



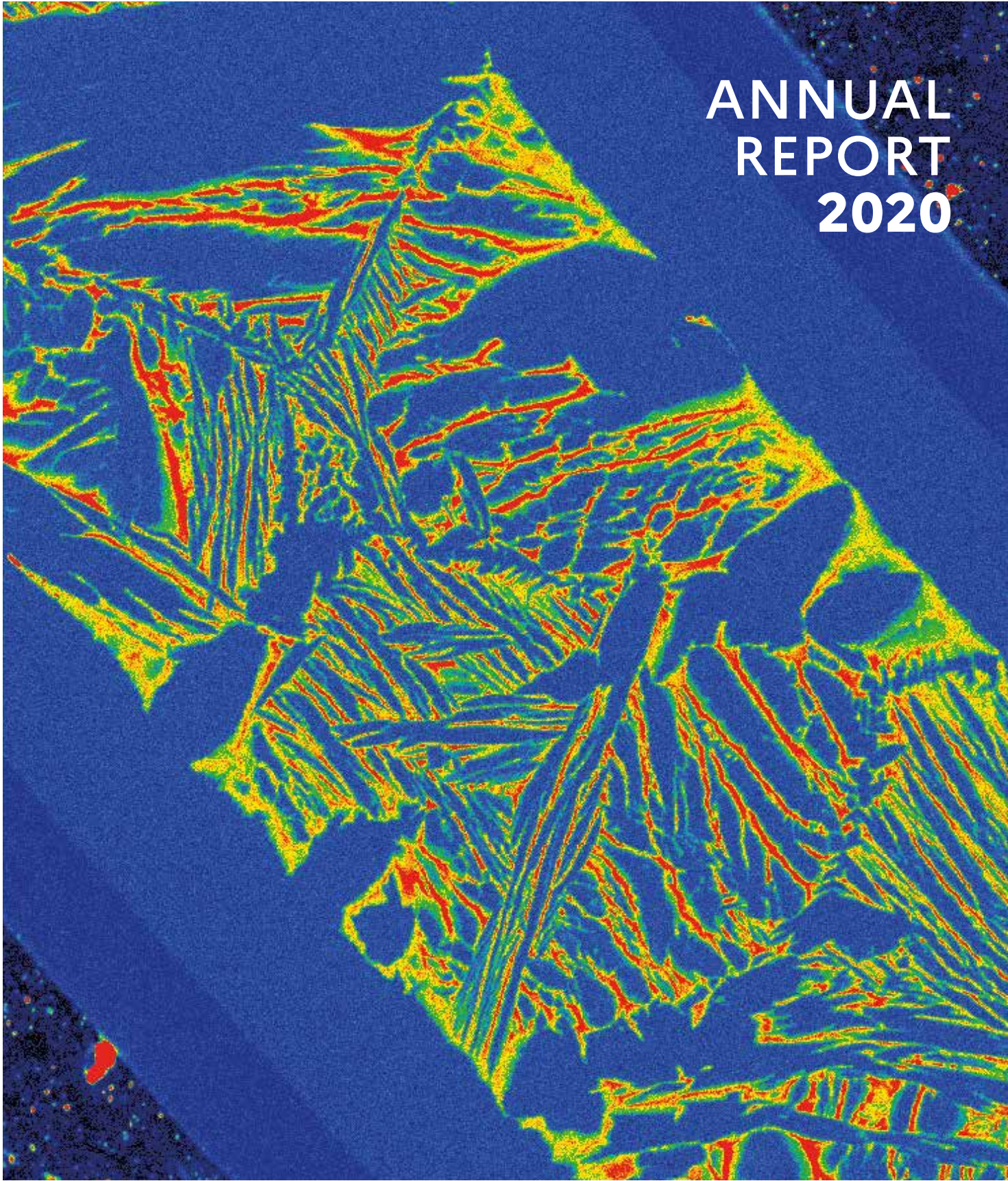
RÉPUBLIQUE  
FRANÇAISE

*Liberté  
Égalité  
Fraternité*

**IRSN**

INSTITUT DE RADIOPROTECTION  
ET DE SÛRETÉ NUCLÉAIRE

# ANNUAL REPORT 2020



MEMBER OF

**ETSON**



PROFIL

# The public expert on nuclear and radiological risks

Assess, research, protect, anticipate and share: these are the missions of IRSN in the service of public authorities and the public. IRSN's uniqueness lies in its ability to bring together researchers and experts to anticipate questions regarding the evolution and control of nuclear and radiological risks. The women and men of IRSN are committed to publicizing their work and sharing their knowledge with society. They thus contribute to improving access to information and creating the conditions for dialogue with stakeholders. IRSN participates in formulating government policies on nuclear safety and security, health, the environment and emergency response management. A French industrial and commercial public undertaking (EPIC) under the joint responsibility of the Minister for the Environment, the Minister of Defense, and the Ministers for Energy, Research and Health, IRSN fully follows governmental modernization policies as evidenced by its approach to risk management and the implementation of a comprehensive policy on social responsibility.



To know more  
[www.irsn.fr](http://www.irsn.fr)

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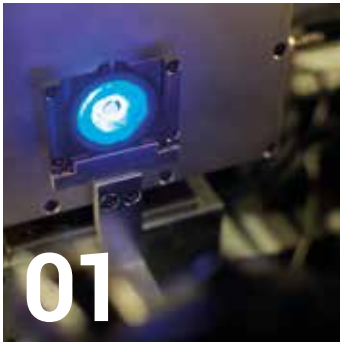
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## Corporate social responsibility

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# [ Editorial

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

**Jean-Christophe Niel,**  
Director General



For IRSN, as for most companies and organizations, 2020 was a year that tested our ability to adapt to changes that were both rapid and profound, and 2021 will be a year for taking stock of what we have gone through in the past twelve months. The first conclusion to be drawn from the Covid-19 pandemic is the high capacity for resilience demonstrated by the Institute in difficult times, thanks to the commitment shown by everyone to fulfilling their duties. Despite the organizational difficulties generated by the health crisis, the collective determination of our teams to adapt to the new ways of working and operating has enabled IRSN to honor its commitments. By adopting new tools, following new remote working procedures and complying with

unprecedented health protection measures, everyone has played their part in ensuring that the Institute's notices could be submitted in a timely fashion to the authorities and public bodies, that our crisis center could be fitted out, and that we could continue to pursue such essential activities as the recruitment of new employees, budget planning for 2021, social dialogue and the signing of partnership agreements. A second observation is the care shown to others by the people of the Institute, be it in the form of donations of individual protective equipment such as masks to hospitals or initiatives such as the "Stay@home challenge". We extend our heartfelt thanks to them all.



The first conclusion to be drawn from the health crisis is the high capacity for resilience demonstrated by the Institute at a difficult time.

JEAN-CHRISTOPHE NIEL

**Learning from the experience of the health crisis**

In addition to the observations of individual and collective behavior, a whole debate has been launched on the subject of feedback from the Covid-19 pandemic, under the guidance of Louis-Michel Guillaume, the IRSN Deputy Director General in charge of defense and security missions. The debate aims to identify the lessons that will lead to progress in terms of the Institute's operations and professional activities, as well as any study or research needs that the health crisis has brought to light. For, even if 2021 offers the prospect of bringing this Covid-19 pandemic under control thanks to vaccination, the challenge is nevertheless to prepare ourselves as best we can to face any new pandemic in the future and to ask ourselves questions about how to manage unforeseen situations. It is also about taking advantage, daily and long-term, of the new modes of operation developed as a matter of urgency, including working from home. This debate focuses in particular on crisis management.

**Building on our fundamentals to move forward**

The first of these fundamentals is the role of IRSN as a public expert on radiological and nuclear risks, responsible for informing decisions at the scientific and technical level for all activities involving ionizing radiation. This implies that any evaluation should always meet the highest standards of science, and should always be state-of-the-art, independent, and impartial. This is an indispensable prerequisite for IRSN to continue to be a trusted partner for the public authorities,

its partners and society as whole, by meeting the expectations of these others in terms of quality, transparency, and openness. This role of public expert also means that IRSN must continue to monitor radiological and nuclear risks at the national, European, and international levels, in particular through its involvement in the oversight of facilities and transport, the use it makes of lessons learned, its environmental monitoring networks, and the many institutional relationships forged both in France and abroad.

The second cornerstone of the Institute is its culture of risk anticipation, based in particular on the lessons learned from crises of various kinds: nuclear, such as the accident that occurred precisely ten years ago at the Fukushima-Daiichi power plant; chemical, such as the Lubrizol accident in September 2019; and health, such as the Covid-19 pandemic. In these crisis situations - however diverse they may be - it is clear that the anticipation, preparation, and involvement of every protagonist as befits their situation are essential factors in ensuring prevention and protection. For its part, IRSN must be an instrument of anticipation for the public authorities in the field of risk management - particularly risks related to the use of ionizing radiation - and the development of a safety culture. With this in mind, IRSN has set a certain number of priorities: boosting research linked to expertise; taking advantage of the data and digital revolution, in particular with the use of artificial intelligence; identifying changes in societal concerns through a reinforced policy of dialogue with the public; capitalizing on skills and knowledge; continuing to build a network of partners in France and abroad; utilizing business intelligence, in particular to prevent or monitor potential or actual emergency situations. These are all commitments enshrined in the objectives and performance contract between the Institute and the State for the period 2019-2023.



The final aspect of our fundamentals is our quest for performance and efficiency. As such, IRSN is pursuing four major transformation programs on the following topics: modes of collaboration, managerial practices, digital technology, and social and societal relations. The Institute, indeed, has to be efficient, effective, and forward-looking in order to fulfil its research and expert assessment missions, anticipate tomorrow's needs, contribute to the development of doctrines, support the State in drawing up its public policies, and interact with society. These major transformation programs will culminate in the evaluation of how the Institute is succeeding in its transformation, in order to provide the community with the best levels of service that can be expected.

#### **Preparing for the future**

Whatever decisions are taken in our country in the nuclear field, in terms of both energy and defense, the role of IRSN will be to help ensure compliance with the absolute requirements in terms of nuclear safety and security and the protection of people and the environment against ionizing radiation. Throughout 2020, the Institute initiated or continued to pursue structural projects that will put us in a position to meet the expectations of the public authorities, our partners and society in the future. An example of this is in environmental metrology, with the construction of a laboratory for the processing and analysis of environmental samples at the Le Vésinet site (Yvelines), to increase our measurement and innovation capacity in these fields. Another example is in the field of nuclear safety research, with the continuation of tests conducted in the CABRI experimental reactor on the behavior of nuclear fuel in accident situations. With regard to the protection of workers exposed to ionizing radiation, the overhaul of the SISERI dosimetric monitoring information system will make it a one-stop shop for information and data consultation for the various parties involved in the radiological monitoring of workers.



**Even if 2021 offers the prospect of bringing the Covid-19 pandemic under control, the challenge is nevertheless to prepare ourselves to face any new pandemic in the future.**

**MARIE-FRANCE BELLIN**

Lastly, to increase its efficiency, in 2020, IRSN continued to review its major risks management system and streamline its facilities at the Fontenay-aux-Roses (Hauts-de-Seine) and Cadarache (Bouches-du-Rhône) sites as part of a multi-year real estate strategy and the recovery plan. In the same spirit, the Institute carried out a joint evaluation with the French Nuclear Safety Authority (Autorité de Sûreté Nucléaire - ASN) of the process for examining the cases on which it works. This joint audit concluded that the ASN-IRSN relationship was working well overall and identified areas for improvement to meet the needs of future safety analysis report reviews.

In March 2021, IRSN will commemorate the accident at the Fukushima-Daiichi nuclear power plant through various initiatives to recall the lessons learned from this tragic event and the Institute's contribution to the action taken to prevent such a situation arising in our country, and to limit its health and environmental consequences should it ever occur. Last but not least, IRSN will be celebrating the 20<sup>th</sup> anniversary of the Institute's creation in May 2001. Aside from its festive nature, this jubilee will also be an opportunity for us to reflect, internally and with all our stakeholders, on our actions in the service of nuclear safety, security, and radiation protection, in keeping with our values of excellence, independence, sharing and foresight. •

# [Point of view

**Louis-Michel Guillaume,**  
Deputy Director General for Defense  
Missions, in charge of the Defense,  
Security and Non-proliferation  
Division

Marked by the constraints of the Covid-19 pandemic, 2020 has provided the IRSN teams in charge of nuclear defense safety, nuclear security, and nuclear and chemical non-proliferation with the opportunity to take stock of how they conduct their activities. The pandemic has affected the pursuit of our missions to varying degrees depending on the activities concerned. It has had relatively little impact on nuclear defense safety activities, such as the examination of safety analysis reports concerning the reception of Suffren nuclear attack submarines, or the safety review of work programmed in CEA centers, to cite but two examples.

The constraints imposed by the health crisis were, however, felt differently in the field of nuclear security activities, whose sensitivity is often incompatible with a telecommuting environment. In order to estimate as accurately as possible the number of personnel needing to be mobilized on IRSN sites, intensive dialogue was conducted with the competent authorities and operators in order to identify the priority issues to be examined. Likewise, the test activities were adapted to the constraints relating to physically accessing facilities. However, it has been possible to make progress on high-stakes issues such as assessing the sensitivity of the IT architecture of nuclear facilities to malicious acts.

Although hampered for most of the year by the inability to make site visits, the nuclear and chemical non-proliferation and international cooperation activities continued apace, with the experts managing to accompany the inspections carried out by Euratom and the IAEA in the nuclear field and the OPCW in the chemical field.



For the latter, the delegation received by the IRSN Deputy Director General in charge of defense and security missions on February 1, 2020, to issue authorizations for activities relating to products listed in schedule 1 of the Chemical Weapons Convention, testifies to the trust placed in IRSN by the public authorities.

Internationally, DEND experts were able to participate in the 3<sup>rd</sup> International Conference on Nuclear Security organized by the IAEA in February and to organize, in November, the annual symposium of the European Safeguards Research and Development Association (ESARDA), which France will chair in 2021. Lastly, as part of the preparations for Brexit, they assisted the French authorities in defining the new rules for the exchange and control of nuclear materials with the United Kingdom. The lessons learned from the challenges faced throughout 2020 will feed into the reflections that will be conducted in 2021 with a view to strengthening the overall coherence of our actions in the service of the authorities and the powers that be. •



# [Highlights 2020

## January

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**Final review of the IVMR project in 2020:** the project entitled In-Vessel Melt Retention (IVMR) is an IRSN initiative, started in 2015 and funded by the European Commission.

> [page 15](#)



## March

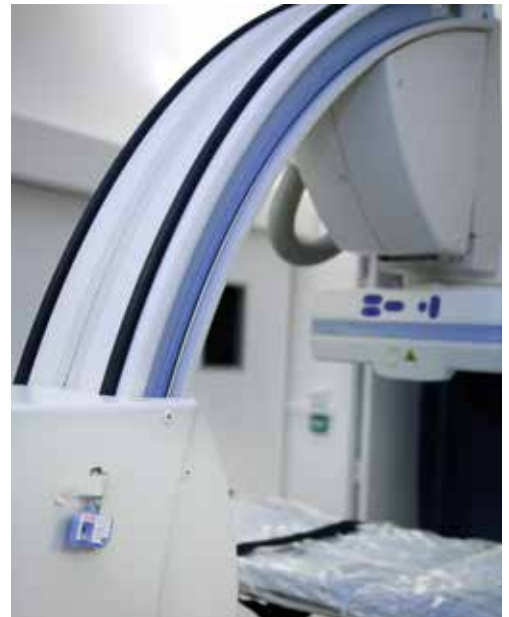
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**PRIODAC:** obtaining marketing authorization for potassium iodide extended to repeated doses in adults and children over 12 years of age.

> [page 21](#)

**RP4-900:** IRSN's main conclusions and recommendations.

> [page 24](#)



## April

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**Publication of the 6<sup>th</sup> review** of diagnostic reference levels in medical imaging (NRD).

> [page 38](#)

**IRSN mobilized its crisis organization** monitor the situation and assess the consequences of the propagation into France of potentially contaminated air masses during the fire which broke out in the exclusion zone of Chernobyl (Ukraine).

> [page 42](#)

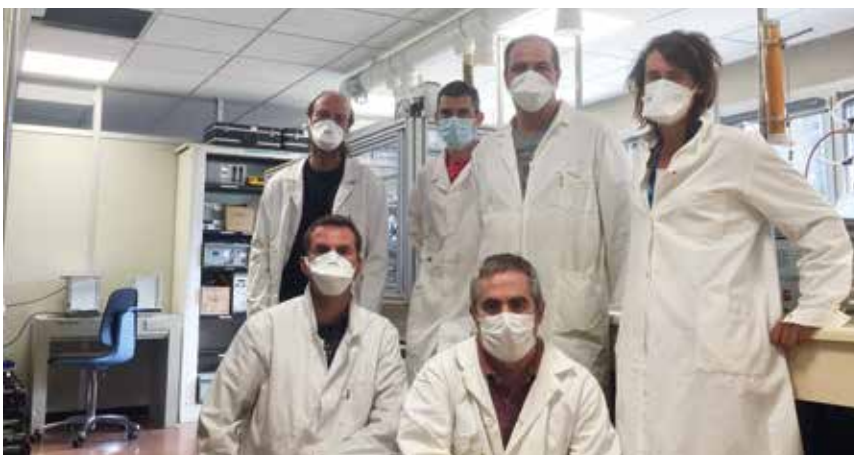


## May

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**IRSN contributes** to work on protective masks in the context of the Covid-19 epidemic.

> [page 27](#)





## July

**Launch of the H2020 LD SAFE research project** on laser cutting for nuclear reactor dismantling.

> [page 18](#)

**Continued safety review of French Navy projects.**

> [page 32](#)

## August

**From August 25 to 27, 2020,** IRSN participated in an international crisis exercise as part of the IAEA's Response and Assistance Network (RANET).

> [page 43](#)



## November

**Launch of the tritium activity measurement campaign in the Loire.**

> [page 41](#)

## December

**Certification of CABRI** by the IAEA with ICERR status.

> [page 19](#)

**Security of ionizing radiation sources against malicious acts**

IRSN has developed an e-learning module on the protection of ionizing radiation sources with the European Nuclear Safety Training and Tutoring Institute (ENSTTI).

> [page 34](#)

**Report on image quality and delivered dose in digital mammography.**

> [page 39](#)



## September

**EXPRI report:** analysis of the exposure of the population to ionizing radiation due to diagnostic medical imaging examination.

> [page 38](#)

## October

**First test of the COAL program**

the Institute conducted the first campaign of the COAL test program in a thermal hydraulic loop made available by Stern Laboratories in Canada.

