NORM & TENORM Monitoring

A Platform for Environmental Radiation Monitoring: a solution for Oil & Gas HSE challenges

CAEN SyS

Systems & Spectroscopy Division

Digitizing Nuclear Waste

The Challenge

Naturally occurring radioactive materials (NORM) and technologically enhanced naturally occurring radioactive materials (TENORM) consist of materials, usually industrial wastes or by-products enriched with radioactive elements found in the environment, such as uranium, thorium and potassium and any of their decay products, such as radium and radon. Produced water discharges and spills are a good example of entering NORMs into the surrounding environment.

Natural radioactive elements are present in very low concentrations in Earth's crust, and are brought to the surface through human activities such as oil and gas exploration or mining, and through natural processes like leakage of radon gas to the atmosphere or through dissolution in ground water. Another example of TENORM is coal ash produced from coal burning in power plants. If radioactivity is much higher than background level, handling TENORM may cause problems in many industries and transportation.

Dr. Massimo Morichi

International Qualified Radioprotection and Nuclear Measurements Expert

Radiation

IRRADIATION

External exposure

Gamma radiation from ^{226}Ra and ^{208}Tl (^{232}Th progeny)

DOSE RATE up to few μSv/h (outside pipes) up to hundreds μSv/h* (inside pipes)

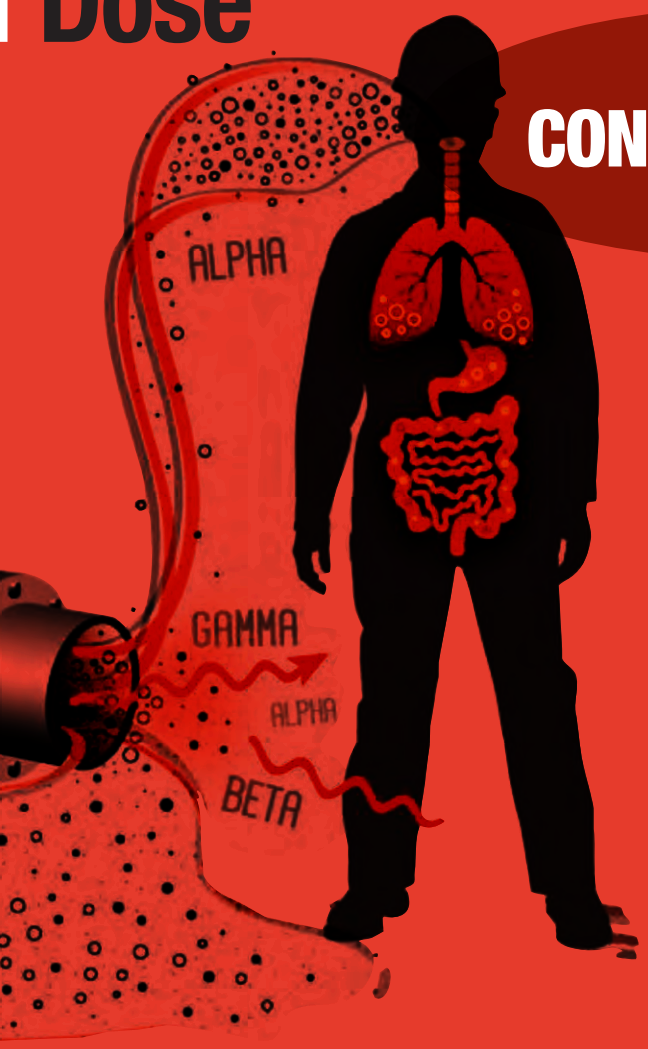
* about 1000 times greater than background!

Application of

- Minimizing the duration of exposure
- Ensuring optimum distances between any accumulation of NORM and exposed people
- Maintaining shielding material between NORM and exposed people

Normal Operational Condition

n Dose



CONTAMINATION

Internal exposure

Radionuclides ingestion and inhalation during cleaning, repairing, replacing or refurbishing phase

DOSE RATE up to 1.3 mSv/g depending on:
- AMAD (Activity Median Aerodynamic Diameter)
- Chemical forms Lung absorption

