

**IRSN**

INSTITUT  
DE RADIOPROTECTION  
ET DE SÛRETÉ NUCLÉAIRE

*Enhancing nuclear safety*

# ANNUAL REPORT 2016





# ENHANCING NUCLEAR SAFETY IN FRANCE AND INTERNATIONALLY

Further to Act N°2015-992 of August 17, 2015 on energy transition for green growth, the legislative part of the French Environment Code defines the missions of IRSN, the National Institute for Radiological Protection and Nuclear Safety, the public expert in nuclear and radiological risks, together with those of ASN, the French Nuclear Safety Authority, and of the local information commissions (CLI). Decree N°2016-283 of 10 March 2016 on IRSN, which implements the Act, places the organization under the joint supervision of the Ministry of the Environment, Energy, and the Sea, the Ministry of Education, Higher Education and Research, the Ministry of Social Affairs and Health, and the Ministry of Defense.

IRSN is the nation's public service expert in nuclear and radiation risks, and its activities cover all the related scientific and technical issues in France and in the international arena. Its work therefore concerns a wide range of complementary fields, including environmental monitoring, radiological emergency response, radiation protection and human health in normal and accident situations, prevention of major accidents, and safety and security relating to nuclear reactors, plants, laboratories, transportation, and waste.

It also carries out assessments in the nuclear defense field. In addition, IRSN contributes to government policy in nuclear safety, the protection of human health and the environment against ionizing radiation, and measures aimed at safeguarding nuclear materials, facilities and transportation operations against the risk of malicious acts. Within this context, it interacts with all the organizations concerned including public authorities, in particular nuclear safety and security authorities, local authorities, businesses, research organizations, and stakeholder associations.

## HUMAN RESOURCES

**1,770<sup>1</sup>**

**employees**, including many specialists, such as engineers, doctors, agronomists, veterinarians, technicians, experts and researchers, with 48 doctors or persons qualified to direct research. IRSN is also the place of work of: **73<sup>2</sup> doctorate students and 19<sup>2</sup> post-doctorate students**.

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## BUDGET

**287 €M**

**spent by IRSN in 2016:**

- **41.4% of budget devoted to research** excluding property projects and Feurs;
- **49% of budget allocated to technical support and public service missions** excluding property projects and Feurs.

1. This workforce consists of 1,627 persons on permanent contracts and 143 on fixed-term contracts (including 764 persons assigned to other organizations, but excluding 21 temporary assignments).

2. Expressed in full-time equivalent terms.

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**Dominique Le Guludec,**  
Chairperson of the IRSN Board of Directors

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As the new French President embarks on his first term of office, **we find ourselves confronted with social choices relating to energy and healthcare**, in the face of greater public expectations concerning protection against risks of various kinds, as reflected over the years in the IRSN Barometer. These choices and expectations call for investments both in human and financial terms that, given today's economic situation, give rise to concern among all those with responsibilities in risk governance, industry or action concerning civil society. But **what about public stakeholders and, in particular, IRSN, France's public service expert in risk assessment and control?**

Being optimistic is never easy, especially in the current economic climate. And yet, whether I look back over the past year, or ahead to the coming months, I do feel optimistic about the resources IRSN has been given to fulfill its missions.

#### **IRSN - reinforced and solid**

The French Act on energy transition for green growth of August 17, 2015, written into the Environmental Code, and then the Decree of March 10, 2016, provided a general view of the nuclear and radiological risk governance system, and specified IRSN's general missions within it.

## « IRSN WILL RISE TO THE CHALLENGE OF EXCELLENCE. »

**IRSN has seen its role within the overall nuclear safety system reinforced with regard to licensees and nuclear industry managers**, to ensure they effectively assume their responsibilities, to ASN, with its decision-making and regulatory authority, and to an increasingly watchful civil society.

In spite of cut-backs on government spending, IRSN has on the whole preserved its level of funding, and has even seen an increase in its human resources, reflecting the importance of its work. Although they have not been financed, **IRSN was granted 20 additional positions to deal with its growing work load, particularly regarding assessments**; this increased work load was recognized in the findings of an audit ordered by the government. Furthermore, a recent parliamentary amendment now allows industry to contribute more largely to IRSN's budget, another reason why we can look to the future with increased confidence.

In addition to these external factors that consolidate its situation, IRSN has strengthened its scientific and technical resources, starting with investments. These include property investments, with the new buildings at Le Vésinet and Fontenay-aux-Roses and, more importantly, investments in its experimental and research facilities, of which **no fewer than ten have brought about significant progress in the past three years**. To mention just some of these achievements:

- **Safety:** PEARL, a large-scale facility for studying damaged core behavior and associated cooling methods; PERSEE, a research facility focusing on filtering and dynamic containment performance; ODE, an experimental research facility concerned with monitoring and observing the behavior of concrete blocks subjected to accelerated aging conditions; and, last but not least, the CABRI experimental reactor, a major facility for research on nuclear fuel safety.
- **Radiation protection:** ALPHEE, a radiation therapy instrument for learning more about the effects of ionizing radiation on tissue; MIRCOM, an extension of IRSN's AMANDE nuclear accelerator, designed to explore the effects of ionizing radiation within cells; MICADO-LAB, which is used to study the effects

of gamma radiation on ecosystems, from mechanistic effects to transgenerational studies; and PARISII, a research facility for in vivo studies on the effects of internal contamination in various radionuclides.

Lastly - and perhaps most significantly - **IRSN's solidity owes much to the men and women in its teams**, and their constant level of skill and commitment, even if the economic situation has forced us to slow down the rate of wage increases, as is the case everywhere, and even if room remains for improvement in terms of efficiency.

### The road to renewal for the future

My optimism is also grounded in IRSN's capacity to take on the challenges of a fast-changing world. IRSN is already on the road to renewal, reconsidering its strategic choices, the way it works, and its system of management. **This ability to step back and call into question the way we work is essential if we are to stay in the race.**

Research is a particularly demanding area in this respect and IRSN must be capable of adapting to it. Biology is undergoing real conceptual and technical change; research is now conducted only through networks; information technology is having a huge impact on data. **Competition and expectations are increasing at the same time as recurring revenue drops**, and we must turn increasingly to EU and international programs for funding.

Investments and equipment are the tools we need to take us down the road to renewal, provided we use and share them to the best advantage, while drawing scientists from outside the organization. IRSN must raise the profile of its research activities both in France and within international networks, in particular by holding on to its strategic position in European radiation protection research. Although the assessment by HCERES in 2017 will be a gauge of this renewal initiative, the real challenge will be the five- or ten-year forecast in the fields of safety, biology, healthcare, and radiation protection.

### Two examples illustrate this trend:

Firstly, **IRSN devotes a great deal of energy to the European research area for radiation protection.** The success of the "Concert" joint programming initiative (1st call in 2016) and other significant events, such as the European Radiation Protection Research Weeks, are significant steps forward in this area. **IRSN is at the center of these developments; it must hold on to this advantage and ensure its growth.**

Secondly, **IRSN's commitment to opening up to society also reflects the need to develop initiatives that involve the public**, as it is the public that ultimately stands to benefit from our success in addressing challenges. The "Dialogues in Fukushima", initiated and managed by local civil society in Japan, but in which IRSN's contribution was immensely appreciated, demonstrate the recognition of IRSN's expertise in teaching, listening and adapting, whether in the context of technical discussions or exchanges with the local population.

The various points mentioned above in this overview, together with the other achievements you will discover in the report, justify my optimism concerning the current situation of a solid, reinforced IRSN. **We must now set out on the road to renewal with determination and the necessary foresight.** The Board of Directors will firmly support these initiatives, and I know that IRSN will rise to the challenge of excellence both in its assessment and research activities.





Jean-Christophe Niel,  
Directeur général

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Consolidated by the decree of March 10, 2016, IRSN is an organization with widely recognized expertise, an outstanding workforce and high-quality equipment, something I have noted for myself since I took up my position in April 2016.

The year 2016 also saw the reinforcement of the **French system for regulating civil nuclear activities**, which is the responsibility of two organizations: ASN, which is in charge of “sovereign” activities, and IRSN, which is in charge of research and assessment. **The regulations concerning IRSN have also emphasized the importance of research** and the involvement of all stakeholders in discussions within the Research Policy Committee on the direction of IRSN’s scientific work. The year ended on three positive notes for the future: a stable budget, increased human resources, and the adjustments to the contribution paid by nuclear licensees. These decisions reflected how important our supervisory authorities, the government and parliament consider our missions and the trust they place in us.

It is true that expectations are equal to this trust, especially regarding our ability to address the issues of nuclear and radiological risks. These issues concern two areas:

- Safety, security, and protection against ionizing radiation, which must be ensured at the highest level;
- The public’s growing need to understand and take part in decision-making on issues relating to health or environmental risks, a need reflected in international agreements.

Looking back over my first year as Director General, I am struck by the quality of IRSN’s research work, the great variety of its activities and, above all, the dedication of its teams to driving progress in nuclear safety and security and radiation protection. Our action in 2016 testifies to this and you will be able to find out more about it in this annual report, as well as the scientific and technical reports on our website that complement it.

However, I would first like to go back over some of the key events of the year that illustrate how IRSN’s strategy is deployed.

## « IRSN WILL HAVE MANY CHALLENGES TO FACE IN ITS FUTURE ACTIVITIES. »

Over the coming years, these issues will be extremely important, imposing on IRSN the need to be in a constant state of readiness to mobilize all of its assessment resources - at a time of public spending cuts - without compromising its research work, which is the guarantee of high-level expertise. IRSN must also continue its initiative to open up to civil society in all its activities, with a view to greater transparency and more stakeholder involvement.

With this in mind, I have launched an initiative to put IRSN’s action in perspective over the next ten years, and to take steps to rationalize its operation now.

### Deploying the scientific strategy

The first line of action for IRSN is to go on deploying its scientific strategy within a national and European framework by developing partnerships, in France and abroad, with its counterparts, academic research organizations and teams, and industry, while making sure to preserve its independence. This strategy will be part of French national research strategy as well as European research agendas. Many research programs saw considerable progress in 2016, and IRSN was involved in 22 projects in the fields of safety, health and waste, in response to the second call for projects under Europe’s H2020 framework program.

It continued its policy of developing experimental facilities to support this work.

For example, the MIRCOM ion microbeam facility, designed to explore the cellular and intra-cellular effects of ionizing radiation, reached a number of significant milestones.



In the field of nuclear safety, IRSN leads the European program on in-vessel corium retention in the event of a severe accident on a nuclear reactor. The seminar organized on this topic in Aix-en-Provence in June 2016 was attended by 120 people from 21 countries, representing 60 organizations, including from some large nations, such as China, Russia and the United States.

The year 2016 saw the official opening of some new experimental safety research facilities such as the ODE facility in Cadarache, designed to study the aging of concrete used in the construction of nuclear reactor containment buildings, and the PERSEE facility in Saclay for the study of radioactive gas purification, partially funded by the investment in the future program.

Another event in 2016 concerned the CABRI reactor, which achieved criticality for the first time since 2003, an essential step in preparing the first tests for studying nuclear fuel behavior following an accident involving the loss of control of the nuclear reaction. The tests, performed as part of an IRSN-led international program, are scheduled for early 2018.

### **Setting priorities to focus on the main issues of nuclear safety and security and protection against ionizing radiation.**

The second line of action is to work towards greater strategic consistency with the public authorities, while preserving the independence of IRSN's assessment work. In particular, this entails creating or strengthening a joint strategic program for assessment activities calling on IRSN resources in order to ensure technically unquestionable, operational support that is in proportion to needs.

A significant amount of work was completed in the field of national defense, with the "reactor safety committees" on the Suffren-class submarine program, the RES test reactor, and the examination of documentation on the cleanup and dismantling of CEA's secret regulated nuclear defense facilities.

In the field of security, IRSN devoted a considerable effort to its work for the Senior Defense and Security Official (HFDS) of the Ministry for the Ecological and Inclusive Transition, notably concerning the EPR.

Our dense relations with ASN generated some 600 technical notices and reports. As part of its initiative to ensure the most proportional response to risks, IRSN focused particularly on the nuclear safety issues involved in extending the service life of EDF reactors, the safety review of existing facilities, new builds (including EPR, RJH and Cigeo), the decommissioning of facilities that have been shut down (EDF's gas-cooled reactors, Areva's UP2-400 plant, various CEA facilities), and the deployment of post-Fukushima measures.

At the same time, support for the public authorities is constantly being adapted to new challenges. The transposition of the Council Directive laying down basic safety standards, which is the new framework for radiation protection in Europe, was obviously a priority for IRSN in its work to support the ministries in charge of the transposition, namely the Ministry of Environment Directorate-General for Risk Prevention (DGPR), the Ministry of Health Directorate-General for Health (DGS), the Ministry of Labor Directorate-General for Labor (DGT), and ASN.

Turning to the field of healthcare, IRSN helped to optimize doses delivered to patients during medical imaging examinations by updating the diagnostic reference levels (DRLs) in conventional radiology, CAT scanning and nuclear medicine. This work was carried out under its contract with the DGS.

Lastly, IRSN issued its first ever report to the Environmental Authority in 2016 on the environmental impact study of the National Radioactive Materials and Waste Management Plan (PNGMDR). This announces the introduction of "environmental approaches" in our safety and radiation protection analyses concerning waste management solutions.

### **Openness to society: further innovation**

The third line of action, opening up to society, is an action for which IRSN is well-known and on which there is a broad consensus within the organization. I wish to work towards even greater transparency and public participation in nuclear safety, radiation protection and, more generally, risk management.



This naturally means furthering the efforts already undertaken by IRSN with the local information commissions and committees (CLI and ANCCLI). But I also intend to widen the scope of our activities beyond our traditional assessment work, to develop new lines of research, and cover fields other than nuclear facilities, with a special focus on the world of healthcare. Innovation is vital, as is developing interaction with stakeholders in our specialist fields, something we are currently experimenting in the assessment of the Cigeo project safety options report (DOS), and stepping up work with counterpart organizations. These efforts will add substance to the Charter on Openness to Society that we have just signed with six other organizations involved in risk assessment and research and providing assistance in public decision-making.

### **Facing multiple challenges**

IRSN will have many challenges to face in its future activities.

Assessment work on the safety of new facilities, the conditions for extending the service life of reactors, and decommissioning operations will continue, with some key dates up ahead. Research in this area must benefit from the new programs in which IRSN is involved.

The management of all categories of radioactive waste will also draw on IRSN's resources, whether to assist the authorities or in a research context.

In today's world of terrorist and cyber threats, efforts to ensure the protection of nuclear facilities and nuclear material transport must be sustained in line with safety considerations and in close collaboration with public security forces.

Understanding the action of ionizing radiation, from the cellular level to humans and ecosystems, must help us better control the effects of its diagnostic and therapeutic use in the medical field, as well as its impact in the field of low doses.

At a time when Europe is undergoing significant changes, IRSN must maintain its commitment to European research agendas and to the construction of a Europe of technical safety organizations through the ESTON association.

Lastly, IRSN must constantly seek to reduce the risk of accidents and, at the same time, remain in a state of preparedness to respond to a radiological emergency at any time by developing its emergency response strategy and tools.

### **Adapting for greater efficiency**

IRSN is adapting to a rapidly changing environment and the high expectations of its supervisory ministries, authorities, partners, the public and other stakeholders.

In this respect, I launched two projects for the future in 2016.

The first is the structural reorganization of our radiation protection activities, which concerns health and the environment. The aim is to fulfill IRSN's public service role with even greater efficiency by consolidating our position in French and European research, enhancing synergies between our research and assessment activities, better publicizing and clarifying our action, and consolidating our emergency response organization. The new organizational structure was set up on July 1, 2017.

The second, IRSN's 2030 project, will define our strategic ambitions for 2030. Built on a collective approach, in interaction with the other stakeholders, and aimed at excellence, independence, sharing and foresight, the project must enable us to adapt to our changing environment, and define appropriate strategic directions, as well as the related operating principles. It will be flowed down to the operational level in our programs and action plans and be taken into account in the new performance target agreement and programs with our supervisory ministries.

I have every confidence in the ability of IRSN's teams to rise to these multiple challenges, to adapt with a view to greater efficiency, and to remain constantly alert for the benefit of our fellow citizens.



**Georges-Henri MOUTON,**  
Deputy Director General, in charge  
of Defense-related missions

**A**s in 2015, security and defense remained our top priorities, with the terrorist attacks at home, and sustained military operations overseas to avert this threat.

On the domestic front, this situation has led to increased mobilization to **ensure maximum security levels in and around nuclear facilities and nuclear material shipments**, as the current level of threat is such that the possibility of a terrorist attack on such high-profile targets cannot be ruled out.

Further to the reorganization implemented in 2015, IRSN's Nuclear Defense Expertise Division (DEND) contributes to this effort by increasing its support for the Ministry of Energy Senior Defense and Security Official (HFDS), and planning ahead for the changes required to enhance nuclear security.

In addition, **it appears urgent for licensees to commit the necessary financial resources to ensure that nuclear facilities and nuclear material shipments meet the requirements specified by the HFDS.**

**for Defense-related Facilities and Activities with the technical support it needs** at this very busy time, with a large number of new facilities, such as the RES test reactors and Suffren, the new nuclear-powered attack submarine, nearing commissioning; ongoing design work on SN3G, the future nuclear-powered ballistic missile submarine (SSBN), whose safety options report has already undergone an important assessment by IRSN; and the work involved in monitoring facilities already in service.

## « AS IN 2015, SECURITY AND DEFENSE REMAINED OUR TOP PRIORITIES. »

Turning to efforts to combat the proliferation of weapons of mass destruction, the second half of 2016 saw a number of OPCW inspections rarely attained in France.

Similarly, DEND provided the authorities with technical support in connection with its nuclear material accountancy responsibilities, and is preparing for the consequences of Brexit, which could lead the United Kingdom to withdraw from the Euratom Treaty.

As part of its contribution to the implementation of the nuclear deterrent policy, **IRSN is working to provide the Nuclear Safety Authority**

Lastly, IRSN is also working at a steady pace on dismantling and cleanup operations on old nuclear weapons manufacturing plants. In this particular area, DEND is involved in the overall initiative launched by IRSN to help determine the best solutions to be adopted, given the risks involved, taking into account current regulations or contributing to discussions on possible changes.

# ACTIVITY KEY FIGURES

## INTERNATIONAL



**212**

bilateral agreements signed with research and assessment organizations (235 in 2015)



**42**

countries involved in these agreements (41 in 2015)

**61**

international projects underway under the aegis of OECD-NEA, the European Commission, or ANR (64 in 2015)

## RESEARCH



**41.4%**

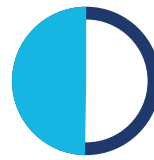
budget devoted to research excluding property projects and Feurs (40.7% in 2015)

**231** publications in Journal Citation Reports (217 in 2015)

**407** scientific lectures at conferences (554 in 2015)

**20** dissertations defended (28 in 2015)

## TECHNICAL SUPPORT FOR PUBLIC AUTHORITIES



**49%**

of budget devoted to technical support and public service missions excluding property projects and Feurs (49.4% in 2015)



**104** technical notices to High Civil Servant for Defense and Security (194 in 2015)

**119** technical notices to the Senior Defense and Security Official in charge of nonproliferation (113 in 2015)

**77** technical notices to the nuclear defense safety Authority (70 in 2015)

**531** technical notices and reports to ASN (543 in 2015)

## DISSEMINATION OF KNOWLEDGE

# 2,455,336

visits to the IRSN website  
(2,357,915 in 2015)

# 351

notices and reports published  
on the IRSN website (78 in 2015)

# 146,189

pages consulted in the "Research"  
section of the IRSN website  
(169,339 in 2015)

# 24

requests for IRSN action  
received from local information  
commissions (33 in 2015)

# 1

IRSN publication (2 in 2015)

# 16

IRSN operations at local information  
commissions (15 in 2015)

# 117

students from French and foreign schools  
took part in the radiation protection  
workshops in schools initiative (114 in 2015)

## INTELLECTUAL PROPERTY



# 25

french patents in force  
(including 10 co-owned)  
(23 including 4 co-owned in 2015)

# 42

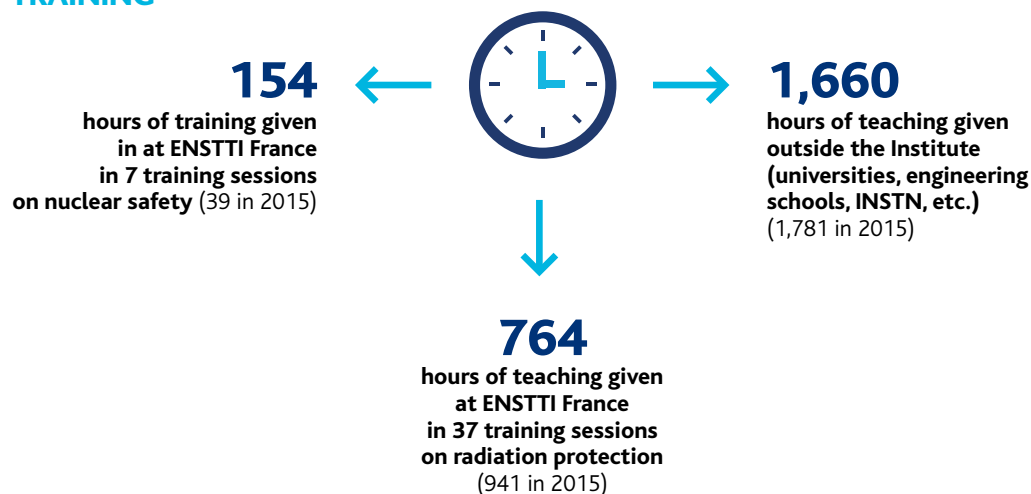
patents in force abroad  
(41 in 2015)



# 28

software applications and  
databases placed with the  
software protection agency  
APP (including 7 co-owned)  
(23 including 8 co-owned  
in 2015)

## TRAINING



# 43,250

hours of training given to maintain  
the skill levels of engineers and experts  
(36,323 in 2015)

# 1.39 €M

spent on training  
(1.24 €M in 2015)

## BUDGET BREAKDOWN

# 276 €M

revenue (279 €M in 2015)

# 287 €M

revenue including 25 €M for equipment investment  
(304 €M including 41 €M in 2015).



### Operating and investment expenditure

- 91% Operating expenses
- 9% Investment



### Total funding

- 59.4% Budget act 190 grant
- 1.3% Budget act 212 grant
- 22.7% Operators' contribution
- 16.6% Other French or foreign funds (aside from budget act)



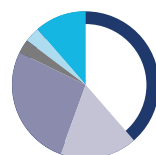
### Amount of other funds

## 39.48 €M

french funds

## 6.24 €M

foreign funds



### Foreign funds

- 38.85% Riskaudit
- 16.85% Others
- 26.6% European Union
- 3.2% Nuclear Power Joint Venture Co.
- 3.2% Gesellschaft für Anlagen-und Reaktorsicherheit - GRS (Germany)
- 11.3% NRC



### French funds (aside from budget act)

- 13.6% State
- 28% EDF
- 3.7% Areva
- 5.2% CEA
- 5.9% ANR
- 3% ENSTTI
- 40.6% Others

## SERVICE CONTRACTS

# 38.9 €M

revenue (41.1 €M in 2015)

## 24,695 customers

(25,256 in 2015)

## 20.13 €M

commercial services (22.65 €M in 2015)



## 10.39 €M

Dosimetry (10.46 €M in 2015)

## 0.80 €M

Biological analyses (0.84 €M in 2015)

## 1.86 €M

Riskaudit (1.96 €M in 2015)

## 2.57 €M

EDF (0.88 €M in 2015)

## 0.60 €M

Training (0.60 €M in 2015)

## 3.91 €M

Others (7.91 €M in 2015)

IRSN financial report 2016 is available on the website [www.irsn.fr](http://www.irsn.fr)

## HUMAN RESOURCES

### DISTRIBUTION OF EMPLOYEES



**44**

employees recruited on permanent contracts (77 in 2015)

**1,627**

permanent contracts (1,650 in 2015)

**1,770**

employees (1,827 in 2015)

**143**

on fixed-term contracts (177 in 2015)



■ 54.2% Men  
■ 45.8% Women

**73**

doctorate students (72 in 2015)

**19**

post-doctorate students (30 in 2015)

**48**

doctors or persons qualified to direct research (44 in 2015)

**64**

persons assigned to other organizations (71 in 2015)

**21**

temporary assignments (22 in 2015)



■ 76.2% Executive staff  
■ 23.8% Non-executive staff

### AVERAGE AGE

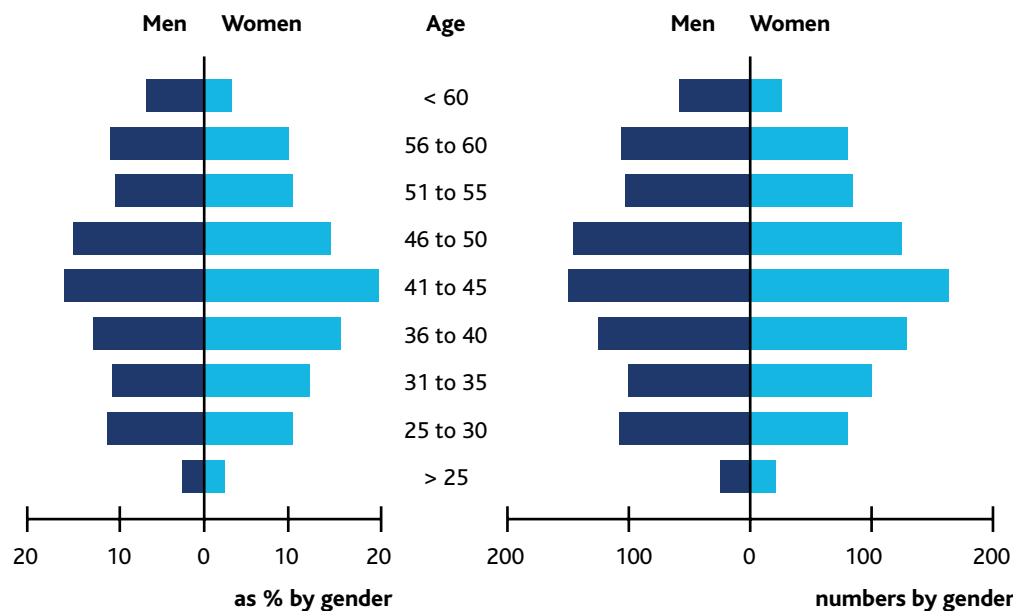
**43.3**

years for women (42.4 in 2015)

**44.6**

years for men (44.2 in 2015)

### DISTRIBUTION OF MEN/WOMEN BY AGE GROUP



### LOCATIONS



■ 80.8% employees on permanent contracts in the North Region  
■ 19.2% employees on permanent contracts in the Southeast Region





# STRATEGY

Public expert, IRSN advances scientific knowledge in the service of managing all nuclear and radiological risks.