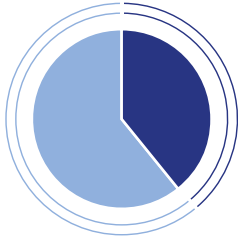
> [page 18](#)



# [Key figures

REVENUE

**39.2%**  
of budget devoted to research



**273M€**  
revenue

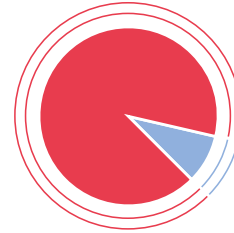
**271M€**  
of spendings, of which

**14M€**  
of investment in equipment

PROFIL

**1,816**

EMPLOYEES  
(WORKFORCE ON 31/12)



**1,657**  
ON INDEFINITE  
TERM CONTRACTS

**159**  
ON FIXED TERM  
CONTRACT

**54**  
availabilities

**85.26**  
doctoral students

**53**  
PhDs or persons  
qualified to direct  
research

**7.53**  
post-doctorate students

INSTITUTE ACTIVITIES

INTERNATIONAL

**230**

bilateral cooperation agreements in force with research and assessment organizations

**63**

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

**49**

countries involved in these agreements

**8**

projects for which IRSN is coordinator

RESEARCH

**229**

publications listed in Journal Citation Reports

**20**

theses defended

**151**

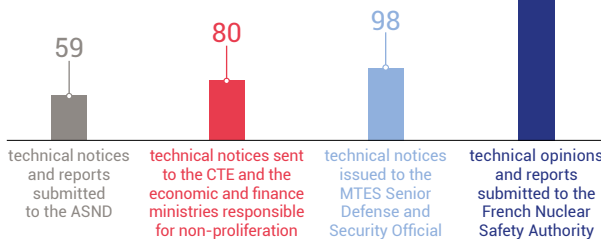
presentations in conferences



TECHNICAL SUPPORT FOR PUBLIC AUTHORITIES

**52%**

budget devoted to technical support and public interest missions



FORMATIONS



**126**

teaching hours given during the 17 radiation protection training sessions

**161**

teaching hours given during the 8 nuclear safety training sessions

CRISIS



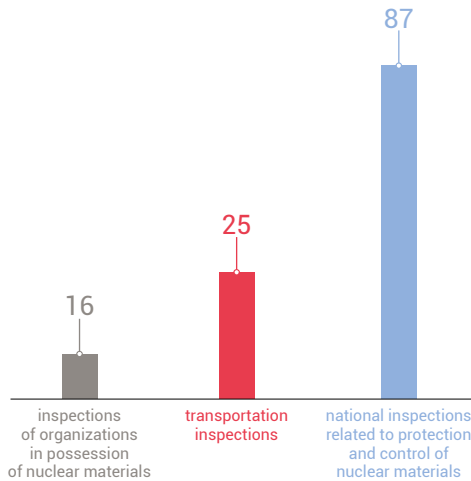
**6**  
action taken by the emergency response center, CNPE Nogent

**2**  
national nuclear emergency exercises excluding defense

**2**  
ionizing radiation dose assessments by biological dosimetry

**13**  
meetings involving IRSN as part of CODIRPA's work on post-accident management

NUCLEAR DEFENSE SAFETY



**4**  
missions to escort international inspections involving the chemical weapons ban

**29**  
missions to escort inspections involving international nuclear material control

**46**  
technical checks on approved equipment for transportation of nuclear materials

HUMAN AND ENVIRONMENT



**507**  
monitors make up France's remote monitoring network, including T el ery stations

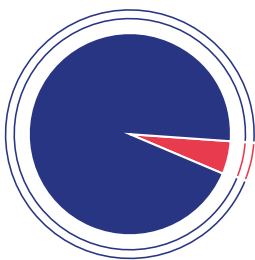
**505**  
sampling points for radioactivity monitoring throughout France

**572**  
whole-body counts for the individual monitoring of workers, including 479 using mobile facilities

**4,978**  
environmental samples taken for radiological measurements

**139**  
ambient dose rate measurement points

THE SPREAD OF KNOWLEDGE



**3,577,114**  
pages viewed on the IRSN website

**190,750**  
pages viewed in the "Research" section (formerly the "scientific site") of the IRSN website

**11**  
IRSN interventions in local information committees

**194**  
notices and reports published on the IRSN website

**104**  
requests for IRSN involvement received from local information commissions

 **FIND OUT MORE**  
[www.irsn.fr](http://www.irsn.fr)







39.2%

OF BUDGET ALLOCATED  
TO RESEARCH (EXCLUDING  
FEURS PROJECT)



20

THESES DEFENDED



151

PRESENTATIONS  
IN CONFERENCES

01

# Research



**A**

s a source of new knowledge, research at IRSN is the irreplaceable scientific and technical basis for reliable and independent expertise.

As finalized research, it is intended to provide answers to the questions raised today by IRSN experts in the context of the safety analysis of nuclear facilities, radiological monitoring of the environment, and the actions of the experts to protect the public from the effects of ionizing radiation. This research, which is finalized but often basic research, investigates fields that may not be of immediate interest in terms of conducting expert assessments, but whose study is necessary to be able, when the time comes, to assess the new technologies and organizations developed by industry, from a nuclear safety and radiation protection perspective.

The research conducted by the Institute is defined by its characteristics as a partnership, as evidenced by the raft of bilateral and multilateral collaborations entered into nationally with the academic and industrial world, and at European and international level, both within the ETSON network of European technical safety organizations - in particular as part of the H2020 program - and with organizations such as the OECD's Nuclear Energy Agency (NEA) or the International Atomic Energy Agency (IAEA). In France, 2020 was marked by the renewal of the current framework agreement with the French National Center for Scientific Research (CNRS) and the launch of a roadmap structuring the collaboration with five of its institutes, as well as the renewal of the quadripartite agreement that will shape the Institute's relations with the CEA, EDF and Framatome in the coming years in the area of nuclear safety and radiation protection research. Internationally, IRSN's reaccreditation by the IAEA as an International Center based on Research Reactors (ICERR) is also an illustration of this.

While the health crisis last year affected how some research projects were run, by limiting physical access to test facilities, it did not prevent the continuation of important activities for the Institute, such as the doctoral program. Hence, despite being unable to access their laboratories throughout the entire first lockdown, the hundred or so doctoral and post-doctoral students involved in the IRSN research training program were able to continue working in 2020, thanks in particular to the committed involvement of their supervisors and colleagues. Similarly, reflections on the potential of making IRSN platforms available for use by external partners also progressed over the course of the year. In this regard, the Board of Directors validated the program to deploy tools for mapping, interactive presentation, and operational management of the platforms, designed to encourage the emergence, in the spirit of COP 2019-2023, of projects enabling these platforms to be used by industrial stakeholders. With the aim of consolidating IRSN's position on the nuclear safety and radiation protection research scene, this development approach is also to be extended to include academic partners, as demonstrated by the signing of a partnership between IRSN and the Paris-Sud Geosciences Laboratory (GEOPS) of the University of Paris-Saclay, for pooling the use of equipment and sharing knowledge and know-how.



# Nuclear safety research



## Limiting the release of gaseous fission products in the event of a reactor core meltdown accident: the MIRE project gets a 30-month extension

Launched in January 2014 by IRSN, the project to mitigate releases into the environment in the event of a nuclear accident (MIRE) is one of seven projects run by the Institute and selected for funding by "Investissements d'avenir" as part of the "Research into Nuclear Safety and Radiation Protection" (RSNR) RFP operated by the ANR. It brings together various academic and industrial partners with the objective of reducing the release of gaseous fission products in the event of a reactor core meltdown.

As such, it includes various lines of research whose overall aim is to issue recommendations aimed at replacing the filters used when venting the containment atmosphere with more efficient filters, trapping as a priority elements such as volatile iodine or ruthenium tetroxide. Currently, the sand filters used in French nuclear power plants can indeed retain most of the aerosols in suspension in the containment system in the event of a serious reactor accident, but they do not significantly reduce the release of gaseous fission products.

Initially scheduled to run six years, the MIRE project benefited in 2020 from a 30-month extension financed by the "Programme des investissements d'avenir" (PIA), in light of the results obtained at the end of the first phase of the project. This has enabled better assessment of the releases associated with the venting phase of the containment system atmosphere in the event of a core meltdown and a better understanding of the performance and limits of existing filters as well as of the trapping capacity of certain porous materials. The second phase of the project will explore the capabilities of these materials further upstream, in particular by carrying out tests simulating as closely as possible accident conditions in pressurized water reactors.

..... AT A GLANCE .....

**IN EARLY NOVEMBER, THE ETSON AWARD WAS PRESENTED TO A TEAM OF RESEARCHERS FROM CEA, CNRS AND IRSN** for their contribution to the study of the behavior of tritiated dust in fusion reactors such as ITER or the Cadarache Tokamak. This prize was awarded to Samuel Peillon of IRSN for the best contribution produced jointly by a team of young engineers from various technical nuclear safety organizations and EUROSAFE members.



### Stabilization and retention of corium in reactor vessels: final review of the IVMR project in 2020

The project entitled In-Vessel Melt Retention (IVMR) is an IRSN initiative, started in 2015 and funded by the European Commission to assess the effectiveness of the in-vessel retention (IVR) strategy for corium - a mixture of molten radioactive materials and steel - during a core meltdown accident for reactors with a power rating greater than or equal to 1,000 MWe, using external cooling.

This project, coordinated by IRSN, brought together 32 international organizations who met at a final seminar in January 2020 to review the results of over four years of research. A new methodology for evaluating the IVR (in-vessel retention) strategy has been developed. It is based first of all on a transient deterministic approach, one based on a physical description of the system made up of the corium and the reactor vessel, as well as on a model established on the basis of physical laws and which takes into account the evolution of this system from the arrival of the corium in the bottom of the vessel until the vessel's eventual rupture. It is also based on the use of a new safety criterion, based on the residual thickness of the vessel, which is more general than the criterion previously used, based on a comparison of heat flows.

Using this methodology, it has been possible to identify reactor design parameters that have a highly favorable effect on in-vessel retention. It can thus be concluded that an optimal choice of these parameters makes it possible to design a high-power reactor (beyond 1,000 MWe) for which vessel rupture would be avoided. For reactors where these parameters are not favorable, external cooling is the only way to delay vessel rupture, with variable levels of efficacy. The project provided an opportunity to make significant developments to the Accident Source Term Evaluation Code (ASTEC) software, used by many organizations around the world, specific to in-vessel corium retention. This software, originally developed jointly by IRSN and its German counterpart, GRS, and now operated and maintained by the Institute, enables simulation of all the phenomena occurring during a core meltdown accident in a water-cooled reactor. As the IVR strategy concerns some 15 reactors worldwide, and certainly more in the decade to come, the seminar ended with a forum to define how to follow up the R&D projects on the subject, in other international settings.

 **FIND OUT MORE**  
[www.ivmr2020.com](http://www.ivmr2020.com)



AT A GLANCE

#### IRSN IS INVOLVED IN 14 PROJECTS SELECTED BY THE EUROPEAN COMMISSION AS PART OF ITS 4<sup>TH</sup> H2020 CALL FOR PROPOSALS

In the field of nuclear safety, these projects concern in particular the problems of the aging of structures and equipment – notably, the metallic materials of which they are made –, the dismantling of facilities, probabilistic studies on the seismic risk, and managing the risk of hydrogen explosion in an accident situation. In the field of radiation protection, the projects deal with the risks associated with exposure to radon and natural radioactive materials (NORM) and with the preparation of a strategic agenda concerning the medical applications of ionizing radiation.



## 229

PUBLICATIONS LISTED  
IN JOURNAL CITATION REPORTS

#### Source term evaluation and mitigation: completion of STEM2 and launch of ESTER

In the event of a fuel meltdown accident in a nuclear reactor, highly volatile radioactive products such as iodine and ruthenium may be released into the environment. The set of information that characterizes these releases is referred to as the "source term."

In order to better understand the various possible physical-chemical forms of these releases and to afford better protection against them, IRSN and eight partners from Germany, the United States, the UK, Canada, Finland, Japan, South Korea and Sweden conducted the Source Term Evaluation and Mitigation (STEM) program. This was carried out in two phases, from 2011 to 2019, under the auspices of the NEA. The second phase of this program, designated STEM2, was completed with the presentation of its main results. The test data obtained made it possible to develop and consolidate simulation models of the various physical-chemical states of radionuclides such as iodine and ruthenium under severe accident conditions in a nuclear reactor. These models are used in calculation tools designed to assess releases - particularly in gaseous and aerosol form - under accident conditions. Sharing the models in an international framework makes it possible to strive towards a common understanding of the behavior of these fission products, which may prove decisive in defining actions to protect populations beyond the evacuation perimeter, typically within 24 hours of the start of the accident.

During the STEM2 program review seminar, IRSN and its partners identified the need to better identify the origin of deferred radioactive releases, which may occur in the event of a fuel meltdown accident, following remobilization of fission products that are mainly deposited in the reactor primary circuit. The partners decided to launch, still within the framework of the NEA, the ESTER program dedicated to the understanding of this phenomenon.

### **IRSN acquires new testing equipment and optimizes its capacity for simulating major reactor accidents**

Contaminant transfer - two major aspects of nuclear facility safety - IRSN continued in 2020 to equip its test platforms with additional data acquisition resources.

The first of these concerns the study of the phenomenology of loss-of-coolant accidents (LOCA) in spent fuel storage pools, one of the consequences of the accident at the Fukushima-Daiichi nuclear plant. The Institute was able to complete the testing already carried out as part of the DENOPI research program to study accidental dewatering of fuel assembly pools, thanks to the ASPIC test device installed in 2020 on its THEMA platform, a thermohydraulic research installation. This device makes it possible to study, in a full-scale installation, the thermohydraulic phenomena related to the cooling of a partially or totally dewatered spent fuel assembly.

Regarding the transfer of airborne contaminants between a nuclear facility and the outside environment, the Institute has acquired two air flow loops designated DIESE and BEMOL which have been added to the MISTRAL platform, an experimental facility dedicated to research in the fields of air dispersion

and containment. In a key area for the protection of people and the environment, these new resources, representative of the complexity of a nuclear facility's ventilation network, will make it possible to improve the deposition models currently used in calculation codes, the on-site measurement of the performance of successive very high efficiency filtration (VHEF) barriers, and the monitoring of releases into the environment.

Lastly, the developments made on the ASTEC software system in order to enhance its operability have made it possible to complete the major accident studies carried out as part of the fourth safety review of 900 MWe reactors (RP4-900). ASTEC is also being used more and more at international level, establishing it as a benchmark code for serious accidents.

AT A GLANCE

#### **RENEWAL, IN NOVEMBER, OF THE FRAMEWORK AGREEMENT BETWEEN IRSN AND CNRS**

This represents an important step in the structuring of both the Institute's scientific partnerships and its relations with the academic world. It lays the foundations, for the next five years, for closer collaboration between the two organizations on major scientific issues related to nuclear safety and radiation protection. In this spirit, the coordination committee that has been set up will devote the next few months to drawing up a roadmap that will define the shared scientific ambition to be implemented over the duration of the agreement.



AT A GLANCE

**SIGNING AT THE END OF APRIL OF A GENERAL COOPERATION AGREEMENT FOR THE CONCRETE CONSORTIUM,**

bringing together IRSN, the Gustave Eiffel University (UGE) in Marne-la-Vallée, the LMDC (Materials and Construction Durability Laboratory) of the National Institute of Applied Sciences in Toulouse, and the Mechanics and Acoustics Laboratory (LMA), a CNRS Joint Research Unit. Via this four-year agreement, the partners aim to deepen their understanding of the consequences of internal concrete swelling pathologies on the mechanical properties of nuclear structures by complementing the experiments conducted within the framework of the international ODOBA project.



**AGORAS project members assess eight years of research in nuclear risk governance**

The Fukushima-Daiichi nuclear accident in March 2011 provided an opportunity to consider the lessons learnt concerning the human and organizational dimensions involved in nuclear risk management. It is in this context that IRSN participated, as part of the Research into Nuclear Safety and Radiation Protection program, in the AGORAS project (a French project to improve the governance of the organizations and networks involved in nuclear safety), launched in 2014. The organization of this project involved two complementary components:

- an accident prevention component analyzing the impact of the Fukushima accident on the approach to nuclear facility safety and on the relationships between those involved in nuclear risk governance;
- a crisis management component analyzing how this accident has contributed to changing the way nuclear accidents are perceived and to how to prepare for the management of accident and post-accident situations.

The project's closing symposium discussed the lessons learned, starting with the complexity of the technical and organizational systems mobilized, which can generate specific risks such as inertia in decision-making or in the updating

of technical reference systems, and which may pose difficulties for maintaining knowledge and skills at the requisite levels. In this respect, another achievement of the project concerns the capacity of certain tools, such as fundamental rules or safety guides, to allow better management of this inertia by helping to articulate, on the one hand, the state of knowledge necessary for expert assessment and, on the other, the state of the facilities. The members of the AGORAS project also debated the procedural framework of crisis management, to ensure that mastering crisis management endows those involved with greater agility and does not contribute to creating paralyzing routines.

IRSN now intends to work with all those operationally involved in nuclear risk governance to take advantage of the project's results and to develop the links forged between these stakeholders and academic researchers.

 **FIND OUT MORE**  
[www.irsn.fr/AGORAS](http://www.irsn.fr/AGORAS)



### Cooling of a reactor core during a LOCA: first test of the COAL program

A loss-of-coolant accident (LOCA) in a nuclear reactor causes the fuel to heat up, and this must be controlled by the safety injection systems so that the resulting damage does not jeopardize the cooling of the reactor core and its meltdown is prevented. The thermomechanical behavior of the fuel and the thermal hydraulics in the reactor core in such a situation are the subject of the "Loss of Coolant Study" (PERFROI) project, launched in 2013 by IRSN as part of the Nuclear Safety and Radiation Protection Research program with a scheduled duration of eight years.

As part of the PERFROI program to study coolant loss, the Institute conducted the first campaign of the COAL test program in October 2020, in a thermal hydraulic loop made available by Stern Laboratories in Canada, the purpose of which is to study the ability to cool a reactor core in a LOCA situation. In such a situation, the deformations of the fuel rod cladding due to the internal pressure of the rods are likely to alter the circulation of water in the reactor core, thus compromising the possibilities of cooling the core. While these deformation phenomena may already have been investigated, the COAL program aims to study more particularly, through tests on clusters of non-irradiated rods with simulation of partial plugging and fuel relocation, the cumulative effect of reduced cooling capacity along with local overpower transients linked to the relocation of fuel into the "swollen" parts of the rods. The results of these tests will be used to validate the models of the DRACCAR software, developed by IRSN to simulate the behavior of nuclear fuel during a LOCA.

