



RÉPUBLIQUE  
FRANÇAISE

*Liberté  
Égalité  
Fraternité*

**IRSN**

INSTITUT DE RADIOPROTECTION  
ET DE SÛRETÉ NUCLÉAIRE



Annual  
report

MEMBRE DE

**ETSON**

APPROVED BY THE IRSN BOARD OF DIRECTORS  
ON FEBRUARY 28, 2022

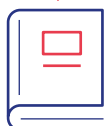
PHOTO CREDITS

© Francesco Acerbis, © Philippe Castano,  
© Martial Chevreuil, © Antoine Devouard, © Philippe  
Dureuil, © Marine Nationale, © MEDDE – Arnaud  
Bouisson, © Noak/Le Bar Floréal, © ORANO NPS,  
© Philippe Puisseux/Emapress, © r.baltz@me.com,  
© L. Zylberman/Graphix Images, iStock, © Alain  
Chapel IRSN

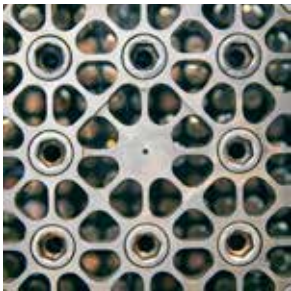
**Cover:** © Close-up on the nautical Drone camera used  
for sampling at sea, for measure radioactivity. Science  
Village, Espace René-Lebas, Cherbourg-en-Cotentin,  
October 3, 2020.

ENGLISH LANGUAGE ANNUAL REPORT  
ISSN 2679-6791

DESIGN AND EXECUTION  
 [AGENCEZEBRA.COM](https://www.agencezebra.com)



- EDITO  
> page 05
- HIGHLIGHTS  
> page 08
- KEY FIGURES  
> page 10



# 01

RESEARCH  
> page 12



# 04

RADIATION PROTECTION FOR THE ENVIRONMENT AND FOR PEOPLE  
> page 40



# 02

NUCLEAR SAFETY EXPERTISE  
> page 18



# 05

CRISIS AND POST-ACCIDENT  
> page 46



# 03

NUCLEAR DEFENSE SAFETY, NUCLEAR SECURITY, NUCLEAR AND CHEMICAL NON-PROLIFERATION  
> page 24



# 06

TRANSFORMATION, OPENNESS TO SOCIETY AND CSR  
> page 50

## 360° VIEW

How IRSN monitoring benefits people and the environment

page 30 <

GOVERNANCE  
> page 56

ORGANISATION CHART  
> page 60

GLOSSARY  
> page 62

## The public expert on nuclear and radiological risks

Expert appraisal, research, protection, forward planning, sharing: such is the remit of IRSN in its service to the public authorities and the public at large. IRSN can boast the unrivalled capacity to combine the expertise of researchers and experts, in order to anticipate questions arising in relation to changes in nuclear and radiological risks and how to manage these risks. IRSN teams are keen to publicise their work and share their knowledge with society. In pursuing this approach, they help to improve access to information and to create the conditions for dialogue with stakeholders. IRSN contributes to public nuclear safety and security policies, as well as health, environmental and crisis management policies. As a Public Industrial and Commercial Establishment ("EPIC" - *Établissement public à caractère industriel et commercial*) overseen jointly by the French Ministry of the Environment, the French Ministry of Defense, and the French Ministries of Energy, Research and Health, all that IRSN does is fully in line with the Government's modernisation policies, as testified by its risk management approach and by its implementation of a global corporate social responsibility policy.







# Edito



**Marie-France BELLIN**,  
Chair of the Board of Directors



**Jean-Christophe NIEL**,  
Director General

## FULFILLING OUR MISSIONS

IRSN fulfils its missions: this was the conclusion of the Court of Auditors, in June 2021, following its auditing of the Institute. The fact that this conclusion comes from the legal body responsible for assessing public policies and overseeing the proper use of public money, and which is renowned for its demands and rigour, this is for us a positive and essential endorsement.

In 2021, just as in 2020, accomplishing these missions in order to meet the challenges facing the Institute was made more complex by the pandemic. IRSN rose to the challenges of its many commitments and obligations by adapting its working methods to protect its employees and to pursue its relations with its many interlocutors: the public authorities, government bodies, TSO peer bodies, industrialists, research organisations and, more generally, society at large. Our thanks go out to all concerned.

## BETTER ANTICIPATION FOR BETTER CONTROL

Nuclear power plant systems have a life cycle that stretches out over the long term. Certain facilities are ageing, and across industry needs are being expressed for fresh capacity, against a background of major climatic, technological and societal changes. The ways in which ionising radiation is used in the fields of healthcare, diagnostics and therapy are also evolving rapidly. More and more questions are being raised about the impact of the environment on human health, including the impact linked to radioactivity.

For a technical organisation responsible for assessing radiological and nuclear risks in all their forms, having at hand when needed the necessary know-how and skills for expressing a reliable and independent scientific judgement, as expected by all those with a stake in managing these risks, presupposes anticipation of all these changes.

This is the ambition guiding the research conducted in 2021 with a view to examining major safety dossiers such as the 4th periodic review of the 1,300 MWe reactors or the establishment of new test platforms, such as EVA, ASPIC and MIDI. These platforms will help us to anticipate the ageing of nuclear facilities and the mechanisms leading to serious accidents, through reinforcing via experimentation the models created using simulation tools.

This same ambition drives our interest in emerging safety issues, such as those associated with small modular reactors (SMR).

It is also the driving force behind our research into the development of a new strategy for the handling of patients suffering from acute radiation syndrome, the clinical treatment of over-irradiation through the use of stem cells, the seal behaviour of deep geological repositories over very long periods, and the development of methods and tools for the rapid detection of trace radioactive nuclides in the environment for better monitoring.

Lastly, it is also what has motivated the in-house selection of five exploratory study projects, launched in 2021, for the benefit of future finalised research programmes on topics as varied as radionuclide deposits in rural areas, the development of irradiated fuel simulation, the application of machine learning, complications following treatment with iodine 131, and understanding DNA damage.

Anticipation is also about preparation: preparing in particular for a nuclear or radiological disaster by taking part, in 2021, in national exercises such as the SECNUC governmental exercise or international exercises with the IAEA, by taking action in real-life situations such as when radioactivity attributed to a steelworks is detected. Another initiative is improving know-how through research with a seminar on what the human and social sciences can bring to the capacity of organisations to adapt to unforeseen events.



### SHARING IN ORDER TO MAKE PROGRESS

Risk assessment, through research or expert appraisal, requires the fostering of a questioning attitude predicated on the safety culture. This questioning attitude is nurtured in particular through sharing, in other words the capacity to dialogue with all stakeholders involved in risk management.

So, for the benefit of the greater public good, this means sharing the issues and priorities with the authorities, and in 2020 and 2021 IRSN accordingly renewed most of its conventions with the authorities or administrations it supports.

IRSN is in constant interaction with its international peer organisations. Hence, to mark the 10th anniversary of the Fukushima disaster, IRSN organised an in-person event, the EUROS SAFE 2021 Forum, under the aegis of the Etson network, on the subject of "Nuclear and Radiation Safety in a disruptive world", followed by a seminar on the human and social sciences research conducted in light of the accident.

In 2021, the Institute created an occupational training and mentoring structure called IRSN Academy, which will allow us to build on our capital of know-how and skills.

Lastly, the desire to enhance the expert appraisal work of IRSN through the incorporation of the insights and questions emerging from the dialogue with the stakeholders permeated the technical dialogues conducted in the framework of the 4th review of the 900 MWe reactors. This approach lays the groundwork, in line with our objectives and performance contract, for the implementation in early 2022 of a standing committee for dialogue with society, designated ODISCE.

### BEING INDEPENDENT IN ORDER TO BE CREDIBLE

The independence of IRSN is taken to betoken the impartiality of its scientific and technical judgement, and of its investigations into topics of import that fall within its remit. From this point of view, the research already referred to as a forward-planning tool means that IRSN always has at its disposal the latest knowledge and information.

IRSN also debates the concepts, methods and positions it develops. Hence, for the 10th anniversary of the Fukushima accident, in 2021, IRSN summarised its reflections on the response capacity of people and organisations to unforeseen situations and to highly improbable events, and on managing a post-accident situation, in a report entitled "Anticipation and resilience. Considerations a decade after the Fukushima Daiichi accident", which was shared internationally.

IRSN deals with situations likely to present challenges in terms of nuclear safety or radiation protection. In 2021, following unusual readings of the tritium concentration in the river Loire made by an association, IRSN continued with its large-scale campaign of sampling and behaviour modelling for this radioactive element in the Loire. The results have been presented regularly to the pluralist monitoring committee set up for this.

Lastly, in 2021, the Institute's Ethics Commission (CED), working on behalf of its Board of Directors, provided details in its report about the notices published between early 2020 and mid-2021 on the links of interest, the ethics of the research business and the conditions for providing services to industry.

### EXCELLING IN ORDER TO ENLIGHTEN

With the objective of achieving the highest possible quality in its efforts to serve the public authorities and society, IRSN strives to maintain the skills of its teams at the highest level in the fields of expert appraisal and research.

In 2021, IRSN concluded or renewed structural partnerships in nuclear safety and radiation protection with benchmark institutes such as, in France, the CNRS or the Gustave Roussy cancer research centre, and abroad with the likes of the Universities of Singapore and Fukushima. IRSN has also been designated a "Capacity building centre" by the IAEA and will have its status as a WHO "collaborating centre" renewed in 2022. These partnerships stand in recognition of the skills of IRSN and provide motivation for continuing to reinforce these skills.

For the Institute, the quality demonstrated in the exercise of its radiation protection monitoring or in the conduct of its research or appraisal programmes draws in no small measure on the quality of its data and the

management of these data. In 2021, IRSN published its digital strategy and continued to deploy its strategy for optimising data use. This means that several projects in fields as diverse as the dosimetry of workers, crisis management and the exploitation of lessons learned now draw on artificial intelligence.

Lastly, IRSN is deploying its CSR policy around the roadmap for the years 2021-2023 with procedures concerning the circular economy, digital sobriety, energy retrofitting as part of the recovery plan, etc.

### ACCELERATING OUR TRANSFORMATION IN 2022 SO AS TO MEET EXPECTATIONS EVER MORE EFFICIENTLY

IRSN, the operational principles of which were determined by Governmental decree in 2002, will celebrate in 2022 its 20th anniversary of questioning, researching, innovating, assessing, recommending and sharing. These have been two decades guided by the constant objective, in an ever-changing society, of contributing to the protection of our fellow citizens and the environment in face of the risks linked to ionising radiation, by acting to underpin nuclear safety and security and radiation protection.

2022 will provide us with the opportunity to reflect on the path taken since the merger of IPSN and OPRI to create a major public scientific and technical body for the assessment of nuclear and radiological risks in all their forms, involving expert appraisal and research and covering the civil and defense fields, safety and radiation protection, and distinguishing between the appraisal and decision-making functions.

Yet above all, true to our strategy for 2030 and making the most of our 20 years of experience, and in line with the modernisation initiatives of the Government while maintaining a permanent dialogue with all our institutional interlocutors and representatives of society, we shall continue to pursue, with the highest standards of excellence and responsibility, our managerial, digital, work-mode and societal transformation in order to best leverage the changes to the environmental, energy, health and safety context for the benefit of protection against ionising radiation, and ensuring nuclear safety and security.



## Edito



**Louis-Michel GUILLAUME,**  
Deputy Director General  
for defense missions and in charge  
of the Defense Security  
and non-proliferation division


2021 was marked by the extension of the health crisis linked to the Covid-19 pandemic. Drawing on the experience acquired throughout the previous year in adapting its organisation and work methods to this particular context, IRSN was able to reinforce the overall consistency of its actions in order to uphold its commitments with regard to the authorities and government bodies.

In this way, in the field of nuclear defense safety, the Institute continue to pursue in 2021 its expert appraisal missions in support of the Directorate of nuclear security (*Délégué à la sûreté nucléaire - DSN*) for facilities and activities of interest to defense. It examined in particular, with regard to safety, the lessons learnt from naval propulsion boilers, those linked to the operational commissioning of the *Suffren*, the first nuclear attack submarine of the *Barracuda* programme, and changes to the facilities dedicated to French nuclear deterrence on the sites of the CEA.

As part of its safety assessment missions for nuclear facilities, the Institute has contributed to consolidating the technical and regulatory corpus framing the various components of its activities. It has proceeded with the modernisation of its platforms, linked both to the analysis of the effects of explosions and weapons on a site or transportation involving nuclear materials and the study of potential vulnerabilities of nuclear facilities in the face of cyber-attacks.

In matters of nuclear or chemical non-proliferation, it is worth underlining the contribution of IRSN to the organisation of the 2021 symposium of ESARDA<sup>[1]</sup>, held jointly with that of the American INMM<sup>[2]</sup>. In the framework of the French chairing of ESARDA, this symposium enabled reinforcement in particular of the Association's links with the IAEA by way of a cooperation agreement relating in particular to knowledge capitalisation. In this area, also worthy of note is the success of the first international training programme of the IRSN Academy, dedicated to the implementation of safeguards.

Whether concerning nuclear defense safety, nuclear security or non-proliferation, the IRSN teams strove in 2021 to make further progress in satisfying the expectations of the authorities and government bodies. In 2022, the latter can count once again on the commitment of all concerned to continue optimising the organisation and methods of the Institute, for facing the coming challenges.



*In 2021, and against the background of the health crisis, IRSN was able to reinforce the overall consistency of its actions in order to uphold its commitments in the fields of nuclear defense safety, nuclear security and non-proliferation.*

[1] European Safeguards Research and Development Association

[2] Institute of Nuclear Materials Management

# Highlights 2021



## February

**PUBLICATION OF THE NEW EDITION** of the reference work entitled *"Elements of nuclear safety - Pressurised water reactors"*, with Jean Couturier as the main author.

## April

**JEAN-CHRISTOPHE NIEL** is granted a second term as Director General of IRSN.

**ORGANISATION OF AN IRSN-ANCCLI SEMINAR** with civil society stakeholders, entitled *"Fukushima, Chernobyl: consequences of a nuclear accident on health"*.



## January

**IRSN TAKES PART IN THE EUROPEAN ROUND TABLE** on information and public participation in the field of radioactive waste management.

**SIGNING OF A SCIENTIFIC COLLABORATION FRAMEWORK AGREEMENT AIMED AT LINKING UP THE RESEARCH ACTIVITIES OF IRSN AND THE GUSTAVE ROUSSY CENTRE** for an "Integrated research project on the radiobiology of tumours and healthy tissues" (PIRATT).

## March

**IRSN ENGAGES IN A MAJOR EUROPEAN STUDY** of radon and naturally radioactive materials: RADONORM.

**FOLLOWING THE EPISODE OF SAHARAN SANDSTORMS OVER FRANCE (FEBRUARY 2021)**, IRSN publishes the results of its activity concentration measurements of caesium-137 (Cs-137) in the air sampled by the stations of its OPERA network during the first week of February 2021 and compares them with the average measured values in February 2019 and 2020.



## May

**PUBLICATION OF THE "UPDATED KNOWLEDGE ON THE BIOLOGICAL EFFECTS OF TRITIUM" REPORT:** a summary of 10 years of research into human and environmental radiotoxicology, in collaboration with the Canada Nuclear Laboratories (CNL).

**APPOINTMENT FOR A 5-YEAR TERM** of the members of the IRSN Scientific Council. Mr. Robert BAROUKI, Director of the Inserm 1,124 unit of the University of Paris and Head of the metabolomics and proteomics biochemistry department at the Necker hospital for sick children, is appointed Chair of the Scientific Council.



## September

**INAUGURATION OF 3 NEW NUCLEAR REACTOR SAFETY RESEARCH FACILITIES OF IRSN.**

**PARTICIPATION OF 68 SCIENTISTS FROM IRSN AND THE CNRS** in a workshop dedicated to interdisciplinary environmental research based on the observation of social ecosystems.

**IRSN DESIGNATED CAPACITY BUILDING CENTRE (CBC)** of the IAEA in the field of medical management of radiological and nuclear emergencies.

## October

**SMALL MODULAR REACTORS (SMR)** of less than 300 MWe have for several years generated growing interest worldwide: IRSN publishes an information bulletin on the safety of SMRs.

## June

**DENSIFICATION PROJECT FOR POOLS C, D AND E AT ORANO'S LA HAGUE FACILITY:** publication of the illustrated and annotated notice by IRSN.

**TRITIUM IN THE LOIRE:** IRSN publishes the results of a study conducted in the framework of a pluralist monitoring committee.

**ORGANISATION OF A SEMINAR BETWEEN IRSN AND THE WORLD HEALTH ORGANISATION (WHO)** to review the actions undertaken by IRSN in 2021 and identify the coming needs of the WHO.



## November

**SYMPOSIUM: "AFTER THE FUKUSHIMA DAIICHI ACCIDENT: ADAPTING TO THE UNEXPECTED", ORGANISED BY IRSN.**

Ten years after the disaster at the Fukushima Daiichi nuclear power plant, IRSN submits for debate the results of the human and social sciences research it has undertaken, to draw the lessons from this major nuclear accident.

**EUROSAFE 2022** Organised in 2021 by IRSN, EUROSAFE is the leading event for nuclear safety specialists.

## July

**PUBLICATION** of the *Report on the exposure of the French population to ionising radiation for the period 2014-2019.*

**KICK-OFF MEETING** of the ORRCH-IDEeS participative multi-exposure research project in the Dunkirk region.





# Key FIGURES



## Budget

39.1%

OF BUDGET ALLOCATED TO RESEARCH (EXCLUDING FEURS PROJECT)



282 M€

revenue  
272 M€ of spendings, of which 13 M€ of investment in equipment



## Institute's activity internationally

285

bilateral cooperation agreements in force with research or appraisal organisations

45

countries involved in these agreements

64

international projects in progress under the aegis of OECD NEA, the European Commission or the ANR

6

projects for which IRSN is coordinator



## Researching

269

publications listed in Journal Citation Reports (JCR)

271

scientific presentations at conferences

25

theses defended

## Technical support for public authorities

52.6%

OF BUDGET ALLOCATED TO TECHNICAL SUPPORT AND PUBLIC SERVICE MISSIONS (EXCLUDING FEURS PROJECT AND NORIA)

52

technical notices issued to the HFDS (Senior defense and security official) of the Ministry of Ecological Transition (MTE)

66

technical notices sent to the CTE and to the HFDS (Senior defense and security official) of the finance ministries

66

technical notices and reports submitted to the ASND

393

technical notices and reports submitted to the French Nuclear Safety Authority



## Profil

1,725

EMPLOYEES AS AT 31/12



1,587

ON PERMANENT CONTRACTS

138

ON FIXED-TERM CONTRACTS

44 on temporary assignment

21 on secondment to other organisations

52 PhDs or persons qualified to direct research

87.6 doctoral students

14.6 post-doctorate students



**Nuclear defense safety**

**22**  
inspections during transportation

**25**  
inspections steered by holders of nuclear materials

**107**  
national inspections steered by IRSN on the protection and inspection of nuclear materials

**45**  
missions to escort inspections involving international nuclear material control

**5**  
missions to escort international inspections involving the chemical weapons ban

**60**  
technical checks on approved equipment for transportation of nuclear materials



**Human capital**

**44.92**  
years old for women

**45.89**  
years old for men

**79.54%**  
executives

**20.46%**  
non-executives



**Environment and People**

**518**  
beacons

**139**  
ambient dose rate measurement points

**508**  
sampling points for radioactivity monitoring throughout France

**5,344**  
environmental samples taken for radiological measurements

**782**  
whole-body counts for the individual monitoring of workers, including 730 using mobile facilities

**Crisis**

**2**  
action taken by the emergency response center, CNPE Nogent

**7**  
national nuclear emergency exercises excluding defense

**3**  
national nuclear emergency exercise involving defense-related facilities

**21**  
meetings involving IRSN as part of CODIRPA's work on post-accident management



**Formations**

**985**  
hours of teaching provided outside the Institute (University, School of Engineering, INSTN, etc.)

**315**  
hours of teaching provided in the 17 radiation protection sessions

**112**  
hours of teaching provided in the 8 nuclear safety sessions





# Research

The research programmes conducted by IRSN are closely linked to its expert appraisal missions. Nuclear facility safety, health, crisis situation management, environment monitoring and protection, security and non-proliferation of nuclear materials: whatever the field of activity concerned, the research results provide the Institute's experts with fresh knowledge enabling them to better assess, in total independence, the risks and the mechanisms developed to address these risks.

