



**HAL**  
open science

## Metrology supporting the European regulation for radiation protection

João G Alves, Margarida C Caldeira, Annette Röttger, Behnam Khanbabaee, Christelle Adam-Guillermin, Teemu Siiskonen, Miloš Živanović, Amra Šabeta, Denis Glavič-Cindro

► **To cite this version:**

João G Alves, Margarida C Caldeira, Annette Röttger, Behnam Khanbabaee, Christelle Adam-Guillermin, et al.. Metrology supporting the European regulation for radiation protection. Radiation Protection Dosimetry, 2023, 200 (2), pp.155-163. 10.1093/rpd/ncad289 . irsn-04352600

**HAL Id: irsn-04352600**

**<https://irsn.hal.science/irsn-04352600v1>**

Submitted on 19 Sep 2024

**HAL** is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.



Distributed under a Creative Commons Attribution 4.0 International License

# Metrology supporting the European regulation for radiation protection

João G. Alves<sup>1,2,\*</sup> , Margarida C. Caldeira<sup>2</sup>, Annette Röttger<sup>3</sup>, Behnam Khanbabaee<sup>3</sup>, Christelle Adam-Guillermin<sup>4</sup>, Teemu Siiskonen<sup>5</sup>, Miloš Živanović<sup>6</sup> , Amra Šabeta<sup>7</sup> and Denis Glavič-Cindro<sup>8</sup>

<sup>1</sup>Universidade de Lisboa (UL), Instituto Superior Técnico (IST), Departamento de Engenharia e Ciências Nucleares, Centro de Ciências e Tecnologias Nucleares, EN 10 km 139,7, Bobadela LRS 2695-066, Portugal

<sup>2</sup>UL-IST, Laboratório de Proteção e Segurança Radiológica, Centro de Ciências e Tecnologias Nucleares, Portugal

<sup>3</sup>Radiation Protection Dosimetry, Physikalisch-Technische Bundesanstalt (PTB), Bundesallee 100, Braunschweig D-38116, Germany

<sup>4</sup>Institut de Radioprotection et de Sûreté Nucléaire (IRSN), Centre de Cadarache - Bât 159, p. 108 - BP3, Saint Paul Lez-Durance 13115, France

<sup>5</sup>Sateilyturvakeskus (STUK), Jokiniemenkuja 1, Vantaa 01370, Finland

<sup>6</sup>Department of Radiation and Environment Protection, University of Belgrade, Vinča Institute of Nuclear Sciences (VINS), National Institute of the Republic of Serbia, Mike Petrovića Alasa 12-14, Vinča, Beograd 11351, Serbia

<sup>7</sup>Institut za mjeriteljstvo Bosne i Hercegovine (IMBiH), Branilaca Sarajeva 25, Sarajevo 71000, Bosnia and Herzegovina

<sup>8</sup>Department of Low and Medium Energy Physics, Institut "Jožef Stefan" (IJS), Jamova cesta 39, Ljubljana 1000, Slovenia

\*Corresponding author: jgalves@ctn.tecnico.ulisboa.pt

## Abstract

The European Association of National Metrology Institutes (EURAMET) within its research programme European Metrology Programme for Innovation and Research (EMPIR) funded project EMPIR 19NET03 supportBSS that contributes to the establishment of a European Metrology Network (EMN) for Radiation Protection (RP). The EMN-RP was established in September 2021 with the intent to work as a meeting point for the metrology community and all stakeholders in the field of ionising radiation regulation, thus providing quality assurance for measurements in each of the exposure situations contemplated in the European Legislation. Within project EMPIR 19NET03, work package 3 aims at the preparation of a Strategic Research Agenda (SRA) by identifying the metrology needs to support the European legislation and regulation in Radiation Protection and of two Roadmaps for metrology services, one under the European Council Directive 2013/59/EURATOM and the other under the EURATOM Treaty. Following a Gaps Workshop held in September 2020 and a second internal workshop that took place in April 2022, a questionnaire was prepared for distribution to the stakeholders, e.g. RP platforms and authorities, academia, industry, among other, together with an accompanying paper. In this paper, the authors present the state of the art of European legislation in RP, address the importance of metrology, the practices and activities that need metrology to meet the requirements set in the regulations, emphasise the need for quality assured measurements in all fields, highlight the stakeholders contributions in their specific area and show their vision of the EMN-RP.