### Launch of the H2020 LD SAFE research project on laser cutting for nuclear reactor dismantling

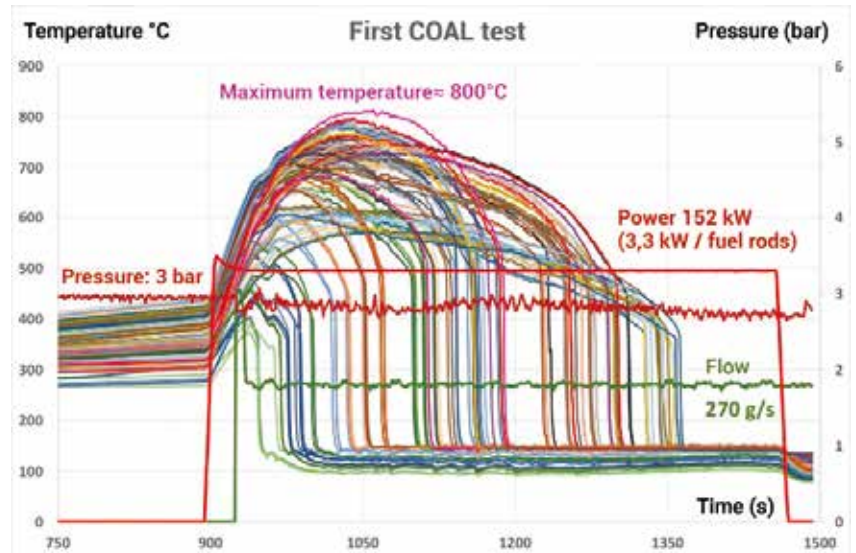
The decommissioning and dismantling of many nuclear reactors over the next few decades will involve large-scale cutting operations that must be optimized in three respects: safety, time, and investment. In this context, IRSN is participating in the H2020 LD SAFE project, with a contribution combining research and expertise, which aims to assess the risks associated with laser technology, particularly for cutting equipment such as the reactor vessel and its internal components. Due to their large dimensions, the thickness of the metal they are made of and the complexity of their structure, they cannot efficiently be cut using conventional techniques such as mechanical cutting, plasma arc cutting or abrasive water jet cutting. Used for more than a decade by the manufacturing industries, laser cutting technology is now identified in Europe and around the world as a promising alternative, but its safety, particularly in terms of the dissemination of potentially radioactive aerosols, and its effectiveness remain to be proven for the dismantling of nuclear facilities.

In this context, the LD-SAFE project launched in July 2020, for a duration of four years, aims to study the maturity of laser cutting technology in the air and underwater, in terms of technique, safety, environmental impact, and economic viability. Run by a consortium comprising CEA, IRSN, Lloyd's Register Consulting-Energy AB, Technatom, and Tecnel, the initial work began in the fall.



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ACTIVE PATENTS IN FRANCE  
(INCLUDING 9 CO-OWNED)



..... AT A GLANCE.

#### THE FRAMEWORK AGREEMENT ON R&D COLLABORATION BETWEEN IRSN, CEA, EDF AND FRAMATOME WAS RENEWED FOR A PERIOD OF FOUR YEARS,

until December 31, 2023. This framework agreement covers the planning and implementation of multi-year collaborative R&D actions, carried out by IRSN and CEA, in the fields of power reactor safety, worker health and environmental transfers.

It is also an essential tool for financing the Institute's R&D.

### CERTIFICATION OF CABRI BY THE IAEA WITH ICERR STATUS

France has applied to the IAEA for renewal of its ICERR (International Centers based on Research Reactors) status for the period 2020-2025. The objective of these centers is to help Member States, especially the newer ones, to obtain quick access to relevant nuclear infrastructure based on research reactors (RRs) to achieve their capacity building and R&D objectives. The research facilities associated with this ICERR include certain CEA laboratories and the experimental reactors located at Cadarache, such as CABRI, which the CEA operates on behalf of IRSN, in particular for this certification renewal.

### Thermodynamic characterization of fuel debris and fission products: completion of the NEA TCOFF project

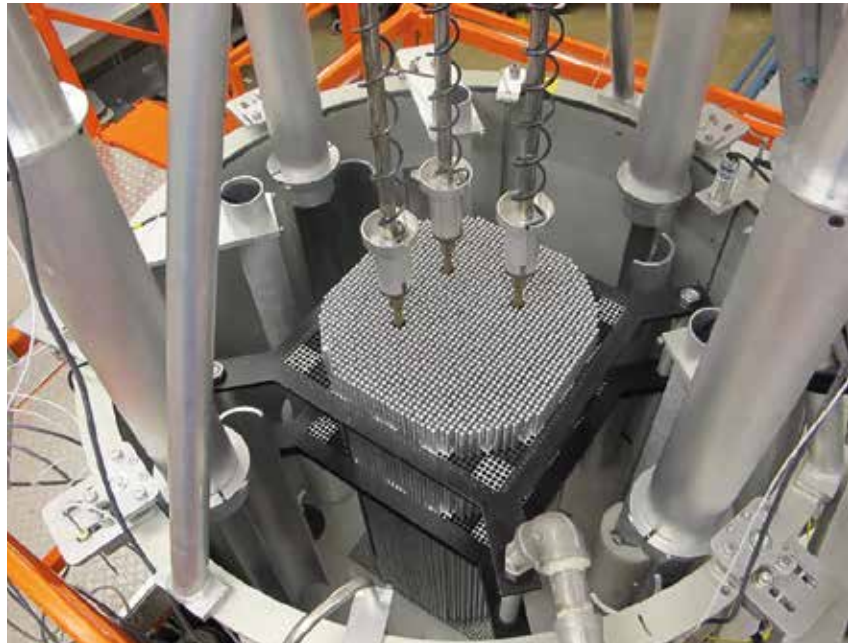
The Thermodynamic Characterization of Fuel Debris and Fission Products project (TCOFF), based on the analysis of the progression of serious accident scenarios at the Fukushima-Daiichi nuclear power plant, is one of three research projects initiated by Japan under the auspices of the NEA.

TCOFF consisted, between 2017 and 2020, in conducting joint thermodynamic assessments of the progression of serious accident scenarios inside and outside the reactor vessel of Fukushima-Daiichi reactors 1, 2 and 3, with the aim of characterizing, in particular, fuel meltdown, corium relocation, fission product behavior, and the chemical composition and phases of fuel and structural debris, as well as their formation mechanisms. IRSN played an important role in this project by making available, in particular, the NUCLEA and MEPHISTA thermodynamic bases of its MASTER software platform, which carries calculation codes dedicated to severe accidents, including the ASTEC code. TCOFF will have helped to improve our knowledge of cesium chemistry in particular and to consolidate achievements in the thermodynamic characterization of fuel debris and fission products and in the obtaining of new data.

### IRSN collaborates with the DoE in the preparation of new criticality experiments in the framework of the PRINCESS project

PRINCESS (PProject for IRSN Neutron physics and Criticality Experimental data for Supporting Safety) is run by IRSN in collaboration with various foreign partners with test facilities in this domain, including the US Department of Energy (DoE), in particular for the purpose of validating scientific software for different radionuclides.

The challenge of the project is twofold: one, to manage the safety margins relative to criticality in nuclear installations



and the transport of radioactive materials; and two, to better characterize the neutron properties of the materials used in them.

Under the current cooperation agreement between the DoE and IRSN, the DoE is providing its test resources while IRSN is helping to design the experiments. Now, after carrying out experiments to validate the neutron data of radionuclides such as plutonium, the two partners plan to carry out experiments on rhodium and molybdenum. In this regard, in 2020 IRSN finalized two deliverables to mark the culmination of major work on the design of critical experiments in the SPRF/CX facility of the SANDIA National Lab: for rhodium (a neutron absorber found as a fission product in spent fuel), the Institute sent its preliminary experiments design report to its American partner, and, for molybdenum (an absorber used in particular in research reactor fuel and also found as a fission product in spent fuel reprocessing facilities), its detailed design report. These documents will enable experiments to be carried out to validate the neutron data of these fission products as considered in the safety demonstrations of spent fuel reprocessing operations, with experiments on molybdenum planned for 2021-2022.

### THEMATIC STUDIES ON OPERATING EXPERIENCE FEEDBACK FROM NUCLEAR POWER PLANTS

The consortium led by IRSN, its German counterpart GRS, and the Czech Statni Ustav Radiacni Ochrany v.v.i. (SURO) Institute won the call for tenders launched by the European Union in this field, as part of the European Clearinghouse on Operating Experience Feedback, a platform for sharing operating experience at nuclear facilities.



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ACTIVE PATENTS ABROAD

# Health and environment research

## Study of the side effects of radiotherapy: entering the operational phase of the MIRCOCOM microbeam

In order to better identify the biological mechanisms of the side effects of radiotherapy, IRSN has since 2009 been running the ROSIRIS program (Radiobiology of integrated systems for the optimization of treatments using ionizing radiation and evaluation of the associated risks). The main objective of this program is to understand the physical and biological mechanisms that are triggered following irradiation, from the transfer of energy from the radiation to the molecules to the later biological effects.

The implementation of ROSIRIS relies in particular on an experimental facility, the MIRCOCOM microbeam installation, located at Cadarache (Bouches-du-Rhône). This is one of the few facilities in the world capable of targeting, with micrometric precision, cellular or sub-cellular elements with a defined number of charged particles and of tracking the early biological effects of irradiation by video-microscopy. After an initial cell irradiation campaign at the end of 2018, MIRCOCOM entered the operational phase in 2019, enabling exploration of radiation-induced dysfunctions at the subcellular, cellular, and tissue scale, right up to small multicellular organisms.

The latest results obtained in late 2019 and early 2020 with 4 MeV protons made it possible to determine a microbeam diameter and targeting accuracy of 2 µm on cells. These results demonstrate the capacity of the microbeam to perform precise and reproducible irradiations of cellular and subcellular structures.

Two publications were submitted in 2020 on the work carried out by IRSN during the first microbeam test campaigns. Two theses, one in physics, the other in biology, are currently in progress on the MIRCOCOM facility. Two collaborative projects were also begun in 2020, one with the CEA on the study of the repair mechanisms for radiation-induced DNA damage, and the other with the CNRS on the molecular homeostasis of the myotube after exposure to ionizing radiation. These two topics were the subject of experimental campaigns on MIRCOCOM in 2020.

Ultimately, the ROSIRIS program should make it possible to improve prediction of the appearance of complications in healthy tissue, to optimize - and even personalize - radiotherapy protocols, and to open up new avenues of treatment for prophylactic or curative purposes.



## Obtaining marketing authorization for potassium iodide extended to repeated doses in adults and children over 12 years of age

In the event of a nuclear accident resulting in the release of radioactive iodine into the environment, as was the case at Fukushima-Daiichi, the intake of stable potassium iodide by the population helps saturate the thyroid and thus prevent the fixation of radioactive iodine isotopes, thereby limiting the risk of thyroid cancer. Examination of the methods of administering this stable iodine in situations of repeated or prolonged radioactive releases was conducted by IRSN as part of the PRIODAC ("Repeated stable iodine prophylaxis in accident situations") research program. Launched in March 2014 for an initial period of five years and funded under the PIA "Investment in the future" program, PRIODAC was extended for three years in 2020 in order to consolidate the definition of a repeated prophylaxis best suited to the most sensitive categories of the population, namely pregnant women and young children.

The results obtained in the first phase (2014-2019) conclude that an intake of 130 mg per day repeated for seven days would lead to satisfactory efficacy of thyroid saturation without notable toxicity. These results served as the scientific basis for obtaining a new marketing authorization for potassium iodide for repeated use in adults and children over the age of 12.

PRIODAC thus illustrates the link between research and technical support intended to guide the actions of the authorities responsible for protecting the population.

• AT A GLANCE •

### ESTABLISHMENT OF A SCIENTIFIC COLLABORATION BETWEEN IRSN AND THE UNIVERSITY OF TOKYO FOR THE STUDY OF AEROSOL DISPERSION

In the context of preparing to remove the corium from the Fukushima-Daiichi reactors, the objective of this collaboration is to improve knowledge on the interactions between droplets and solid aerosols in order to mitigate the dispersion of the latter during the corium cutting operations. Concluded for a period of five years, this collaboration has already led to around a dozen aerosol collection tests being carried out using water mist in IRSN's TOSQAN facility.



### IRSN advances in innovative therapeutic strategy for hematopoietic syndrome

Patients with acute radiation syndrome following overexposure suffer from partial or total destruction of their blood stem cells leading to a drop in immunity and a defect in blood coagulation, resulting in significant and potentially fatal infections and internal bleeding. It is therefore crucial to be able to treat these patients with hematopoietic stem cells, the source of blood cells.

IRSN is therefore pursuing various research programs, including the GIPSIS project, run in conjunction with Sorbonne University, with the aim of developing an innovative therapeutic strategy for hematopoietic syndrome by generating hematopoietic stem cells from induced pluripotent stem cells (iPS). The project has made it possible to genetically reprogram skin cells to make them capable of multiplying infinitely and differentiating into all the cell types that make up an adult organism, just as embryonic stem cells do.

Leading directly out of the GIPSIS project, the feasibility of the production and differentiation of iPS cells has been demonstrated for obtaining blood stem cell grafts of sufficient size to treat a human patient. This proof of concept marked the transition from the R&D phase to the deployment of operational therapies. It resulted in November 2020 in the signing of an agreement between the Établissement français du sang (the organization handling blood donations in France) and the TreeFrog Therapeutics company, in collaboration with IRSN, for the production of universal, ready-to-use hematopoietic grafts from stem cell banks.

### Remediation of contaminated soil and effluent: closure of the DEMETERRES project

IRSN is a stakeholder in the DEMETERRES project, on the development of bio- and eco-technological methods for the rational remediation of effluents and soils in support of a post-accident rehabilitation strategy. Supported by the Investment in the future program, this project was launched in 2013 based on feedback from the post-accident management of the Fukushima-Daiichi disaster in terms of the operational strategy for remediating contaminated soil and effluents. This management had indeed revealed the shortcomings of the technologies implemented at the time, in two respects: one, the sustainable restoration of the use of soils, particularly for agricultural purposes; and two, the generation of volumes of waste that exceeded the capacities of the available treatment channels.

Within the international consortium coordinated by the CEA to conduct the DEMETERRES project, whose closing seminar was held in December 2019, IRSN focused on the interactions between potassium and cesium with a view to either limiting the latter's uptake into plant roots or increasing it for phytoremediation purposes.

### AT A GLANCE: IRSN PARTICIPATION IN THE EUROPEAN RADONORM PROJECT,

launched in 2020 for five years and led by the German Federal Office for Radiation Protection (BfS). This project aims to improve the protection of workers and the general public against radon and industrial process residues containing naturally occurring radioactive materials (NORM) by improving knowledge of the effects of low doses of ionizing radiation emitted by these materials. The objective is to develop scientific recommendations in support of future regulations in this field.





02

# Nuclear safety expertise



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TECHNICAL NOTICES AND REPORTS SUBMITTED TO ASN (EXCLUDING DEFENSE-RELATED ACTIVITIES)



5

TECHNICAL REVIEWS PERFORMED TO SUPPORT ASN ADVISORY COMMITTEE MEETINGS REGARDING SAFETY



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TEACHING HOURS GIVEN DURING THE 8 NUCLEAR SAFETY TRAINING SESSIONS



The primary objective of the expert assessment work carried out by IRSN is to provide scientific and technical support for the positions taken by the authorities and public bodies on a range of issues in the fields of nuclear safety and radiation protection.

In the spirit of both its 2030 strategy and the contract of objectives and performance that binds it to the State for the period 2019-2023, the Institute continued throughout 2020 to pursue its modernization actions with one concern always to the fore: continually improving the quality of service provided to the community. The reflections of its teams on the robustness of its organization and its processes are grounded in this desire for optimization. The strengthening of the Institute's collaboration with its institutional clients, through agreements such as those renewed in the defense sector, also feeds into this.

Given the health situation that characterized 2020, IRSN has also had to demonstrate its ability to adapt its expert assessment activities to activity postponements, such as unit shutdowns for maintenance and core refueling. Despite the constraints imposed by the crisis, the Institute was able to carry out major expert assessments, such as the summary notice issued for the fourth periodic safety review of 900 MWe reactors.

Again in the spirit of optimizing its activities on behalf of the public authorities, IRSN continued to work on prioritizing the safety analysis reports for review, in particular by identifying in more detail the issues involved in each case. At the same time, and with the aim of improving the working process between the Institute and the French Nuclear Safety Authority (ASN), IRSN and ASN conducted a joint assessment of the way they operate with regard to technical instructions for fuel cycle facilities, waste, and dismantling. This joint assessment of relations between the two organizations has enabled the Institute to draw useful lessons for adapting its response to safety issues by ranking ASN requests in terms of priority and workload.

In parallel, IRSN has continued its efforts to involve stakeholders in its expert assessment work, in the context of opening up its workings to society. In 2020, this resulted in technical dialogue initiatives aimed at the public and addressing certain safety issues of major importance to the community. The Institute has thus made available to the public annotated notices and webinars intended to make the expertise on these subjects as accessible as possible to the common citizenry. It has also integrated into its questioning some of the queries raised by the public during technical discussions.

In 2020, IRSN's activity in nuclear safety assessment was marked by the submission to ASN, in March, of the summary notice on the fourth periodic review of 900 MWe reactors. A major priority set jointly by the ASN and IRSN in the protocol they signed, this notice collates the conclusions of some forty notices issued by the Institute during this review. This illustrates the close link between research and expert assessment, as shown by the tests carried out in the Viktoria loop, a facility dedicated to experiments representative of the conditions that could be encountered in a reactor in the event of a core failure accident, and the studies carried out using ASTEC code, a software system that simulates all of the phenomena involved in a reactor core meltdown accident. The other major safety assessment dossier that mobilized IRSN experts in 2020 was the continuation of the pre-commissioning examination process for the Flamanville EPR with, in particular, the assessment of the treatment of weld deviations in the main steam lines of the EPR.

At the same time, IRSN experts continued the safety review of several nuclear fuel cycle facilities, such as INB 118 at the Orano plant in La Hague, and research facilities, such as the high flux reactor at the Laue-Langevin Institute in Grenoble.

Seeking to optimize the efficiency of its expert assessment work, IRSN continues to innovate in its decision-making methods and tools. After launching in 2019, with the support of the FTAP (Fund for the Transformation of Public Action), the PIREX tool, which uses deep learning to enable its experts to make best use of the operating feedback databases of nuclear facilities, in 2020 the Institute developed a decision support tool in the field of fire risk. Centered on the SEVEN software, this tool uses artificial intelligence to make the best possible use of research data to aid with expert appraisals and risk assessment, pursuing a logic of "augmented expertise".





**RP4-900: IRSN's main conclusions and recommendations**

Issued on March 31, 2020, the summary notice on the periodic review of 900 MWe reactors as part of their fourth 10-yearly inspections program (RP4-900) consolidated more than 40 expert assessments conducted by the Institute as part of its technical support for the French Nuclear Safety Authority. This review takes into account feedback from the accident at the Fukushima-Daiichi plant in Japan and EDF's wish to extend the operating life of its reactors. It represents more than 200,000 hours of work, or more than 130 full-time equivalent workers over the 2015-2020 period. IRSN experts focused on two major issues: one, compliance of the facilities with their design standards and, two, improvement of the safety level of these facilities, to align them more closely with reactors of more recent design.

At the end of this extensive work, IRSN considered that the work program proposed by EDF should enable EDF to achieve the objectives set for this review by ASN, subject to substantial additional information being provided on facility modifications and safety demonstrations. This additional information concerns, for example, the resistance of certain existing equipment to a "hardened core" earthquake (i.e.: an earthquake of greater intensity than that considered when the facilities were designed and taken into consideration following the Fukushima-Daiichi accident), and the risks of clogging of the reactor cooling water recirculation circuits that are used in accident situations. Following this work, which signals an important milestone in terms of expert assessment, a specific phase will begin for each of the thirty-two 900 MWe reactors, giving rise to specific analyses for each reactor.