Upstream of this essentially finalised research, the exploratory research is designed to investigate the relevance of new concepts and new research channels for informing the choices to be made in the future. After being selected by an internal Institute assessment committee, five exploratory research projects were launched in 2021. They involve the use of learning algorithms for the estimation of neutron spectra, the development of a method for measuring the deposition flux of submicron atmospheric particles, the manufacture of an irradiated fuel simulat, the study of the mechanisms of transcriptional and translational implementation and regulation after low-dose exposure to ionising radiation, and the study of the biomolecular factors involved in salivary complications in the treatment of differentiated thyroid cancer coupled with the improvement of dose characterisation in the salivary glands.

Faced with the complexity of the topics dealt with and the extent of the experimental resources required, IRSN conducts its research in partnership, in particular in the framework of projects funded by the European Commission as part of framework programmes for research and innovation, such as Horizon 2020 – for which 33 projects were still active at the Institute in 2021 for the EURATOM component alone – and Horizon Europe, which has just been launched by the OECD/NEA, and at national level by the Agence nationale de la recherche (National research agency).

To define its research policy and orientate its programmes, IRSN can draw on two additional bodies: the research orientation committee, composed of representatives of the Institute's main stakeholders, and which guarantees the appropriate coverage of the questions and issues, both societal and political, and the scientific council, composed of personalities selected on account of their scientific and technical skills, which advises and supports the Institute in the strategic management of its scientific activities. This council was re-elected in 2021 with 11 members serving a five-year term.

25

THESES  
DEFENDED  
IN 2021 BY IRSN  
DOCTORAL  
STUDENTS

52

PhDs OR  
PERSONS  
QUALIFIED  
TO DIRECT  
RESEARCH

44

ACTIVE PATENTS  
IN FRANCE AND  
79 ACTIVE PATENTS  
ABROAD







# Development of partnerships in France and abroad

**Even if the enduring Covid-19 health crisis continued to limit access to the test facilities, slowing down certain research programmes and inhibiting direct contacts between organisations, to the detriment of intensive collaboration, 2021 nevertheless saw the signing or renewal of major cooperation contracts between IRSN and leading partners, both at home and abroad.**

In 2021, IRSN concluded or renewed several partnerships in different fields of research into nuclear safety or radiation protection. At the start of the year, it signed a collaboration agreement for five years with the Gustave-Roussy cancer research centre in the framework of the integrated research project on the radiobiology of tumours and healthy tissues (PIRATT). This is aimed at advancing the scientific knowledge of the benefit/risk balance in radiotherapy with the objective of preserving healthy tissues which are exposed when delivering high doses of radiation for treating tumours. Following the signing of a new framework agreement between CNRS and IRSN in late 2020, the two organisations undertook to structure their partnership through the drafting of a roadmap. The main identified topics gave rise to the organisation of several workshops, which will be used to define the scientific and technical objectives to be pursued over the duration of the agreement and the mechanisms for running the collaboration.

Internationally, IRSN continued its collaboration with the Singapore Nuclear Safety and Research Initiative of Singapore University (NUS/SNRSI), in particular in the fields of radiochemistry and radiobiology. The Institute also signed, on 8 March, a cooperation agreement with the Japanese University of Medicine of Fukushima aimed at reinforcing the current exchanges – in particular between scientists and students – as well as the scientific collaborations addressing the consequences of a nuclear accident. In the field of safety-criticality research, the Institute and the US Department of Energy (DOE) renewed, without a time limit, their cooperation agreement, resulting in the production, in the facilities of the Sandia National Laboratory, of the first experiment entirely designed by IRSN.



# Safety research

**The study of the phenomenology of the possible initiators of serious reactor accidents (fires or loss of primary coolant) and their potential consequences (core meltdown) with a view to their prevention and their mitigation occupied a central place in 2021 in the safety research conducted by IRSN, alongside the research on the ageing of facilities, and in particular the ageing of the metallic and concrete components of which they are composed.**

The IRSN is pursuing a "post-Fukushima" Nuclear Safety and Radiation Protection Research (RSNR) project designated PERFROI, the purpose of which is to study the cooling capacity of a reactor core in a loss-of-coolant accident (LOCA) situation. After launching in 2020, within this framework, an initial test campaign ("COAL") using an experimental system developed internally and installed in a thermohydraulic loop made available by STERN Lab in Canada, IRSN last year successfully conducted a new phase of its research programme. The results of this second campaign, comprising 26 tests, yielded precious information for the validation and improvement of the digital models, in particular the DRACCAR software, developed by the Institute to simulate LOCA situations and used in support of its expert appraisals.

In May, IRSN brought together the club of users of the ASTEC (Accident Source Term Evaluation Code) software system, who contribute to the progress and development of its new features. Maintained and developed by the Institute, this system can be used to simulate all phenomena involved in a reactor core meltdown accident, from trigger event to source term.



**THE CONCRETE CONSORTIUM** launched a programme in September 2020 for a four-year period aimed at eliminating the scientific obstacles linked to managing the ageing of concrete structures. IRSN and its partners – various major academic players in the research into the behaviour of concrete – held a project stage seminar on 18 and 19 November 2021.

IN BRIEF



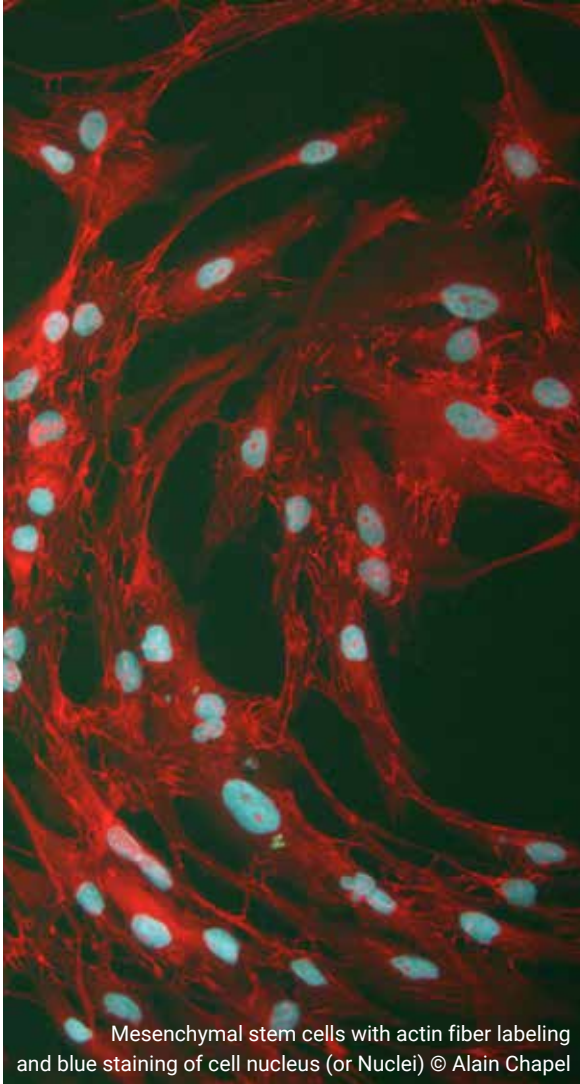
**EVA, ASPIC AND MIDI** are the names of three new nuclear reactor safety research facilities of IRSN dedicated – in the framework of the call for projects: "Nuclear Safety and Radiation Protection Research" (RSNR) – to the study of steel fatigue and of dewatering accidents involving a spent fuel deactivation pool. Located in Cadarache (Bouches-du-Rhône), these facilities were inaugurated on 29 September 2021.

IN BRIEF

In the field of research into fires, IRSN conducted in June the last phase of the PRISME-3 campaign – a project overseen by the OECD/NEA – with fire tests in corridor spaces, representing a first on the international stage. 2021 also marked the end of the modernisation work on the GALAXIE research platform, situated at Cadarache (Bouches-du-Rhône), whose test facilities enable the Institute to conduct the programmes required for managing the fire risk in nuclear facilities.

In 2021, IRSN began work on six collaborative research projects selected by the European Commission on the ageing of nuclear facility structures and equipment and improving their long-term safety. With regard to ageing, one project concerns the concrete components of a reactor vessel and four others concern the metallic materials of the vessels and components of the primary circuit. A sixth project addresses fracture mechanics in a multi-physics approach to cold shock and vessel failure. These various projects are scheduled to run for 4 years.





Mesenchymal stem cells with actin fiber labeling and blue staining of cell nucleus (or Nuclei) © Alain Chapel

# Health research

**Although the most notable healthcare research projects in 2021 were dedicated to developing treatments for victims of exposure to high doses of ionising radiation, the year was also marked by the ramping up of research in the human and social sciences applied to radiation protection and its application for healthcare professionals.**

Launched in late 2019 for a period of four years and with the support of the ANR (*Agence nationale de la recherche* - National research agency), the RESCUE project aims to develop a new clinical treatment strategy based on the provision of freezable and ready-to-use hematopoietic grafts for victims of radiation poisoning, following an emergency radiological or nuclear situation, who develop acute radiation syndrome (in its hematopoietic form). Following on from the GIPSIS project, which had made it possible to demonstrate in the laboratory the possibility of generating a long-term functional hematopoietic graft from human induced pluripotent stem cells (hiPSC), the research in the RESCUE project conducted in 2021 aims at validating this proof of concept on a large animal model before moving on to clinical trials.

Still in the field of the treatment of victims of radiation poisoning, 2021 saw the continuation of the ANR INTRUST project, managed by IRSN and designed to develop a treatment for victims of acute radiation syndrome (in its gastrointestinal form). If the tests prove to be conclusive, INTRUST will also open up a new avenue for the handling of patients suffering from digestive complications following radiotherapy and those suffering from a chronic inflammatory disease of the intestine.

In the field of human and social sciences linked to radiation protection, IRSN is conducting ergonomics research to support radiotherapy centres in managing change, such as the appropriation of a new medical imaging system. Another project conducted in 2021 has made it possible to produce, in collaboration with the healthcare professionals concerned, a guide designed to support them in maintaining healthcare safety in situations of technical or material change.

In addition, IRSN has continued, in partnership with the radiotherapy department of the Gustave-Roussy centre, its research project into the methods for analysing risks in a complex and human socio-technical system (MARSCH), with the aim of developing a new approach to risk analysis in radiotherapy.



## TAKING INSPIRATION FROM CHEMISTRY FOR INNOVATION IN RADIATION PROTECTION

An international workshop was organised by IRSN in April 2021 for the MELODI and ALLIANCE research platforms. The purpose of this workshop was to assess the possible contribution of a method developed to transpose the evaluation of the toxicity of chemical stressors (Adverse Outcome Pathway) on health and the environment on to the effects of exposure to radiological stressors. A potential application would be that of simultaneous exposure situations to these two types of stressor.

IN BRIEF



**ORRCH-IDEes** (pluralist research orientation on chronic risks – initiatives in the territory of Dunkirk for the environment and for health) is a participative research project launched by IRSN in 2021 on the health impacts linked to environmental multi-exposure (nuclear and/or chemical of industrial or agricultural origin) in the Dunkirk region.

IN BRIEF

# Environmental research

**In the field of environmental research, 2021 was particularly notable for the launch of the VSEAL project. The aim of this project is to assess the containment capacity over a very long period of the seals of a geological repository for high level waste (HLW) and intermediate-level long-lived waste (ILW-LL).**

## GEOLOGICAL REPOSITORY FOR HLW/ILW-LL: LAUNCH OF THE VSEAL PROJECT

Among the research projects launched by IRSN in 2021 in the field of the environment, VSEAL concerns the assessment of the containment capacity over a very long period of the seals of a geological repository for high level waste (HLW) and intermediate-level long-lived waste (ILW-LL). This capacity is based in particular on the hydromechanical resistance of the seals: closure of cells, shafts and chutes. In order to enable its experts to assess the safety files drawn up by ANDRA in the framework of the Cigéo project, IRSN is carrying out active research into this topic.

Conducted in its underground research laboratory in Tournemire (Aveyron), the VSEAL experimental project uses a 1 m-diameter, 10 m-deep excavation equipped with some 60 sensors. The objective is to observe over an approximately 15-year period the effects of resaturation water and hydrogen likely to be produced by the corrosion of storage components on maintaining over time the seal properties of a bentonite seal. This type of clay, capable of swelling significantly, is what has been chosen to seal the Cigéo installation at the end of the period of use.



## ASSESSMENT OF IRSN RESEARCH ACTIVITIES IN THE FIELD OF ENVIRONMENTAL RISKS

In January 2021 a commission conducted an audit of the IRSN thematic research group dedicated to environmental risks (GTR-RE). This audit, which mobilised the IRSN teams concerned by this topic, was conducted in the framework of a periodic external assessment of the research activities of IRSN, according to the procedure approved by the High Council for the assessment of research and higher education (HCERES).

Studying radionuclide transfers in atmospheric, marine, terrestrial and continental aquatic environments; studying the eco-toxicological impact of radionuclides; integration of knowledge for environmental risk assessment; cross-functional topics such as associated infrastructures or research and metrological resources: the audit enabled the various teams to take stock of their research activities and to present their five-year projects. The feedback at the end of the audit underlined the quality of the GTR-RE activities and projects, the efficiency of the triple association of observation with experimentation and with modelling, the unique character of the actions undertaken by the GTR-RE in the French and international research landscape, and the relevance of its positioning within European bodies. In addition, in July 2021 the commission formulated recommendations on the benefits of research for IRSN expertise, governance, skills management, infrastructures and research resources, as well as for partnerships, and these recommendations will be set out in an action plan for the five years to come.

# Research linked to the crisis

IRSN published an article in the review *Applied Radiation and Isotopes* about the development and validation of an algorithm for automating the detection of radioactive trace elements in the ambient air, and reducing the analysis time. By breaking down the measured spectrum into the individual spectra of the radionuclides present, this spectral demixing algorithm is designed to enable rapid detection of a discharge in the case of an incident or accident. It will also contribute to improving the detection limits of radionuclides in the environment, where the artificial radioactivity levels are very low, helping to underpin the Institute's mission in terms of the radiological monitoring of the environment.





# Nuclear safety expertise

## 393

TECHNICAL NOTICES  
AND REPORTS  
SUBMITTED  
TO THE FRENCH  
NUCLEAR SAFETY  
AUTHORITY

Based in particular on an ongoing research effort and on the feedback from previous safety assessments, the expert appraisal work of IRSN is intended to shore up the positions of the authorities and government bodies in relation to all nuclear safety dossiers, whether relating to facilities that are in operation, under construction or being decommissioned, or else new concepts such as small modular reactors (SMR).

Again in 2021, the work of IRSN on safety appraisals was made possible by an effort to adapt to the requirements imposed by the Covid-19 health crisis, leading in particular to the postponement of activities, such as unit shutdowns for maintenance and core refuelling. Furthermore, in response to the ramp-up in expert appraisal activities linked to decommissioning and the recovery of old waste, IRSN has reviewed its organisation by bringing together its experts in this field within the same department, thereby enabling a cross-functional approach to the examination of dossiers from different nuclear operators and the ranking of expert assessment priorities.

## 353

EQUIVALENTS  
FULL TIME DEVOTED  
TO NUCLEAR  
SAFETY EXPERTISE

While 2020 saw the publication of the summary notice of the 4th periodic review of 900 MWe reactors (RP4 900), 2021 was the year in which, one, work began on the generic phase of the 4th periodic review of the 1,300 MWe reactors (RP4 1,300) and, two, expert appraisals were conducted for the commissioning of the EPR reactor at Flamanville (Manche).





### IRSN PUBLISHES AN INFORMATION NOTE ON THE SAFETY ISSUES OF SMALL MODULAR REACTORS

SMRs, or "small modular reactors", are reactors with a power rating of less than 300 MWe and are characterised by a simplified design compared to the high power reactors that make up the current fleet of nuclear power plants. Among the 70 reactor concepts proposed around the world – most of them at a preliminary stage – EDF's reactor is a pressurised water reactor (PWR) concept, designated NUWARD and designed for export. The analysis of the information available tends to demonstrate that SMRs have, in principle, favourable characteristics with regard to compliance with more demanding safety objectives than high-power reactors, in terms of limiting discharges in normal or accident situations – including serious accidents – and core meltdown frequency. In its information note, the Institute points out however that these different concepts must be examined in detail in order to take up a more advanced position on the safety level that can be attained by this type of reactor.