STRATEGY AND GOVERNANCE

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KNOWLEDGE MANAGEMENT

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TRANSPARENCY AND INFORMATION

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# STRATEGY AND GOVERNANCE

As public expert, IRSN advances scientific knowledge for the benefit of nuclear and radiological risk management. Using its research, methods, and interactions with all stakeholders, IRSN provides completely independent assessments of these risks and their consequences. It thus contributes to their prevention and detection and to the limitation of their effects so as to protect people and the environment.

## A new decree for IRSN

In 2016, the decree of March 10, 2016 (No 2016-283) set out IRSN's general missions, which had been reaffirmed by the energy transition act for green growth of August 17, 2015 written into the Environment Code.

The decree consolidates the French system of control over civil nuclear activities—a two-part system of overall supervision by ASN and scientific and technical oversight by IRSN. The decree also affirms the importance of research for nuclear safety and radiation protection, requiring IRSN's scientific research orientations to be discussed with all stakeholders within the Research Policy Committee (COR). Lastly, it broadens the scope of IRSN's mission in radiological emergencies to include the provision of expertise to the public authorities (ministries, regional government departments, etc.) when they seek assistance during nuclear or radiological emergencies.

The decree also strengthens IRSN's governance to reflect the importance of its missions. It changes its supervisory ministries (replacing Industry with Energy) and specifies the term of office of the General Management (five years, renewable). It strengthens the representation of elected officials on the Board of Directors through the inclusion of two members of parliament, and it formalizes the inclusion of ASN's Chairman on the same Board, as required by the energy transition act.

## The new Director-General's five objectives for IRSN

At hearings before the French Senate and National Assembly prior to taking up his new post, the new Director-General, Jean-Christophe Niel, set out his plans for meeting the challenges ahead. He set out his plans for IRSN in terms of five objectives:

- to develop IRSN's scientific strategy in liaison with stakeholders preferably by means of partnerships;
- to improve IRSN's strategic coherence with the public authorities, particularly ASN, while guaranteeing the independence of IRSN's assessment activities;

- to boost IRSN's contribution to transparency and public participation in nuclear safety, radiation protection and, more generally, risk management;
- to make the most of IRSN's human potential;
- to ensure IRSN functions efficiently and is managed responsibly as regards the environment.



## RESEARCH: DEVELOPING SCIENTIFIC STRATEGY WITH STAKEHOLDERS

Having state-of-the-art knowledge available and gaining new knowledge with which to carry out assessments, so as to improve safety, security and radiation protection, are the two main objectives of the research carried out by IRSN.

### The scientific strategy deployment

At the start of the year, IRSN published its scientific strategy, which sets out for the next 10 years the main scientific issues to be addressed in terms of radiation protection, safety and security and sets guidelines for the research that IRSN is planning to carry out. This formalization of its scientific strategy supports IRSN's research programming; for a number of years IRSN has striven to adapt its resources to the different challenges faced, in an increasingly demanding context.

The strategy was developed in liaison with IRSN's research teams by **formulating a research policy for each thematic area**. Having taken into account the opinions of external bodies—first and foremost that of the Scientific Council, whose role in evaluating the relevance of IRSN's research program was confirmed by the new decree—these policies will enable IRSN to prepare and **update its research program with greater certainty and in greater detail**.

This task, begun in 2016, will be completed by mid-2017.

### The continuation of the building of European research

EU cooperation on safety and radiation protection research must contribute both to improving knowledge in line with jointly defined strategic orientations and to the pooling of resources for greater effectiveness. For a number of years **IRSN and its partners have been engaged in the construction of a common research effort, encouraged by the European Commission**. This has resulted in groupings of research bodies within platforms and associations.

This structural change is at its most advanced in the field of radiation protection, as a result of the reflection process conducted by platforms and associations such as MELODI, the Radioecology Alliance, NERIS and EURADOS, which are all contributors to the joint research programming consortium CONCERT. CONCERT has been tasked by the European Commission with allocating and managing a large share of the budget dedicated under Horizon 2020 to radiation protection of humans and the envi-

ronment and to preparing for emergencies. Following on from OPERRA (set up under FP7), CONCERT launched its first call for proposals in 2016, with a total budget worth €30 million of which €22 million was provided by the European Commission. Of the three projects chosen, IRSN is running the TERRITORIES (To Enhance uncertainties Reduction and stakeholder Involvement TOwards integrated and graded Risk management of humans and wildlife In long-lasting radiological Exposure Situations) project and is contributing to the CONFIDENCE (COping with uncertainties For Improved modeling and DECision making in Nuclear emergenCiEs) project.

In the same spirit of European integration of research strategy and research, the first *Radiation Protection Week* in September 2016 brought together the European R&D platforms involved in research into the effects of low doses of ionizing radiation.

## > FOCUS

### COR: PUBLICATION OF TWO NEW REPORTS PUBLICATION

In 2016 IRSN's Research Policy Committee (COR) published two new reports. The first looked at IRSN's current and future research into severe accidents. It expressed support for the scientific and technical approaches taken by IRSN and made recommendations concerning organizational and human factors. The second looked at openness to society in the realm of research: it identified existing best practices as regards dialog with civil society and made recommendations for encouraging civil society's involvement in identifying research priorities, for involving civil society in the long-term monitoring of research, and for supporting the dissemination of research results to stakeholders.

As regards reactor safety, the partners in NUGENIA, an association for research into Generation II and III reactors, concluded the NUGENIA+ project in 2016 with a proposal for an organization to coordinate the entire research management process, particularly in safety, under the Horizon 2020 framework program. However, the Commission has no plans at present to seek the setting up of a similar consortium to CONCERT in the safety field.

The NUGENIA Forum brought together 260 participants in Marseille in early April to look at projects related to Generation II and III reactors that they are planning to put forward in October 2016 for the Horizon 2020 call for proposals. These projects, which were submitted to the European Commission in October 2016, have a large nuclear safety component.

Lastly, as regards radioactive waste management, the JOPRAD project, in which IRSN is participating, is preparing to set up a European joint R&D program on the disposal of high level long-lived waste, using a similar model to the program on radiation protection. One of its aims is to establish a governance model that integrates all the different stakeholders (waste management operators, safety authorities and experts, academic researchers, etc.). A conference held in Prague in September 2016 provided an opportunity to review the project's progress and particularly the strategic research agenda, governance and joint programming of future research actions.

### Horizon 2020 call for proposals

In the context of the Euratom research programs funded by the European Commission, the second call for proposals for FP8 (Horizon 2020) closed in October 2016. Proposals were submitted for 72 projects covering safety, health, waste and Generation IV reactors. IRSN is involved in 22 projects. 10 projects were chosen.

→ **260** participants in the NUGENIA Forum on Generation II and III reactors



## MAJOR RESEARCH PROJECTS IN 2016

Many major milestones were reached in 2016, particularly by IRSN's experimental platforms. **In the field of severe accidents**, IRSN's scientific strategy is to fill the remaining gaps in knowledge so that effective solutions can be developed to prevent radioactive releases or, failing that, to limit and control them in the event of a severe accident. The European IVMR (In Vessel Melt Retention) project run by IRSN with 23 partners is studying the potential for the stabilization and **in-vessel retention of corium in water reactors**. As part of this research, in 2016 IRSN hosted an international conference attended by the key global players in this field to share their knowledge and discuss the problems associated with this corium management strategy.

As far as **the aging of materials and facilities is concerned**, the opening in 2016 of the ODE experimental platform marked a milestone in the setting up of the ODOBA project to study the aging of the concrete used in the containments of nuclear facilities.

The PERSEE (experimental platform for research into radioactive waste purification) test bench went into operation in 2016. It is designed to characterize the performance of devices **used to purify radioactive gaseous waste** at nuclear facilities in operational situations ranging from normal conditions to severe accident scenarios at nuclear reactors. The initial research is looking at iodine-131 purification and is part of national (MIRE) and European (PASSAM) research programs.

The achievement of criticality in late 2015 by the **CABRI reactor** and the continuation in 2016 of qualification tests are key steps towards the completion of upgrading work on this experimental reactor, which will enable the international CIP program for the study of reactivity accidents to be run.

The DENOPI project, set up to study the cooling **capacity of spent fuel stored in pools** and supported by the ANR future investments program, received additional funding because of the importance of the research theme and the complexity of its experimental setup.

**Regarding radiation protection, IRSN has developed and upgraded several experimental facilities** used for its research with, among others, the upgrade of the image guided micro-irradiation system (SARRP), the development of the MIRCOM ion microbeam facility and the completion of PARISII (an experimental platform for research into the incorporation of radioactive substances through ingestion or inhalation).

**In the geosciences and waste management field**, IRSN is participating in the European MODERN 2020 project to develop strategies and technologies **for monitoring deep geological waste repositories**. For their experiments these research projects are using the Tournemire experimental facility and are contributing to the development of the MELODIE tool, which is used to model **the behavior of a geological disposal facility** as a whole and to assess its performance. The project illustrates the experimental flexibility, much appreciated by the research partners, offered by the Tournemire facility and the complementary role it can play compared to a less accessible deep geological facility.

Finally, **in the human and social sciences research field**, IRSN is continuing to research organizational and **human factors by developing** projects with academic researchers. A highlight of 2016 in this field was the Risk Conference held in Nantes from 16 to 19 November, led by the RESOH chair at the Ecole des Mines in Nantes, which is supported by IRSN. The conference provided an opportunity to give an update on the chair's research work, to explain the difficulties and the value of research on industrial land, and to share the results of the research with other research teams.

### Preparation for HCERES assessment

As part of preparations for a research assessment by the High Council for Evaluation of Research and Higher Education (HCERES) planned for late 2017, IRSN asked HCERES to approve the external assessment body it uses for its research units. The assessment body will require as many specialist evaluation committees as there are thematic research groups (15 in total). The body is supervised by IRSN's Scientific Director and is supported by the Inspection Committee.

The supporting documents for the application for approval of the body were submitted to HCERES in September 2016. In parallel, IRSN began a self-assessment process to enable it to prepare the documentation for its evaluation, which will be submitted to HCERES in June 2017.

## SUPPORT FOR THE PUBLIC AUTHORITIES: IMPROVING STRATEGIC COHERENCE

IRSN's core activity is **providing expertise to the French authorities responsible for safety and security and, via government departments, to any public authorities** in France that seek its assistance. It is also responsible for implementing public policy in the fields of health, the environment, emergency response management, and worker protection from ionizing radiation. For many years IRSN has had to cope with increasing challenges in terms of safety, radiation protection and nuclear security in a context of persistent difficulty obtaining the resources it needs to fulfill its role. Against a backdrop of public spending cuts, an increase of 20 FTE posts is vitally important for IRSN.

IRSN has therefore implemented a strategy to **improve its efficiency**. This strategy has prompted it to share with the authorities its approach **to prioritizing the subjects** to be addressed and adapting its resources to the safety, security and radiation protection issues involved in the cases passed to it.

### Strategic and operational coherence

In addition to periodic activity reviews, **ASN and IRSN** have also introduced **a task prioritization process and a multi-annual timetable** for technical investigations of major issues. Work is being done with ASN to improve both strategic and operational coherence.

As regards strategy, the development of a system for the prioritization of around 50 tasks (compared to the more than 500 deliverables that IRSN produces each year as part of the support it gives to ASN) has delivered a 88% achievement rate of these priorities (compared with 66% four years ago). Its failures to meet the priorities in full are limited to a few jointly agreed changes in priority (between zero and two each year) because of contextual changes, but they are mainly due to the delayed submission of documentation and responses by the industry, preventing IRSN from moving forward with its assessments.

## AUDIT OF THE AGREEMENT BETWEEN ASN AND IRSN

In June 2016 an audit of IRSN was carried out at ASN's request on the terms of application of the agreement between ASN and IRSN. The audit looked at how the general terms of the agreement are implemented in the context of expert assessments, and at practical examples of application in the field of pressurized reactor safety. It did this by examining "standard" tasks (analysis of equipment modification applications submitted by licensees, examination of feedback from the operation of nuclear power reactors, examination

of programs and works planned during unit outages for refueling) and more complex tasks involving multiple areas of competence, such as the analysis of safety reviews of 1300 MWe reactors. The audit conclusions did not find any significant failings or weaknesses with respect to the agreement between IRSN and ASN and indicated that the processes had reached a good level of maturity. The findings were accompanied by recommendations and suggestions for IRSN and ASN. The issues examined included ethics, improving communication at all levels, and mutual understanding of the roles, organization and personnel in each of the two entities.

ASN and IRSN have updated their **joint vision of the main issues for the oversight of civil nuclear**, originally drawn up in April 2014; the update was submitted to the Minister of the Environment in June 2016. The aim of the update was partly to **review the resource requirements** of both bodies and to submit a joint request for funding as part of the budget cycle. **The application for funding from the 2017 budget was successful.**

This strategic coherence also has an impact in operational areas. For example, investigations carried out following the discovery of anomalies in the EPR reactor vessel at Flamanville 3 identified a need for rapid safety reviews of certain reactors in operation which had components that deviated significantly from their specifications (e.g. significantly higher carbon content in steam generator bottom heads). This caused priorities set out in the ASN/IRSN memorandum of understanding to be adjusted so that IRSN could mobilize teams to work on this. The work led to the issue of a number of reports in 2016 (in the summer in the case of steam generator bottom heads made by Creusot Forge and in November for those made by JCFC), enabling ASN to give a quick decision. ASN and IRSN decided to introduce a joint communication system so that decisions taken by ASN and the results of safety assessments by IRSN used as the basis for those decisions can be announced simultaneously.



**This desire for strategic and operational coherence also applies to other beneficiaries of IRSN's support.**

**In 2016 the Directorate-General for Civil Protection and Emergency Response (DGSCGC) and IRSN renewed their framework agreement on the provision of technical support** with the desire on the part of both organizations to leverage new synergies in order to make their action more effective within the national response system in the event of a nuclear or radiological emergency.

In the health field, a substantial amount of work was done in 2016 with the **Directorate-General for Health (DGS), culminating in the renewal in December 2016** of the five-year agreement between them. This agreement is supplementary to the Ministry of Health's supervision of IRSN. The agreement provides for the establishment of an annual memorandum of understanding identifying the issues and priorities to be assessed for the DGS each year. The agreement also sets out the terms of **IRSN's involvement in the health agency coordination bodies**, particularly the Health Agency Networking Committee (CASA) and the weekly health security meeting that enables rapid operational responses to be implemented where necessary.

2016 was also a significant year from the point of view of legislation and governance, following the publication of the act on health system modernization on January 26, 2016. One of the orders implementing this act confirmed CASA's role and another, expected by IRSN, should provide certainty over the conditions on which IRSN may be required to perform medical assessments (such as the one carried out in Epinal in a case of over-irradiation). As regards governance, IRSN also contributed to the drafting of the DGS's strategic plan and took part in the audit of IGAS commissioned by the DGS, under the supervision of agencies and licensees.

**The transposition of Directive 2013/59/Euratom** of December 5, 2013 laying down basic safety standards for protection against the dangers arising from exposure to ionizing radiation was one of the main strategic topics dealt with by IRSN as part of its **technical support for the Directorate-General for Labor**. IRSN worked hard on **converting the requirements laid down by the Directive into regulations**, particularly in the context of preparation of the draft decree amending the Labor Code. The draft decree was examined by the government's Working Conditions Policy Committee.

In relation to the **Directorate-General for Risk Prevention**, IRSN's activities have involved **both strategic and operational matters**. On the operational side, for example, IRSN provided support to the Directorate-General on the politically sensitive issue of assessing the health and environmental consequences of disposal on the Mange-Garri site of bauxite residues from aluminum production by the Altéo factory in Gardanne. This assessment relied not only on models and calculations but also on measurements taken by IRSN. The results were presented to the site monitoring committee in September 2016.

### A proven national emergency response organization

IRSN took part in several emergency response exercises in 2016, one on a particularly large scale involving government ministries. For IRSN these exercises were to test the appropriateness of its organizational position in the national response plan for nuclear and radiological emergencies—as a member of the Interministerial Emergency Response Group (CIC), nationally as provider of expertise to all public authorities (using expertise supplied by its emergency response center), and locally (departmental and local prefectures). IRSN's role is part of a system of complementary activities performed by different emergency response entities in a major nuclear or radiological emergency, as defined by the decree of March 10, 2016 (N° 2016-283).





## BILATERAL COOPERATIONS

The collaboration with the Japanese nuclear regulatory authorities (NRA), one of many bilateral cooperations led by IRSN, was renewed in 2016. In March 2016 the NRA's technical director toured IRSN's research facilities and in September Japanese experts visited Cadarache for a week of work on waste management, with the launch of two research projects on this theme. Finally, joint conferences were organized in Tokyo in November on fire protection and severe accidents.

A new research cooperation agreement was signed with the United Arab Emirates in December 2016. Following an initial commitment in 2014 on the exchange of information on safety, this new agreement marks a step forward in cooperation with the UAE safety authority and will enable joint research projects to be run. One early initiative is the development of a joint environmental study taking account of specific regional differences.

## INTERNATIONAL: TSO SYSTEM DEPLOYMENT

Internationally IRSN works to promote and affirm the importance of expertise and knowledge for safety and radiation protection. This conviction guides its action in relation to European and international authorities and its bilateral cooperations.

### Strengthening of ETSON

In Europe, **IRSN is an active member of ETSON**, the European technical safety organizations (TSO) network. ETSON continues to grow and in 2016 welcomed two new members: ENEA (Italy) and the Romanian TSO, RATEN ICN. ETSON also began a reflection process with the objective of consolidating its strategy. The aim is to develop ETSON's activities and recognition and to increase its involvement with the European Union and groups of authorities. In particular, **ETSON signed a collaboration agreement in 2016 with FORO**, the Spanish-speaking regulators' group (Spain and Latin America). This agreement allows for the exchange of information on each body's activities, particularly in the field of training.

ETSON also worked to formalize its current cooperation with the IAEA, with a view to signing a collaboration agreement in 2017. This rapprochement will increase the involvement of ETSON's experts in the IAEA's work, both on the preparation of documents and on specific missions.

### Finalization by IAEA of a reference document on the function of TSOs

Within the IAEA, the TSO Forum plays a key role in ensuring the place of science and technology in improving nuclear safety is recognized.

As part of this, experts from IRSN contributed to a **document finalized in 2016 explaining what TSOs are and what they do within national inspection and control systems**. The work, which involved a number of different bodies and countries, particularly the NRC in the US, GRS (IRSN's German counterpart), Russia and Canada, will be published in 2017.

The Forum also focused in 2017 on countries starting to go down the nuclear route. In particular it recommended development of the scientific and technical capability of these countries for safety inspections. The Forum also set up a working group on sharing information and best practices in R&D.

**The European and Central Asian Safety Network (EuCAS) was set up in 2016 under the auspices of the IAEA with IRSN's active involvement.** Its members are the TSOs and safety authorities of eleven European countries and four Central Asian countries, and it aims to develop cooperation between them on safety and radiation protection. The first working meeting was organized in 2016 at the IAEA, attended by IRSN, ETSON, HERCA (Heads of the European Radiological Protection Competent Authorities) and the European Commission.

## INTERNATIONAL SERVICES

IRSN was extremely busy in 2016 with the provision of services for Riskaudit as part of INSC contracts. The beneficiaries of these services were safety authorities in the following countries: Belarus (licensing of two nuclear power reactors); Armenia (assessment of measures taken to limit the consequences of a severe accident); Philippines, Vietnam and Egypt (training of personnel in safety assessment and radiation protection); and Brazil (development of safety studies). IRSN also conducted a series of tests on the Viktoria Loop, in complete transparency with the Chinese safety authority (NNSA), in order to qualify equipment supplied by Bertin for the reactors of Chinese designer CNPE. IRSN also completed its contribution to a contract led by ASN, signed in 2014, to provide assistance to the Chinese safety authority (NNSA) and its technical support body (NSC) in four areas: the hypotheses used in accident studies, severe accidents, assessment of external floods, and management of operational experience.

In 2016, IRSN was also involved, under Riskaudit's guidance, in the preparation of contracts with the safety authorities of China (effluents, waste disposal, etc.), Mongolia, and Armenia (ability of the Metsamor power plant to continue operating safely). These proposals were supported by the European Commission.

The experience gained from these missions enhances IRSN's expertise and know-how.



## OPENNESS TO SOCIETY: ENRICHING IRSN'S CONTRIBUTION TO TRANSPARENCY AND PUBLIC PARTICIPATION

**Building a more local presence and using innovation to ensure stakeholder involvement** in discussions and explorations in its core areas of expertise have been IRSN's driving principles as regards openness to society. Moreover, these principles accord with the granting of new prerogatives to the local information commissions (CLIs) by the energy transition act of August 17, 2015, an initiative in its first year.

**To build a more local presence**, IRSN has worked with various different local initiatives aimed at awakening interest in **radon concentrations in buildings** (including homes), measuring those concentrations and sharing information and solutions for controlling them. Two projects are worthy of mention: a campaign in Haute-Vienne pro-

viding support to local residents, including remediation, and a Franco-Swiss cross-border project co-financed by the European Commission's "Interreg" programs to develop a platform for pooling data and tools to support decision-making. IRSN believes that, with radon, the issue is raising awareness among residents and building industry professionals of the importance of carrying out radon measurements and then taking proportionate action in view of the concentrations measured.

In an initiative combining both principles local action and innovation to achieve stakeholder involvement in safety matters **the discussion days held by IRSN on 3 and 4 October 2016, in conjunction with Anccli, the local information commission for the major energy facilities at Tricastin (Cligeet) and ASN**, looked at the topic **"Extending the service life of 900 MWe reactors beyond 40 years: what are the safety issues and who decides?"**. The discussions days were targeted at members of CLIs and associations, and they aimed to disseminate a better

understanding of the safety issues and to discuss the involvement of CLIs in the four reviews of these reactors and how civil society's involvement might contribute to safety. There were 145 participants at both days, which were held in Valence, close to the first site to be affected by the service life extension (Tricastin). The initiative also complies with the energy transition act, which demands public involvement (in the form of a public inquiry) in all ten-yearly outages once a reactor has been in service for 35 years.

One other area of innovation concerns **the review of the safety options report for the Cigeo (deep geological waste disposal facility) project**, submitted by Andra in 2016. IRSN is supporting ASN by assessing this report ahead of the examination of the construction license application. IRSN took the initiative of including a civil society consultation stage at the start of its technical review. A discussion group was set up for this purpose, with around fifteen members from the Bure CLIS, Anccli and the citizens' panel set up for the public debate, as well as non-institutional experts. The aim of this consultation, at a key stage of the assessment process, was to find out people's concerns and any issues that seemed particularly important to the participants, so that IRSN could take account of them in its review.

Finally, IRSN made an effort to ensure the conditions were in place for a **technical dialog** with stakeholders as part of the technical examination of the test program planned by Areva following the discovery of an anomaly affecting **the composition of the steel in some parts of the vessel head and the vessel lower head destined for the EPR** at Flamanville. Three meetings attended by Anccli, the Flamanville CLI, IRSN and ASN reviewed the description of the anomaly, the justification file submitted by Areva, the analysis by IRSN and ASN, and the changes made to the test program as a result of the initial results.

→ 145

participants in the discussion days for local information commission members on extending the service life of 900 MWe reactors beyond 40 years.

## WORKSHOPS IN SCHOOLS

IRSN took part in the 9th International Radiation Protection Workshops in Schools, held in Bastia (Corsica) in late March. Pupils from 13 French and foreign schools, including pupils living on contaminated land in Belarus, Ukraine and Japan, attended the event. It provided these pupils with an opportunity to present the work they had done during the year at workshops organized by their teachers, with the support of radiation protection experts.