**RP4-900: IRSN tests on the risk of clogging for reactor building sump filters**

As part of RP4-900, and in order to better assess the risk of clogging of containment system sump filters, which constitutes a major safety issue, IRSN has conducted tests in experimental facilities in order to obtain new knowledge on the subject, demonstrating once again the close link between research and expert assessment activities.

Hence, tests were carried out in the VIKTORIA experimental loop, built in collaboration with the Slovak engineering company VUEZ and inaugurated in 2011 in Levice (Slovakia).



These joint test campaigns involving IRSN and VUEZ are part of the research conducted on reactor accidents, and in particular loss-of-coolant accidents (LOCA) following a breach in the primary circuit. In situations such as these, indeed, the role of the backup systems is to assure both short- and long-term, thanks to a water recirculation circuit, the cooling of the reactor core and the evacuation of the residual power of the core out of the vessel. The water required is first pumped into a tank located outside the reactor building, then, when the tank is empty, recovered from the sumps located at the bottom of the reactor building, cooled, and returned to the primary circuit. Laden with debris, this water must be filtered to ensure the proper functioning of the backup systems, and ultimately ensure the cooling of the core.

The results obtained have made it possible to better appreciate the effects of certain parameters on the risk of clogging - such as the temperature and chemistry of the water, the nature of the debris, etc. - in order to support the conclusions of the Institute regarding the safety analysis report presented by EDF.

SUMMARY NOTICE

**SUMMARY NOTICE OF THE IRSN**

on the periodic review of 900 MWe reactors as part of their fourth 10-yearly inspections program (RP4-900).



**40**

EXPERT ASSESSMENTS CONDUCTED BY THE INSTITUTE AS PART OF ITS TECHNICAL SUPPORT FOR THE FRENCH NUCLEAR SAFETY AUTHORITY



**200,000**

WORKING HOURS EITHER THE EQUIVALENT OVER 130 EQUIVALENTS FULL TIME (ETPT) FOR THE PERIOD 2015-2020



### **Examination of aging under irradiation of nuclear reactor vessels**

As part of RP4-900, IRSN assessed the suitability of the reactor vessels concerned to be maintained in operation for up to 50 years. An essential component of reactor safety, they cannot be replaced. However, the steel of which they are composed ages under the effect of neutrons from the reactor core. While the 900 MWe units of the EDF fleet are progressively reaching 40 years of operation, the original service life hypothesis for calculating the effect of neutron irradiation, the operator must demonstrate the fitness of the reactor vessels to operate for 10 more years, an absolute prerequisite for extending the working life of the reactors. The safety analysis report submitted by EDF was examined in depth by IRSN experts in several stages, covering the key elements of vessel performance: assessment of the quantity of neutrons received, changes in steel properties, generic and specific defects to be considered in the vessels, and quantification of the stresses to which the vessel is subjected in an accident situation. To carry out this analysis, the Institute's experts conducted their own assessments, in particular using neutron, thermal-hydraulic and solid mechanics models developed in the framework of research programs that IRSN has led with several partners in these various disciplines. It took all the skills sets within the Institute and the ability of the teams concerned to work together to deal, in the allotted time, with the complexity of the multi-physical nature of the issues raised by this dossier. This analysis was also the subject of extensive discussions with representatives of civil society, within the framework of the technical dialogues organized with ANCCLI and the public consultation conducted under the aegis of the HCTISN.

At the end of this process, IRSN considered that the suitability of the reactor vessels for continued operation for up to 50 years had been demonstrated, subject to additional information expected from EDF for certain vessels affected by specific defects, and also subject to the results of the in-service inspections carried out during the 10-yearly inspection of each reactor.

### **RP4-900: Involving stakeholders in the assessment process**

Since 2014 - and throughout the expert assessment process related to RP4-900 - an ongoing technical dialogue has been established between IRSN and civil society in order to offer the latter access to the work of the Institute's experts and help ramp up the skills of the Institute's members.

This dialogue has taken various forms. Firstly, in order to discuss the safety issues associated with this 4<sup>th</sup> periodic review and its orientations, members of ANCCLI and IRSN formed a working group that met five times between 2014 and 2016. In addition, ANCCLI, CLIGEET (Local information committee on the major energy facilities at Tricastin), ASN and IRSN jointly organized a dedicated seminar in October 2016 in Valence (Drôme). Furthermore, three meetings were organized between 2017 and 2018 by ANCCLI, ASN, and IRSN to collect questions from civil society about the expert assessments conducted as part of this review, on specific topics such as reactor aging and reactor compliance with safety standards, internal and external stresses, and serious accidents.

As part of the public consultation conducted by the HCTISN on RP4-900 with the aim of involving civil society in examining the conditions for the continued operation of these reactors beyond 40 years, IRSN contributed to the debates at various public meetings (Bugey, Chinon, Cruas, Dampierre, Gravelines, Le Blayais, Saint-Laurent-des-Eaux and Tricastin), as well as on the platform dedicated to this consultation (<https://concertation.suretenucleaire.fr/>).

The Institute has also regularly added educational documents and other information to its own website and the consultation website, to further inform the debate. Lastly, the Institute has published a number of annotated notices presenting and explaining in a didactic manner the approach and conclusions of its experts on a certain number of subjects, and in a general way explained, through the published notices, how the questions raised by participants drawn from civil society, concerning this 4<sup>th</sup> safety review, were taken into account and addressed.



AT A GLANCE

**IN JUNE 2020, IRSN AND EDF, UNDER THE AEGIS OF THE NEA, LAUNCHED THE INTERNATIONAL SOCRAT BENCHMARKING**

of the behavior of overhead cranes during an earthquake. The failure of this kind of equipment, so widely used in the nuclear industry, can, for some scenarios, contribute significantly to the probability of core meltdown. The SOCRAT (Seismic simulation of Overhead CRANE on shaking Table) benchmark aims therefore to identify the best practices for modeling how these cranes behave along with the most relevant failure criteria, in order to come up with useful recommendations for the industrial world. This benchmark has drawn on experimental studies carried out with the AZALEE shake table of the CEA. Participation in this NEA-sponsored benchmark is open to all experts - from research bodies, technical safety organizations, regulatory authorities, etc. - interested in the modeling of experimentally tested cranes.

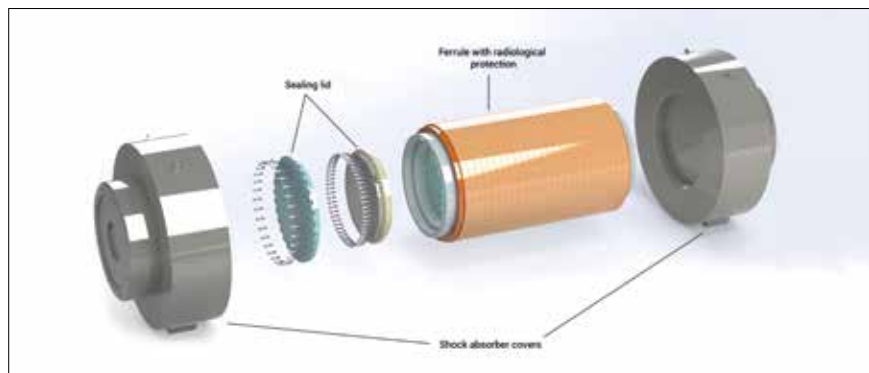
**IRSN ASSESSMENT OF THE NEW ORGANIZATION OF THE FRAMATOME LE CREUSOT PLANT**

The Framatome Le Creusot plant produces large parts required for the manufacture of primary components for nuclear reactors. The assessment of the new organization established in this plant, carried out by IRSN at the request of ASN, constitutes an atypical assessment for the Institute, since this facility is not an INB (basic nuclear facility). However, due to the nature of the components manufactured there, it does present some important quality and compliance issues, and ultimately, therefore, safety issues. The scope of the assessment focused mainly on the processes and practices recently applied within the plant to improve the quality of parts. IRSN also examined the procedures implemented by management to provide the plant's personnel with the skills required to carry out their activities and to maintain the skills required for current

and future parts manufacturing projects. In addition, actions to improve the plant's interfaces with the various stakeholders (suppliers, subcontractors, engineering, customers, etc.) in the manufacturing and supply chain were analyzed. This mission demonstrated the benefits of synergy between research and assessment, through the participation of an IRSN laboratory dedicated to the study of organizational and human risks in the assessment conducted by the Institute on the subject of supply chain management.

**Transporting radioactive materials: IRSN examination of the compliance of the new TN Eagle® package design**

At the request of the French Nuclear Safety Authority (ASN), IRSN examined in 2020 the compliance of the new TN Eagle® package design with the regulations on the transport of radioactive materials, based on the application for approval submitted by Orano TN in December 2019. This concerns transport by road, rail, river or sea, in the public domain, of this type of package model, intended for the transport of spent fuel assemblies from pressurized water or boiling water reactors. The package could also be used for dry storage of spent fuel. The IRSN assessment does not cover the use of this type of package for the latter purpose. The Institute did however examine the safety of transport after a storage phase (management of material aging, etc.). On the basis of the safety analysis report submitted and the information provided by Orano TN during the assessment, IRSN considers that the TN Eagle® package model complies with the requirements of the 2018 edition of the IAEA regulations applicable to Type B(U) packages for the transport of fissile materials.



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**Ten-year safety review of INB 118 at Orano's La Hague facility: the IRSN assessment**

In September 2020, IRSN submitted to ASN its assessment report on the ten-yearly periodic safety review of the STE3 effluent treatment plant (INB 118) at Orano's La Hague facility and its environmental and health impact.

In view of the operator's commitments and the action plan defined by the operator for the continued operation of the facility, IRSN concludes that the conditions are met in terms of safety to allow it to operate for the next ten years, subject to verification by the operator of the seismic behavior of handling equipment - a check that could potentially lead to modifications being made to this equipment - and additional investigations concerning certain active effluent tanks.

More specifically, the IRSN report notes the importance of the firefighting equipment in the storage halls for drums containing waste from effluent treatment, in order to control the fire risk, particularly in the event of an earthquake. Furthermore, the report emphasizes the importance of compliance with safety requirements regarding the behavior of equipment that would be used to limit the consequences in the event of an extremely damaging incident on the site.

**IRSN and ASN jointly evaluate their relationship**

The technical support provided by IRSN to ASN is formalized via a multi-year agreement that specifies the fields and technical procedures to which this technical support relates. The implementation of this agreement was the subject of a joint evaluation, the conclusions of which were presented to the executive directors of both bodies on September 29, 2020. From the risk assessment carried out by the Institute to the position taken by the Authority, the entire technical appraisal system implemented was examined.

The ASN-IRSN agreement plays an essential role, insofar as each year the Institute sends the Authority some 500 assessment notices, reports and technical notes covering many areas: safety of nuclear facilities, transport packages, waste, radiation protection, monitoring



of radioactive sources, emergency situation management, etc. The joint evaluation carried out by members of the two bodies aimed at verifying the suitability of this agreement and its constituent processes to the variable safety issues from case to case, and to improve their practices in terms of operation.

Based on investigations carried out on laboratories, fuel cycle plants and dismantling facilities, fields that have undergone profound changes in recent years with, in particular, the global application of safety reviews, the mission concluded that the process was working well overall. The proposed improvements and recommendations include the establishment of specific steering committees for examining high-stake dossiers, the definition of a shared appraisal strategy for the next safety review campaign, and the development of collaborative IT projects to facilitate exchanges.

AT A GLANCE

**IMPLEMENTATION OF THE NUCLEAR SAFETY DIRECTIVE 2014/87/EURATOM BY EU MEMBER STATES**

At the request of the European Commission, an "ETSON" consortium led by the German TSO, GRS, and including IRSN among its members, conducted a study on this subject, the conclusions of which were presented in October 2020. For its part, IRSN has conducted a study based on the responses from safety authorities to a questionnaire designed to illustrate the implementation of the directive in each country. It has also contributed to the project by presenting the safety improvements made to French nuclear reactors for managing serious accidents.



**Lead contamination of outdoor public spaces: IRSN participates in an ANSES expert group**

Under instructions from the French Ministries of Health and Labor, ANSES (the French national health and safety agency for food, the environment, and the workplace) wanted to include IRSN in its emergency collective expertise group (GECU), in order to benefit from the knowledge acquired by the Institute in the field of the behavior of aerosols. An expert from the Institute therefore took part in this work. Indeed, in order to analyze the measures taken by the operators of nuclear installations to confine radioactive particles, the Institute has long been conducting research programs on the measurement of aerosols and the resuspension of particles, in conjunction with various partners.

Although IRSN's competence lies primarily in the nuclear and radiological fields, it is nevertheless important that the Institute's knowledge can be shared for the assessment of other health risks. This applies for example to the risk linked to lead contamination, such as that resulting from the fire at Notre-Dame Cathedral in Paris, which raises questions of public health.

The results and conclusions of the work of the GECU, mandated to provide expertise on the contribution of lead contamination of outdoor public areas to human exposure, led to the publication of an ANSES notice on February 7, 2020.

**IRSN participation in the establishment by WENRA of safety reference levels for research reactors**

The Safety Reference Levels are drafted in the form of safety requirements, established by consensus and based on the best practices of the member nations of the Western European Nuclear Regulators Association (WENRA). At the request of the European Nuclear Safety Regulators Group (ENSREG) to develop safety reference levels for existing research reactors, WENRA has created a dedicated working group to address this objective. IRSN sits, in support of ASN, in meetings of this group, whose work was initiated in 2017, contributing its knowledge in the field of French research reactor safety. The group began by assessing the possibility of transposing the 342 safety reference levels applicable to existing power reactors to research reactors. While it concluded that nearly 90% of these reference levels could be applied to all research reactors, with certain adaptations if necessary, the working group added a topic concerning experimental devices used in research reactors and developed a guide concerning probabilistic safety studies of these reactors, in support of the single reference level defined for this topic.

All of the chosen reference levels were then sent for comment to all those with a stake in research reactors. After being accepted by WENRA in November 2020, the reference levels applicable to existing research reactors are now available on the association's website. Furthermore, WENRA has asked the chair of the working group to propose a five-year action plan, which will be examined at the next WENRA plenary meeting, scheduled for April 2021, and in which IRSN and ASN will participate.

**AT A GLANCE • PROFESSIONAL TRAINING FOR EUROPEAN TSO EXPERTS**

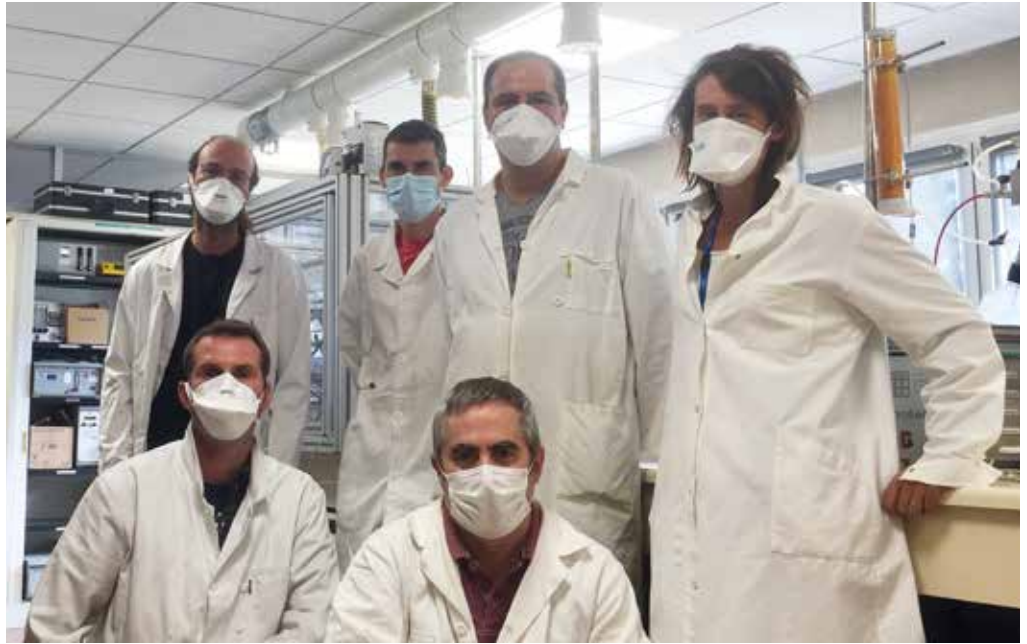
In 2020, IRSN and its European partners within the ENSTTI (European Nuclear Safety Training and Tutoring Institute) EEIG decided to terminate this 10-year program in favor of models better suited to post-Covid conditions.

IRSN will remain involved in the professional training of European TSO experts and will continue ENSTTI's pioneering work on the harmonization of training courses for nuclear safety and security and radiation protection analysts.

In particular, IRSN has taken over the training activities that ENSTTI had been providing since 2012 in support of two European Commission projects on the training of safety authorities and TSOs outside the EU in nuclear safety and nuclear material control.

IRSN will also remain a partner in the European Leadership for Safety Education (ELSE) project, initiated by ENSTTI and supported by the Université Côte d'Azur.





**IRSN contributes to work on protective masks in the context of the Covid-19 epidemic**

In addition to general protective measures and social distancing, wearing a mask helps limit person-to-person transmission of pathogens such as SARS-CoV-2, the cause of the Covid-19 pandemic. In the context of the health crisis that most countries in the world are having to weather, the demonstration of the effectiveness of these masks in terms of filtration is an essential criterion in satisfying the expectations of protection for the populace. IRSN is contributing to the work on this subject, drawing on its experience in protecting people from particulate contamination in nuclear environments, since radioactivity and viruses alike are transported by aerosols.

The subject of masks - whether barrier masks, surgical masks or FFP2 masks - raises many questions: what type of mask for what type of use (personal or collective protection)? Can it be reused after washing? Does performance remain constant and, if so, under what conditions? For IRSN, which has developed recognized expertise in aerosol physics and has facilities that enable it to acquire knowledge and assess the performance of personal protective equipment as part of its mission as an expert in the protection of workers exposed to radiological risks, it was only natural that it should make its knowledge and facilities available to the community - both nationally and internationally. In 2020, therefore, the Institute responded to requests from AFNOR concerning barrier masks, and also to various consortia, with a view to measuring changes in the filtration

performance of masks subjected to various sterilization processes. The results of this work have provided all stakeholders, both public and industrial, with the means for jointly assessing the initial filtration performance of the masks evaluated and how this performance is maintained post-treatment.

**Sharing knowledge about significant events: day of exchanges to identify the needs of CLIs (local information committees)**

On June 23, 2020, ANCCLI (National Association of Local Information Committees and Commissions) and IRSN jointly organized a knowledge-sharing day on the handling of significant events. This day, which was greatly appreciated by the participants, brought together all the players concerned (inspectors, experts, operators, civil society). It provided an opportunity to share the practices of the CLIs in terms of information and processing of significant events declared by French nuclear operators to the nuclear safety authority, as well as the different stages in the "life cycle of an event". In addition to supporting the development of the skills of civil society stakeholders, a workshop was held to specify the needs of CLIs with regard to the Integrated Feedback Platform (PIREX) project. This digital platform, which IRSN is developing using the capabilities of artificial intelligence to process these significant events, was the winner of the 2019 call for projects from the Fund for the Transformation of Public Action (FTAP).