ALARA Principle

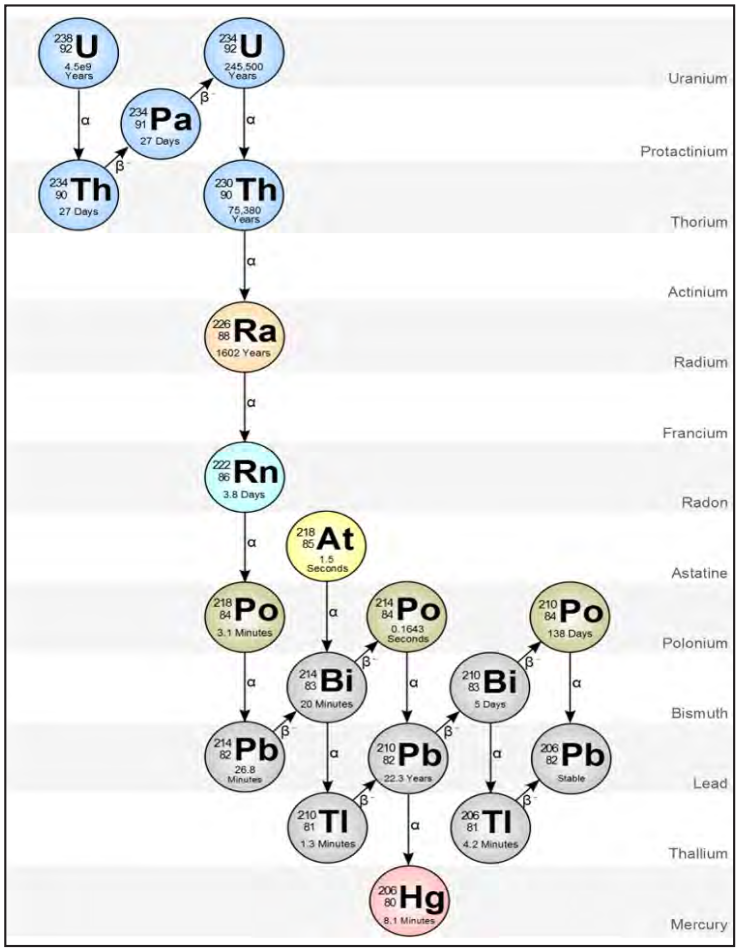
- Protective equipment (respiratory and clothing)
- No smoking, drinking, eating, chewing, etc,
- Housekeeping practises to prevent the spread of NORM contamination

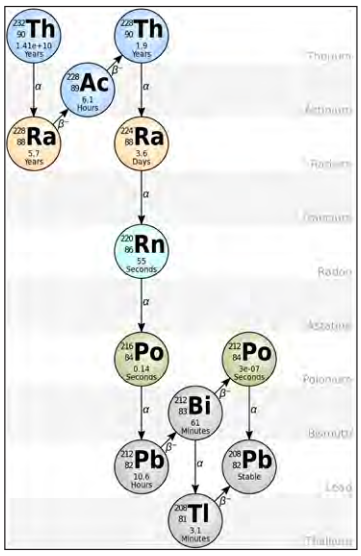
Maintenance and/or Cleaning Condition

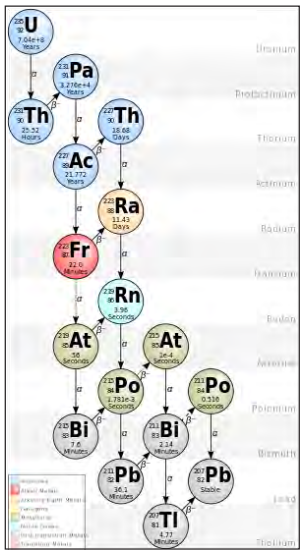
NATURAL RADIOACTIVITY

NORM (Naturally Occurring Radioactive Material)

«Materials which may contain any of the primordial radionuclides or radioactive elements as they occur in nature, such as radium, uranium, thorium, potassium, and their radioactive decay products, that are undisturbed as a result of human activities (U.S. Environmental Protection Agency)».







