rain gauge and wind speed and direction sensors.

The manufacturer does not specify a calibration period but recommends that calibration cycles be determined by the user's quality program and recommends a rapid method of checking the stability of the sensor calibration using a reproducible arrangement of a long half-life isotopic source such as Cesium-137. (To perform this check, an average value for background is computed by averaging for about 5 minutes, then placing the check source in a reproducible location, averaging the readings for about 2 minutes, and subtracting the background. If carefully performed, this method should be reproducible to within about 1 percent.)



### 3.3 D-TECT SYSTEMS RAD-DX

The Rad-DX uses a 6 cm<sup>3</sup> CsI scintillation crystal within a compact black or white weatherproof enclosure. It is available with or without a liquid crystal display (LCD) touch screen. The Rad-DX measures exposure rates from 1 µR/h to 100 mR/h and is sensitive to gamma radiation energies from 59 keV to 2 MeV.

While in a non-alarming state, the Rad-DX averages the dose rate over a configurable time period, having a default setting of 15 seconds. Data is typically transmitted every 10 seconds. In an alarm condition, however, settings automatically change to 1 second for both dose rate averaging and data transmission. There are four configurable alarm levels.

The Rad-DX can communicate through a proprietary wireless mesh connection called D-tect SensorNet, in which multiple devices can be connected at distances of up to 1,000 meters. An Ethernet or Wi-Fi connection to the internet can also be used. Each radiation monitor can be controlled and reviewed by a computer on the network or across the internet on a tablet, remote computer, or smartphone. The software display shows real time exposure rate in multiple graph formats or past event logs can be reviewed. Multiple Rad-DX units can be monitored on a wide area map. Software can be configured to send emails and text message alerts.

The Rad-DX is powered by 120 volts AC and includes a lithium ion backup battery with a 3-hour life. Annual calibrations at a calibration laboratory are recommended.



*Image courtesy of D-tect Systems*

### 3.4 MIRION TECHNOLOGIES ECOGAMMA-G

The EcoGamma-g uses two GM detectors housed within a weatherproof aluminum cylindrical enclosure to measure low and high range exposure rates from 1  $\mu$ R/h to 1,000 R/h. The detectors are sensitive to gamma energies from 30 keV to 5 MeV.

A combination of flash memory and non-volatile random access memory on the device continuously stores 180 days of data at one minute intervals, including dose rates, detector status, count rates, alarms and faults. The historical data is maintained by the device to assure that data will continue to be captured and stored even if communications have been lost. The EcoGamma-g uses hard-wired Ethernet and USB ports and built in software for two-way communication via the web or with a connected system or computer.



*Image courtesy of Mirion Technologies*

The EcoGamma-g user interface runs on the web (with Flash 10 or greater browsers) or on a desktop computer. Multiple EcoGamma-g units can be supported on a single system. The interface is used for device set up and for audible and visual alarm and fault annunciation. The interface also has data analysis capabilities, including an interactive data display of historical and current data in various forms such as histograms and tables, statistical analysis and display of time domain data, plotting of trends, saving of historical data, performance monitoring, and generating reports. An optional communication software development kit is available to allow creation of custom applications.

The EcoGamma-g is powered through an Ethernet (1.25 W) or USB (0.5 W) cable, and can be customized for backup power options. The detector housing has a threaded base that accommodates a variety of mounting options or customized modular add-ons (such as backup power). An LED operating status indicator is located at the base of the monitor; no controls are located on the instrument. It includes an embedded temperature sensor and logs temperature data to provide supplemental meteorological information.

The EcoGamma-g has self-test functionality and continuously evaluates detector performance, high voltage, communications, and critical circuit operation. Full calibration software is integrated into the unit with linearity check functions. The calibration interval is 24 months. At least two dose rates in the low and high ranges are required. Calibration data is loaded and retained by the device maintaining complete calibration history within the device.

### 3.5 MIRION TECHNOLOGIES RDS-31 PERIMETER AREA MONITORING SYSTEM

This perimeter monitoring system is based around the RDS-31 handheld survey meter, which uses a GM detector to measure dose rates from 1  $\mu$ rem/h to 10 rem/h and is sensitive to gamma ray energies from 48 keV to 3 MeV. It is enclosed in a NEMA 4X weatherproof enclosure and the handheld device can be removed to conduct radiation surveys as needed.

