IRSN

INSTITUT
DE RADIOPROTECTION
ET DE SÛRETÉ NUCLÉAIRE

Enhancing nuclear safety

ANNUAL REPORT

2011

RESEARCH EXPERTISE 10 YEARS

ENHANCING NUCLEAR SAFETY IN FRANCE AND AROUND THE WORLD

IRSN, a public authority with industrial and commercial activities, was set up under Article 5 of French Act No. 2001-398 of May 9, 2001, enacted through Order No. 2002-254 of February 22, 2002. This Order was amended on April 7, 2007 . The Institute is placed under the joint authority of the Ministries of Defense, the Environment, Industry, Research, and Health.

It is the nation's public service expert in nuclear and radiation risks, and its activities cover all the related scientific and technical issues. Its areas of specialization include the environment and radiological emergency response, human radiation protection in both a medical and professional capacity, and in both normal and post-accident situations, the prevention of major accidents, nuclear reactor safety, as well as safety in plants and laboratories, transport and waste treatment, and nuclear defense expertise.

IRSN interacts with all parties concerned by these risks (public authorities, in particular nuclear safety and security authorities, local authorities, companies, research organizations, stakeholders' associations, etc.) to contribute to public policy issues relating to nuclear safety, human and environmental protection against ionizing radiation, and the protection of nuclear materials, facilities, and transport against the risk of malicious acts.

HUMAN RESOURCES

1,718 (1)

employees, including many specialists, such as engineers, doctors, agronomists, veterinarians, technicians, experts and researchers, with 36 doctors or persons qualified to direct research. IRSN is also the place of work of:

- 71 (2) **doctorate students,**
- 21 (2) **post-doctorate students.**

BUDGET

282 €M

spent by IRSN in 2011:

- 40.2% **of budget devoted to research,**
- 50.2% **of budget allocated to technical support and public service missions.**

(1) This workforce consists of 1,614 persons on permanent contracts and 104 on fixed-term contracts (including 56 persons assigned to other organizations, but excluding 25 temporary assignments).
(2) Expressed in full-time equivalent terms.

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01/

PARIS – FRANCE (November 7-8)

IRSN, WITH THE SUPPORT OF ITS GERMAN AND BELGIAN COUNTERPARTS, ORGANIZED THE EUROSAFE 2011 FORUM, ENTITLED "NUCLEAR SAFETY, NEW CHALLENGES, GAINED EXPERIENCE AND PUBLIC EXPECTATIONS". ONE OF THE KEY ISSUES ADDRESSED BY THE FORUM WAS THE NEED TO UPDATE SAFETY METHODS BASED ON LESSONS LEARNED FROM THE FUKUSHIMA ACCIDENT.

ORGANIZATION

2011 – IRSN COMES OF AGE.

AGNÈS BUZYN,
CHAIRPERSON

In less than ten years, IRSN has built up an audience and gained genuine recognition among the general public and authorities alike.
The accident at Japan's Fukushima nuclear power plant made 2011 a year in which IRSN had to capitalize on the many resources of all its divisions to report on developments in the situation on the ground (under considerable media pressure), perform complementary safety assessments within tight deadlines, and start thinking ahead to the "post-Fukushima" period. This sustained effort in 2011 was rewarded by recognition from our supervisory authorities and support in terms of concrete resources. Despite its close involvement in responding to this emergency, the Institute remained determined to fulfill all its "traditional" obligations as effectively as always, and consolidated its position as a major institutional player on the national and international nuclear safety scene. The range and scale of the actions carried out and described in this annual report are ample proof of this.

The quality of its experts' work during the nuclear emergency in Japan also enabled IRSN to gain credibility with the general public. The Institute put all its scientific expertise to work, adopting an educational and transparent approach. The dramatic events at Fukushima thus helped to reinforce the dynamic strategy of opening up to society that IRSN had already been following for several years.
While its expertise was clearly demonstrated during the Fukushima accident, it was also important for the Institute to learn some lessons from events in the past year concerning both its assessment activities and its research work.

This major nuclear emergency and its impact on human health and the environment highlighted the fact that a single organization with interdisciplinary expertise in the fields of safety, radiation protection and the environment, could be more effective in responding to an accident situation and answering the general public's concerns. IRSN's unique interdisciplinary expertise was recognized as a major asset all over the world, including in Japan. At the end of 2011, the Institute made some organizational changes to reinforce this interdisciplinary approach at the operational level.

The complementary safety assessments (or "stress tests") performed in the wake of Fukushima were a concrete example of how a risk assessment organization could set standards and provide technical support to meet the need for continuous improvement in the field of nuclear safety and radiation protection through tangible changes. It was within this context that the "hardened safety core" concept emerged from discussions between nuclear operators and IRSN. The material effect of this will be stronger defense in depth in France, and I know that the Institute will be keen to defend the need for this with its counterparts around the world.

As soon as feedback from the accident began to arrive, IRSN set to work to determine how it should adjust its research programs. Research is a major component of assessment in its own right, helping to bring about sustainable improvements in safety. The next few years should see IRSN's scientific objectives and research projects begin to take a new direction, particularly concerning mitigation, reactor lifetime extension and low-dose ionizing radiation. In order for this work to meet with success, the research requirements identified by the Institute based on feedback from Fukushima must be brought to the fore. This will mean entering into partnerships with national research organizations and, more importantly, pooling international resources. In retrospect, this justifies all the effort the Institute has devoted to international activities in recent years, in particular, the involvement of its research teams in European research programs in these areas.

Lastly, during the dramatic events of last year, IRSN's experts and researchers were able to measure their individual responsibility and the impact of their day-to-day work in the Institute's public service activities aimed at driving progress in nuclear safety and protecting the population. I am sure that all IRSN's employees will find a lasting source of motivation in their personal share of responsibility in the Institute's research and assessment work.
The recognition of IRSN as one of the world's foremost players in nuclear safety was thus confirmed in 2011, and the Institute was able to demonstrate its maturity as an assessment and research organization. This year's annual report provides an account of the full range of the Institute's achievements in this area, in all its divisions.

ENHANCING NUCLEAR SAFETY: A NEED HIGHLIGHTED BY THE FUKUSHIMA DISASTER

JACQUES REPUSSARD, DIRECTOR GENERAL

The year 2011 will remain overshadowed by the tragedy that struck Japan when a powerful tsunami hit the coast of Honshu, destroying three of the six reactors at the Fukushima-Daiichi nuclear power plant, and leading to the long-term evacuation of tens of thousands of people from a radiologically contaminated region covering hundreds of square miles.

Fukushima was the third major incident involving nuclear safety on a global scale, after the Three Mile Island accident in the USA in 1979, and the Chernobyl disaster in the Soviet Union in 1986. It came as a tragic reminder that we must never drop our guard when it comes to risk control, whether in nuclear safety or other areas.

All through the weeks and months following the accident, IRSN's teams worked hard to monitor developments in real time, to understand what was happening and forecast probable consequences as accurately as possible, in order to provide the French authorities and all other parties concerned with regularly updated information and practical guidance where necessary. At the height of the emergency and in the midst of great concern, this work involved performing the most accurate analyses possible for the French community in Japan, to assess uncertainties as to whether more major quakes could lead to further severe consequences, and to assess the exact situation at nuclear sites that had been damaged by the tsunami. This annual report sets out to provide an exact account of events at Fukushima, together with a summary of IRSN's analyses of the situation. In the last months of 2011, the Institute started working with the JAEA to assess environmental contamination in some parts of the Fukushima Prefecture. IRSN was also involved in developing international scientific partnerships in the field of nuclear safety and radiation protection, in order to draw lessons from the accident.

I would like to take this opportunity to pay tribute to all those at the Institute who played a part in this outstanding effort, both in France and Japan. IRSN's response to events at Fukushima and its role as one of the world's leading analysts of the accident and its radiological impact demonstrate that the Institute's strategy, which it has been developing for nearly ten years now, has taken it in the right direction.

IRSN follows a policy of scientific and technical excellence in the fields of safety and radiation protection. Its research work is aimed at learning more about major accident phenomena and their possible radiological impact on human health, the environment and its ecosystems, as well as on agricultural produce, and modelling these impacts through the use of increasingly effective tools, suitable for use in emergency conditions. Other activities in this field include assisting the safety authorities by performing assessments of facilities currently in service and implementing state-of-the-art systems and methods for monitoring radioactivity in France and assessing population exposure to ionizing radiation.

Ever since its creation, one of IRSN's major commitments has been to open up to society. This has gradually enabled it to develop a genuine capacity to listen and respond effectively to the demand for information, as well as the desire for stakeholders in society to become actively involved in many of the Institute's areas of activity. In this area, IRSN's experts spontaneously addressed the many issues emanating from the Fukushima accident, as each phase unfolded, over and beyond the missions assigned by the public authorities. This entailed working closely with the French ambassador and his teams to answer questions raised by the French community in Japan, then dealing with questions in France, communicating through the media, the IRSN website, which reached a record audience over that period, and a special telephone service set up to provide a personal interface between those concerned about risks and IRSN's experts.

Lastly, thanks to its active and, now, long-standing involvement in international scientific cooperation networks, IRSN was able to gain extremely fast access to reliable and essential data for accident appraisal, including plans of the affected reactors (BWR's are not operated in France), and exchange technical information with its counterparts in the other countries in a spirit of mutual confidence.

Over the coming years, the events at Fukushima, like all major accidents, will raise further questions and, no doubt, lead to a renewed focus on the need for innovation in the fields of nuclear safety and radiation protection. By the second half of 2011, IRSN had already begun work on implementing European "stress tests", also known as "complementary safety assessments" in France. Following analysis of the reports submitted in this connection by nuclear operators, and its own work ■■■

■■■ on the subject, the Institute has proposed an innovative concept referred to as the "hardened safety core". This is aimed at guaranteeing that all the vital safety functions of a nuclear reactor would remain available, whatever the circumstances, and that emergency response teams on site are protected as effectively as possible.

Work on modernizing IRSN's radiological alert network across the country is also continuing, while operational tools are being developed to assess onsite radiological situations following a radioactive release. These tools will make it possible to anticipate changes in the situation more effectively and adjust forecasts to in situ measurement results. In this way, they will be able to guide the action of the public authorities and onsite response teams and, at the same time, provide information for the public, which will help to create and maintain greater trust.

IRSN also contributes to efforts to develop scientific and technical cooperation within Europe. The aim is to share research costs in certain areas and promote the necessary standardization of safety and radiation protection practices. In this respect, the Institute is closely involved in a number of specialized networks and associations, principally ETSON (the European TSO Network), MELODI (the European association for research on the effects of low-dose ionizing radiation), SNETP (a European nuclear research platform for research on nuclear reactors, including safety aspects), and ENSTTI (the European Nuclear Safety Training and Tutoring Institute, which provides occupational training for experts in security, safety and radiation protection). Cooperation of this type is also giving rise to a growing number of TSO consortiums, set up to meet the demand for technical support and assessments by countries wishing to invest in nuclear power plants. IRSN has succeeded in gaining a foothold in this highly competitive market to develop its business in the sector.

Last but not least, in addition to the work mentioned above, the Institute pursued throughout the year its traditional core activities, which are aimed at enhancing nuclear safety and security, and protection against ionizing radiation. These are all described in a number of periodic reports, most of which can be consulted on the Institute's website. Similarly, many continuous improvement initiatives have been undertaken at the Institute, focusing on strategic management, communication, administration, and the management of human resources, one of IRSN's most vital assets.

I hope you enjoy reading this annual report, which provides a faithful account of all the above mentioned activities.

IRSN AND ITS VITAL ROLE IN THE APPLICATION OF THE FRENCH DEFENSE CODE.

MICHEL BRIÈRE, DEPUTY DIRECTOR GENERAL
IN CHARGE OF DEFENSE-RELATED MISSIONS

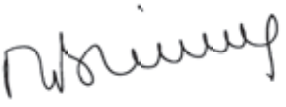
IRSN, the French Institute for Radiological Protection and Nuclear Safety, was created ten years ago. Since then, it has become an essential part of the country's institutional scene, and politicians, those working in government departments and the media, as well as other stakeholders are all familiar with its main responsibilities and types of action, namely:

– conducting research and building up scientific and technical knowledge,
– fulfilling two public service missions: radiological monitoring of the environment in France and monitoring the exposure of workers, patients and the general public to ionizing radiation,
– providing the public authorities with technical support, including during emergencies,
– providing a range of scientific and technical services.

When it comes to application of the French Defense Code, however, one of IRSN's activities, "technical assistance to public authorities", as set out in the Decree enacted to create the Institute, deserves a closer look. This technical assistance goes beyond the technical support activity mentioned above. It entails playing a direct role in the State's sovereign activities whenever these call for specialized methodological expertise or scientific or technical systems (such as for metrology, analysis, or data management). Listed below are some noteworthy examples of this type of action carried out by DEND, IRSN's Nuclear Defense Expertise Division:

– some fifty DEND experts are trained and authorized to carry out "control officer" functions, defined under Articles L1333-4 and 5 of the French Defense Code, in connection with the protection and control of nuclear materials, and the related facilities and transport. This involves performing technical verifications of facilities and shipments, using measuring devices developed by IRSN. Around 250 facilities and shipments are inspected every year;
– similarly, IRSN's Deputy Director General is responsible for examining and approving nuclear transport agreements in France on behalf of the French Government, under the same regulations. DEND Transport Operations experts assist the Ministry of Ecology, Sustainable Development, Transport and Housing by monitoring most of these shipments (around 1600 per year) in real time, and implementing the related communication and warning systems;
– in order to verify that the Chemical Weapons Convention is correctly applied in France, the relevant authorities have empowered a number of DEND experts to represent the French Government on the ten or so international verifications conducted by OPCW inspectors at French chemical plants every year. Their technical skills and strict methodology guarantees that these international inspections of the French chemical industry are performed correctly.

These assistance operations are, for the most part, technical in nature and call for the use of measurement systems and sophisticated assessment methods. This is why they have been entrusted to IRSN, which already provides the relevant authorities with assessment support in other closely-related areas. Together, these operations form a coherent and, more importantly, effective whole. They motivate our experts by setting them high standards and consolidating their skills. They also forge closer links between the Institute and the authorities.



HIGHLIGHTS

JANUARY 10-14

IRSN, CEA and the University of Pisa in Italy jointly organized a course on the phenomenology of core meltdown accidents in Generation II and III nuclear reactors. The course was attended by a hundred people from various organizations, including young researchers, doctorate students, nuclear operators, people in industry, TSOs, and safety authorities. Twenty countries were represented, including Korea, Russia, and the United Arab Emirates, in addition to European countries.

JANUARY 21-22

IRSN was at the ORAMED international seminar organized at UPC in Barcelona, Spain. The seminar provided an opportunity to present the main outcomes of ORAMED, an EC-funded project aimed at developing methods for precisely estimating the exposure of medical workers.