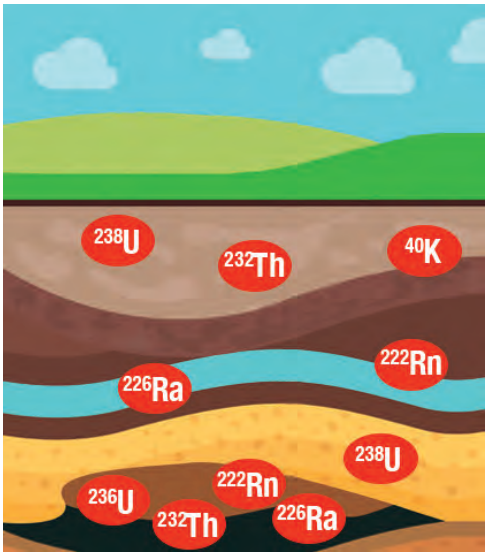
TENORM (Technically Enhanced - NORM)

«NORM that have been concentrated or exposed to the accessible environment as a result of human activities such as manufacturing, mineral extraction, or water processing (U.S. Environmental Protection Agency)»

NORM and TENORM

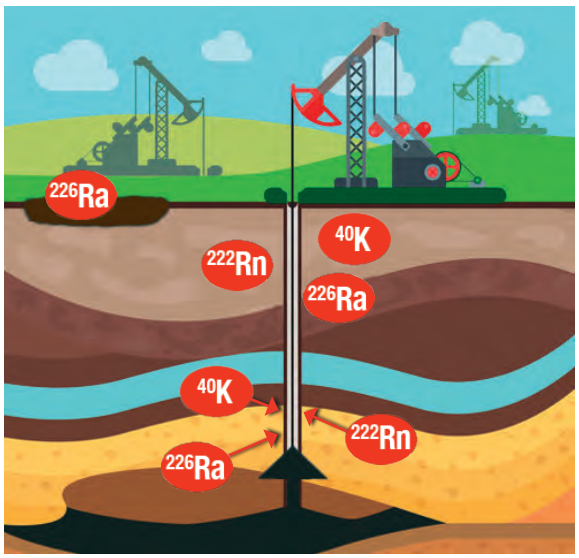
NORM

- ^{238}U and ^{232}Th decay chains and ^{40}K
- **Undisturbed** as a result of human activities
- **NOT exposed** to accessible environment



TENORM

- **NORM concentrated** and **exposed**
- ^{238}U and ^{232}Th **not soluble**
- Increase of external exposure to workers and population



(TE)NORM in Industrial Field

- Primary concern radionuclides belong to decay chains of the naturally occurring primordial radionuclides 238U and 232Th, in particular:
  - 226Ra (1620 y half-life, from 238U decay)
  - 228Ra (5,75 y half-life, from 232Th decay)
  - 222Rn (3,8 d half-life, from 238U decay)
- During drilling, a mixture of oil, gas and formation water (briny solution contained in reservoirs) is pumped to the surface
- Water is separated from the oil and gas into tanks or pits, where it is referred to as «produced water»
- 226Ra and 228Ra may remain in solution or settle out to form sludges, or form mineral scales inside pipes and drilling equipment

SCALES

- pressure and temperature drops can lead to the solubility products of Group II elements, including Radium
- following precipitation as sulphate and carbonate scales
- mainly **226Ra, 228Ra and 224Rn and their progeny**

Fly Coal Ash

CEMENT FLY ASH

nosphogypsum (fertilizer)

Oil&Gas industry

SLUDGES

- composed of dissolved solids which precipitate from produced water as its temperature and pressure change
- generally consists of oily, loose material often containing silica compounds, but may also contain large amounts of barium
- mainly **226Ra, 228Ra and 224Rn and their progeny**

DigiWaste Platform

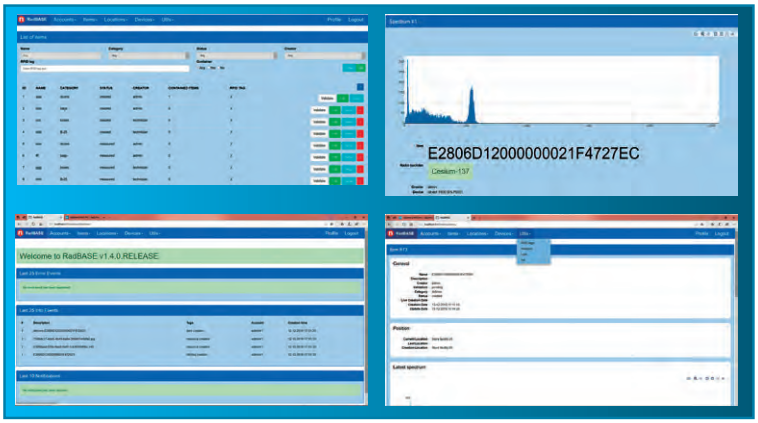
The Solution

CAEN developed a Platform providing a seamless digitization of NORM and TENORM monitoring activities. The system offers easy tracking of any NORM contaminated item as well as any location of radiological interest, thanks to the use of specialized, rugged, radiation tolerant UHF RFID tags. The data included in the RFID tags is integrated into a central database, where all relevant information associated with NORM and TENORM, monitoring activities, is securely stored and easily accessed by authorized personnel.