Measurements are stored on the handheld survey meter's internal memory. Data can be transmitted via Mirion's WRM2™ system using built-in radio transmitters wirelessly linked to a remote computer (approximately 6000 meter line of sight range). Cellular or satellite are also possible communication options. Mirion's Televue 3000 software platform facilitates communication and monitoring of multiple networked radiation monitoring stations. The Televue 3000 software platform has browser-based functionality and allows users to access data from any computer or tablet on the network. It can also be configured to work with Google Maps to display live data based on GPS coordinates. When integration with RadResponder is completed, the Televue 3000 server will be able to send data to the RadResponder network.

The RDS-31 Perimeter Area Monitoring System can accommodate various power sources including AC power, solar panels, or batteries. Backup battery life is approximately 5 days when transmitting at 5-minute intervals. Enclosure mounting options include wall, tripod, and post-mounting. Weather sensors with a serial output can be integrated into the monitoring system. An alarm strobe is available for visible and audible notification of alarms.

Annual calibration is recommended.



*Image courtesy of Mirion Technologies*

### 3.6 THERMO FISHER SCIENTIFIC™ RAD EYE™ AREA MONITOR

The RadEye Area monitor is a wall-mounted, weatherproof enclosure made of high impact plastic with a transparent door that is paired with the user's choice of portable RadEye instrument for area monitoring applications. For environmental gamma radiation monitoring, it is recommended to be configured with the RadEye PRD-ER model which uses a NaI detector to measure exposure rates from 1  $\mu$ R/h to 10 R/h for gamma energies from 60 keV to 1.3 MeV.

The duration of the dose rate measurement, and the frequency of reporting may be configured by the user from seconds to minutes to hours. Flash memory in the RadEye PRD-ER stores 1,600 data points. The count rate, exposure rate, and alarm status are transmitted via a watertight RS-232 cable connection to a personal computer. The RadEye Area Monitor is typically used as a standalone device for area monitoring at radiation facilities, however, with the Thermo Scientific Viewpoint Enterprise Remote Monitoring System, data from multiple area monitors can be centrally processed and analyzed. The Viewpoint Enterprise Remote Monitoring System allows for real-time monitoring of exposure rate and alarms, along with storage and display of historical exposure rate data.

The RadEye Area Monitor is powered via an AC/DC adapter cable and contains rechargeable batteries and built-in battery charger in case of power failure.

It can be complemented with an external alarm unit with horn and beacon signaling and can be remotely acknowledged. The alarm unit can be placed up to a distance of 10 meters (other lengths upon request) from the area monitor via cable. The additional cost of the external alarm is \$2,795.

Annual recalibration is recommended.



*Image courtesy of Thermo Scientific*

### 3.7 BERTIN INSTRUMENTS SPECTROTRACER

The SpectroTRACER can be configured with one of three scintillators, NaI, CeBr<sub>3</sub>, or LaBr<sub>3</sub>, and the optional GM module incorporates two GM tubes and allows extension of the measurement range up to 100 R/h. Various size scintillator crystals are available. The NaI comes in 3 x 3 inch or 2 x 2 inch; the CeBr<sub>3</sub> is 1.5 x 1.5 inch, and the LaBr<sub>3</sub> detector is 1.5 x 1.5 inch or 1 x 1 inch. The detectors are housed in a hermetically sealed aluminum tube and are sensitive to gamma ray energies from 30 keV to 3 MeV. The built-in computer performs spectrum stabilization, nuclide identification, calculation of exposure rate and nuclide specific activity for soil, air, or water.



*Image courtesy of Bertin Instruments*

The SpectroTRACER offers user-configurable measurement cycles of 1, 10, 30, 60, or 120 minutes and allows for two cycles simultaneously. The data transmission cycle may be selected from 1 minute to 24 hours. Two independent cycle times can be set by which the device automatically calculates and stores spectrum data and identified nuclides. This data can be stored for later download or automatically pushed to a data center. The instrument can store 2 GB of data, which is approximately equivalent to 1 year of data using a 10 minute sampling mode. The device comes standard with Ethernet/LAN and built-in FTP server and webserver. Options for data transmission include Wi-Fi, cellular, RF, and satellite. The exposure rate data output of the SpectroTRACER is configured for automatic upload to RadResponder. Data can be accessed via a web browser using web-based central data management. The associated software, called DataEXPERT, is a professional database with communication, data visualization, and analysis capabilities. Data can be accessed and configured via WebVIEW data using any standard browser. The SpectroTRACER can be powered by 10- to 24-volt (2.5-watt) DC or AC power. Optional backup batteries are available for 1 to 10 days of autonomous operation. A solar panel option is also available. Weatherproof cabinets in different sizes are available for wall or ground installation and can incorporate an alarm, a display, or sensors such as rain, wind, and temperature.