FEBRUARY 3-4

A delegation from the Norwegian Radiation Protection Authority (NRPA) visited IRSN. The purpose of the visit was to strengthen collaboration between the two organizations and renew the 2005 framework agreement. Talks focused in particular on the organizations' involvement in the STAR network of excellence. STAR signed a contract with the European Commission in January to pool skills in the radioecology field in Europe.

MARCH 9

Four European technical safety organizations - IRSN, GRS (Germany), UJV (Czech Republic) and LEI (Lithuania) set up ENSTTI, the European Nuclear Safety Training and Tutoring Institute. In creating ENSTTI, the founding organizations, in association with the European Union and the IAEA, aim to meet requirements for assessment and research skills in the nuclear safety sector relating to civil nuclear development programs in Europe and the world as a whole.

MARCH 11

An 8.9-magnitude earthquake occurred 80 km off the coast of Japan, causing a 14 m high tsunami that swept over the protective walls of the Fukushima Daiichi nuclear power plant. The emergency generators were flooded and the water intakes used for cooling the reactor were damaged. IRSN mobilized its emergency response center and set its experts to work.

APRIL 11

IRSN's supervisory ministries and Agnès Buzyn, IRSN Chairperson and Jacques Repussard, its Director General, signed the Government/IRSN Contract of Objectives 2010-2013. The contract testifies to the Government's approval of IRSN's strategic areas of action, identifies the key operational issues to be addressed, and seeks to optimize the Institute's governance and efficiency.

APRIL 20-22

IRSN attended the commemorative conference on the Chernobyl accident, which was held in the Ukrainian capital, Kiev, in the presence of Nathalie Kosciusko-Morizet, the French Minister of Ecology, and Éric Besson,

the Minister of Energy. IRSN's contribution was a speech by Jacques Repussard on nuclear safety in the 21st century.

MAY 30

IRSN took part in the public hearing on nuclear security and the future of the nuclear sector organized by the French Parliamentary Office for the Evaluation of Scientific and Technological Choices (OPECST). IRSN's contribution concerned the protection of nuclear reactors, while Jacques Repussard spoke on the topic of nuclear safety organization.

JUNE 1

First IRSN visiting committee (scientific assessments of study and research programs).

JUNE 6-8

IRSN took part in a symposium organized by EAMEA, the School of Military Applications for Atomic Energy, on the theme of nuclear risk control.

JUNE 7

Jacques Repussard took part in the international ministerial seminar on nuclear safety, chaired by Nathalie Kosciusko-Morizet, the French Minister of Ecology. The Minister also took the opportunity to visit the TOSQAN facility. Located at IRSN's Saclay center near Paris, the facility is used to validate water vapor condensation models under thermal-hydraulic conditions that are representative of a severe accident.

JUNE 9-10

The Committee for the Safety of Nuclear Installations (CSNI) held its 49th meeting in Paris. The meeting, organized by the OECD Nuclear Energy Agency, was chaired by Jacques Repussard.

JUNE 14-17

IRSN attended the 22nd meeting of TRANSSC, the Transport Safety Standards Committee. The meeting was held in Vienna, Austria, and marks the end of the IAEA safety regulations review cycle, which began in 2009.

JUNE 23

IRSN and the Canadian research organization, AECL, signed a collaboration agreement. Under the agreement, the two organizations are to carry out a joint research program to learn more about the possible health impact of chronic exposure to low doses of tritium.

JUNE 20-24

IRSN was joint organizer of ICRER 2011, the International Conference on Radioecology and Environmental Radioactivity, in Hamilton, Canada. Items on the agenda put forward by the Institute included the impact of low-dose ionizing radiation on health and the environment.

JUNE 27-JULY 22

ENSTTI organized a training session in Munich, Germany, entitled "Introduction to Nuclear Safety", intended for people from European and international safety organizations and from industry.

AUGUST 29-SEPTEMBER 2

IRSN took part in the ETSON JSP Summer Workshop in the Czech capital, Prague.

AUGUST 31

Jean-Yves Grall, Director General for Health at the Ministry of Labor, Employment and Health came on a visit to IRSN.

SEPTEMBER 9

The Charter for Openness to Society, signed in October 2008 by ANSES, the French agency for food, environmental and occupational health and safety, INERIS, the French national institute for the study of industrial environments and risks and IRSN, was signed by two other public institutions on September 9, namely IRSTEA, the French research institute for agricultural and environmental engineering, and IFSTTAR, the French institute of science and technology for transport, development and networks. In signing the charter, the institutions reaffirm their commitment to dialogue with stakeholders in civil society within the context of their assessment and research activities.

SEPTEMBER 14

IRSN and ANCCLI organized a seminar on key nuclear safety issues following the accident at Japan's Fukushima-Daiichi nuclear power plant. The technical topics addressed at the seminar give local information commissions a fuller grasp of the documentation submitted to ASN by nuclear operators as part of the complementary safety assessments made available to the public.

SEPTEMBER 14-16

IRSN and the Health, Safety and Environment Department of the University of Bordeaux organized the 46th French language ergonomics society congress in Paris.The congress addressed the question of "how ergonomics can contribute to integrated industrial and professional risk management".

SEPTEMBER 19-23

The European Technical Safety Organizations Network, ETSON, was involved in setting up an IAEA forum that was announced during the Agency's 55th General Conference in Vienna, Austria. Invited by the IAEA Board of Governors to attend the conference as an observer, ETSON took part in the event held to mark the launch of the Forum. This demonstrates the fact that ETSON is now institutionally-recognized as an intermediary of a major international agency.

SEPTEMBER 20

An interdisciplinary group on the radon risk was set up in the Franche-Comté region in eastern France. IRSN, the Metropolitan Community of Montbéliard, and the association Atmo Franche-Comté, launched an interdisciplinary initiative on radon risk prevention in the region. The group sets out to define the resources and tools required to address this important public health issue through various housing policies and, more specifically, those aimed at improving the quality of air inside homes and buildings.

NOVEMBER 2-4

The third international MELODI workshop, held in Rome, Italy, was chaired by IRSN's Director General. This year's workshop focused on the progress made in research into the health impact of exposure to low-dose ionizing radiation.

NOVEMBER 14-18

IRSN attended the international conference organized by the IAEA in the Moroccan capital, Rabat, entitled "International Conference on Research Reactors: Safe Management and Effective Utilization".

NOVEMBER 30-DECEMBER 1

A delegation from Rosatom, the Russian State Atomic Energy Corporation, visited IRSN during a seminar on safety, security and radiation protection during the transport of nuclear materials. Experts from both organizations had very constructive talks on safety assessment, regulations governing the transport of nuclear materials, radioactive sources, and spent fuel, as well as emergency response organization in the event of transport accidents. They agreed to meet again for further talks on these topics in 2012.

MAIN REPORTS

All IRSN reports and scientific and technical publications can be consulted on the Institute's website on **www.irsn.fr**

RADIATION PROTECTION AND HUMAN HEALTH

- 2010 Report on occupational exposure to ionizing radiation: lower collective dose in spite of the increased number of workers monitored
  Publication date: October 2011

- Radiation therapists and the need for safer treatment
  Publication date: August 2011

- Doses to CT scan and conventional radiology patients - Results of a public sector multicenter study
  Publication date: May 2011

ENVIRONMENTAL MONITORING

- 2010 management report of the national network of environmental radioactivity measurements
  Publication date: October 2011

- Assessing radiological and dosimetric impact in a nuclear post-accident situation
  Publication date: February 2011

- Good practices guide for laboratories measuring radioactivity in a post-accident situation
  Publication date: February 2011

- Contextual data and assumptions for carrying out predictive assessments of radiological and dosimetric impact at the start of the post-accident transition phase
  Publication date: February 2011

- IRSN 2009 report on environmental radiological monitoring in France: working towards a change in monitoring strategy
  Publication date: February 2011

- Regional radiological report - "Val de Loire" prototype survey
  Publication date: January 2011

NUCLEAR SAFETY

- IRSN's viewpoint on safety and radiation protection issues relative to French nuclear power plants in 2010
  Publication date: February 2012

- Organizational and Human Factors in risk management: generally accepted ideas generally lead to disappointment
  Publication date: December 2011

- Lessons learned from incidents reported between 2009 and 2010 at nuclear laboratories and plants, and at nuclear facilities in the process of being dismantled
  Publication date: December 2011

- Approach to the assessment of fire risks at nuclear facilities
  Publication date: July 2011

- IRSN's viewpoint on safety and radiation protection issues relative to French nuclear power plants in 2009
  Publication date: November 2011

OTHERS

- Reference document collection: "Consideration of BORAX-type reactivity accidents applied to research reactors". Rapporteur J. Couturier, August 8, 2011 edition
  Publication date: September 2011

- HDR series: "Variability of atmospheric deposition and transfer of artificial radioelements in soils", by Laurent Pourcelot
  Publication date: September 2011

- Guideline series: "ICRP Publication 105, Radiological Protection in Medicine".
  Publication date: December 2011

- IRSN barometer 2011: Risks and safety as perceived by the French.
  Publication date: June 2011

- Risks as perceived by opinion leaders.
  Publication date: June 2011

SUMMARIES OF ASSESSMENT REPORTS SUBMITTED TO THE ADVISORY COMMITTEES AND PUBLISHED IN 2011 CAN BE DOWNLOADED FROM:

WWW.IRSN.FR/RUBRIQUE NOTICES AND REPORTS

ACTIVITY: KEY FIGURES

INTERNATIONAL

Number of bilateral agreements signed with research and assessment organizations.

38 countries involved in these agreements. (34 in 2010)

74 international projects in progress. (84 in 2010)

INTELLECTUAL PROPERTY

Number of French patents in force.

50 patents in force abroad. (63 in 2010)

16 software applications and databases placed with the software protection agency, APP. (2 in 2010)

SERVICE CONTRACTS

36.2 €M revenue. (39.2 in 2010)

25,557 customers. (24,304 in 2010)

RESEARCH

40.2% of IRSN's budget (1) devoted to research. (43.3% in 2010)

215 publications in *Journal Citation Reports*. (158 in 2010)

21 dissertations defended. (25 in 2010)

320 scientific lectures at conferences. (329 in 2010)

TRAINING

1,810 participants in IRSN training courses over the year. (2,153 in 2010)

2,580 hours of teaching given outside the Institute (universities, engineering schools, INSTN, etc.). (2,406 in 2010)

1,400 hours of teaching given in 140 training sessions on radiation protection. (1,372 in 2010 – 143 training sessions)

850 hours of training given in 28 nuclear training sessions. (735 in 2010 – 29 training sessions)

TECHNICAL SUPPORT FOR PUBLIC AUTHORITIES

50.2% of IRSN's budget (1) devoted to technical support and activities in the general interest. (47.9% in 2010)

593 technical notices to ASN. (658 in 2010)

95 technical notices to ASND. (84 in 2010)

409 technical notices to the security authority. (386 in 2010)

HUMAN RESOURCES

Number of employees recruited on permanent contracts

41,412 hours of training given to maintain the skill levels of the Institute's employees. (60,471 in 2010)

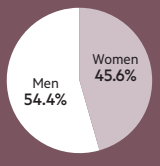
Average age

41.8 for women.

43.4 for men.

Proportion of managerial/ non-managerial staff

Proportion of women/men



Distribution of employees on permanent contracts
Northern Region: 1,292 employees.
Southeast Region: 322 employees.

DISSEMINATION OF KNOWLEDGE

13,495,176 visits to the IRSN website.
(1,631,014 in 2010)

27 notices and reports published on the IRSN website.
(41 in 2010)

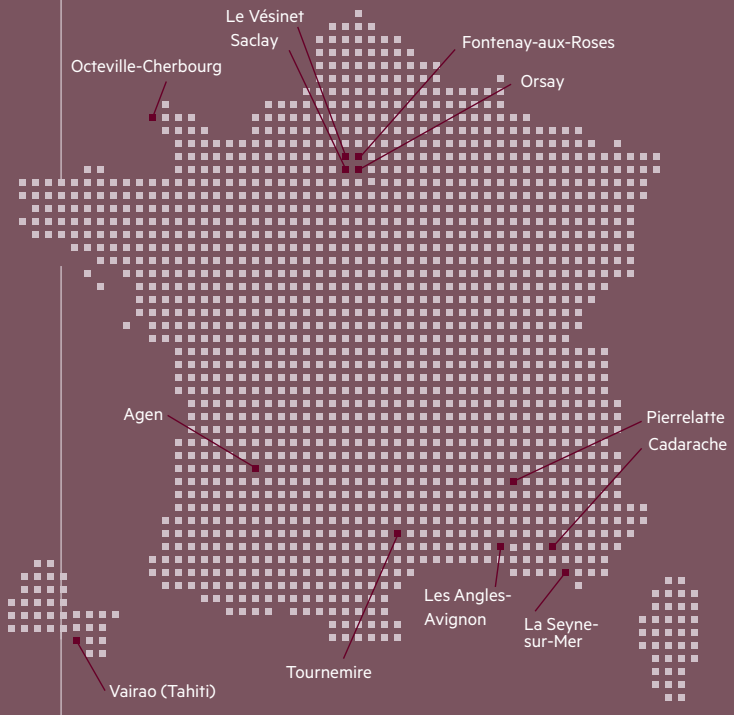
30 IRSN operations at local information commissions.
(12 in 2010)

278,992 consulted in the "Research" section (formerly the "scientific site") of the IRSN website.
(204,000 in 2010)

51 requests for IRSN action received from local information commissions.
(25 in 2010)

3 IRSN publications. (1 in 2010)

LOCATIONS as of December 31, 2011

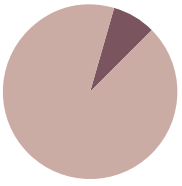


BUDGET BREAKDOWN

293 €M
revenue. (316 €M in 2010)

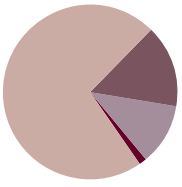
282 €M
expenditure including 18 M€ for equipment investment.
(313 €M including 25 €M in 2010)

Operating and investment expenditure



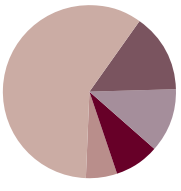
7.94% Investment
92.06% Operating expenses

Total funding



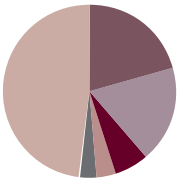
72.16% Budget Act 190 grant
15.19% Other French or foreign funds (aside from Budget Act)
11.43% French and foreign operators' contributions (aside from Budget Act)
1.22% Budget Act 212 grant

French funds (aside from Budget Act)



Other **59.44%**
EDF **14.67%**
State **11.84%**
Areva **8.48%**
CEA **5.57%**

Foreign funds



Riskaudit **48.09%**
EU **20.72%**
Other **18.14%**
Stuk **6.16%**
GDF SUEZ Belgium **3.68%**
Batelle energy Alliance **3.22%**

ORGANIZATION CHART

EXECUTIVE COMMITTEE (as for 30 mars 2012)

The IRSN Executive Committee is chaired by the Director General and made up of 24 members representing the Institute's operational and functional divisions. It meets twice monthly to examine matters of strategy, development, operation, and the positions adopted by the Institute on various topics.