Fast and reliable dose assessment
Data storage and measurement formalization
Data treacebility
Quality and Transparency

Normal Operation - Pipe SCALES

Under normal operation condition, for each point measurement identified by radioprotection expert, a UHF RFID tag can be associated and the most relevant information can be stored in (e.g. dose rate value measured at 1 m from a specific pipe section or valve, date & time of the measurement, the operator who performed the measurement). Contemporarily, the entire set of data (including gamma spectrum, picture, audio note) is securely transferred to the RadBASE. In this way, RadBASE collects the results of all the periodic measurements while the information stored in the local tag memory is refreshed at any new measurement. Thanks to this approach, Site Managers or HSE managers can easily get warned of any significant difference in consecutive measurements of the same spot and monitor the correct execution of the tasks by the operators. RadBASE can then show trend plots of the measurements and automatically generate reports.

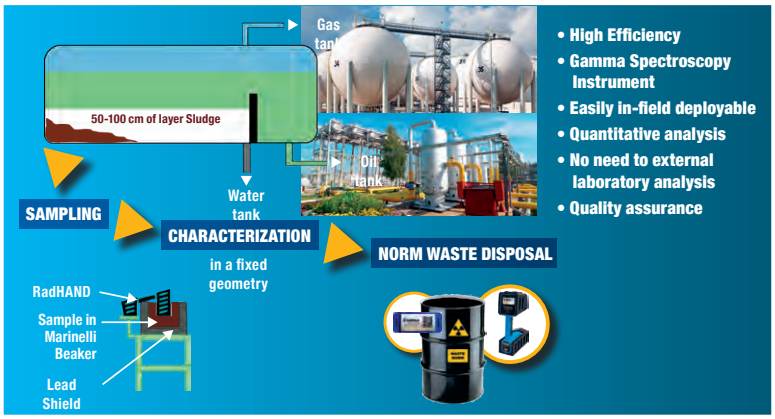


Pipe Scales Cleaning & Maintenance

Under maintenance and/or cleaning conditions, operators can look for contaminated items by means of the RadHAND instrument. By monitoring the dose rate values, in fact, operators can easily spot possible radiation contamination and immediately start the isotope identification. Once the measurement is complete, a RadRFID tag is applied on the measurement item or on the drum containing the contaminated item and the operator can read back its unique ID number either via RFID or barcode scanning. At this point, an unambiguous association between the item and the related RFID tag is established. RadHAND writes into the tag memory the most important set of information regarding the measurement, as dose rate and identified nuclides, identity of the operator who performed the measure, date and location. At the same time, the user can take a picture of the object, record a vocal note and submit all the data to the central database. Once the assessment is complete, operators dedicated to the clean-up and disposal can access the site, scan the RFID tags using the RadREAD devices and retrieve all the useful information from the database and the tags to complete their tasks.

Oil & Gas Separator Cleaning - SLUDGE

The DigiWaste Platform can be successfully applied even in the Oil & Gas separator cleaning activities. In this case, the operator can collect a sample of sludge deposited into the separator, put it in a well-known container (e.g. Marinelli beaker) and characterize it in a fixed geometry. A specifically designed lead shielding can be provided with the Platform in order to reduce the background and so allowing the operator to perform the measurement characterization on-field without the need to send the sample to an external analysis laboratory. According to the obtained results, the sample can be then properly disposed, and all the information are saved and stored into the database and digitally associated to the RFID tag. The latter is physically attached to the container (drum, bag, 1m3 container, etc.) where the NORM waste is disposed, and contains the most relevant information about the contained material. Info such as exposure rate at a certain distance, identified radionuclides, date & time of the last measurement, ID of the operator who performed the last measurement can be written into the tag.



DigiWaste Platform

The Benefits

DigiWaste Platform offers several major benefits in terms of optimization, safety, security, and compliance. These advantages are achieved by having easy, fast, and reliable access to all the information collected at any time during the D&D cycle. encies.