### 3.8 RADIATION SOLUTIONS INC. (RSI) RS-252D

The RS-252D integrated deployable gamma monitoring system uses a 3 x 3 inch NaI crystal paired with a GM detector housed in a weatherproof aluminum enclosure. (The GM detector may optionally be mounted external to the NaI detector housing.) The instrument measures the air kerma rate<sup>xxiv</sup> and ambient dose equivalent rate and is sensitive to gamma energies from 15 keV to 3 MeV. Measurement cycle and data transmission cycles can be set from 1 second to 1 hour.

The RS-252D can store 10,240 samples locally (i.e., greater than a year of 1-hour integrated data) and it also stores all 1-second raw samples for 24 hours. Built-in GPS provides time and location information for each data point. Data transmission is via Bluetooth, Ethernet, Wi-Fi, or cellular. The RS-252D works with an associated Data Gateway Server software suite that integrates data from multiple radiation monitors at a central computer. The software allows for plotting of monitoring stations on to publicly available, internet-based maps or on to customer-provided digital maps. The software can display the real time dose rate versus time and allows the user to view historical data. The RS-252D smartphone app also allows the user to change system parameters such as alarm threshold, with such functionality optionally password protected. The user interface is available for Android, iOS, and Microsoft Windows.

The radiation monitor is configured to be supplied by either AC or DC power; however, a power distribution unit can be added for switching between power sources. The GM detector is calibrated annually. (The system continuously monitors the spectral stabilization so that the NaI detector does not require periodic calibration.)



*Image courtesy of Radiation Solutions Inc.*

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<sup>xxiv</sup> Air kerma is a radiation quantity that measures the energy released when radiation dislodges electrons from atoms in air. It is expressed in units of rad or Gy.

### 3.9 THERMO FISHER SCIENTIFIC, RADHALO™ FIXED MONITOR (FM)

The RadHalo FM uses a 3 x 3 inch NaI spectroscopic detector paired with a GM detector in an enclosure made from polyester with a fiberglass fill. It measures dose rate from 1  $\mu\text{rem/h}$  to 1,000  $\text{rem/h}$ . The duration of the dose rate measurement, and the frequency of reporting may be configured by the user as seconds, minutes, or hours. Spectroscopic capability provides automatic identification of nuclides.

The RadHalo FM is capable of storing more than 10,000 spectra. Data is transmitted with 1,024 bit encryption. Data communication is accomplished via an Ethernet port/LAN interface or Wi-Fi (Wi-Fi can be disabled). Other communication options include radio telemetry (2.4 GHz), cellular communications, and satellite.

The RadHalo FM can be controlled from a mobile device, including managing alarms and settings. Live count rate can be streamed to the mobile device. The integration of RadHalo FM data with RadResponder is planned, with implementation driven by customer requirements.

The radiation monitor is designed to be mounted to a structure such as a wall or pole. It is powered by a lithium titanate oxide battery pack charged by connection to 120-volt AC power. A pole-mounted solar panel power is optional.

Field service support and onsite calibrations are optional. The RadHalo detector optimizes itself during use, but it is recommended that a calibration be conducted on the detector every 1 to 2 years.



*Image courtesy of Thermo Scientific*

## 4.0 VENDOR CONTACT INFORMATION

Additional information on the radiation monitoring systems included in this market survey report can be obtained from the vendors listed in Table 4-1.