The event looked at a variety of topics such as nuclear medicine, waste management, radiation protection in gamma radiography, radiation protection of flight crew members, and the management of post-accident situations. It is part of an outreach program to disseminate a radiation protection culture to young people using a practical, multi-disciplinary approach encouraging discussion between pupils, teachers and scientists.

Openness to society is also an area that is enriched by finding out the practices used and discussions held in other countries. In the international sphere, **IRSN ran the European PREPARE WP3 program** on taking account of the requirements of stakeholders for **the management during post-accident situations of goods contaminated in accidents.**

PREPARE WP3 was launched in early 2013 and was completed at the start of 2016. The results were presented at the final conference held in Bratislava from January 20 to 22, 2016. The purpose of PREPARE WP3 was to contribute to the development of strategies for managing foodstuffs and feedstuffs contaminated in a nuclear accident or radiological event. It was unusual in relying on panels of stakeholders formed by the **11 participating European countries: producers, distributors, consumers, experts, associations, authorities, industrial companies, academics, etc.**

One strength of the study was that it could use the first-hand experience of Japanese entities involved in managing the Fukushima accident. The reflection process begun during PREPARE WP3 will continue in a European working group set up within the European NERIS platform dedicated to managing nuclear and radiological accident and post-accident situations.

It emerged from the PREPARE study that it is necessary to involve stakeholders in discussions about the management of contaminated products but also to respect their values : the aim is not to make the accident seem acceptable (the public are victims of it), but to foster mutual trust and understanding between the stakeholders as early as possible, using networks already in existence. Post-accident situations are complex, with a variety of interests at play. Therefore new methods of governance are needed that take account not only of health considerations, but also of ethical and economic considerations.

#### **New signatories to the inter-institute charter on openness to society**

Following on from the first **inter-institute charter** on openness to society signed in 2008, seven public establishments have now affirmed or reaffirmed **their commitment to dialog with civil society representatives as part of their assessment and research activities.**

**Anses, the BRGM, Ifsttar, Ineris, Irstea and Santé Publique France joined IRSN** in making a commitment, by signing this charter at the end of 2016, to pursue a policy of openness and to develop transparency in their research, assessment and/or risk appraisal processes, to improve the sharing of scientific knowledge and the related uncertainties, and to take better account of the contribution society can make to research and risk assessment processes.

# KNOWLEDGE MANAGEMENT

**Because knowledge is of vital importance in the field of nuclear and radiological risk assessment, knowledge management is vital to give IRSN an overview of the key knowledge** it needs to hold at present and in future for the fulfillment of its missions and to show the significance of knowledge for IRSN's core functions (research creates knowledge, expertise uses knowledge, competence built on knowledge, openness and participation in the sharing of knowledge). In 2016 a dedicated intranet portal was launched for knowledge management purposes.

The aim of this portal is to create a "one-stop shop" for IRSN's knowledge and to explain the role, methods, operation and deliverables of knowledge management. It provides access to every public reference document and to the document databases linked to IRSN's knowledge production.

A directory of experts gives access to information about their specific fields and areas of expertise and their contributions to knowledge production. A special tool has been developed to make it easier to search for knowledge in a primary database containing more than 40 years' worth of safety research and assessments. The current version of the portal has been designed so that it can evolve as the database is enriched in the areas covered by IRSN.



## CAPITALIZATION AND SHARING

**Seven books containing knowledge** gathered from interviews conducted as part of a drive to **capitalize on the knowledge of “critical knowledge-holders”** can be accessed through the portal. Five of them concern pressurized water reactors (PWRs): behavior of metal components; civil engineering safety assessment; instrumentation and control; incidents and accidents linked to the storage and handling of spent fuel; and elements of nuclear safety for severe accidents. Two others concern the safety aspects of fast reactors and radionuclide transfers in the atmosphere. Collaborative areas for sharing and updating the knowledge are gradually being introduced.

The writing of reference publications has continued. The publication on pressurized water reactor research in the Science and Technology Series will be released shortly.

## ANALYSIS

**Strategic knowledge analysis** (in the fields of emergency response management and the environment) has continued, leading to the **production of knowledge management action plans**. New analyses are being started and are at the stage of objective-setting (updated PWR safety) or action plan definition (Waste - Geosphere). Work has continued in line with the commitment made in the performance target agreement to complete the strategic analyses for all fields by the end of 2018.

IRSN has continued to implement an organizational structure specifically for knowledge management deployment, appointing the knowledge management coordinator (CMC) within each department or division.

# TRANSPARENCY AND INFORMATION

In accordance with the requirements set out in the energy transition act for green growth concerning transparency and public participation and information, IRSN is stepping up its communication effort both by providing educational materials and by diversifying the methods it uses to convey information to a broad sector of the public.

## More extensive publication of assessment reports

Begun in 2009, the publication of IRSN's reports for ASN has now been extended to include all assessment reports (except where this is prevented by national security considerations), and is now bimonthly. These reports present IRSN's position upon completing its scientific and technical examination of risk assessment and risk management, and any recommendations. **IRSN is thus continuing to improve its transparency.**



## A DIVERSIFIED PRESENCE

Keeping the general public informed about matters related to radioactivity and the results of its work has been one of IRSN's longstanding activities, as part of **its policy of transparency and education, through the media and a variety of different initiatives:** the internet, through its own website and sites dedicated to specific topics, an active presence on social networks (Facebook, Twitter accounts, LinkedIn, etc.), paper publications and their digital versions (Repères magazine and the scientific journal Aktis), press relations and the use of online media, exhibitions and public dialog initiatives.

The initiatives undertaken in 2016 include participation **in the Science Fair**, with regional representation of IRSN at workshops for schools and the general public in Vieille Charité (Marseille); participation in the Science Village at Yves Montand College (Vinson-sur-Verdon); and an exhibition and workshops at the Institut de Formation de Manipulateurs d'Electroradiologie Médicale at Poissy-Saint-Germain-en-Laye.

Similarly, **the IRSN/ASN exhibition "Radioactivity: hundreds of questions, one exhibition"** was shown at more than 35 venues, including Civet in May, and Nîmes and Grainville-la-Teinturière in March. It was also made available to the CLIs at Penly/Paluel, Chooz, Chinon and Dampierre for their public meetings. The exhibition was also shown at the **Mayors' Forum (Salon des maires)**, at the tenth gathering of radiation protection specialists organized by the French Radiation Protection Society (SFRP) and at the meeting of the centers for scientific, technical and industrial culture. Finally, **a partnership was set up with Poissy-Saint-Germain hospital** to use the exhibition as part of an initiative to develop information provision in the medical field.

## MAIN FINDINGS OF THE BAROMETER 2016

Every year, IRSN gathers the opinions of the French public on issues related to social and environmental concerns, scientific expertise, and situations involving risk, including civil use of nuclear. From a survey carried out in late 2015, the Barometer 2016 revealed four major trends, apart from terrorist attacks, that have left a deep scar in the minds of the French public. Among environmental topics, there has been a significant increase in concern about issues related to climate change. The fact that the United Nations Climate Change Conference (COP21) coincided with the survey may explain this increase. The second trend is an increase in public trust in France in science and in experts working in the nuclear sector. Support was also expressed for the publication of assessment results so that they could be used as the basis for forming opinions. Thirdly, it emerged that the French public has a preference for renewable energies: solar and wind are replacing nuclear economically and have grown compared with 2013. Finally, although 46% of respondents believe that “every precaution is taken to ensure a very high level of safety at French nuclear power plants”, severe accidents such as those at Chernobyl and Fukushima remain the most strongest argument against nuclear energy.

In 2016 IRSN also published the entire history of Barometer data on its website.

<http://barometre.irsn.fr/>

## NEW FORMATS FOR BETTER INFORMATION

### Public exposure to ionizing radiation: an online calculator

As part of its national radiological monitoring role, in 2016 IRSN published **updated figures for the average exposure of the French population** to ionizing radiation. Because everyone is exposed in different ways to different sources of ionizing radiation, whether of natural origin or in the context of medical care, in 2016 IRSN put a **calculator on its website enabling members of the public to estimate their personal dose** by reconstructing their habits.

### Three minute thesis

Since 2015, **the Three Minute Thesis competition organized by IRSN** has enabled doctoral student volunteers to attempt to sum up three years' work on their thesis in just three minutes, to present their work in an accessible but informative way to an audience of lay people. Covering various subject areas (health, nuclear safety, seismology, etc.) the Three Minute Thesis videos are now available on IRSN's website.

> 35

venues for IRSN/ASN exhibition  
"Radioactivity hundreds of questions"



rotection de l'homme  
re les rayonnements

**IRSN**

INSTITUT  
DE RADIOPROTECTION  
ET DE SÛRETÉ NUCLÉAIRE

*Enhancing nuclear safety*



# PANORAMA 2016



# PANORAMA

JANUARY 2016

## HEALTHCARE

IRSN chairs the Scientific Council of the French Veterans' Health Observatory (OSV).

JANUARY 14, 2016

## RESEARCH

Kickoff meeting of the Cathymara project, concerning in particular, **improved measurement of iodine-131 in children**, in the event of large-scale radiological accidents, and bringing together 41 researchers.



JANUARY 25 & 29, 2016

## TRAINING

IRSN gave a radiation protection course in China, under a European contract.



FEBRUARY 5, 2016



## RESEARCH FACILITY

The MIRCOCOM experimental facility was officially opened at Cadarache. It is composed of a microbeam line providing micrometric accuracy. **It will contribute to radiobiological research, especially work aimed at learning more about radiation therapy complications**, carried out under the ROSIRIS research program. It will also be used in research into low-dose ionizing radiation.

JANUARY 28 & FEBRUARY 10, 2016



## HARDENED SAFETY CORE

IRSN submitted its report to the Advisory Committee for Reactors on the extreme external hazards to be considered for the « hardened safety core » of EDF PWRs under construction or in operation.

FEBRUARY 11, 2016

## RADIATION PROTECTION

IRSN presented to the Advisory Committee RADE its **findings on the use of dose constraints as a public protection measure**.

FEBRUARY 11, 2016

## NUCLEAR ACCIDENTS

Thirty years on from Chernobyl and five years after Fukushima, IRSN gave a **press conference to go over the health impact of these accidents**.

safety - security

radiation protection

events - others



MARCH 10, 2016

## GOVERNANCE

A new decree was published for IRSN (decree No. 2016-283 of March 10, 2016). Along similar lines to the «TECV Act» (energy transition for green growth, of August 17, 2015), **the decree strengthens IRSN's governance and reaffirms its scientific and technical responsibilities** within the French regulation system for the civil nuclear sector.



MARCH 11, 2016

## OPENNESS TO SOCIETY

IRSN attends a public meeting in Chinon on the topic «Radioactivity, hundreds of questions», organized by the Chinon CLI.



MARCH 12, 2016



## FUKUSHIMA

«Kotoba», a web documentary on **the initiative for dialogue taken in the Fukushima prefecture between the population and Japanese and international experts** went on line.

MARCH 15, 2016



## TRANSPARENCY

IRSN's reports to ASN are now published on a bimonthly basis and have been extended to include all reports that do not concern national defense. These reports are available on IRSN's website. They reflect IRSN's desire for greater transparency concerning its risk assessment and management activities.

MARCH 30-31, 2016

## EPR FLAMANVILLE 3

IRSN presented the Advisory Committee for Reactors with its report on fuel storage and handling safety for the Flamanville 3 EPR.



APRIL 4-7, 2016

## STANDARDIZATION

IRSN chaired the 27th annual meeting of the ISO TC85/SC2 Radiological Protection subcommittee in New Delhi, India.

APRIL 22, 2016

## IRSN

Jean-Christophe Niel was appointed Director General of IRSN.

MAY 2016

## CRITICALITY

IRSN participated in an international interlaboratory comparison exercise on criticality accident dosimetry, in close collaboration with its American partners in this field. In this context, IRSN is collaborating in the PRINCESS project and took part in the annual technical review of America's Nuclear Criticality Safety Program (NCSP).



MAY 9-13, 2016



## RADIATION PROTECTION

IRSN took part in the International Radiation Protection Association (IRPA) congress in Cape Town, South Africa.

MAY 10, 2016

## NONPROLIFERATION

The web portal for electronic declarations, designed to make it easier for the companies concerned to enter and send declarations of their business activity relating to a nuclear program, was put on line.

MAY 2016

## RADIOACTIVE WASTE

A new version of the radioactive waste management website was put on line.



MAY 31, 2016



## REGIONAL ACTION

IRSN took part in the Mayors' Forum (Salon des maires), where it shared a stand with ASN.

JUNE 1-3, 2016

## INTERNATIONAL NEWS

IRSN attended the Ricomet 2016 conference which was held in Bucharest, Romania, from June 1 to 3. The conference was on **risk perception, communication and ethics related to exposure to ionizing radiation.**



JUNE 6-7, 2016



## CORIUM

The international scientific seminar organized by IRSN on the topic « **In-vessel corium retention strategy**: current state of knowledge and prospects », brought together the world's major stakeholders in the field to **share knowledge and discuss the issues of corium management strategy.** This topic is an essential part of severe accident research and is the subject of the European project « In-Vessel Melt Retention » (IVMR), a project led by IRSN and bringing together 23 partners.

JUNE 7-9, 2016



## EUROPEAN RESEARCH

IRSN organized the second periodic review of the 64 partners of Europe's OPERRA project in Kuopio, Finland.

JUNE 8, 2016

## AGING

IRSN presented the Advisory Committee on Pressurized-water Reactors with its report on the behavior of austenoferritic steels used in the cast elbows in reactor coolant systems, an essential factor in predicting aging.

JUNE 14, 2016



## OPENNESS TO SOCIETY

IRSN took part in the symposium organized by the Bure CLI on the health impact of nuclear facilities.

JUNE 14, 2016

## IRSN SITES

The IRSN Board of Directors confirmed the latest decisions concerning the closure of IRSN's sites in La Seyne-sur-Mer and Agen.



JUNE 20, 2016

## NUCLEAR MATERIALS

In connection with its civil nuclear material accountancy responsibilities, IRSN published a revised version of the manual that sets out nuclear material accountancy rules. The previous edition dates back to 1995. This document reminds all parties concerned of their responsibilities and obligations in this area.



JUNE 21-24, 2016

## TRAINING

IRSN gave Singapore authorities and radiation protection managers a course in radiation protection, organized by ENSTTI.

JUNE 24, 2016

## EPR VESSEL

IRSN gave the Advisory Committee on Nuclear Pressure Equipment an update on work to demonstrate that the upper and lower head closure domes of the Flamanville 3 EPR proposed by Areva are suitable for operational use; IRSN also reported on test progress.

JUNE 27-JULY 1, 2016

## SAFETY

IRSN reported to the Advisory Committee for Laboratories and Plants on the safety review of INB 55 (LECA).

JUNE 27-JULY 1, 2016

## INTERNATIONAL NEWS

IRSN jointly led the French delegation to the 63rd session of UNSEAR, during which it presented a report on the effects of uranium.

safety - security

radiation protection

events - others

JUNE 27-JULY 1, 2016

## SEVERE ACCIDENTS

IRSN presented the Advisory Committee for Reactors with its report on severe accident management at operating nuclear reactors, in connection with the post-Fukushima hardened safety core, and the plan to extend reactor lifetimes.

JUNE 30 & JULY 1, 2016

## EPR FLAMANVILLE 3

IRSN presented the Advisory Committee for Reactors with its report on Flamanville 3 EPR accident studies.

JULY 1, 2016

## INTERNATIONAL COOPERATION

IRSN took part in launching EuCAS, a new network for cooperation between Europe and central Asia in the fields of nuclear safety and radiation protection.

JULY 7, 2016



## CHERNOBYL FALLOUT

At the request of Mercantour National Park's Health, Safety and Working Conditions Committee, IRSN presented an explanation of residual cesium-137 in the soil due to fallout from the Chernobyl accident.



AUGUST 26, 2016



## EXPOSURE TO IONIZING RADIATION

A calculator was made available for distribution to the public for estimating individual exposure to ionizing radiation.

SEPTEMBER 6, 2016

## WORKERS

IRSN published its 2015 report on Occupational Exposure to Ionizing Radiation in France. In 2015, the number of workers monitored rose by 1.7% compared with 2014, to reach a figure of 365,830.



SEPTEMBER 7 & 8, 2016



## WASTE RESEARCH

The European project JOPRAD (for research into the deep geological disposal of radioactive waste) organized a seminar in Prague, to report on the project's progress, including, in particular, the strategic research agenda, governance, and joint programming of future research initiatives.

SEPTEMBER 15, 2016



## FACILITY

The AMANDE/MIRCOM facility obtained a 4 MeV proton microbeam with a diameter of less than 1  $\mu\text{m}$  under vacuum. This facility will be used to explore radiation-induced malfunctions not only at DNA level, but also in intra- and intercellular communication.

SEPTEMBER 19-23, 2016



## LOW DOSES

IRSN attended the first European Radiation Protection Week in Oxford, UK, an event that brought together European R&D teams involved in research on the effects of low-dose ionizing radiation, including: MELODI (low-dose effects), EURADOS (dosimetry), NERIS (emergency preparedness and the management of postaccident situations), ALLIANCE (radioecology) and EURAMED (health protection).

SEPTEMBER 26, 2016

## SEISMIC HAZARD

IRSN jointly organized the first workshop of the French seismological and geodetic network devoted to the seismic hazard.

SEPTEMBER 26, 2016



## ENVIRONMENT

IRSN presented the Altéo site monitoring committee in Marseille with the results of its **assessment on the radiological impact of the red mud storage facility near Gardanne.**



SEPTEMBER 27, 2016



## CABRI

The CABRI reactor operated at power for the first time **following renovation work.**

OCTOBER 2, 2016

## SAFETY

IRSN reported to the Advisory Committee for Laboratories and Plants on the safety review of INB 98 (the FBFC plant in Romans-sur-Isère).

OCTOBER 3 & 4, 2016

## 4TH TEN-YEARLY OUTAGE INSPECTIONS

As part of its initiative to involve stakeholders in discussions relating to major assessments, **IRSN organized a seminar on the theme «Extending the service life of 900 MWe reactors beyond 40 years: safety issues and participation»** with ANCCLI, the Local Information Commission on the Major Energy Facilities at Tricastin (CLIGET), and ASN.

OCTOBER 3 & 5, 2016



## RESEARCH

The **ROSIRIS research program underwent assessment by the Inspection Committee**, made up of independent experts who assess all IRSN's research activities. ROSIRIS is aimed at learning more about the mechanisms behind the side effects of radiation therapy.



OCTOBER 11, 2016



## RISK PERCEPTION

Publication of the **IRSN barometer 2016: risks and safety as perceived by the French.**

OCTOBER 12, 2016



## AGING

**Official opening of the ODE facility in Cadarache, designed to study the aging of concrete used in the construction of nuclear reactors and waste disposal facilities.** This new facility will be used in the experimental phase of the ODOBA project (Observatory of the durability of reinforced concrete structures).

OCTOBER 20, 2016

## NUCLEAR SECURITY

Epées 9 nuclear security exercise, simulating a terrorist attack on a research reactor.

NOVEMBER 3 & 4, 2016



## RADIATION PROTECTION

IRSN took part in the 18th meeting of HERCA, the Heads of the European Radiological Protection Competent Authorities, in Dublin.



NOVEMBER 7 & 8, 2016

## EUROSAFE

300 experts gathered in Munich for the EUROSAFE Forum.

NOVEMBER 24, 2016

## RADIATION PROTECTION OF PATIENTS

Publication of the report «Assessment and Optimization of Doses Delivered to Patients during Medical Imaging for the years 2013 to 2015».

NOVEMBER 24, 2016

## CARBON SEGREGATION

IRSN submitted to ASN its assessment of the risks of failure in EDF nuclear plant steam generators with abnormally high levels of carbon in the steel making up their bottom head. This analysis was carried out further to the detection of a similar anomaly in the bottom head of the Flamanville 3 EPR vessel.



DECEMBER 9, 2016

## ENVIRONMENT

Publication of the 2015 Report on Radioactivity Monitoring in French Polynesia.

DECEMBER 9, 2016



## RESEARCH FACILITY

The PERSEE facility for the study of radioactive gaseous waste purification systems at nuclear facilities was officially opened in Saclay.



DECEMBER 9, 2016

## TRANSPORT

Publication of the report on the safety of radioactive material transport in France in 2014 and 2015.



DECEMBER 9, 2016

## SAFETY

Publication of the public report on reactor safety in 2015.

DECEMBER 14 & 15, 2016

## EPR FLAMANVILLE 3

IRSN submitted its report to the Advisory Committee for Reactors on the design of the Flamanville 3 EPR systems for ensuring safety and protection against the effects of internal and external hazards.





## 2016 AWARDS



### AWARDS FOR EXCELLENCE

#### THE EUGENE P. WIGNER AWARD

was granted to Luiz Leal by the American Nuclear Society (ANS) on November 7 for his extensive research on the measurement, assessment and processing of nuclear data at the application level.



#### THE EXMELIN AWARD

was granted to Sarah Baghadi by Procorad on June 17, for her thesis work on the development of a method for detecting and rapidly analyzing urine samples for actinides that may be released in the event of a nuclear accident (U, Pu, Am, Th, etc.), and thus rapidly identify contaminated individuals.



#### THE JEAN BRICARD AWARD

was given to Anthony Rondeau by ASFERA on September 7, for his thesis work on the study of air suspension mechanisms, as applied to the accidental suspension of dust in the future tokamak ITER.

### PRIZEWINNING POSTERS

#### BEST POSTER AWARD

*"Theoretical and Experimental Studies of  $S(\alpha,\beta)$  Thermal Scattering Kernel"*, Vaibhav Jaiswal, at an ISIS Neutron training course (April 12-21)



#### BEST POSTER AWARD

*"Particle entrainment due solely to electrostatic forces"*, Samuel Peillon and Mamadou Sow, at the 22nd European Aerosol Conference (EAC-2016, September 4-9)



#### BEST POSTER AWARD

*"Modeling of the human genome with DnaFabric for the calculation of radio-induced DNA damage"* by Sylvain Meylan, at the 13th International Conference on Radiation Shielding (ICRS-13, October 3-6)



#### PRIX DES POSTERS ÉLECTRONIQUES

*"Tomosynthèse mammaire: dose et contrôle de qualité interne"* by Julie Sage and Karen Fezzani, at the Journées francophones de la radiologie (JFR 2016, October 14-17)





# ACTIVITIES

Through its research, methods, and interactions with all stakeholders, IRSN provides completely independent assessments of nuclear and radiological risks and their consequences.



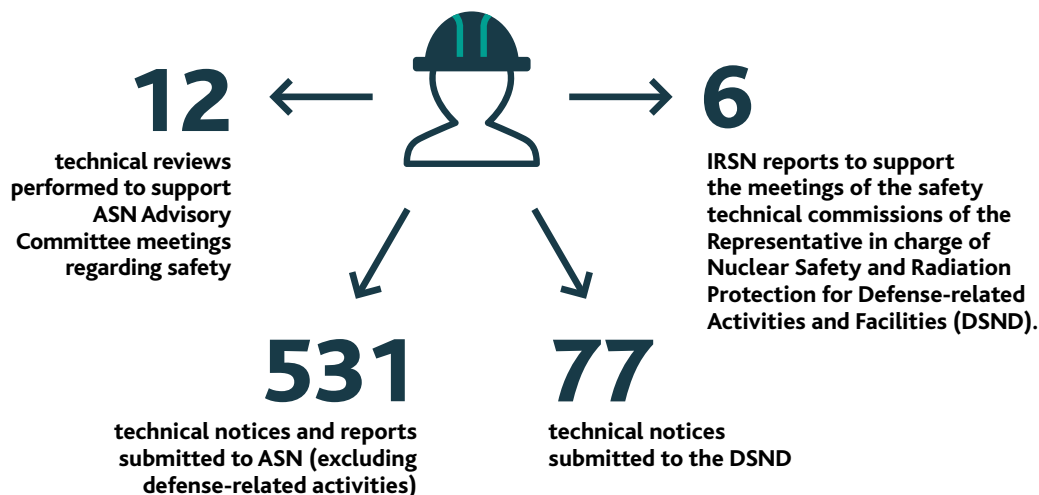
# SAFETY

As the public body responsible for assessing nuclear and radiological risks, IRSN supports the government and public authorities in their efforts to enhance the nuclear safety of facilities.

For this purpose, it combines a program of rigorous, operational assessment work, adapted to safety and radiation protection objectives - from the design to decommissioning of facilities and equipment - with a policy of excellence in research, in line with its commitments in the performance target agreement with the French government for the 2014-2018 period.

To achieve these goals, IRSN relies in particular on operating experience feedback from past events, and on the results of research and studies in areas such as aging, severe accidents, earthquakes or fuel behavior. This work concerns all civil and defense-related nuclear facilities, as well as the transport of radioactive materials and, in most cases, is carried out as part of European and international collaborations.