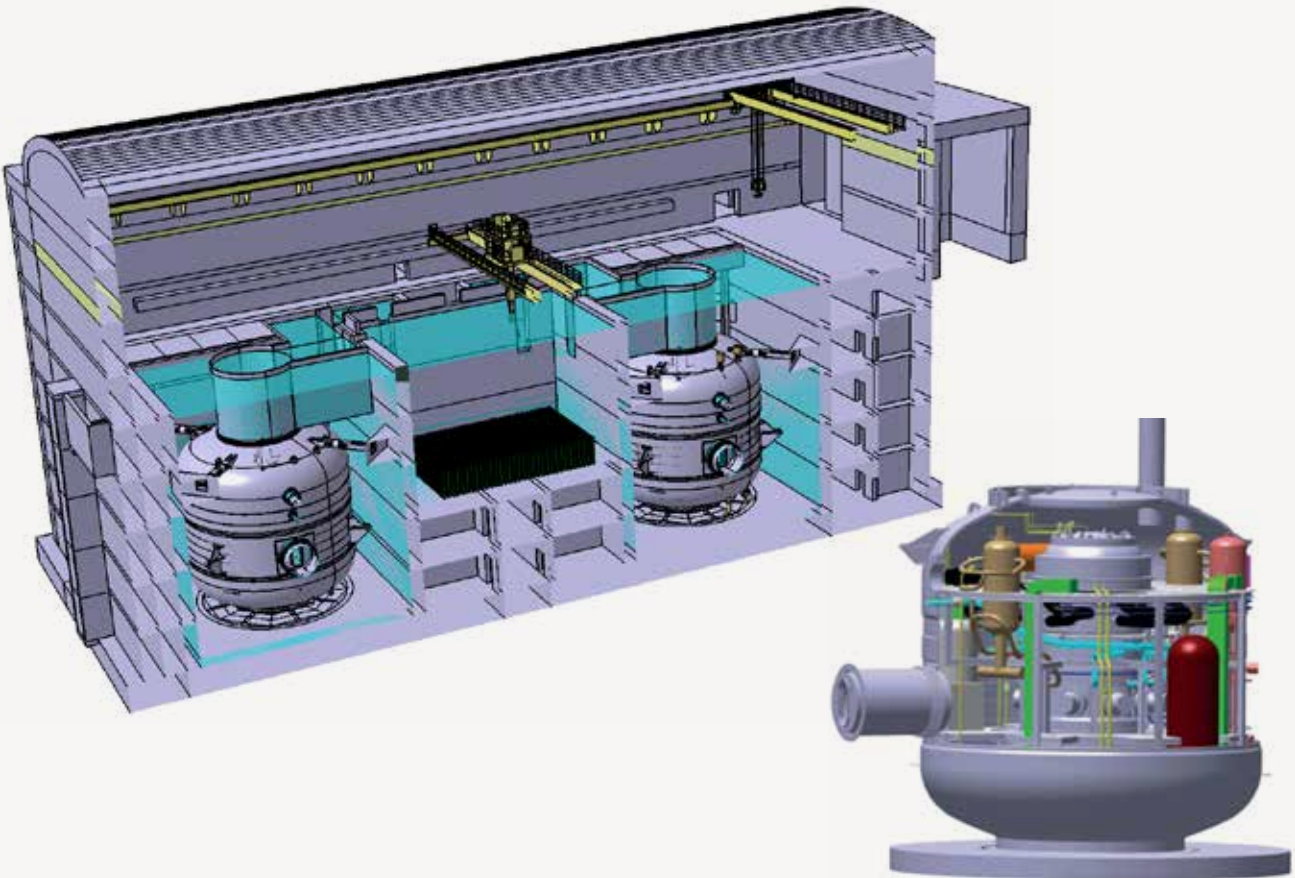
IN BRIEF

### PREPARING FOR RP4 1,300

Built for the most part in the 1980s, the twenty 1,300 MWe French nuclear power plants are now entering the generic phase of their 4th ten-year safety review (RP4 1,300). In 2021, IRSN undertook the examination of the corresponding safety dossiers transmitted by EDF with a view to drafting – as it had done in 2020 for the 4th periodic review of the 900 MWe reactors (RP4 900) – a notice to serve as the technical basis for the ASN position on the fitness of the reactors concerned to remain in operation. This generic phase will be completed with a 10-yearly inspection of each reactor, comprising tests such as a hydraulic test of the primary circuit and inspection of the reactor vessel, along with a strength test of the double concrete enclosure surrounding the reactor building.

### START-UP TESTS OF THE FLAMANVILLE EPR

IRSN has also conducted an appraisal of the results of the start-up tests conducted by EDF in the framework of the commissioning authorisation request for the Flamanville EPR reactor (EPR FLA-3), in order to ensure that the equipment and systems of the reactor operate in accordance with the study hypotheses and satisfy the set criteria in terms of performance. The Institute's analysis shows that, despite the volume of work carried out by EDF being significant, the number of test procedures not carried out or only partially carried out is still substantial. These procedures will be rolled out in the next phase of start-up tests scheduled for the third quarter of 2022.



View, in synthetic images, of the principle of the SMR reactor studied by the Nuward consortium © Nuward Consortium

20

OPERATING REACTORS  
OF 1,350 MWe  
IN FRANCE ENTER  
IN THEIR FOURTH  
10-YEARLY REVIEW



#### DECOMMISSIONING OF THE BRENNILIS NUCLEAR REACTOR

In March 2021, IRSN presented to the "decommissioning" permanent group of experts of ASN the conclusions of its complete decommissioning expert appraisal of the Monts d'Arrée nuclear power plant situated at Brennilis (Finistère), closing down the 70 MWe EL4 reactor which was shut down in 1985. The Institute examined in particular the organisation defined by EDF for facilitating the liaison between its engineering and the teams assigned to the on-site operations, and the clean-up principles for the site structures and land. It determined that EDF should aim first and foremost for a clean-up level compatible with any public use of the site. In its conclusions, it underlined the emergence of technical topics that may be transposed from the decommissioning currently underway of the Chooz A reactor (Ardennes). The topics concern, for example, the capacity of EDF to decontaminate steam generators, so as to reduce the level of radioactivity of the waste and the radiological exposure of the workers, or the use of remote-controlled underwater cutting equipment in the reactor vessel.

#### OPERATION OF 1,450 MWe REACTORS

At the request of the ASN, IRSN has examined the possibility, in safety terms, of operating the 1,450 MWe reactors (N4 series) concerned by a phenomenon of accelerated corrosion of the M5 alloy fuel ducts, attributed mainly to nucleate boiling and to the low iron content of the material batches used for manufacturing these ducts. This accelerated corrosion phenomenon also affects, to a lesser degree, certain 1,300 MWe and 900 MWe reactors, due to the lesser thermohydraulic stresses. Although this phenomenon has not yet been encountered in France, it has already been observed abroad on reactors operated in Germany and Brazil. EDF has undertaken to pursue investigations in order to improve the detailed understanding of the mechanisms at the origin of this phenomenon, and also envisages compensatory measures on the four reactors of the N4 series in order to reduce the probability of occurrence and the potential consequences. IRSN has deemed satisfactory the provisions tabled by EDF, the efficacy of which will be verified by means of a monitoring programme.

#### INCIDENT OF UNCONTROLLED DRAINAGE OF THE MAIN PRIMARY CIRCUIT OF A REACTOR AT GOLFECH

Classed as level 2 on the international INES scale on account of its potential consequences for the safety of the Golfech nuclear power plant (Tarn-et-Garonne), the uncontrolled evacuation of the main primary circuit of reactor 2 when it was being drained, on 8 October 2019, was subject to an in-depth analysis by IRSN in 2020 and 2021. This analysis brought to light a number of factors, strongly interlinked, that had weakened several lines of defense: technical, human and organisational. Following the appraisal by IRSN, the management of the EDF nuclear facilities and the Golfech nuclear power plant undertook to implement diverse technical and organisational actions for making sensitive transitions more robust, and in particular those involving the draining of the main primary circuit.

4

1,450 MWe  
OPERATING  
REACTORS  
IN FRANCE



### EXPERTS INTERACTING WITH CITIZENS

In the framework of its transparency and openness to society policy, IRSN contributed in 2021 to various initiatives aimed at associating civil society with its expert appraisal work. In parallel, it continued to pursue its training initiatives on nuclear safety with representatives of Local information commissions (CLIs) and, more generally, engaged in exchanges on the technical issues surrounding nuclear safety. The Institute also organised, in conjunction with the ANCCLI, a day of exchanges on 22 June 2021 on the subject of continued operation of 900 MWe reactor vessels "beyond 40 years". This day was an opportunity to explore in detail the expert appraisals carried out, to specify what conclusions had been made, and to answer the questions that had been gathered. With the ANCCLI and the CLIS de Bure, IRSN held discussion meetings on 3 February and 30 March on HLW/ILW-LL waste management. It also took part in a public meeting organised by the French Ministry of Ecological Transition on 8 March on the topic of the initial lessons from the public post-debate consultation on the 5th National plan for the management of radioactive materials and waste.

IN BRIEF



### EUROSAFE 2021 FORUM

Organised by IRSN under the aegis of the ETSO network of European TSOs, on 22 and 23 November, the EUROSAFE 2021 Forum brought together in Paris some 250 participants from around 20 countries to discuss the topic: *"Fukushima-Daiichi accident, Covid-19 and threats linked to climate change: nuclear and radiological safety in a disruptive world"*.

### ELEMENTS OF NUCLEAR SAFETY PRESSURISED WATER REACTORS

A new version of the publication entitled *"Elements of nuclear safety"*, coordinated and drafted mainly by Jean Couturier in an IRSN collection, the initial version of which had been published in 1996, this new edition can be downloaded from the IRSN website. It presents the state of play in the field of nuclear safety knowledge over its 40 chapters, providing additional insights, such as the history of the technical and regulatory changes, the progress made in safety through R&D, lessons learned from feedback, etc.

IN BRIEF



### PERIODIC REVIEW OF THE HIGH FLUX REACTOR OF THE LAUE-LANGEVIN INSTITUTE

A nuclear reactor designed for scientific research in various domains, such as materials physics or molecular biology, the high flux reactor (RHF) operated in Grenoble by the Laue-Langevin Institute (ILL) underwent a periodic review. After appraisal of the corresponding dossier, IRSN highlighted the major work carried out by the ILL on verifying the conformity of the installation with the applicable requirements and on reassessing its safety, involving in particular provisions constituting the "post-Fukushima hardened core" of the reactor in the event of extreme hazards. IRSN did nevertheless point to the need for additional safety improvements, in particular reinforcing the polar crane of the reactor building and managing the consequences of any fire that might break out in this building.





#### DENSIFICATION PROJECT FOR POOLS C, D AND E AT LA HAGUE

While pending the commissioning by EDF of its future spent fuel assemblies storage pool, Orano is planning to increase the operational capacity of three spent nuclear fuel storage pools that it operates on its site at La Hague (Manche), by reducing the size of the storage equipment used (densification). At the request of the ASN, IRSN conducted an appraisal in 2021 of the safety options dossier for this project and issued a notice, available in commented version on its website. In its conclusions, the Institute considers that the safety options chosen for this densification are globally suitable. It identified, moreover, matters that should be taken into account in the dossier provided, in support of the future authorisation request. These concern in particular the design of the new storage facilities and the efficiency of the pool water cooling systems.







# Nuclear defense safety, nuclear security, nuclear and chemical non-proliferation

## 66

TECHNICAL NOTICES  
AND REPORTS  
SUBMITTED  
TO THE ASND

Within a formalised conventional framework, IRSN provides support or technical aid to the DSND (Representative in charge of Nuclear Safety and Radiation Protection for Defense-related Activities and Facilities), the HFDS (Senior Defense and Security Officials) of the Ministry of Ecological Transition (MTE) and the Ministries of the Economy, Finance and Recovery (MEFR), and the EURATOM Technical Committee (CTE).

## 52

TECHNICAL NOTICES  
ISSUED TO THE HFDS  
(SENIOR DEFENSE  
AND SECURITY OFFICIAL)  
OF THE MINISTRY  
OF ECOLOGICAL  
TRANSITION (MTE)

The missions entrusted to the Institute cover the fields of the nuclear safety of facilities and activities of interest to defense, protection against acts of malice, and the control of nuclear materials, facilities and transport (with the exception of the field of deterrence), as well as the application in France of the international treaties for combating the proliferation of chemical or nuclear weapons of mass destruction.

This comprises the technical appraisal of dossiers submitted by operators to the Authorities, the conduct of studies in disciplines such as cybersecurity or the effects of weapons and explosives, as well as various activities that are more directly operational, in particular supporting inspections designed to check compliance with the requirements linked to the international undertakings incumbent on France, keeping centralised accounts of nuclear materials, or monitoring the transportation of nuclear materials on national territory.

IRSN also conducts studies or tests in partnership with specialised national or international organisations on personal protective equipment (PPE), in order to test the equipment's capacities and vulnerabilities. In 2021, efforts were focused on the development of rapid pre-analysis tools for the effects of an explosion on a facility or during transportation, as well as on the reproduction of a command and control system for the application of cyber-attack intrusion tests.

## 66

TECHNICAL NOTICES  
SENT TO THE CTE  
AND TO THE HFDS  
(SENIOR DEFENSE  
AND SECURITY OFFICIAL)  
OF THE FINANCE  
MINISTRIES





# Nuclear defense safety

**In 2021, IRSN continued its activities in support of the Directorate of nuclear security (*Délégué à la sûreté nucléaire* - DSN) for facilities and activities concerning defense in the framework of ongoing nuclear-powered submarine programmes. The Institute has also examined the safety of laboratories and plants relevant to defense, such as CEA Valduc (Côte-d'Or).**

## NAVAL PROPULSION

IRSN periodically examines the feedback from naval propulsion boilers for the DSND (Representative in charge of Nuclear Safety and Radiation Protection for Defense-related Activities and Facilities). The lessons learnt from the period 2017-2019, in particular from the action plans implemented in the context of extending the service life of *Rubis*-type submarines, were presented to the reactor safety commission on 24 June 2021. At this meeting, which marked the culmination of many technical exchanges since the start of 2020 between the IRSN expert appraisal services and the French Navy, the commission was able to note how well the feedback process had been appropriated by those concerned, and underlined the quality of the work accomplished, not least with respect to the set deadlines.

Furthermore, as part of its support for the DSND, IRSN was involved in the operational commissioning of the *Suffren*, the first nuclear attack submarine of the *Barracuda* programme, the sea trials for which began in 2021. The construction of the next submarines, taking place in Cherbourg (Manche), will give rise to the safety review of the *Duguay-Trouin*, scheduled for 2022.

The Institute has also conducted a safety assessment of the work carried out to adapt the ground support facilities for the on-board nuclear boilers, for the naval bases at Brest (Finistère) and Toulon (Var).

## LABORATORIES AND PLANTS RELEVANT TO DEFENSE

IRSN has examined from a safety perspective the planned changes on the CEA Valduc site (Côte-d'Or), dedicated to French nuclear deterrence. Current programmes relate both to the reconfiguration of existing facilities and the construction of new facilities in order to keep up-to-date and adapt to the needs of deterrence. In 2021, the Institute took part in the meeting of the laboratories and factories safety and waste management commission (CSLUD), which represents one of the safety review gates of this long-haul programme.

# Nuclear security

**In 2021, the main actions of IRSN in the field of nuclear security related to the revision of the regulatory corpus on nuclear security, the examination of studies of acts of malice on nuclear sites, the signing of collaborative agreements, and the development of innovative tools in the fields of detonation technology and cybersecurity.**

## NUCLEAR FACILITIES SECURITY APPRAISALS

In 2021, IRSN conducted in-depth technical examinations of studies of acts of malice on nuclear sites, and in particular the CEA sites at Cadarache (Bouches-du-Rhône), Fontenay-aux-Roses (Hauts-de-Seine), Marcoule (Gard) and Saclay (Essonne). Submitted at the end of 2021, the first notice from IRSN relating to CEA site security concerned the site at Fontenay-aux-Roses. To conduct this wide-ranging work and coordinate the contributions from its experts, IRSN organised itself in project mode, reflecting the number of persons involved and the various facets to be studied.

## PRODUCTION OF AN ASSESSMENT GUIDE FOR THE SECURITY OF OPENINGS

After several years supporting the MTE and ASN in the formulation of national regulations for the security of radioactive sources, published in late 2019, IRSN was called upon to draft an assessment guide for the resistance of doors and openings. This document comprises the fundamentals in the field of physical protection for enabling all inspectors called upon to travel to a site to pronounce on the vulnerability of the access mechanisms put in place by the operators, in the industrial domain or in other sectors, with regard to the specific characteristics of each of these mechanisms.



## ANNUAL MEETING ON SECURITY AND SAFEGUARDS WITH THE DOE

On the 4th and 5th of October 2021, IRSN organised the 14th annual meeting of the "Permanent Coordinating Group" with the US Department of Energy (DOE). Besides reviewing the current programmes, this meeting provided the opportunity to discuss future actions in fields such as cybersecurity, transport security, metrology, and training on the monitoring and accounting of nuclear materials.

IN BRIEF



## SAFETY ASSESSMENT AND PROTECTION EXERCISES (EPEES) 13-14

On 2 December, IRSN organised a nuclear security exercise for the HFDS (Senior Defense and Security Officials) of the MTE, an exercise that for the first time took place jointly on two different nuclear facilities (EDF and ORANO Tricastin). This exercise required the mobilisation, notably, of around 50 people from IRSN to run it and to assess it, and involved several hundred participants from the entities concerned.

IN BRIEF

## REGULATORY REVISION OF NUCLEAR SECURITY

As part of its expert appraisal and technical assistance remit for the HFDS (Senior Defense and Security Official) of the Ministry of Ecological Transition (MTE), IRSN had contributed in 2020 to the revision of the decree relating to the implementation of the regulations on the protection and control of nuclear materials, their facilities and their transportation (PCMNIIT regulations). Decree 2021-713 of 3 June 2021 provides for the coming into force of the new regulations on 1 January 2023, and IRSN took part throughout the year in thematic work groups and steering committees for revising all the implementation orders.

## SECURITY APPRAISALS:

### A FRAMEWORK FOR WORKING WITH THE MTE

Drafted jointly with the Ministry of Ecological Transition (MTE), this document details the general terms of the implementation of expert appraisal work conducted by IRSN in the framework of its support to the nuclear security department of the MTE.

## RENEWAL OF AGREEMENTS LINKING IRSN TO THE SID AND ISL

The renewal for three years of the partnership agreement with the Defense Infrastructure Service (*Service d'infrastructure de la Défense* - SID) will enable IRSN to conduct joint testing with the SID on different topics and to benefit from a dedicated space for exchanging with the experts on the protection of the Armed Forces infrastructures. The renewal for three years of the partnership agreement with the Saint-Louis Franco-German research institute (ISL) will enable the continuation of the joint testing programme and make it possible to benefit from a dedicated space for exchange. In the framework of this agreement, a PhD thesis co-funded by both institutes and co-directed by IRSN and the CNRS will enable IRSN to reinforce, in complete independence, its knowledge of topics with major security implications.





#### CYBERSECURITY OF INDUSTRIAL SYSTEMS: CONDUCTING TESTS ON THE HYDRA PLATFORM

In the field of cybersecurity, IRSN is developing a platform designated HYDRA, which enables the reproduction of a variety of digital systems and the conducting of tests that could not be carried out in a nuclear power plant in operation. Based on the reproduction of a realistic command and control version of a reactor and the definition of cyber-attack scenarios produced in 2020, IRSN carried out tests in 2021 designed to identify the potential vulnerabilities of the system. HYDRA reinforces the expert appraisal capacity of the IRSN cybersecurity engineers, whose work, until now centred on analysing documents and conducting interviews with the operators, has now been enhanced with a simulation tool that is both original and relevant.



#### SECURITY OF IONISING RADIATION SOURCES: AN E-LEARNING MODULE AIMED AT BUSINESSES

Aimed at those responsible for nuclear activities who hold, use, manufacture, distribute, import, export or transport sources of ionising radiation, and at the persons authorised to access and convey these sources, this module designed by IRSN proposes training in the new regulatory texts that frame the security of the sources.

