Flying DEMon, a newborn startup for environmental monitoring

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Abstract—Gamma-ray spectroscopy and dosimetry are complementary techniques used to locate and identify radioactive sources containing gamma-ray-emitting radioisotopes. Gamma-ray spectroscopy is extensively studied for various applications across multiple fields, including homeland security, environmental radioactivity monitoring, tackling illegal trade of radioisotopes, and medical sciences.

Introducing our newly established startup, Flying DEMon s.r.l., comprised of young researchers, academic professors, and backed by university support. Our venture aims to advance project development, leveraging the grant awarded through the E-TEC2 contest initiated by ENAC. The team will showcase their comprehensive work plan, highlighting the project’s competitiveness and self-sustaining potential.

The objective of our startup is to harness cutting-edge technologies in the field of gamma spectroscopy and dosimetry, adaptable for deployment via Unmanned Aircraft Systems (UAS). This innovation holds significant promise for environmental monitoring, facilitating tasks such as pinpointing widespread radioactive sources or identifying concealed and hard-to-reach nuclear waste. Additionally, this advancement holds potential for applications in military, security, and industrial oversight.

Our research focus primarily revolves around real-time and rapid gamma-ray analysis in open-field environments. Our group not only supports the core project objectives but also enables its applicability in diverse and non-traditional sectors, such as Agritech.

Index Terms—Gamma spectroscopy, radioactivity dosimetry, environmental monitoring, startup

I. INTRODUCTION

The phenomenon of natural environmental radioactivity is an intricate and pervasive aspect of the Earth’s composition that has captivated the attention of scientists, researchers, and environmentalists alike. From the moment our planet came into existence, various radioactive elements have been an integral part of its geological and biological makeup. These naturally occurring sources of radiation emanate from elements like uranium, thorium, and potassium, which are found within the Earth’s crust, oceans, and atmosphere. While often associated with potential health risks, natural environmental radioactivity also plays a fundamental role in shaping landscapes, influencing ecosystems, and contributing to the dynamic balance of the planet’s natural processes. Natural radioactivity can also be influenced by human activities, and its natural concentration can change in the vicinity of urbanized centers, industrial facilities, extractive mines, and other human-altered environments. One of the most compelling environmental issues the world is poised to confront in the twenty-first century is the disposal of nuclear waste. The remarkably prolonged half-lives of associated environmental hazards of nuclear waste have rendered its satisfactory disposal a seemingly insurmountable challenge. Radioactivity monitoring encompasses the meticulous surveillance of both man-made radioactive sources and naturally occurring environmental radioactive sources. Among the latter, a distinction is drawn between Naturally Occurring Radioactive Materials (NORM) and their evolved form, Technologically Enhanced NORM (TENORM). NORM encompasses materials harboring primordial radionuclides and natural radioactive elements like radium, uranium, thorium, and potassium, along with their radioactive decay progenies such as radium and radon. Importantly, these materials remain undisturbed by human activities, maintaining their natural state as outlined by Chakl 2008 [1]. TENORM, on the other hand, materializes as a byproduct of industrial processes that exploit natural resources, spanning fields such as coal combustion, fertilizer production, metal and oil processing, and mineral ore extraction. The International Atomic Energy Agency (IAEA), International Commission on Radiological Protection (ICRP), and Rahman 2012 [2]–[4] have collectively emphasized the significance of TENORM in this context. The crux of concern arises when the presence of unwanted substances surpasses the concentrations of the environmental radioactive background radiation levels, a situation elucidated by Chapman [5].

Italy has meticulously crafted a comprehensive legal framework to regulate and monitor radioactive environmental levels, encompassing a range of statutes and regulations that underscore the nation’s commitment to public health and environmental safety. These legal provisions, aligned with international agreements and tailored to address national priorities, establish a robust system for tracking and managing radioactive substances in the environment.

Key among these laws is Legislative Decree No. 230/95, 979-8-3503-3694-8/23/531.00 ©2023 IEEE

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which transposes European Union directives on radiation protection into Italian law. This decree outlines the fundamental principles and requirements for the protection of workers, the general public, and the environment from ionizing radiation. It sets forth guidelines for the assessment of exposure levels, the establishment of dose limits, and the licensing and supervision of activities involving radioactive materials.

Legislative Decree No. 152/2006, commonly referred to as the Environmental Code, is another pivotal statute. It addresses environmental protection comprehensively and includes provisions specifically related to the monitoring of radioactivity in air, water, soil, and food. This decree establishes the legal basis for regulating radioactivity levels from various sources, including both naturally occurring and technologically enhanced radioactive materials.