**03**  
**Nuclear**  
**defense safety,**  
nuclear security,  
nuclear and chemical  
non-proliferation



**59**

TECHNICAL NOTICES  
AND REPORTS SUBMITTED  
TO THE ASND



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MISSIONS TO ESCORT  
INSPECTIONS INVOLVING  
INTERNATIONAL  
NUCLEAR MATERIAL  
CONTROL



**46**

TECHNICAL CHECKS ON  
APPROVED EQUIPMENT  
FOR TRANSPORTATION  
OF NUCLEAR MATERIALS



In the context of its support and technical assistance for the competent authorities, IRSN offers its expertise in the fields of nuclear defense safety, nuclear security, and nuclear and chemical non-proliferation. This support is exercised within the framework of many varied activities: expert case assessment, participation in inspections or controls, conducting studies or research, or contributing to State actions with regard to non-proliferation. It is also reflected in IRSN's participation in the work of the European Commission or the IAEA.

In 2020, IRSN renewed its agreements with 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).

In the field of naval propulsion, the Institute has, in particular, finalized the examination of the preliminary safety report for the future third-generation nuclear-powered ballistic missile submarine (SNLE) and the examination of safety analysis reports relating to the infrastructure for the Suffren nuclear attack submarines (SNA), in line with the progress of this weapons program. It also continued its assessment of files related to the review of an INBS on Île Longue (Finistère). In the field of research and experimental reactors, IRSN examined the safety options file for the INBS at the CEA center in Cadarache (Bouches-du-Rhône), and in the field of defense-related fuel cycle installations, it continued the safety review related to work scheduled at the various CEA and Orano centers in Pierrelatte (Drôme).

In the field of nuclear security, IRSN has focused on priority actions in the context of a high and lasting threat. These actions concern in particular the expert assessment of the measures implemented by operators in order to ensure the conformity of facilities and transport to the protection and control requirements of materials against the threat of malicious actions.

The challenge for IRSN is not only to provide this expertise in the context of procedures and the analysis of dossiers submitted by operators, but also to carry out the operational missions provided for in the regulations, such as providing support for inspections designed to verify compliance with the requirements linked to the commitments made by France, or keeping centralized accounts for nuclear materials.

Lastly, in order to provide ever more responsive support to the competent authorities, IRSN has continued to renew its tools, including various information systems and software designed for centralized accounting of nuclear materials or the study of cybersecurity at nuclear facilities, and has continued with the digitizing of procedures relating to the protection and control of nuclear materials, their facilities and transport, as well as the protection of ionizing radiation sources.





# Nuclear defense safety

## NAVAL PROPULSION

### Continued safety review of French Navy projects

As part of its technical support to the DSND (Representative in charge of Nuclear Safety and Radiation Protection for Defense-related Activities and Facilities), IRSN continued to review structural projects for the French Navy in 2020: it supported the continuing sea trials of the nuclear attack submarine (SNA) Suffren, as well as work on adapting the ports of Brest and Toulon to accommodate the submarine.

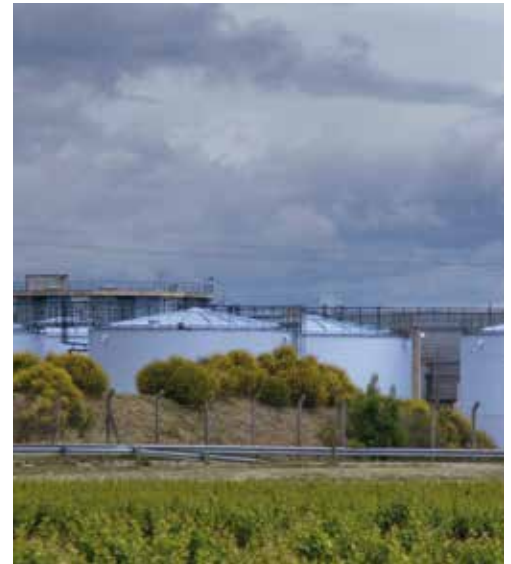
In parallel, the review of the technical design baseline and of the preliminary safety report for the 3<sup>rd</sup> generation nuclear-powered ballistic missile submarines (SNLE-3G) marked an important step. As part of France's deterrence policy, these vessels, which will replace the Le Triomphant class submarines, must meet a high level of safety requirements, taking into account, on the one hand, lessons learned from the past, such as the improvements made to the design and to the means of control and testing, and, on the other, changes in doctrine, particularly in terms of susceptibility to attacks or serious accidents. The same requirement applies to the future modernization of the facilities intended to accommodate the submarines in Cherbourg, Brest and Île-Longue.

Despite the complexity inherent in the Covid-19 health crisis, the commitment of the teams of both IRSN and the operator has made it possible to continue pursuing these reviews even during the lockdown period and to convene, in July 2020, a reactor safety commission which was able to submit its conclusions to the DSND.



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TECHNICAL NOTICES SUBMITTED  
TO THE MTES SENIOR DEFENSE  
AND SECURITY OFFICIAL



## LABORATORIES AND PLANTS RELEVANT TO DEFENSE

### Assessment conducted at the Marcoule CEA site

As part of the waste recovery and packaging program at the Marcoule CEA site (Gard department), IRSN examined various safety dossiers in 2020, including the safety review of the pillboxes at the site's liquid effluent treatment plant.

In its report to the French Nuclear Safety Authority (ASND), IRSN emphasized the importance of the expected improvements and the definition of practical measures to be taken to limit the consequences of an earthquake. The IRSN's conclusions were presented to the laboratories and factories safety and waste management commission (CSLUD) so that it could formulate its opinion.

The Institute has also finalized the assessment of the safety analysis reports for existing and future modules of the multi-purpose intermediate storage facility (EIP) as part of the review of existing cells and the commissioning of new cells.





# Nuclear security



## EXPERTISE

### Examination of the EDF reactor fleet safety study

By virtue of the Ministerial Order of August 3, 2011, issued in implementation of the Defense Code, a complete security study of facilities authorized to hold nuclear materials must be conducted in order to show that the measures proposed by the operator to ensure the protection of these materials in its facilities can prevent malicious acts that could lead to unacceptable radiological consequences.

IRSN's in-depth technical examination of an initial security study conducted by EDF made it possible to analyze the technical and organizational measures proposed to prevent any act aimed at altering, damaging or dispersing nuclear materials. The Institute's assessment examined in detail the identification of threats and potential targets, as well as assessing the vulnerability of these potential targets. This analysis work, which required substantial dialog with the operator, constitutes a pilot investigation that will serve as a baseline for examinations in the years to come.

## STUDIES

### Cybersecurity studies: simulation of attacks and intrusion by cybercriminals using the HYDRA platform

The HYDRA simulation platform, which IRSN has acquired, allows complex IT architectures to be modeled in order to study their resistance to cyberattacks. Thanks to this equipment, built on a base provided by Airbus Cybersecurity, the Institute has the capacity to study in the laboratory the impacts of cyberattacks, whether targeted or generic. Consisting of a set of servers, HYDRA is able to clone the industrial computing environments typically found on nuclear sites. By combining virtualization and the possibility of connecting to actual equipment, the platform offers an accurate representation of environments, allowing the Institute's engineers to reproduce real attacks as well as to hypothesize malicious scenarios and see what effects they have on equipment. Based on these results, IRSN's broader expertise makes it possible to work through the physical consequences on the nuclear facilities.

### Resumption of IRSN's experimental activities on the effect of explosions

Understanding the physical mechanisms governing the propagation of blast waves resulting from the detonation of explosive charges is of major concern for the safety of nuclear facilities. To extend its knowledge in this field, IRSN therefore conducted six test campaigns between 2006 and 2011 using a table to study the pressure levels generated by different detonations.

Under a framework agreement with Ariane Group, IRSN resumed the implementation of pyrotechnic test campaigns with this service provider, authorized in the use of explosives. To this end, the Institute has designed models that reproduce the 3D geometry of an actual nuclear installation, allowing sensors to be inserted at the points of greatest interest in terms of conducting measurements. Thanks to a scaling law enabling full-scale extrapolations to be made on the basis of a scaled-down experiment, the results of these tests facilitate improved modeling of blast wave effects on an actual nuclear installation. They thus provide the Institute's expert assessment engineers with factual arguments on the resistance of structures to blast effects for the analysis of safety files for nuclear facilities.



Airbus' Cyber Range Platform



## TECHNICAL ASSISTANCE

### **Continued analysis of requests for approval for the implementation and monitoring of nuclear material shipments in the context of Covid-19**

The operational transport section (EOT) of the IRSN nuclear defense expertise operational division (DEND) is responsible, in particular, for managing and processing requests for approval for the transportation of nuclear materials and for monitoring these shipments. Under normal circumstances, this monitoring is carried out by two five-person shifts, which can be reduced according to other requirements such as technical inspections or controls. During lockdown, business continuity was maintained with a reduced staff of two two-person shifts, with the remaining team members working from home.

This adaptation was designed to reduce the risk of contamination due to working in an open-space environment, and to keep team members in reserve in the event of enforced quarantine. This mode of organization worked perfectly, making it possible to examine all requests for approval to transport nuclear materials to supply nuclear power plants or the Orano MOX fuel fabrication plant in Marcoule (Gard department). During the first lockdown period, the technical inspection and control missions carried out by EOT on behalf of the HFDS (Senior Defense and Security Official) of the Ministry of Ecological Transition (MTE) were interrupted, in order to focus on transport management and monitoring activities. These activities were resumed in the summer and continued through the second period of lockdown.

## INTERNATIONAL

### **International: monitoring cooperation between IRSN and DoE**

The partnership dedicated to nuclear safeguards and security between IRSN and the U.S. Department of Energy (DoE) is governed by a memorandum of understanding (MoU) signed in July 2006. Under this agreement, the teams of the Institute and of DoE's National Nuclear Security Administration (DOE/NNSA) respectively propose collaborative actions on subjects of common interest for which each of the two partners provides a share of the funding.

This agreement is scrutinized at the annual meeting of a permanent coordination group. The 13<sup>th</sup> edition of this meeting was held via videoconference in October 2020. This provided the opportunity to take stock of ongoing collaborations on various subjects such as R&D in cybersecurity, reinforcing the security of nuclear materials for road transportation, and developing guides for the use of gamma spectrometry measurement systems in nuclear security. A new initiative was decided upon, to develop a workshop on the coordination between physical protection and the physical tracking and records of nuclear materials during a nuclear security event.

### **Security of ionizing radiation sources against malicious acts**

As part of the January 1, 2021 implementation of the November 29, 2019 Order on the protection of ionizing radiation sources against malicious acts, IRSN has developed an e-learning module on the protection of ionizing radiation sources with the European Nuclear Safety Training and Tutoring Institute (ENSTTI). Released on December 1, 2020, this e-learning module is intended for managers of nuclear activities who are holding, using, manufacturing, distributing, importing, exporting or transporting ionizing radiation sources, along with personnel authorized to access and transport ionizing radiation sources.



### **FROM FEBRUARY 10 TO 14, 2020, IN VIENNA, 10 IRSN EXPERTS PARTICIPATED IN THE 3<sup>RD</sup> IAEA INTERNATIONAL CONFERENCE ON NUCLEAR SECURITY (ICONS 2020)**

They led several roundtables and presentations on issues such as illicit trafficking in nuclear materials, implementation of national regulations, and cybersecurity. They also took part in an event dedicated to the implementation of standardized tests for radioactive material detection systems.

.....AT A GLANCE.

# Nuclear and chemical non-proliferation

## CHEMICAL WEAPONS CONVENTION (CWC)

### **Issuance by the IRSN Deputy Director General of Defense and Security of activity authorizations for products covered by table 1 of the CWC**

Since February 1, 2020, the IRSN Deputy Director General in charge of national defense and security missions (DGA/D) has been delegated by the French Minister for Industry to issue authorizations for activities related to the chemical categories deemed subject to greatest proliferation under the Chemical Weapons Convention (CWC). To be eligible for these authorizations, the activities carried out with these products must be for medical, pharmaceutical, research or protective purposes and in quantities limited to what can be strictly justified by these purposes.

In this context, the chemistry office of the IRSN nuclear materials non-proliferation and accounting department analyzes each dossier and sends a report to the DGA/D, with a view to an authorization decision being issued on this basis, as well as on the conclusions of the preliminary inspection carried out on site by the services of the Ministry for Industry.

The first authorization was issued in September 2020 and two new dossiers are due to be submitted in 2021.



## NUCLEAR SAFEGUARDS

### **Participation of the IRSN, on behalf of the Directorate General for Energy and Climate (DGEC) and the Euratom Technical Committee (CTE), in drawing up the implementation order for the French additional protocol to the Non-Proliferation Safeguards Agreement.**

This order, published on March 13, 2020, specifies the declaration procedures for manufacturers and the role of IRSN as a collector of these declarations. In this regard, the Institute is involved in collecting declarations via its dedicated PASTEL portal and clarifies what is expected of operators. It is also involved, in close collaboration with the CTE, in providing support for the broader access requirements of the IAEA in accordance with the provisions of the French additional protocol.

### **Organization by IRSN of the 2020 symposium of the European Safeguards Research and Development Association (ESARDA) on behalf of the Euratom Technical Committee (CTE), under the French chairmanship of the Association.**

Building on the diverse work of the 2019 symposium, including in particular a world café aimed at energizing the association's activities, and despite the context of the Covid-19 health crisis, the 2020 ESARDA symposium brought together up to 160 participants for some highly appreciated and fluent virtual exchanges. This demonstrated the capacity of the Association to serve as a forum of exchange for developing safeguards.







04  
Radiation  
protection  
of people and  
the environment



4,978

ENVIRONMENTAL SAMPLES  
TAKEN FOR RADIOLOGICAL  
MEASUREMENTS



505

SAMPLING POINTS FOR  
RADIOACTIVITY MONITORING  
THROUGHOUT FRANCE



126

TEACHING HOURS GIVEN  
DURING THE 17 RADIATION  
PROTECTION TRAINING  
SESSIONS





**T**he IRSN is involved in environmental monitoring and the protection of people against ionizing radiation with the aim of contributing ever more effectively to public policies aimed at encouraging a global approach to environmental health issues, as testified by the guidelines of the 4<sup>th</sup> National Health and Environment Plan (PNSE). The IRSN contribution to work carried out in 2020 to better understand the origin of certain cancer clusters - such as the cases of glioblastoma observed around the Salindres chemical platform in the Gard region - is an illustration of this. More generally, the Institute intends to intensify its efforts to make environmental and health data available, with the aim of eventually contributing to the creation of a national Green Data Hub.

The first strategic area to be highlighted in the field of radiation protection for humans is the intention of IRSN, which is currently conducting preclinical research on the effects of prolonged exposure to ionizing radiation, to work more closely with organizations and hospitals in charge of clinical research and to contribute to the debate led by the French National Cancer Institute (INCa) on the future of cancer research. Using the power of artificial intelligence to increase the efficiency of processing data from radiation monitoring of workers is a second area of development in the field of radiation protection for human health. With this in mind, in 2020 the Institute, in conjunction with the DGT (the French Directorate General for Labor), began renovating SISERI, its information system for monitoring exposure to ionizing radiation, with funding from the Fund for the Transformation of Public Action (FTAP). The augmented expertise of the diagnostic reference level database, the subject of the ExPRI project, also illustrates this trend.

In the field of environmental monitoring, IRSN is pursuing its policy of acquiring in-depth knowledge of the radiological state of a given territory through the territorial radiological surveys it conducts in various regions of France. 2020 has been a particularly rich year in this respect, with the publication of findings relating to three regions: the Mediterranean, the South West and the North East.

With regard to crisis management, in the context of the Covid-19 pandemic and the associated restrictive measures, IRSN was able to demonstrate the robustness of its organization during several events that occurred in the course of 2020, in particular the forest fires that ravaged the Chernobyl region in Ukraine from April onwards, and the outbreak of a fire at the Creys-Malville site in Isère.

In the field of natural hazards, the Institute has carried out and published, in close collaboration with academic teams, work aimed at better understanding the characteristics of the earthquake in Le Teil (Ardèche) that occurred in November 2019 and has initiated a European research project entitled DARE aimed at studying seismic site effects in the Rhône Valley.

Lastly, IRSN has intensified its dialogue with society, particularly through its interactions with local information commissions (CLIs), associations and all the institutional players who relay the public's concerns about health and radiation protection.



# Radiation protection for human health

AT A GLANCE

## MITOCHONDRIA AND RADIOTHERAPY

IRSN is a partner in the project "Mitochondrial import machinery regulated by CHCHD4\* and its targeting for cancer treatment". Supported by the Gustave Roussy Institute, this project aims to study the impact of mitochondrial metabolism on tumor growth and response to irradiation. More precisely, it has enabled the investigation of the molecular communication between tumor cells and vascular endothelial cells whose behavior is influenced by mitochondria following radiation therapy.

## OCCUPATIONAL EXPOSURE TO RADON

IRSN has issued advice on the changes introduced by the International Commission on Radiological Protection (ICRP) with the updating of dose coefficients for radon in the workplace. The Institute concludes that one consequence could be a lowering of the reference level for radon in the workplace. IRSN also stresses the complexity of using different dose coefficients according to professional activities set against their relative utility, since radon exposure also concerns the public in the home environment.

\* Mitochondrial protein that regulates the cell's oxygen consumption and therefore its metabolism

## Involvement in cancer research

At the request of the French National Cancer Institute (INCa), IRSN took part in the discussions initiated as part of the ten-year cancer control strategy. In particular, the Institute shared its work and insights on cancer treatment, especially concerning the consequences of external and internal radiotherapy and the delivery of the right dose to the tumor while guaranteeing the protection of healthy tissues. The Institute's action in this field aims at limiting undesirable effects related to radiotherapy treatments in order to improve patients' quality of life as much as possible. During the discussions between the two organizations, various subjects were addressed, such as the evaluation of new treatment mechanisms and protocols, and the utility of creating a database to systematically evaluate the treatments carried out, to link doses to effects, or to develop innovative treatments for the management of after-effects. The Radiotransnet initiative, in which IRSN is a partner, is one of the projects designed to consolidate efforts to drive forward national cancer research. Officially certified by INCa at the end of 2018 for a period of two years, this project aims to structure translational research - from the preclinical phase to the clinical stage - in the field of radiotherapy. It involves more than 80 laboratories with the aim of identifying research priorities by promoting scientific and clinical interactions at the interface of radiotherapy and radiobiology. Four seminars were held in 2019 and 2020 to identify recommendations that will inform a strategic research agenda. In this regard, INCa has already included in its ten-year cancer control strategy a strategic focus on limiting the after-effects of cancer treatments and improving patients' quality of life. IRSN, meanwhile, has renewed its historic partnership with Gustave Roussy in this strategic area.

## 6<sup>th</sup> review of diagnostic reference levels in medical imaging

In April 2020, IRSN published its 6<sup>th</sup> review of diagnostic reference levels (NRD) in medical imaging, for the period 2016-2018. Based on data submitted by professionals, this review demonstrates a drop in the dosimetric values in every field: the great majority of them being between 0 and 25% below the DRLs in force since July 1, 2019. In order to limit radiological exposure related to mammography procedures in particular, IRSN recommends the

collection of data from real examinations and not the use of dummies, in order to assess the quality of the radiographic image or to calibrate the radiological exposure of patients. It also proposes to expand data collection to include new tests. Lastly, it suggests utilizing an approach that integrates the image quality required for producing the diagnosis, alongside the dose optimization approach.