## KEY FIGURES



## 2016 PUBLICATIONS

- IRSN's Position on Safety and Radiation Protection at Nuclear Power Plants in France in 2015
  - Safety of the Transport of Radioactive Materials for Civilian Use in France in 2014 and 2015
  - Addressing Cultural Aspects of Organizations in Industries at Risk
  - Very Low-Level Radioactive Waste: Should Policy be Changed?
  - Considerations on the Performance and Reliability of Passive Safety Systems for Nuclear Reactors
-

# SAFETY OF CIVIL NUCLEAR FACILITIES

At the request of the Nuclear Safety Authority (ASN), IRSN carries out examinations of nuclear facilities with the aim of constantly improving their safety. In 2016, this work focused particularly on examining the measures taken by licensees following the post-Fukushima stress tests, assessing the safety risk induced by defects observed in parts making up the EPR and some steam generators at EDF nuclear power plants, and preparing the fourth ten-yearly outage inspections of 900 MWe reactors.

## FOURTH TEN-YEARLY OUTAGE INSPECTION OF 900 MWE REACTORS

As part of its assessment of the conditions under which it would be acceptable to extend the lifetime of 900 MWe reactors, IRSN **examined in 2015 the guidelines proposed by EDF**, based on the objectives set by ASN during the fourth ten-yearly outage inspections of the reactors concerned. This examination showed that **the guidelines proposed by EDF were generally in line with the objectives set**, particularly in terms of the facilities' continued compliance and safety improvements.

The effects of aging must be controlled to ensure continued compliance. This particularly concerns parts that cannot be replaced, such as the reactor vessel or the containment, or parts that are difficult to replace, such as some buried piping or electrical cables. Close attention is also paid to the extensive renovation of some systems, such as instrumentation and control.

Safety improvements, where the chief concerns are greater consideration of hazards and more effective management of severe accidents by meeting the objectives set for the EPR, will be examined in 2019. **IRSN will give its opinion on the generic phase of the safety review once all these examinations have been completed.**

Meanwhile, IRSN will examine the changes that EDF has submitted to ASN for approval, in accordance with the new regulations introduced by the Act on energy transition for green growth. **It will also contribute to the public inquiry required for extending the operating life of reactors beyond 35 years.**

## INTERNATIONAL: IRSN HELPS CHINA TO ASSESS THE FLOODING HAZARD

In February 2014, IRSN undertook **an assignment to provide the Chinese Nuclear Safety Authority, NNSA, and its technical safety organization, NSC**, with assistance in the field of nuclear reactor assessment, focusing particularly on the external flooding hazard and its consequences. This assistance, which was set out in an ASN-led contract signed with the European Commission under the European Commission's Instrument for Nuclear Safety Cooperation, was completed in October 2016.

Heading a group of European flooding experts, IRSN introduced its Chinese contacts to its assessment methods, the lessons learned from the partial flooding at the Le Blayais plant in 1999, and the various approaches that could be adapted for their purposes. It also proposed a detailed draft safety review guide for the Chinese to study and eventually use for carrying out their own assessments.

**In addition to flooding, the work carried out by IRSN covered severe accidents, studies of accidents using best-estimate methods, and analysis of operating experience feedback.**



## ANALYSIS OF THE TOP AND BOTTOM VESSEL HEADS OF THE FLAMANVILLE 3 EPR

As well as examining the documentation submitted by EDF to ASN to support its operating license application in March 2015, **IRSN is checking that the facility meets the requirements set out in the safety analysis report.** In particular, it is examining manufacturing defects detected in equipment, as well as qualification test programs carried out on this equipment under accident conditions and onsite tests, and their results.

At the end of 2014, it was discovered that the carbon concentration of the domes making up the top and bottom vessel heads of the Flamanville EPR was higher than expected and that this could affect their toughness. Areva responded by proposing a test program to determine the exact mechanical characteristics of these domes. Taking into account **IRSN's and ASN's conclusions in their review of this program in 2015, and based on the initial test results obtained, Areva extended its test program** by performing tests on a third dome, with more significant segregations and improved characterization of the material through its thickness. It also completed the dossier on the risk of sudden failure.

**In 2016, IRSN continued to analyze accident scenarios** (using the SOFIA simulator in particular) leading to thermal shocks in order to assess the risk of sudden failure in the parts of vessel top and bottom heads presenting a higher concentration of carbon than initially expected.

At the same time, **IRSN, ANCCLI, ASN and the Flamanville CLI set up informative meetings** with stakeholders to share technical information on these issues.

## ANOMALIES AFFECTING STEAM GENERATORS IN EDF'S FLEET

Following the anomaly detected on the top and bottom vessel head of the EPR reactor vessel in Flamanville (in northwest France), EDF discovered that certain steam generator channel heads contained excess carbon, thus reducing the mechanical strength of the constituent steel. **ASN requested IRSN to study the information that EDF had submitted to justify continued operation of each piece of equipment concerned.**

Following an initial assessment, ASN decided that reactors equipped with **Creusot Forge steam generators could be restarted in the summer 2016.** Then on November 30, IRSN gave its opinion of the steam generators manufactured by Japan Casting and Forging Corporation (JCFC) used in ten 900 MWe plants, and presenting the same type of chemical anomaly with higher carbon concentrations.

The analytical approach adopted by IRSN to treat the anomaly was aimed at obtaining a reasonable level of assurance that the anomaly did not affect the assessment of the risk of sudden failure of the steam generators concerned. IRSN called on BEL-V, its Belgian counterpart, to confirm its assessment of the mechanical properties of the steels with high carbon concentrations. ASN and IRSN also went to Japan to visit the manufacturer JCFC and understand more clearly what caused the excess carbon.

Subject to implementation of its recommendations and the results of inspections required by ASN, **the assessment conducted by IRSN led it to conclude that there was no risk of sudden failure of the JCFC steam generators** used with the 900 MWe reactors concerned, except for Bugey 4, Fessenheim 1 and Tricastin 4, for which EDF had yet to determine its method for analyzing the sudden failure risk.

IRSN then examined certain items in the EDF documentation on the JCFC steam generators installed on the two reactors at the Civaux plant. In early 2017, it issued a favorable opinion together with the same recommendations as those made for the JCFC steam generators on the 900 MWe reactors.

## THE SOFIA SIMULATOR: IMPROVING CONFIGURATIONS

SOFIA is a simulator developed by IRSN, in partnership with Areva, to simulate the operation of all types of reactors (900 MWe, 1300 MWe, N4 and the Flamanville EPR) under normal conditions and in the event of an accident. It undergoes constant improvements to ensure that it has state-of-the-art physical models and configurations that are consistent with actual conditions at nuclear power plants.

In 2016, SOFIA was given a more physical model of reactor vessel domes and a new version of the CATHARE 2 computer code for all reactor types. Work on updating the simulator to integrate the latest changes relating to ten-yearly outage inspections also began; they are scheduled for completion by the end of the third quarter of 2017.

## REACTOR STRESS TESTS

In 2016, IRSN continued to examine EDF's responses to the technical requirements issued by ASN, **following the stress tests performed after the Fukushima accident.**

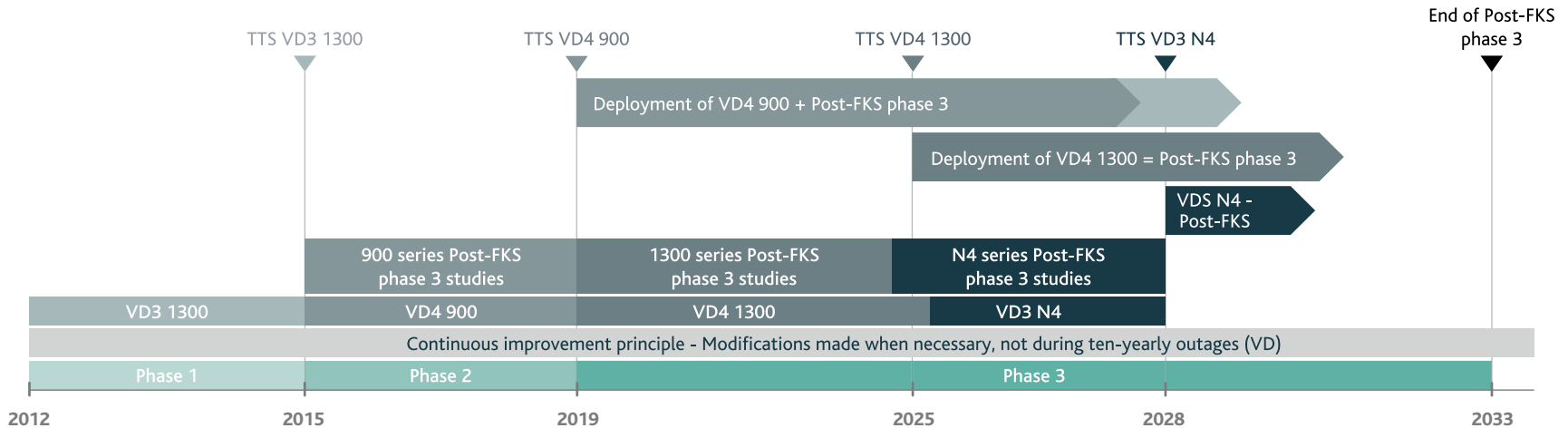
This included presenting to the Advisory Group for Reactors **its analysis of natural hazards considered by EDF to provide its nuclear plants with levels of protection** against external natural hazards - such as earthquakes, flooding and extreme climatic events - that are significantly higher than those considered in the design basis.

**IRSN found that the approach adopted and the proposals made by EDF regarding flooding were satisfactory. Further work is required on climatic hazards regarding,** for example, the ability of facilities and organizational measures to withstand and respond to more severe ambient temperatures than those considered in the design basis. Regarding the seismic hazard applicable to the hardened safety core, IRSN found EDF's proposals satisfactory at half its sites. **The seismic stresses proposed for the other half appeared inadequate in some cases,** or called for better characterization of historic earthquakes, soils or surrounding faults.

IRSN presented the results of **its assessment of the new severe accident measures** proposed by EDF to meet the safety objectives defined for extreme situations, calling for the implementation of the "hardened safety core", and with a view to extending reactor lifetimes. These measures include corium stabilization in the event of vessel failure and an additional system for removing residual heat outside the containment. **IRSN found these measures acceptable in principle but specified a number of points to be considered** concerning the detailed design of the measures, the operating strategy (with appropriate instrumentation) and the performance of the related safety studies.

**It also completed the examination of all the technical assumptions** concerning the safety improvements required by ASN, and analyzed several important measures that now need to be implemented by EDF, including the new generators. In addition, it assessed the strategies proposed for potential accident situations arising from the total loss of heat sink or electrical power following an extreme hazard. **The assessment will be presented to the Advisory Group for Reactors at the beginning of 2017.**

Timetable for the deployment of post-Fukushima measures in line with the ten-yearly outages, as announced by EDF.





# EXPERIMENTAL REACTORS

IRSN adopts the same multidisciplinary approach to assessing the safety of experimental reactors as it does for other facilities. Experimental reactors have also had to undergo post-Fukushima stress tests and must now implement reinforced safety measures.

## EXAMINATION OF THE “HARDENED SAFETY CORE” OF THE HIGH-FLUX REACTOR

Following the stress test carried out on the High-Flux Reactor in Grenoble, the Institut Laue-Langevin (ILL), the licensee that operates the reactor, made significant changes to reinforce **the resistance of the facility to extreme hazards, particularly earthquakes and flooding.**

In this context, IRSN examined the following points in 2016:

- **the conditions for commissioning a new “seismic depressurization system” (CDS),** designed to depressurize the reactor building containment following a fuel melt accident, and thereby limit radioactive release. IRSN believed that implementing the CDS would improve containment performance of this reactor in an accident situation. ILL should, however, provide additional evidence concerning the behavior of the outer metal containment of the High-Flux Reactor in the event of an extreme hazard;

- **the design requirements of the new seismic emergency shutdown system,** designed to trigger a reactor emergency shutdown in the event of an extreme earthquake. IRSN found the requirements specified by ILL satisfactory;

- **the adaptations defined by the licensee for the metal containment of the reactor,** namely the installation of rupture disks designed to open in the event of flooding, and the construction of a corridor and walkway connecting the new “hardened safety core” control and emergency room and the reactor building in extreme flooding situations. IRSN found these adaptations acceptable.



# NUCLEAR FUEL CYCLE FACILITIES

There are many different kinds of nuclear fuel cycle facilities, implementing a wide range of materials and processes. Under the French "TSN" Act relative to transparency and security in the nuclear field, these facilities are subject to a ten-yearly safety review, and IRSN deploys considerable resources to examining the documentation relating to this review.

## EVAPORATOR WEAR AT AREVA NC PLANTS

The R2 and T2 facilities of Areva's plants in La Hague are designed for separating out uranium and plutonium and fission products that are found in the solutions resulting from spent fuel dissolution. In these facilities, the fission product solutions obtained are concentrated in evaporators before being transferred to storage tanks prior to vitrification.

When the thickness of the evaporator walls was measured, it was found that corrosion in the lower part of the evaporators was more significant than expected. This could shorten the lifetime of the evaporators, as the metal from which they are made must meet a minimum thickness to prevent any risk of leakage. The licensee reviewed this minimum thickness, taking into account the different stresses (chemical, thermal, mechanical) to which the evaporators are exposed, and proposed compensatory measures aimed at slowing down corrosion.

In addition, Areva subjected the evaporators to closer monitoring and began to replace them.

In the opinion it issued in 2016 based on the licensee's proposals, **IRSN strongly recommended setting up an annual monitoring program for each evaporator** and reinforcing the measurement of residual steel thicknesses. Finally, **it considered that the additional measures proposed by Areva NC to provide more effective containment of the facilities in the event of leakage should be set up as soon as possible.**



## AREVA NP NUCLEAR FUEL FABRICATION PLANT

On November 2, 2016, IRSN presented the Advisory Committee for Laboratories and Plants with its assessment of the safety review report on Areva NP's recently renovated nuclear fuel fabrication plant (INB 98) in the town of Romans-sur-Isère.

IRSN found that **the renovation had improved safety and radiation protection**, particularly concerning the reduction of uranium contamination in rooms under normal operating conditions, the seismic behavior of facilities, and fire safety. In its assessment, IRSN identified a number of optimization measures already in place that the licensee should continue to implement during facility renovation work.

In 2012, the licensee also launched a program to provide additional protection against criticality risks. IRSN noted a number of other measures to be added to this extensive program that has yet to be finalized.

Lastly, the licensee reviewed onsite safety organization. In IRSN's opinion, the licensee should ensure that this organization is efficient and that the safety basis and operational documents are mutually consistent.

Given the additional action defined by the licensee during the review, **IRSN found that the measures introduced with a view to the continued operation of this facility were satisfactory.**

## ACTIFS LECA ACTIVE FUEL EXAMINATION LABORATORY

On July 12, 2016, IRSN presented the Advisory Committee for Laboratories and Plants with its assessment of the safety review report on LECA, the Active Fuel Examination Laboratory (INB 55), located on the Cadarache site in southern France and operated by CEA.

LECA began operating in the 1960s and underwent extensive renovation work between 2001 and 2008. The purpose of this work was to improve safety measures (particularly concerning the confinement of radioactive materials and protection against fire and criticality risks) and the seismic behavior of the building in the event of a "maximum historically probable earthquake".

Within the context of the safety review, CEA put forward plans to strengthen this building to meet seismic margin earthquake (SME) requirements. The earthquake level is that already considered to analyze the behavior of the shielded cells installed in the LECA building.

IRSN considered that **strengthening the building to SME standards was not feasible given the properties of the building.**

**It therefore recommended taking steps to mitigate the potential radiological** impact of any earthquake damage to the building (e.g. by significantly reducing the quantity of radioactive material that might be dispersed). It also considered that CEA should immediately launch its project to replace this laboratory, which has been announced for 2025.

### SAFETY REVIEWS OF LABORATORIES AND PLANTS

Many nuclear fuel cycle laboratories and plants were commissioned during the 1960s, at a time when safety requirements were not the same as today.

IRSN's task relating to the safety review of these facilities is to determine whether licensees have taken adequate steps to bring their facilities into compliance with current requirements.

# HUMAN AND ORGANIZATIONAL FACTORS

Since 2012, IRSN's Human and Social Sciences Laboratory (LSHS) has been conducting research and studies on human and organizational factors within the context of facility safety, risk management, and the influence of stakeholders on assessment processes.

## SAFETY CULTURE IN AT-RISK INDUSTRIES

In September 2016, IRSN published a report on safety culture in industries presenting particular risks. The report shows **the results of a study on the use of this notion in nuclear facility safety assessments.**

The concept of safety culture elaborated by IAEA appeared after the Chernobyl accident. It is now at the center of many initiatives to improve risk management. Starting out from this observation, the report develops the idea that safety culture cannot be considered merely as a management tool for human activities.

It goes on to define culture as a structured set of values, norms and beliefs shared by a group of people, and built on their experience. This implies that any action relating to culture involves long time frames, and calls for several levers to be brought into play simultaneously, namely organization, management tools, and professional development measures. **The report reasserts the importance of cultural aspects in the definition and implementation of safety and radiation protection management.** It also stresses, however, that when studying these aspects and the impact they might have, time must be taken to understand the principles underlying different levels of collective work units - team, professional group, site, company, etc.

## IAEA CONFERENCE ON HUMAN AND ORGANIZATIONAL FACTORS IN NUCLEAR SAFETY

IRSN took part in the international conference organized by IAEA in February 2016 on the use of **the safety culture concept. The conference was attended by 400 people.**

Its purpose was to review lessons to be learned from the past, the current situation, and safety prospects. The agenda was divided into four main themes: the role of leadership and management, systemic approaches to safety, analyzing high-reliability organizations, and assessing safety culture.

**IRSN contributed to discussions in several areas including nuclear safety management practices.** In particular, a study of the Fukushima accident allowed it to put the spotlight on organizational dynamics in emergency situations. IRSN experts also addressed the importance of analyzing operating practices, and lessons to be learned from large-scale industrial accidents.

# REACTOR AGING

One of IRSN's tasks is to examine applications to extend the operating life of French nuclear reactors beyond 40 years. To be able to do this effectively, it conducts research and studies on the assessment of certain aging phenomena. This involves the use of new facilities for studying the behavior of materials and components that play an essential role in maintaining the integrity of the reactor containment barriers.

## START OF THE ODOBA PROGRAM

The ODE experimental facility built by IRSN on the Cadarache site in the south of France consists of blocks of concrete that are fitted with instruments for monitoring aging - whether natural or accelerated. **It was opened on October 12, 2016.** It will be used as part of the ODOBA program to study aging in the concrete used in nuclear facility containment buildings in order to determine the possible lifetime of these structures.

The program, which was started up with the prospect of French nuclear reactors having their operating life extended, must help understand the phenomena behind pathologies affecting concrete, and improve knowledge of their impact on mechanical properties, and on the confinement performance of concrete structures, such as reactor containment buildings or, more generally, waste disposal facilities.

It is also aimed at validating nondestructive examination equipment and developing computing tools for predictive purposes.

ODOBA is scheduled to last ten years. It is carried out in collaboration with five foreign partners and with scientific and technical support from national research organizations specialized in the fields concerned.

## BEHAVIOR OF MATERIALS: THE MIST JOINT LABORATORY AGREEMENT RENEWED

IRSN, CNRS and the University of Montpellier have prolonged their joint laboratory agreement on the Laboratory for Micromechanics and Structural Integrity (MIST), for another five years. The laboratory pools the partners' research resources in an effort to understand and predict the behavior of materials and structures, as well as the microstructural changes in materials, under degraded conditions related to thermomechanical stress or aging.

The research carried out at MIST since its creation has enabled IRSN to boost its operational assessment capability, allowing it, for example, to acquire a fuller understanding of the permeability of cracked concrete, or to propose more realistic laws on nuclear fuel behavior for use in the accident simulation software that it develops.

**MIST will now focus its research efforts on acquiring fresh knowledge, particularly in the field of steel or concrete aging.** This work will be used to analyze the results of the ODOBA experimentation program.

# SEVERE ACCIDENTS

The studies and research conducted by IRSN in the field of reactor core melt accidents are aimed at learning more about the phenomena involved in this type of accident. Such knowledge helps to assess the appropriateness and benefits of action taken to reduce the probability or mitigate the impact of accidents. It also contributes to the development of software used for assessing the possible risks of radioactive release to the environment due to a severe accident.

## INTERNATIONAL SEMINAR ON IN-VESSEL RETENTION OF CORIUM

In June 2016, IRSN and the European Commission Joint Research Center (JRC) organized an international seminar on in-vessel retention of corium in the event of a core melt accident in a nuclear water reactor. The seminar brought together leading stakeholders in the field from around the world, including safety authorities, technical safety organizations and industrial firms. It was attended by **130 participants representing more than 60 organizations from 20 countries**, providing them with an opportunity to share knowledge and exchange views.

Debates addressed the main issues relating specifically to in-vessel retention of corium. Some of these issues are currently the focus of work carried out as part of the European In Vessel Melt Retention (IVMR) program. This program, coordinated by IRSN, is aimed at expanding knowledge and developing computer tools to reach a consensus on the best methodology for assessing the effectiveness of measures implemented to stabilize and retain corium in a water reactor vessel. Launched in June 2015, the program is scheduled to last four years. It involves 23 partners from 14 countries and employs a variety of experimental test methods and devices.

> **60**

organizations from 20 countries took part in the international conference held by IRSN and the JRC on in-vessel corium retention

## POST-FUKUSHIMA R&D: ACCIDENT SIMULATION

In connection with its post-Fukushima R&D work, IRSN contributes to the OECD BSAF project, which seeks to estimate the degree of damage to the three stricken reactors of the Fukushima-Daiichi plant, and their current status, using the main severe accident simulation codes

At the end of the first part of the project, IRSN and the U.S. Nuclear Regulatory Commission (USNRC) conducted a detailed interlaboratory comparison between IRSN's ASTEC code and the American MELCOR code, following the analysis of disparities in the results obtained by simulating the phases of fuel damage in each reactor vessel, and hydrogen release. The comparisons, published at the end of 2016 in a USNRC public report (NUREG), highlight the overall consistency of the simulations, and explain the choices of morphological models of damaged fuel that lead to the main differences observed.

In the second part of the project, IRSN used the ASTEC code in 2016 to perform detailed assessments of deposits inside the facilities and environmental release for the main radionuclides.

It found that only the monitors installed in the environment provided quantitative information on the transport and deposition of radionuclides after their release from the reactors. Adopting a novel approach, IRSN proposes that this information be used to estimate release from the reactors based on inverse methods of the atmospheric dispersion codes. The release values indirectly obtained from environmental data will be used to confirm accident progression diagnostics and the degree of reactor damage deduced from simulation results obtained with ASTEC.

## CONCLUSIONS OF THE EUROPEAN PASSAM PROJECT

The PASSAM project, launched following a European call for projects, was completed in 2016. The four-year project significantly improved knowledge concerning the effectiveness of filtration methods for use in the event of a severe accident in a light-water reactor. Led by IRSN, the project involved nine partners from six countries.

The mostly experimental work focused on ways of reducing atmospheric release in the event of a severe accident in a nuclear reactor that would involve venting the containment building. This research led to a better understanding

of the main physicochemical phenomena involved in trapping fission products as aerosols or gas. Its purpose was not only to improve some existing systems, but also to propose more innovative ones.

With the contributions by the different partners, the project has led to the creation of an extensive database on these filtration systems. This should be used to improve some of the models in severe accident computer codes - and thereby enhance emergency operating procedures - as well as to assist safety authorities in preparing their recommendations and help plant operators to decide where to install filtration systems.

## UPDATE ON THE PROGRES EXPERIMENTAL PROGRAM

**PROGRES** is an experimental program launched by IRSN, in June 2015, to determine how agglomerations – or debris beds – that might result from reactor core damage during an accident could be effectively cooled to slow down and stop accident progression. The selected test configurations are designed to find answers to this question, whether the debris bed is located in the reactor core, at the bottom of the vessel or in the reactor pit.

The first test campaign in the PROGRES program, which was carried out at the PEARL facility, was completed at the end of November 2016. It studied the impact of various parameters on the effectiveness of reflooding. The parameters considered included initial debris temperature (up to 700°C), debris specific power during the arrival of the water (up to 300 W/kg), and water injection rate or pressure (up to 9 bar). Water was injected from the top or bottom of the debris bed. A new tool for assessing the effectiveness of reflooding has already been proposed, based on an analysis of the initial results.

The next test campaign, scheduled to start in January 2017, will focus on the effects of debris bed geometry.



# FUEL

Fuel research is aimed at learning more about phenomena that could affect fuel during use in normal and accident situations. It provides IRSN with the skills, knowledge and simulation tools required for in-depth assessment of core behavior in present or future nuclear reactors.

## THE CABRI EXPERIMENTAL REACTOR: NOW READY FOR NEW RESEARCH PROGRAMS

The CABRI research reactor, in which a water loop reproducing the conditions found in a pressurized water reactor had been installed, achieved criticality in late 2015. During the following year, complete neutron characterization tests on the core of the reactor were performed at low power, followed by operating tests at power, designed to validate the operation of the new water loop. All these qualification tests will complete the renovation and modification work carried out by IRSN in readiness for the CABRI International Program (CIP) for the study of reactivity accidents. Led by IRSN under the aegis of NEA, the program brings together French and foreign partners from twelve countries to conduct research into the behavior of nuclear fuel rods and cladding, in the event of a reactivity accident in a pressurized water reactor.