IN BRIEF

#### STUDY OF THE EFFECTS OF EXPLOSIONS AND WEAPONS ON REINFORCED CONCRETE STRUCTURES

In 2021, IRSN updated the DOPEX platform for the development of rapid pre-analysis tools for the effects of explosions and weapons on facilities or transport involving nuclear materials. The purpose of this is to make available a set of tools enabling the rapid assessment of damage to structures following a malicious attack. The tools developed have been subject to validation by comparison with experimental values obtained, inter alia, from tests conducted on the site of ARIANE GROUP, with which the Institute is in partnership.

# Nuclear and chemical non- proliferation

**In the field of nuclear non-proliferation, IRSN can point to three highlights in 2021: its contribution to the annual congress on nuclear safeguards of the ESARDA association; the analysis of the new administrative framework for trade and cooperation on nuclear materials, equipment and technologies between the Member States of EURATOM and the United Kingdom; and its contribution to the French response to the EURATOM questionnaire aimed at assessing the timeliness of revising regulation 302/2005.**

**In the field of the non-proliferation of chemical weapons, IRSN is participating in the national group coordinated by the Ministry for Europe and Foreign Affairs to define the priorities of France for the 5th review conference of the CWC.**

## IRSN CONTRIBUTES TO THE ORGANISATION OF THE 2021 SYMPOSIUM OF ESARDA

The European Safeguards Research & Development Association (ESARDA) and the Institute of Nuclear Materials Management (INMM) jointly held, last August, their annual symposium. Due to the constraints linked to the Covid-19 crisis, the symposium was held by video conference. With France currently chairing the Association, IRSN made seven contributions, including one co-authored with the EURATOM Technical Committee and the Belgian Federal Agency for Nuclear Control (FANC). These contributions dealt with subjects such as the development of software for the characterisation of nuclear materials using weighing methods, the IT tools developed by the Institute to facilitate the follow-up of inspections, and the implementation of inspection regimes in EURATOM Member States and countries outside the European Union.

The symposium also saw the signing of a cooperation agreement between ESARDA and the IAEA, notably in favour of actions related to the capitalisation of knowledge.

## IMPACT OF THE EURATOM-UK AGREEMENT ON TRADE AND COOPERATION IN NUCLEAR MATERIALS, EQUIPMENT AND TECHNOLOGY

In late December 2020, EURATOM and the UK signed an agreement setting out the administrative framework for future trade and cooperation in nuclear materials, equipment or technology between the EU and the UK. IRSN, which is responsible in particular for transmitting operator notifications for nuclear material imports and exports to EURATOM, took part in a meeting on 25 January to present this new agreement to industrialists in the nuclear sector. As part of its technical support for the EURATOM Technical Committee (ETC), the Institute sent a notice to the committee in February 2021 after analysing the constraints that this agreement could create on exchanges in this field with the United Kingdom.



## PREPARATION FOR THE 5TH REVIEW CONFERENCE OF THE CWC

As part of its technical support for the French authorities, IRSN proposed, within the framework of the five-year review of the Chemical Weapons Convention (CWC), a number of technical avenues for reinforcing or increasing the efficiency of the verification regime of the Organisation for the Prohibition of Chemical Weapons (OPCW). These proposals will inform the French position at the conference, as defended by the Ministry for Europe and Foreign Affairs, in accordance with France's political line within the OPCW.

## IRSN ACADEMY HOLDS ITS FIRST ENTIRELY REMOTE TRAINING COURSE ON NON-PROLIFERATION

12 trainees in 11 different time zones took part, from 20-30 September 2021, in the first international training course of the new IRSN Academy, entitled *"Implementing nuclear safeguards in practice"*.

IN BRIEF



## EURATOM QUESTIONNAIRE RELATING TO REGULATION 302/2005

Based on its expertise in international safeguards for nuclear materials and its field experience in accompanying inspections conducted by EURATOM in France, IRSN contributed, as part of its technical support for the EURATOM Technical Committee (ETC), to the drafting of the French authorities' response, scheduled for October 31, to the questionnaire sent by the European Commission as part of its project to revise European Regulation No. 302/2005 on the safeguards for those in possession of nuclear materials (uranium, plutonium, thorium) within the Member States of the European Union.

IN BRIEF



# 360° VIEW



How IRSN  
monitoring  
benefits  
people and the  
environment







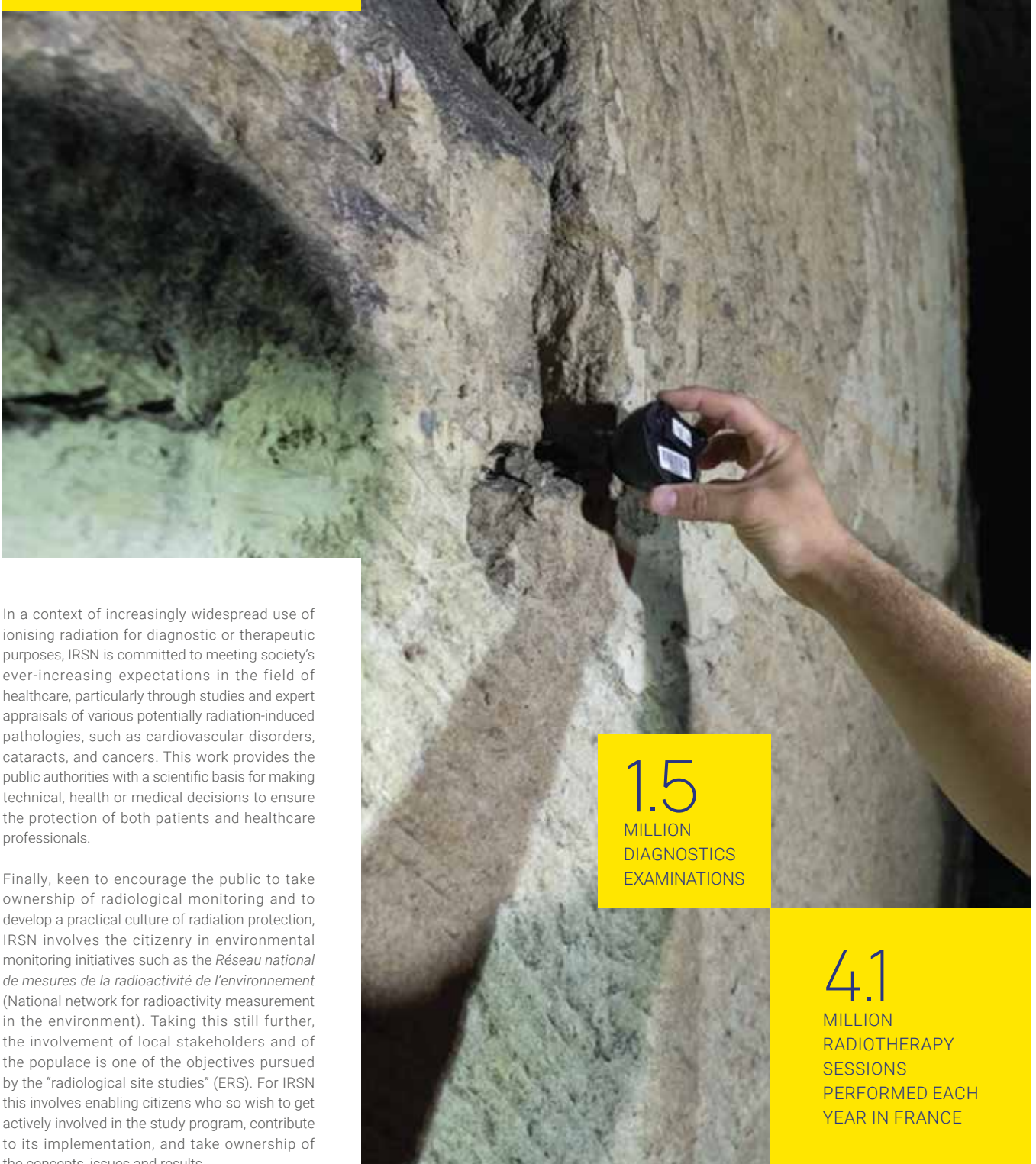
SERVING  
PEOPLE

➤ page 33

KNOWING THE RADIOLOGICAL  
STATUS OF THE ENVIRONMENT  
IN ORDER TO BETTER PROTECT IT

➤ page 37

The protection of people and the environment constitutes an essential mission of IRSN, enshrined in the founding articles of the Institute. To this end, IRSN carried out a set of actions which draw on appropriate resources, such as the collection of environmental monitoring data by means of remote measurement networks and sampling, and the radiological monitoring of people by means of databases and computational tools using artificial intelligence. The Institute draws up on this basis periodic reports of the radiological exposure of the entire French population or of certain population categories (workers, patients, children, etc.) and makes these documents available to the public on its website.



In a context of increasingly widespread use of ionising radiation for diagnostic or therapeutic purposes, IRSN is committed to meeting society's ever-increasing expectations in the field of healthcare, particularly through studies and expert appraisals of various potentially radiation-induced pathologies, such as cardiovascular disorders, cataracts, and cancers. This work provides the public authorities with a scientific basis for making technical, health or medical decisions to ensure the protection of both patients and healthcare professionals.

Finally, keen to encourage the public to take ownership of radiological monitoring and to develop a practical culture of radiation protection, IRSN involves the citizenry in environmental monitoring initiatives such as the *Réseau national de mesures de la radioactivité de l'environnement* (National network for radioactivity measurement in the environment). Taking this still further, the involvement of local stakeholders and of the populace is one of the objectives pursued by the "radiological site studies" (ERS). For IRSN this involves enabling citizens who so wish to get actively involved in the study program, contribute to its implementation, and take ownership of the concepts, issues and results.

1.5

MILLION  
DIAGNOSTICS  
EXAMINATIONS

4.1

MILLION  
RADIOTHERAPY  
SESSIONS  
PERFORMED EACH  
YEAR IN FRANCE



BENCHMARK

# SERVING PEOPLE

PATIENTS, WORKERS, THE GENERAL POPULACE: THE MONITORING ACTIONS PROVIDED BY IRSN AIM TO CAPITALISE ON PEOPLE'S EXPOSURE TO RADIOACTIVITY IN ORDER TO ALERT THE PUBLIC AUTHORITIES IN THE EVENT OF AN ABNORMAL SITUATION. THIS MONITORING IS REFLECTED IN THE PERIODIC PUBLICATION OF EXPERT REPORTS, THE CONCLUSIONS OF WHICH MAY CONTRIBUTE, IN CERTAIN CASES, TO THE IMPLEMENTATION OF ACTIONS AIMED AT REDUCING EXPOSURE SITUATIONS. THE INSTITUTE CONTRIBUTES IN THIS WAY TO PUBLIC HEALTH.



## 387,452

WORKERS HAVE BEEN MONITORED FOR THEIR EXPOSURE TO IONIZING RADIATION AS A RESULT OF THEIR ACTIVITY IN 2020

## 94%

MORE THAN OF MONITORED WORKERS RECEIVED AN ANNUAL DOSE OF LESS THAN 1 mSv

REGULATORY ANNUAL LIMIT OF

## 20 mSv

EXCEEDED FOR SIX WORKERS (FIVE IN 2019)

## 197,485

ROUTINE INTERNAL EXPOSURE ANALYSES

### Close monitoring of worker exposure

Since 2006, IRSN has published annually a report on the monitoring of workplace exposure to artificial or natural sources of ionising radiation. In accordance with the French Labour Code (articles R.4451-1 ff.), the report concerns all monitored workers in all sectors – civil and defense – involving ionising radiation sources: medical and veterinary activities, nuclear or non-nuclear industry, research and teaching, as well as workers likely to be exposed to natural radioactivity. The monitoring concerns both external exposure and internal exposure by inhalation, ingestion or absorption through the skin.

The dosimetric information or exposure measurements are periodically transmitted by the accredited dosimetry laboratories or by airline companies where flight crews are concerned.

All this is centralised and saved in the SISERI information system, managed by IRSN at the request of the DGT (*Direction générale du travail* - Directorate-General for labour). Only the occupational physicians and radiation protection counsellors have access to any or all of the SISERI data concerning the workers under their charge. To guarantee the protection of the stored data, access to SISERI is nominative and delivered to an individual designated in advance by the employer. Although the system has regularly evolved to incorporate regulatory changes and take account of user feedback, a major overhaul was undertaken in 2021, in particular to facilitate data entry and access to information, but also to eventually make the system interoperable with the related information systems of the Government or of private operators, such as certain laboratories that monitor external and/or internal exposure. The new portal is designed to integrate functionalities using artificial intelligence tools, such as the automatic detection of potentially abnormal doses, taking into account the context of worker exposure. The overall work has drawn significantly on collaboration with the users, so as to best meet their expectations, for collaboration that is run by IRSN Lab, the Institute's innovation laboratory.



### Regulatory dose limits

#### Exposure limits measured according to body area and age of worker

The annual limits applicable in France (article R.4451-6 of the Code of Labour) are recapitulated below:

ENTIRE BODY  
(effective dose)

20 mSv

Worker

6 mSv

Young worker (16 - 18)

RING AND BRACELET  
(equivalent dose)

500 mSv

Worker

150 mSv

Young worker (16 - 18)

EYE LENS  
(equivalent dose)

20 mSv

Worker

15 mSv

Young worker (16 - 18)

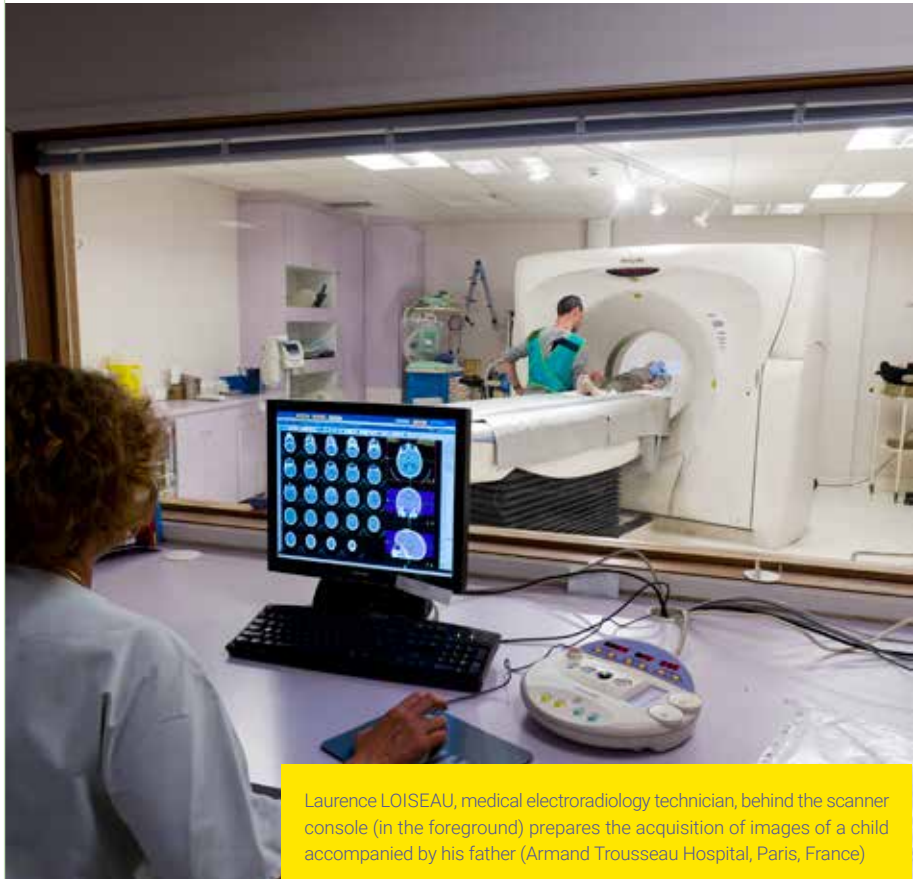


*IRSN provides technical and scientific support to the DGT in the field of ionising radiation, and in particular radiation protection for workers.*

*As well as the technical notices published, in particular in the framework of the drafting of regulatory texts, IRSN conducts long-term regulatory missions such as the management of SISERI, the production of the annual workers exposure report, and proficiency testing of accredited dosimetry laboratories. It also responds to specific referrals such as those on radon in agricultural cavities or tourist caves. There is therefore a great deal of interaction between us. Our collaboration with IRSN is characterised both by the level of its expertise and by the quality of our working relationship, which has enabled real progress to be made in the safety of workers, as testified by the recent regulatory reform aimed at improving worker protection. The wealth of expertise of IRSN, covering all the fields of radiation protection, is an important asset, as its positioning on the international bodies, which allows us to benefit from the undeniable advantage of international comparisons in matters of radiation protection. Yet above and beyond all that, its main asset resides in the skills, reactivity and availability of its teams."*

#### **Anne AUDIC**

Vice Deputy Director, Sub-Directorate for Working Conditions, Health and Safety at Work, DGT (*Direction générale du travail - Directorate-General for labour*)



Laurence LOISEAU, medical electroradiology technician, behind the scanner console (in the foreground) prepares the acquisition of images of a child accompanied by his father (Armand Trousseau Hospital, Paris, France)

### **Medical imaging and exposure to ionising radiation**

Among the categories of the population exposed to ionising radiation, IRSN periodically analyses the exposure of the French population to ionising radiation due to diagnostic medical imaging examinations, in line with the missions entrusted to it under the Public Health Code. Hence, the latest ExpRI report, published in late 2020, relates to the year 2017 and analyses the evolution of this exposure since 2012.

The proposed analysis is broken down per mode of imaging (conventional, interventional and dental radiology, CT scanning and nuclear medicine),

by anatomical region explored, by age and by sex. The analysis is conducted based on procedures taken from a representative sample of health insurance beneficiaries.

The latest report concludes that exposure is globally well managed, thanks to improved skills in radiation protection by professionals and the improvement of the imaging systems, as well as awareness-raising actions that have been implemented. One point of vigilance does need to be underlined: this concerns the issue of recurrent examinations, in general on patients being monitored for serious pathologies. The question of potential long-term radiation-induced effects needs to be considered.



# 45.4%

OF THE FRENCH POPULATION UNDERWENT IN 2017 ONE OR MORE DIAGNOSTIC PROCEDURES (43.8% IN 2012); 32.7% NON-DENTAL EXAMINATIONS



A GLOBALLY LOW ANNUAL EFFECTIVE DOSE PER INDIVIDUAL, STABILISED AT

# 1.53 mSv

(1.56 mSv IN 2012)



## Diagnostic reference levels

To limit the exposure of patients to ionising radiation when undergoing examinations for diagnostic purposes or interventional procedures, "diagnostic reference levels" (DRL) have been established in the public health code for the most frequent and/or most irradiating procedures (X-rays, scans, etc.). These DRLs are established for standardised examinations and patient types and must not be exceeded without justification for everyday procedures. As part of its radiation protection for people remit, IRSN has been tasked with establishing these DRLs and regularly updating them on the basis of annual dosimetric assessments transmitted by the healthcare establishments. To support healthcare professionals, two experts specialised in medical physics can be reached by telephone or by email, and a dedicated website provides up-to-date information on the topic.