Table 4-1 Vendor Contact Information

Vendor	Address/Phone Number	Website/E-Mail
Bertin Instruments	2096 Gaither Rd, Suite #230 Rockville, MD 20850 1-844-7BERTIN	<a href="http://www.bertin-instruments.com">www.bertin-instruments.com</a>
Reuter-Stokes Baker Hughes, A GE Company	8499 Darrow Road Twinsburg, OH 44087 1-844-991-0474	<a href="https://www.industrial.ai/measurement-sensing/radiation-measurement/environmental-monitoring">https://www.industrial.ai/measurement-sensing/radiation-measurement/environmental-monitoring</a>
D-tect Systems	313 West 12800 South #302 Draper, UT 84020 801-260-4000	<a href="http://www.dtectsystems.com">www.dtectsystems.com</a> <a href="mailto:info@dtectsystems.com">info@dtectsystems.com</a>
Mirion Technologies	RDS-31: MGPI, Atlanta, GA 1-770-432-2744 EcoGamma-g: Canberra Meriden, CT 1-800-243-3955	<a href="http://www.mirion.com">www.mirion.com</a> <a href="mailto:sales-smy@mirion.com">sales-smy@mirion.com</a> <a href="mailto:customersupport@mirion.com">customersupport@mirion.com</a>
Thermo Fisher Scientific	168 Third Avenue Waltham, MA 02451 800-678-5599	<a href="http://www.thermofisher.com/radiationsecurity">www.thermofisher.com/radiationsecurity</a>
Radiation Solutions Inc. (RSI)	5875 Whittle Rd. Mississauga, ON, L4Z 2H4 Canada 1-905-890-1111	<a href="http://www.radiationsolutions.com">www.radiationsolutions.com</a> <a href="mailto:sales@radiationsolutions.ca">sales@radiationsolutions.ca</a>



## 5.0 SUMMARY

This market survey report provides information on ten fixed-position direct radiation monitoring systems capable of continuous, unattended real-time measurement of the external radiation exposure rate ranging from natural background to emergency levels. These products may be applicable for use as a dispersed network of monitoring stations to provide situational awareness of the radiation environment in the aftermath of a radioactive release.

Three of the products are capable of identifying the specific radionuclide along with exposure rate. Two products incorporate removable, handheld radiation instruments installed into fixed weatherproof housings. Radiation detector technologies include GM, HPIC, CsI, NaI, CeBr<sub>3</sub>, and LaBr<sub>3</sub>. Prices vary from under \$3,000 to over \$30,000; however, individual products differ in what options are included in the standard price. Most products have options for meteorological sensors, back-up batteries or alternate power supplies, and varying data transmission solutions. The products also have a variety of software systems for display, storage, and visualization of current and historical radiation exposure rate data. Five products are currently capable of automatic upload of exposure rate data to RadResponder. Emergency responder agencies that consider purchasing fixed-position direct radiation monitoring systems should carefully research each product's overall capabilities and limitations in relation to their agency's operational needs. Agencies should also consider impacts associated with integrating equipment into their power and IT infrastructure, data management and concepts of operations, and required maintenance.

## 6.0 ACRONYMS

AC	Alternating Current
AEL	Authorized Equipment List
API	Application Programming Interface
BT	Bluetooth
CREST	Continuous Radiological Environmental Surveillance Telemetry
DC	Direct Current
DHS	U.S. Department of Homeland Security
DSL	Digital Subscriber Line
EPA	U.S. Environmental Protection Agency
FDNY	Fire Department of New York
GDN	Gamma Detection Network
GM	Geiger Mueller
GPS	Global Positioning System
GSA	General Services Administration
HPIC	High Pressure Ionization Chamber
IEC	International Electrotechnical Commission
IEMA	Illinois Emergency Management Agency
IP	International Protection
IR	Infrared
IT	Information Technology
JSON	JavaScript Object Notation
LED	Light Emitting Diode
NARAC	National Atmospheric Release Advisory Center
NEMA	National Electrical Manufacturers Association
NJDEP	New Jersey Department of Environmental Protection
NRC	Nuclear Regulatory Commission
NUSTL	National Urban Security Technology Laboratory
NYC	New York City
PIC	Pressurized Ionization Chamber
PoE	Power over Ethernet
PRD	Personal Radiation Detector
RDD	Radiological Dispersal Device
REMS	Radiological Emergency Management System
RF	Radio-Frequency
RFI	Request for Information
S&T	Science and Technology Directorate
SAVER	System Assessment and Validation for Emergency Responders
USB	Universal Serial Bus
XML	Extensible Markup Language



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