## Introduction: aim and vision of the European Metrology Network (EMN) for radiation protection

Radiation protection is a core issue for the society. This is reflected by specific European regulations addressing the public, emergency, occupational and medical exposure to ionising radiation. The aim is to protect European citizens and biota against the danger from ionising radiation by restricting the exposure. The success of this measure depends on the quality of data, mainly

the quality of measured data. Only reliable data assures that limits and reference levels are respected. Such data should be produced by procedures and measurements that are quality assured. This implies that only measurement devices that are truly suitable for the purpose of measurement in the respective exposure situation should be used.

*The EMN for radiation protection aims to provide quality assurance for all these measurements in the respective exposure situation addressed under the European legislation<sup>(1)</sup>.*

Received: June 20, 2023. Revised: October 19, 2023. Accepted: November 3, 2023

© The Author(s) 2023. Published by Oxford University Press.

This is an Open Access article distributed under the terms of the Creative Commons Attribution Non-Commercial License (<https://creativecommons.org/licenses/by-nc/4.0/>), which permits non-commercial re-use, distribution, and reproduction in any medium, provided the original work is properly cited. For commercial re-use, please contact [journals.permissions@oup.com](mailto:journals.permissions@oup.com)

Limits and reference values for ionising radiation have been implemented for all kind of exposure scenarios: for life, work, in emergency, in environmental, technical and medical applications and for special intake processes like inhalation or ingestion. The challenge is to assure that the limits and reference levels are respected, and that the measurements are performed using measurement devices that are calibrated and tested for the adequate conditions of use and with acceptable measurement uncertainty. The vision of the EMN is to provide the capacity to implement quality assurance traceable to the International System of Units (SI) (2019)<sup>(2)</sup> for all scenarios addressed by the regulation in the upcoming years. As this is an enormous task with limited funds, staff and infrastructure, this will only be possible by smart specialisation.

*We are convinced that within this process, radiation protection will reach a new quality level in Europe and the smart specialisation will give members and partners the necessary support for their existing or planned business model in order to provide services in radiation protection.*

### State of the art in regulation

The European Council Directive 2013/59/EURATOM<sup>(3)</sup> laying down the Basic Safety Standards (BSS) for protection against the dangers from exposure to ionising radiation, is the main European regulation on Radiation Protection. The BSS Directive is transposed by every European Union member state and therefore is or has been recently enforced.

The EURATOM Treaty<sup>(4)</sup> establishes the European Atomic Energy Community (EURATOM) and its main aims are: to promote research and dissemination of technical information; to set uniform safety standards to protect the public and industry workers; to facilitate research; and to ensure civil nuclear materials are not diverted from peaceful use. The EURATOM Treaty also promotes harmonisation and the periodic communication of measurement results to the European Commission and to the public.

Several Council Directives complement the BSS on specific domains and require the measurement of different quantities to ensure compliance with the regulations. The objectives of these legislations cover, for instance, water for human consumption<sup>(5)</sup>, contamination of food and feed stuff following an accident or radiological emergency<sup>(6)</sup>, radiological surveys of the environment, to name a few (see Table 1 in topic 5). Other relevant documents prepared by the European Commission also require the assessment of parameters: Radiation Protection 162<sup>(11)</sup> for medical equipment, Radiation Protection 160<sup>(9)</sup> and Radiation Protection 188<sup>(10)</sup> on the technical recommendations for monitoring individuals exposed to external and internal radiation, respectively.

At the same time, the International Atomic Energy Agency (IAEA) issued a document equivalent to the BSS, the General Safety Requirements Part 3: Radiation Protection and Safety of Radiation Sources: International Basic Safety Standards<sup>(13)</sup>. The implementation and enforcement of the IAEA BSS is not compulsory, however, member states that benefit from the IAEA's technical cooperation programmes should comply with the IAEA BSS. Complementary documentation produced by the IAEA, e.g. Safety Standards and Safety Guides, among other, provide guidance on the implementation of the BSS.

The BSS defines three exposure situations (planned, existing and emergency), categories of exposure (occupational, public and patient in medical exposures) and three principles of radiation protection: justification, optimisation and dose limitation. The first two principles apply to all exposure situations, but dose limitation is only applicable to planned exposure situations that derive from practices and activities. The exposure should not surpass the dose limits defined in terms of the Effective Dose and Equivalent Dose established for the exposed workers and members of the public.

In the case of existing and emergency situations, dose limitation no longer applies, as it might be difficult or impossible to control. Reference levels for the public and workers are used instead. Reaching these levels should trigger actions.

### Contribution from metrology

National Metrology Institutes (NMI) and Designated Institutes (DI) in the field of Ionising Radiation (IR) realise the reference fields used for the definitions of the basic physical quantities relevant for dosimetry (e.g. absorbed dose, air kerma, fluence and activity), based on dosimetry and activity standards.