Data Access

Quick access to all information produced during the D&D activity cycle

Tagging

Easy identification and tracking of all RFID-tagged items

Automation

Automation inventory of tagged waste containers and report generation

Categorization

Waste bagging, caterization and group-waste monitoring

Task Assignment

Assign Operator-specific tasks and instructions

Sorting

Waste sorting according to user defined criteria

Synchronization

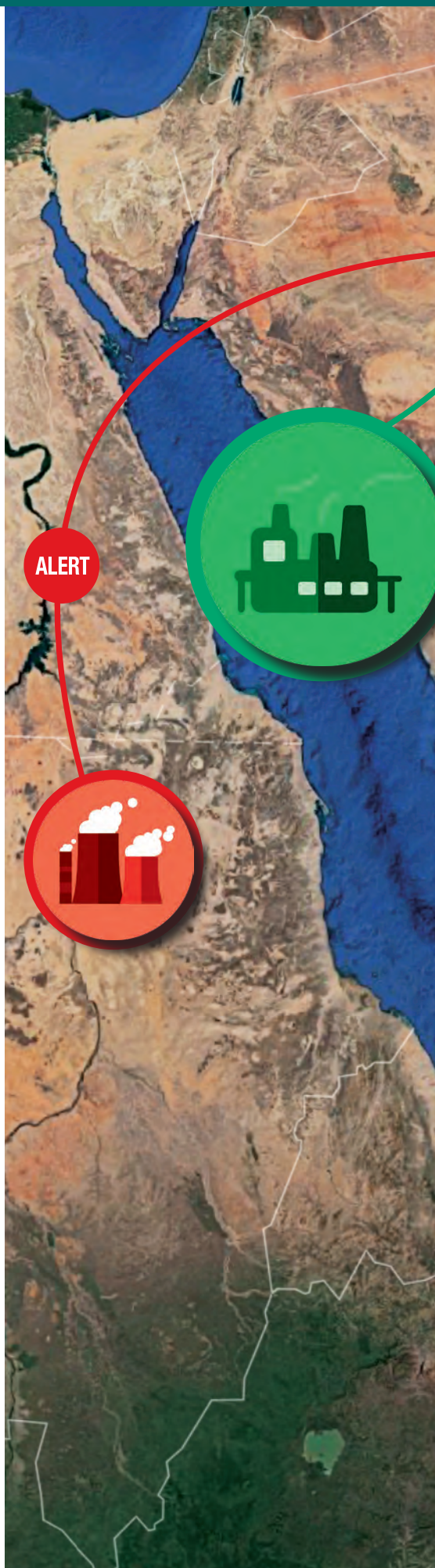
Continuous monitoring and update of waste data