> Executive committee: **1/**Jean-Bernard Chérié **2/** Didier Champion **3/**Alain Cernès **4/** Michel Brière **5/** Thierry Charles **6/** Didier Demeillers **7/** Patricia de la Morlais **8/** Jocelyne Aigueperse **9/** Giovanni Bruna **10/** Jean-Marc Péres **11/** Sylvie Cadet-Mercier **12/** Christian Duretz **13/** Bruno Dufer **14/** Jean-Claude Micaelli **15/** François Besnus **16/**Jérôme Joly **17/** Matthieu Schuler **18/** Marc-Gérard Albert **19/** Marie-Pierre Bigot **20/** Jean-Christophe Gariel **21/** Daniel Quéniart **22/** Jacques Repussard **23/** Martial Jorel

BOARD OF DIRECTORS

- **Agnès BUZYN,** Chairperson

SENIOR MANAGEMENT COMMITTEE

- **Jacques REPUSSARD,** Director General
- **Michel BRIÈRE,** Deputy Director General in charge of defense-related missions
- **Jean-Bernard CHÉRIÉ,** Deputy Director General in charge of administrative affairs
- **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
- **Didier DEMEILLERS,** Director of Financial, Business and Legal Affairs
- **Alain CERNÈS,** Inspector General and Quality Director

OPERATIONAL DIVISIONS

DEFENSE, SECURITY AND NON-PROLIFERATION

■ **Michel BRIÈRE,** Deputy Director General
in charge of defense-related missions

NUCLEAR DEFENSE EXPERTISE

■ **Jean-Marc PÉRES,** Director
> Safety and radiation protection of defense-related nuclear activities and facilities
> Security of nuclear materials, transport and facilities
> Implementation of international inspections
> Technical support and studies

RADIATION PROTECTION, ENVIRONMENT, WASTE AND EMERGENCY RESPONSE

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

PROTECTION OF HUMAN HEALTH

■ **Jocelyne AIGUEPERSE,** Director
> Radiation protection studies and assessments
> Radiobiology and epidemiology
> External dosimetry
> Internal dosimetry

ENVIRONMENT

■ **Jean-Christophe GARIEL,** Director
> Environmental risk research and assessment
> Study and monitoring of radioactivity in the environment
> Environmental sample processing and metrology

WASTE AND GEOSPHERE

■ **François BESNUS,** Director
> Characterization of sites and natural hazards
> Geosphere transfer research
> Radioactive waste and natural radioactivity assessment

EMERGENCY RESPONSE

■ **Didier CHAMPION,** Director
Radiation protection response and support
Emergency situations and response organization

NUCLEAR FACILITY AND SYSTEM SECURITY

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

SAFETY RESEARCH

■ **Jean-Claude MICAELLI,** Director
> Incidents and accidents
> Severe accidents
> Confinement and air dispersion of pollutants
> Internal hazards and industrial risks
> Experimental studies and research

NUCLEAR SAFETY EXPERTISE

■ **Christian DURETZ, Director**
> Pressurized water reactors
> Transportation and fuel cycle facilities
> Research facilities and reactor decommissioning
> Assessment of equipment and structures
> Neutronics and criticality risks

SYSTEMS, NEW REACTORS AND SAFETY INITIATIVES

■ **Sylvie CADET-MERCIER,** Director
> Systems and risks
> Development of skills and operating experience feedback
> Organizational and economic factors in risk management

FUNCTIONAL DIVISIONS

STRATEGY, DEVELOPMENT AND PARTNERSHIPS

■ **Matthieu SCHULER,** Director
> General strategy and scientific and technical programming
> Partnership and contracting policy
> Relations with supervisory authorities, partners and customers
> Openness to society
> Promotion and development of the Institute
> Strategic technology watch and exploiting knowledge
> Teaching and training in radiation protection

INTERNATIONAL AFFAIRS

■ **Marc-Gérard ALBERT,** Director
> International relations
> International Business Development

COMMUNICATIONS

■ **Marie-Pierre BIGOT,** Director
> Public relations
> Websites
> Information and media relations
> In-house communications

SUPPORT DIVISIONS

HUMAN RESOURCES

■ **Patricia DE LA MORLAIS,** Director
> Social policy
> Human resource management
> Staff administration and pay

FINANCIAL, BUSINESS AND LEGAL AFFAIRS

■ **Didier DEMEILLERS,** Director
> Budget monitoring
> Administration of expenditure and revenue
> Application of tax and customs regulations
> Cost accounting and management control
> Commercial and legal support

SECURITY, ASSETS AND INFORMATION SYSTEMS

■ **Bruno DUFER,** Director and IRSN Security Officer
> Security of assets and sites
> Buildings and logistics
> Health, safety, and environmental protection
> Sustainable development
> Information systems

ACCOUNTING OFFICE

■ **Stéphane ROCHARD,** Accounting Officer

BOARD OF DIRECTORS

24
MEMBERS

5
MEETINGS IN 2011

5
-YEAR MANDATE

COMPOSITION (as of february 2012)

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 activity report. It also approves the budget, decisions involving changes, year-end financial statements and income appropriation.

TEN GOVERNMENT REPRESENTATIVES

Patrick RENVOISÉ, Nuclear Safety Inspector for DGA, the French Defense Procurement Agency, representing the Minister of Defense. **Régine BRÉHIER,** Director of Research and Innovation, representing the Minister of the Environment. **Françoise TUCHMAN,** Deputy Director of Environmental and Food Risk Prevention at the French Directorate General for Health, representing the Minister of Health. **Charles-Antoine LOÜET,** Deputy Director for the Nuclear Industry, Directorate General for Energy and Climate, representing the Minister of Industry. **Maria FAURY,** Scientific Director of the Energy, Sustainable Development, Chemistry and Process Department of the Directorate General for Research and Innovation, representing the Minister of Research. **Guillaume DEDEREN,** Head of the Major Risks Office at the Directorate for Defense and Civil Protection, representing the Minister of Civil Protection. **Jean-Denis COMBREXELLE,** Director of Labor Relations, representing the Minister of Employment. **Marine CAMIADE,** Head of the Energy, Profit-sharing, Industry and Innovation Office at the Budget Directorate, representing the Minister of the Budget. **Bernard DUPRAZ,** Representative in charge of Nuclear Safety and Radiation Protection for Defense-related Activities and Facilities. **Nicolas CHANTRENNE,** Head of the Nuclear Safety and Radiation Protection Mission.

SIX ADVISORY MEMBERS

Serge AUBERT, Air Force Major General, nominated by the Minister of Defense. **Jean-Claude DELALONDE,** Chairman of the National Association of Local Information Commissions and Committees, nominated by the Minister of the Environment. **Patrick LEDERMANN,** Vice-President of the Nuclear Division at Alstom Power, nominated by the Minister of Industry. **Jean-Marc CAVEDON,** Director of the Division for Research into Nuclear Energy and Safety at the Paul Scherrer Institute in Switzerland, nominated by the Minister of Research. **Agnès BUZYN,** Chairperson, Board of Directors, physician and professor of hematology, nominated by the Minister of Health. **Claude BIRRAUX,** Vice-President of the Parliamentary Office for the Evaluation of Scientific and Technological Choices.

EIGHT STAFF REPRESENTATIVES

Yves BRISSET, CFE-CGC. **Nicolas BRISSON,** CGT. **François DUCAMP,** CGT. **Thierry FLEURY,** CFDT. **François JEFFROY,** CFDT. **Yves BRISSET,** CFE-CGC. **Christophe SERRES,** CFDT. **Carine STRUP-PERROT,** CGT.

EX OFFICIO OR ASSOCIATE MEMBERS

Laurent MICHEL, Director General of Risk Prevention and Government Commissioner. **Bernard ABATE,** Auditor General. **Jacques REPUSSARD,** Director General. **Michel BRIÈRE,** Deputy Director General in charge of defense-related missions. **Stéphane ROCHARD,** Accounting Officer. **Philippe BOURACHOT,** Works Committee Secretary. **André-Claude LACOSTE,** Chairman of the French Nuclear Safety Authority.

MAIN ACCOMPLISHMENTS 2011

> **Approval of the Government/IRSN Contract of Objectives for 2010-2013.**
> **Definition of the framework and rules for the completion of the Cabri water loop project.**
> **Launch of the property restructuring project at the Le Vésinet and Fontenay-aux-Roses sites.**
> **Settlement of the dispute concerning the radiological incident at the Feursmétal site.**
> **Review of IRSN's general organizational structure including the creation of operational divisions.**

STEERING COMMITTEE FOR THE NUCLEAR DEFENSE EXPERTISE DIVISION (CODEND)

COMPOSITION (as of february 2012)

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.

Bernard DUPRAZ, Chairman of CODEND, Representative in charge of Nuclear Safety and Radiation Protection for Defense-related Activities and Facilities. **Édouard GUILLAUD,** Admiral, Armed Forces Chief of Staff. **Laurent COLLET-BILLON,** Engineer General for Armaments, representing the DGA, the French defense procurement agency. **Jean-Paul BODIN,** Inspector General of the Armed Forces, Administrative Secretary General of the Ministry of Defense. **Éric CHAPLET,** Vice-Admiral, Nuclear Weapons Inspector. **Julien DUBERTRET,** Budget Director, Ministry of the Budget. **Patrick MAISONNAVE,** representing the Director of Strategic Affairs, Security and Disarmament at the Ministry of Foreign and European Affairs. **Dominique LAMIOT,** Secretary General, Ministry of the Economy, Finance, and Industry, Senior Defense and Security Official of the Ministry of the Economy, Finance, and Industry. **Jean-François MONTEILS,** Secretary General, Ministry of Ecology, Sustainable Development, Transport, and Housing, Senior Defense and Security Official of the Ministry of Ecology, Sustainable Development, Transport, and Housing. **Jean-Baptiste FLEUTOT,** Chief Medical Officer of the French Armed Forces, advisory member appointed by the Minister of Defense. **Serge POULARD,** advisory member appointed by the Minister of Industry.

MAIN ACCOMPLISHMENTS 2011

> "Defense and security" examination of:
– of the DEND 2010 Activity Report and the IRSN 2010 Annual Report;
– DEND research and studies in the security field;
– the DEND 2012 activity program.

11
MEMBERS

3
MEETINGS IN 2011

5
-YEAR MANDATE FOR BOTH ADVISORY MEMBERS

SCIENTIFIC COUNCIL

12 MEMBERS

2 MEETINGS IN 2011

5 -YEAR MANDATES

COMPOSITION (as of February 2012)

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.

Michel QUINTARD, Scientific Council Chairman, CNRS Research Director at the Toulouse Institute of Fluid Mechanics, nominated by the Minister of Research. **Philippe ACKERER,** Deputy Director of the Institute of Fluid and Solid Mechanics in Strasbourg, nominated by the Minister of the Environment. **Jean-Claude ANDRÉ,** Emeritus Research Director, Scientific Advisor at the CNRS Institute for Engineering and Systems Science, nominated by the Minister of Labor. **Dietrich AVERBECK,** CNRS Emeritus Research Director at the Curie Institute, nominated by the Minister of Health. **Bernard BONIN,** Deputy Scientific Director of the CEA Nuclear Energy Division nominated by the Minister for Research. **Yves-Sébastien CORDOLIANI,** medical practitioner, human radiation protection expert, nominated by the Minister of Health. **Denis GAMBINI,** medical practitioner, researcher at the Occupational Health Department at the Hôtel-Dieu hospital in Paris, nominated by the Minister of Labor. **Pierre LAROCHE,** Chief Medical Officer of the French Armed Forces, Head of the Medical Division of the Armed Forces' Radiation Protection Department, nominated by the Minister of Defense. **André PINEAU,** Professor at the Paris School of Mine Engineering, nominated by the Minister of Industry. **Bernard SEVESTRE,** Head of the Radioactive Sources Team at the CEA Nuclear Energy Division nominated by the Minister of Research. **Patsy-Ann THOMPSON,** Director of Environmental Assessments and Protection at the Canadian Nuclear Safety Commission, nominated by the Minister of the Environment. **George YADIGAROGLU,** Emeritus Professor of Nuclear Engineering at the Swiss Federal Institute of Technology, nominated by the Minister of Industry.

MAIN ACCOMPLISHMENTS 2011

The Scientific Council is responsible for assessing IRSN's scientific activities and sets up ad hoc commissions for this purpose. In 2011, its examinations focused on:
– critical software assessment methods;
– severe accident research strategy.
During its meeting on May 18, 2011, the Scientific Council decided to test another investigation method by organizing days of scientific discussions and think tanks, with the option of inviting experts from outside. The first of these discussions took place on December 7, 2011 to examine methods for taking into account events which, though unlikely to occur, could have serious consequences.

ETHICS COMMISSION

4 MEMBERS

2 MEETINGS IN 2011

4 -YEAR MANDATE

COMPOSITION (as of February 2012)

MISSIONS

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

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. **Jean-Claude AMEISEN,** biologist, immunologist, professor of medicine at University of Paris Diderot and Bichat Hospital, – member of the French National Ethics Advisory Committee, Chairman of INSERM's Ethics Committee. **Jacques ARRIGHI de CASANOVA,** Member of the Council of State (Conseil d'Etat), Vice-President of the Litigation Section of the Conseil d'Etat since 2010. Associate Professor at Paris 2 - Assas University. **Eric VINDIMIAN,** Engineer General specializing in agricultural engineering, water and forests, Regional Director of IRSTEA (French research institute for agricultural and environmental engineering), specialist in the impact of toxic substances on the environment and health and in assessing government environmental policies.

NUCLEAR SAFETY AND RADIATION PROTECTION RESEARCH POLICY COMMITTEE – COR

COMPOSITION (as of February 2012)

MISSIONS

The Nuclear Safety and Radiation Protection Research Policy Committee is an advisory body to the IRSN Board of Directors, giving opinions on research objectives and priorities in the fields of nuclear safety and radiation protection. It adopts a global approach that takes into consideration the requirements of society and the public authorities. It thus complements 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: Maria FAURY, Scientific Director of the Energy, Sustainable Development, Chemistry and Process Department of the Directorate General for Research and Innovation, representing the Minister of Research. **Marie-Christine FAVROT**, Health, Strategy and Research Task Officer to the Director General for Health, representing the Ministry of Health. **Claire HUBERT,** Head of Research – Directorate for Health and Innovation, representing the Ministry of Ecology. **Pascal QUENTEL,** Head of Nuclear Security and Assessment Division – French Defense Procurement Agency, representing the Ministry of Defense **Thierry LIEVEN,** Subdirectorate for Nuclear Industry, Directorate General for Energy and Climate, representing the Ministry of Industry.

Representative of the Directorate General for Labor: Thierry LAHAYE, in charge of matters relating to the protection of workers against physical hazards – Directorate General for Labor, representing the Ministry of Labor.

ASN representative: Jean-Christophe NIEL, Director General.