The white triangle in Figure 1 points towards medical exposure and includes a set of characteristics of measurement relevant for all practices and activities: traceability, accuracy, uncertainty (and the detection limit). 'Traceability of measurement' means the measurand can be related to the primary standard (and ultimately to the Bureau International des Poids et Mesures (BIPM)) through a traceability chain. 'Accuracy of measurement' means how close the measurement is to the correct value. 'Precision of measurement' indicates how much the measurement results are scattered. 'Uncertainty of measurement' provides a quality of the measurement as it represents the knowledge on the measurement system, informing that the measured value can lie in the range  $M \pm u(M)$ . The triangle points to medical exposure suggesting the lower the value of  $u(M)$ , the uncertainty, the better. The 'detection limit' represents a value over which a reliable measurement

**Table 1.** Documents of the European Commission and the European Atomic Energy Community which have needs to be supported by metrology: reliable measurement results are the base for compliance with this regulation, directives and technical recommendations

Topic or title	Document	Exposure situation	Category of exposure	Specific quantity named with link to metrology
Water for human consumption	Council Directive 2013/51/Euratom <sup>(5)</sup>	Planned	Public	Activity concentration
Contamination of food and feedstuff following an accident or radiological emergency	Council Regulation 2016/52 <sup>(6)</sup>	Emergency	Public	Activity concentration
Radon reference levels, Construction materials	Council Directive 2013/59/Euratom <sup>(3)</sup>	Existing, Planned	Workers and public	Activity concentration
Protection of the health of workers and public against the dangers of ionising radiation	Council Directive 2013/59/Euratom <sup>(3)</sup>	Existing, Planned, Emergency	Workers, public and environment	Activity concentration, $H_p(d)$ , $H^*(d)$
Safe management of spent fuels and radioactive waste	Council Directive 2011/70/Euratom <sup>(7)</sup>	Planned	Workers and public	Activity concentration, $H^*(d)$
Framework for nuclear safety of nuclear installations	Council Directive 2014/87/Euratom <sup>(8)</sup>	Planned, Emergency	Workers and public	Activity concentration, $H^*(d)$
Licensing requirements for the release of radioactive effluents into the environment	Council Directive 2013/59/Euratom <sup>(3)</sup>	Existing, Planned	Workers, public and environment	Activity concentration, $H^*(d)$
National radiological surveys of the environment	Based on articles 35 and 36 of Euratom Treaty <sup>(4)</sup>	Existing, Planned, Emergency	Public and environment	Activity concentration, $H^*(d)$
Technical Recommendations for monitoring workers to external radiation	EC: Radiation Protection 160 <sup>(9)</sup>	Planned	Workers	$H_p(d)$ , $H^*(d)$ , $H'(\Omega, d)$ for estimate of $E$ , $H$
Technical Recommendations for monitoring workers to internal radiation	EC: Radiation Protection 188 <sup>(10)</sup>	Planned	Workers	Intake, activity concentration, for estimate of $E$ , $H$
Criteria for Acceptability of Medical Radiological Equipment used in Diagnostic, Radiology, Nuclear Medicine and Radiotherapy	EC: Radiation Protection 162 <sup>(11)</sup>	Planned	Workers and patient	Quality control of equipment, several quantities

Note:  $E$  effective dose;  $H$  equivalent dose;  $H_p(d)$  personal dose equivalent;  $H^*(d)$  ambient dose equivalent,  $H'(\Omega, d)$  directional dose equivalent. For biota, ICRP Publication 136<sup>(12)</sup> recommends the use of absorbed dose and related quantities such as the dose coefficients, among other.

can be performed above the general noise or background. Below that value, the measurement cannot be trusted.

The link between metrology and regulation is set by the white arrows from the established quantities in terms of which measurements of the operational and basic physical quantities are performed and used to estimate the limiting quantities.