It comprises 12 tests on various types of fuel (UO<sub>2</sub> or MOX) at different burnups and using different cladding materials. The first two tests were performed in 2002 in the sodium loop with which the CABRI reactor was equipped at the time. Tests will be resumed, this time in the water loop, when CEA, the licensee, has obtained authorization from ASN.

## FUEL STORAGE POOL UNCOVERY ACCIDENTS

In 2016, IRSN continued its work on the DENOPI<sup>1</sup> project for studying the possibility of cooling spent fuel stored in pools, in the event of cooling system failure. As part of the project, which is supported by the ANR investment in the future program, it is planned to create special mockups for studying:

- thermal-hydraulic phenomena: the year 2016 saw the design of an “integral” mockup for the study of pool thermal hydraulics in the event of loss of cooling. At the same time, significant progress was made in modeling and numerical simulation for a better understanding of the various physical phenomena concerned;
- the effectiveness of spraying the rods in a fuel assembly for the purpose of studying mitigation possibilities. A first cold test device was accepted for assessing spray water penetration inside the fuel assembly with air flowing in the opposite direction. The first tests were carried out in 2016. Design studies are now under way for a second device, this

time for hot tests on the effectiveness of spraying in the presence of steam flowing in the opposite direction, generated when the fuel assembly is uncovered;

- the risks of oxidation phenomena likely to impair cladding integrity: demonstration of the beneficial effect of preoxidation using water vapor, and the detrimental effect of nitrogen.

The relevance of the DENOPI project and the potential of the facility have led to additional funding from the Belgian body, BelV, which joined the project in 2016, an expression of interest by the USNRC, which should jointly fund the project as of 2017, and renewed support from the French General Commission for Investment.

<sup>1</sup>. This project receives French government funding managed by ANR under the investment in the future program (ANR-RSNR).





## LOSS OF COOLANT ACCIDENTS

Work relating to the PERFOI<sup>2</sup> project continued in 2016 for the purpose of improving knowledge of core cooling in a water reactor during a loss of coolant accident (LOCA). The project, which is funded by the investment in the future program (PIA), EDF and USNRC, comprises several **test programs**:

- **ELFE**, an experimental test program that produced significant results in 2016 on the impact of the oxide layer and hydriding on Zircaloy-4 creep laws. Additional tests are required, however, on samples that are oxidized on both sides and with a hydrogen content representative of that obtained during reactor operation;
- **tests on the COCAGNE facility** at Cadarache in the south of France. In 2016, IRSN conducted acceptance tests on this facility, which is used to simulate the thermal and mechanical conditions observed in a fuel assembly inside the reactor to study fuel rod deformation;
- **the COAL tests**, for which preparations continued in 2016. This included performing preliminary calculations using the DRACCAR code, making heater rods, and designing the test device for studying the reflooding of fuel assemblies containing deformed rods. The first experiment campaign is scheduled for 2018.

CGI granted more funding in 2016, while IRSN contacted other British and Korean partners to obtain additional financing.

2. This project receives French government funding managed by ANR under the future investments program (ANR-RSNR).

# CRITICALITY

The criticality accident is a major hazard studied in nuclear facilities, especially regarding fuel cycle facilities and the transport containers for radioactive materials. To enhance its assessment capabilities to prevent this risk, IRSN carries out research to obtain a fuller understanding of the neutron phenomena involved. Within this context, it builds partnerships to gain access to criticality experiment programs.

## INCREASED COLLABORATION WITH THE UNITED STATES

IRSN took part in the annual technical review of the Nuclear Criticality Safety Program (NCSP) led by the United States Department of Energy (US DOE), which took place in Albuquerque, USA in the middle of March 2016. The participation of a non-American organization in this event is exceptional and testifies to IRSN's special relationship with its American partners, as well as the recognition of its expertise in criticality research. It also illustrates the partnership strategy that IRSN has developed with leading international laboratories in order to obtain the experimental knowledge it requires to develop its expertise in the field of criticality, as well as reactor core neutron physics.

As part of this international partnership strategy, exemplified by its PRINCESS project (PProject for IRSN Neutron physics and Criticality Experimental data for Supporting Safety), IRSN joined the NCSP three years ago. It plays an active role in defining the program and takes part in experimental work. This collaboration also concerns work on numerical simulation tools, nuclear data assessments, and training. **IRSN contributes its criticality research expertise to the program and, in return, has privileged access to the program results.**

## NEW VERSION OF THE CRISTAL CRITICALITY PACKAGE

The CRISTAL package is the result of a project involving Areva, CEA and IRSN that dates back to the 1990s. **It is a computer tool used for criticality risk assessment** in fuel cycle facilities as well as during the transportation of radioactive materials. It comprises neutron physics software (such as the Monte-Carlo MORET code developed by IRSN), a nuclear database, computing procedures and a user interface (LATEC, a software workbench).

**Version V2 of CRISTAL was released on July 1, 2016.** Among other things, it incorporates version 1.3 of LATEC, which benefits from the first feedback from users. In addition, the CRISTAL package provides a solid database for qualification purposes, which now comprises more than 3,000 criticality experiments, and is the subject of an applied training course at ENSTTI. CRISTAL V2 will soon be available from the OECD/NEA Data Bank.

> **3,000**

criticality experiments form the basis for qualification of the "CRISTAL" computer tool for assessing criticality risk

# FIRE AND CONTAINMENT

Containment is a major safety function regarding the control of radioactive release to the environment. IRSN carries out research in this area to learn more about the phenomena relating to particle suspension mechanisms, and to assess the performance of containment systems under normal and abnormal conditions, or following an accident involving a fire or explosion.

## PERSEE EXPERIMENTAL FACILITY COMMISSIONED

As part of its research on how to reduce radioactive release and mitigate the impact of an accident, IRSN continues its R&D work to improve existing processes and develop new, more effective systems. Within this context, the experimental research program on radioactive iodine purification is aimed at assessing the performance of systems that are or could be used in the nuclear industry for the purification of radioactive iodine in all the operating domains of a nuclear facility.

**PERSEE, the experimental research facility on radioactive effluent purification, was commissioned at the end of October 2016, to respond to the growing need to purify radioactive gaseous effluent, in particular iodine-131. The facility is used to characterize the performance of all types of media, absorbent materials and iodine traps under normal operating conditions and following an accident.**

In the event of a severe accident in a pressurized water reactor, iodine isotopes account for a very significant proportion of the radioactivity released. The expertise developed around a facility of this type will also help to plan ahead for future research on the purification of ruthenium, fluorine, noble gases, and even tritium and carbon-14. Apart from its use in related French and European research programs, PERSEE is also intended to help licensees assess the performance of the materials used in the iodine traps installed in the ventilation systems of their facilities.



## RENOVATION OF THE GALAXIE EXPERIMENTAL PLATFORM

**Renovation work on the ventilation system of the GALAXIE experimental platform at Cadarache began in 2016.**

The purpose of this work is to increase the capabilities and attractiveness of the experimental devices by improving the quality of measurements, in particular concerning the ventilation flow rate, and the concentration and composition of the gases and aerosols conveyed (CO<sub>2</sub>, CO, unburned gases, soot and simulants of radioactive particles that would be found in suspension in the event of fire).

The joint interest research program carried out in collaboration with Areva on the mechanisms behind the suspension of radioactive materials in the event of solvent fires will be carried out at these facilities.

## DEVELOPMENT OF MODELING TOOLS

The year 2016 saw significant upgrades to several tools developed by IRSN. **Version v1.8 of the SYLVIA model for simulating fire, ventilation, and airborne contamination in a nuclear facility was released for use** in June. The main advances concern the models used in the PRISME project for studying cable raceway fires, and models used for studying steam condensation in ventilation systems to obtain better estimates of the HEPA filter clogging that might ensue.

**A 3D multiple-material thermal model for propagating heat inside a heterogeneous medium, composed of several materials, was used in conjunction with the ISIS computer code to simulate a fire involving bitumen drum disposal packages destined for the CIGEO radioactive waste disposal facility.** Specifically, this involved studying the effects of the heat flux generated by a fire surrounding a disposal package on the risk of thermal runaway of the bituminous matrix, caused by exothermal reaction with salts.

**The first version of P<sup>2</sup>REMICS, a tool for simulating gas and dust explosions at industrial facilities, was released.** P<sup>2</sup>REMICS is used to simulate the formation of an explosive atmosphere in a room, together with the deflagration phenomena associated with the ignition of this reactive mixture.

The validation of P<sup>2</sup>REMICS has been extended to the tests for the ANR Mi-thygene project, which is aimed at learning more about hydrogen explosions in a PWR containment building. The tests include those performed in the ENACCEF-2 containment by the University of Orleans ICARE laboratory. These involve studying flame propagation in an H<sub>2</sub>/air mixture inside a tube containing a series of obstacles that can accelerate the flame. Comparisons between calculations and experiments mainly focus on the change in flame velocity and on the gas pressure reached inside the test containment.

This tool is already used to support IRSN's assessment activities. For example, during the examination of the documentation accompanying the operating license application for the Flamanville 3 EPR, it was used to carry out a counter-calculation to assess the impact of a hydrogen explosion in a room, as well as the common mode risks between two separate divisions of the reactor.

# NATURAL HAZARDS

In order to enhance knowledge of the effects of natural external hazards likely to undermine the safety of nuclear facilities, IRSN is involved in several research and study programs that have been stepped up since the Fukushima accident.

## RESEARCH AND STUDIES ON NATURAL HAZARDS

IRSN's research on natural hazards is aimed at enhancing the robustness of the methods used for assessing extreme hazards. **Its seismic research work involves systematically analyzing the uncertainties associated with the databases used to characterize the seismicity of French nuclear sites**, and testing probabilistic methods to complement the deterministic approach adopted in the basic safety rule applicable to date. **IRSN's flooding studies focus on learning more about the extreme hazards listed by ASN** in its 2013 guide on the protection of regulated nuclear facilities against external flooding. As in the seismic field, the studies particularly explore **the potential of probabilistic assessments**. They also draw on **historical data** obtained by collaborating with historians at the University of La Rochelle on the subject of coastal flooding.

This research is carried out as part of several projects involving various partners:

- the RSNR SINAPS project<sup>3</sup> on ensuring and securing the long-term safety of nuclear facilities was started in early 2014 for a period of five years. It is part of the investment in the future program (PIA). Its goal is to ensure suitable structural behavior in the event of hazards. In 2016, IRSN studied various methods for modeling wave propagation from seismic sources to the sites concerned;
- the TANDEM project devoted to modeling the effects of tsunamis in the Atlantic and the Channel, and also part of the investment in the future program (PIA). Its results are expected in 2017-2018. IRSN's contribution particularly concerns the assessment of the tsunami hazard on the French coasts. In 2016, it studied tsunamis that could be generated in the Azores-Gibraltar region;
- a joint study carried out with CEA and ISTERRE (University of Grenoble) on the characteristics of particular site effects, in other words the ability of some geological formations to amplify seismic movements, was completed in 2016.

In addition to the above action, IRSN began to set up a group of international experts to build a database (SURE) on surface fault breaks. It also proposed creating a database on storms and historic coastal floods with its French partners.

In the field of probabilistic studies, the European ASAMPSEA\_E project to extend the scope of probabilistic safety assessments (PSAs) served to prepare guides for performing PSAs, taking into account the natural hazards that can pose a threat to several reactors on the same site.

<sup>3</sup> This project receives French government funding managed by ANR under the investment in the future program (ANR-RSNR).

# DEFENSE-RELATED FACILITIES AND ACTIVITIES

IRSN provides technical support to the French Representative in charge of Nuclear Safety and Radiation Protection for Defense-related Activities and Facilities (DSND), who reports to the French Ministers of Defense and of Industry. In this capacity, IRSN assesses the safety and radiation protection of the nuclear facilities and transport within the scope of the DSND's responsibilities.

## ASSESSMENT OF THE PROVISIONAL SAFETY ANALYSIS REPORT FOR THE SUBMARINE SUFFREN

The French Navy launched the **BARRACUDA program to replace the nuclear-powered attack submarines (SSN)** currently in service. With a view to the commissioning of Suffren, the first SSN in the program, IRSN completed its examination of the submarine's safety basis, as well as the documentation concerning port facilities at Cherbourg, where the new core will be loaded and trials performed. This examination, which had to be carried out in a very limited time, led to the fourth meeting of the reactor safety commission.

Suffren benefits from all the experience acquired by France since the construction of Redoutable, its first nuclear-powered submarine, launched in March 1967. Although its design is not a real technological breakthrough, Suffren does bring significant safety improvements. To carry out its assessment, IRSN developed new simulation tools adapted to the specific features of a nuclear propulsion reactor. These tools helped to improve its knowledge, especially regarding mechanical and thermal phenomena, nuclear fuel, and severe accidents.

## BEGINNING OF THE SAFETY ASSESSMENT FOR THE SN3G PROGRAM

IRSN examined the **safety options report (DOS) for the future third-generation, nuclear-powered ballistic missile submarine (SNLE3G)**, which will eventually replace the second generation of the same type (SNLE2G), consisting of four submarines. The purpose of this was to ensure that the safety options presented would effectively enhance safety, and that the safety issues arising in particular from new knowledge were properly addressed. The analysis also entailed looking ahead to identify any points requiring further work, or those that might call for studies to incorporate changing civilian safety concepts and policies, and adapt them to the specific requirements of naval propulsion.

## MORONVILLIER SITE DECOMMISSIONING AND CLEANUP

The **PEM experiment center at Moronvilliers** in the east of France is on the list of defense-related nuclear experimental facilities and sites. Following its shut-down, CEA initiated **a decommissioning and cleanup program for the site**. The program raises a number of issues relating to the management of polluted sites and soils, including large-scale radiological and chemical characterization, induced waste management, and post-cleanup monitoring. In order to assess the decommissioning and decontamination strategy proposed by CEA for this highly sensitive work, IRSN put its expertise to work in environmental issues, and more especially in the management of polluted sites in the civil sector. The conclusions of the assessment will certainly strengthen its approach to future cleanup programs concerning other sites.

# RADIOACTIVE WASTE MANAGEMENT

Radioactive waste management is a crucial part of any industrial project involving the use of radioactive materials. France set up a regulatory framework for the implementation of waste management solutions for all categories of radioactive waste generated by the nuclear industry. This was achieved under the Act of June 28, 2006 on the sustainable management of radioactive materials and waste, and the National Radioactive Materials and Waste Management Plan (PNGMDR). Within this context, IRSN's expertise is used in assessing the safety of various implemented or planned management solutions, as well as the robustness of the management strategies deployed.

## QUESTIONS CONCERNING THE MANAGEMENT OF VERY LOW-LEVEL WASTE

Should management solutions for very low-level waste (VLLW) be adapted? This question is addressed by IRSN's report entitled "Déchets radioactifs de très faible activité : la doctrine doit-elle évoluer?" ("Very low-level radioactive waste: Should strategy change?"), which was submitted to the French Parliamentary Office for the Evaluation of Scientific and Technological Choices (OPECST) on February 17, 2016. The report observes that the increasing amounts of waste generated by major decommissioning programs, whether under way or planned, will have a real impact on current waste management solutions, particularly as Andra's Cires waste collection, storage and disposal facility will soon reach saturation point.

Work has thus begun to consider how existing management solutions could be adapted. Three main possibilities are considered: diversifying disposal solutions to reduce transportation, i.e., disposing of the lowest-level waste near decommissioning sites or on nuclear sites; recycling by melting recoverable materials, particularly metals, which entails determining the economic and industrial feasibility of the possible recycling solutions, and demonstrating that the recycled products will have no impact and; lastly, adapting site cleanup initiatives, as proposed in ASN's recently published Guide 24, when total decontamination involves major implementation problems, and when the quantities of very low-level waste generated outweigh the expected benefits of cleanup operations.

Whatever the solution(s) adopted, confidence in the selected management solution will be based on its capacity to reliably characterize the radioactive level of the materials or waste generated and the pollution of the site. **In this respect, IRSN considers that research must be carried out** to identify the best radiological characterization techniques and methods, and make them available for use.

It emphasizes that any choices regarding a change in strategy can only be validated with the **full involvement of civil society**, and that steps should be taken to **debate the issues and explore all avenues, without overlooking any of the aspects concerned**.

## EXAMINATION OF THE PNGMDR ENVIRONMENTAL ASSESSMENT REPORT

The Environmental Authority asked IRSN for an assessment before publishing its notice on July 20, 2016 on the environmental assessment of the National Radioactive Materials and Waste Management Plan (PNGMDR) 2016-2018, which is regularly updated under the joint authority of ASN and DGECC. The assessment determines to what extent the measures recommended in the PNGMDR limit the environmental impact of all types of waste management activities. It thus examined efforts to minimize waste volumes and prevent waste dispersal, potential risks of soil, water and air pollution, possible risks to biodiversity, and “conventional” sources of pollution, etc.

Based on its examination of the assessment report, IRSN found that the measures contained in the plan generally limited the potential environmental impact of waste, considering such essential criteria as health protection and environmental preservation. It did, however, point out some areas where improvements could be made. In particular, it recommended studying the environmental impact of the management solutions adopted for very low-level waste (VLLW) and low-level long-lived waste (LLW-LL)





# GEOLOGICAL DISPOSAL OF RADIOACTIVE WASTE

The specific nature of geological disposal projects calls for a combination of assessment expertise, research resources and measures to ensure the involvement of social stakeholders. IRSN is involved in all these areas, both at the national and European levels. As part of its work in four ongoing H2020 projects, it helps to promote the emergence of a European research strategy, define new governance methods involving various stakeholders and using tools aimed at improving their skills (SITEX II and JOPRAD) and, of course, contributes to the scientific research required to increase knowledge and improve safety in the long term (MODERN and CEBAMA).

## SITEX II: INVOLVING CIVIL SOCIETY IN THE GOVERNANCE OF RADIOACTIVE WASTE DISPOSAL

Within the context of the European SITEX II project, which it has coordinated since June 2015, IRSN took part in testing a method aimed at involving civil society more directly in studies of long-term management options for **high and intermediate-level long-lived waste**. **Involving civil society in the governance of a radioactive waste disposal facility is one of the six lines of research for the 18 partners in the SITEX II project**, which is aimed at developing an international network of experts in the safety of such waste repositories.

The test was carried out as an exercise in Budapest in June 2016. During the exercise, **35 participants, divided into groups comprising a mixture of institutional stakeholders and representatives of civil society and NGOs, were asked to test several waste management scenarios by subjecting them to a variety of disruptive events**, such as serious delays, loss of funding, or terrorist attack.

They were then asked to perform a robustness assessment based on a set of criteria defined in advance: disposal flexibility, transfer of risk to future generations, robustness in terms of technological progress, safety, etc. The participants in this collaborative and comparative assessment exercise stressed the benefits of sharing views as a way of calling into question established methods. This confirms the advantages of stakeholder involvement in a technical assessment.

## OPERATING EXPERIENCE FEEDBACK ON THE ACCIDENTS AT THE WASTE ISOLATION PILOT PLANT IN THE USA

After operating for 15 years under nominal conditions, the Waste Isolation Pilot Plant (WIPP), a deep geological radioactive waste repository in New Mexico in the United States, was the scene of two accidents in February 2014. First a fire broke out in the northern part of the underground facility, then radioactive release occurred in the southern area.

In 2016, IRSN published on its website an updated review of the main inquiries set up by the American authorities to report on the causes and consequences of these events. For IRSN, the analysis of the events highlights several conditions that are essential to safety in an underground disposal facility: the waste packages must provide a robust containment barrier; a monitoring system must be set up to detect and correct any anomaly before radioactive material is released; the safety demonstration must take into account potential deviations in operating control and; lastly, measures to mitigate the impact of any incident must be incorporated in the design of the facility.

## HALF-WAY REPORT ON THE EUROPEAN JOPRAD PROJECT

IRSN is involved in JOPRAD (Towards a European Joint Programming on Radioactive Waste Disposal), a project aimed at **better coordinating European research in the field of deep geological disposal of radioactive waste**. Launched in June 2015 and scheduled to last 30 months, JOPRAD brings together waste management operators, TSOs, academic research organizations and expert groups from civil society. For the first time, participants are working together to define shared research goals, and set up an exchange network between the different communities, as well as a training scheme.

A seminar in Prague in September 2016 allowed participants, including NGOs, to discover the progress made in the work on the strategic research agenda - the final version of which will be presented in London in spring 2017 - and on the governance of future European research activities. This joint research agenda and the proposals regarding the governance of scientific research will provide a working basis to propose the implementation of European Joint Programming as of 2019, according to the current schedule of the European Commission H2020 framework program.

## MODERN 2020: PREPARING TO MONITOR FUTURE GEOLOGICAL WASTE REPOSITORIES

Modern2020 is a European project set up to **develop and test tools and methods for implementing an operational monitoring program for deep geological radioactive waste repositories**. The purpose of monitoring is to ensure that the repository remains within the operating domain for which it was designed.

In this project, IRSN is particularly concerned with work to define monitoring strategies and to demonstrate that the selected sensor technologies are operational. Concerning the last point, **IRSN is conducting two *in situ* tests at the Tournemire underground laboratory**, as well as performance tests on sensors of various technological design when exposed to radiation in its IRMA gamma radiation facility in Saclay. The first *in situ* test, which studies the performance of the wireless transmission system, was set up in spring 2016. A second test to study aging under *in situ* conditions of a wide variety of sensors will be set up within a year. The first results of these tests are expected in two years.

## CEBAMA: UNDERSTANDING AGING PHENOMENA IN CONCRETE IN GEOLOGICAL REPOSITORIES

The purpose of the Cebama project is to **study changes in the physicochemical behavior of various cement-based materials, under conditions studied to represent the geological repository designs** planned in Europe.

The project considers many issues, including the identification of interface processes between the cementitious materials and host rock (clay rock or granite), and between the cementitious materials and the swelling clay (bentonite) used in the seals. Identifying these processes will make it possible to assess their impact on the physical properties of the materials involved.

Within this context, **IRSN is performing a series of three *in situ* tests at its Tournemire underground laboratory to study the effect of temperature (70°C)** on the interfaces between low-pH concrete and clay rock. The experimental devices were installed in the spring 2016 and will be dismantled for post-mortem analysis by the end of 2019.

# NUCLEAR SECURITY

In 2011, the regulations on the protection and control of nuclear materials, nuclear facilities and nuclear material transport were extended to include malicious acts with potential radiological consequences. In particular, these regulations require licensees to carry out a study to demonstrate the level of protection provided, the action taken to respond to an attack, and the organizational structure set up to manage it. In order to assess these studies, IRSN adopts an interdisciplinary approach with contributions from experts in nuclear safety, radiation protection, and physical protection against malicious acts.

# NON-PROLIFÉRATION

International nuclear material control is undergoing some major changes, essentially aimed at enhancing the effectiveness and efficiency of inspections. IAEA and EURATOM are seeking in particular to improve their methods so that resources are assigned where they are most needed, and thus reduce the number and duration of assignments. In such a constantly changing environment, it is IRSN's task to ensure that France and French companies comply with international requirements, and that the application of these requirements is not detrimental to the interests of France and French industry.

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## 2016 PUBLICATION



Account Coding Manual for Nuclear Materials

# NUCLEAR SECURITY

## EXAMINATION OF NUCLEAR POWER PLANT UPGRADES

EDF must bring its nuclear power plants into compliance with the 2011 regulations on protection against malicious acts. Within this context, the licensee carried out an inventory of its facilities in 2012 that IRSN assessed. The licensee then made a security model of its nuclear facilities and set up an engineering change program. This “security” program includes several mostly generic changes that will be introduced in all plants over a period of several years. **IRSN is responsible for examining the most important of these.** They include installing new plant monitoring systems (cameras, video wall) and tighter access control to facilities (biometric authentication, secure access badge processing). At the same time, **IRSN is also assessing the Flamanville 3 EPR security study.**

The aim of these assessments is to ensure that the measures implemented by EDF provide its facilities with adequate protection against design-basis threats. They will also help to identify any additional measures required.

## MODERNIZATION OF NUCLEAR MATERIAL TRANSPORT SECURITY MEASURES

On January 1, 2016, IRSN commissioned a new application called Mazarine, which is designed to help it carry out its work relating to the security of nuclear material transport. This task is assigned to IRSN under French regulations. IRSN - and more specifically IRSN Transport Operations (EOT) - handles **more than 1,500 nuclear material transport requests every year. It is involved on three levels: issuing the approval for the shipment; monitoring the shipment; and alerting the authorities in the event of a malfunction or incident**, whether due to a technical problem or malicious act. As the information tools previously used by EOT were nearing obsolescence, IRSN designed an application with improved functions, featuring tools for checking that administrative transport requests comply with regulations, and for monitoring the shipments concerned.

In addition, Mazarine can easily incorporate changes to national regulations on the transport of nuclear materials and protection against threats. In this respect, it simplifies the detection of any need to alert the safety authorities. This modernization will continue with the improvement of interfaces with national emergency response centers.