COMPANIES AND PROFESSIONAL ASSOCIATIONS

Philippe GARDERET, Scientific Vice-President – Areva. **Noël CAMARCAT,** Nuclear Research and Development Officer – Generation and Engineering Branch – EDF. **Fabrice BOISSIER,** Director of Risk Control – Andra. **Dietrich AVERBECK,** Curie Institute, SFRP representative. **Jean- Marc COSSET,** Head of Radiotherapy at the Curie Institute, SFRO representative.

EMPLOYEES IN THE NUCLEAR SECTOR

Representatives of national labor unions: Jean-Paul CRESSY, FCE-CFDT. **Jean-François DOZOL,** FO. **Claire ETINEAU,** CFTC. CFE-CGC (to be appointed). **Alain VASSAUX,** CGT.

ELECTED REPRESENTATIVES

OPECST representatives: Claude LETEURTRE, Member of Parliament for Calvados. Other representative to be appointed.

Representative of the Local Information Commissions (CLI): Monique SENÉ, Vice-President of ANCCLI.

Representatives of towns with a nuclear facility, proposed by the Association of French Mayors: Yves LE BELLEC, Mayor of Pierrelatte. **Bertrand RINGOT,** Mayor of Gravelines.

ASSOCIATIONS

David BOILLEY, President of ACRO. **Jacky BONNEMAINS,** President of Robin des bois. **Élise CHAMPEAU,** President of MANES, an association that supports victims of industrial diseases and accidents in the nuclear and chemical sectors and their friends and families. **Maryse ARDITI,** France nature environnement. **Simon SCHRAUB,** Administrator of the Ligue nationale contre le cancer.

ADVISORY MEMBERS

Jean-Claude DELALONDE, President of ANCCLI. **Henri REVOL,** President of the High Committee for Transparency and Information on Nuclear Safety. **Agnès BUZYN,** Chairperson, IRSN Board of Directors, ex officio Chairperson of the Nuclear Safety and Radiation Protection Research Policy Committee.

RESEARCH ORGANIZATIONS

Christophe BEHAR, Director of Nuclear Energy – CEA. **Thierry DAMERVAL,** Director General for Strategy – Inserm. Paristech (to be appointed). **Farid OUABDESSELAM,** President of Grenoble 1 – Joseph Fourier University, representative of the French Conference of University Presidents (CPU). **Cyril THIEFFRY,** Task Officer for Radiation Protection and Nuclear Affairs – IN2P3, CNRS representative.

FOREIGN MEMBERS

Jean-Jacques VAN BINNEBEEK, Director General – AVN – Belgium. **Ted LAZO,** NEA (Nuclear Energy Agency) – OECD. **Christophe BADIE,** Environmental Assessments Department – Health Protection Agency (HPA) – United Kingdom. **George YADIGAROGLU,** Professor Emeritus of Nuclear Engineering at the Swiss Federal Institute of Technology.

EX OFFICIO MEMBERS

Catherine CEZARSKY, Atomic Energy High Commissioner. **Laurent MICHEL,** Government Commissioner and Director General of Risk Prevention at the Ministry of Ecology, Energy, Sustainable Development and the Sea. **Michel QUINTARD,** IRSN Scientific Council Chairman, CNRS Research Director at the Toulouse Institute of Fluid Mechanics. **Jacques REPUSSARD,** Director General.

MAIN ACCOMPLISHMENTS 2011

- **A working group was set up to coordinate feedback from COR stakeholders to prepare the strategic agenda of STAR, the European network of excellence.**
- **The summary report on the EDEX working group's appraisal of IRSN research on NPP service life extension was validated.**
- **Work began on guidelines for post-Fukushima research.**

43
MEMBERS

2
PLENARY MEETINGS IN 2011

02/

LEVICE – SLOVAKIA (December 14)

THE VIKTORIA LOOP EXPERIMENTAL FACILITY WAS OFFICIALLY OPENED BY HIS EXCELLENCY JEAN-MARIE BRUNO, FRENCH AMBASSADOR TO SLOVAKIA, MILOS ZACHAR, DIRECTOR OF VUEZ, AND JACQUES REPUSSARD, DIRECTOR GENERAL OF IRSN AT A CEREMONY ATTENDED BY A HUNDRED REPRESENTATIVES FROM 25 NUCLEAR SAFETY ORGANIZATIONS.

SUMMARY & STRATEGY

PROGRESS AND MAIN ACTIVITIES IN 2011

IRSN'S ADAPTABILITY PUT TO THE TEST IN A YEAR OF CONTRASTING EVENTS

IRSN's ability to respond rapidly to events was certainly put to the test in 2011, a year full of contrasts which began with signs of renewed interest in restarting nuclear power programs around the world, only to see nuclear energy called into question after the accident at Japan's Fukushima-Daiichi nuclear power plant. The event had political repercussions, with countries such as Germany and Belgium deciding to opt out of nuclear electricity within the next fifteen years, and Italy abandoning its nuclear power ambitions. The year 2011 was also one where IRSN worked particularly closely with its foreign counterparts, the French public authorities and the national community to address new fundamental questions raised regarding uncertainties in the safety and security of nuclear facilities, as well as nuclear emergency response capabilities. The answers to these questions will provide guidance during the debate on France's future nuclear policy. Within this new context, IRSN demonstrated - and must continue to demonstrate - its ability to adapt to the search for even higher standards of nuclear safety and human and environmental protection against ionizing radiation.

98 PERSON.YEARS DEVOTED TO INTERNATIONAL ACTIVITIES. (90 IN 2010)

One of the key events of the year at the institutional level was the signing of the Government/IRSN Contract of Objectives 2010-2013 by the Institute's supervisory ministers, Chairperson and Director General. The new contract is the result of several months of discussions and testifies to the Government's approval of IRSN's four strategic areas of action: research, support for the public authorities and other customers, promoting transparency and openness to civil society, and developing its international profile. This second Contract of Objectives sets out operational targets in four areas - safety, security, radiation protection, and emergency response and putting risks into pespective. It consolidates IRSN's operating procedures and improves the management of programs and human and financial resources.

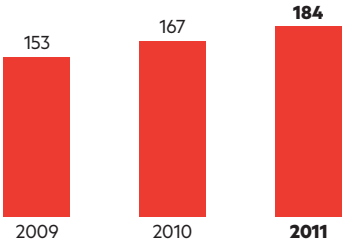
The main event of the year 2011 from the operational point of view was, without doubt, the nuclear accident that occurred following the earthquake and tsunami that struck the Fukushima-Daiichi nuclear power plant and the Tohuko coast in Japan on March 11. The accident had a far-reaching impact around the world, raising questions on approaches to nuclear safety emergency response and putting risks into perspective. As well as providing the French authorities with support within the national emergency response teams mobilized for the accident, IRSN experts found themselves having to deal with situations that had been considered highly unlikely before the disaster, and calling into question a number of methods and ways of working. In light of these events, the Institute can rely on two "allies" in its efforts to find credible and transparent solutions to the questions raised: a) the reaffirmation in the Government-IRSN Contract of Objectives 2010-2013 of the need for new scientific knowledge and independent assessments to allow the Institute to move forward with its efforts to enhance nuclear safety; b) the creation of a fixed grant, as of 2011, providing the Institute with funds

IRSN's Director General, Jacques Repussard, addressed the 450 experts gathered at the EUROSAFE 2011 forum in Paris.

that keep pace with responses while guaranteeing its total independence.

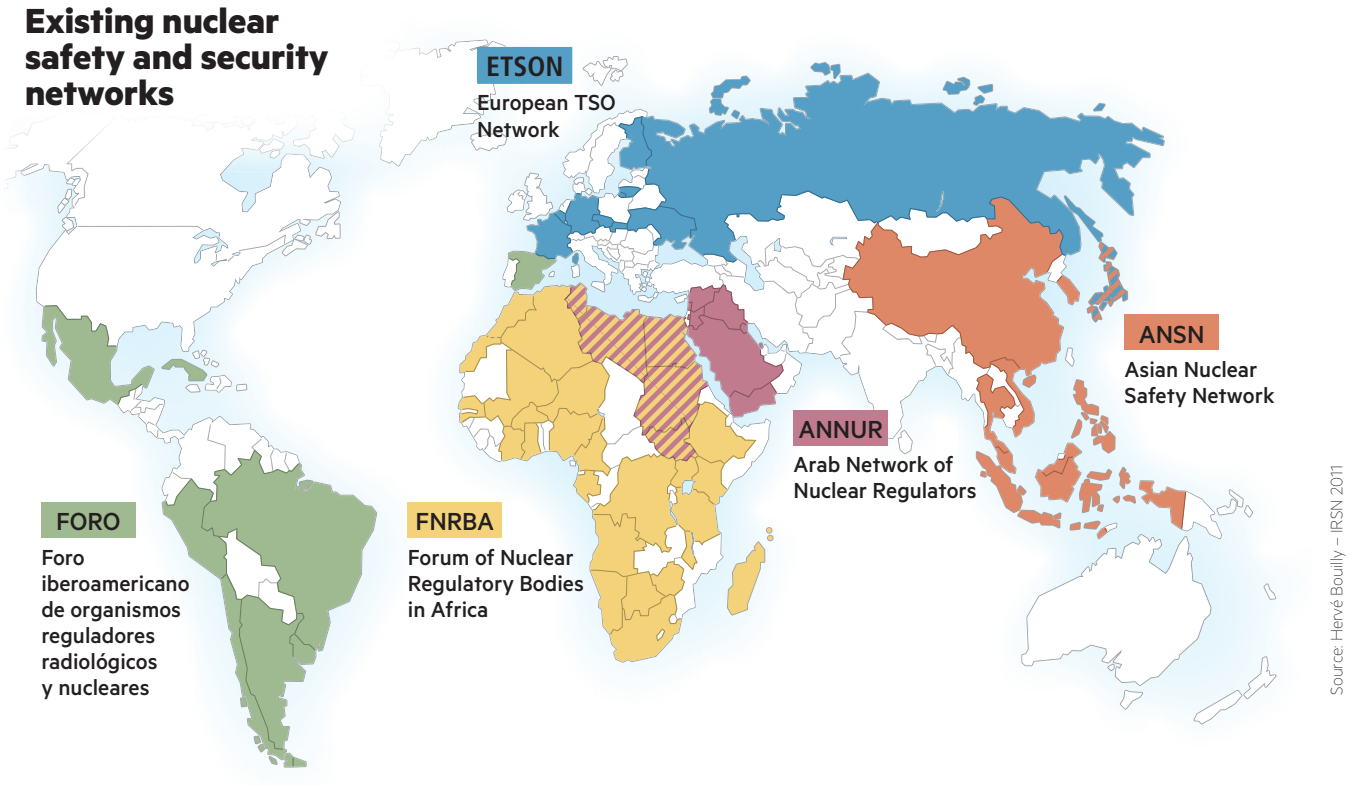
International activities: helping to boost the role of TSOs

As part of the initiative to develop its international activities, which was stepped up through increased collaboration among nuclear technical safety organizations (TSOs) following the Fukushima-Daiichi accident, IRSN worked to give TSOs greater influence and a higher profile in Europe and the rest of the world.
To this end, the Institute was a key contributor in the drafting of a document stating the position of the TSOs in ETSON (the European TSO Network) on research requirements regarding the safety of Generation II and III nuclear reactors. This position paper is the TSO contribution to ensuring that nuclear safety objectives are given the highest priority in sustainable nuclear energy technology platform (SNETP) and European Union FP7 programs.
IRSN also joined the French authorities at the IAEA Ministerial Conference on Nuclear Safety held in Vienna in June 2011. The conference was called to improve the global nuclear safety framework, with a particular focus on independence, transparency and emergency preparedness and response, stronger safety standards, draw lessons from the Fukushima-Daiichi accident in order to strengthen systematic periodic safety reviews in all countries, international critical peer reviews, and reinforced cooperation and procedures for exchanging information during crisis situations. The IAEA's plan will subsequently allow



IRSN PARTICIPANTS IN INTERNATIONAL EXPERT GROUPS.

IRSN to develop cooperation and support activities in many fields to enhance nuclear safety around the world. At the same time, the Institute continued to work with many foreign partners, especially in countries interested in setting up nuclear power programs, helping them to develop their projects by providing them with safety assessments and assistance, in most cases in collaboration with other TSOs.
On July 6, IRSN jointly organized a workshop in Cologne, Germany to discuss nuclear emergency response issues in light of the Fukushima accident and, more particularly, to define a joint organizational framework for information sharing and analysis in order to provide improved information to government authorities and the public. The workshop,



•–• *A round table was organized at the IAEA General Conference in 2011 to allow international nuclear safety networks to present their activities and share the knowledge and experience acquired around the world.*

which brought together TSOs from ETSON, was also attended by JNES, Japan's TSO, which is an associate member of the network. A genuine need for dialogue between TSOs regarding emergency response is one of the lessons learned from the Fukushima accident, and the JNES-European TSO workshop provided an opportunity to compare approaches in different countries and define priority measures. These included defining more clearly ways in which information on nuclear facilities could be networked, and developing the necessary skills and resources in countries that lack adequate emergency response capabilities. With this in mind, the proposals put forward include the development of a harmonized range of training courses, assistance with emergency response center engineering, and possible twinning of such centers during emergencies. Organizing regular international exercises involving the various TSOs would facilitate networking during emergencies and help keep the public authorities of each country, the European Commission, and the public better informed.

Another way in which IRSN contributes to increasing the role of TSOs in Europe and the rest of the world is through its strong support for the IAEA's decision to organize networking among TSOs. Following the recommendations made at various international conferences on nuclear safety technical support, such as the one held in Tokyo in 2010, and chaired by IRSN's Director General, the IAEA decided to set up a global TSO forum. The decision was announced at the Agency's 55th General Conference in Vienna in September 2011. A round table organized during the conference provided an opportunity for international nuclear safety networks to present their activities and for ETSON to stress the approach to safety analysis shared by its members (including IRSN), an approach based on state-of-the-art scientific knowledge and independent assessments. It confirmed a unanimous desire for nuclear safety experts to step up efforts to gather and share their knowledge and experience more effectively and on a global level.

Research: continued investment in efforts to enhance nuclear safety

The vital contribution of research activities to the development of methods and tools used by TSOs like IRSN to cope with major emergencies was clearly demonstrated in 2011. Such methods and tools allow IRSN to estimate radioactive release from damaged reactors, model the trajectory of contaminated air

masses, and take extreme accident scenarios into account. And it was this sustained effort to expand its scientific and technical knowledge that enabled it to respond effectively to various issues following the accident at the Fukushima-Daiichi nuclear power plant. For example, results from two international programs headed by the Institute, PHEBUS PF and ISTP, proved useful during the events at Fukushima. These programs are designed to evaluate radioactive release from a pressurized water reactor in the event of a core meltdown accident. A number of computing tools were also used to evaluate radioactive release from damaged reactors and predict its trajectory and the radioactive doses to which the public could be exposed.