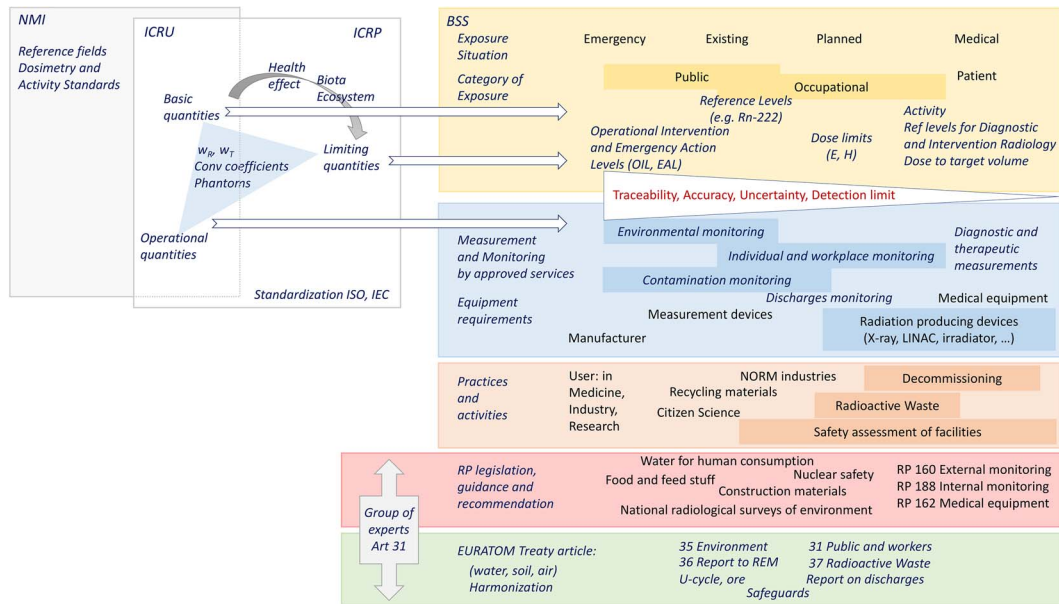
## Practices and activities that need metrology to meet requirements

Why, how and where metrology services are needed: in order to meet the requirements in planned exposure situation, it is necessary to show compliance with the limits on effective dose and equivalent dose. Or on dose constraints, reference levels, parametric values, among other, but generally on dose or activity concentration

values derived from measurements that will correspond to an increment on the total effective dose. In existing situations, the radiation protection of the environment relies on activity concentration and dose measurements in the ecosystem (water, sediment, soil and biota).

From the regulation point of view, and to show compliance with the established limits and reference levels, environmental, individual and workplace monitoring is necessary.

In emergency situations, operational intervention levels (OIL) trigger actions for the protection of workers and the public. In medical exposure to ionising radiation, in the case of radiotherapy the main aim is to deliver the prescribed dose to the target volume protecting the healthy surrounding tissues and organs as much as possible. For the protection of the patient in radiodiagnostics, diagnostic reference levels should be defined.



**Figure 1.** Scheme on how metrology supports radiation protection and the relevant radiation protection legislation. The regulation is given in yellow at the top and red and green at the bottom of the figure. The contribution of metrology is represented in gray and white including the white arrows. Practices and activities making use of metrological services (in blue) that need to show compliance with the regulations mentioned in topic 5 are represented in orange.

Monitoring of workers exposed to external and internal radiation is performed by approved services following well established procedures inspected by the authorities. Established procedures, in turn, entail a certain level of quality assurance, traceability, accuracy and awareness of uncertainty levels—validation for acceptance by authorities.

Manufacturers of radiation producing devices e.g. X-ray, linear accelerators (LINAC), cyclotron, irradiators, radioactive sealed sources, as well as manufacturers of measurement devices aim at compliance with established procedures.

### The role of ICRP, ICRU, ISO and IEC

The International Commission on Radiological Protection (ICRP) periodically publishes its recommendations, known as ‘The recommendations of the ICRP’. The most recent ICRP Publication 103 (2007)<sup>(14)</sup> form the basis of the present BSS, the current legislation to protect human health with the objective to manage and control exposures to ionising radiation, so that tissue reactions are prevented, and the risks of stochastic effects are reduced to the extent reasonably achievable. Concerning the environment, ICRP Publication 108 (2008)<sup>(15)</sup> also proposes the implementation of a radiological protection system to maintain biodiversity and the protection of natural habitats, communities and ecosystems.

ICRP sets the System of Radiation Protection and along with the International Commission on Radiation Units and Measurements (ICRU) the quantities and units necessary to quantify the health effect of ionising radiation on human systems as well as on biota and ecosystems and are adequate for measurement.

The basic physical quantity absorbed dose (or activity) does not allow for the quantification of biological effects (tissue reactions and stochastic effects) induced by ionising radiation. The protection (or limiting) quantities effective dose and equivalent dose derived from the basic physical quantities modified with radiation weighting factors and tissue-weighting factors, take into account the ionisation density created by the incident ionising radiation particle (e.g. photons, electrons, protons or other) along its path and the relative importance of the irradiated tissue or organ to the total detriment.

The dose limits are established in terms of effective dose and equivalent dose. However, these quantities that relate to the radiation induced effect are theoretical and not measurable in practice. In order to overcome this problem ICRP and ICRU defined the operational quantities that are measurable in practice, also derived from the basic physical quantities modified by a quality factor (and conversion coefficients) that provide a reasonable estimate (ideally an overestimation) of the protection (limiting) quantities, to be on the safe side of Radiation Protection.