The “Ispettorato Nazionale per la Sicurezza Nucleare e la Radioprotezione” (ISIN), stands as a cornerstone of Italy’s commitment to ensuring the highest standards of radiological safety and protection. Operating under the purview of the Ministry of Health, ISIN plays a pivotal role in overseeing and regulating activities related to nuclear safety, radiological protection, and the management of radioactive substances.

ISIN’s responsibilities encompass a wide spectrum of activities, including the regulation and supervision of nuclear facilities, radiological practices, and the transport of radioactive materials. Through rigorous inspections, audits, and assessments, ISIN ensures compliance with safety standards, thus mitigating potential hazards associated with ionizing radiation.

Moreover, ISIN collaborates closely with other regulatory bodies such as the Regional Environmental Protection Agencies (ARPA) and the National Institute for Environmental Protection and Research (ISPRA). This synergy facilitates comprehensive radiological monitoring and response across various environmental compartments.

On the other side, the “Agenzia Regionale per la Prevenzione e la Protezione dell’Ambiente” (ARPA) in upholding rigorous standards of radiological safety and environmental preservation. These agencies, distributed across different regions of Italy, are entrusted with the crucial responsibility of monitoring, assessing, and managing radioactivity levels in various environmental compartments. Through a combination of legal mandates, scientific expertise, and collaboration, ARPA agencies contribute significantly to safeguarding public health and maintaining the integrity of the environment.

Leveraging their specialized knowledge and advanced monitoring techniques, ARPA agencies systematically evaluate radioactivity levels in air, water, soil, and food, leaving no stone unturned in their pursuit of comprehensive environmental radiological control. They conduct routine surveillance, respond swiftly to emergent radiological incidents, and provide accurate, timely information to the public. By collaborating with institutions like the National Institute of Health (ISS), they contribute to Italy’s collective efforts in ensuring the safety of both its citizens and the environment.

A. Gamma spectroscopy and dosimetry

Two primary approaches can be employed to address the challenges posed by the detection, quantification, and identification of radioactive materials in the environment. Gamma spectroscopy is a powerful analytical technique used to identify and quantify gamma-ray emitting radioactive isotopes present in various samples. Gamma rays are a type of ionizing radiation emitted during radioactive decay processes. These rays have high energy and can penetrate materials, making them useful for studying the composition of substances, ranging from environmental samples to industrial materials. Dosimetry is the measurement and assessment of radiation doses received by living organisms, objects, or the environment. It plays a crucial role in understanding and managing the potential health risks associated with exposure to ionizing radiation. There are several types of dosimetry, including personal dosimetry, environmental dosimetry, and medical dosimetry. Both gamma spectroscopy and dosimetry are integral to understanding, monitoring, and managing the potential risks and benefits associated with ionizing radiation in various contexts. They contribute significantly to ensuring the safety of individuals, the environment, and medical practices that involve exposure to radiation.

II. A newborn Start-Up

Flying DEMon s.r.l. (Drone for Environmental Monitoring, see logo in Fig. 1) was established in 2023 as an innovative startup by a group of researchers from INFN (National Institute for Nuclear Physics), following the successful attainment of a project from the “Ente Nazionale per l’Aviazione Civile” known as #ETEC-Second Edition. This project aims to provide funding for startups and small medium enterprises. Subsequently, the company was registered as an innovative startup with the Chamber of Commerce.

The company’s primary objective is to deliver services in the field of detection and environmental monitoring of radioactive elements. During its early months, the startup received accreditation as a spinoff of the University of Bari (Uniba). The founders’ team (see Fig. 2) possesses extensive experience and expertise garnered from years of research and development activities within the field of astroparticle physics and high-energy experiments conducted in collaboration with INFN (National Institute for Nuclear Physics), the University of Bari, and the “Politecnico di Bari”.

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**Fig. 1.** Flying DEMon logo.
Fig. 2. Flying DEMon team.

### III. BUSINESS MODEL

The company’s main revenues will be generated from monitoring services offered to both public entities and private enterprises. The cost of these services will be estimated based on the required flight hours and subsequent data processing, with the issuance of a measurement report interpreted by our radioactivity experts. Specifically, it is estimated that a total of three working hours for two operators will be needed for data processing and generating final results for the client for each actual flight hour. The service cost for the client will be calculated in Flying Hours, FH (1 FH = 1 actual flight hour + 2 hours of processing for two operators) (see Fig. 3). Additionally, the consultancy will offer the possibility of issuing certification by a qualified expert. A cost of 300 €/FH anticipated in addition to fixed costs for instrument maintenance, travel expenses, etc.