The Institute's research policy was also validated by AERES, the French agency for the evaluation of research and higher education, which audited IRSN's research units. In the summary report it handed over to IRSN in 2011, AERES highlighted the degree of maturity the Institute had reached in the field of radiation protection and nuclear safety assessments and research in less than ten years of existence. The Agency also made a particular note of IRSN's research excellence in the main fields of its core scientific activity, namely: the effects of exposure to low-dose ionizing radiation, radiopathology, radioecology, nuclear fuel behavior in accident situations, nuclear reactor core meltdown, prevention of criticality risks, and the effectiveness of containment systems in preventing the spread of radioactive materials. Another point stressed by AERES was the strategic need for significant, unrivaled and high-performance experimental resources. In its recommendations, the Agency encouraged IRSN to: strengthen its research management strategy, while ensuring that research and assessment activities continue to interact closely; increase the number of researchers with accreditation to supervise research; improve the organization of partnerships with universities; and intensify efforts regarding scientific publications. IRSN responded to one of these recommendations by setting up the Strategy, Development and Partnerships Division (DSDP), which brings together strategy and programs, particularly in the research field.

12%

OF RESEARCH PROGRAM FUNDING COMES FROM EXTERNAL REVENUE.
(12% IN 2010)

The IRSN-coordinated Safety Assessment for Reactors of Generation IV - or SARGEN IV - project was approved by the European Commission for the Euratom 7th Framework Programme (FP7) in 2011, reflecting the Institute's active involvement in projects aimed at organizing research. The goal of SARGEN IV is to standardize safety assessment methods used for Generation IV fast neutron reactors currently studied in Europe. The project brings together 22 European partners, including the seven safety organizations belonging to ETSON, research centers, universities and reactor designers.

Results from experimental programs such as PHEBUS PF were used by IRSN during the emergency situation following the Fukushima-Daiichi accident.

•–• *ETSON held its general assembly in Paris on November 9, 2011. The event was attended by representatives of member organizations - Bel V, GRS, IRSN, LEI, UJV, VTT, VUJE – and associate members JNES, SEC-NRS and SSTC.*

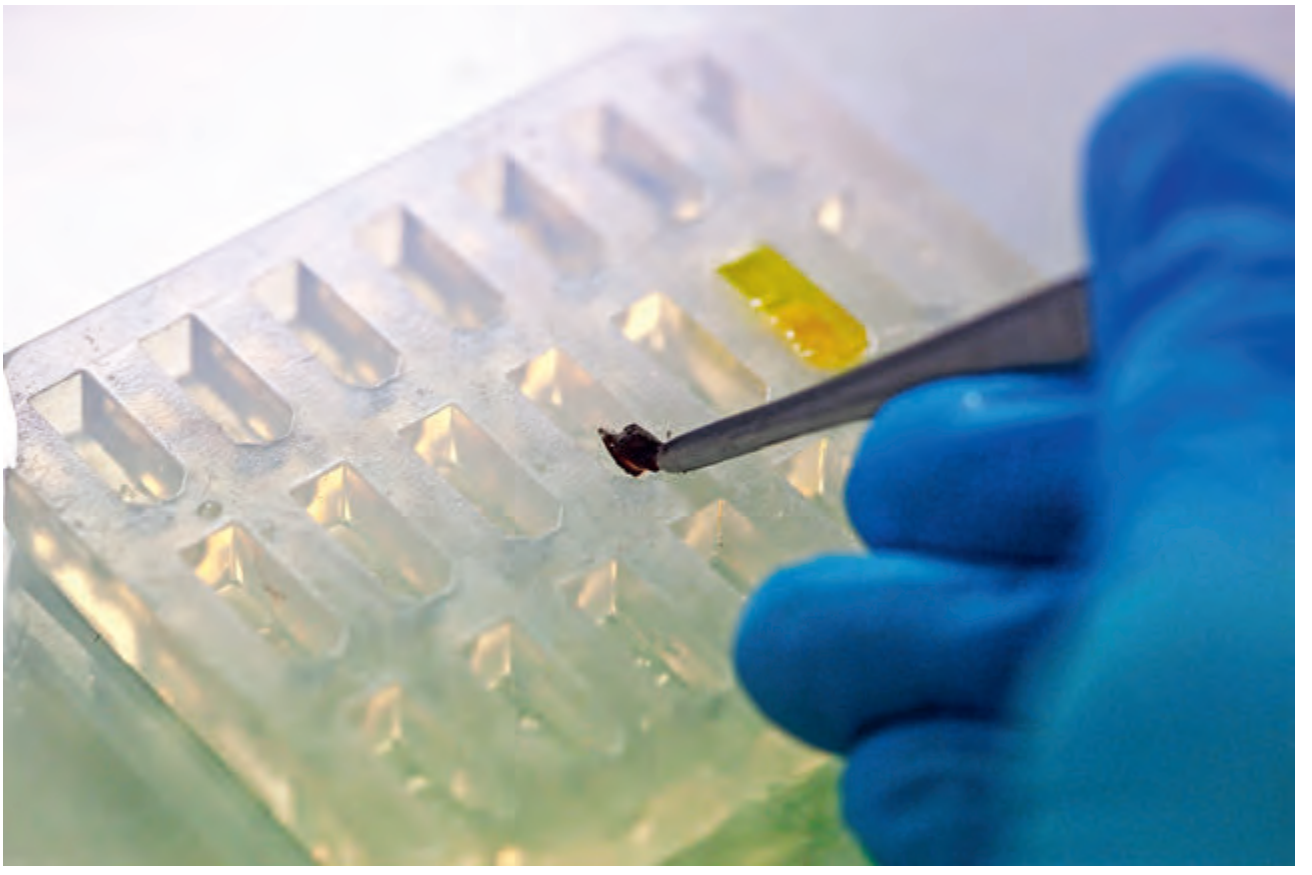
Another example is the Institute's commitment to the DoReMi network of excellence, in which 22 European and Japanese technical safety organizations, universities and government agencies work on joint research projects to learn more about the effects of chronic exposure to low-dose ionizing radiation on human health. In the field of radioecology, STAR, a European network of excellence, launched its first collaborative project, a sign of IRSN's involvement in European interdisciplinary and decisive research projects. The systematic organization of these collaborative research projects is part of a strategy to rationalize the research resources used by IRSN in order to drive progress in nuclear safety and radiation protection.

Lastly, a special Atomic Energy Committee was organized last July to examine, in particular, the impact of the Fukushima-Daiichi accident on research activities in the safety and radiation protection fields. A call for projects for an amount of €50 million was issued as part of the future investments initiative, via the French national research agency, ANR, to lend impetus to a number of priority actions. Priority concerns are accident-initiating events, accident prevention, and emergency response.

Assessments: the dual challenge of rapid response and adaptability

The Fukushima-Daiichi accident spurred an increase in IRSN's assessment activity in 2011, testing its ability to respond and adapt to a situation where close

•–• *IRSN organized two scientific seminars in 2011 in connection with the DoReMi European network of excellence. Their aim was to shed light on the effects of exposure to low-dose ionizing radiation.*



IRSN was actively involved in the safety audit carried out at nuclear facilities following the Fukushima-Daiichi accident.

monitoring of French facilities currently in operation remains a priority.

As a result of the Prime Minister's decision in 2011 to have a safety audit performed at French nuclear facilities in response to the Fukushima-Daiichi accident, IRSN set to work closely with ASN to define the specifications for the complementary safety assessments required, and examine the documentation submitted by the operators of the facilities concerned. The assessments focused first on the 58 power reactors in service today, the Flamanville 3 EPR currently under construction, experimental reactors, and nuclear fuel cycle facilities. Prior to the assessments, the operability of equipment and systems already planned at nuclear facilities had to be examined. IRSN submitted its report on complementary safety assessment packages to ASN and advisory committee members on November 4, 2011. The report was published on November 17 the same year.

IRSN examined the robustness of the safety systems in place at French nuclear facilities by reviewing existing safety studies and examining documents submitted by operators in September 2001. It also assessed how these systems performed during a series of beyond design-basis stress tests.

These highly complex technical tasks had to be completed within a limited time period, and without compromising the continuous monitoring of operating facilities.

Examining the safety options proposed for the Atmea 1 reactor, a 1100 MWe pressurized water reactor designed by Atmea, a joint subsidiary of Areva and Mitsubishi Heavy Industries, was another task that put the Institute's responsiveness and adaptability

50.2%

OF IRSN'S BUDGET WAS ALLOCATED TO TECHNICAL SUPPORT AND PUBLIC SERVICE MISSIONS. (47.9% EN 2010)

On September 14, 2011, more than 80 people, mostly from local information commissions, attended the seminar organized by IRSN and ANCCLI on nuclear safety issues following the Fukushima-Daiichi accident.

to the test. This work deserves a special mention as it involved assessing the design principles of a Generation III reactor, during which the Institute had to incorporate, in mid-examination, the first lessons learned from the Fukushima-Daiichi accident.
In a completely different area, the Mediator crisis, which broke out in 2011, led the French authorities to reconsider assessment principles and procedures for all public health issues. The Minister of Health therefore entrusted the French general inspectorate of social affairs (IGAS) with the task of assessing the existing public health assessment system to determine whether it meets its objectives in terms of independence, quality, and legitimacy. As it carries out a number of missions relevant to the public health system, IRSN was asked by IGAS to discuss a range of assessment-related issues, such as the role of assessment in the health system, assessment requests and how assessments are carried out, the independence of experts, stakeholder involvement in the assessment process, and how results are exploited. The hearing gave the Institute an opportunity to compare its assessment policy in these areas with expectations. IGAS made some general observations: each player's role should be clarified; procedures and assessments should be transparent; relations between public health agencies and their supervisory authorities (which initiate the assessment) should be formalized. These observations confirm the principles and procedures already adopted by IRSN in its assessment activities.

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STUDENTS FROM 10 FRENCH AND FOREIGN SCHOOLS TOOK PART IN THE RADIATION PROTECTION WORKSHOPS IN SCHOOLS INITIATIVE ORGANIZED IN GRENOBLE.
(197 IN 2010)

Openness to society: a transparency policy consolidated by the Fukushima accident

The relevance of IRSN's initiative to open up its activities to society was highlighted by the Fukushima accident, which has led to stricter requirements for both existing and planned nuclear facilities. In particular,

•–• *On September 9, 2011, the Charter for Openness to Society was signed by five public institutions for research, analysis, and evaluation of health and environmental risks, namely ANSES, ISTREA, IFSTTAR, INERIS and IRSN.*

the event has put the spotlight on two new aspects of the Institute's policy in this area: firstly, the desire to move closer to stakeholders on technical matters by initiating dialogue at the same time as safety analysis work, and, secondly, the desire to move closer in geographical terms through partnerships with local authorities. The first point was illustrated in 2011 during talks between IRSN experts and stakeholders, in particular local information commissions, prior to the complementary safety assessments carried out on French nuclear facilities. The second point was reflected in a joint initiative with the Metropolitan Community of Montbéliard, which aimed at alerting the public to the radon risk in homes to improve prevention measures, and supporting local stakeholders. In the same way, the Institute stepped up efforts to increase skills among representatives of civil society, particularly in local information commissions and committees. In April, it joined the Dampierre CLI in organizing a public meeting in Orleans to discuss the findings of the environmental radiological report that it had prepared in 2010 for the Val-de-Loire area. The report was the first of a series aimed at obtaining an environmental reference state for French nuclear sites, to be used for assessing radiological anomalies and the impact of any accidental radioactive release. IRSN also worked with INERIS, the French national institute for the study of industrial environments and risks, and ANSES, the French agency for food, environmental and occupational health and safety, at a joint seminar at the end of March to review the inter-institute Charter on Openness to Society, two years after it came into effect. Two new organizations signed the charter in September, namely IFSTTAR (French institute of science and technology for transport, development and networks) and IRSTEA (French research institute for agricultural and environmental engineering). In addition, IRSN published an inventory of its activities over the past two years relating to its initiative to open up to society. It also produced a report on the monitoring committee that was set up to help implement test cases on opening up the Institute's activities, as recommended by Georges Mercadal.

TRANSPARENCY AND COMMUNICATIONS POLICY

2011 - A BIG MEDIA YEAR FOR IRSN

The accident at the Fukushima-Daiichi plant put the IRSN's communication and information teams to work as no other single event had before. The Institute spared no effort to keep the authorities and general public regularly updated through its website and media action on the situation in Japan and its possible impact on French citizens living there, in the overseas territories or in metropolitan France. The considerable media coverage given to the Institute as a result of these events provided the public with a chance to discover the important role played by a TSO and the extent of its scientific and operational capabilities.

A press conference was organized on March 17, 2011 with the French Ministers of the Environment and Industry and Agnès Buzyn, Chair of IRSN's Board of Directors, when the ministers in question visited the IRSN emergency response center.

A single figure reflects how great public demand for information was in the weeks that followed the Fukushima-Daiichi accident: more than two million visitors connected to the www.irsn.fr website during the week March 20-26, 2011, nearly five times more than the total number of connections recorded for the whole of 2010. To meet the demand from the authorities and private citizens as effectively as possible, IRSN posted daily bulletins on its website giving the latest news on the damaged reactors, maps showing the trajectory of the contaminated air masses, and summaries of data gathered by the "network" of radioactivity monitors in France and Japan, etc.

At the same time, IRSN responded to more than 1400 requests for the press. All this media coverage revealed to the public the role played by France's technical safety organization in the nuclear safety and radiation protection fields, along with its scientific and operational capabilities. The sharp increase in the number of contacts from the foreign press in 2011 shows that the French were not the only ones to learn more about IRSN.

Complementary safety assessments: IRSN publishes its analysis report

The report on nuclear operator complementary safety assessments reports that IRSN submitted to ASN and advisory committee members was released on November 17, 2011. Following the press conference organized for the event, IRSN put an information notice online entitled *"IRSN analysis and conclusions of its examination of the complementary safety assessment reports submitted to ASN by nuclear operators following the Fukushima accident"*, together with its full report entitled *"Post-Fukushima complementary safety assessments: the performance of French nuclear facilities in extreme situations, and relevance of the proposed improvements"*. In this report, IRSN sets out its assessment method and the grounds for its recommendations that additional

safety requirements be imposed to guarantee that vital functions at nuclear facilities continue to operate in the event of extreme situations which, though exceptional, remain possible. In addition to these specific activities, the Institute continued to put online reports on reactor safety, environmental monitoring, and worker monitoring.

www.irsn.fr

Repères: mission accomplished

IRSN continued to publish its quarterly magazine *Repères*, drawing on the results of a readership survey carried out at the end of 2010, in which readers expressed the opinion that the publication provided useful information for professionals in the healthcare and nuclear safety sectors. The four issues published in 2011 respectively focused on: radon exposure, ETSON's contribution to progress in safety and radiation protection, pediatric radiation protection, and the preparation of French radiation protection standards based on current international recommendations. During the year, IRSN worked on several improvements to the magazine, to be introduced as of 2012.