In summary, ICRP Publication 103<sup>(14)</sup> having inspired the EU Council Directive (BSS)<sup>(3)</sup> and IAEA GSR Part 3<sup>(13)</sup>, sets the basis for legislation, the preparation of standards and regulations and the practice of radiological protection in general.

The International Standardization Organization (ISO) and the International Electrotechnical Commission (IEC) develop and publish international standards that represent global consensus and state of the art know-how, e.g. for the realisation of the reference fields used by metrology laboratories and quantities, for the conformity assessment of electric and electronic products and related services ensuring safe and reliable measurements. Worldwide acceptance of these standards implies the use of harmonized procedures and methods.

### European legislation relying on quality assured measurements

The EU seeks to protect people and biota from the dangers of ionising radiation. In daily life, we are exposed to various sources of ionising radiation, for example, natural radiation sources, medical applications, industrial practices and effluents from nuclear installations, fallout from nuclear weapon testing or the impact of nuclear accidents. Exposure to increased levels of ionising radiation can be harmful to human health.

Documents of the European Commission and the European Atomic Energy Community which have needs to be supported by metrology are listed in Table 1. For this purpose reliable measurement results are the base for compliance with the given regulation, directives and technical recommendations.

The Euratom Community seeks to protect its citizens and biota against the dangers of increased levels of exposure. The Euratom Community has established a set of basic safety standards to protect workers, members of the public, the environment and patients against the dangers arising from ionising radiation. These standards also include emergency procedures that were strengthened following the Fukushima nuclear accident.

The Basic safety standards (Council Directive 2013/59/Euratom)<sup>(3)</sup> ensure:

- the protection of workers exposed to ionising radiation, such as workers in the nuclear industry and other industrial applications, medical staff and those working in places with high indoor radon concentration or in activities involving naturally occurring radioactive material (NORM);
- the protection of members of the public, for example, from radon in buildings and building materials;
- the protection of the environment, as the state of the environment can impact human health in the long-term;
- the protection of medical patients, for example, by avoiding accidents in radiodiagnostics and radiotherapy;
- strengthened requirements on emergency preparedness and response incorporating lessons learnt from the Fukushima accident.

The basic safety standards are developed in consultation with a group of scientific experts in public health and in radiation protection.

In the event of a nuclear accident, fast and accurate sharing of information can make a huge difference in ensuring people's safety. Under the Euratom Treaty<sup>(4)</sup>, the European Commission is responsible for exchanging information quickly and manages two platforms for such exchange e.g. ECURIE<sup>(16)</sup> and EURDEP<sup>(17)</sup>. The Euratom Treaty is encouraging progress in the field of nuclear energy, is strictly limited to civilian uses of nuclear energy and aims to promote research, to achieve security of supply for all EU countries and to establish a system for supervising the peaceful use of nuclear materials intended for civilian use and ensuring high common standards for health and safety.

The main tasks laid down in the Euratom Treaty are:

- promote research, cooperation in research and exchange of technical information—a Joint Research Centre was established;
- establish uniform safety standards to protect the health of workers, the general public and the environment and ensure that they are applied;
- facilitate investment and ensure, particularly by encouraging joint ventures, the establishment of the basic installations necessary for the development of nuclear energy;
- ensure through a common supply policy that all users in the Community (now the EU) receive a regular and equitable supply of ores and nuclear fuels—a Euratom Supply Agency was established;
- control the appropriate (in particular, non-military) and peaceful use of nuclear materials—Euratom safeguards are ensured by dedicated inspectors, who carry out physical and accounting checks in all nuclear installations in the Community;
- exercise a right of ownership of some special fissile materials (fissile materials are composed of atoms that can be split by neutrons in a self-sustaining chain-reaction to release enormous amounts of energy);
- create a common market in specialised materials and equipment, with free movement of capital for

investment in the field of nuclear energy and freedom of employment for specialists;

- establish with other countries and international organizations such relations as will foster progress in the peaceful uses of nuclear energy.

Remark: Euratom and EU share the same executive bodies and some common institutions since the Merger Treaty (1967). The sharing of powers given to the institutions in the Euratom Treaty differs from those of the EEC bodies (now the EU bodies acting within the scope of the EU). The Parliament in particular has less control over Euratom, with only consultative powers (no co-decision). The Euratom Supply Agency, a specific Euratom body, has legal personality and financial autonomy and is under the supervision of the Commission. Since the Merger Treaty, Euratom also shares a single administrative budget with the EU institutions. The R&D expenditures under the Euratom Treaty are however kept under a separate budget.