## NUCLEAR SECURITY EXERCISE PERFORMED

On October 20, 2016, the EPEES 9 nuclear security exercise simulated a terrorist attack on the reactor at the Institut Laue Langevin (ILL) in the city of Grenoble. A preliminary tabletop phase was carried out to test the suitability of the organization set up by the operator in charge of emergency response concerning security, as well as its resources and those of the government in an urban context. At the end of this phase, the licensee reinforced its system of protection. EPEES 9 involved many people and organizations: the licensee, the Prefect, the State Prosecutor, the rapid deployment forces, the bomb disposal unit, emergency response teams, CEA Grenoble, the ASN national and

local emergency organization, and the IRSN emergency response teams, with fifteen coordinators and assessors. SESAM - IRSN's department for security assessment regarding malicious acts - was responsible for creating the scenario and preparing and coordinating the exercise, with help from SESUC, the emergency response assessment department. On December 15, 2016, IRSN presented the stakeholders with the lessons learned from observations made during the exercise, which were gathered together in a special assessment guide produced for this purpose.

## PROGRESS IN THE PROTECTION OF NUCLEAR MATERIAL TRANSPORT

In June 2016, the French Ministry of the Environment, Energy and the Sea decided to set up a new group of experts for the protection of nuclear material transport against malicious acts. IRSN is the group's secretary and provides it with logistic support, as well as expertise through the special studies it conducts. For the record, the work of the previous group of experts on transport led to the definition of design-basis threats, including means of attack, and a methodology for implementing the necessary conditions to protect shipments against threats of sabotage. In 2016, the work carried out consisted in presenting the results obtained by implementing the method.

**IRSN assessed the effect of various forms of attack on packages containing nuclear materials.** Drawing on the resulting inventory, it proposed prioritizing risks in terms of the intrinsic vulnerability of the transported packages. It then identified additional technological measures to protect the materials inside the packages. It also proceeded to analyze the possibilities of reinforcing the organizational measures relating to the security of nuclear material transport. At the same time, **it initiated a study for drafting technical specifications for additional security systems installed on nuclear material transport vehicles to enhance security in this area.**

## RADIOACTIVE MATERIAL TRANSPORT AND THE IMPORTANCE OF TEST CONDITIONS FOR NEW PACKAGE MODELS

When the safety of radioactive materials is at stake, it is vital for qualification testing on transport packages to guarantee the confinement of the materials under real transport conditions, including in the event of accident. For this reason, IRSN makes every effort to ensure the representativeness of mockups used in tests (collisions, drops, fire, etc.) carried out in the context of approval applications for new package models. For this purpose, the designer submits a program setting out the tests it plans to perform, with details of the characteristics of the mockup used, the test slab, drop sequences, etc. **IRSN then checks that this mockup is representative in terms of geometry, weight, and mechanical characteristics.**

It checks that the actual mechanical characteristics allow sufficient margins considering the specified minimum characteristics. **It then analyzes the test results obtained in order to give a technical opinion of package performance under all transport conditions.** Note that if the packages are involved in safety studies, they are also concerned by security studies. Consequently, package characteristics are also considered as important data for security studies relating to nuclear material transport and threats from malicious acts.

# NUCLEAR NONPROLIFERATION

## NEW VERSION OF THE CODIFICATION MANUAL FOR NUCLEAR MATERIAL ACCOUNTANCY

A centralized accountancy system is essential for protecting nuclear materials and controlling them inside facilities. To be effective, the accountancy reference manual must be known and shared by all parties concerned, whether at nuclear power plants or in centralized departments.

This technical reference manual provides a formal list of rules and practical procedures, and is used by license holders on a daily basis. The new version published by IRSN presents accountancy notions and details of changes in regulations since 1995 in concise informative sheets. A summary is included to allow users to easily find the information and the common codes they require.

## WEB PORTAL FOR COMPANY ONLINE DECLARATIONS

To optimize the process that began in 2004, IRSN opened the PASTEL web portal for online declarations at the end of 2015. **PASTEL provides the companies concerned with a simple tool for completing and submitting their declarations of nuclear-related activity. It also makes it easier for IRSN to gather, centralize and analyze the data transmitted under France's Additional Protocol to the Safeguards Agreements on nuclear materials and facilities signed with IAEA.**

This protocol contributes to the fulfillment of France's international obligations regarding nonproliferation. It is also aimed at providing more information about the State's activities, particularly regarding collaboration with other countries, thus increasing IAEA's capacity to detect clandestine activities.

Under the French Protocol, France must declare its R&D activities, cooperation, and transfers of certain equipment and materials to any non-nuclear weapons State. IRSN gathers the information sent by all parties concerned, and ensures that it is complete, verified and consistent. It then prepares the national declaration sent to IAEA by the Euratom Technical Committee (CTE), which is the responsible French authority. Targeted training sessions attended by 65 organizations subject to declaration requirements were organized to coincide with the opening of the portal, the related declaration manual was updated, and a 24/7 hotline was set up during the declaration period.

# CHEMICAL WEAPONS BAN

All the States Parties to the Chemical Weapons Convention (CWC) have undertaken to make a fair and exhaustive declaration of the activities of their industrial chemical sites. To ensure that France abides by its international commitments, IRSN, under its agreement with the Ministry of Industry, completes the declarations that France must submit to the Organization for the Prohibition of Chemical Weapons (OPCW), analyzes documents and draft documents regarding inspections of products covered by the Convention, and escorts all OPCW inspections carried out in France.

## FEEDBACK FROM OPCW DAY

OPCW Day commemorates the entry into force of the Chemical Weapons Convention. Last year, it was held on May 2-4 at OPCW headquarters in The Hague. IRSN was there to present French expertise relating to commitments under the Convention in the industrial sector. **It demonstrated its competence in preparing national declarations required by the OPCW and in escorting international inspections.** IRSN is delegated by the Senior Defense Official of the Ministry of Industry to implement the CWC in France. The Convention is aimed at destroying chemical weapons and preventing their reemergence, by controlling certain chemical precursors which, although they are conventionally used in industry, could be diverted from their peaceful use in order to manufacture weapons. IRSN described its method for achieving the twofold objective of an exhaustive and fair

national declaration. This method is based in particular on the transposition of OPCW decisions in French law, data crossing, partnerships with unions in the chemical industry, traders and customs, and a training and information initiative for industry. IRSN has escorted more than 120 inspections since 1997.

It has developed a method for preparing companies for inspections and for anticipating requests from OPCW inspectors.

In order to ensure that these inspections go smoothly, IRSN visits more than 20 companies every year and goes to the sites concerned as soon as an inspection notification is received. Its task is to protect French industrial secrets while ensuring that obligations under the Convention are met.

IRSN provides the Ministry of Foreign Affairs with significant scientific and technical support on these topics.

> **120** OPCW inspections have been accompanied by IRSN since 1997

# RADIATION PROTECTION – HUMAN AND ENVIRONNEMENT HEALTH

IRSN's action in this field is aimed at ensuring that people and the environment are suitably protected against ionizing radiation.

It focuses on three main areas: radiological monitoring, assessments and research. This includes monitoring the exposure levels of workers and the public, developing measurement systems and equipment, conducting radioecology studies and research into the effects of chronic radiation exposure, and the medical treatment of radiation-induced lesions. IRSN adopts a multidisciplinary approach to all these subjects, in collaboration with national, European and international experts.

## KEY FIGURES



→ **6 247** environmental samples taken for radiological measurements

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



→ **740** whole-body radiation counts performed for worker monitoring, including 240 fixed and 500 using mobile equipment

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**430** monitors (including 393 stationary Teleray monitors, 30 mobile monitors and 7 river monitors) making up the national remote monitoring network

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**130** ambient dose rate measurement points

## 2016 PUBLICATIONS



2015 Management Report of the National Environmental Radioactivity Measurement Network (RNM)

2015 Report on Radioactivity Monitoring in French Polynesia

Occupational Exposure to Ionizing Radiation in France: 2015 Report



# ENVIRONMENTAL MONITORING

The goal of environmental monitoring by IRSN is to characterize radioactivity in the environment through measurements and the use of suitable analytical methods. Its purpose is to ensure that nuclear and radiological activities comply with regulatory authorizations and, more generally, that radiological conditions remain satisfactory throughout the country. It also helps to detect any abnormal situations that might result from a radiological or nuclear accident in France or abroad. This activity, carried out in consultation with stakeholders and the public, includes a continuous effort to improve measurement tools and resources.

## REPORT ON THE RADIOLOGICAL STATE OF THE ENVIRONMENT IN FRANCE IN 2011-2014

At the beginning of 2016, IRSN published the latest edition of the Report on the Radiological State of the Environment in France, as it has done on a regular basis since 2004 as part of its radiation protection work, which includes continuous monitoring and issuing alerts when necessary. The report consolidates and analyzes all the measurements taken between June 2011 and December 2014 by the members of the National Environmental Radioactivity Measurement Network (RNM), namely IRSN - through its nationwide operational radiological monitoring system - and other public and private organizations, including the licensees of nuclear facilities, local authorities, associations, and NGOs. The 2011-2014 report shows, for the first time, assessments of population exposure to ionizing radiation based on environmental measurement results, and puts these results into perspective.

In particular, the report shows that the levels of radioactivity measured in the vicinity of nuclear sites remain low, and only contribute very slightly to the annual exposure of the French population. The highest calculated doses are well below those associated with natural radioactivity.

The atmospheric deposits due to the Fukushima accident in Japan were 500 to 1,000 times lower than those measured immediately after the Chernobyl disaster in Ukraine, and their influence has fallen below the measurement threshold since mid-2011.



## DORDOGNE DRAINAGE BASIN: A PILOT SURVEY FOR RADIOLOGICAL MONITORING OF FORMER MINING SITES

IRSN has adopted a new approach to the radiological monitoring of the 250 former uranium mines that were in use from 1948 to 2001 in 27 French departments. It has chosen the drainage basin of the Dordogne River, where 23 of these sites are located, to carry out a pilot survey.

An initial inventory focused on monitoring water streams, which are the major transfer pathways for radionuclides. IRSN drew up a map showing the distribution of uranium and radium-226 concentrations in this area, based on 93 samples of water, sediments and water plants, as well as an analysis of locally grown food produce.

**According to the survey, former mining sites have no perceptible environmental impact on the scale of the drainage basin, outside directly mined areas.** In line with its policy of opening up to society, IRSN invited local stakeholders to take part in preparing the sampling plan for the survey, and organized meetings to present the results.

→ **250** former uranium mines are involved in the radiological monitoring carried out on former uranium mining sites

## ASSESSMENT OF PAST PLUTONIUM DISCHARGE IN THE LOIRE

Two of the reactors at the Saint-Laurent-des-Eaux A nuclear power plant in the center of France experienced core melt accidents: reactor SLA1 on October 17, 1969, and reactor SLA2 on March 13, 1980. In April 1980, the container of a fuel element burst in a storage pool, leading to significant contamination of the pool water. The water was filtered, then discharged into the Loire River.

IRSN, working with the University of Tours, took a sedimentary archive in the banks of the Loire, downstream from the city of Angers. Its analysis revealed increases in plutonium concentration for 1969 and 1980, the years in which the two accidents at the Saint-Laurent-des-Eaux plant occurred.

Using this approach, **IRSN designed the Archéo project, which will help to reconstruct the radiological environmental impact of the nuclear industry, based on an analysis of the sedimentary archives of all the main rivers:** the Loire, Rhône, Rhine, Garonne, Meuse, Moselle and Seine.

## CERTIFICATION OF RADIOACTIVITY MEASUREMENT LABORATORIES: SIX INTERLABORATORY COMPARISON EXERCISES

The reliability of the measurements performed by the laboratories in the National Environmental Radioactivity Measurement Network (RNM) is crucial for effectively monitoring environmental radioactivity levels. As part of its assistance to the public authorities and its operational support to the RNM, **IRSN coordinates and conducts periodic interlaboratory exercises as part of the procedure that laboratories must go through when applying for certification.** During these exercises, laboratory analysis results obtained from identical samples of a variety of matrices (water, soil, filters, milk, plants, etc.) are compared with reference values determined by IRSN.

In 2016, **IRSN organized five such exercises for 74 laboratories** applying for RNM certification, as well as **an exercise for 13 laboratories belonging to the DGAL and DGC-CRF network.** The exercises are carried out in accordance with a procedure accredited by COFRAC and backed up by a dedicated website (CILEI).

These tests, which have been in place since 2003, are part of an effort to ensure the continuous improvement of measurement quality.

## INTERNATIONAL RADIOECOLOGY RESEARCH COLLABORATION AT CHERNOBYL

On August 30 and 31, 2016, IRSN took part in a workshop organized in Ukraine by COMET (Coordination and implementation of a pan-European instrument radioecology), an international consortium of which IRSN is a member. The theme of the workshop was: “Thirty years after the Chernobyl accident what do we know about the effects of radiation on the environment?”

The event was attended by researchers, experts, regulatory bodies, NGOs and the media. It provided an opportunity to look back over the radioecology research conducted in the past few decades in the Chernobyl exclusion zone on the effects of chronic exposure to ionizing radiation in non-human species.

IRSN is involved in all the work of COMET, a research project that was launched in August 2013 for a period of four years, bringing together thirteen organizations from ten countries in the European Union, as well as Ukraine and Japan. More specifically, IRSN coordinates research on the effects of low-dose exposure. Among other things, the workshop highlighted the indisputable contribution of in situ studies that focus particularly on the characterization of the total doses absorbed by organisms, and the need for access to data relating to effects.

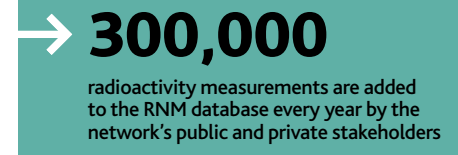
## NEW WEB PORTAL FOR THE RNM

The National Environmental Radioactivity Measurement Network (RNM), which IRSN manages, **has revamped its public access website**. The network, whose steering committee is chaired by ASN, pools all the environmental radioactivity monitoring data in France, and ensures its quality and consistency.

Since 2010, the website ([www.mesure-radioactivite.fr](http://www.mesure-radioactivite.fr)) has provided users with access to the 300,000 radioactivity measurements taken every year by RNM members in the private and public sectors.

**The only initiative of its kind in Europe, this browsing space allows individuals to learn more about radioactivity monitoring around their home and place of work and to keep track of it over time.**

The new, easier-to-use website features a “guided” browsing tool with a region-by-region approach for the general public. It provides access to a selection of 15 measurement types that are the most representative of the radiological state of the environment. An “advanced” consulting tool, intended for a more informed public, allows access to the entire database. User can carry out their own searches and exports, based on the 1,300 measurement combinations available on the site (type of sample, radionuclides, and measurement units).



## FOCUS

### INVENTORY OF RESIDUAL RADIOACTIVITY FROM NUCLEAR TESTING AND ACCIDENTS

Thirty years after Chernobyl, IRSN has evaluated the residual effect of fallout from the accident, and from atmospheric nuclear weapons testing, on the population in the most exposed regions of France (affected areas of the Vosges, Jura, southern Alps, Pyrenees and eastern Corsica). It measured activity in soil, sediment, and food samples taken in 2013 and 2014 in the areas affected by residual fallout, as well as the dose rate in the air. The radiological survey report, published by IRSN in 2016, on residual artificial radioactivity

shows that external exposure to radioactivity due to residual fallout from the past is almost exclusively related to cesium-137 in the fallout from Chernobyl. Internal exposure through the ingestion of foodstuffs, however, is generally related to the incorporation of strontium-90 from nuclear testing. Doses to the population due to the incorporation of this radionuclide were nevertheless extremely low. Doses due to cesium-137 only need to be taken into consideration for people whose diet includes a lot of mushrooms and game, where doses can reach 0.5 mSv/year.

# RADON AND POLLUTED SITES

In recent years, IRSN has taken part in a joint initiative with local institutional and professional stakeholders to raise public awareness to the risks associated with radon, and to encourage the persons concerned to detect and measure the presence of this naturally occurring, carcinogenic radioactive gas and take action to prevent its concentration. IRSN also studies the impact of past or present industrial activity on the environment and population.

## RADON CAMPAIGN IN HAUTE-VIENNE

Radon is a radioactive gas that pollutes the air inside buildings. It is also the second cause of lung cancer, after tobacco smoking. It occurs naturally throughout France, but more especially in regions with granite subsoils.

As part of its work to help local and regional authorities to manage the radon risk, IRSN started a pilot program with **two intercommunal authorities in Haute-Vienne**, a department where radon exposure is particularly high. This joint initiative, which will last nearly two years, called “Radon: let’s take up the challenge, let’s have a change of air”, sets out to provide residents with comprehensive assistance, including: measuring radon, locating radon concentrations and taking steps to reduce them, contacts with contractors to carry out works, and conducting control measures. The initiative began with the free distribution of a measurement kit to all interested residents of the 15 municipalities concerned. In all, 811 residents went to their town hall to pick up their dosimeters.

In May, IRSN provided each household taking part with individual and confidential information on the radon concentration measured in their home. Residents who were interested were then given advice and assistance by IRSN and Felletin building trade school to help them reduce their radon exposure, and assess the effectiveness of the steps taken.

The program will be completed in mid-2017, when IRSN will analyze the feedback from this initiative, which is both innovative, in terms of the variety of tools deployed and the types of assistance given, and original because of the decision to put citizens at the center of radon risk management.

→ **811**

people collected radon measuring kits from town halls under the pilot program run in Haute-Vienne



## ASSISTING THE PAYS DE LA LOIRE DREAL IN THE WASTE ROCK INVENTORY

The radon measurement campaign carried out by Areva in connection with the national inventory of waste rock used in the public domain, revealed a number of buildings with very high radon concentrations. **In June 2016, following a request from the Pays de la Loire Regional Directorate for the Environment, Town and Country Planning and Housing (DREAL), IRSN was asked to assess and give a second opinion on several homes in Mortagne-sur-Sèvre and Saint-Germain-sur-Moine, in the west of France,** where Areva had measured very high radon concentrations. The aim was to determine why radon was present. These assessments were in connection with the national inventory of waste rock used in the public domain, and also part of IRSN's support to the public authorities for the management of radon exposure in areas with a particularly high risk.

## ASSESSMENT FOR THE RECONVERSION OF THE VAUJOURS SITE

**For the past two years, IRSN has assisted ASN and the department prefects on the project to reconvert Vajours Fort,** in the Greater Paris region.

From 1955 to 1997, the fort was used by the CEA's Military Applications Division to carry out explosive experiments and to study the dynamic behavior of materials in response to shock. Some of these experiments involved the use of natural or depleted uranium compounds. The site reconversion project, led by a company called Placoplatre, has been set up with a view to mining a gypsum seam under the old fort, and carrying out any necessary cleanup and dismantling work on the existing superstructures and infrastructure.

In 2014-2015, IRSN examined two phases of work on the demolition of 250 existing buildings. Then, **in 2016, it analyzed the work methods planned to deal with buried piping on a part of the site.** It found that the overall radiological monitoring strategy adopted by the licensee should, in principle, make it possible to check that there is no residual contamination in this piping after washing, or in the wash water. IRSN did, however, detect some additional requirements and points that called for further clarification before this strategy could become operational. Lastly, it considered that the steps taken by the licensee for managing rubble from the piping work were satisfactory from the regulatory viewpoint.

## ASSESSMENT OF THE IMPACT OF THE RED MUD STORAGE FACILITY IN GARDANNE

**Further to a request by the Directorate-General for Risk Prevention (DGPR), IRSN examined the study to determine the radiological impact of the bauxite residue disposal facility at Mange-Garri,** near Gardanne in the south of France, on the surrounding population. Following a change in the license granted to the Alteo plant in Gardanne to discharge bauxite residue to the sea, this waste product must now be stored at a special land facility. Given the natural radioactivity of the residue, and the risk of dust dispersal, the disposal facility has raised the issue of risks to the public.

IRSN began by examining the assessment carried out by the company. The examination confirmed that the site presented only **a slight radiological risk, but also revealed gaps in the models used in the impact assessment.** To supplement its analysis, IRSN then helped to gather data as part of a measurement campaign supervised by BRGM, the French Geological Survey. Although the campaign was too short to provide dust dispersal scenarios representative of all the meteorological conditions liable to affect the site, the results of the analyses performed confirmed IRSN's initial findings. IRSN presented the results of its assessment to the Alteo Site Monitoring Commission on September 26, 2016.

# RADIATION PROTECTION IN THE WORKPLACE

IRSN is responsible for pooling all data concerned with monitoring occupational exposure to ionizing radiation in France. In addition, it produces an annual report on occupational exposure according to the main sectors of activity. In 2016, as part of the transposition into French law of the European Euratom directive on basic safety standards for radiation protection, IRSN was involved in work to improve regulations on radiological monitoring in the workplace.

## OCCUPATIONAL EXPOSURE REPORT



# 386,070

workers monitored (+1.7% compared with 2014)

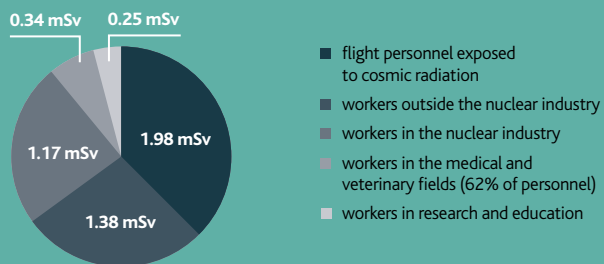


# 0,17 → 2

mSv average individual external exposure (compared with 0.16 mSv in 2014)

cases where the regulatory 20 mSv limit was exceeded (compared with 9 cases in 2014)

## Exposure by sector of activity (average values)



IRSN monitors occupational exposure to ionizing radiation as part of its activities relating to continuous radiation protection monitoring, and support for the public authorities. The 2015 report covers all sectors of activity subject to the licensing or declaration regime.

## TRANSPPOSITION OF COUNCIL DIRECTIVE EURATOM 2013/59

In 2015, IRSN was actively involved in transposing into French law the Council Directive Euratom 2013/59 of December 5, 2013, which lays down basic safety standards for radiation protection. In 2016, it stepped up its technical support to the authorities in charge of this transposition, carrying on from the work completed in 2014 and 2015.

In this context, it played an active part in and devoted considerable resources to the **regulatory revision of the Public Health Code and Labor Code, in association with the Directorate-General for Labor (DGT), ASN, and representatives from industry and from various associations.** IRSN's role in this work involved **incorporating all the latest requirements: lowering the equivalent dose limit to the lens of the eye, lowering the reference level for radon concentration in the air, and reviewing the notion of radiation protection specialist (PCR in France).**

The goal was to make regulations simpler and ensure greater consistency between protective measures against ionizing radiation and the legal provisions set out in the Labor Code.

IRSN's close involvement will continue with its participation in drafting the implementing orders of the transposition decree. All this work is scheduled for completion by the end of 2017.



## COORDINATING THE INITIATIVE TO HARMONIZE OCCUPATIONAL DOSE MONITORING IN EUROPE

Individual dose monitoring is carried out to obtain objective information on the levels of occupational exposure to ionizing radiation, and to assess the effectiveness of radiation protection measures. Until recently, monitoring practices could vary from one EU Member State to another.

As part of its work on the new Council Directive Euratom 2013/59, the European Commission assigned IRSN the task of **developing a European “platform” for harmonizing these practices.** The result is “ESOREX-Platform”, which has been set up to encourage EU Member States to exchange information on regulatory measures, individual monitoring practices, and national statistics on occupational exposure, made available in the same format. **IRSN is in charge of technical maintenance and coordination of the platform, which brings together 22 European countries.**

Of these, 14 have already provided information on the procedures used to monitor exposed workers, and 11 have entered national exposure statistics. Designated national experts in occupational dose monitoring can access the entire content of the platform, while some information is also available for consultation by the general public<sup>4</sup>.

4. <https://esorex-platform.org>.

## A NEW CUSTOMER WEB PORTAL FOR THE IRSN DOSIMETRY LABORATORY

The IRSN dosimetry laboratory provides **24,000 businesses and professionals from many sectors of activity with passive dose monitoring services, in full compliance with regulations,** and in a highly competitive market.

In 2016, **the laboratory moved into a new building on the IRSN site in Le Vésinet, near Paris.** It also added new features to its “customer” web portal that was opened in 2015. Customers can now complete online all the steps they need to manage their passive dosimetry. In particular, they have access to **tools for reconstructing dose histories** to optimize the future exposure of their employees, and for secure, paperless access to dosimetric results.

The dosimetry laboratory manages other projects aimed at increasing customer satisfaction, including a new tool for managing customer relations to enhance sales and customer support, improving sales and production line administration, and extending its COFRAC accreditation to all measurement processes.

# EFFECTS OF CHRONIC EXPOSURE

Chronic exposure of living organisms to ionizing radioactivity is the subject of specialized research aimed at characterizing the induced biological mechanisms to quantify the related risks for human health and the environment. IRSN is closely involved in setting up joint European research platforms and projects on this topic.