Traceability

Historical data traceability of the waste

Mapping

New-site characterization with interactive mapping of sources



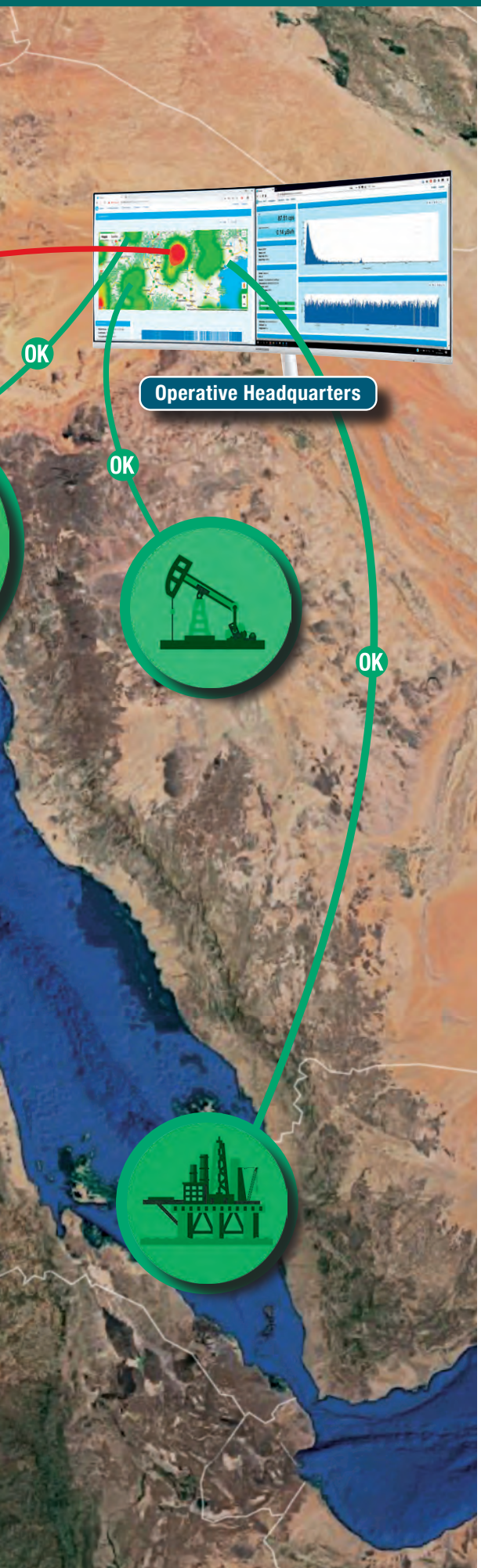
TOTAL BENEFITS

Cost Saving

Reduced Operational Time

Improve Quality Assurance

Enhanced ALARA



Data Fusion

RadBASE is a very flexible framework for data storage and management. It can merge data produced by diverse sources and run user-defined analysis for the optimization of the operational processes:

- Operators ID
- Operators categories
- Item ID
- Item category
- Item descriptions and attributes (e.g. matrix, chemicals, etc)
- Locations
- GPS and Indoor positioning
- Dose Rates
- Identified Nuclides
- Pictures
- Voice Notes
- Operational workflows and steps
- Tracking of items
- Item inventory
- Gamma Spectra
- Count Rates
- Hot Spot (Nuclide picture - position)
- Measurement Distance
- Measurement Duration

BENEFITS

NORM regulations vary beetwen countries

ICRP - IAEA - EURATOM
- Radon Gas
- Any U-decay and Th-decay member

EPA
- Radon Gas
- Surface Soil for radium
- Subsurface Soil (below 15cm)

Best Practises
Operating Safety Local Acts

CAEN

Oil & Gas NORM Monitoring Solutions

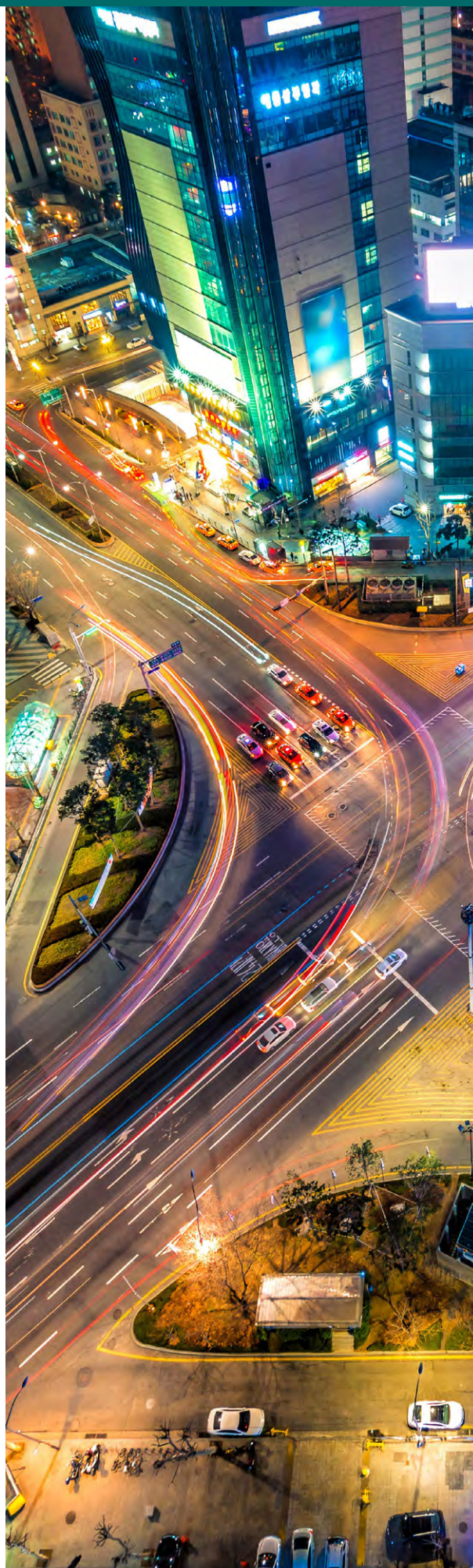
GAMON Platform & Benefits

The Solution

The GAMON Platform is a unique and innovative system, capable of empowering authorities and institutions with the ability to respond to a wide range of operational activities and complex radiological situations in a single, simple, reliable solution. It allows the operator to supervise all GAMON systems implemented in the field via a simple yet powerful web interface. The GAMON Platform is built upon a foundation of smart systems designed to be interconnected into a network of sensors. The GAMON Platform combines a cloud database application for visualization and analysis from all GAMON systems for autonomous and real-time measurements.