### Organisation of the Stakeholders by the main topics

To develop a Strategic Research Agenda (SRA) and roadmaps for metrology services underpinning radiation protection regulation the feedback from Stakeholders is essential. Therefore, a study of the SRA and equivalent strategic documents produced by the radiation protection platforms e.g. Multidisciplinary European Low Dose Initiative (MELODI), European Radiation Dosimetry Group (EURADOS), European Alliance for Medical Radiation Protection Research (EURAMED), European Platform on preparedness for Nuclear and Radiological Emergency Response and Recovery (NERIS), European Radioecology Alliance (ALLIANCE) and Social Sciences and Humanities in Ionising Radiation Research (SHARE), as well as relevant organisations such as the European Association of National Metrology Institutes' (EURAMET) Technical Committee on Ionising Radiation (TC-IR), IAEA, BIPM, Heads of Radiation Protection Authorities (HERCA), among other, was performed. By the identification of research needs and by establishing a link to metrology issues Table 2 was created. The perspective of each platform and organisation in each specific field (e.g. public, environmental and ionising radiation in the ecosystem; Occupational and emergency exposures; Medical use of ionising radiation) together with the fundamental or applied research character of the topic, its relative importance if identified by more than one, was noted. A questionnaire is under preparation in order to collect information to prepare the SRA.

### Visualisation of the involvement of metrology in radiation protection

The complex situation described in Chapters 1–4 is depicted in Figure 1. The figure is intended to serve as an introduction to this field and does not intend to cover all aspects involved. The European regulation that directly benefits from metrological improvement in radiation protection is mentioned in topic 5 and the Stakeholders that benefit from metrology in radiation protection are mentioned in topic 6.

EURAMET's European Metrology Networks (EMNs) aim at realising EURAMET's vision of building metrology capabilities based on high quality scientific research and an advanced metrology infrastructure. The EMNs coordinate the identified measurement needs and formulate the measurement services and research and knowledge transfer accordingly.

In recent years, the EU's regulations on the radiation protection of human health and the environment have become ever more complex due to stricter legal dose assessments, exposure and activity limits as well as reference levels for activity concentrations, technological developments and emerging complex practices. New radiation practices and new technological developments have resulted in the use of radiation fields of growing complexity. Therefore, the metrology for radiation protection measurements and legal dose assessment is a highly complex task. It requires increased efforts in all member states to build up and maintain sustainable metrological competence. Increased digitalisation will lead to digital legal dosimetry over the next few years. Legal dose assessment and an associated dose registry is currently a national issue, but exposed workers are active internationally, therefore their personal dose values must be combined into a single value. This is only possible if dose assessment is performed in each country with the same level of reliability and if combining dose values is done based on harmonised data processing.

The EMN for Radiation Protection established in 2021 will provide the base to implement and to guarantee the same metrological quality of radiation protection for all European citizens by harmonising procedures and combining the capabilities in service and research (i.e. calibration, type testing and reference fields with the vocabulary explained in the International Vocabulary of Metrology<sup>(18)</sup>, and the requirements laid down in the ISO/IEC 17025:2017<sup>(19)</sup> standard. This requires a coordinated approach to ensure that the required metrological quality in the dissemination of the radiation protection quantities is reached for all dose assessments performed under the European regulation: The basic aim is to balance between the required redundancies while avoiding unnecessary

**Table 2.** Stakeholder needs and research interest expressed in their respective SRA or comparable documents grouped in three main fields

Stakeholders	Public, environmental and ionising radiation in the ecosystem	Occupational and emergency exposures	Medical use of ionising radiation
RP platforms	ALLIANCE, EURADOS	NERIS, EURADOS	EURAMED, SAMIRA, EURADOS
Authorities	HERCA	HERCA	HERCA
Relevant org. Metrology	IAEA, ICRP, ICRU BIPM-CCRI, EURAMET, NMI, DI	IAEA, ICRP, ICRU BIPM-CCRI, EURAMET, NMI, DI	IAEA, ICRP, ICRU BIPM-CCRI, EURAMET, NMI, DI
Research	Academia	Academia	Academia
Medicine	Discharges (hospitals)	Hospitals and clinics	Hospitals and clinics
Industry		Manufacturer of radiation producing devices: X-ray, LINAC, cyclotron, irradiators, radioactive sources	Manufacturer of radiation producing devices: X-ray, LINAC, cyclotron, irradiators, radioactive sources
Industry	Manufacturer of measurement devices	Manufacturer of measurement devices	Manufacturer of measurement devices
Industry	NORM industries, recycling	NORM industries, recycling	
Industry	Discharges (Radioactive Waste, other)	Radioactive Waste	
Industry	Safety assessment of facility, Decommissioning	Safety assessment of facility, Decommissioning	Safety assessment of facility, Decommissioning
Single user	Citizen Science		

Note: Acronyms of the organizations at the end of the document.

duplication of work to free up resources to address the new technological needs.