Events: an ideal opportunity for dialogue with the public and professionals

Encouraged by the success of the events it organizes, IRSN continued its various traveling exhibitions. These included Nuclear Power and Society, an event organized in partnership with ASN, which moved to Chambéry at the beginning of 2011, La robe et le nuage (The Gown and the Cloud), which drew more than 1,000 visitors to Nantes between June and September, and Gafforisk, an exhibition designed to increase awareness, particularly among young people, of the nuclear risk, within the context of emergency drills carried out in 2011.

The Institute also took part in the Science Fair jointly organized with CEA on September 19 on the Saclay site near Paris, and opened the doors of its Tournemire experimental station in southern France to the public on June 19, answering questions from more than 800 visitors.

The EUROSAFE forum held in Paris on November 8-9, 2011 was one of the major professional events of the year, with a record attendance of nearly 500 persons from 43 countries taking part in discussions around "Nuclear safety: new challenges, gained experience and public expectations". During the forum, an inventory of technical knowledge concerning the accident that occurred at the Fukushima-Daiichi plant on March 11, 2011 was presented during a special seminar.

Lessons learned for emergency response and future research programs for ETSON were also discussed. Lastly, IRSN organized a number of conferences and symposiums, such as the event jointly organized with SELF, the French-language ergonomics society, on the theme "Ergonomics, an integrated approach to risks", and the symposium organized for the official opening of the Viktoria loop experimental facility in Levice, Slovakia. The Institute also took part in trade exhibitions such as Nuclear 2011 in Shenzhen, China.

IRSN BAROMETER

THE ECONOMIC CRISIS AND THE FUKUSHIMA ACCIDENT: MAJOR CONCERNS FOR THE FRENCH PUBLIC

Every year since 1988, the IRSN Barometer on risks and safety has kept close track of how the French public perceives nuclear and radiological risks, compared with other types of risks and concerns. The survey conducted for this purpose includes a number of questions recurring every year, plus other more topical questions.

Results from the survey carried out last October show how the Fukushima-Daiichi accident has impacted the French population's confidence in the country's nuclear safety system. In light of the current economic crisis, it comes as no surprise that the IRSN Barometer confirms that socio-economic risks are the chief concerns of the French public. Their environmental concerns therefore appear to rank lower, even though the survey shows that these concerns clearly remain. Looking more specifically at the nuclear sector, and in spite of the French Government's order for a general safety audit on the country's nuclear facilities, fears concerning nuclear risks rose, as expected, some months after the Fukushima-Daiichi accident, the results of which were not yet known at the time of the survey. Ninety percent of respondents considered that nuclear site operators should protect their facilities against "all risks, even events considered highly unlikely". Another trend observed is a greater public demand for transparency and the need for assessments by multiple expert sources. In the event of a crisis, 90% of respondents said it was important to have access to detailed information, as the crisis unfolded, while more than 80% thought that stakeholders and international experts should take part in safety assessments of French nuclear facilities. Along the same lines, they asked for greater access to expert reports and opinions. The decision made (at the Government's request) to release to the public IRSN's report on complementary safety assessments as soon as it is submitted to ASN seems particularly in line with these expectations, and helps to lend credibility to Government action to enhance nuclear safety.

PROMOTING A SAFETY AND RADIATION PROTECTION CULTURE

CONTRASTING TRENDS IN THE DEMAND FOR TRAINING

While the demand for training courses in radiation protection regulations and in certain occupational categories in the healthcare sector and industry continued on its downward trend in 2011, the number of applicants for the aptitude certificate for operating industrial radiology equipment (CAMARI) continued to rise. These contrasting trends can be explained on the one hand (at least in part) by budget restrictions brought about by the current economic crisis, and on the other hand, apparently, by stricter radiological inspections and the development of nondestructive testing methods, including industrial radiology. The year also saw an increase in nuclear safety training activities at ENSTTI.

1,810 PEOPLE ATTENDED IRSN TRAINING COURSES. (2,153 IN 2010)

Helping to protect individuals who are occupationally exposed to ionizing radiation is one of IRSN's responsibilities. Within this context, the Institute continues to organize training courses in radiation protection for those working in healthcare, industry, and research. It also offers training in nuclear safety and the monitoring and control of nuclear materials. While the numbers of healthcare personnel applying for training in patient radiation protection have seen a downturn, radiation protection training for those working in industry (excluding nuclear facilities) saw a significant increase. The number of persons attending IRSN training courses in this area rose from 13% to 30% of the annual total (2010 trainees for the year 2011).

Training courses in patient radiation protection mainly concerned personnel using radiological equipment in operating rooms in hospitals and clinics, as a large number of those working in imaging and radiotherapy centers were already trained as of 2010.

Whatever the case, IRSN observes that budget restrictions have led some organizations and companies to cut back on staff training investment. In view of this situation, IRSN made every effort to maintain its training activities for the medical sector through mailing initiatives and involvement in a range of professional events to promote its training offer in a highly competitive market.

One exception to this generally dull picture is training for radiation protection specialists, where demand remains very high. This is no doubt because the labor code imposes the presence of a radiation protection specialist wherever personnel runs the risk of exposure to radioactivity owing to the presence or use of ionizing radiation sources. The year 2011 saw the resumption of five-yearly training courses for those wishing to renew their accreditation in this area, as well as initial training courses, where an extra session had to be programmed in mid-year to meet the demand.

Progress in CAMARI-related activities confirmed

The year 2011 also saw a rise in the number of candidates for the aptitude certificate for operating industrial radiology equipment (CAMARI), which reached 714, compared with 664 the previous year. Of this number, 401 took the written exam in 2011, compared with 375 in 2010, and 313 took the oral exam, as against 289 in 2010. In view of these rising numbers, IRSN had to increase the number of examination sessions, with two sessions for the written exam and four for the oral every month. In December, IRSN organized a new session of CAMARI oral exams in Morocco for five candidates who had passed the written examination in 2010. This initiative was organized under the partnership agreement with AMS-AP, the Moroccan association for welding and pressure vessels. The partnership avoids the need for Moroccan candidates to come to France to take the CAMARI examination, and allows CNESTEN, Morocco's national center for nuclear energy, science and technology, AMS-AP, and the Moroccan authorities concerned to benefit from IRSN's expertise with a view to setting up a radiation protection system for industrial radiography purposes.

•–• *IRSN organized more regulatory training courses for radiation protection specialists.*

New nuclear safety training session organized by ENSTTI

Following an initial session in Germany and France between July and September 2010, the European Nuclear Safety Training and Tutoring Institute (ENSTTI) organized a training session in Munich during the summer 2011. The event, a great success, was attended by 15 participants from European and international nuclear safety radiation protection organizations as well as from industry. Participants in the second four-week session of specialized classes – and especially trainees from industry – found the technical visits and the high standard of teaching particularly valuable. The originality of ENSTTI's approach is that it draws on all the expertise and resources of the member and partner TSOs to provide short applied training sessions and long tutoring periods aimed at sharing European know-how in nuclear safety and radiation protection research and assessment. Since March 2011, this joint European initiative has had the status of a European Economic Interest Grouping (EEIG) formed by IRSN and two other European TSOs – GRS (Germany) and LEI (Lithuania) – and is supported by ETSON, the European TSO network.

•–• *ENSTTI provides training courses aimed at passing on European know-how in the field of nuclear safety and radiation protection.*

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CAMARI CERTIFICATES ISSUED.
(341 IN 2010)

03/

FONTENAY-AUX-ROSES – HAUTS-DE-SEINE
(December 18)

THE SOFIA SIMULATOR WAS OFFICIALLY OPENED BY THE FRENCH PRIME MINISTER FRANÇOIS FILLON, IN PRESENCE OF NATHALIE KOSCIUSKO-MORIZET, MINISTER OF ECOLOGY, ERIC BESSON, MINISTER OF ENERGY. THE PRIME MINISTER HAS ALSO VISITED THE IRSN'S EMERGENCY RESPONSE CENTER.

ACTIVITIES

SAFETY

MANAGING BOTH EMERGENCIES AND EVERYDAY ACTIVITIES

Although more than one hundred IRSN experts were mobilized during the second half of 2011 to analyze the reports of complementary safety assessments conducted by French operators of nuclear facilities, the Institute continued to carry out its routine activities of assessing the safety of nuclear power plants, fuel cycle and research facilities. In order to base these assessments of existing and future facilities – such as Generation IV reactors – on state-of-the-art scientific and technical knowledge, IRSN has continued its research works on fire prevention, major accident phenomenology and other areas that are vital to the safety of nuclear facilities. It has also responsed many requests from around the world for safety assessments, particularly from countries with nuclear power programs, such as the United Arab Emirates. Lastly, it continued to provide technical support in the field of safety for defense-related activities.

11 TECHNICAL INSTRUCTIONS PREPARED FOR MEETINGS OF STANDING ADVISORY GROUPS OR COMMITTEES FOR REACTORS, PLANTS, AND WASTE. (12 IN 2010)

SAFETY OF EXISTING FACILITIES

MONITORING REACTORS

IRSN supports ASN, the French nuclear safety authority, by assessing the safety of reactors in operation and during construction and dismantling work.

Incidents of clogging agents accumulating in pressurized water reactors

A number of significant events occurred at facilities in 2009 in France prompted IRSN to inquire on the massive influx of vegetable debris and other clogging agents upstream of the filters placed on the cooling water supply lines of nuclear reactors. The consultation of the feedback drawn over significant safety-related events related to massive influxes of clogging agents reported by EDF between 1979 and 2009, the Institute found that the clogging agents in question varied greatly, the frequency of occurrence varied from site to site, and the impact on equipment depended on the type of clogging agent. IRSN concluded that the problem should be handled using an approach similar to that currently in use for external hazards.

Operating reactors feedback between 2006 and 2008

IRSN submitted its feedback analysis on operating PWR operation between 2006 and 2008 to the advisory committee for nuclear reactors in January 2011. This analysis is conducted by IRSN every three years as part of a continual safety improvement approach. IRSN issued recommendations on a variety of topics, including the devices' management then temporary changes in facilities, checking of equipment performance following maintenance operations, maintenance requiring the shutdown of safety-related equipment, and steam generator degradation.

In the run-up to this advisory committee meeting, IRSN conducted assessments of feedback on safety,

IRSN carried out studies to assess the effectiveness of thickening the existing reactor foundation raft at the Fessenheim NPP in Alsace.

radiation protection, environment impact and the approaches adopted by EDF to ensure that its facilities set a high standard and to reduce the number of reactor trips. These assessments were also accompanied by recommendations.

Project to reinforce the foundation raft of the Fessenheim reactor

In 2011 IRSN conducted a series of studies for the purposes of determining, in 2012, the effectiveness of measures proposed by EDF to reinforce the foundation raft at the level of the pits of reactors 1 and 2 at the Fessenheim power plant in eastern France. The measures call for adding an extra layer of concrete under each reactor vessel further to the decision issued by ASN on July 4, 2011 requiring reinforcing the foundation raft of reactor 1 at Fessenheim before June 30, 2013, "in order to significantly increase its corium strength in the event of a severe accident involving ex-vessel progression." IRSN's civil engineering and radiation protection experts contributed to this assessment.
The Institute reviewed the value of options other than those proposed by EDF (concrete type, cooling method, etc.) using the MEDICIS corium-concrete interaction software developed by the Institute and validated using lessons learned from national and international experimental programs.

Generic anomalies affecting 900 MWe reactors

In 2011 IRSN reviewed proposals put forward by EDF to correct two generic anomalies affecting 900 MWe reactors. The first, reported by EDF in February 2011, related to premature wear of connecting rod bear-

IN THE WORDS OF...

YANN RICHET,

Researcher at IRSN's Criticality Analysis Department

"At IRSN, we have been making increasing use of applied mathematics to supplement conventional safety approaches, particularly in the areas of safety assessments and emergency response management.
The numerical tools and models used in situations such as the Fukushima Daiichi accident bring additional data to the decision-making process by including uncertainties about the available data. Statistical models are useful for quantifying risks of failure and margins of safety when assessing the safety of facilities.
The mathematical tools developed by IRSN help experts to find answers to interrelated and complex scientific problems and thus gain a comprehensive understanding of safety issues that are usually dealt with individually. Applied mathematics are also used to develop consistent and cross-functional safety approaches. The Institute works actively with its partners in the academic world and industry to master these tools that are vital to IRSN's missions."

IRSN was involved in monitoring progress in construction work on the Flamanville 3 reactor in Normandy.

ings on 26 emergency and station blackout diesel generators installed at these reactors. IRSN provided ASN with its assessment on the issue and, over the course of 2011, continued to evaluate the general safety problem posed by the loss of reliability of the generators using the results of measures taken on the sites. The second anomaly, reported by EDF in early 2011, concerned measurement uncertainties related to the adjustment of the high-head safety injection system (HHSI) flow rate to the three main pipes of the reactor coolant system.
It was found that the instrumentation used was not accurate enough for this adjustment and did not guarantee that safety criteria would be met in the event of a LOCA. In its July 2011 assessment, IRSN recommended checking the balance of the HHSI flow rate during subsequent outages of all 900 MWe reactors.
www.irsn.fr

A big year for EPR assessments

In 2011, IRSN continued to assess the detailed design of the Flamanville 3 EPR in Normandy and its operating principles, while helping to monitor the progress of construction work on the new reactor.
IRSN accepted EDF's demonstration of compliance with the initial specifications for the automated safety system used to operate the reactor following the initial phases of an accident. The presentation of these findings before the advisory committee on reactors ended several years of inquiry into the architecture of the EPR's I&C system and the platforms used.
IRSN also reviewed all the systems designed to ensure the containment of radioactive substances. The Institute recommended looking into the possibilities of controlling and filtering potential releases in the event of an accident in the buildings closed to the reactor building.
After reviewing a working draft of the Flamanville 3 safety analysis report submitted by EDF in late 2010, IRSN considered that a fuller demonstration of the reactor's safety was necessary.
In addition to assessing the detailed design, IRSN will investigate whether the Flamanville 3 reactor

complies with state-of-the-art safety and building standards. In 2011 the Institute continued to participate extensively in the inspection program set up by ASN. A great deal of attention was focused on the concreting of the internal containment and the walls of the pools in the reactor and fuel storage buildings, as well as welding on the safety-related the tanks. Lastly, IRSN issued its findings on the impact study and the preliminary safety analysis submitted by EDF to ASN as part of its construction license application for an EPR on the Penly site in Normandy. In both cases, IRSN's assessments revealed many weaknesses.

www.irsn.fr

Supporting safety in Ukraine

In June 2011 IRSN's experts presented the State Nuclear Regulatory Inspectorate of Ukraine (SNRIU) with the findings of their safety analysis reviews and their assessment of safety improvements to Ukrainian VVER reactors currently in operation in Ukraine. Begun in 2007 and funded by the European Commission as part of its support programs, this work was carried out in collaboration with GRS experts from the Riskaudit EEIG.

The Institute was also appointed to carry out three significant tasks:

- define the regulatory requirements concerning the development of a project to build a research reactor;
- make a final assessment on the updating of the comprehensive program to modernize Ukraine's VVER reactors, taking into account IAEA recommendations and post-Fukushima measures planned by the operator;
- advise the SNRIU as to the best safety options for a future power reactor.