## Continuing optimization of medical imaging doses

As part of its public health remit, IRSN provides its expertise in the field of medical imaging for diagnostic purposes, with the aim of optimizing the doses to which patients may be exposed.

The Institute therefore periodically examines the exposure of the population to ionizing radiation due to diagnostic medical imaging examinations (ExPRI report). It issued a new report in 2020, covering 2017 and comparing the data collected to the data from 2012. This report provides an analysis by imaging modality (conventional, interventional and dental radiology, CT and nuclear medicine), by anatomical region explored, by age and by sex. The report is based on diagnostic imaging procedures extracted from a representative sample of health insurance beneficiaries. The changes observed in the averages of the frequency of procedures and the annual effective dose per individual are low overall, with the latter stabilizing at 1.53 mSv (compared to 1.56 mSv in 2012). Nuclear medicine, the third-largest contributor to the collective effective dose, is the modality with the largest increase over these five years, both in frequency and in contribution to the collective effective dose. However, computed tomography remains by far the most significant contributor to the exposure faced by the population (74.2%). The report also highlights the problem of cumulative examinations, which lead to several hundred thousand patients nationwide receiving effective doses that can exceed 100 mSv over a three-year period, raising the question of possible long-term radiation-induced effects.

In 2020, IRSN issued advice on Image Guided Radiotherapy (IGRT). Based on an inventory of practices and industrial solutions to optimize these practices, IRSN recommends setting up multidisciplinary groups in radiotherapy departments, deploying specific procedures for pediatrics, and underpinning training.

**Report on image quality and delivered dose in digital mammography**

The Direction générale de la santé (Directorate general for health) (DGS) tasked IRSN with conducting an assessment of digital mammography facilities used for organized breast cancer screening. This request from the DGS followed on from the INCa's observation of the heterogeneity of cancer detection rates by these facilities, between one reading systems manufacturer and the next.

IRSN quantitatively analyzed external quality control documents relating to image quality and delivered dose for a sample of digital mammography facilities. A total of 126 reports were analyzed, representing approximately 6,000 items of used data. IRSN also compared the doses delivered by the facilities using the Diagnostic Reference Level (DRL) database in order to detect any differences between brands of mammography equipment.

These analyses did not reveal any significant differences in the detailed results of the image quality checks between the different brands of reading systems. On this basis, it is not possible to conclude that the lower technical performance of certain brands might explain the differences in cancer detection rates observed by INCa. This assessment did however highlight the existence of a clear difference in average doses likely to be delivered to the mammary gland depending on the type of mammography facility, leading IRSN to recommend that the technical and clinical performance of the types of facility with the highest exposure rates and the lowest tumor detection rates should be examined. Investigations will continue as part of the action plan developed by the DGS in collaboration with INCa, ANSM (the French national agency for the safety of medicines and health products) and IRSN.

Lastly, IRSN participated in a European awareness campaign for the appropriate use of medical imaging examinations, launched on November 8, 2020, on the occasion of International Radiology Day. With the ASN as coordinator in France, this campaign was conducted in a European context by 19 member countries of HERCA (Heads of the European Radiological Protection Competent Authorities). IRSN led the working group that drew up the forms for doctors requesting radiological examinations.



.....AT A GLANCE.

**RADIOLOGICAL EXPOSURE OF WORKERS**

IRSN has published the results of dosimetric monitoring of 395,000 people exposed to ionizing radiation in the course of their professional activity in 2019. The headcount of the monitored workforce had increased by 1.2% compared to 2018 and the collective dose measured by passive external dosimetry had increased by 8%. These results are mainly related to the increased volume of maintenance work in the nuclear industry and to the increase in doses received by flight personnel exposed to cosmic radiation, in connection with solar activity. For the first time, this report is available in a digital and interactive version at [expro.irsn.fr](http://expro.irsn.fr).



**572**  
WHOLE-BODY COUNTS FOR THE INDIVIDUAL MONITORING OF WORKERS, INCLUDING 479 USING MOBILE FACILITIES

..AT A GLANCE.

**RADON & RADIOACTIVITY: IRSN LAUNCHES A NEW SMARTPHONE APP**

This app allows anyone to estimate their individual exposure to the various components of naturally occurring ionizing radiation (radon, cosmic radiation, terrestrial radiation or through consumption of foodstuffs) based on a short questionnaire on their way of life and their place of residence.

.....AT A GLANCE.

**RADON AND TERRITORIAL ACTIONS: THE CITIZEN AS AN ACTOR IN CONTROLLING THE RADON RISK IN THE HOME**

As part of its strategy of opening up to society, IRSN has been contributing for several years to the development of territorial actions dedicated to the management of the radon risk in the home. Reflection is ongoing, with a view to involving local stakeholders over the long term and identifying innovative ways to enable them to fully play their role in controlling the radon risk, from raising awareness and encouraging measurements to supporting the implementation of remediation work.



# Radiation protection of the environment



## 507

MONITORS MAKE UP  
FRANCE'S REMOTE  
MONITORING NETWORK

AT A GLANCE

### MONITORING

In 2020, IRSN published the radiological findings for the North East, South West and Mediterranean regions. These studies update the intelligence surrounding environmental radiological markings in these regions, and they complement the regular monitoring of radioactivity in the French environment, carried out in the vicinity of nuclear facilities, with the purpose of detecting any changes or deviations from the reference levels.

### ACTIVE FAULTS

IRSN has made available online a database listing potentially active faults in mainland France. Produced with the support of the Ministry of Ecological Transition, this database identifies faults whose past or current seismic activity can be used as a basis for assessing the seismic hazard to be taken into account for the safety of nuclear facilities.

### Working on a technical guide for assessing the radiological risk to wildlife

As part of its work on addressing the radiological risk to wildlife, IRSN, at the request of ASN, has coordinated the production of a technical guide, finalized in December 2020, on the impact of a nuclear facility or activity on flora and fauna. This work was carried out by a multidisciplinary and pluralist group led by the Institute and composed of stakeholders concerned with the radiation protection of the environment: operators, planning departments, local authorities and civil society.

The proposed method is based, just as for the chemical risk, on the principle of "deviation from the reference", i.e.: comparing exposure to a reference value. The second founding principle of this method is the use of a graduated approach on three levels, from most conservative to most realistic: levels 1 and 2 equating to a negligible risk. The third level is only applicable when there is doubt as to the negligible nature of the risk assessed in light of the first two levels. Besides the consistency of the risk assessment method, whether for chemical, health or radiological risks, the involvement of all the members of the working group in the co-production of the document should be highlighted.

### Tritium and water intended for human consumption

At the request of the DGS and ASN, IRSN analyzed the regulatory quality reference for tritium in water intended for human consumption.

In its analysis, the Institute points out that tritium is one of the least toxic radionuclides, according to the most recent scientific data. It underlines moreover that the latest epidemiological studies do not demonstrate any specific risk from tritium, either because the studies do not specifically address exposure to this radioactive element, or because of the lack of statistical significance of the assessments, due to the small number of cohorts on which they are based. The Institute's analysis also shows that the ingestion of tritium in drinking water, at levels observable in the environment, leads to only extremely low exposure. Therefore, the Institute has determined that the scientific data acquired do not justify a significant and rapid change in the criteria and levels of tritium risk management in place. It does however recommend that the validity of the radiological risk management models and criteria be periodically reviewed and the results shared.

### Assessment of doses received in French Polynesia from 1975 to 1981

At the request of the Compensation Committee for Victims of Nuclear Tests, IRSN examined an assessment of the effective doses potentially received by the populations of French Polynesia over the period 1975-1981.

This complex assessment had to take into account the main radionuclides contributing to the three exposure channels (ingestion, external exposure and inhalation). For this purpose, the Institute drew on three sources of information: declassified CEA reports; international bibliography; and measurements of cesium-137, strontium-90, and plutonium isotopes from aerosol filters dating from that period and preserved in its samples library.

The results of this assessment show that the radiological exposure of the populations of Tureia, the Gambier Islands and Tahiti to fallout from atmospheric nuclear testing between 1975 and 1981 is below 100  $\mu$ Sv/year, or one-tenth of the natural exposure in French Polynesia and the limit of 1 mSv/year set for public exposure to ionizing radiation.

### Reconstructing the contamination path in French waterways

Led by IRSN, the TRAJECTOIRE project was launched in January 2020 for a four-year duration. It was selected by the Agence nationale de la recherche (National research agency) and aims to reconstruct the trajectory of contaminants resulting from human activities and detected at the outlets of the main French river basins: Garonne, Loire, Meuse, Moselle, Rhine, Rhone, Seine. The project cross-references documentary archives listing human activities (industrial discharges, consumption patterns, production, standards, regulations, etc.) in these environments and sedimentary archives tracing the history of their contamination. The data obtained will be analyzed to determine a cause-and-effect relationship between human activities and contamination. Three families of contaminants will be studied: radionuclides, microplastics and rare metals used in high-tech industry.

The ultimate objective of the TRAJECTOIRE project is to develop a predictive model of contaminant concentrations in river systems by considering the evolution of pressures resulting from human activities, based on climate and societal change scenarios. The research will enable the trajectories of the contaminants studied to be assessed, via the response of the environments subjected to human-activity disturbances affecting their river basins, as well as the capacity of large rivers to return to their initial state after a disturbance, in other words, their resilience capacity.





### Radiological study of the Saint-Alban site

In 2020, IRSN continued the radiological study begun in 2019 around the Saint-Alban site (Isère). After taking more than 300 samples in 2019, the focus in 2020 was on taking samples from the aquatic environment and conducting local surveys to update information on the lifestyles of nearby residents. Saint-Alban is the first site chosen by the Institute to develop a methodology that can be applied routinely to improve its knowledge and its approach to assessing the environmental and health impact of nuclear sites. The radiological studies make it possible to diversify the types of samples and the types of analysis of environmental samples, and to check the suitability of the modeling tools to the particular site specifics. The studies are also intended to address the concerns of local populations and to get them involved in measuring environmental radioactivity, so as to better understand the issue of radiological risk. To this end, a study monitoring group was formed by the CLI (local information commission) of Saint-Alban in order to share and exchange on the progress, the results, and the involvement of local stakeholders (farmers, hunters, fishermen, families, etc.) for the purposes of the study.

### IRSN organizes training in gamma spectrometry

Inspecting the radiological quality of foodstuffs is carried out by laboratories approved by the State. They benefit in this regard from the methodological support of IRSN, which, in its capacity as a national reference laboratory, provides training and organizes intercomparison tests to ensure that laboratories are capable of carrying out these inspections and to help maintain the skills of their staff.

Measuring radioactivity in foodstuffs is based on operations that require a high degree of qualification. It is therefore important for the 12 laboratories in France approved for this activity to have periodic training sessions to perfect their practice through exercises related to the different key phases of the measurement process. IRSN is responsible for running this network of laboratories, providing training, and organizing the intercomparison tests required to issue approvals.

For this reason, on October 8 and 9, 2020, the Institute organized gamma spectrometry training days at its site in Le Vésinet (Yvelines) for 10 laboratories of the Service commun des laboratoires ("Common laboratories service"), a service of the French economic and financial ministries with a national remit, and the network of veterinary and departmental analysis laboratories. These training days also provided an opportunity for IRSN and laboratory experts to discuss the specifics of measuring the various samples taken in the course of their food monitoring activities and, more generally, to discuss all the technical issues related to this activity.

AT A GLANCE

#### WASTE STORAGE

After the public debate on the National Radioactive Materials and Waste Management Plan, technical discussions with civil society on the disposal of high-level and intermediate-level long-lived waste resumed in 2020, with the identification of technical issues to be addressed, such as alternatives to geological disposal. On this topic, a webinar took place on September 25, followed by an information day on December 15 concerning waste packages.

The TRAJECTOIRE project aims to provide stakeholders with a tool to assist in the development of environmental regulations and provisions, such as how to conduct dismantling and remediation operations, or how to manage materials such as critical metals used by new technologies, with a view to protecting aquatic environments.

#### Launch of the tritium activity measurement campaign in the Loire

In November 2020, IRSN, in conjunction with ASN, began a campaign to measure tritium activity in the Loire river, based on samples taken in the town of Saumur (Maine-et-Loire). This campaign aims to explain the origin of an abnormally high tritium activity (310 Bq/L) in the Loire measured by ACRO (Association pour le contrôle de la radioactivité dans l'Ouest) in January 2019. It follows on from the modeling of expected tritium levels in the Loire, based on the declared releases of EDF's nuclear power plants (CNPE), which did not enable the same kinds of concentrations to be reproduced in Saumur. The hypothesis issued by IRSN was that there was an imperfect mixing of releases from the Chinon power plant, leading to heterogeneity in the distribution of tritium on the river bed over long distances. The four-month sampling campaign begun at the end of 2020 should allow this hypothesis to be examined in greater detail.

The objectives and methodology of this campaign were presented on October 19, 2020 to representatives of the stakeholders: the town of Saumur, the CLI (local information commission) of Chinon, ACRO (Association pour le contrôle de la radioactivité dans l'ouest), the "civic samplers network" (Réseau de préleveurs citoyens), and EDF. The latter expressed the desire to form a pluralist monitoring committee, which convened on December 2, 2020, in Saumur.

# Crisis monitoring and management

## International crisis exercise

From August 25 to 27, 2020, IRSN participated in an international crisis exercise as part of the IAEA's Response and Assistance Network (RANET). This type of exercise is designed to test the procedures of Member States and international organizations that may request or offer international assistance in the event of a nuclear or radiological emergency. The technical scenario of the exercise, which considered an accident situation occurring in France, was prepared and run by IRSN.

The Institute's crisis organization was activated, including for the first time the mobilization of the newly created international cell of the Technical Crisis Center.

In addition to the usual expert assessment missions in situations of emergency, the exercise enabled the implementation of alert and information-sharing procedures with the IAEA, to share our strategies for measuring radioactivity in the environment, and to use an assessment method that is now common to all crisis centers: the 3D3P method. Seven countries took part in this exercise: Belarus, Bulgaria, France, Pakistan, Russia, South Africa, and the United States.

## Fire outbreak at the Creys-Malville site: IRSN activates its crisis organization

On June 30, 2020, IRSN activated its crisis organization after being informed of a fire that broke out inside the reactor building being dismantled at the Superphénix nuclear power plant in Creys-Malville, Isère. As part of this mobilization, the Institute deployed its mobile measuring equipment in the field, in agreement with the authorities, in order to take in situ readings and samples in the environment of the nuclear site. The measurement results and analyses of samples taken in the Institute's laboratories did not reveal any increase in the level of radioactivity attributable to this event in the environment of the Creys-Malville nuclear site.

## CRISIS MANAGEMENT: IRSN MOBILIZED FOLLOWING THE FIRE ON THE NUCLEAR ATTACK SUBMARINE, PERLE

On June 12, 2020, IRSN activated its crisis organization after being informed of a fire on board the nuclear attack submarine, Perle, in Toulon.

This submarine had been in dry dock since January 2020. For the work being done on the vessel, the reactor had been shut down and there was no nuclear fuel on board.

The Institute helped the authorities to monitor the situation throughout the period of the fire.

In particular, the Institute used its fixed measurement resources located near the naval base and deployed mobile resources from the IRSN site in Les Angles (30) to confirm the absence of any radiological impact.

## Monitoring of forest fires in Chernobyl

On April 4, 2020, a fire broke out in the exclusion zone of Chernobyl (Ukraine). Such an event, which has already happened before, can lead to the resuspension of cesium 137 in the air. This is why IRSN mobilized its crisis organization to monitor the situation and assess the consequences of the propagation into France of potentially contaminated air masses. In particular, it analyzed on a daily basis all the measurements from its own environmental monitoring networks - such as the stations of its OPERA-AIR network dedicated to monitoring the radioactivity of atmospheric aerosols - as well as the information communicated by its European, and in particular Ukrainian, partners.

On the basis of these data and numerical simulation models, IRSN experts established an estimate of the radioactivity remobilized by the flames and of the dispersion of the plume in Europe using meteorological data provided by Météo France. They regularly published situation notes on these fires and on the associated radiological impact: an impact that remained very low and without health consequences for the population and the environment.

6

ACTIONS TAKEN BY THE  
EMERGENCY RESPONSE CENTER,  
CNPE NOGENT

2

NATIONAL NUCLEAR  
EMERGENCY EXERCISES  
EXCLUDING DEFENSE

### Rising levels of radioactivity in the air in Northern Europe

From June 28 to July 22, 2020, the Institute activated its crisis organization, at the lowest level, following the detection in Northern Europe of elevated levels of radioactivity in the air. During the month of June, the safety and radiation protection authorities of the Scandinavian countries detected various artificial radionuclides in the atmosphere (cobalt-60, cesium-134, cesium-137 and ruthenium-103 in particular). This increase was also detected by the Comprehensive Nuclear-Test-Ban Treaty Organization. The measurements made by the stations of the OPERA-AIR network in the north of France did not reveal the presence of radionuclides linked to this episode. Using data provided by Météo-France and measurement results available in Europe, the Institute carried out simulations

to locate the release zone and to evaluate the quantity of radionuclides released. The most plausible area of release is in a territory covering part of the Baltic States and western Russia, although it is not possible to specify the exact location of the release point. Concerning the cause of the release, IRSN shared the IAEA's analysis of an origin probably linked to a reactor in operation or shut down for maintenance. The Institute indeed noted a significant activity of cobalt-60, an "activation product" that forms in the core of nuclear reactors. The other radionuclides measured and their relative proportions correspond to irradiated nuclear fuel whose irradiation would have ended several months ago.



.....AT A GLANCE.

#### PROVIDING MEDICAL CARE

As part of an IAEA mission carried out at the request of the Peruvian authorities, IRSN experts took action to manage the medical care of a Peruvian patient following overexposure during an interventional radiology procedure. Their work alongside the local medical teams made it possible to make a diagnosis and propose the most appropriate treatment.

#### Lebanon

Following the explosion in the port of Beirut on August 4, 2020, the Lebanese government requested the assistance of the IAEA, through its assistance network, RANET. As the explosion may have led to loss of integrity among the medical or industrial radioactive sources, the Lebanese authorities required expert assistance to carry out a radiological characterization of several sites in Beirut and to conduct radiological measurements of several environmental samples (soil, sea water, building materials) taken in Beirut. In collaboration with the MEAE and the CEA/DRI, IRSN drew up a response to this request for assistance, which was submitted by the ASN to the IAEA. The proposal for assistance from France, involving participation of IRSN experts in the field mission and the measurement of samples in the Institute's laboratories was accepted by the Agency and approved by the Lebanese government. The IAEA mission visited Beirut from September 11 to 18, 2020. In addition to the IAEA coordinators, it included two experts from IRSN and two Danish experts. The mission was able to carry out the radiological characterization of several conventional waste storage sites and to check the integrity of equipment containing radioactive sources in two hospitals and some industrial facilities. Samples were subjected to radiological measurements in IRSN's metrology laboratories, the results of which were communicated as soon as they were obtained to the IAEA and the Lebanese authorities: the samples measured did not show any abnormal level of radioactivity.