#### A. Market

Flying DEMon s.r.l. offers its services to both public entities responsible for environmental radioactivity control (see “Introduction”) and private companies that need to maintain their radioactivity levels below legally established limits, ensuring a safe working environment for the long- and short-term health of their employees. Our service is designed to provide rapid analysis of extensive or difficult-to-access areas, delivering quick results and accurate reports of the obtained data. Some examples of potentially interested public entities include the “National Inspectorate for Nuclear Safety and Radioprotection” (ISIN), which currently measures radionuclide activity deposited in the soil by collecting soil samples and analyzing them in the laboratory. This process is somewhat imprecise as it doesn’t account for potential accumulation points due to landscape configurations. The utilization of drone surveys would allow for an initial analysis of large areas in these zones, providing a more reliable assessment of the executed sampling. This measurement is typically performed periodically by the entity. The map on the right in Fig. 4 illustrates the national territorial coverage of Cs-137 activity deposition measurements, highlighting limited coverage especially in central and southern Italy [9].

![Fig. 3. Explanatory pie chart illustrating the company’s expenditure, earnings, and reinvestment model.](image)

![Fig. 4. Left: Gamma network central control spots of the ISIN. Right: Annual concentration of Cs-137 activity in ground deposition. [9]](image)

The second type of clientele that the company targets are the businesses that are required by law to monitor the levels of radioactivity in their work environments. The service will be offered to consortia (for example, those in the metalworking or agri-food sectors), proposing the issuance of certifications mandated by law, provided by qualified experts. This way, customers will receive a certification with legal value. The list of activities that are legally required to monitor radioactivity is connected to the reuse and disposal of certain materials, such as processed and semi-processed metals, and is identified by a CER code (“Codice Europeo dei Rifiuti” the European Waste Code). Some of the companies currently involved in waste disposal related to these materials in Apulia have been identified: Oikos [10] s.r.l., Glob Eco [11] s.r.l., Ecologica [12] s.r.l., etc. Glob Eco s.r.l., headquartered in Molfetta (BA) in Apulia (Italy), specializes in environmental services and is focused on the collection and treatment of special waste. Oikos s.r.l., based in Bari, is a well-established service company in the environmental sector, providing consultancy, remediation, and waste disposal services. Ecologica s.r.l. offers customers a wide range of waste disposal services for various types of waste.

### IV. SERVICES OFFERED

The company provides customers with a comprehensive range of services, starting from design and planning, all
the way to addressing issues related to radioactivity in specific areas. Our services encompass conducting surveys using drones to cover extensive zones “in-situ” and in “real-time”. The ultimate outcome delivered by our team is a meticulous report of the analyzed area. This report includes identification of potential radioactive hotspots, quantitative assessment of radiation exposure (dosimetry), analysis of gamma spectra, and expert interpretation of the data. Additionally, if necessary, we can provide a certification issued by a qualified secondary level radioactivity expert.

A. Monte Carlo simulation and Digital twin

Each specific customer requirement is thoroughly examined through the utilization of a simulation software based on GEANT4 (Fig. 5), custom-developed by Flying DEMon team members [6], [7]. This enables us to professionally determine the optimal measurement plan for every customer request, considering the minimum dosimetric and spectroscopic thresholds required. This approach streamlines the verification process, ensuring efficient identification of potential radioactive sources within the analyzed area of interest.

B. Spectroscopy and dosimetry service

We employ both commercial tools and innovative instruments, designed and crafted by us [8], utilizing crystalline scintillators for conducting on-site and laboratory dosimetric analyses. Furthermore, we possess specialized equipment for radioisotope measurements using gamma spectroscopy of samples. This enables the detection of any traces of radioactivity surpassing natural radioactivity levels and facilitates the identification of present radioisotopic sources (see Fig. 6).

C. Radiometric survey “in-situ”

Our company specializes in the field of environmental monitoring services for the detection of gamma-emitting radioactive sources. We harness innovative and advanced technologies, such as drones equipped with highly sensitive detection equipment (see Fig. 7), to conduct precise and detailed surveys. Our goal is to ensure a safe and operational environment for both businesses and the public sector. We provide customized solutions to meet the specific needs of each client, delivering accurate and timely assessment of harmful radiation presence. Our experience and expertise allow us to effectively identify and map radioactive sources, contributing to responsible environmental management and enhanced community safety.

D. Agritech 4.0

The term “Agritech 4.0” refers to the application of Industry 4.0 technologies in the agricultural sector. Industry 4.0, also known as the fourth industrial revolution, is characterized by
the widespread use of advanced digital technologies to automate and optimize production processes. Flying DEMon employs dosimetric spectroscopic techniques using UAS drones to create maps of agricultural land and study soil composition and hydration uniformity (see Fig. 8). Low-energy gamma ray measurements, generated by radionuclides like radon, can serve as secondary indicators of soil composition characteristics, thus facilitating the assessment of suitable areas for new crops. Furthermore, in conjunction with other sensors, these measurements can help address and understand the causes of unproductive or underutilized zones.

REFERENCES


[10] Oikos s.r.l. “https://www.oikosambiente.it/”