### Summary: vision of the EMN for radiation protection

Radiation protection is often misunderstood as a need coming from the support of nuclear applications, such as nuclear power production or military use of nuclear weapons. Within the political movement for renewable and green energies and earlier by the Peace Movement, radiation protection suffered from reduced funding flanked in parallel by increased restrictions associated to the lowering limits from the legislation: the lower the better was the consensus. This collateral effect of ideological presumptions raised the danger of knowledge loss in Europe and loss of quality infrastructure to maintain the existing traceability chains for environmental surveillance, radiation protection for medical, technological and emergency needs.

*Our mission is to correct the ideologically biased steering of the past and to change the steering process towards sustainable funding of radiation protection at the European level. As radiation protection will always be multi-functional and multi-usable, the members and partners see their core responsibility in supporting the European legislation by metrology.*

The internationally agreed pillars of radiation protection (ICRP 103<sup>(14)</sup>) are: Justification, Optimisation, Dose Limitation. *Justification* means that any decision

that alters the radiation exposure situation should do more good than harm, *Optimisation* intends that doses should all be kept as low as reasonably achievable, taking into account economic and societal factors, while *Dose Limitation* addresses that the total dose to any individual should not exceed the appropriate limits.

European legislation is following this concept closely and to support it, especially *Dose Limitation* has a direct link to reliable data produced by quality assured assessment processes, like measurements or calculations based on measured data. As the reliable data is fundamental for decisions taken on *Optimisation* and to some extent also in *Justification* it can be concluded that our aim is directly in line with the three pillars of radiation protection.

*It is our mission to support European legislation with reliable data including uncertainties and to clearly express where such reliable data is not available.*

*We will jointly use our capacities to overcome the existing gaps in reliable data by following our aim.*

### Funding

This work was prepared in the framework of project EMPIR 19NET03 supportBSS Work Package 3 on the development of a Strategic Research Agenda (SRA) and Roadmaps for metrology services underpinning radiation protection regulation. 19NET03 supportBSS has received funding from the EMPIR programme



## Acronyms

Acronym	Organization <i>the corresponding SRA or equivalent document studied (as of April 2021)</i>
MELODI	Multidisciplinary European Low Dose Initiative <i>Strategic Research Agenda of the Multidisciplinary European Low Dose Initiative (MELODI)</i> (2019)
EURADOS	European Radiation Dosimetry Group <i>Visions for Radiation Dosimetry over the next two decades—Strategic Research Agenda of the European Radiation Dosimetry Group: Version 2020</i> . JF Bottollier-Depois, et al. EURADOS report 2020–04, Neuherberg, (2020)
EURAMED	European Alliance for Medical Radiation Protection Research <i>Common strategic research agenda for radiation protection in medicine</i> , Insights Imaging 8, 183–197, DOI: <a href="https://doi.org/10.1007/s13244-016-0538-x">10.1007/s13244-016-0538-x</a> (2017)
NERIS	European Platform on Preparedness for Nuclear and Radiological Emergency Response and Recovery <i>Strategic Research Agenda of the NERIS Platform</i> , version November (2019)
ALLIANCE	European Radioecology Alliance <i>Strategic Research Agenda for Radioecology</i> , 3rd version [draft] 30 November 2019 (2019)
SHARE	Social Sciences and Humanities research related to Ionising Radiation Strategic research agenda for the SHARE platform, October 2020
IAEA	International Atomic Energy Agency <i>Medium Term Strategy 2018–2023</i>
BIPM-CCRI	Bureau International des Poids et Mesures, Consultative Committee for Ionizing Radiation <i>Strategy 2018–2028 Consultative Committee for Ionizing Radiation (CCRI)</i>
HERCA	Heads of Regulatory Competent Authorities Several documents available at the HERCA's website
CONCERT	EJP-CONCERT European Joint Programme for the integration of Radiation Protection Research <i>Updating the SRAs of Melodi, Alliance, Neris, Eurados and Euramed</i> . Salomaa, S. (lead author) et al. (deliverable 2.12, December 2019)
EURAMET	European Association of National Metrology Institutes <i>Information available in the web page</i>
SAMIRA	Strategic Agenda for Medical Ionising Radiation Applications <i>European Commission staff working document SAMIRA</i> , 5 February 2021 <a href="https://www.europeansources.info/reco rd/staff-working-document-on-a-strategic-agenda-for-medical-ionising-radiation-applications-samira/">https://www.europeansources.info/reco rd/staff-working-document-on-a-strategic-agenda-for-medical-ionising-radiation-applications-samira/</a>

co-financed by the Participating States and from the European Union's Horizon 2020 research and innovation programme. 19NET03 supportBSS denotes the EMPIR project reference.