**The latest report published in spring 2020 based on data transmitted to the Institute between 2016 and 2018 indicates a reduction in doses to the tune of 12% in scanning, 7% in radiology, and 3% in nuclear medicine.**

## Programmes aimed at epidemiological monitoring

In parallel to the radiological monitoring of the population as a whole, IRSN continues to monitor certain cohorts (children, practitioners, etc.) for epidemiological purposes. The acquired data is fed into studies conducted both nationally and on a European level.

This is the case for the COCCINELLE cohort, relating to 19,000 children who have undergone before the age of 16 an interventional cardiology procedure aimed at diagnosing and treating a cardiovascular disease. The objective of this cohort is to assess the risk of developing a solid tumour cancer or leukaemia associated with radiological exposure during childhood, a period of particular sensitivity to ionising radiation. The "Enfant Scanner" ("Child Scan") cohort, established by IRSN in collaboration with around 20 university hospital centres, comprises more than 100,000 children born after 1 January 1995 and who were exposed to a first scan between 2000 and 2011. This monitoring is being continued in order to provide sufficient statistical power to be able to confirm certain preliminary results suggesting an increased risk of certain cancers associated with the dosage.

For several years, IRSN has also been conducting a study, entitled O'CLOC, in conjunction with interventional cardiologists, on the risk of radiation-induced cataracts among this category of practitioner. The analysis of the results obtained, compared to those from a control group of non-exposed workers and who are comparable in terms of both age and clinical characteristics, has demonstrated a risk of posterior subcapsular cataracts that is almost 4 times higher among interventional cardiologists.

## Exposure of the French population: what conclusions?

The reports on the French population's exposure to ionising radiation published regularly by IRSN take into account exposure linked to ionising radiation of natural origin (cosmic and telluric radiation, radon and ingestion of natural radionuclides), medical imaging, atmospheric fallout from major accidents and nuclear weapons tests, as well as operating discharges from authorised nuclear activities. This analysis make it possible to obtain a global state of play and periodically measure the evolution of this exposure. The report published by IRSN covers the period 2014-2019.

It establishes that the average effective dose per inhabitant remains globally unchanged, at 4.5 mSv/year, compared to the previous edition, published in 2015 for the period 2008-2013. The study shows that the main sources of this exposure are medical procedures for diagnostic purposes (34%) and exposure to radon (33%). Next come telluric irradiation (14%), the incorporation of natural radionuclides (12%), cosmic radiation (7%) and, lastly, the industrial and military usage of radioactivity essentially linked to old fallout from atmospheric nuclear testing and the Chernobyl disaster (<1%). These constitute average values and may vary according to individual lifestyles and geographical locations.

**To enable anyone to calculate their own exposure to radioactivity, both natural and artificial, IRSN has designed and made available an online calculation tool.**

### IN THEIR OWN WORDS

*As a radiologist specialised in paediatric imaging, I am heavily involved in the medical follow-up of young patients, and my diagnostic and interventional clinical activity has naturally led me to become actively involved in the field of radiation protection for patients. This therefore leads me to collaborate regularly with IRSN, concerning scientific studies on the exposure of children to ionising radiation, the drafting of information booklets, the results of the ExPRI reports, and the evolution of paediatric diagnostic reference levels. These diagnostic reference*

*levels, or DRL, have become – for the most common procedures – a tool for analysis and optimisation of the practices, and their updating makes it possible to measure the technical progress made by the manufacturers and the optimisation work carried out by radiologists. Even if reducing the delivered doses in an examination is an essential objective, it must not under any circumstances be detrimental to the diagnostic performance of our examinations. Currently, the examinations that are subject to DRL are defined according to the techniques used and the anatomical zone. It is highly probable that the DRL values of these examinations will continue to evolve, but it will be vital to take into account the clinical indication. Lastly,*

*a new dosimetric indicator has been introduced thanks to the DRL: the Diagnostic Guide Value (DGV). These values will allow radiologists to embark on a more demanding optimisation effort, since these values are only today available for adults, and it would be good if they could be proposed for paediatric examinations."*

### Prof. Hubert DUCOU LE POINTE,

Head of the radiology department, Armand-Trousseau Children's Hospital, Paris



Role of the medical physicist and use of DRLs at the Orléans Regional Hospital



## Greater or lesser exposure to each source

### Average exposure value with typical variation range

#### 1 MEDICAL DIAGNOSIS

1,5 mSv

Variation range: from 0 to 15 mSv

This is a primary source of artificial exposure. It depends on the type of examination (X-ray or scan) and the area of the body to be examined, as well as the number of procedures in the year. For the same person, the medical exposure can vary markedly from one year to the next.

#### 2 RADON GAS

1,5 mSv

Variation range: from 0.54 to 3.2 mSv

Radon gas emanates mainly from granitic and volcanic rocks. Exposure varies according to the characteristics of the soil, the building (materials, foundations, ventilation which may or may not facilitate the transfer of the gas) and the way of life (frequency of ventilation).

#### 3 RADIATION FROM THE SOIL

0,63 mSv

Variation range: from 0.36 to 1.1 mSv

Terrestrial (telluric) radiation depends on the nature of the soil. For example, the presence of granite, rich in radioactive elements, increases the effective dose. Other factors that cause exposure to vary are the time spent indoors and the building materials used.

#### 4 WATER, FOOD AND TOBACCO

0,55 mSv

Variation range: from 0.4 to 3.1 mSv

Food and the water in drinks naturally contain radioactive elements. Frequent consumers of fish and shellfish are more exposed to this sort of exposure, as are smokers.

#### 5 COSMIC RADIATION

0,32 mSv

Variation range: from 0.3 to 1.1 mSv

Cosmic radiation is caused by particles from the Sun and the galaxy bombarding the Earth. This most concerns people travelling frequently by air and inhabitants of high-altitude regions.

#### 6 INDUSTRIAL AND MILITARY NUCLEAR FACILITIES

0,012 mSv

Variation range: from 0.0093 to 0.046 mSv

This exposure is related to the fallout from old nuclear weapons tests and the Chernobyl accident. Nuclear power plants and installations have little impact on the exposure of the population: this ranges from 0.001 mSv/year in the environment close to industrial sites to 0.00011 mSv/year if we consider the entire French population.



### Expertise in the service of public authorities and international bodies

To support the public authorities on questions linked to ionising radiation, IRSN is regularly called upon to conduct expert appraisals on the possible consequences of IR on human health.

The Institute thus recently published a report on image quality and delivered dose in digital mammography. The appraisal carried out for the DGS (*Direction générale de la santé* - Directorate-General for health) related to digital mammography facilities, in light of the observation by the National Cancer Institute of the non-uniformity of the detection rates of breast cancers depending on the systems used. Although the analysis did not bring to light any differences concerning the interpretation systems, it did nevertheless point to a clear disparity in the average doses likely to be delivered to the mammary gland, leading IRSN to recommend that the technical and clinical performance of certain systems should be scrutinised. By the same token, IRSN produced in 2018 an assessment of the French fleet of scanners and an analysis of the impact of the year of manufacture on the doses delivered to patients. The study observed that the average age of these scanners at the time of renewal is 6.1 years; that 83% of the scanners more than 10 years old are located in public establishments; and that the

dose indices show a 20 to 30% reduction between scanners installed pre-2009 and those installed in 2015. The Institute therefore recommended that scanners aged more than 10 years old should be replaced as a priority and those that are less than 7 years old used in paediatrics.

Lastly, IRSN expertise can be called upon in France and abroad in cases of radiological incidents or irradiation requiring emergency medical treatment. For example, IRSN was called in to take emergency care of a South American worker severely exposed during contact with industrial radioactive sources.

This recognition was formalised by the IAEA in 2021, with the designation of IRSN as an IAEA capacity-building centre in the field of medical management of radiological and nuclear emergencies (see next chapter).





## BENCHMARK

# KNOWING THE RADIOLOGICAL STATUS OF THE ENVIRONMENT IN ORDER TO BETTER PROTECT IT

TÉLÉRAY:

454

INSTALLED SENSORS, 20 MILLION  
MEASUREMENTS PER YEAR

25

AUTOMATIC GAMMA  
SPECTROMETRY BEACONS  
INSTALLED IN 2021 CLOSE  
TO NUCLEAR FACILITIES

OPERA-AIR:  
SAMPLING STATIONS;

2,400

SAMPLES PER YEAR

HYDROTÉLÉRAY:  
READINGS FROM

7

GAMMA SPECTROMETRY  
MEASUREMENT STATIONS  
INTEGRATED EVERY 2 HOURS

23

IRSN WATER SAMPLERS AND  
6 OPERATOR WATER SAMPLERS  
WHOSE SAMPLES ARE TRANSMITTED  
TO IRSN; SAMPLING OVER A PERIOD  
OF 6 DAYS AND MEASUREMENT  
INTEGRATED OVER ONE MONTH

IRSN KEEPS A PERMANENT WATCH ON THE RADIOLOGICAL STATUS OF THE ENVIRONMENT, ESSENTIAL FOR DETECTING ABNORMAL SITUATIONS. IN ADDITION TO THIS MONITORING, IRSN CONDUCTS STUDIES ON A REGIONAL SCALE AND, MORE RECENTLY, STUDIES CENTRED ON THE NEAR ENVIRONMENT AROUND NUCLEAR FACILITIES. IT IS ALSO CALLED UPON BY THE AUTHORITIES FOR BOTH PLANNED AND EMERGENCY OPERATIONS AT POTENTIALLY CONTAMINATED SITES.

### A network spanning the entire territory...

In order to determine the radioactivity in the air and detect any abnormal spikes, IRSN conducts permanent monitoring, using two complementary measurement networks that it manages: Téléray and OPERA-Air.

The Téléray network measures the ambient radioactivity. This is a real-time warning tool for events of a certain magnitude. The measurements are made using a set of 442 sensors spread throughout the country (mainland France and overseas departments/territories), as well as in Tokyo and Kiev. They transmit their data to the remote monitoring room of the Institute, and this information is made public via the site [www.teleray.irsn.fr](http://www.teleray.irsn.fr). Téléray complements the radiological monitoring systems maintained by the nuclear operators and is intended to provide independent information on the ambient levels of radioactivity for the benefit of the public authorities, the elected officials, and the population.

The OPERA-Air network consists of constantly-running aerosol samplers. They filter the ambient air and trap the dust that can then be analysed in the laboratory. In this way, the samples make it possible to obtain a precise measurement of the radioactivity fixed on the aerosols.

Unlike Téléray, the information provided by OPERA-Air enables the detection of low quantities of artificial radioactivity, but their analysis takes several days whereas, with Téléray, the information is known in real time.

To monitor the radioactivity in water, IRSN uses the Hydrotéléray network, which continuously measures the radioactivity of the main French rivers receiving waste discharge from nuclear power plants, upstream of the rivers' estuaries or the point where they leave the country. In addition, a network of water samplers continuously samples the water

and the materials in suspension in the waterways. These samplers are generally downstream of nuclear facilities and at the coastline. The IRSN water samplers are also equipped with settling tanks, for analysing the materials in suspension in the water. Lastly, continuous sampling of rainfall is also conducted, with monthly analysis in the proximity of nuclear sites. Away from these sites, rainwater is collected and analysed in the event of a radiological incident.

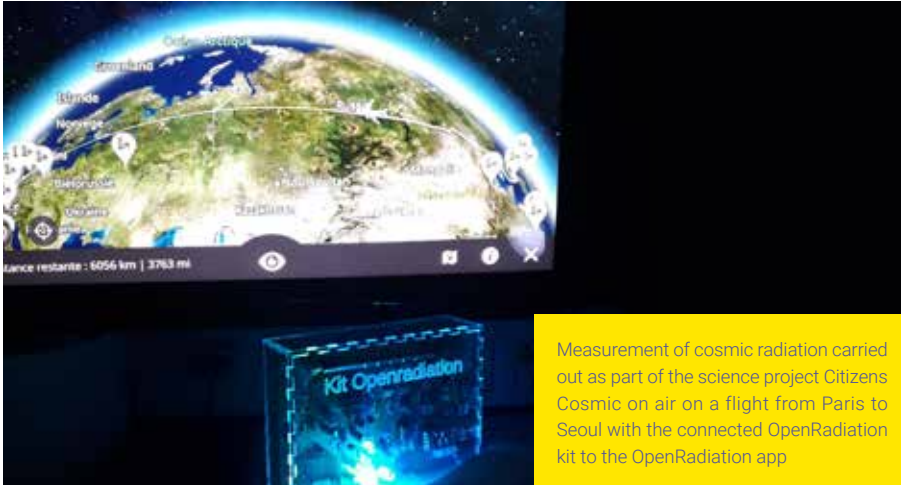
### ... and all environments

IRSN takes samples across the entire national territory: water, soil, fauna and flora (land or aquatic), and food. These samples are measured for the main artificial or natural radionuclides present in France. In this context, the Institute can draw upon a "network" of samplers – operators, local authorities, State services and public bodies – who transmit the samples to IRSN for treatment and analysis.

Lastly, IRSN conducts an annual sampling and analysis campaign for foodstuffs produced and consumed in French Polynesia, thereby contributing to the assessment of the exposure of those residing in the various archipelagos. The sampling strategy chosen enables determination of people's exposure by external exposure, inhalation and ingestion.







Measurement of cosmic radiation carried out as part of the science project Citizens Cosmic on air on a flight from Paris to Seoul with the connected OpenRadiation kit to the OpenRadiation app

#### IN THEIR OWN WORDS

OpenRadiation was conceived after the Fukushima-Daiichi accident, with the development of apps for the general public on smartphones for measuring radioactivity.

It is a participatory project with an educational goal, making available to the public a tool for measuring radioactivity in the environment. The project began in 2013 with the involvement of IFFO-RME, IRSN, PLANETE SCIENCES and SORBONNE UNIVERSITE, then to be joined by ANCCLI. After the development of the system – database, website, app with connected dosimeter – the site was brought into service in late 2017. It today accounts for more than 300,000 recorded measurements made by some 250 contributors. Other actions have been undertaken, and we are working in particular on the use of these data in the Institute's crisis management, to complement the existing field data, in near real-time. Lastly, users have played their part in the overhaul of the site, and their requests will be included in the new version."

**Jean-François BOTTOLIER-DEPOIS**  
Vice-director of healthcare,  
IRSN health and environment division

#### IN THEIR OWN WORDS

Collaboration between IRSN and the DGAL concerns the radiological monitoring of the territory, in the framework of the radionuclides monitoring plan

that we implement with the support of the Institute, which for its part carries out the environmental analyses and sampling, including on foodstuffs. Recently we called upon the expertise of the Institute to look into the conditions imposed by the European Commission on the import of foodstuffs and animal feed originating in or coming out of Japan following the accident at the Fukushima-Daiichi nuclear power plant.

The high level scientific and technical expertise of IRSN as a risk assessor for the food chain is a precious asset for our services. The Institute is the benchmark national laboratory for the analysis of radionuclides in food. It also supports us in crisis situations by taking samples for monitoring the situation nationwide and by modelling the contamination of agricultural production."

**Diane CUZZUCOLI**  
Monitoring and inspection plans coordinator, DGAL (Direction générale de l'alimentation - National Food Directorate)

## Protecting sewage system personnel

Because they may be exposed to radioactive effluent discharged from medical laboratories or the nuclear medicine departments of hospitals, sewage system workers and those tasked with the spreading of sludge resulting from wastewater treatment can benefit from a new calculation tool, developed and put online by IRSN in 2019, for estimating the impact of this effluent on their health.

Designated CIDRRE, this digital template is accessible to all those concerned and provides dose estimates for the different workstations.

## Information and transparency

Created in 2003, the RNM (*Réseau national de mesure de la radioactivité* - National radioactivity measurement network) is managed by IRSN. It is tasked with centralising the information about the radiological status of the environment in all its components – air, water, soil, fauna, flora and food products – and making the information available to everyone. The network of course includes IRSN, the ASN and the ASND, but also the State services, health agencies, public institutes, the nuclear industry, qualified individuals, and consumer and environmental protection associations. Since 2010, all data can be accessed from the website [www.mesure-radioactivite.fr](http://www.mesure-radioactivite.fr).

66 contributors (in 2016) transmitted environmental radioactivity measurements to the national network. An average of 25,000 measurements are transmitted each month.

## Partners

A key element in the management of emergency nuclear or radiological situations, assessment of the accidental atmospheric discharges helps in producing a better assessment of the consequences on the environment and the population. This is the context within which IRSN and Météo France pool their scientific and technical expertise: exchanging meteorological and radiological data and services in the framework of the radiological monitoring of the environment; study and research programmes on extreme climatic hazards or atmospheric dispersion models; integration of radiological monitoring equipment on the various Météo-France sites, and so on. This partnership was renewed in 2019.



## Better characterisation of the territories

In order to obtain an inventory of the radioactivity across the territory, IRSN conducts studies referred to as "regional radiological observations" which each cover part of the national territory and which culminate in the production of reference documents. Regularly updated, these documents report on the radiological "background noise" (natural radioactivity and residual radioactivity from old fallout such as from nuclear weapons testing or the accident at Chernobyl) and on the influence of nuclear facility discharges in the geographical zone concerned. These observations, produced according to the specific features of each of them, would serve as a basis of comparison in the event of an accidental discharge, and they contribute in this way to guiding the deployment of reinforced monitoring. These studies complement the regular monitoring of radioactivity in the French environment, the results of which are centralised by the National metrological network for environmental radioactivity (RNM).

Having covered the whole of France with these regional observations, the Institute wished to deepen its scientific knowledge of the environment close to nuclear facilities by studying more particularly the influence of a power plant such as the one at Saint Alban (Isère), the first installation to have been the subject of a radiological site study on its environment as well as on the exposure of the neighbouring population to its discharges (see next chapter).

## Monitoring the radiological status of the French environment

It is on the basis of monitoring data centralised by the National metrological network for environmental radioactivity (RNM) that the Institute regularly publishes its Report on the radiological monitoring of the environment in France. This document analyses the measurement results in order to report, in complete transparency, on the radioactivity levels in the French environment, whether or not in proximity to nuclear facilities, and to estimate the exposure of the population. This report therefore provides the most global overview possible of all radioactivity measurements made in the environment by the various stakeholders concerned. The latest report was published in 2018 and relates to the period 2015-2017. The results presented put the data acquired during this period into perspective in relation to the data from previous years.

**300,000**  
MEASUREMENTS CONDUCTED ANNUALLY IN FRANCE BY THE STATE SERVICES AND PUBLIC ESTABLISHMENTS, BY NUCLEAR FACILITY OPERATORS, AND BY OTHER PUBLIC, PRIVATE OR ASSOCIATIVE STAKEHOLDERS

## Understanding radon better

Radon, a radioactive gas of natural origin, represents a third of the average exposure of the French population to ionising radiation. It is present across the entire surface of the planet at variable concentrations from one region to the next.