The GAMON Geo-Referenced web application allows operators and administrators to easily visualize network status and dataflow in real time. Additionally, by leveraging integrated data-fusion algorithms, operators can easily manage ongoing in-field procedures and reduce emergency intervention time.

The GAMON Platform relies on intelligent, cutting-edge, digital MCA electronics to perform data analysis and execute source identification algorithms. System network and integration options include GPS, WiFi, Bluetooth, and Long-Range (LoRa) wireless communication protocols as well as wired communication via USB and Ethernet. All data are automatically stored to a secure database via web (TCP/IP) protocol. The data can be read from this database via the GAMON web application included with the system.



The Benefits

The GAMON Platform can be tailored to specific customer needs, offering critical advantages and capabilities such as rapid deployment, multi-station network development and increased personnel safety and security, in compliance with international standards. These benefits are achieved by having easy, fast, secure, and reliable access to all real time measurements. Its intuitive graphical interface allows the user to fully monitor and control the detector system, guaranteeing rapid and well-founded decision making for a prompt response to emergencies.

Data Access

Local database with historical data stored on device non-volatile memory

Georeferenced System

Georeferenced information for dose rate heat map

Fast Deployment

Easy configuration of the network for security purposes

Smart Communication

Redundant interfaces and failover configuration capability

Harsh Weather Tollerant

Extended operational temperature range and enhanced spectrum stabilization

Multi-system Network

Data fusion of heterogeneous systems in the network

TOTAL BENEFITS

Multisystem Integration

Enhanced ALARA

Prompt Deployment and Connection

Cost Saving

CAEN SyS in a nutshell

CAEN Spectroscopy Division

CAEN SyS, the new Systems & Spectroscopy Division of CAEN SpA., is a leader worldwide in development of Radiation Measurements Systems and Spectroscopy Solutions, engaged with high performance operations involving Nuclear Facilities, Measurements Laboratories, Security and Safeguards Applications.

CAEN SyS Systems & Spectroscopy Division is built upon CAEN traditions of teamwork and partnership.

The CAEN Network Companies is a cluster of Companies with excellence know-how. Decades of collaboration and co-development with very large international research projects have maximized CAEN SyS capability to translate customer's needs and expectations into cost-effective and reliable solutions.

CAEN SyS enormously benefits from its foundational relationship with CAEN, a world leader in designing multi-input electronics for a wide range of radiation detectors, and nowadays is involved in several leading-edge R&D collaborative projects, to continue expanding and developing expertise in high-level electronic design, and to extend competence and skills into complementary and relevant applications for the benefit of the community.

CAEN SyS is committed to delivering exceptional nuclear measurement instrumentation, expertise and technical support, offering radiation detection instrumentation and integrated turn-key solutions with added value and operational benefit for customers, enhancing safety and security through nuclear measurements in the SECURITY, SAFETY & SAFEGUARDS and LABORATORIES areas.

For more information visit: www.caensys.com

Publications

The CORSAIR Project. Characterization of a Portable instruments for NORM Characterization of Stone Blocks; *D. Abbado, M. Alberi, E. Chiarelli, P. De Felice, A. Deserventi, M. Donati, E. Fanchini, A. Fazio, L. Fanucci, F. Giordano, G. Guiducci, A. Iovene, L. Luciani, G. Manessi, F. Mantovani, M. Marini, S.Mohsen, M. Montuschi, M. Morichi, S. Panicacci, A. Pepperosa,* K.G.C. Raptis, F. Rogo, A. Serafini, V. Strati, G. Tona; Abstract ANIMMA 2021

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A Gamma-ray Imaging Camera for NORM Radioactivity Detection; C. Altomare, L. Di Venere, E. Fanchini, F. Giordano, F. Loparco, M. Morichi, F.R. Pantaleo, P. Spinelli, L. Swiderski; ICPPA 2020 Journal of Physics: Conference Series 1690 (2020) 012065 IOP Publishing doi:10.1088/1742-6596/1690/1/012065 1

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Printed in Italy, OCTOBER 2023
Technical Documentation & Communication Office - CAEN SyS

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