## References

- Röttger, A., et al. *Metrology for radiation protection: a new European network in the foundation phase*. Adv. Geosci. 57, 1–7 (2021) Special Issue: Geoscience applications of environmental radioactivity <https://doi.org/10.5194/advgeo-57-1-2021>.
- Bureau International des Poids et Mesures. *Le Système International d'Unités (SI)/The International System of Units (SI)*, ninth edn. Edited by BIPM, Sèvres, France (2019).
- European Union Council Directive 2013/59/EURATOM Laying down the Basic Safety Standards (BSS) for protection against the dangers from exposure to ionizing radiation, and repealing Directives 89/618/Euratom, 90/641/Euratom, 96/29/Euratom, 97/43/Euratom and 2003/122/Euratom, OJ L 13, 17.1.2014, p. 1–73 (2013)
- General Secretariat of the Council of the European Union. *Consolidated version of the Treaty establishing the European Atomic Energy Community*. (Luxembourg: Publications Office of the European Union, EURATOM Treaty) (2016).
- European Union Council Directive 2013/51/Euratom Laying down requirements for the protection of the health of the general public with regard to radioactive substances in water intended for human consumption OJ L 296, 7.11.2013, p. 12–21 (2013)
- European Union Council Regulation (Euratom) 2016/52 Laying down maximum permitted levels of radioactive contamination of food and feed following a nuclear accident or any other case of radiological emergency, and repealing Regulation (Euratom) No. 3954/87 and Commission Regulations (Euratom) No. 944/89 and (Euratom) No. 770/90 OJ L 13, 20.1.2016, p. 2–11 (2016)
- European Union Council Directive 2011/70/Euratom. Establishing a Community framework for the responsible and safe management of spent fuel and radioactive waste. OJ L 199, 2.8.2011, p. 48–56 (2011).
- European Union Council Directive 2014/87/Euratom. Amending Directive 2009/71/Euratom establishing a Community framework for the nuclear safety of nuclear installations. OJ L 219, 25.7.2014, p. 42–52 (2014).
- European Commission. *Technical recommendations for monitoring individuals occupationally exposed to external radiation*. (Luxembourg: Radiation Protection RP160 Directorate-General for Energy and Transport) (2009).

10. European Commission. *Technical recommendations for monitoring individuals for occupational Intakes of radionuclides*. Radiation Protection RP188, Directorate-General for Energy (Luxembourg) (2018).
11. European Commission. *Criteria for acceptability of medical radiological equipment used in diagnostic, radiology, nuclear medicine and radiotherapy*. (Luxembourg: Radiation Protection RP162, Directorate-General for Energy) (2012).
12. ICRP Publication 136. *Dose coefficients for non-human biota environmentally exposed to radiation*. Ann. ICRP **46**, 1–136 (2017).
13. International Atomic Energy Agency (IAEA). *Radiation Protection and Safety of Radiation Sources: International Basic Safety Standards*. Safety Standard Series n° GSR Part 3. (Vienna: International Atomic Energy Agency) (2014).
14. ICRP Publication 103. *The 2007 recommendations of the international commission on radiological protection*. Ann. ICRP **37**, 2–4 (2007).
15. ICRP Publication 108. *Environmental protection—the concept and use of reference animals and plants*. Ann. ICRP **38**, 4–6 (2008).
16. European Commission. The European Community Urgent Radiological Information Exchange. (Luxembourg: ECURIE, Directorate-General for Energy) <https://ecurie.jrc.ec.europa.eu>.
17. European Commission. The European Radiological Data Exchange Platform. (EURDEP, Joint Research Centre, Radioactivity Environmental Monitoring) <https://remon.jrc.ec.europa.eu>.
18. Joint Committee for Guides in Metrology. *JCGM 200 International vocabulary of metrology, Basic and general concepts and associated terms (VIM)*, third edn. (London: Sage) (2012).
19. International Standardization Organization and International Electrotechnical Commission. *General requirements for the competence of testing and calibration laboratories*. ISO/IEC Standard 17025:2017 (Geneva: International Organization for Standardization) (2017).