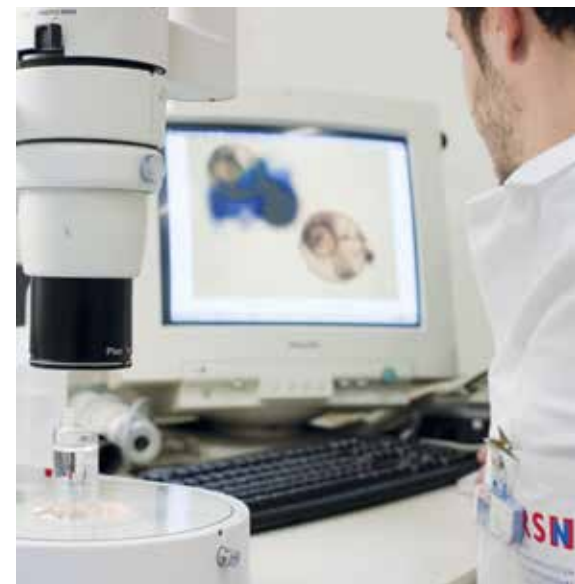
## COMMISSIONING OF THE MICADO-LAB FACILITY

IRSN is actively involved in international collaboration projects set up to **study biological mechanisms resulting from the chronic exposure of living organisms to low-dose radiation. In this context, it develops irradiation facilities such as the MICADO-Labo** facility installed at Cadarache in the south of France.

A cesium-137 irradiator, installed at the center of this facility, is used to expose various non-human biological models, including vertebrates, invertebrates, and culture cells to a photon field in a 5  $\mu\text{Gy/h}$  to 100  $\text{mGy/h}$  dose rate range.

Working in conjunction with laboratories that specialize in breeding ecotoxicological reference species (fish, nematods, microcrustaceans) and cellular and molecular biology laboratories, this irradiator will be a reference platform. It is used to simulate various environmental exposure scenarios, under controlled conditions, and to determine the induced effects on several scales, ranging from molecular to physiological effects on organisms, or to transgenerational effects.

As of January 2017, MICADO-Lab will be open to IRSN's research teams, and national and international collaboration teams, in particular for the purposes of European research projects.





## STUDY ON CHRONIC EXPOSURE TO LOW-DOSE RADIATION IN MICE WITH A PREDISPOSITION TO ATHEROSCLEROSIS

IRSN conducts research into the effects of chronic exposure to radiation at low doses and low dose rates (cesium-137 contamination or external exposure to gamma radiation). Results obtained in mice with a predisposition to developing atherosclerosis have revealed what is known as radioadaptive response. They show that **exposure to radiation at low doses and low dose rates for eight to nine months stimulates the body's antioxidant and anti-inflammatory defense systems**, thereby limiting the development of atherosclerosis.

Initial in vitro studies of human aortic cells show the gradual development of the same radioadaptive response.

The results suggest that at doses with values below one Gy, and dose rates below one  $\mu\text{Gy/h}$ , the mechanisms involved in the functioning of the vascular system and, more especially, in the pathology of atheroma, are different from those described for exposure to radiation at high doses (several tens of Gy) and high dose rates (several Gy/h).

## UNDERSTANDING MORE ABOUT THE ECOTOXIC MECHANISMS OF CESIUM

IRSN, in collaboration with a team from CEA, **has published research findings on the identification of the transporters responsible for the uptake of cesium via the roots of a plant and its translocation to the aerial parts of the plant. This research is part of IRSN's work to learn more about the ecotoxic mechanisms of radionuclides.**

The research, begun in 2013 and coordinated by CEA, is part of a broader project called DEMETERRES (the name comes from the French for "development of bio- and ecotechnologies for integrated effluent and soil remediation"). The project, backed by the investment in the future program for research in the field of nuclear safety and radiation protection, and managed by ANR, the French national research agency, seeks to develop a set of innovative remediation technologies for cesium- and strontium-contaminated soil and effluent, to contribute to cleanup strategy following a nuclear accident.

As cesium and potassium behave in a similar way, IRSN's studies combined the molecular and functional knowledge acquired concerning potassium root transporters, and cesium transfer kinetics according to potassium nutrition in plants.

This integrated approach should lead to new assumptions regarding the molecular mechanisms that are directly or indirectly involved in cesium root uptake.

# PROTECTION IN HEALTHCARE

Fuller understanding of how radiation-induced lesions affect body tissues and organs could lead to better-targeted and more effective treatment for patients. IRSN is actively involved in research in this area and takes part in projects aimed at improving dosimetry techniques for use at the nanometric scale.

## FIRST RESULTS ON SARPP

Stereotactic radiation therapy has been in use for about ten years, particularly in the treatment of small lung tumors. It is used to deliver high radiation doses, divided into smaller doses, to small volumes.

SARPP, which stands for Small Animal Radiation Research Platform, is a system designed to deliver scanner-guided microdoses of radiation to small animals. IRSN acquired this system to characterize tissue lesions observed in the target volume, as well as their impact on the rest of the lung.

**Physicists and biologists worked together on this platform to model stereotactic lung radiation therapy in mice, and to produce scanner images.** These images were used to define the target volume and plan how the dose is delivered according to the different structures that the rays pass through.

## ON THE ROAD TO PERSONALIZED DOSIMETRY IN CANCER TREATMENT USING TARGETED ALPHA THERAPY

Alpha emitters are among the more recent radiopharmaceuticals administered in nuclear medicine for cancer treatment. They have the advantage over beta emitters (iodine-131, strontium-89) in that they deliver more energy over a shorter distance. This makes them more cytotoxic to tumor cells, while limiting unwanted irradiation of healthy tissue.

In 2013, radium-223 was the first alpha-emitting radiopharmaceutical to receive marketing authorization across Europe, which is a sign of the interest that targeted alpha therapy has aroused. In order to optimize the doses delivered to the patient when using this innovative technique, IRSN develops methods and tools for taking into account the patient's anatomical and functional data, and defining opti-

mum, personalized dosimetry. **It worked with Georges-Pompidou European hospital to adapt the imaging protocol for fixing radium-223 to optimize dose calculations, and help determine maximum tolerated doses.**

This imaging protocol was accepted as part of Phase I/II of the EIFFEL multicenter clinical trial (involving HEGP, Cochin, IGR, Caen, and Bordeaux) on the use of radium-223 to treat secondary bone cancer from kidney cancer.

## BIBLIOGRAPHICAL STUDY OF TOMOSYNTHESIS

Tomosynthesis is a recent breast imaging technique whose main advantage is that it does not require the superposition of tissues. It would also seem to be more sensitive than mammography for the detection of breast cancer. It has therefore aroused considerable interest among professionals and is already used in France, although its exact role and clinical indication have yet to be clearly defined.

In order to provide input for the French Advisory Committee on Breast Cancer Screening, and support for the French National Cancer Institute, **IRSN conducted and published a bibliographical study on the performance of this innovative medical imaging technique.**

**It issued recommendations for healthcare professionals and the authorities** to provide a framework for the use of this technique in France, as special attention must be paid to the design and quality inspection of tomosynthesis systems, the radiological exposure of the breast, and the quality of image obtained. These recommendations focus in particular on the characterization of the doses delivered to the mammary gland, and the creation of regulatory quality control of facilities by the French National Agency for Medicines and Health Products Safety (ANSM).

## 2013-2015 DRL REPORT ON DOSIMETRY IN MEDICAL IMAGING

In 2016, IRSN published its fifth report on the **analysis of dosimetric data provided by medical imaging professionals for the period from 2013 to 2015**, in accordance with regulations on diagnostic reference levels (DRL).

The report provides an assessment of practices across the country and suggests possible changes that could be made to DRL regulations. In a similar vein to the 2011-2012 report, it shows that doses delivered to patients have fallen in conventional radiology, scanning, and nuclear medicine examinations by 10%, 15% and 3% respectively.

In view of these observations of national practices, IRSN recommended lowering DRL values in adults, and for almost all examinations.

The report also shows that the doses received by interventional radiology patients argue for the inclusion of this discipline in the DRL system. Given the almost total lack of data on pediatric radiological examinations, IRSN is currently heading a joint initiative with pediatric radiologists to gather data in this area and update the DRLs accordingly.





## ROSIRIS SCIENTIFIC ASSESSMENT: TAKING STOCK OF PROGRESS

ROSIRIS is an interdisciplinary program that was set up in 2010 to **learn more about radiation therapy complications from a biological angle, by adopting an approach combining expertise in micro- and nanodosimetry, radiobiology, systems biology, and radiopathology.**

In 2016, the program went through a scientific assessment process, based on the method put forward to the High Council for Evaluation of Research and Higher Education (HCERES) by IRSN's external assessment body.

So far, this program has provided new knowledge of the mechanisms behind complications in radiation therapy and their development and should eventually lead to improved risk assessment models. The approach adopted seeks to connect, on a step-by-step basis, the initial deposition of energy to the most delayed biological effects.

A new multiscale model of the DNA molecule is used to simulate all the DNA breaks that are directly or indirectly induced by energy deposition. The entire simulation process was validated based on its ability to reproduce experimental results.

The data has been organized to build interaction networks and identify the important agents in the biological effects observed. The goal is to establish a direct link between the function (or malfunction) observed and the agent revealed by modeling.

The role played by key molecular agents in the development of radiation-induced digestive lesions was demonstrated through the use of three different models of transgenic mice.

# EMERGENCY AND POST-ACCIDENT SITUATIONS

Providing the public authorities with rapid, high-quality, operational technical support in emergency situations is among IRSN's missions. As the nation's public service expert in nuclear and radiation risks, IRSN has a clearly defined role in the French National Response Plan for Major Nuclear or Radiological Accidents, where it is tasked with assessing risks and predicting how the accident will unfold.

It also helps in preparing recommendations for the protection of people and the environment. Its organizational structure has long been adapted to these tasks and is regularly tested and improved. It draws on specially trained teams and material resources to ensure effective emergency response.

## KEY FIGURES



5

national nuclear emergency exercises involving defense-related activities

8

national nuclear emergency exercises excluding defense-related activities.



2

ionizing radiation dose assessments by biological dosimetry



8

meetings involving IRSN in connection with CODIRPA's work on post-accident situations



0

action taken by the emergency response center

# EMERGENCY PREPAREDNESS AND RESPONSE

IRSN provides the public authorities with support in the event of an incident or accident, and puts forward proposals to the safety authorities on technical, health and medical measures to protect the population and environment in the region concerned. For IRSN's teams, preparedness is tested mainly through participation in national and international exercises.

## TWO PATENTED IMPROVEMENTS FOR WHOLE-BODY RADIATION COUNTS

Drawing largely on feedback from the Fukushima accident, **IRSN has developed two tools for performing internal contamination measurements that meet a number of requirements that were not covered until now. Two patent applications were filed for these tools in 2016.**

Thyroid contamination measurement in children was not very effective at Fukushima, because the detectors used were calibrated using an adult-sized thyroid phantom. **This led IRSN to develop a series of thyroid phantoms of different sizes, called FANTHY, made using a 3D printer. These represent thyroid volumes at different ages** and are used to calibrate detection systems more rigorously and thus obtain more accurate estimates of the risk to children's health induced by exposure to radioactive iodine.

The second tool, called **PORTIK**, is a new portable device for **internal contamination measurements that is designed to perform whole-body radiation counts on stretcher cases, wheelchair users or people with reduced mobility.**

## NEW INROADS IN EPR SPECTROSCOPY FOR RAPID DOSE MEASUREMENT

Characterizing radiation exposure and assessing the received doses are essential for effectively treating the victims of a radiological accident. Electron paramagnetic resonance (EPR) spectroscopy is one of the techniques that IRSN uses to provide the most suitable response in these situations. EPR is used to estimate the dose generated by ionizing radiation in materials by quantifying the production of free radicals, whose number is proportional to the dose.

As this method has proved effective in many assessments, IRSN continues research in this area to regularly broaden its scope. **In the past five years, it has developed new, minimally invasive protocols for victims that can be used to estimate received doses from nail samples or just a few milligrams of tooth enamel.**

Measurement performance on tooth enamel samples was evaluated in 2016. The results showed that one person could measure 120 samples a day, with a correct classification rate of 93% in the 0-1 Gy range, and of 100% for doses above 2 Gy. Other research was aimed at identifying the radical species used for nail dosimetry, in order to optimize protocols for isolating the radiation-induced component of the signal.

**These advances shorten analysis times and thus considerably increase IRSN's measurement capability in post-accident situations.**

## MORE TOOLS FOR ASSESSING RADIOLOGICAL RISKS

IRSN has increased its resources for assessing radiological risks in emergencies, in order to optimize the operational support it provides the authorities. This effort is part of its emergency response management initiative and preparatory work.

**Assessments are being prepared on mobile tools for characterizing the affected areas**, a gamma camera designed to locate high concentrations of soil contamination, and unmanned aerial vehicles to obtain photos and videos of hilly or mountainous areas where access is difficult. In emergency situations, the authorities and Prefects concerned need the most accurate information possible on the radiological situation on the ground to decide on the steps to be taken to protect the population. The resources above will help meet this need.

IRSN has also begun to **renovate the communication system for its teams on the ground**. A specialized communications vehicle forms the backbone of this new system. Equipped with high-performance technology (dish antenna, 3G/4G, WIFI, radio), it will enhance connection capabilities with IRSN's emergency response center in Fontenay-aux-Roses, near Paris.

## A SIGNIFICANT CONTRIBUTION TO THE GOVERNMENT EMERGENCY PLAN

In 2014, the Ministry of the Interior published a guide aimed at facilitating the application of the national emergency response plan to a major nuclear or radiological accident at the level of zones or departments.

### **In 2016, IRSN helped the Ministry in its work with prefectures in charge of zones that apply the plan at their level.**

It also contributed to the ongoing task of planning and improving the response to a nuclear accident, as requested by the government, and embodied in a road map implemented with the national plan.

IRSN collaborated with the authorities on 10 of the 12 initiatives that make up the road map coordinated by the General Secretariat for Defense and National Security (SGDSN). It carried out various studies that are essential to the work of the ministries involved, particularly with regard to reviewing measures implemented to protect the population in the emergency phase of a nuclear accident, and to updating post-accident management policy.

10 / 12

actions on the roadmap coordinated by the SGDSN benefited from IRSN's expertise

## AGREEMENT SIGNED WITH "GIP SOURCES HA"

GIP Sources HA is the name of a public interest group that organizes the retrieval and disposal of spent high-activity sealed sources. It was set up in 2009 by CEA and CisBio International to ensure optimum conditions of safety and security in the management of unused sealed sources, made or supplied by the two companies in France and abroad. In order to accomplish this task, which meets one of the commitments made by France at the Washington and

Seoul security summits, the public interest group wished to set up a collaboration agreement with IRSN. Under the agreement signed in April 2016, IRSN will provide the public interest group with technical expertise. In the summer of 2016, it completed its first work under the agreement, by performing an assessment of radioactive sources in Lebanon in preparation for their return to France.

## PARTICIPATION IN 12 NATIONAL EMERGENCY EXERCISES

For more than 20 years, the organization of IRSN's material and human resources has been regularly tested and improved to provide the public authorities with optimum technical and operational support in the event of a nuclear or radiological emergency.

In 2016, **its emergency response center was activated during 12 national emergency exercises.** These provided an opportunity to check IRSN's response capabilities and the quality of its action, as well as the efficiency of its policy for managing the skills of its emergency response teams. New team members are periodically hired and trained through the newly created emergency response module at IRSN's internal university. IRSN's emergency response teams take part in a growing number of national emergency exercises organized by the authorities. This provides them with further training, which is supplemented by participation in local exercises organized by some companies in the nuclear industry.

**In all, IRSN took part in twenty national and local exercises in 2016.** It also continued its efforts to raise employees' awareness of emergency management.





# POST-ACCIDENT ACTIVITIES

IRSN is involved in preparing French policy on managing the post-accident phase of a possible nuclear accident. Within this context, it works on analyzing feedback from post-accident management of the Fukushima accident.

## PARTICIPATION IN CODIRPA WORK

IRSN has been involved in the activities of the ASN-led Steering Committee for the management of the post-accident phase of a Nuclear Accident or a Radiological Emergency (CODIRPA) since the Committee was set up. CODIRPA's work is now set out in the road map of the national response plan for major nuclear or radiological accidents.

In 2016, IRSN was involved in a working group on waste (GT Déchets), set up at the beginning of the year for a period of two years. The purpose of the group is to define aspects of policy and strategy aimed at reducing contamination in areas concerned by an accident, and managing the resulting waste. The working group draws on CODIRPA's previous work and on feedback from accidents at Chernobyl and Fukushima.

Another working group focuses on stakeholder involvement. Here, IRSN is helping to prepare a radiation protection good practices guide intended for people who might one day be affected by a nuclear accident. The guide will draw on the work carried out as part of the ETHOS program in Belarus, CODIRPA's activities, and the European PREPARE program, as well as on documents distributed to the Japanese population following the Fukushima accident.

## FEEDBACK FROM THE FUKUSHIMA DAICHI ACCIDENT

If any lessons are to be learned from how the Fukushima accident was managed, French policy in emergency response management must be set against the realities encountered in Japan. In this context, IRSN began a study to compare the measures recommended by French policy with the situation in Japan, highlighting both their strengths and weaknesses. The purpose of the study is to provide concrete input for a potential review of post-accident policy.

It seeks to centralize and synthesize all the data on the management of the Fukushima accident, and thus contribute to the work carried out by IRSN itself and the public authorities on emergency management (for both the emergency and post-accident phases). The topics covered include protecting the population, managing the consumption and marketing of foodstuffs, and decontamination and waste management.

## DIALOGUE BETWEEN THE LOCAL POPULATION AND EXPERTS AT FUKUSHIMA

From late 2011 to the end of 2015, IRSN took part in the "initiative for dialogue on the rehabilitation of living conditions in the Fukushima prefecture", organized by ICRP and Japanese NGOs to understand the issues facing the local population in their everyday life following an accident. Twelve meetings were organized to allow local stakeholders (farmers, teachers, parents, students, municipalities, consumers, etc.) to share their experiences and talk with Japanese and foreign radiation protection experts.

IRSN carried out a study with the French Nuclear Protection Assessment Center (CEPN) to see what initial lessons could be learned for France. The study emphasizes the importance of human aspects and the crucial need for residents to have direct access to dose measurement. It shows how experts can help by addressing the local population's concerns.

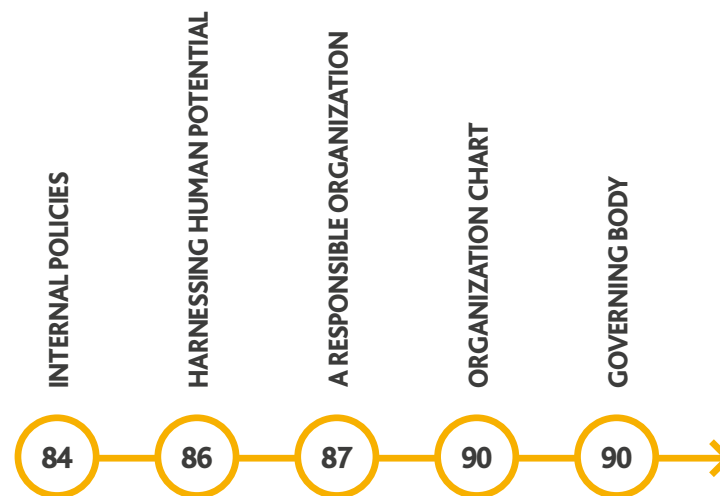
In order to share this experience and the lessons learned, IRSN coordinated the production of a trilingual web documentary that was put online in March 2016. The documentary, entitled "*Kotoba: Dialogues in Fukushima*" goes back over the history of these dialogues and includes many personal accounts by residents.

In October 2016, IRSN continued this type of initiative and took part in another dialogue organized in Kawauchi in cooperation with the University of Nagasaki.



# EFFICIENCY

IRSN contributes to preventing and detecting nuclear and radiological risks as well as limiting their effects in order to protect people and the environment.



# INTERNAL POLICIES

The action of IRSN's functional divisions is aimed at harnessing human potential, ensuring that the organization is run efficiently and responsibly, and continuing its modernization. All these objectives are part of an initiative to improve the management and development of multiyear programming throughout IRSN's activities, in line with the regularly updated 2016-2018 Medium Term Plan (PMT), which was submitted to the Board of Directors in February 2016.

## IMPLEMENTATION OF THE DECREE ON BUDGET MANAGEMENT AND PUBLIC ACCOUNTING

The Decree of November 7, 2012 on budget management and public accounting, which was introduced to improve financial management and public accounting in public organizations, has been enforced at IRSN since February 2016.

Public budget execution is now expressed in terms of commitment authorizations and payment appropriations, with commitment authorizations only being granted to «firm» commitments. The main purposes of this initiative are to improve the quality of financial management and accounting, reinforce management culture, enhance management efficiency, and overhaul the processes and organization of public bodies. **This reform entailed significantly reworking the processes and tools used at IRSN to support budget management; it should eventually make it easier to keep track of the budget.**

## FLEXIBLE WORKING HOURS: INTRODUCTION OF PERSONALIZED WORKING HOURS AND DAYS OFF

Following the agreement on flexible working hours that it signed with the trade unions at the end of 2015, **IRSN began in 2016 to prepare for the deployment of a badging system, which is planned to come into service on January 1, 2017.**

It was decided to opt for a single technical solution installed on computers, and available via the intranet on all IRSN sites and for all IRSN staff.

The system meets regulatory requirements on mandatory breaks.

At the same time, managers will have access to monitoring and analytical tools.



The trade unions took part in deciding how the selected procedures could be implemented in practical terms, and progress was regularly reported Works Council meetings.

A trial run was carried out in November with 250 staff in both operational and functional divisions, to fine tune the application and answer employees' questions. It revealed a number of particular situations, including some site-specific cases.

A quarterly review will be organized with the trade unions in 2017 to examine the operational feedback, and make any adjustments that may be required.

## ELECTRONIC INVOICE PROCESSING

As part of its initiative to modernize budget, financial, and accounting management, in line with the Decree on budget management and public accounting, **IRSN has developed tools for receiving and sending electronic invoices.** This more modern way of working imposes the need to secure the organization's information system to ensure the integrity of documents and the traceability of operations, and to maintain control of authorizations. Ultimately, this will make it easier to keep accounts for outgoing and incoming invoices.

At the same time, these changes have made it possible to automate invoice processing and ensure secure document management and filing.

In addition, electronic invoicing **reduces the time suppliers have to spend on sending, processing and keeping track of invoices**, and saves postage and paper filing costs. It introduces a new service with online tracking of invoices that have been sent, and a special space for handling queries.

## CHANGING ORGANIZATION

IRSN is adapting its organization to provide an effective response to the French government's modernization policies and to be part of the new dynamics. In 2016, these changes focused on two areas: regulatory changes relating to budgets, and new security issues.

Regarding economic performance and, in particular, efficiency in opening up public procurement contracts to competition, a new organizational structure was set up to meet new requirements, such as those set out in Order 2015-899 of July 23, 2015. The new structure allows for the extra work load due to the new thresholds and rules concerning competition, as well as the related publication procedures.

On the subject of security, IRSN took action to strengthen its resources to address new issues raised by technical progress, regulatory changes, and counter-terrorism. This included setting up a special department in 2016 that brings together specialists in various areas of expertise concerning both facility and transport security. It is also developing new technical skills, especially in cybersecurity, which is now central to protection and control systems at nuclear facilities.

At a time of ever stricter requirements, IRSN plans on improving its capacity to assess the action taken by licensees of nuclear facilities and of those responsible for transporting nuclear materials. The new department will also be expected to enhance synergy between specialists in nuclear safety and nuclear security to ensure that the specific requirements of each area are given due consideration.

# HARNESSING HUMAN POTENTIAL

## INTERNAL UNIVERSITY - LATEST NEWS

IRSN's Internal University was created in 2014 to provide education and training for staff, and ensure that knowledge is passed on and shared. **The year 2016 saw the creation of a new specialized module to design training courses in strategy, management, and communication.** Its goals are to promote and share IRSN's strategy and ambitions regarding communication and openness to society, and to develop management culture. It has begun work on preparing an awareness module, the first sessions of which are scheduled for the second semester of 2017. Training sessions based on operational experience feedback to improve IRSN's practices and overall performance (organizing responses for national and international calls for projects, ANR, Horizon 2020, RSNR, etc.) were also created. These courses, which are important for ensuring that IRSN's strategy is applied throughout the organization, were attended by sixty employees.

**Work also began on reviewing the organization and methods of the seminar for newcomers.** The aim is to favor interactivity and exchange, in particular with the Director General and managers. In the new seminar, workshops led by managers are proposed to new employees from various sectors of activity and different sites, giving them the opportunity to get to know one another, discover the full range of IRSN's activities, and develop a shared culture. This initiative will be completed in 2017.

**The emergency response and assessment modules continue to add to the training courses** on offer, and propose innovative teaching methods, including simulations of meetings of an advisory group on safety, and role plays for on-call staff at the emergency response center. They are also continuing to develop core skills by introducing new specialized modules (fire, criticality, operating experience feedback analysis, etc.).

The work carried out in 2016 in the field of internal educational engineering has also made a significant contribution to the deployment of IRSN's training policy, and driven progress towards the ambitious objectives the Internal University has set for itself.



# A RESPONSIBLE ORGANIZATION

## REINFORCING THE QUALITY SYSTEM

Following an audit, **IRSN's certification was renewed by AFNOR in July 2016**, a new service provider selected after a competitive bidding process. The auditors did not find any noncompliance or weakness, and made an initial diagnosis of the steps to be taken to obtain the 2015 version of the ISO 9001 certification, which IRSN wishes to acquire in early 2018. An action plan has been initiated for this purpose. It entails a coordinated approach between major risk management and the quality management system. A Risk Management Committee has been set up for this purpose. It works hand in hand with the Quality Committee to identify quality processes that might give rise to major risks, and to take the necessary steps for improved risk management.