29

... SOFTWARE PROGRAMS  
AND DATABASES REGISTERED  
WITH APP, THE AGENCY  
FOR THE PROTECTION  
OF PROGRAMS (INCLUDING  
7 CO-OWNED)

IRSN

05

Transformation





# 2

2020 turned out to be a pivotal year in IRSN's transformation process, with the ambitions arising from the IRSN 2030 project necessarily tied in with the adaptations linked to the Covid-19 health crisis.

This particular context also marks the first effective year of transformation of the Institute, in particular for developing its broader appeal and for maintaining the skills necessary to carry out its expert assessment and research missions.

As the cornerstone of this development, the transformation department that has been created to this end has set itself the target of enhancing both the Institute's attractiveness as an institution and its performance and efficiency in meeting the challenges of nuclear safety and radiation protection.

This is the spirit in which four transformation programs have been launched in the areas of digital technology, management, organization and collaboration modes, and CSR\*. In addition, in order to accelerate and test these programs in innovative ways, the Institute has created the IRSN Lab, a multidisciplinary innovation laboratory for the benefit of all employees.

Indeed, the health crisis has forced a change in how we think about how work is done day to day at the Institute. The transition from a face-to-face collaboration mode to an environment where a large part of the activity is done remotely, while modifying how we monitor work performance daily, has promoted accountability and greater cross-functionality, aided by the general availability of digital collaborative work tools. This has also reinforced the objective of developing a project mode of operation, and exchanges between user communities.

In addition, protecting employees from contracting COVID, in particular through the widespread use of teleworking, has necessitated a digital transformation effort, enabling the institution as a whole to be made mobile while maintaining the very high level of IT security inherent, for example, in safety assessment activities.

In 2020, IRSN's data management strategy was given a boost with the implementation of a data policy and the creation of a Chief Data Officer post with responsibility for orchestrating, in particular, artificial intelligence and augmented expert assessment projects designed to increase the efficiency of the work performed by the Institute's experts.

To summarize, 2020 has seen the gradual implementation of a transformation dynamic designed to make it easier for the Institute to pursue constant development, with flexibility, and to adapt to its context, by encouraging initiatives and experimentation.

\* Corporate Social Responsibility



# Relations with society

.....AT A GLANCE.....

## NUCLEAR ENGINEERING VOCABULARY

On September 2, 2020, 16 lists of some thirty terms were published in the Journal Officiel, as proposed by the "nuclear energy" college of the French language enrichment body, which includes two IRSN experts.

## The main trends of the IRSN 2020 Barometer

Published in June 2020, the IRSN Barometer on how the French population perceives risks and safety concerns provides a snapshot of the population's stance with regard to risks and the trust they place in the public authorities to manage these risks. This 2020 edition is based on a survey of 1,000 people conducted in late 2019. At that time, people were mainly concerned by poverty and exclusion, followed by climate change and terrorism, with increasing prominence accorded to "global geopolitical instability." Regarding industrial facilities, the Barometer did not record any changes following the fire at the Lubrizol plant in Rouen in September 2019: chemical facilities remained stable (18%), in third place behind nuclear power plants (33%) and radioactive waste storage (20%). What is more, the confidence of the French population in science and expertise is still high, and access to transparent and quality information is something most people are in favor of.

Since the field survey was conducted prior to the Covid-19 crisis, IRSN included questions from the Barometer in an "omnibus" survey of 1,000 people conducted in May 2020. The results show that the opinion that the French have of experts remains high but is declining: 44% have a "high opinion", against 55% "average". In addition, the risk attributed to virus research laboratories has increased significantly, placing them behind nuclear power plants, radioactive waste storage facilities and chemical facilities.

## Significant progress in opening up to society

An IRSN priority for several years now, openness to society has been supported since 2009 by a Charter that reflects the Institute's desire to meet the need for transparency and society's desire for dialogue with experts. 10 years after adopting this Charter, this has led to lasting and productive contact between the Institute and civil society.

These exchanges are reflected, for example, in the Institute's response to regular requests from local information commissions and associations, enabling it to share its knowledge on nuclear safety, environmental monitoring, and the health of the populace and of workers. By the same token, the publication of its notices and reports on the Internet and access to the scientific articles it publishes also illustrate its desire for transparency in nuclear and radiological risk management. In return, citizen involvement enriches expertise and research by providing multiple points of view.

In response to a growing demand from civil society to be involved in risk assessment, particularly at local level, the technical dialogues have evolved significantly, in partnership with ANCCLI. The 4<sup>th</sup> periodic review of 900 MWe reactors and the storage of radioactive waste are the most recent examples of this. The same is true of pluralistic territorial initiatives, particularly concerning the management of the radon risk. Lastly, participatory science projects are being developed, an example of which involves the measurement of radioactivity in the environment (OpenRadiation project).

.....AT A GLANCE.....

## PARTICIPATIVE SCIENCE

The first meeting of the OpenRadiation community took place in Paris on January 13, 2020.

It brought together 80 citizens involved in this open science project (open source and open data). Directly prompted by the Fukushima-Daiichi nuclear accident, OpenRadiation involves citizens from all over the world in measuring radioactivity in the environment.



**FIND OUT MORE**  
[www.openradiation.org](http://www.openradiation.org)



# Optimizing the Institute's resources

## Towards a new European and international affairs department for IRSN

IRSN has long been involved in scientific and technical cooperation in the fields of expertise and research in nuclear safety and radiation protection with numerous partners around the world. In addition, the Institute provides services for the benefit of a number of partners, in particular within the framework of funding set up via the European Instrument for Nuclear Safety Cooperation (INSC).

In order to underpin the overall management of its institutional actions and services, in 2020 the Institute initiated a process of reflection aimed at fostering internal synergies and disseminating its know-how more effectively so as to improve nuclear safety worldwide and, in particular, in countries on Europe's doorstep. This reflection has led to the creation, as of January 1, 2021, of the European and International Affairs Department, which will be responsible for implementing the Institute's global strategy both within the European field of influence and with regard to bilateral relations and cooperation with the relevant multilateral organizations.

## IRSN maps its corporate risks

Both as an ISO 9001-V2015-certified organization and under its Contract of Objectives and Performance (COP 2019-2023), IRSN has incorporated corporate risk management into its quality management system. Quality management is structured around 15 processes that cover all of its operational, functional and support activities.



The risks to be prevented relate to various areas such as human resources management, project management, compliance with financial and accounting rules, compliance of facilities, ethics and codes of conduct, and information systems security. They also concern business continuity, which has been particularly relevant in 2020.

In order to implement the appropriate control measures, in 2020 the Institute mapped the risks associated with its activity - with a shared vision of their causes and consequences - and established a rating in terms of severity, probability of occurrence, and effectiveness of the existing control measures. This process identified 33 risks to be managed within the Institute, including 12 "major" risks, presented to the Board of Directors. Requiring monitoring by executive management, these risks are the subject of an annual indicator in the 2019-2023 State-IRSN Performance Target Agreement.

AT A GLANCE

### OPERATIONAL CONTINUITY OF THE CSE DURING THE HEALTH CRISIS

The health crisis did not interrupt the functioning of the CSE (Social and Economic Committee). On the contrary, its activity intensified, with the CSE meeting 21 times (instead of the usual 11) in 2020. It quickly set itself up in remote operation to continue carrying out all its missions during the lockdown period, and in particular to participate in the deployment of business recovery and continuity plans. It did of course also deal with all the non-health-crisis topics that were still relevant. Created in December 2019, the CSE and its sub-committees have successfully taken over the missions that used to be the province of the Works Committee.



### **Development of the human resources management policy**

Among its strategic orientations, IRSN has undertaken to review its strategic workforce planning (GPEC) mechanisms, in particular to better attract and retain new employees, and to reorientate its employment policy in favor of young people while offering incentives for employees to take retirement. These objectives are manifested by the following:

- The launch of the Tra-G project, a large-scale cross-functional project that will run over three years and which includes several work packages, all related to GPEC tools. Tra-G mobilizes, for these different task areas, within thematic working groups, a wide spectrum of the Institute's skills set, from information systems to human resources management, and including operatives and skills management. The main projects initiated in 2020 include the reconstruction of a jobs and skills repository, jobs evaluation, and the overhaul of the annual and professional interview. In addition, the development of the "employer brand" through the deployment of a recruitment task force enabled the Institute to improve its results in 2020.
- The signing, in March 2020, of a unanimous agreement on the transmission and renewal of skills, which provides for an increase in retirement benefits for employees born in or before 1961, provided they undertake to retire between the ages of 62 and 64. In parallel, the Institute is committed to strengthening its policy of recruiting young engineers and researchers and boosting the number of work-study students.

### **Streamlining the real estate assets**

IRSN's second long-term property strategy was approved, on March 5, 2020, by its Board of Directors. Its priority is to streamline IRSN's real estate holdings, in particular by reducing the amount of tertiary space and pooling the spaces dedicated to scientific activities at the Fontenay-aux-Roses (Hauts-de-Seine) and Cadarache (Bouches-du-Rhône) sites. The strategy also aims to improve the management of the Institute's real estate holdings through sustainable development and technological development initiatives, and to improve the quality of life in the workplace.

As part of the implementation of this strategy, in October IRSN responded to the call for projects for funding renovation work on the real estate holdings of the French State. This led to a series of operations to improve the energy performance of buildings at the Cadarache, Fontenay-aux-Roses, Orsay (Essonne) and Le Vésinet (Yvelines) sites being selected. Furthermore, a project to construct a large building on the Cadarache site will make it possible to bring together under one roof all the scientific, technical and administrative service activities currently scattered across thirteen buildings on the site. These operations, financed by the government's stimulus plan, will begin in early 2021.

### **Making optimum use of the scientific and technical platforms**

In July 2019, IRSN created a department in charge of optimizing the use of its scientific and technical platforms. Its mission is to take stock of facilities and equipment, to support units in constructing projects, and to promote access to the platforms. In the first year, the platforms were mapped and a project was conceived for sharing the map with users (internal, partners, customers, prospects). Several 3D virtual tours (Tournemire station, etc.) were conducted and an IRSN Scientific Platforms Day was organized in October on the subject of ion probes, bringing together some sixty participants for a webinar.

Two projects were also supported in 2020. Submitted in December 2020 for a call for generic projects from the ANR and involving three partners (the University of Aix-Marseille, the Sartorius company and IRSN), the objective of the first project - DESIRELESS - is to study the degradation of polymer materials by irradiation. The second project is an agreement, signed in October 2020 with the GEOPS laboratory (UPS), for promoting scientific collaborations, pooling equipment, and responding to shared calls for projects.



# Digital transformation

..... AT A GLANCE .....

## OPTIMIZING DATA USE

In 2020, IRSN created the post of Chief Data Officer. This new post ties in with the Institute's strategy, in compliance with the data protection requirements, to make best use of its data through organizing data in such a way as to be able to identify, collect, exploit, and leverage the data.

## PIREX, a new step towards augmented expertise

Conceived as a "decision-making aid" for processing significant events reported by French nuclear operators, the PIREX platform is part of IRSN's digital transformation and, in particular, of its "augmented expertise" initiatives. It is endowed with artificial intelligence algorithms and data-visualization principles enabling us to envisage new practices regarding the processing of feedback at the Institute. Winner of the 2019 call for projects from the Fund for the Transformation of Public Action (FTAP), PIREX was deployed in 2020 within IRSN and will gradually be made available to ASN, to operators, and then to civil society, to support extensive sharing of lessons learned from feedback. Thanks to the platform, IRSN will occupy an even more central role in the feedback processing ecosystem.

## Development of a national portal based on SISERI

The project for a national portal for monitoring worker exposure to ionizing radiation was selected in July 2020 by the FTAP. Submitted jointly by the DGT and IRSN, it addresses the government's priorities for modernization and simplification, in particular by allowing greater transparency of data and better traceability of workers' exposure.

The project is based on the overhaul of SISERI, the information system for monitoring the dosimetry of workers exposed to ionizing radiation, which is managed by IRSN. The project should enable optimization of the mechanism by minimizing the need to consolidate data from different sources. Ultimately, SISERI will be the one-stop-shop for information and data consultation for those involved in monitoring the exposure of workers to ionizing radiation: workers themselves, employers, occupational health services, measurement organizations and laboratories, works inspectorate, IRSN. To offer a portal as closely aligned as possible to the needs of these stakeholders, the project is part of a user-centric approach, with the support of the IRSN Lab, an innovation platform launched in 2020 that makes it possible to experiment with new methods for finding solutions to organizational, scientific and technical, or societal problems.

As well as offering interoperability with related State or private operator information systems, 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. With this in mind, the Institute is currently developing a prototype as part of a call for expression of interest financed by the DITP (interministerial directorate for public transformation).



..... AT A GLANCE .....

## COLLABORATIVE

The digital transformation program adopted in 2019 was continued in 2020, with a particular focus on actions related to the development of collaborative tools and a digital and roaming work environment. Initially planned to promote teleworking, these actions, initiated before the pandemic, became a priority with the first lockdown linked to the health crisis. Employees adapted quickly to these measures, heralding more profound changes in how work is organized, with, for example, remote meetings being favored in preference to travelling physically around sites. In addition to providing mobile tools for employees, the program has also seen the evolution of the information system, with the storage of data in the Cloud, to ensure connectivity, flexibility, and innovation.

# Managerial transformation

IRSN is obliged to adapt to a societal environment that has undergone profound changes in recent years, both in terms of professional practices, with the advent of digital technology and home working, and in terms of how we relate to work, with the growing importance attached by employees to the quality of life in the workplace.

In this context, IRSN has embarked on a managerial transformation program to involve managers in these changes and in the transformations required for the Institute to function properly, transformations that are also essential in terms of attracting people to IRSN and keeping them there. This program is based on a governance structure that includes the human capital department, the knowledge and skills management department, the IRSN innovation laboratory (see below), the TIM, a think-tank created in mid-2019 that brings together managers with pioneering ideas about new

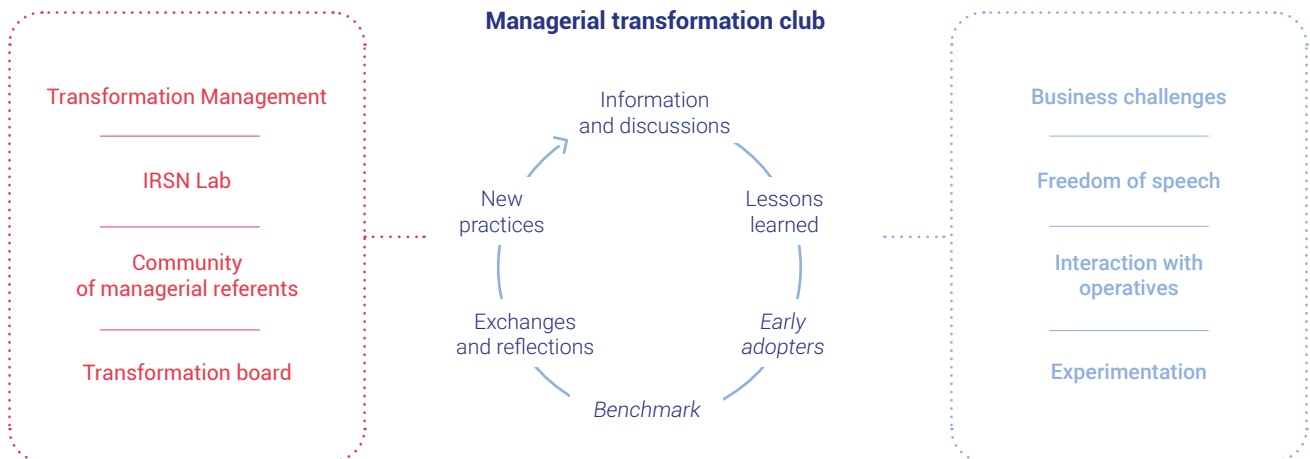
management methods, and the managerial transformation board, created in mid-2020, a circle of high-level managers. The program is based on the principle of collective intelligence, innovation, and experimentation.

By way of example, work has been undertaken on career paths, mentoring, and management principles, involving not only managers but also employees from all IRSN units, executives and non-executives, managers and non-managers. A process for sharing practices has also been initiated, which in September enabled the IRSN Staff Committee (CEM) to discuss their experience of managerial transformation with the managers of "La Française des Jeux".

Finally, in November, the first seminar on managerial transformation brought together all of the Institute's managerial staff, remotely, to discuss these issues.

## Transformation of the managerial model via collective intelligence

A continuous process centering the end-user at the heart of our considerations and encouraging the emergence of new ideas and approaches.



# Transformation through the development of new collaborative work methods

As part of its IRSN 2030 strategy, IRSN is committed to developing new modes of collaboration based on knowledge sharing, collective intelligence, and experimentation, in order to deploy new ways of working together. This approach, which is reliant on all the men and women of the Institute, aims to advance the IRSN corporate culture towards an organization more open to learning, by reinforcing its agility and performance in a changing environment. This is manifested by actions designed to develop:

- project management, practitioner communities;
- methods of collective intelligence;
- new associated skills (cross-functional management, collaborative facilitation, etc.) and a project management business line;
- knowledge-sharing tools;
- multi-purpose collaborative spaces (redesign of the "SESHAT project" library, in-house university training rooms, etc.).

Hence, for example, in order to develop project management, a multi-stakeholder workshop in 2020 led to the production of a prototype "project manager kit" (training course, reference framework, project management tools, a dedicated practitioner community). This kit will be enhanced as the testing progresses.



In order to adapt to the health crisis, the development of skills has focused on digital learning and remote collaborative modes of operation and interaction (e-learning, webinars, virtual classrooms, etc.) and the deployment of TALENTSOFT FORMATION (a new interactive platform for ongoing professional training that includes digital training).

## Transforming IRSN via innovation

With IRSN Lab we aim to accelerate the Institute's transformation through innovation. Created as part of the IRSN 2030 strategic project, IRSN Lab is an innovation platform for experimenting with new methods for finding solutions to organizational, scientific, technical or societal challenges. Launched in 2020, some of the workshop work was conducted remotely. IRSN Lab can draw on a team consisting of a manager and facilitators called upon as needed, surrounded by a first circle of employees who are particularly involved in the Institute's transformation through innovation process. IRSN Lab has dedicated spaces designed to stimulate team creativity.

The methods for finding solutions are user-oriented. It is about identifying user expectations so that the users themselves appropriate the proposed solutions. Numerous work topics are being studied: internal organization, the role of the citizen in the face of radon risk, project management, the production of prototype measuring devices, etc.

06

# Corporate social responsibility







**B**acked by the IRSN 2030 strategic approach, and encouraged by the Ministry of Ecological Transition through the Eco-responsible Public Services approach and, more generally, by the sustainable development objectives set by France for 2030, the Institute's CSR approach was underpinned in 2020 with methods particularly suited to the health context.

This approach is structured around a CSR policy signed off in 2020 that focuses on four areas:

- an institute committed to the protection of all;
- a mission and actions to benefit the environment;
- a requirement for excellence and responsibility;
- active involvement in the evolution of society.

The first actions to be defined prefigure the CSR roadmap planned for 2021.

#### **Governance for involving the entire Institute**

The CSR governance within IRSN was developed for implementation of the first actions in 2020.