Issuing from the disintegration of the uranium and radium naturally present in the earth and in rocks, radon is classified by the International Agency for Research on Cancer (IARC) as a certain carcinogenic for the lungs. It is considered to be the second cause of lung cancer in France, behind smoking and ahead of asbestos, and as such is the subject of vigilance on the part of the public authorities.

Knowledge of the geological characteristics of the territory therefore makes it possible to establish a map of the zones in which the presence of radon at high concentrations in buildings is most probable. IRSN has therefore produced, at the request of the ASN, a national map as well as departmental and regional maps of the radon potential in the geological formations. This mapping constitutes a technical basis for guiding the implementation of a risk management policy linked to this gas, since it enables targeting of the zones in which its presence in homes at high concentrations is most probable. At municipal level, the mapping enables priorities to be defined for radon detection.



As part of its remit to inform the general public, IRSN has developed an application, Radon & Radioactivity, which can be used to estimate the exposure level to ionising radiation, of cosmic or telluric origin, linked to radon, to the consumption of foodstuffs, or to medical procedures. It also specifies the risk potential linked to radon according to where you live. It is available on Android and (since September 2021) for iPhone.

IN BRIEF

## The three stages in producing a radiological report









# Radiation protection for the environment and for people

26%  
OF FRENCH  
PEOPLE CONSIDER  
HEALTH AS ONE  
OF THEIR PRIORITIES  
(SOURCE: *BAROMÈTRE  
IRSN 2021*)

782  
WHOLE-BODY  
COUNTS FOR  
THE INDIVIDUAL  
MONITORING  
OF WORKERS,  
INCLUDING  
730 USING MOBILE  
FACILITIES

As public expert in the protection of the environment and people against ionising radiation, the Institute continued to pursue in 2021 an environmental monitoring policy based on the continuous acquisition of in-depth knowledge about the radiological status of the French territory and the geographical zones of which it is composed. Hence, in parallel to the measurements taken nationwide, the Institute produced in 2021 its latest territorial radiological observations, which have made way for the first radiological site survey.

As part of its contribution to major public policies that aim, among other things, to encourage comprehensive consideration of environmental health issues – such as the 4th National Health and Environment Plan – IRSN has also conducted studies in fields such as human and environmental radiotoxicology and, in 2021, published a summary of these studies, entitled *“Actualisation des connaissances sur les effets biologiques du tritium”* (“Updated knowledge on the biological effects of tritium”). In the same spirit, the Institute has also continued its actions aimed at improving protection of the public against radon.

In the field of healthcare, IRSN has also extensively collaborated with major partners, such as the Gustave Roussy Institute on the national scale, or the WHO, ICRP and UNSCEAR internationally, to which it has offered in particular its expertise on radiological monitoring.

Lastly, it has strengthened its exchanges with society by way of seminars and round tables, at which experts and citizens are able to share information and field questions on major issues, such as the environmental component of radioactive waste management, or the health consequences of a nuclear accident.

# Radiation protection of the environment

## BETTER UNDERSTANDING THE RADIOLOGICAL STATUS OF THE TERRITORIES

In September 2021 the Institute published its latest regional observation – for the Normandy and Hauts-de-France regions – reporting on the baseline environmental radiological status for this territory. This ties in with the seven observations already produced by IRSN for the different regions of France, in order to enhance our knowledge of the natural and artificial radioactivity levels in the various components of the environment, and to provide a great deal of data, often for the first time, of the situation both near to and far from nuclear facilities. By covering large zones, the regional observations have mainly made it possible to characterise the background noise (natural and ancient anthropogenic) of the regions concerned.

As a complement to the continuous monitoring of the environment on a national scale, this approach, first undertaken in the mid-2010s, has now made way for the radiological site surveys. The first of these was conducted in 2021 and involved the Saint-Alban NPP (Isère). It uses resources enabling characterisation of the influence of plant discharges on the surrounding environment. The purpose of the survey is to improve knowledge relating to the impact of a nuclear site on its environment, to estimate more realistically the exposure of the neighbouring populations, to contribute toward informing the authorities and the general public and, lastly, to help populations take a stake in measuring environmental radioactivity. A second survey was run in 2021 in the environment of the ORANO site at Malvézi (Aude).



## UPDATED KNOWLEDGE ON THE BIOLOGICAL EFFECTS OF TRITIUM

In May 2021, IRSN published the summary of 10 years of research into human and environmental radiotoxicology in a report entitled *Actualisation des connaissances sur les effets biologiques du tritium* ("Updated knowledge on the biological effects of tritium"). This document complements the Institute's work on the behaviour of tritium in the environment (2017) and on the radiological quality criteria applied to tritium in water destined for human consumption (2020). It details the experimental studies in the human and environmental radiotoxicology of tritium, conducted since 2010 by IRSN in collaboration with the Canadian Nuclear Laboratories (CNL). The results obtained complement the prior understanding and are globally in phase with the scientific literature. For most of the biological parameters studied, the induced modifications are only observed for the highest exposure levels.

To enable the stakeholders in civil society to discuss this report with experts, the Institute organised on 8 July a virtual seminar at which its experts, and those of the ASN, CEA, CNL, SEPIA-Santé and associations, were able to discuss the latest issues linked to the presence of tritium in the environment and its effects on health. More than 300 people took part in this seminar.

## MANY EXCHANGES BETWEEN EXPERTS AND SOCIETY

In the framework of the technical exchanges with society on the topic of high-level waste and intermediate-level long-lived waste (HLW/ILW-LL), five meetings were organised in 2020 and 2021, more specifically on the alternatives to geological repositories and waste packages. These meetings made it possible to answer many questions raised by society with a view to the upcoming IRSN expert appraisals on the Cigéo project.

In addition, IRSN took part in January 2021 in a European round table dedicated to information and public participation in the field of radioactive waste management, which was organised by the European Commission's Directorate-General for Energy and the Nuclear Transparency Watch association. The objective of this round table was to review the implementation of the Aarhus Convention in the field of radioactive waste management in Europe, and in particular the implementation of the transparency provisions of the Radioactive Waste Directive, as well as public access to research and expertise.

The Institute presented its feedback from the public debate in 2019 dedicated to the National Radioactive Materials and Waste Management Plan at a session dedicated to France and in which participated the Association nationale des comités et commissions locales d'information (National association of local information committees and commissions) and the Ministry of Ecological Transition (MTE).



In the framework of the webinars organised by the European Radioecology Alliance, two mornings were dedicated to PhD students, on 7 and 14 June 2021, to give them the opportunity to share their work with the community on a wide range of topics: (post-) accident exposure situations, resource contamination (agricultural, water...), management and remediation of uranium mining sites; the Chernobyl exclusion zone, uranium mines and the Irish Sea; bacteria, plants, crustaceans, insects, fish, amphibians and birds. Among the 17 presentations from 12 institutes and seven countries, IRSN was represented by two PhD students.

IN BRIEF



### Measuring tritium in the Loire

At the fourth meeting of the Pluralist monitoring committee of the study of tritium concentrations in the water of the Loire at the Cessart bridge in Saumur, which took place on 28 June 2021, IRSN presented the conclusions of its study launched following publication by a network of citizen samplers of a measurement of 310 Bq/L in January 2019. More than 1,100 samples were taken and measured by IRSN between November 2020 and 2021, at a rate of seven daily samples. In the course of the study, no atypical tritium measurement in the waters of the Loire came to light, with the activity concentrations of tritium varying between the decision threshold (2.5 Bq/L) and approximately 60 Bq/L, including in the period between late November and early December 2020, when the hydraulic conditions of the river and the discharges from the nuclear power plants were similar to those of 21 January 2019.

In addition, this study, which implemented the modelling of tritium concentrations downstream of the Chinon power plant based on field measurements, enabled better characterisation of the conditions conducive to the dispersion of discharges between Chinon and Saumur and of the representativeness of the measurements made at the multi-parameter station of the operator situated downstream of the Chinon power plant.

# Radiation protection for people

## EXPOSURE OF WORKERS TO IONISING RADIATION

In 2021 IRSN published its annual report on the monitoring of occupational exposure to artificial or natural sources of ionising radiation for 2020. Unlike in previous years, this report indicates the monitoring of a cohort down 1.9% compared to 2019, with 387,452 workers. The report also established a 35% reduction in the collective dose for all monitored workers (72.5 H.Sv) and in the average individual dose (0.78 mSv). This reduction concerns all sectors and is mainly linked to the consequences of the health crisis which have required, in particular, the postponement of certain maintenance work in the nuclear industry, and which also caused the drop in air traffic. As far as indoor exposure is concerned, the percentage of positive analyses (0.4%) remained relatively stable compared to 2019. Among the monitored workers, six exceeded the regulatory limit of 20 mSv/year for outdoor exposure and one for indoor exposure.

All the detailed results are presented on the Internet, accompanied by a focus on fields concerned by radiation protection such as, for example, decommissioning sites, flight crews, or the monitoring of the eye lenses of workers in the medical field.

## RADON RISK PREVENTION

As part of radon risk prevention in the occupational environment, IRSN undertook in 2021, at the request of the DGT (Directorate-General for Labour) and the Ministry of Agriculture, a radon measurement campaign in agricultural cavities (cheese, wine and mushroom cellars). Considering the paucity of data on radon concentrations currently available for these workplaces, the objective is to better evaluate the exposure of workers exercising their activities in these places. The measurement campaign conducted by the Institute will be pursued over several years in order to collect a significant volume of data in order to bring to light any specific characteristics particular to these types of underground spaces. The results of the measurements could then help employers to assess the risks for their employees and enable the Ministry of Labour to implement a specific risk prevention policy.





**AS PARTNER OF PARIS PUBLIC HOSPITALS (AP-HP - ASSISTANCE PUBLIQUE DES HÔPITAUX DE PARIS)**, IRSN conducted a measurement campaign involving personnel potentially exposed to radiological contamination by means of anthroporadiometric measurements. For the first time, the mobile laboratory of the Institute took up residence from 8-23 March 2021 with the personnel of the Cochin Hospital and the Georges-Pompidou European hospital. 17 members of staff benefited from this examination.

**IN BRIEF**



**ON 28 JUNE 2021, IRSN HELD THE ANNUAL ACTIVITIES MONITORING MEETING THAT IT RUNS AS A COLLABORATING CENTRE WITH THE WORLD HEALTH ORGANISATION.**

With its third four-year mandate renewed in 2018 as a collaborating centre, IRSN supports the WHO in the field of radiation protection and health: technical appraisals in emergency radiological or nuclear situations, dissemination of knowledge related to the consequences of exposure to radon, and the drafting of reference documents relating to radiological risk management in the medical field.

**IN BRIEF**



**IN THE FRAMEWORK OF ITS IN-HOUSE UNIVERSITY,** IRSN dispenses accreditation training aimed at experts who may be called upon to access data covered by medical confidentiality. This training relates to the regulatory context and framework of accreditation, the legal framework, the general regulations on data protection, and cybersecurity. It also includes a practical case study. Since October 2020, four training sessions have been organised for 49 employees.

**IN BRIEF**



### **Fukushima, Chernobyl: consequences of a nuclear accident on health**

Three years after the seminar entitled *"Radioactivité et santé : où en sommes-nous ?"* ("Radioactivity and health: the state of play"), ANCCLI and IRSN wished, in line with their commitment, to bring together once again the various stakeholders, in particular the members of the local information commissions, associations and stakeholders in civil society. The objective of this 2021 seminar was to engage in discussions on the particular topic of the effects on health of nuclear accidents and share knowledge on this subject at two complementary meetings held by video conference on 8 April and on 30 September/ 1 October. Among the topics addressed were the lessons learnt from monitoring the populations of the contaminated territories around Chernobyl, the health monitoring programme put in place by the Fukushima Medical University, and health research in post-accident situations.





# Internationally recognised expertise

## SUPPORTING THE IAEA FOR RADIOLOGICAL AND NUCLEAR EMERGENCIES

At the 65th general conference of the IAEA, IRSN was designated a Capacity Building Centre of the IAEA in the field of medical and healthcare management of radiological and nuclear emergencies. This designation marks the recognition of the Institute as a partner of the Agency, to which it regularly provides its operational support. In recent years, more than 10 severely exposed victims from contact with industrial radioactive sources or as a result of overdoses in radiotherapy have been able to benefit from this assistance from the IAEA. The Institute also supports the Agency in its training and standardisation actions. This recognition consolidates the Institute's position as a leader in the field of medical and healthcare preparation and management for these emergency situations.

## REINFORCED PRESENCE IN THE FIELD OF RADIATION PROTECTION

IRSN experts recently took up posts on the two main international bodies in the field of radiation protection.

The head of the IRSN research department on the biological and health effects of ionising radiation was appointed Chair of Committee 1 (Radiation Effects) of the International Committee on Radiological Protection (ICRP) for the period 2021-2025, and seven other experts from the Institute joined the ranks of the Commission's four committees.

As for the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR), the French delegation this year includes seven people from IRSN. These appointments mark the recognition of the Institute experts' skills on the international stage.





**IRSN**

**OPERATEUR**

**GEMINI**

**9**



# Crisis and post-accident

As part of its contribution to managing nuclear risks and their consequences on people and the environment, IRSN provides its support to the public authorities in situations of radiological or nuclear emergency. As part of this mission, it takes part in the monitoring and warning system in the event of an incident or accident involving sources of ionising radiation, activates its technical crisis centre (CTC), centralises the results of measurements made in the environment, and dispatches its mobile resources on site. In parallel, it proposes to the safety authorities measures aimed at ensuring the protection of the population, workers and the environment, and at re-establishing the safety of facilities.

For this, the Institute possesses crisis organisation that can be activated around-the-clock in less than one hour and which is capable of mobilising, in every field concerned by an emergency situation, a coordinated team of 400 experts in the CTC, based on the site at Fontenay-aux-Roses (Hauts-de-Seine) and equipped with a communication cell. The members of the crisis team convene there to analyse in real time the information transmitted by the nuclear facility operators, by Météo France and by the Téléray network (which conducts real-time measurement of the radioactivity in the air), to establish a diagnostic of the situation and a forecast of its development, and to assess the discharges and the consequences for people and the environment. The CTC coordinates a mobile cell which is responsible, on the ground, for taking measurements in the environment and on people, and coordinates the fixed laboratories of the Institute, the remote monitoring network support, and the dispatching of representatives to the Prefect concerned and the interministerial crisis cell (CIC - *Cellule Interministérielle de Crise*).

IRSN takes part every year in national crisis exercises, to which it contributes the preparation of scenarios, and in international exercises, particularly for the IAEA, as well as in-house exercises on topics such as acts of malice.

7  
NATIONAL  
NUCLEAR  
EMERGENCY  
EXERCISES  
EXCLUDING  
DEFENSE

1

### IRSN PARTICIPATION IN AN EMERGENCY EXERCISE ORGANISED BY THE IAEA

Bringing together 77 Member States and 12 international organisations, this highest-level and most complex emergency exercise of those of the Agency aimed to test the responses to a simulated accident at the Barakah nuclear power plant, situated in the United Arab Emirates. It brought to light the need to continuously reinforce cooperation at both national and international level with regard to rapid exchanges of information, diagnostics and forecasts, assistance and coordination in informing the public.

IN BRIEF



### ARTIFICIAL INTELLIGENCE: GROWTH LEVER FOR THE DOSIMETRIC ANALYSIS CAPACITIES IN CRISIS SITUATIONS

In a radiological or nuclear emergency situation, medical and healthcare management relies on the rapid estimation of the individual doses received both in the triage phase on site and in the diagnostic phase in the hospital. Coordinated by IRSN in the framework of the ASTRID 2020 programme, funded by the AID (*Agence de l'innovation de défense* - Defense Innovation Agency) and operated by the ANR (*Agence nationale de la recherche* - National research agency), the artificial intelligence project for the detection of chromosomal aberrations in biological dosimetry (INCREASED) aims to adapt the most powerful artificial intelligence algorithms to the automatic detection and classification of chromosomal aberrations revealing the radiological exposure of victims. The time savings and the increased number of analyses envisaged by this new approach are essential to operational management. Scheduled to run for three years, INCREASED presents a wide range of applications both in the context of accident situations, including those resulting from acts of malice, and for the health monitoring of persons exposed in the course of their professional activity.

### DETECTION OF RADIOACTIVITY IN THE LME STEELWORKS: IRSN ACTIVATES ITS CRISIS ORGANISATION

From 23 to 26 October 2021, IRSN set up its technical crisis centre (CTC) following an incident leading to detection of radioactivity in the steelworks of the LME company, Trith-Saint-Léger (North department), where metals from different scrap dealers are melted down. In association with the DREAL (*Direction Régionale de l'Environnement, de l'Aménagement et du Logement* - Regional Department for the Environment, Development and Housing) and the prefecture, the Institute dispatched on site a team of 11 people to confirm the presence of caesium 137 in the installation, to identify the process zones revealing traces of radioactivity with a view to establishing the measurement priorities for the internal exposure of workers, and to characterise the site environment in the search for possible contamination. The inspections carried out over two days on 98 people at the steelworks site and the measurements made on the soil and plants in the steelworks environment revealed no internal contamination of the people or radiological marking of the environment.

### CONTRIBUTION OF IRSN TO THE SECNUC GOVERNMENTAL CRISIS EXERCISE

This exercise, which took place on 18 and 19 May 2021 aimed at testing the capacity of the State to handle the post-accident management of a major accident occurring on a nuclear reactor and leading to radioactive discharges into the environment. The Institute set up its technical crisis centre (CTC), comprising 45 people, and took part in the various structures of the Interministerial Crisis Cell (CIC). The first day of the exercise was dedicated to managing the crisis (evacuating the population, prohibiting consumption, food recommendations, etc.), and the second took the form of thematic workshops aimed at anticipating the questions to be dealt with in a post-accident logic (protection of the population, continuity of social and economic life, continuity of power supply, waste management, and communication).

The feedback from the SGDSN was able to confirm, in particular, in light of the exchanges during the exercise, the utility of the direct interactions of the crisis management department with IRSN and the need to guarantee, long-term, in the event of an actual crisis, a high level of representation in the operational centres.

Cs  
137

### CAESIUM 137 IN A PLUME OF DESERT DUST FROM THE SAHARA

Measurements made in early February 2021 by IRSN demonstrated that the very low caesium 137 activity in the transported particles had contributed to a slight increase in the aerosol concentration in the air, leading to deposits in the order of 0.1 Bq/m<sup>2</sup> with a negligible impact in dosimetric terms.

IN BRIEF

# Special Fukushima 10 years on

## "ANTICIPATION AND RESILIENCE: CONSIDERATIONS 10 YEARS ON FROM THE FUKUSHIMA - DAIICHI ACCIDENT"

This is the title of the report published in 2021 by IRSN to mark the 10th anniversary of the accident in the Japanese nuclear power plant. Addressing topics such as the robustness of facilities and the response capacity of people and organisations to unforeseen situations, how to deal with the risks associated with the combination of malfunctions or events with very low probabilities, and the management of post-accident situations, this publication aims to provide insight born of the feedback from the Fukushima-Daiichi accident, both in order to improve the robustness of nuclear facilities faced with extreme hazards and for improving post-accident management.