The 2015 version of the ISO 9001 standard also provides for closer ties between the quality management system and the organization's general strategy. With this in mind, IRSN identified interested parties in 2016, together with the quality system issues related to its general strategy.

## HEALTH IN THE WORKPLACE: ADDICTION PREVENTION CAMPAIGN

Following on from the action carried out in 2015 for the prevention of psychosocial risks, **IRSN started an addiction awareness campaign in 2016**. A series of conferences was therefore proposed for all employees, with the participation of Dominique Lhuillier, a psychologist and professor at the CNAM engineering school. Three such conferences were held: two in Fontenay-aux-Roses and one in Cadarache. They involved 130 staff.

As part of the same initiative, managers were given special attention, as they play a crucial role in the quality of life in the workplace. A working group, composed of the occupational health physician, the social worker, and voluntary operational and functional staff, prepared a kit for managers, comprising practical guides on how to handle cases of addiction.

In 2016, 60 new managers followed the training course in place since 2015 to increase awareness of the risks of addiction and offer tools for detecting, guiding and supporting employees who might be confronted with such issues. The one-day course presents concrete examples and proposes solutions through real-life simulations. The course, which is intended for all IRSN managers, will be maintained in 2017.

→ **60** managers trained  
in addiction prevention



## DELIVERY OF BUILDING Z AT LE VÉSINET

On January 29, 2016, IRSN's new building at Le Vésinet, called Building Z, was accepted following 15 months of work.

**The two-story laboratory and industrial process building, has a total area of some 4,000 m<sup>2</sup>, and meets environmental standards applicable to commercial buildings.** Since June 2016, the building has been home to the IRSN Dosimetry Laboratory (LDI), the Radiotoxicological Medical Analysis Laboratory (LAMR), and some of the site's logistics resources and activities.

The building gives IRSN the modern, optimum infrastructure it needs to provide professionals exposed to ionizing radiation with an efficient, high-quality service for dose monitoring and radiotoxicological analysis.

The handover of the old building to the developer in charge of the eco-district is scheduled for January 20, 2017, bringing to a close one of the projects on IRSN's Multiyear Property Master Plan.



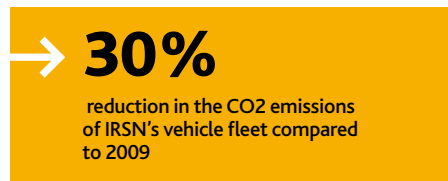
## INITIATIVE TO IMPROVE CORPORATE SOCIAL RESPONSIBILITY

As in previous years, **IRSN continued its efforts to ensure that greater consideration is given to environmental responsibility and sustainable development criteria in all its policies.** Observations made during the year, highlighted the improvements relating to this action. For example, at the end of 2016, CO2 emissions from IRSN's vehicle fleet had fallen by about 30% compared with 2009. This was achieved by gradually renewing the fleet with electric or hybrid vehicles. Similarly, annual energy consumption per employee dropped by 16% over the same period.

At the same time, **IRSN continued to increase the number of its contracts incorporating a social responsibility clause.**

In 2016, controlling energy costs and reducing waste were the focus of attention. In this context, IRSN began to introduce remote electric, gas, and water meters at all its Cadarache facilities, for a consolidated view of its consumption. Meanwhile, a study was begun at Fontenay-aux-Roses and Le Vésinet to identify areas where energy savings could be made.

In 2016, IRSN took many **initiatives to increase awareness among staff of the need to cut down on waste,** including posters giving reminders on good practices, especially concerning printing and waste sorting, and a workshop encouraging staff to recycle used or defective equipment.



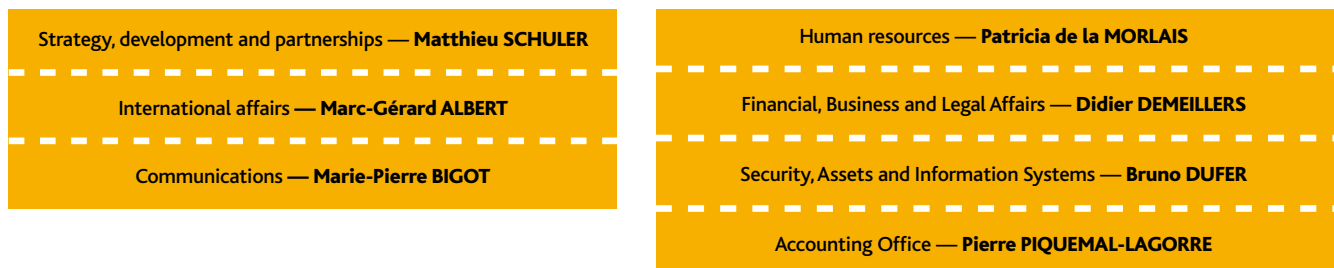
# GOVERNING BODY

## ORGANIZATION CHART

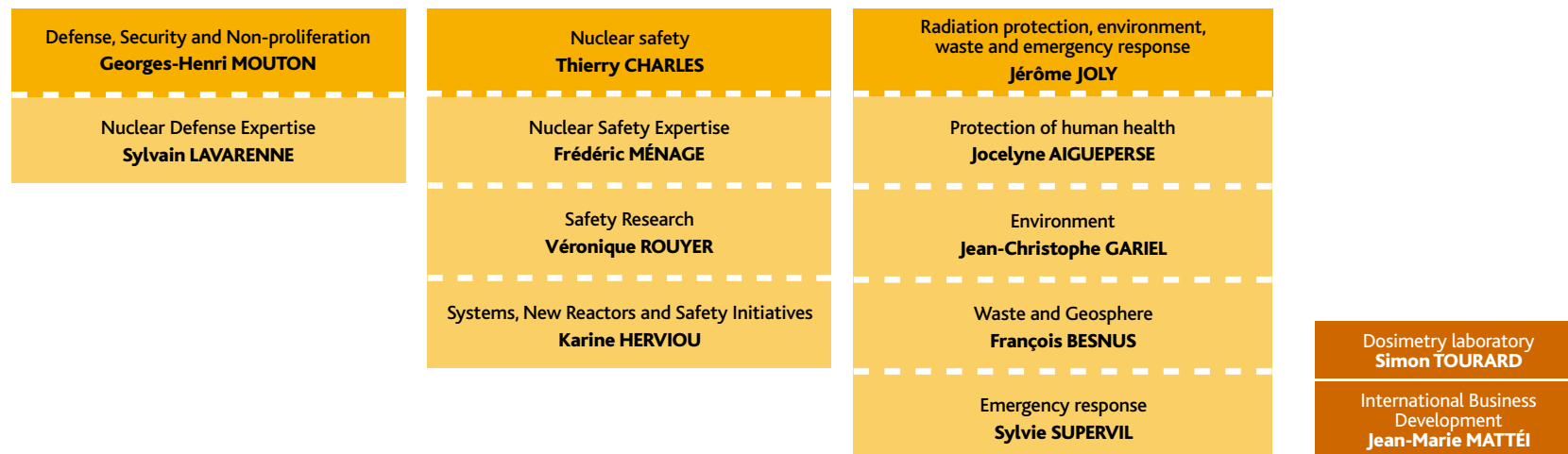
(AS OF FEBRUARY 15, 2017)



## FUNCTIONAL AND SUPPORT DIVISIONS



## OPERATIONAL DIVISIONS AND BUSINESS UNITS



## SENIOR MANAGEMENT COMMITTEE

**Jean-Christophe NIEL**  
Director General

**Georges-Henri MOUTON**  
Deputy Director General, in charge  
of Defense related missions

**Jean-Bernard CHÉRIÉ**  
Deputy Director General,  
in charge of Administration

**Thierry CHARLES**  
Deputy Director General  
in charge of nuclear safety

**Jérôme JOLY**  
Deputy Director General  
in charge of radiation protection

**Giovanni BRUNA**  
Scientific Director

**Martial JOREL**  
Director of Knowledge  
Management

**Matthieu SCHULER**  
Director of Strategy,  
Development and Partnerships

**Marie-Pierre BIGOT**  
Director of Communications

**Marc-Gérard ALBERT**  
Director of International Affairs

**Patricia DE LA MORLAIS**  
Director of Human Resources

## EXECUTIVE COMMITTEE (AS OF FEBRUARY 15, 2017)

The IRSN Executive Committee is chaired by the Director General and made up of 26 members representing the Institute's operational and functional divisions. It meets once monthly to examine matters of strategy, development, operation, and the positions adopted by the Institute on various topics.



## EXECUTIVE COMMITTEE MEMBERS

Jocelyne AIGUEPERSE (1)  
Marc-Gérard ALBERT (2)  
François BESNUS (3)  
Marie-Pierre BIGOT (4)  
Giovanni BRUNA (5)  
Karine HERVIOU  
Thierry CHARLES (7)

Jean-Bernard CHÉRIÉ (8)  
Michel CHOUHA\* (9)  
Patricia de la MORLAIS (10)  
Didier DEMEILLERS (11)  
André ROUBAUD (12)  
Jean-Christophe GARIEL (13)  
Jérôme JOLY (14)

Martial JOREL (15)  
Didier LOUVAT\*\* (16)  
Jean-Marie MATTÉI (17)  
Frédéric MÉNAGE (18)  
Véronique ROUYER (19)  
Georges-Henri MOUTON (20)  
Jean-Christophe NIEL (21)

Sylvain LAVARENNE (22)  
Pierre PIQUEMAL-LAGORRE (23)  
Matthieu SCHULER (24)  
Sylvie SUPERVIL (25)  
Simon TOURARD (26)

\* Riskaudit - \*\* ENSTTI

## BOARD OF DIRECTORS

(AS OF FEBRUARY 15, 2017)

### Missions

**Deliberations by the Board of Directors rule on IRSN activities. More specifically, the Board deliberates on general conditions governing the Institute's organization and operation, its strategy and program, and its annual report. It also approves the budget, decisions involving changes, year-end financial statements and income appropriation.**

**A member of parliament (nomination pending)**

### A senator

**Michel BERSON**, Senator and member of the French Parliamentary Oice for the Evaluation of Scientific and Technological Choices.

### Ten government representatives

**Norbert FARGÈRE**, Nuclear Safety Inspector for DGA, the French defense procurement agency, representing the Minister of Defense.

**Laurent TAPADINHAS**, Director of Research and Innovation, representing the Minister of the Environment.

**Joëlle CARMES**, Deputy Director of Environmental and Food Risk Prevention at the French Directorate-General for Health.

**Aurélien LOUIS**, Deputy Director for the Nuclear Industry, Directorate-General for Energy and Climate, representing the Minister of Industry.

**Frédéric RAVEL**, Scientific Director of the Energy, Sustainable Development, Chemistry and Process Department of the Directorate General for Research and Innovation, representing the Minister of Research.

**Faouzia FEKIRI**, Head of the Risk Resilience Assessment Oice of the Directorate General for Civil Protection and Emergency Response, representing the Minister of Civil Protection.

**Frédéric TÉZÉ**, Deputy, Subdirectorate for Working Conditions, Health and Safety, Directorate-General for Labor, representing the Minister of Labor.

**Jean-Baptiste MINATO**, Head of the Energy, Proitsharing, Industry and Innovation oice at the Budget Directorate, representing the Minister of the Budget.

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

**Pierre-Franck CHEVET**, Head of the Nuclear Safety and Radiation Protection Mission.

### Five advisory members

**Jean-Claude DELALONDE**, Chairman of the National Association of Local Information Commissions and Committees, nominated by the Minister of the Environment.

**Bruno DUVERT**, Air Force Brigadier General, nominated by the Minister of Defense.

**Dominique LE GULUDEC**, Chairperson of the IRSN Board of Directors, Professor of Medicine, Head of the Nuclear Medicine Department of Bichat Hospital in Paris, nominated by the Minister of Health.

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

**Agnès SMITH**, Professor at the Ecole nationale des céramiques industrielles de Limoges, nominated by the Minister of Research.

### Eight staff representatives

**Léna LEBRETON**, CGT.

**Nicolas BRISSON**, CGT.

**François DUCAMP**, CGT.

**Marie-Paule ENILORAC-PRIGENT**, CFE-CGC.

**Thierry FLEURY**, CFDT.

**François JEFFROY**, CFDT.

**Olivier KAYSER**, CFE-CGC.

**Christophe SERRES**, CFDT.

### Ex officio or associate members

**Jean-Pascal CODINE**, Budget Comptroller.

**Philippe BOURACHOT**, Works Committee Secretary.

**Marc MORTUREUX**, Director General of Risk Prevention and Government Commissioner.

**Georges-Henri MOUTON**, Deputy Director General, in charge of Defense-related missions.

**Jean-Christophe NIEL**, Director General.

**Pierre PIQUEMAL-LAGORRE**, Accounting Officer.

## STEERING COMMITTEE FOR THE NUCLEAR DEFENSE EXPERTISE DIVISION – CODEND

(AS OF FEBRUARY 15, 2017)

### Missions

The committee examines the activity program prepared by the nuclear defense. Expertise division before it is submitted to the institute's Board of directors. It is consulted when the Board of directors is called upon to make decisions relating specifically to the 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.

**Pierre de VILLIERS**, General, representative of the Armed Forces Chief of Staff.

**Éric SCHERER**, Rear-Admiral, Nuclear Weapons Inspector.

**Norbert FARGÈRE**, Engineer General for Armaments, representing the DGA, the French defense procurement agency.

**Frank BARRERA**, Colonel, representing the administrative Secretary General of the Ministry of Defense.

**Jean-Baptiste MINATO**, Representing the Budget Director.

**Chloé BAUDREUX**, Representing the Director of Strategic Affairs, Security and Disarmament at the Ministry of Foreign and European Affairs.

**Christian DUFOUR**, Deputy Head of the Economic and Nuclear Infrastructure Security Department, representing the High Civil Servant for Defense and Security of the Ministry of the Economy, Finance, and Industry.

**Christophe QUINTIN**, Head of the Department of Defense, Security and Economic Intelligence, representing the High Civil Servant for Defense and Security at the Ministry of Environment, Energy, and the Sea.

**Serge POULARD**, Advisory member, appointed by the Minister of Industry.

## SCIENTIFIC COUNCIL

(AS OF FEBRUARY 15, 2017)

### Missions

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.

**Pierre TOULHOAT**, Deputy CEO of the French Geological Survey (BRGM), IRSN Scientific Council Chairman.

**Jean-Christophe AMABILE**, Chief Medical Officer, radiation protection specialist at the Armed Forces Radiation Protection Department (SPRA).

**Hugues DELORME**, Professor specialized in neutron physics at the School of Military Applications of Atomic Energy (EAMEA).

**Patsy-Ann THOMPSON**, Director of Environmental and Radiation Protection and Assessments at the Canadian Nuclear Safety Commission, nominated by the Minister of the Environment.

**Frank HARDEMAN**, Director in charge of Radiation Protection-Environment-Health at the Belgian Nuclear Research Center (SCK-CEN).

**Jean-Paul MOATTI**, University professor.

**Guy FRIJA**, University professor.

**Denis VEYNANTE**, Research Director at the French National Center for Scientific Research (CNRS).

**Éric ANDRIEU**, Professor at the Toulouse National Polytechnic Institute (INP).

**Bernard BONIN**, Deputy Scientific Director of the CEA Nuclear Energy Division, nominated by the Minister of Research.

**Denis GAMBINI**, Medical practitioner, researcher at the Occupational Health Department at the Hôtel-Dieu hospital in Paris, nominated by the Minister of Labor.

**Didier BAPTISTE**, Scientific Director at the French National Institute for Occupational Health and Safety Research (INRS).

## ETHICS COMMISSION COMPOSITION

(AS OF FEBRUARY 15, 2017)

### Missions

Included as part of the order organizing 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 within the Institute for separating 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.

**Jean-Pierre DUPUY**, Chairman of the Commission, Corps des Mines Engineer General, philosopher, professor at the École Polytechnique and Stanford University, California, and member of the French Academy of Technology.

**Agnès BUZYN**, Doctor and professor of hematology, Chairperson, National Authority for Health (HAS).

**Marc CLÉMENT**, Public reporter to the Administrative Appeal Court in Lyon, member of the Environmental Authority of the General Council for the Environment and Sustainable Development.

**Éric VINDIMIAN**, Engineer General in rural engineering, water and forests, Regional Director of the Irstea (French research institute for environmental and agricultural science and technology), specialist in the impact of toxic substances on the environment and health and in 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.

**Frédéric WORMS**, Professor of Philosophy at the Ecole Normale Supérieure, Director of the Centre international d'étude de la Philosophie française contemporaine (part of the République des savoirs, USR 3608 ENS/Collège de France/CNRS), Member of the French National Ethics Advisory Committee (CCNE).

## NUCLEAR SAFETY AND RADIATION PROTECTION RESEARCH POLICY COMMITTEE – COR

(AS OF FEBRUARY 15, 2017)

### Missions

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

### Public authorities

#### • Supervisory ministry representatives:

**Bruno GILLET**, Task Officer, Directorate-General for Research and Innovation, representing the Ministry of Research. Representative of the Directorate-General for Health, representative of the Ministry of Health.

**Lionel MOULIN**, Head of the Environmental Risks and Health Mission, Research Department, Directorate for Research and Innovation, representing the Ministry of Environment, Energy, and the Sea.

**Jean-François CAU**, Nuclear Safety Inspector, DGA (French defense procurement Agency).

**Mayeul PHELIP**, Task Officer at the Policy and Supervisory Office, Directorate-General for Energy and Climate, representing the Ministry of Environment, Energy, and the Sea.

#### • Representing the Ministry of Labor:

**Thierry LAHAYE**, in charge of matters relating to the protection of workers against physical hazards, Directorate General for Labor.

• **Representative of French Nuclear Safety Authority:**  
nomination pending.

### Companies and professional associations

**Noël CAMARCAT**, Nuclear Research and Development Officer, Generation and Engineering Branch, EDF.

**Bernard LE GUEN**, EDF representing SFRP.

**Bertrand de l'ÉPINOIS**, Safety Standards Director, representing Areva.

**Jean-Jacques MAZERON**, Head of the Radiotherapy-Oncology Department, Pitié-Salpêtrière Hospital, SFRP representative.

**Soraya THABET**, Director of Risk Control, Andra.

### Employees in the nuclear sector

#### • Representatives of national labor unions:

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

**Martine DOZOL**, FO.

**Claire ÉTINEAU**, CFTC.

**Jacques DELAY**, CFE-CGC.

**Clément CHAVANT**, CGT.

### Elected representatives

#### • OPECST representatives:

**François COMMEINHES**, Senator for Hérault.

**Denis BAUPIN**, Member of Parliament for Paris.

#### • Representative of the Local Information Commissions (Cli):

**Monique SENÉ**, Vice-President of Ancli.

#### • Representatives of municipalities hosting a nuclear facility, proposed by the association of French Mayors: nomination pending.

nomination pending.

**Bertrand RINGOT**, Mayor of Gravelines.

### Associations

**David BOILLEY**, President of Acro.

**Jean-Paul LACOTE**, France Nature Environnement.

**Simon SCHRAUB**, Director of the Ligue Nationale Contre le Cancer.

### Advisory members

**Jean-Claude DELALONDE**, President of ANCCLI.

**Marie-Pierre COMETS**, President of the High Committee for Transparency and Information on Nuclear Safety.

**Dominique LE GULUDEC**, Chairperson of the IRSN Board of Directors, ex-officio Chairperson of the Nuclear Safety and Radiation Protection Research Policy Committee.

### Research organizations

**Daniel FAGRET**, Deputy Director General for Strategy – Inserm.

Paristech representative (nomination pending), representative of the French Conference of University Presidents (CPU).

**François GAUCHÉ**, Director of Nuclear Energy, CEA.

**Cyrille THIEFFRY**, Task Officer for Radiation Protection and Nuclear Affairs, IN2P3, CNRS representative.

### Foreign members

**Christophe BADIE**, Environmental Assessments Department, Public Health England, United Kingdom.

**Ted LAZO**, NEA, OECD.

**George YADIGAROGLU**, Professor of Nuclear Engineering at the Swiss Federal Institute of Technology.

### Ex officio members

**Yves BRÉCHET**, Atomic Energy High Commissioner.

**Marc MORTUREUX**, Government Commissioner, represented by **Benoit BETTINELLI**, Head of the Nuclear Safety and Radiation Protection Mission, Ministry of Ecology, Sustainable Development and Energy.

**Pierre TOULHOAT**, IRSN Scientific Council Chairman, Scientific Director at INERIS.

**Jean-Christophe NIEL**, Director-General of IRSN.

## GLOSSARY

### A

**ANCCLI** French national association of local information commissions and committees.

**ANDRA** French national radioactive waste management agency.

**ANR** French national research agency.

**ANSES** French Agency for Food, Environmental and Occupational Health and Safety.

**ASN** French nuclear safety authority.

**ASND** French nuclear safety authority for defense-related facilities and activities.

**ASTEC** Accident Source Term Evaluation Code – Computer code system jointly developed by IRSN and GRS to assess physical phenomena at work during a PWR core meltdown accident.

### B

**BeIV** Subsidiary of the Belgian Federal Agency for Nuclear Control.

**BRGM** French Geological Survey.

**BSAF** Benchmark Study if the Accident at the Fukushima Daiichi Nuclear Power Station - Project carried out under the aegis of the OECD/NEA.

### C

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

**CASA** Health Agency Networking Committee.

**CEPN** Nuclear Protection Assessment Center.

**CIGÉO** Project for a repository in the Meuse/Haute-Marne for the reversible geological disposal of radioactive waste.

**CLI** Local Information Commission.

**CLIS** Local information and oversight committee/now known as CSS, site oversight committee.

**CONCERT** European Concerted Program on Radiation Protection Research.

**COMET** Coordination and implementation of a pan-European instrument radioecology.

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

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

### D

**DGAL** Directorate General on Food Safety.

**DGCCRF** Directorate for Competition, Consumer Rights, and Protection Against Fraud.

**DGEC** Directorate-General for Energy and Climate.

**DSND** Representative in charge of Nuclear Safety and Radiation Protection for Defense-related Activities and Facilities.

**DoE/NNSA** Department of Energy/National Nuclear Security Administration.

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

**DRL** Diagnostic Reference Levels.

### E

**ECS** Complementary safety assessments.

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

**EPR** European Pressurised water Reactor.

**ETSON** European Technical Safety Organizations Network.

**EURADOS** European Radiation Dosimetry Group.

**EURATOM** European Atomic Energy Community.

### H

**HILW-LL** High level and intermediate level long-lived waste.

**HCERES** High Council for Evaluation of Research and Higher Education.

**HEGP** Georges Pompidou European Hospital.

**HFDS** High Civil Servant for Defense and Security – Ministry of Energy, the authority in charge of nuclear material protection and control in France.



## I

**IAEA** International Atomic Energy Agency.  
**ICRP** International Commission on Radiological Protection.  
**IFSTTAR** French Institute of Science and Technology for Transport, Development and Networks.  
**IGAS** General Inspectorate of Social Affairs.  
**IGR** Institut Gustave Roussy.  
**INB** Basic nuclear installation.  
**INBS** Secret basic nuclear.  
**INERIS** French National Institute for the Study of Industrial Environments and Risks.  
**IRSTEA** French Research Institute for Agricultural and Environmental Engineering.  
**IVMR** In Vessel Melt Retention.

## J

**JCFC** Japan Casting and Forging Corporation.  
**JOPRAD** European Joint Programming on Deep Geological Disposal of Radioactive Waste.

## M

**MEEM** Ministry of Environment, Energy, and the Sea.  
**MELODI** Multidisciplinary European Low Dose Initiative Initiative, a European governance instrument set up to organize research into risks relating to low-dose radiation exposure.  
**MOX** Mixture of plutonium and uranium oxides-nuclear fuel.  
**MWe** Megawatt electric, unit of electric power produced. In a pressurized water reactor, the thermal power released is about three times greater.

## N

**NEA OECD** Nuclear Energy Agency.  
**NERIS** Research platform focusing on emergency preparedness and response and the management of post-accident situations.  
**NGO** Non-Governmental Organization.  
**NSC** Chinese Nuclear Safety Center.  
**NUGENIA** Nuclear Generation II & III Association – European association devoted to research into Generation II and III reactors.

## O

**OCDE** Organization for Economic Co-operation and Development.  
**ODOBA** Observatory of the durability of reinforced concrete structures.  
**OPERRA** Open Project for the European Radiation Research Area.

## P

**PCR** Radiation protection specialist.  
**PRINCESS** Project for IRSN Neutron Physics and Criticality Experimental Data Supporting Safety.

## R

**RADIOELEMENT** Natural or artificial radioactive element.  
**RADIONUCLIDE** Radioactive isotope of an element.  
**RESOH** Research on Safety, Organization and People - Chair at the Ecole de Mines in Nantes.

## S

**SFR** Sodium-cooled Fast Reactor.

## T

**TECV** French Act on energy transition for green growth.  
**TSN** French act relative to Transparency and Security in the Nuclear Field.  
**TSO** Technical Safety Organization.

## U

**US-NRC** United States Nuclear Regulatory Commission.

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The logo for IRSN, featuring the letters 'IRSN' in a bold, sans-serif font. The 'I' and 'R' are red, the 'S' is blue, and the 'N' is red with a blue vertical bar on its right side.

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