It is supported by two bodies: the Directors' Circle and the CSR Council.

The CSR Council is made up of some fifty employees of the Institute, all volunteers.

In the context of the pandemic, the Directors' Circle and the CSR Council have actively contributed to IRSN's CSR actions. For example, in 2020, a Biodiversity and Business approach was initiated and, as part of the European Sustainable Development Week, practical data sheets on eco-responsible actions were also distributed.

#### **Ethical and professional conduct requirements**

In accordance with the cross-functional principles of the ISO 26000 standard on corporate social responsibility, the Institute pays particular attention to the requirements of ethics and the code of conduct. This attention is also reflected in the Performance Target Agreement (COP) 2019-2023 and, as such, is monitored annually. Among the actions carried out in 2020, the publication on the IRSN website of the Ethics Commission's 2016-2019 activity report illustrates this commitment and the accompanying requirement for transparency.



# Achievements in 2020

## AN INSTITUTE COMMITTED TO THE PROTECTION OF ALL

### Supporting temporary teleworking

Protective measures related to the pandemic have led to a mass recourse to teleworking for the Institute's employees. While the development of teleworking had already been identified as a topic in the Institute's CSR considerations, its accelerated deployment has led to the drafting of a recommendations guide to help employees in a teleworking situation to adapt to this new environment. Alongside this, a guide for managers has also been distributed to support them in this new mode of remote operation and interaction. A toll-free number has been set up to respond to employees' specific situational needs.

### Guiding employees with long-term illness issues

As an extension of its commitment to the "Cancer and Employment" charter launched by INCa, IRSN has initiated a more comprehensive approach to the care of employees with long-term or chronic illnesses. The aim is to identify innovative ways of keeping people with long-term or chronic illnesses in work, or getting them back to work. The avenues identified to date have been collated in a guide containing all the information on the assistance and support offered within the Institute, and identifying the contacts or representatives best able to support employees depending on their situation.

## A MISSION AND ACTIONS TO BENEFIT THE ENVIRONMENT

### Participation in European Sustainable Development Week

IRSN took part in European Sustainable Development Week, which exceptionally took place from September 18 to October 8, 2020, to promote sustainable development and raise awareness of the issues surrounding CSR. Daily events were proposed via the website: videos, Teams conferences, practical information sheets, reports on mobilization topics championed by the IRSN CSR team. Several themes were addressed, such as biodiversity, the circular economy, and digital sobriety. In particular, the first awareness campaign on digital sobriety was launched to encourage employees to optimize their individual storage space. This CSR criterion was taken into account in the profit-sharing scheme.

Lastly, the actions of associations acting for the benefit of sustainable development, in proximity to the Institute's sites, were highlighted.

### Biodiversity and business

In contributing to well-being in the workplace and being inextricably linked to ecological issues, the environment of the IRSN sites has been the focus of the "Biodiversity and Business" steering committee and workshops set up in 2020, notably at the Fontenay-aux-Roses site.

Here, a site diagnostic, the reappropriation of the environment for the benefit of pedestrians, and improvements to the biodiversity have led to action projects such as the creation of a shared garden or wildlife refuge areas for biodiversity. Other similar workshops are planned for the Cadarache and Le Vésinet sites.



## A REQUIREMENT FOR EXCELLENCE AND RESPONSIBILITY

### An approach to economy and responsibility

The "Responsible Spending" project aims to analyze certain internal practices at the Institute in order to optimize IRSN's running costs, in particular by taking ecological criteria into account. Working groups were formed in March 2020 on topics such as business travel, energy consumption by buildings, press and scientific subscriptions, and the equipment for scientific programs.

### A common charter for openness to society

Expressing their shared desire for constructive and fruitful dialogue with citizens, IRSN and seven other public bodies signed a charter for openness to society in November 2020. Through their joint commitment to this charter these eight signatories - Anses, BRGM, Ifremer, Ineris, Inrae, IRSN, Gustave Eiffel University and Santé publique France - testify to their joint ambition: to provide better understanding of risks and of the means to prevent and mitigate them. They all undertake to deploy specific and lasting mechanisms to encourage dialogue with society by way of three priorities: supporting society's stakeholders in acquiring skills, sharing the available scientific knowledge, and making their work more transparent.

## ACTIVE INVOLVEMENT IN THE EVOLUTION OF SOCIETY

### Launch of a "circular economy" approach

Identified as a priority during discussions on CSR and the optimization of the Institute's resources, a voluntary approach to the circular economy was launched during European Sustainable Development Week by way of two tools: an exchange platform called Océane, initially reserved for the Institute's scientific and technical equipment, and the use of which has now been extended to small equipment and consumables; and the governmental platform designed to simplify the donation process.



# Members of the senior management committee







- ① **Jean-Christophe NIEL**, director general
- ② **Louis-Michel GUILLAUME**, deputy director general for defense missions, in charge of the defense, security and non-proliferation division
- ③ **Jean-Bernard CHÉRIÉ**, deputy director general in charge of the assets and real estate division
- ④ **Karine HERVIOU**, deputy director general in charge of the nuclear safety division
- ⑤ **Jean-Christophe GARIEL**, deputy director general in charge of the health and environment division
- ⑥ **Sylvie SUPERVIL**, director for risks and performance
- ⑦ **Michel ENAULT**, director for transformation
- ⑧ **Patrice BUESO**, director for strategy
- ⑨ **Cyril PINEL**, director for international affairs
- ⑩ **Marie RIET-HUCHELOUP**, director of communications
- ⑪ **Florence BRAVACCINI**, general secretary
- ⑫ **Philippe DUBIAU**, executive director for emergency response reporting to the director general



- **BOARD OF DIRECTORS  
AS OF FEBRUARY 1, 2021**

**Responsibilities**

The Board of Directors, through its deliberations, rules on matters of IRSN's governance. This includes the general conditions governing the Institute's organization and operation, its strategy and program, and its annual report.

It also approves the budget, amending budgets, year-end financial statements and income appropriation.

- **A member of Parliament**

**Perrine GOULET**,  
deputy, Nièvre department

- **A senator**

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

- **Ten government representatives**

**Christian DUGUÉ**,  
nuclear security inspector of the General Directorate of Armaments, representing the Minister of Defense

**Representing the Minister  
for the Environment**

pending nomination

**Joëlle CARMES**,

deputy Director of Environmental and Food Risk Prevention at the French Directorate General for Health, representing the Minister for Health

**Aurélien LOUIS**,

deputy Director for the Nuclear Industry, Directorate General for Energy and Climate, representing the Minister for Energy

**Frédéric RAVEL**,

scientific Director of the Energy, Sustainable Development, Chemistry and Process Department of the Directorate General for Research and Innovation, representing the Minister for Research

**A representant of the Minister for Civil  
Protection**

pending nomination

**Frédéric TÉZÉ**,

deputy Director for Working Conditions, Health and Safety, Directorate General for Labor, representing the Minister for Labor

**Alicia SAOUDI**,

deputy Head of the Energy, Profit-sharing, Industry and Innovation Office at the Budget Directorate, representing the Minister for the Budget

**Alain GUILLEMETTE**,

representative in charge of Nuclear Safety and Radiation Protection for Defense-related Activities and Facilities

**Bernard DOROSZCZUK**,

chairman of the French Nuclear Safety Authority (ASN)

- **Five advisory members**

**Michel FRITSCH**,

Air Force Brigadier General, nominated by the Minister for Defense

**Ginette VASTEL**,

state Doctor of Pharmacology, nominated by the Minister for the Environment

**Marie-France BELLIN**,

chair of IRSN Board of Directors, Professor of Medicine in Diagnostic and Interventional Radiology at Bicêtre and Pierre-Brousse Hospitals, nominated by the Minister for Health

**Laurent MOCHÉ**,

CEO of Edenkia, nominated by the Minister for Energy

**Fanny FARGET**,

director of Scientific Research at the French National Center for Scientific Research (CNRS), nominated by the Minister for Research

- **Eight staff representatives**

**Nicolas BRISSON**,  
CGT

**Laurence FRANÇOIS**,  
CGT

**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 of Risk Prevention and Government Commissioner

**Jean-Pascal CODINE**,  
budget Comptroller

**Jean-Christophe NIEL**,  
director General

**Louis-Michel GUILLAUME**,  
deputy Director General in charge of Defense-related Missions

**Isabelle FLORY**,  
accounting Officer

**Cédric GOMEZ**,  
secretary, Social and Economic Committee

• **STEERING COMMITTEE FOR THE NUCLEAR DEFENSE EXPERTISE DIVISION (CODEND) AS OF FEBRUARY 1, 2021**

**Responsibilities**

The steering committee examines the activity program prepared by the Nuclear Defense Expertise Division (DEND) before it is submitted to the IRSN Board of Directors. It is consulted when the Board of Directors is called upon to make decisions relating specifically to the organization or running of this division and advises the Board of Directors on matters related to division activities.

**Alain GUILLEMETTE,**  
CODEND Chairman, Representative in charge of Nuclear Safety and Radiation Protection for Defense-related Activities and Facilities

**Nicolas LEVERRIER,**  
air brigade general, representative of the army chief of staff

**Marc VÉRAN,**  
rear Admiral, representing the Armed Forces Chief of Staff

**Christian DUGUÉ,**  
nuclear security inspector of the General Directorate of Armaments, representing the Minister of Defense

**Franck MOLLARD,**  
colonel, Chief of Staff of the Secretary General for Administration, representing the Secretary General for Administration of the Ministry of Defense

**Alicia SAOUDI,**  
deputy Head of the Energy, Profit-sharing, Industry and Innovation Office at the Budget Directorate, representing the Minister for the Budget

**François COTTEL,**  
representing the Director of Strategic Affairs, Security and Disarmament at the Ministry of Foreign and European Affairs

**Christian DUFOUR,**  
head of the Economic and Nuclear Infrastructure Security Department, representing the Senior Defense and Security Official of the Ministry of the Economy and Finance

**Mario PAIN,**  
deputy Senior Defense Official, Head of the Department of Defense, Security and Economic Intelligence, representing the Senior Defense and Security Official at the Ministry of Ecological Transition

**Serge POULARD,**  
advisory member, appointed by the Minister for Industry

• **SCIENTIFIC COUNCIL AS OF FEBRUARY 1, 2021**

**Responsibilities**

The Scientific Council examines and gives its opinion on IRSN activity programs and ensures that its research programs are scientifically relevant and of the highest quality. It examines program results in order to prepare recommendations on Institute strategy. It may be consulted by the Board's chairperson or by the supervisory ministers on any subject that comes under the Institute's authority.

**The list of new members of the Scientific Council will be formalized in 2021, at the end of the ongoing renewal process**

• **ETHICS COMMISSION AS OF FEBRUARY 1, 2021**

**Responsibilities**

Mentioned in the decree organizing the IRSN, the Ethics Commission reports to the Board of Directors and is responsible for advising it on preparing ethical charters that are applicable to the Institute's activities and for monitoring their application, including conditions at the Institute for distinguishing between assessment missions performed on behalf of government departments and those performed for public or private operators. It also serves as a mediator when problems of an ethical nature arise.

**Françoise ROURE,**  
inspector General and Chair of the Security, Safety and Risk Section of the General Council on Economy, Industry, Energy and Technology

**Lionel BOURDON,**  
senior Chief Medical Officer and Associate Professor at Val-de-Grâce. Retired. Most recent position: Scientific Director of the French Armed Forces Biomedical Research Institute (IRBA)

**Marc CLÉMENT,**  
president of Chamber at the Administrative Court in Lyon, member of the Environmental Authority of the General Council for the Environment and Sustainable Development. Member of the Implementation Committee of the Aarhus Convention (United Nations)



**Alexandra LANGLAIS,**

CNRS Research Officer in environmental law, CNRS bronze medalist.  
Head of the Environment Section of the Western Institute of Law and Europe (IODE).  
Author of works of research and investigation on laws concerning waste, soil, water law, also member of the GDR NoST (Standards-science and technology research network)

**Mauricette STEINFELDER,**

inspector General, member of the General Council for the Environment and Sustainable Development and the Environmental Authority, retired. Member of the Scientific Council of the Environmental Data and Statistical Studies Department

**Éric VINDIMIAN,**

engineer General in rural engineering, water and forests, specialist in the impact of toxic substances on the environment and health and assessment of public environmental policies, member of the Environmental Authority and Coordinator of the Research and Technology Commission of the General Council for the Environment and Sustainable Development

• **NUCLEAR SAFETY AND RADIATION PROTECTION RESEARCH POLICY COMMITTEE (COR)  
AS OF FEBRUARY 1, 2021**

**Responsibilities**

**An advisory body to IRSN Board of Directors, the Research Policy Committee provides opinions on research objectives and priorities in 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, which focuses on the quality and relevance of the Institute's research programs and outcomes from a scientific perspective.**

• **Public authorities****Supervisory ministry representatives****Sylvain ROTILLON,**

head of the Environmental Sciences and Society Governance Mission, Research Department, Directorate for Research and Innovation, representing the Ministry for Ecological Transition

**François-Xavier GOMBEAUD,**

nuclear Safety Inspector for the DGA, the French defense procurement agency, representing the Ministry of Defense

**Fabrice LEGENDRE,**

task Officer at the Policy and Supervisory Office, Directorate General for Energy and Climate, representing the Ministry for Ecological Transition

**Representative of the Labor Directorate****Hervé VISSEAUX,**

head of the Physical Risk Prevention Unit, Directorate General for Labor

**Representative of the French Nuclear Safety Authority****Bastien POUBEAU,**

chief of Staff to the Director General of ASN

• **Companies and professional associations****Manuel CARRASCO,**

deputy director of the technical department (EDF)

**Bernard LE GUEN,**

chair of the French Society for Radiation Protection (SFRP)

**Bertrand MOREL,**

research and Development Director, representing Orano

**Jean-Marc SIMON,**

associate Professor, practitioner in the Radiation Oncology Department at the Pitié-Salpêtrière Hospital

**Sébastien CROMBEZ,**

Director of Safety, Environment and Sector Strategy at Andra

• **Employees in the nuclear sector****Representatives of national labor 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,

deputy of Maine-et-Loire and one nomination pending

#### Local information commissions (CLI) representative

nomination pending

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

##### Bertrand RINGOT,

Mayor of Gravelines

### • Associations

##### Jean-Paul LACOTE,

representing France Nature Environnement

##### Simon SCHRAUB,

administrator of the Ligue nationale contre le cancer

##### Lionel LARQUE,

Head of the Alliance for Science and Society (Alliss)

### • Advisory members

##### Jean-Claude DELALONDE,

chair of the French Association of Local Information Committees and Commissions (Anccli)

##### Christine NOIVILLE,

chair of the High Committee for Transparency and Information on Nuclear Safety (HCTISN)

##### Marie-France BELLIN,

chair of IRSN Board of Directors, Professor of Medicine and Medical Practitioner in Diagnostic and Interventional Radiology at Bicêtre-Pierre-Brousse Hospitals

### • Research organizations

##### Philippe STOHR,

director of Nuclear Energy, representing CEA

##### Cyril THIEFFRY,

task Officer for Radiation Protection and Nuclear Affairs, IN2P3, representing CNRS

#### Representing Inserm

pending nomination

##### Étienne AUGÉ,

professor of Physics, Vice President of Paris-Sud, representing the French Conference of University Presidents (CPU)

##### Vincent LAFLÈCHE,

director of ParisTech, representing ParisTech

### • Foreign members

##### Christophe BADIE,

environmental Assessments Department, Public Health England, United Kingdom

##### Ted LAZO,

nuclear Energy Agency (NEA), OECD

### • Ex officio members

##### Patrick LANDAIS,

high Commissioner for Atomic Energy

##### Cédric BOURILLET,

Government Commissioner, represented by:

##### Benoît BETTINELLI,

Head of the Nuclear Safety and Radiation Protection Mission, Ministry for Ecological and Inclusive Transition

#### Chair of IRSN Scientific Council,

pending nomination

##### Jean-Christophe NIEL,

Director General of IRSN



## A

**ANCCLI** French National Association of Local Information Commissions and Committees

**ANDRA** French National Radioactive Waste Management Agency

**ANR** French National Research Agency

**ASN** French Nuclear Safety Authority

**ASND** French Nuclear Safety Authority for Defense-Related Facilities and Activities

## B

**BRGM** French Geological Survey

## C

**CABRI** CEA test reactor used by IRSN in experiments to study nuclear fuel safety

**CLI** Local Information Commission

**CODIRPA** French Post-accident Management Steering Committee

**COR** Nuclear Safety and Radiation Protection Research Policy Committee

**CRITICALITY (RISKS)** Risks associated with uncontrolled fission phenomena in fissile materials

**CSR** Corporate social responsibility

**CTE** Euratom Technical Committee

**CWC** Chemical Weapons Convention

## D

**DoE** US Department of Energy

**DOSIMETRY** Assessment or measurement of the dose of radiation (radioactivity) absorbed by a substance or an individual

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

## E

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

**EPIC** French industrial and commercial public undertaking

**EPR** Evolutionary Power Reactor (European pressurized water reactor)

**ETSON** European Technical Safety Organisations Network

**EURATOM** European Atomic Energy Community.

## G

**GPEC** Strategic workforce planning

## H

**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

**INB** Regulated nuclear facility

**INSC** Instrument for Nuclear Safety Cooperation – cooperation contract financed by the European Commission

## M

**MIRCOM** Ion microbeam used in the radiobiology of intra- and inter-cellular communications

**MOX** Mixture of plutonium oxide and uranium oxide – nuclear fuel

**MTES** Ministry for Ecological and Inclusive Transition

**MWe** Megawatt electric, unit of electric power produced

## N

**NEA** Nuclear Energy Agency of the Organisation for Economic Co-operation and Development (OECD)

## O

**ODOBA** Observatory for the durability of reinforced concrete structures. The program studies concrete pathologies and their consequences for nuclear structures

**OECD** Organisation for Economic Cooperation and Development

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

## P

**PIA/RSNR** French program of investment for the future/Research into nuclear safety and radiation protection

**PNGMDR** French National Radioactive Materials and Waste Management Program

## R

**RADIONUCLIDE** Radioactive isotope of an element

## S

**SFRP** French Society for Radiation Protection

**SISERI** Information system for monitoring exposure to ionizing radiation

**STEM** Source Term Evaluation and Mitigation - Program to learn more about the behavior of radioactive materials that could be released to the environment in the event of a fuel melt accident in a nuclear facility

## T

**TSO** Technical Safety Organization

## U

**U.S. NRC** United States Nuclear Regulatory Commission

APPROVED BY THE IRSN BOARD OF DIRECTORS ON FEBRUARY 25, 2021

Image obtained with the SX100 electron microprobe (CAMECA) by the IRSN Mechanics and Materials Experimentation Laboratory on a sample of a fuel cladding in zirconium alloy which has undergone steam oxidation at 1200° C to simulate a Loss Of Coolant Accident (LOCA). The image illustrates the diffusion of iron during accidental phase. The EPMA (Electron Probe MicroAnalysis) microprobe is a tool that uses a beam of focused electrons to bombard the surface of a sample and to collect the X-Ray photons emitted by the various elemental species of the sample. This technique makes it possible to determine the elemental composition of a material with a spatial resolution which is of the order of a micron.

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