The chief executive of IRSN, Jean-Christophe Niel, presented this study at an IAEA conference held from 8 to 12 November 2021, in Vienna, and which was dedicated to reviewing the actions undertaken internationally, 10 years after the Fukushima-Daiichi accident, and to the prospects arising from this.

## IRSN HOLDS A HUMAN AND SOCIAL SCIENCES SYMPOSIUM ON THE TOPIC OF THE FUKUSHIMA-DAIICHI ACCIDENT

Echoing the international conference of the IAEA cited above, the symposium organised by IRSN at Montrouge (Hauts-de-Seine) on 24 November 2021 brought together almost 150 experts to discuss the main lessons learnt from the research conducted by the Institute in the field of the human and social sciences (HSS) following the Fukushima-Daiichi accident. Entitled: *"After the Fukushima-Daiichi: adapting to the unexpected"*, this first symposium organised by the Institute in the field of HSS had the central theme of the capacity of organisations to face up to unforeseen circumstances, not only in a situation of radiological or nuclear crisis but also in the framework of accident prevention integrated into the design and operation of a nuclear facility. It enabled identification of the main areas of consideration on subjects such as the mechanisms leading to the "unexpected" in the demonstration of nuclear safety, the notion of the unforeseen in the work of the expert, and the enhancements that can be generated from discussing the results of research in HSS involving the stakeholders.

## 10 YEARS ON FROM THE MOBILISATION OF IRSN TEAMS AT THE TIME OF THE FUKUSHIMA-DAIICHI ACCIDENT

On 11 March 2011, IRSN set up its technical crisis centre at the request of the government and concentrated its actions on two priorities: contributing to the protection of the French community in Japan; and informing, with its expert's gaze, the public about the potential consequences of the accident for the nation.

As soon as the crisis began, IRSN sent a radiation protection expert and measurement equipment to the French Embassy in Tokyo. By making the results of its analyses available to its peer organisations in Europe, to the ETSON network of the European TSOs, to the United States, to the IAEA and, of course, to Japan, the Institute contributed to the transparent management of this major nuclear crisis. By means of sophisticated dosimetric measurements, it was able to inform the French citizens returning from Japan of the low risk level to which they had been exposed.

In France, it alerted its monitoring networks of the ambient radioactivity throughout the territory in order to inform the public, which still harboured memories of the accident at the Chernobyl plant in 1986. In all, more than 150 experts and technicians would be mobilised by the Institute's crisis mechanism, including in the field of communication, over several weeks. For this purpose, the IRSN website would be adapted to as wide a dissemination as possible of the information and analyses available and would become, with sometimes more than 600,000 daily consultations, a major information instrument for the general public.







# Transformation, openness to society and CSR

In 2021, in the context of the Covid-19 health crisis, IRSN continued to implement the roadmap laid out in its document: *Ambitions & strategy 2030* in order to address future issues in terms of societal expectations, the development of the energy landscape, the development of nuclear technologies and facilities, the use of ionising radiation in medicine, etc. The Institute has undertaken or continued to pursue various actions aimed at adapting its governance to the priorities of its responsible Ministries, its institutional contacts and the community.

It has undertaken the revision of its Ethics Charter and renewed the composition of the committee responsible for keeping its management bodies informed in this regard. With the desire to pursue its mission of sharing the know-how and skills of its experts through training and mentoring, the Institute has created the *IRSN Academy*. Drawing on the precious experience of ENSTTI, whose training and mentoring activities ceased in 2020, *the IRSN Academy* will continue to promote the Institute's know-how in these topics of excellence.

The CSR commitments of the Institute have been broken down into several actions marked by particular highlights, such as mobility week or sustainable development week.

Lastly, the openness to society and transparency approach, along with the actions implemented by the Institute, have been presented and promoted to IRSN's European peer organisations, and IRSN has reinforced its exchanges with stakeholders such as Greenpeace. Also, as it does every year, IRSN has polled the French population on the topic of their perception of risks and safety, in order to understand how this perception evolves over time and to provide a better response to the concerns in the field of radiological and nuclear risks.

# A responsible institute

## THE 2020-2021 REPORT OF THE ETHICS COMMISSION

Independent of the IRSN, the Ethics Commission (CED) is composed of seven members who, under its Chair, Françoise Roure, contribute to the governance of the Institute by providing their insight into questions concerning ethics and code of conduct, be it with regard to research, expert appraisal, interactions with industry, or relations with society. In its activities report for the period 2020-2021, the Ethics Commission details the four notices it published between the start of 2020 and mid-2021 and discusses more broadly the state of the work and the topics treated in the course of the meetings it held over the period concerned.

## ROLLING OUT THE CSR STRATEGY

In a changing world, and in line with the societal expectations and major environmental issues, IRSN deploys its corporate social responsibility policy over a wide spectrum of actions: scientific and technical activities, management modes, and daily practices. This dynamic draws on the dedicated governance set up internally, involving the Institute's employees, as well as externally, with space reserved to exchanges with other stakeholders, in particular the Ministries and public bodies for the pooling of experience. In this way the Institute contributes to the dynamic of Agenda 2034 France, for achieving the 17 sustainable development objectives set by the Member States of the UN.

# Management of human capital

## WORKFORCE RENEWAL: PRELIMINARY CONCLUSIONS

The signing of the agreement on renewal and skills transfer of March 2020 testifies to IRSN's intention to manage the development of its payroll. The initial conclusions for the set of provisions in this agreement are positive: during the subscription period from April 2022 to June 2021, 121 employees signed up for the early retirement scheme out of the 222 who were eligible, constituting a 54.5% subscription rate, higher than the average rate observed for this type of scheme. In parallel, the Institute hirings constituted 37.4% young people aged 30 or under, and 56.9% under-35s in 2020. Lastly, the expected savings are consistent with the simulations made when the scheme was launched.

## A very active year for the Social and Economic Committee

Against the background of the Covid-19 pandemic, the IRSN Social and Economic Committee (CSE) met 14 times in 2021, resuming in the course of the year – when this was possible – its plenary meetings in-person, conditions that are far more conducive to dialogue between management and workers. The CSE pronounced on many recurrent subjects (budget, social policy, strategic orientations, training, etc.) as well as on projects central to employee concerns (DESIR project, IRSN Academy, recourse to exceptional work organisation, etc.). Aside from topics linked to health, safety and working conditions in the context of the health crisis, the Committee monitors in particular the management of the employment situation linked to over-staffing in 2020.



## CONTINUATION OF THE MANAGERIAL TRANSFORMATION PROGRAMME

2021 signalled major progress in the managerial transformation culture, with a general sense of momentum being manifested both in terms of governance and with respect to local managers. Hence, 33 groups of managers were able to work together to develop experiments aimed at making the operation of their units simpler and more fluid. A good proportion of the experiments conducted are being analysed within a "simplification" task force, with a view to rapid deployment across the Institute.

This has meant that, with the renewal of certain managerial mandates, a new approach has been able to be tested for the examination of certain applications for job vacancies in 2021. The objective has been to encourage the emergence of applications from new sources, to expand the assessment body for applicants beyond the purely technical scope of the posts in question, and to promote more collegial decision-making. Furthermore, the Institute's innovation laboratory (IRSN Lab) has contributed to redefining the role of the Institute's governance bodies (executive committee and management committee) for greater efficiency in their operation, decision-making and decision implementation.



# Training and capitalising on knowledge

## FROM ENSTTI TO IRSN ACADEMY

Taking over in 2021 the commercial training activities managed until the end of 2020 by the ENSTTI EEIG, IRSN intends to continue, with its IRSN Academy, to build on its capital of know-how and the skills of its experts with the goal of improving safety and radiation protection in France and worldwide.

The training dispensed in France since September 2021 has enabled 124 people to be trained in the course of 13 training sessions, aimed mainly at professionals responsible for risk prevention, control and management. IRSN Academy obtained, moreover, QUALIOP1 certification in December 2021, proof of its competences in the organisation and management of occupational training.

## IRSN REINFORCES KNOWLEDGE POOLING

Encouraging the sharing of knowledge and collaboration between persons practising the same trade (assistant, manager, etc.) or the same missions (quality, etc.), or who share common interests (CSR, etc.): this is the goal of the communities of practices programme of IRSN, of which eight communities were launched in 2021 and eight others are in the course of preparation. In parallel, the increased number of documents (>500,000) accessible with the internal search engine and implementation of a new collaborative monitoring platform have improved access to and sharing of information and knowledge, enabling employees to use, on a daily basis and in the framework of their activities, the extensive knowledge and know-how assets acquired by the experts of the Institute over the years.

# Digital and innovation

## IRSN PUBLISHES ITS DIGITAL STRATEGY

In a context of the continuous development of digital technologies, their performance and their essential contribution to the fulfilment of its missions, IRSN published its strategy in this regard in January 2021. This strategy is intended to support the development of the Institute in various domains (business needs, interoperability with its major partners, optimising data use, digital communication and information, knowledge management, process digitalisation, digital sobriety, etc.). The objective of the strategy is also to improve the working environment for the Institute's employees and support them in ramping up their digital skills.

## IRSN IMPLEMENTS ITS STRATEGY FOR THE OPTIMISED USE OF DATA

Several projects were conducted in 2021 to structure the management of IRSN data according to the principles of: "FAIR: Findability, Accessibility, Interoperability and Reusability" and to conduct the first optimisation projects: cataloguing the Institute data, defining the repositories, and setting up an access and analysis platform for the Institute's data. These projects are accompanied by acculturation and training initiatives for the employees in data science.

## IRSN LAB DEVELOPS ITS FIELD OF ACTION

Created in order to experiment with new methods for finding solutions to organisational, scientific and technical or societal issues, IRSN Lab continued its actions in 2021 for supporting external and internal projects as diverse as the SISERI platform, the design of ring and Dosiris dosimeters, the editorial strategy of IRSN, the organisation of the crisis centre health cell or of the dispatching unit, and feedback on malfunctions with the quality system. It has also helped teams to specify their needs upstream of or when launching services by means of user-centric methods, and has contributed to the implementation of collective construction on business topics such as the development of R&D roadmaps in the environmental, medical and health fields, and the forecasting of how the expert safety appraisal activity is likely to evolve.

- 60 projects supported
- 100 sessions
- 500 contributors

# 44,703

HOURS OF TRAINING  
PROVIDED TO MAINTAIN  
SKILLS



# Committed and more personalised communication

## CAPTURING THE INTEREST OF THE PUBLIC

The communication department refined its editorial line in 2021 in order to make its research and expertise activities still more accessible to every kind of audience.

## MORE TARGETED COMMUNICATION WITH:

- The creation of new digital formats: podcasts enhancing the content of our magazine, *Repères*, and analysis videos: "4 minutes to understand".  
The same objective: getting closer to our public, making technical and scientific topics easier to understand, and making better use of the social networks.
- The development of digital tools for the general public, such as the "Radon and radioactivity" application. This app makes it possible to estimate an individual's exposure levels to radioactivity from natural sources in just a few clicks and to calculate the radon potential in their habitat.

- The embodiment of our scientific communication in researcher portraits, the promotion of the "3 minutes for a thesis" contest and the contents partnership with the magazine *Pour la science* for publishing in-depth articles on IRSN research projects.
- The active participation of IRSN in the *Fête de la Science* (Science Festival) organised by the Ministry for Higher Education, Research and Innovation, combining meetings with young people and thematic exhibitions in several towns and cities.

Internally, a new intranet has been launched: mirroring the transformation of the Institute, and co-constructed with and for the employees, *MyIrsn* is heavily focused on information and sharing news. The communities created in this intranet enable staff to be organised and brought together around common topics.

# Openness to society

## AN APPROACH PROMOTED ON A EUROPEAN SCALE

The EUROSAFE forum which took place in Montrouge on 22-23 November 2021 provided the opportunity to promote the openness to society actions developed by IRSN and to engage in exchanges with the members of ETSON on the question, for a TSO, of opening up its expertise and research to society. The discussions were facilitated by the establishment of a discussion space for discussing the various initiatives implemented by IRSN: presentation of the Openness to society charter; developing dialogue with civil society and taking account of society's concerns, by way of three emblematic approaches: the 4th periodic review of 900 MWe reactors, the storage of HLW/ILW-LL waste, and the OpenRadiation collaborative project for the measurement of ambient radioactivity by the public. These discussions lay the groundwork for the possibility of more in-depth interactions with certain TSOs, such as BeLV, BfS and CSN.

The round table organised on the role of society in safety and radiation protection enabled the Director of ANCCLI to give an account of the expectations and contributions of society with respect to this type of technical dialogue. He insisted in particular on the conditions necessary for society to be able to "exercise its role of civic vigilance in order to contribute to safety" and highlighted the importance of setting up places to conduct ongoing dialogue over time.

## REGULAR EXCHANGES WITH THE STAKEHOLDERS

In the framework of its policy of openness to society, the teams of the Institute regularly meet with those of associations or NGOs in order to better understand their expectations. This was the case in 2021 with France Nature Environnement, Greenpeace and the *Fondation pour la Nature et l'Homme* (Foundation for Nature and Mankind).

At a meeting held on 21 June 2021 between its experts and the Radiation Protection Advisers (RPA) of Greenpeace, the members of this international network of experts and IRSN presented their respective modes of organisation, methods and measurement resources in the event of a crisis. The discussions mainly related to the need for exchanges in order to test these modes of organisation and to the importance of transparency concerning the information available in the event of a crisis.



## IRSN 2021 barometer: the main trends

Based on an Internet survey conducted from 17 to 25 November 2020, the 2021 edition of the *IRSN Barometer on how the French population perceives risks and safety*, published on 26 May, revealed how French people's concerns have evolved: at the top is health, at 26%, followed by terrorism (19%) and climate change (15%), while "poverty and exclusion", the number one concern in the 2020 edition, dropped into fourth place. The highest perceived risk situations are terrorism (76%), cancer (73%), pandemics (71%) and pesticides (70%). Furthermore, floods and droughts are also becoming subjects of major concern.

Concerning nuclear, 53% of the persons surveyed considered that the construction of nuclear power plants has been a good thing, with 18% thinking the opposite. Although the French population as a whole seems to be fairly opposed to pursuing nuclear over the long-term, with 45% of French people opposed to the construction of new nuclear power plants, their stance is split when it comes to the immediate abandonment of nuclear energy. Lastly, the CNRS, ASN and IRSN are perceived, as they were in the previous edition, as the most competent and most credible of the nuclear stakeholders.

# CSR: a vector for transformation

While the deployment of the IRSN CSR policy was manifested in 2020 by the establishment of dedicated governance, with the creation of a “CSR delegation” and a “CSR council” composed of around 50 voluntary employees, and a “CSR Circle” of directors, 2021 was marked by the finalisation of the CSR 2021-2023 roadmap, providing a breakdown in particular of the transformation dynamics in progress. Internally, procedures have been pursued on the circular economy, the social component of CSR, the “Spending responsibly” approach, digital sobriety, biodiversity, and so on.

Externally, IRSN is actively involved in the governmental schemes dedicated to sustainable development: within the framework of the Sustainable development club for public establishments and companies and its new 2021-2025 roadmap, a new “Climate Fresk” (“*Fresque du Climat*”) (see insert) has been organised, along with a visit to the Institute for all the members of the Club. In parallel, an initial summary of the actions of the Institute relating to the topics monitored by the Eco-responsible Public Services (SPE - *Services publics écoresponsables*) scheme was communicated in July 2020 and included in the global report of the Ministry of Ecological Transition for all its departments and the establishments under its control.



## ACTIONS FOR DEPLOYING OUR COMMITMENTS

**“What was that about CSR?” (“*Vous avez dit responsabilité sociale ?*”): a week dedicated the social component of CSR**

Area 1: An Institute committed to the protection of everyone

April 2021 saw the first edition of the “*Vous avez dit responsabilité sociale ?*” (“What was that about CSR?”) week, with round tables on the topics of disability, returning to work after a long illness, and possible links with local associations.

**“Climate Fresk” (“*Fresque du Climat*”)**

Area 2: A mission and actions to benefit the environment

Launch of a “Climate Fresk” (“*Fresque du Climat*”) aimed at employees, for them to take part in or organise the workshop. Based on the observations of the IPCC, this collaborative initiative has already brought together more than 200,000 people worldwide and enabled widespread raising of awareness about the cause-and-effect links contributing to climate change. After a first Fresk, organised for the management committee, several sessions are planned for the employees.

**A responsible approach to operating expenses**

Area 3: A requirement for excellence and responsibility

The purpose of the “Spending responsibly” approach is to reduce the running costs of the Institute and to focus on sustainable and responsible choices. The actions identified, in particular on the basis of proposals from IRSN employees, in fields as diverse as telephony, work travel, the energy consumption of buildings, and subscriptions to scientific publications, will continue to be deployed until 2023. These include, in 2021, the implementation of a new management policy for promotional objects and cutting down on subscriptions to scientific reviews and publications in favour, in particular, of multi-user digital offerings.

**Circular and solidarity economy: first milestones**

Area 4: Active involvement in changes to society

An internal survey and workshops were held for identifying the first commitments to be made as part of a circular and solidarity economy approach. Four topics were identified as priorities: sharing and donations, purchases, digital, waste, and end of life cycle. The IRSN “Océane” exchange platform has been expanded to add furniture and office equipment to the exchanges of scientific and technical equipment. A community of practice has also been set up to encourage exchanges between employees. A first donation of large-format transport crates found a taker in response to an advert placed on the dedicated governmental platform.

- **Almost 5,000** viewings of the home pages for the replays of the round tables of the European week of sustainable development 2021
- **2** communities of practice: CSR and circular economy
- **31%** of space freed up on the “U” directory for the use of each employee in the framework of the 2021 digital sobriety and clean-up campaign
- **Around 15** IRSN employees trained in running the Climate Fresks



# Governance



## BOARD OF DIRECTORS ON 1 FEBRUARY 2022

### Missions

The Board of Directors rules, through its deliberations, on IRSN matters of governance. More specifically, the Board deliberates on general conditions governing organisation and operation, the Institute's programs and strategy, and the annual report. It also approves the budget, the budget amendments, the year-end financial statements and income appropriation.