Assessment of EDF's strategy for nuclear power plant dismantling

In order to meet the requests made by ASN in 2004, EDF sent, in 2009, an updated version of its application setting out its strategy for the dismantling of Generation I nuclear plants. IRSN's assessment found that, although the strategy presented was adequate, the schedules for the dismantling of EDF's gas-cooled reactors (GCRs) had suffered major postponements due to the failure to find a site on which to build a graphite waste disposal facility. As the exact completion date of this facility is not yet known, IRSN recommended that EDF send an updated version of its application, presenting the options guaranteeing that the facilities would be dismantled as scheduled. This updated application will also have to include information demonstrating the acceptability of the deadlines set in view of the safety of facilities awaiting dismantlement.

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TECHNICAL NOTICES WERE SUBMITTED TO ASN (EXCLUDING DEFENSE-RELATED ACTIVITIES). (658 IN 2010)

Complementary post-Fukushima safety assessments

Twelve days after the triple disaster that hit Japan on March 11, French Prime Minister François Fillon requested an "audit" of all nuclear facilities in France. Just two days after Mr. Fillon's request, the European Council issued a declaration requiring the perfor-

IN THE WORDS OF...

JOËL GARRON,

Specialist in Organizational and Human Factors, Department for the Study of Human Factors, IRSN

"The Finnish operator Fortum contacted IRSN as part of its project to modernize the control room at its Loviisa nuclear power plant. We worked with GRS on this project.
Our job consisted in analyzing the thoroughness and relevance of the international standards listed as references in the design document drawn up by Fortum. In particular, IRSN reviewed the standards on the layout of spaces, work stations and MMIs, the consideration of users in the design process and even model validation. It also entailed supplementing the standards used with feedback from assessments conducted by IRSN on France's reactors, particularly its 1450 MWe series and EPR. This service for a foreign operator was a first for us in the field of human factors and will surely be followed by a second phase designed to ensure consistency between the standards used and design choices."

IN THE WORDS OF...

VÉRONIQUE ROUYER,

Assistant Director for Scientific and Technical Projects, Strategy, Development and Partnerships Sector, IRSN

"2011 was marked by the completion of the main renovation work of the CABRI reactor and particularly by the resolution of complex technical problems raised by the reactor's earthquake resistance, and work on the overhead crane to bring it in line with requirements. The facility is now in the pre-commissioning test phase, a decisive moment in the renovation project. 2011 also saw discussions with CEA, the owner of the project, to more clearly define each party's responsibilities and commitments in the proper completion of the work. As CEA operates the reactor and IRSN supervises the research programs conducted in it to study the behavior of nuclear fuel during accident situations, IRSN and CEA signed, on October 7, 2011, a new contract governing the end of the renovation work. Among other things, this contract sets a cost limit and a maximum period of 24 months between the time when the reactor core may be loaded and the sending of the application for authorization to conduct the experimental tests planned under the international CABRI-CIP project. Once ASN grants this authorization, the facility will be fully operational."

mance of stress tests on all nuclear plants throughout Europe (see box). IRSN was heavily involved on both fronts throughout 2011.

Although the months of March and April 2011 were primarily spent dealing with the emergency and informing the public authorities and the media, IRSN was quickly contacted by ASN to participate in drafting the EU stress test specifications. These specifications also provided a framework for French complementary safety assessments (CSAs), which evaluate the behavior of facilities under extreme situations caused by natural hazards, or following a complete loss of coolant or a prolonged loss of electrical power at more than one facility on a single site. Their purpose is also to assess the availability and organization of the means used to respond to emergencies in these situations.

To carry out these assessments, in early April IRSN brought its operational directions together under a single organization to obtain a cross-functional view of areas as varied as the characterization and impact of hazards, the management of loss-of-safety-function situations and the management of severe accidents and emergencies.

This organization had two overriding objectives:

- organize IRSN's work associated with the CSAs and stress tests;
- set up a suitable structure to learn more about what caused the accident and how it unfolded and, where necessary, amend the safety approach used in France.

A post-Fukushima working group was created along with six subgroups, each in charge of issues relating directly to feedback from the accident.

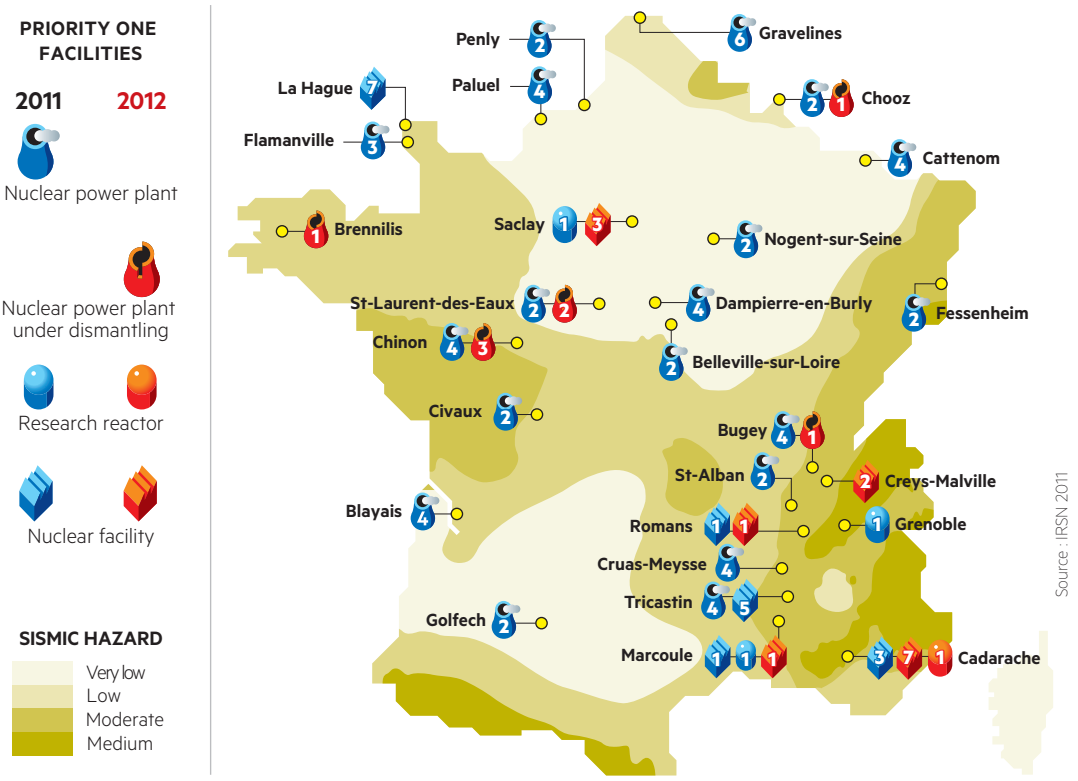
The approach required by the CSAs consists in considering that severe accident situations may be caused by natural external hazards or that, independent of any hazard, their characteristics (duration, number of facilities affected, etc.) may exceed the requirements of the current basement.

The CSAs must therefore make it possible to identify the safety functions to be ensured in these accident situations (earthquake, flood, loss of coolant, loss of electrical power, severe accidents) in order to prevent the occurrence of undesirable situations (core meltdown, uncovery of fuel stored in a pool, significant releases, etc.). The aim is to avoid the serious consequences of a beyond-basement hazard or accident for the environment and the public.

In May the working group determined which information operators should include in their reports. This made it possible to prepare the first phase of the audit – the analysis of the approach used by the operators to meet ASN specifications – prior to receiving the documents describing these approaches, due on June 1. This analysis was presented to the advisory committees for reactors, labs and plants on July 6, 2011.

In the period between this analysis and receipt of the operators' documents, a number of studies were conducted to prepare the analysis of the documents in question. These included assessing the likelihood of earthquakes on each site, identifying flooding protection systems, identifying significant compliance gaps on PWR reactors, identifying materials and systems used in situations of total loss of coolant and power supplies, information on how a severe accident occurs, and the risks posed by the industrial environment.

After receiving the operators' documents on



As part of the complementary safety assessment initiative, 79 civil facilities were examined in 2011. The operators of the 24 other facilities must submit their report by January 15, 2012.

MORE ABOUT

EU STRESS TESTS

On March 24 and 25, the European Council requested that EU Member States conduct stress tests of their nuclear facilities. Stress tests are defined as "a targeted reassessment of the safety margins of nuclear power plants in light of the events which occurred at Fukushima." The scenarios considered include accident situations that could occur, possibly simultaneously, in a site's reactors and spent-fuel pools. It is up to nuclear power plant operators to perform these reassessments, and up to safety authorities to accept or reject them. On September 15, all the countries submitted progress reports to the European Commission. These reports primarily described the methods used by operators to conduct these stress tests. A summary progress report was presented to the Council on December 9. Final national reports, drawn up by each country's safety authorities on the basis of the operator reports and the related reviews, were submitted to ENSREG (European Nuclear Safety Regulators Group) on December 31. These reports were examined during European peer reviews held between January and April 2012, following which an ENSREG report was published. This report will guide decision-making at the European Council scheduled for June 2012. The European Commission has nevertheless requested that further investigations be carried out by the end of November 2012. In addition, ENSREG will set up an action plan aimed at ensuring that peer review recommendations are followed up and that a number of additional actions are implemented.

September 15, IRSN reviewed them by looking at cross-cutting issues, such as fire analyses, explosions, accident management, and the mechanical strength of equipment and structures. It drafted a report and submitted the findings to the advisory committees on November 8-10. The three main findings are as follows:

- A few nuclear facilities do not fully comply with applicable safety requirements. Corrective actions are therefore underway and will be accelerated;
- New knowledge must lead to a proactive review of certain requirements, especially in the case of earthquakes, as our understanding of this phenomenon has increased considerably in recent years;
- The question of how nuclear facilities react under extreme natural conditions must be examined.

To confront these exceptional, but nonetheless conceivable, scenarios, IRSN recommended the adoption of a hardened safety core. Consisting of a certain number of structures, systems and components, this hardened safety core would meet more stringent safety requirements and guarantee that the vital basic functions of nuclear facilities are maintained until off-site resources are able to take over.

This extensive analysis work was completed within a very short time by the operators of the nuclear facilities (including EDF, CEA and Areva) and IRSN, which enlisted the assistance of more than one hundred experts over a period of several months..

www.irsn.fr

MONITORING FUEL CYCLE FACILITIES AND EXPERIMENTAL REACTORS

The aim of the assessment conducted by IRSN is to evaluate the safety of fuel cycle facilities and experimental reactors.

Safety of the ÉOLE and MINERVE research reactors

In 2011 IRSN presented the advisory committee for nuclear reactors with its assessment of the safety of the ÉOLE and MINERVE experimental reactors operated by CEA at the Cadarache Center northeast of Marseille. Conducted on the basis of the safety review application for both reactors, the assessment confirmed that, in light of their characteristics and the operating technical specifications in force – particularly regarding the verifications to be made before every experiment – both reactors could continue operating.
IRSN also reviewed the control of criticality risks in storage facilities and during transfers of fissile materials used in both reactors. The observations made by IRSN during its review prompted CEA to redefine its criticality baseline and make a commitment to increase the reliability of the overhead cranes used to transfer fissile materials at the facility. Lastly, IRSN's review of the facility's earthquake resistance revealed the need for structural reinforcement. This work is expected to be carried out by CEA in 2012.

Commissioning of the Magenta facility

IRSN reviewed the safety analysis report, the general operating rules, the decommissioning plan and the safety-related tests presented by CEA for the purposes of commissioning the Magenta facility located on the site of the Cadarache Center.
Designed for the purposes of storing and characterizing non-irradiated fissile materials, the reactor is equipped with storage facilities as well as various types of equipment (including glove boxes) used to recondition and characterize materials. IRSN's review found that, in light of the commitments made by CEA during the review, the safety and radiation protection measures presented in the documents provided for the commissioning of the Magenta reactor were appropriate, subject to a few recommendations concerning, in particular, the commissioning of the glove boxes mentioned above, and the risk of rainwater accumulating on roofs in the event of drain clogging.
www.irsn.fr

Project to build a research reactor in the Netherlands

In 2011 IRSN lent its technical expertise to the Dutch Ministry of Economic Affairs, Agriculture and Innovation by proposing a list of safety requirements

The EOLE reactor (like MINERVE) is mainly used for neutronic studies in thermal fuel networks.

IN THE WORDS OF...

ÉLODIE CAHEN,

Engineer in charge of assessing the Jules Horowitz research reactor, IRSN

"When completed, the Jules Horowitz reactor on CEA's Cadarache site will be used to study the behavior of fuels and materials and produce radioisotopes for use in nuclear medicine. The reactor's safety is assessed by reviewing its detailed design and monitoring construction quality. In addition to participating in three inspections led by ASN, in 2011 the Institute reviewed the conceptual and structural design packages for the containment building and the reactor pool. Its assessment and the commitments made by CEA during the assessment made it possible to lift ASN's hold points for both structures and allow CEA to begin work on their construction. More specifically, IRSN's reservations about the representativeness of the load created by a borax explosion accident used to design the reactor pool prompted CEA to modify the design of the reactivity control mechanisms and consider the possibility of installing shock absorbers around the edge of the pool."

for the research reactor that the Dutch operator NRG is planning to build in Petten, a town north of Amsterdam, and which will have a thermal output of several dozen megawatts. The Institute based this list on the requirements of competent international organizations (such as IAEA) and design choices adopted for the latest research reactors that have been built or are still under construction around the world. This work will feed the public debate on the construction of the new research reactor.

CONTAINMENT AND FIRE

Containment is a major safety function in the control of radioactive release to the environment. IRSN also conducts research on this issue to gain a better understanding of how fires start in confined spaces and to evaluate the risks of containment failure.

Publication of IRSN's fire hazard assessment baseline

In 2011 IRSN finished and published its fire hazard assessment baseline. Containing the Institute's feedback and explaining state-of-the-art practices in fire hazard assessment, the baseline's purpose is to set out and disseminate the principles the Institute considers should be followed when analyzing fire hazards. Among other things, it specifies the methodology to be used and the evidence of nuclear safety to be provided. The baseline, which was widely disseminated, was presented to ASN and ASND (French Nuclear Safety Authority for defense-related facilities and activities) and a number of foreign counterparts, for example during a meeting held by the OECD in Toronto, Canada. The assessment baseline is accompanied by two documents. The first sets out requirements for the validation and verification of the numerical methods and tools used to estimate the effects of fire in safety demonstrations. The second specifies capability and response time requirements.

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Increase in the number of fire protection services

IRSN provided yet more fire protection services in 2011. For several years the Institute's teams on the Cadarache site have been providing technical services (fire and thermal stress studies) and scientific services (data analysis) as part of the regional partnership platform known as COPERNIC and which has been officially recognized by the region's risk management cluster.