### ONE MEMBER OF PARLIAMENT

**Perrine GOULET**, MP for the Nièvre department

### ONE MEMBER OF THE SENATE

**Stéphane PIEDNOIR**, senator for the Maine-et-Loire department

### TEN GOVERNMENT REPRESENTATIVES

**Christian DUGUÉ**, inspector for nuclear security at the DGA (*Direction générale de l'armement - Directorate-General for Armaments*), representing the Minister of the Armed Forces

**Benoît BETTINELLI**, head of the Nuclear Safety and Radiation Protection mission of the Technological Risks Department, representing the Minister for the Environment

**Joëlle CARMES**, deputy director of environmental and food risk prevention at the DGS (*Direction générale de la santé - Directorate-General for health*), representing the Minister for Health

**Guillaume BOUYT**, deputy director for the nuclear industry at the DGEC (*Direction générale de l'Énergie et du Climat - Directorate-General for energy and climate*), representing the Minister for Energy

**Frédéric RAVEL**, scientific director for the energy, sustainable development, chemicals and processes sector at the DGRI (*Direction générale pour la Recherche et l'Innovation - Directorate-General for research and innovation*), representing the Minister for Research

**Bruno BERTHET**, head of the risk analysis and management office at the DGSCGC (*Direction générale de la Sécurité civile et de la Gestion des crises - Directorate-General for civil security and crisis management*), representing the Minister for civil security

**Anne AUDIC**, deputy director for "work, health & safety conditions" at the DGT (*Direction générale du Travail - Directorate-General for labour*), representing the Minister for employment

**Alicia SAOUDI**, head of the energy, investments, industry and innovation office at the DB (*Direction du budget - Budget Directorate*), representing the Minister in charge of the Budget

**François BUGAUT**, representative in charge of nuclear safety and radiation protection for defense-related activities and installations

**Bernard DOROSZCZUK**, chair of the ASN (*Autorité de Sécurité Nucléaire - Nuclear Safety Authority*)

### FIVE ADVISORY MEMBERS

**Patrick DUFOUR**, auditor General of the Armed Forces on special assignment, nominated by the Minister for the Armed Forces

**Ginette VASTEL**, doctor in pharmacology, nominated by the Minister for the Environment

**Marie-France BELLIN**, chair of the IRSN Board of Directors, university lecturer and hospital practitioner in the department of diagnostic and interventional radiology of the Bicêtre-Paul-Brousse hospital, nominated by the Minister for Health

**Laurent MOCHÉ**, CEO of Edenkia, nominated by the Minister for Energy

**Fanny FARGET**, scientific research director at the CNRS (*Centre national de la recherche scientifique - National scientific research centre*), nominated by the Minister for Research

### EIGHT STAFF REPRESENTATIVES

**Nicolas BRISSON**, CGT

**Laurence FRANÇOIS**, CFE-CGC

**Léna LEBRETON**, CGT

**Patrick LEJUSTE**, CGT

**Annie CONSTANT**, CFDT

**Thierry FLEURY**, CFDT

**David BOIREL**, CFE-CGC

**Sandrine ROCH-LEFÈVRE**, CFE-CGC

### EX OFFICIO OR ASSOCIATE MEMBERS

**Cédric BOURILLET**, director general for risk prevention and Government commissioner

**Jean-Pascal CODINE**, budget auditor

**Jean-Christophe NIEL**, director General of IRSN

**Louis-Michel GUILLAUME**, IRSN Deputy Director General in charge of defense-related missions

**Isabelle FLORY**, IRSN accounting officer

**Cédric GOMEZ**, works Committee secretary

## STEERING COMMITTEE FOR THE NUCLEAR DEFENSE EXPERTISE DIVISION (CODEND) ON 1 FEBRUARY 2022

### Missions

The committee examines the programme of activities prepared by the Institute's Nuclear Defense Expertise Division (DEND) before it is submitted to the Institute's Board of Directors. It is consulted when the Board of Directors is called upon to make decisions relating specifically to the organisation or operation of this division and makes recommendations to the Board of Directors on matters related to DEND activities.

**François BUGAUT**, chair of CODEND, in charge of nuclear safety and radiation protection for defense activities and installations

**Thierry BURKHARD**, general, Armed Forces Chief of Staff. Represented by the Air Force Brigadier-General, Nicolas LEVERRIER

**Joël BARRE**, engineer General for Armaments, DGA. Represented by the Engineer General for Armaments, Christian DUGUE

**Isabelle SAURAT**, government general secretary for the Ministry of the Armed Forces. Represented by Colonel Franck MOLLARD

**Marc VERAN**, vice-admiral, nuclear weapons inspector

**Mélanie JODER**, budget director of the Ministry of the Economy, Finance and Recovery (MEFR). Represented by Alicia SAOUDI

**Philippe BERTOUX**, director of strategic, security and disarmament affairs for the Ministry for Europe and Foreign Affairs. Represented by François COTTEL

**Marie-Anne BARBAT LAYANI**, senior civil servant for defense and security of the Ministry of the Economy, Finance and Recovery (MEFR). Represented by Christian DUFOR

**Émilie PIETTE**, senior civil servant for defense and security of the Ministry of Ecological Transition (MTE). Represented by Mario PAIN

**Serge POULARD**, advisory member

## SCIENTIFIC COUNCIL ON 1 FEBRUARY 2022

### Missions

The scientific council examines and provides its advice on the IRSN activity programmes, and it oversees the quality and scientific relevance of the IRSN research programmes. It assesses the results of these programmes and is able in this way to provide recommendations on the direction of the Institute's activities. It may be consulted by the Board's chairperson or by the supervisory ministers on any subject within the Institute's remit.

**Robert BAROUKI**, professor of Biochemistry at the University of Paris and Head of the Inserm unit T3S: "Toxicology, Therapeutic Targets, Cellular Signalling and Biomarkers", Head of the clinical metabolomics and proteomics biochemistry department at the Necker hospital for sick children; Chair of the Scientific Council

**Jean-Christophe AMABLE**, brigadier General (Medical Doctor), Professor at the Military School of Val-de-Grâce, Director of the French Defense Radiation Protection Service (SPRA)

**Christine ARGILLIER**, research Director and Deputy Scientific Director of the Water Department at the French National Research Institute for Agriculture, Food and Environment (INRAE)

**Bernard BONIN**, scientific Advisor for the Energy Division of the French Alternative Energies and Atomic Energy Commission (CEA)

**Alain KAUFMANN**, director of the ColLaboratory, a collaborative and participatory action research unit at the University of Lausanne (Switzerland)

**Louis LAURENT**, scientific Director at the French National Research and Safety Institute for the Prevention of Occupational Accidents and Diseases (INRS)

**Elsa MERLE**, professor at the PHELMA Engineering School of the Grenoble Institute of Technology

**Michèle SEBAG**, research Director at the French National Centre for Scientific Research (CNRS), Interdisciplinary Laboratory of Digital Sciences of the University of Paris Saclay

**Pierre TOULHOAT**, president of the Environment and Climate Change Division at the French National Academy of Technologies

**Marc VERWERFT**, head of the nuclear fuels group at the Studiecentrum voor Kernenergie/Centre d'Etude de l'Energie Nucléaire (aka the Belgian Nuclear Research Centre), Foundation of Public Utility, SCK CEN (Belgium)

**Denis VEYNANTE**, research director at the French National Centre for Scientific Research (CNRS), macroscopic molecular and combustion laboratory, CentraleSupélec, deputy director of the open data for research department of the CNRS



## ETHICS COMMISSION ON 1 FEBRUARY 2022

### Missions

The Ethics Commission is an advisory body provided for by IRSN's decree of organisation. It is responsible for advising the Board of Directors on preparing ethical charters that are applicable to the Institute's activities and for monitoring their implementation, particularly as regards the conditions under which separation is ensured between expert appraisals carried out on behalf of government departments and those carried out for public or private operators. It also serves as a mediator when problems of an ethical nature arise.

**Françoise ROURE**, president of the Commission since April 2018. Inspector General, President of the "Safety, Security and Risks" Section of the CGEIET (*Conseil général de l'économie, de l'industrie, de l'énergie et des technologies* - General Council of the Economy, Industry, Energy and Technology) and member of the Inspection Committee, PhD in Economics, speciality "International Economics"

**Lionel BOURDON**, senior Medical Officer, Associate Professor, Val-de-Grâce. Retired. Recent positions held: Scientific Director of the Institute for Biomedical Research of the Armed Forces (IRBA, Brétigny-sur-Orge), Director of the research component of the Armed Forces Health Service transformation programme ("SSA 2020"), Senior research professor for the Armed Forces Health Service

**Marc CLÉMENT**, president of the Administrative Tribunal Chamber of Lyon, member of the Environmental Authority of the CGEDD (*Conseil général de l'environnement et du développement durable* - General council of the environment and sustainable development). Member of the Implementation Committee of the Aarhus Convention (United Nations). Member of the Commission since 2015

**Alexandra LANGLAIS**, CNRS researcher in environmental law, CNRS bronze medallist - Environmental research manager at the IODE (*Institut de l'Ouest : Droit et Europe* - Western Institute: Law and Europe) - author of research and expertise documentation on the laws concerning waste, soil, water, etc. Also a member of the GDR NoST (Standards research network - science and technologies)

**Mauricette STEINFELDER**, inspector General, member of the CGEDD (*Conseil général de l'environnement et du développement durable* - General council of the environment and sustainable development) and the Environmental Authority, retired

**Éric VINDIMIAN**, engineer General in rural engineering, water and forests, specialist in the impact of toxic substances on the environment and health and in the assessment of public environmental policies, member of the Environmental Authority of the CGEDD (*Conseil général de l'environnement et du développement durable* - General council of the environment and sustainable development). Member of the Commission since 2009

**Raja CHATILA**, emeritus professor of robotics, artificial intelligence and ethics at the University of Sorbonne in Paris. Member of the College of ethics of the Ministry of Higher Education, Research and Innovation and of the Scientific Council of Orange







## NUCLEAR SAFETY AND RADIATION PROTECTION RESEARCH POLICY COMMITTEE (COR) ON 1 FEBRUARY 2022

### Missions

The committee is an advisory body to the IRSN Board of Directors, giving opinions on research objectives and priorities in the fields of nuclear safety and radiation protection. It adopts a global approach that takes into consideration the requirements of society and the public authorities, complementing the activity of IRSN's scientific council, and which focuses on the quality and relevance of the Institute's research programmes and outcomes from a scientific perspective.

### PUBLIC AUTHORITIES

#### Supervisory ministry representatives

Nomination pending for the Research and innovation department, representing the Ministry of Ecological Transition

**François-Xavier GOMBEAUD**, weapons inspector for nuclear security, Armaments Inspectorate, representing the Ministry of the Armed Forces

**Fabrice LEGENDRE**, task Officer at the Policy and Supervisory Office, Directorate-General for Energy and Climate (DGEC), representing the Ministry of Ecological Transition

#### Representing the DGT (*Direction générale du travail* - Directorate-General for labour)

**Hervé VISSEAU**, head of the physical hazards prevention division, Directorate-General for labour

#### Representative of the ASN (French Nuclear Safety Authority)

**Vincent CLOITRE**, director of the office of the director general of the ASN

### COMPANIES AND PROFESSIONAL ASSOCIATIONS

**Manuel CARRACSO**, deputy director of the technical department - Lyon, EDF

**Bernard LE GUEN**, president of the SFRP (Société française de radioprotection - French radiation protection society)

**Bertrand MOREL**, director of research and development, representing ORANO

**Jean-Marc SIMON**, associate University Professor, hospital practitioner, radiotherapy-oncology department at the Pitié-Salpêtrière hospital

**Sébastien CROMBEZ**, director responsible for safety, the environment and the industrial strategy (DISEF) of Andra

### EMPLOYEES IN THE NUCLEAR SECTOR

#### Representatives of national trades unions

**Jean-Paul CRESSY**, FCE-CFDT

**Martine DOZOL**, FO

**Patrick BIANCHI**, CFTC

**Jacques DELAY**, CFE-CGC

**Christian HOLBÉ**, CGT

### ELECTED REPRESENTATIVES

#### OPECST representatives

**Philippe BOLO**, MP for the Maine-et-Loire department + one nomination pending

#### Representative of local information commissions (CLI)

Nomination pending

#### Representatives of municipalities hosting a nuclear facility, proposed by the Association of French Mayors

**Bertrand RINGOT**, mayor of Gravelines

**Alain GALLO**, mayor of Pierrelatte

### ASSOCIATIONS

**Jean-Paul LACOTE**, representative of France Nature Environnement

**Simon SCHRAUB**, director of the *Ligue nationale contre le cancer*

**Lionel LARQUE**, executive officer of the Alliance sciences-société (Alliss)

### ADVISORY MEMBERS

**Jean-Claude DELALONDE**, president of Anccli (*Association nationale des comités et commissions locales d'information* - National association of local information committees and commissions)

**Christine NOIVILLE**, chair of the High Committee for transparency and information on nuclear safety (HCTISN)

**Marie-France BELLIN**, chair of the IRSN Board of Directors, university lecturer, hospital practitioner in the department of diagnostic and interventional radiology of the Bicêtre-Paul-Brousse hospital

### RESEARCH ORGANISATIONS

**Philippe STOHR**, director of nuclear energy, representing the CEA

**Cyrille THIEFFRY**, task Officer for Radiation Protection and Nuclear Affairs, IN2P3, representing the CNRS

**Inserm**, nomination pending

**Étienne AUGÉ**, professor of physics, Vice-president of Paris-Sud, representing the French Conference of University Presidents (CPU)

**Vincent LAFLECHE**, director of ParisTech, representing ParisTech

### FOREIGN MEMBERS

**Christophe BADIE**, environmental assessments department, Public Health England, United Kingdom

**Ted LAZO**, NEA (Nuclear Energy Agency), OECD

### EX OFFICIO MEMBERS

**Patrick LANDAIS**, atomic energy high commissioner

**Cédric BOURILLET**, government commissioner, represented by Benoît BETTINELLI, Task Officer for Nuclear Safety and Radiation Protection, Ministry for Ecological Transition

**Robert BAROUKI**, chair of the IRSN Scientific Council

**Jean-Christophe NIEL**, director general of IRSN



# Organisation chart

ON 1 FEBRUARY 2022

## GENERAL MANAGEMENT

**Jean-Christophe NIEL**  
Director general

**Louis-Michel GUILLAUME**  
Deputy director general,  
in charge of  
Defense-related missions

**Hervé BARBELIN**  
Deputy director general,  
in charge of Assets  
and Real Estate

**Karine HERVIOU**  
Deputy director general,  
in charge of Nuclear Safety

**Jean-Christophe GARIEL**  
Deputy director general,  
in charge of Health  
and Environment

**Philippe DUBIAU**  
Executive director  
for emergency response

## DIVISIONS

**Defense Security  
and non-proliferation**  
Louis-Michel GUILLAUME

**Laurent MANDARD**  
Director of Nuclear  
defense expertise

**Health and Environment**  
Jean-Christophe GARIEL

**François BESNUS**  
Environment director  
**Jean-Michel BONNET**  
Health director

**Nuclear Safety**  
Karine HERVIOU

**Igor LE BARS**  
Director of  
Safety expertise  
**Patrice GIORDANO**  
Director of  
Safety research

**Assets and Real Estate**  
Hervé BARBELIN

**Jean BATTISTON**  
Real Estate and  
Security Director  
**Jean BATTISTON**  
Director of the  
Fontenay-aux-Roses site  
**Hervé BARBELIN**  
Director of the Cadarache site  
**François VALLETTE**  
Director of the Le Vésinet site

## EXECUTIVE AND SUPPORT DEPARTMENTS

**Cyril PINEL**  
European and  
International  
Affairs director

**Marie RIET-HUCHELOUP**  
Communications  
director

**Michelle AGARANDE**  
Risks and  
Performance  
director

**Patrice BUESO**  
Strategy  
director

**Michel ENAULT**  
Transformation  
director

**Florence BRAVACCINI**  
General  
secretary

**Isabelle FLORY**  
Accounting  
officer







# Glossary

## A

**ANCCLI** | *Association nationale des comités et commissions locales d'information* (National association of local information committees and commissions)

**ANR** | *Agence nationale de la recherche* (National research agency)

**ASN** | *Autorité de Sûreté Nucléaire* (Nuclear Safety Authority)

**ASND** | *Autorité de Sûreté Nucléaire de Défense* (Nuclear Defense Safety Authority)

## C

**CLI** | *Commission locale d'information* (Local information commission)

**CNL** | Canada Nuclear Laboratories

**CNPE** | *Centrale nucléaire de production d'électricité* (Nuclear Power Plant)

**CODEND** | Steering committee for the nuclear defense expertise division

**CODIRPA** | Post-accident phase management committee

**COR** | IRSN nuclear safety and radiation protection research policy committee

**CSR** | Corporate Social Responsibility

**CWC** | Chemical Weapons Convention

## D

**DEND** | Nuclear defense expertise division

**DGAL** | *Direction générale de l'alimentation* (Directorate-General for food)

**DOE** | US Department of Energy

**DOSIMETRY** | Determination, by evaluation or by measurement, of the dose of radiation (radioactivity) absorbed by a substance or an individual

**DRL** | Diagnostic reference levels

**DSND** | Representative in charge of nuclear safety and radiation protection for defense-related activities and installations

## E

**ENSTTI** | European Nuclear Safety Training and Tutoring Institute

**EPIC** | *Établissement public à caractère industriel et commercial* (Public Industrial and Commercial Establishment)

**EPR** | Evolutionary Power Reactor (3rd generation pressurised water reactor - PWR)

**ERS** | *Études radiologiques de site* (Radiological site studies)

**ETSON** | European Technical Safety Organisation Network

**EURATOM** | European Atomic Energy Community

## H

**HCERES** | High Council for the assessment of research and higher education

**HCTISN** | High Committee for transparency and information on nuclear safety

**HFDS** | Senior defense and security official

## I

**IAEA** | International Atomic Energy Agency

**ICRP** | International Commission on Radiological Protection

**INMM** | Institute of Nuclear Materials Management (US)

**IPCC** | Intergovernmental Panel on Climate Change

## L

**LOCA** | Loss-of-coolant accident

## M

**MTE** | Ministry of Ecological Transition

**MIRCOM** | Ion microbeam dedicated to the radiobiology of intra- and inter-cellular communications

**MOX** | Mixture of plutonium oxide and uranium oxide – Nuclear fuel

**MWe** | Megawatt electrical – Measurement unit for the electrical power produced

## N

**NEA** | Nuclear Energy Agency of the OECD

## O

**OECD** | Organisation for Economic Cooperation and Development

**OPCW** | Organisation for the Prohibition of Chemical Weapons

## R

**RADIONUCLIDE** | Radioactive isotope of an element

**RSNR** | *Recherche en matière de sûreté et radioprotection* (Nuclear safety and radiation protection research)

## S

**SFRP** | *Société française de radioprotection* (French radiation protection society)

**SID** | *Service d'infrastructure de la défense* (Defense infrastructure service)

**SISERI** | *Système d'information de la surveillance de l'exposition aux rayonnements ionisants* (Information system for monitoring exposure to ionising radiation)

**SMR** | Small Modular Reactors

**SPE** | *Services Publics Écoresponsables* (Eco-responsible public services)

## T

**TSO** | Technical Safety Organisation





31, avenue de la Division Leclerc  
92260 Fontenay-aux-Roses  
RCS Nanterre B 440 546 018

**MAILING ADDRESS**

BP 17  
92262 Fontenay-aux-Roses Cedex

**TELEPHONE**

+33 (0)1 58 35 88 88

**WEBSITE**

[www.irsn.fr](http://www.irsn.fr)

**E-MAIL**

[contact@irsn.fr](mailto:contact@irsn.fr)

[@irsnfrance](https://twitter.com/irsnfrance)

Find the Annual Report  
online at:

<http://www.irsn.fr/ra-2021>