These services include testing CEA-patented valves under fire conditions; analyzing experimental data for DGA, the French defense procurement agency; testing helicopter components for Eurocopter; and testing electrical cables for ITER. In providing these services, the Institute puts its expertise and knowledge to work for companies, especially those in the region around the Cadarache site, and enhances the skills of its research and development teams.

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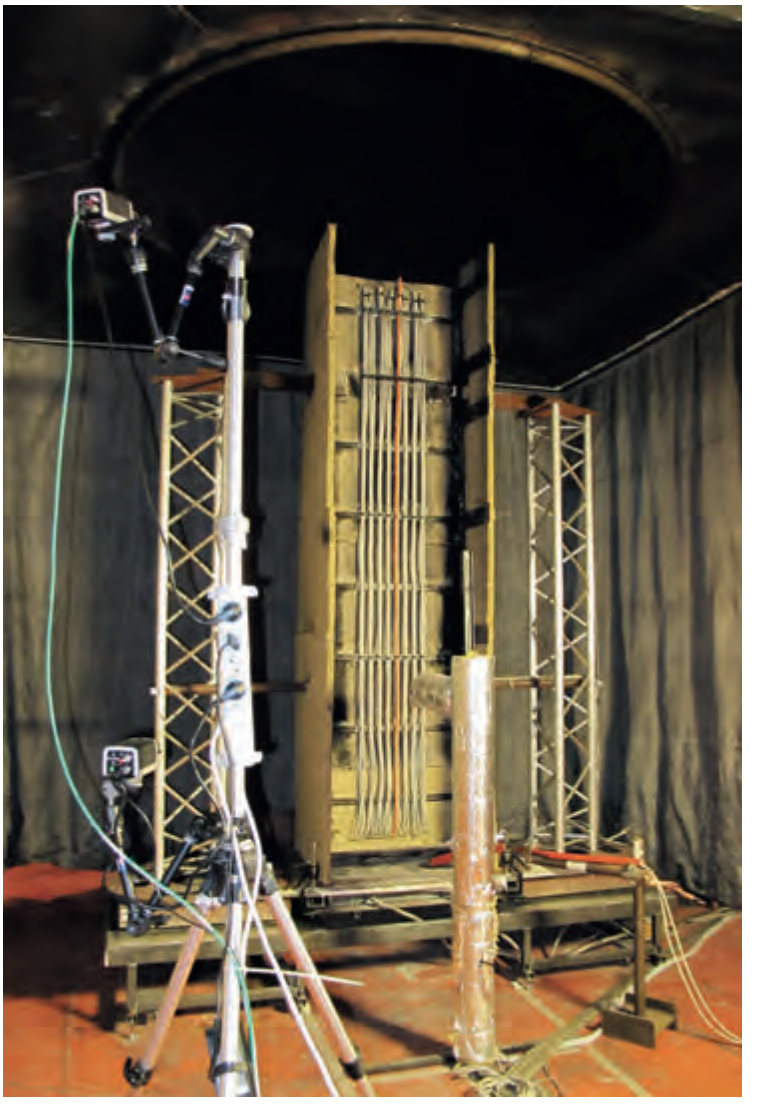
Lessons of the common-interest program on fire

2011 saw the end of the common-interest program led with Areva to study the behavior of radiation containment equipment in nuclear facilities in the event of fire in electrical cabinets. This research program resulted in the development and qualification, at various scales, of a model for predicting the clogging of HEPA filters by combustion aerosols. This model includes parameters that directly influence clogging (weight of the aerosols deposited, size of the aerosols released, condensate content

•–• *Cable fire test facility (ITER).*



Many wind tunnel tests were performed on a mockup of a building representing reference facilities equipped with a ventilation network. The purpose of these tests was to measure leak rates.

and filtration velocity). A method was developed to access model parameters that vary with the size of the aerosols and their condensate content. This common-interest program also made it easier to model industrial ventilation systems used to study ventilation performance during a fire. It reduces, by as much as a factor of forty, the amount of aeromechanical data required, without impairing the quality of results in terms of their relevance.

Initial version of the BADIANE database

IRSN developed and released to its assessment units an initial version of BADIANE, its new database on the behavior of equipment used to contain radiation and isolate areas in the event of fire.
BADIANE contains the results of research conducted in three areas: work stations, fire compartmentalization equipment and filtration devices for ventilation systems. In just a few clicks, it provides all the information needed to determine a characteristic feature of the behavior of a piece of equipment

MORE ABOUT

METROLOGY OF NANOPARTICLES

Because emerging technologies have safety issues that must be investigated immediately, IRSN and CEA signed, in 2011, a partnership agreement on nanoparticles and the risks associated with carbon nanotubes in particular. CEA sought IRSN's expertise to help it develop an analysis technique capable of detecting nanotubes in the form of airborne aerosols in the industries in which they are used. This highly sensitive technique is able to determine the composition of particles suspended in the air. IRSN's contribution to this project consisted in developing a safe, design-basis system to produce aerosols by means of controlled suspension of powdery materials (aluminum oxide, carbon, etc.) and, ultimately, carbon nanotubes. In exchange, IRSN may use the analysis technique to identify, virtually in real time, the release phases of a specific contaminant within soot created by the thermal degradation of materials used in the nuclear industry.

when tested under normal, degraded and accident conditions..

Effects of wind on radiation containment in nuclear facilities

Following the completion of a first phase to characterize the range of pressures exerted by winds on nuclear facilities, a major second step in the TIVANO research program was achieved in 2011 thanks to progress made on a thesis project carried out with the French scientific and technical center for building (CSTB). This project concerned a similarity study of the influence of the wind on airflows inside a facility during normal and degraded operation of the facility's ventilation system. A long series of wind tunnel tests was conducted on two ventilation system models to study their behavior under various steady-state or transient conditions, isothermic situations, and for several wind angles of incidence and velocities. These tests also revealed that, in some accident situations, the wind's effects might lead to a partial loss of containment. In other words, they would reverse airflows between the inside and outside of the facility.

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NATURAL HAZARDS

In order to gain a better understanding of the risks and consequences of natural hazards for nuclear facilities, IRSN is conducting research on earthquakes, heat waves, storms and floods.

Baseline for assessing seismic hazards

In 2011, IRSN took another step forward towards creating a comprehensive reference database for use in assessing seismic hazards, based on the method currently used around basic nuclear installations (INB). The result of several years of R&D work, this reference base now comprises revised seismotectonic maps of metropolitan France, a catalog of seismic parameters (magnitude and depths) based on over a thousand years of history, and a database of potentially active faults. The database version produced in 2011 only covers the southeastern quarter of France. Additional work is in progress to cover all areas located around basic nuclear installations. This master data will lead to better assessments of seismic hazards through the estimation of the seismogenic potential of the Earth's crust at the scale of metropolitan France. These assessments are accompanied by estimations of the uncertainties of the results obtained, without which the assessment would be of little use.

Assessment conducted in the United Arab Emirates

In 2011 IRSN began assessing the characteristics of Braka, the site on which the first nuclear power plant in the United Arab Emirates will be built. Working with GRS as part of a consortium led by the Riskaudit EEIG, the Institute was selected by the UAE's safety authority, following an international RFP, to review a portion of the safety analysis report to be filed with the plant construction license application.

More specifically, IRSN is responsible for reviewing all assumptions on extreme weather conditions, from seismic hazards to the availability of coolant and the geotechnical conditions on which the design of future reactors is based. This review is scheduled to be completed in the first quarter of 2012, but may be extended in order to apply the lessons learned from the Fukushima Daiichi accident.

IN THE WORDS OF...

DAVIDE GUERRA,

Design Engineer, Airborne Pollutants and Containment Study and Research Department, IRSN

"With more than twenty years of experience in modeling ventilation systems, IRSN possesses the expertise needed to study the behavior of these systems under incident or degraded conditions to ensure the containment of radioactive materials and thus eliminate any risk of release to the environment. We put our expertise to work for plant operators and design offices and provide services for facilities that are in operation or are being built or dismantled. CEA and Areva are among the organizations and companies that contact us to analyze the ventilation systems in laboratories and plants, at both the front and back ends of the nuclear fuel cycle. We have been using SYLVIA, a software program developed by IRSN to model complex ventilation systems, for nearly two years now. In the case of existing facilities, we base our work on indoor flow rate and pressure measurements. We always compare our simulations against the results of measurements taken in another operating state. In the case of projects for new facilities, we work using theoretical values and design drawings."

www.irsn.fr

FUELS

IRSN conducts research on nuclear fuels in order to better understand the safety limits to be considered with new methods of managing PWR fuel.

Analysis of the behavior and management of fuels between 2003 and 2009

On June 23, 2011, IRSN presented to the advisory committee for nuclear reactors its analysis of the feedback on PWR fuel behavior between 2003 and 2009.

The analysis revealed a number of points that call for particular vigilance:

- extensive oxidation of the Zircaloy-4 cladding makes it impossible to guarantee that the cladding will not burst under certain accident situations. Furthermore, manufacturing problems with the M5 alloy cladding resulted in loss of fuel integrity in the reactors;
- presence of fuel assemblies from different suppliers in the same reactor makes demonstrating safety complicated, particularly due to the different head losses;
- extensive deformations that delayed, and even prevented, lowering of the rods were reported on the 1450 MWe reactors;
- variability in the composition of refueled cores calls for a change in the scope of fuel management studies.

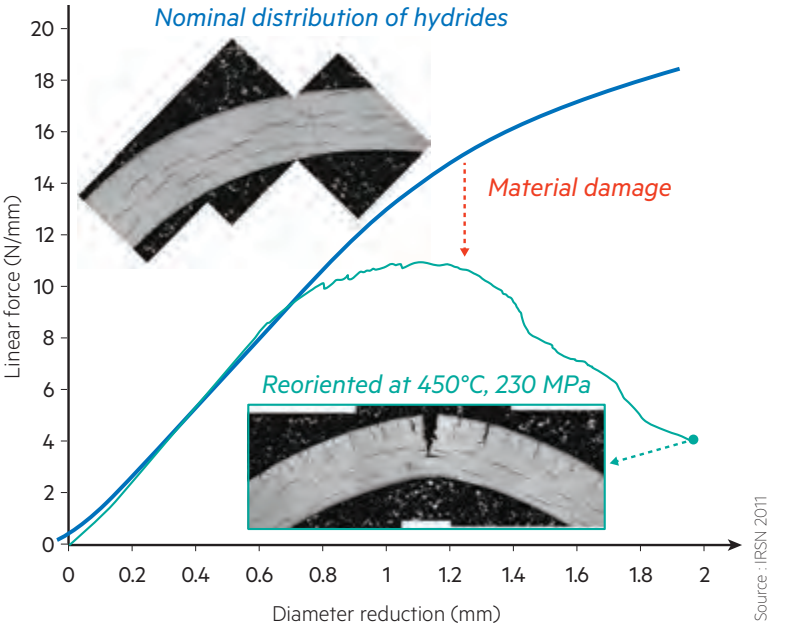
www.irsn.fr

Study of spent fuel embrittlement following transportation

Fuel rod cladding is the first of three barriers that prevent radioactive release to the environment. It can, however, undergo gradual oxidization while the fuel is inside the reactor, with the result that when the spent fuel is shipped to reprocessing facilities, the cladding can weaken, rupture and allow the nuclear materials it contains to spill out.

Broadly speaking, this weakening process can be described as follows: the hydrogen absorbed by the cladding while the fuel is in use inside the reactor exists as a solid solution while the rods are being shipped to the reprocessing facility. When immersed in the spent-fuel pool, the temperature of the water causes the hydrogen to precipitate into hydride platelets that run parallel to the cladding walls.

Beyond a certain level of thermomechanical stress, however, these hydrides precipitate in an orthogonal direction in relation to the cladding walls, which are only a few millimeters thick. These "radial" hydrides weaken the cladding, especially if orthogonal cracks begin to form. To characterize the conditions for applying a wide range of stresses to change the orientation of these hydrides in fuel cladding, IRSN developed an original mechanical experimental protocol in 2011 for studying the acceptable stress limits for the strength of spent-fuel cladding subjected to internal pressure from rods during immersion.



Effect of thermomechanical stress on hydride orientation.

Mechanical behavior of cladding during a loss of coolant accident

During a loss of coolant accident (LOCA), fuel cladding can be exposed to high temperatures (up to 1200°C) in a water vapor atmosphere and potentially rupture. The effects of such exposure are generally evaluated using the results of tests conducted on new cladding.

However, in order to determine the role played by the layer of corrosion that forms under normal reactor operating conditions, IRSN conducted thermomechanical tests in 2011 on cladding that had been precoated with an oxide layer in order to simulate reactor conditions. The layer was found to form a protective barrier that slowed down high-temperature oxidation in water vapor.

However, the results showed that the layer promoted the introduction of hydrogen into the metal under the oxide layer, reducing the mechanical strength of the material. The existence of these two concurrent phenomena confirms the need for results from experiments that simulate real operating conditions.

Nitrogen identified as a culprit in the degradation of air-exposed fuel cladding

IRSN performed experiments involving micro-Raman spectroscopy techniques in collaboration with the Laboratory of Electrochemistry and

Physical Chemistry of Materials and Interfaces (LEPMI) in Grenoble, which is specialized in micro-Raman spectroscopy. These experiments confirmed the presence of nitrogen and identified its various physicochemical phases in oxide layers that form at high temperatures on Zircaloy-4 cladding exposed to air when fuel assemblies are accidentally uncovered. These findings are especially significant as nitrogen accelerates cladding degradation during such accidents.

ACCIDENTS

In 2011 IRSN completed several research programs aimed at characterizing PWR core meltdowns to learn more about the potential consequences of this type of accident on people and the environment.
It also shares its work with its European and international partners as part of a general approach to information sharing.

Close of ASAMPSA2 project

The conference closing the ASAMPSA2 project (Advanced Safety Assessment Methodologies: Level 2 Probabilistic Safety Assessments) marked the end of the external review of the best practices guide for level 2 Probabilistic Safety Assessment. The conference was held from March 7 to 9, 2011, in Espoo, Finland.
Launched in 2008 under the European Commission's Seventh Framework Program for Research and Development (FP7), the ASAMPSA2 project brought together 21 partners (operators, designers, safety authorities and their technical support networks) under the coordination of IRSN.
The project culminated in the creation of a European guide, released in early 2012, on the development and use of PSA2 for Generation II and III nuclear reactors and future Generation IV reactors. Topics of interest for future international projects in the field of probabilistic assessments were also identified at the conference.

www.asampsa2.eu

Final report of the PHEBUS FP program

Launched 20 years ago, the PHEBUS FP international experimental program ended in 2011 with the publication of the final report on the last test known as PHEBUS FPT3. The complex experiments conducted under the program brought into play the entire range of phenomena that occur during a PWR core meltdown prior to a vessel breach, and generated a vast amount of data of significant scientific value.
Since then, this data has been supplemented by the results of separate-effect tests conducted under completely representative conditions in order to gain a deeper understanding of certain phenomena. These data and results are used to validate and improve computer models for assessing radioactive releases into the environment during such an accident.
One of the lessons learned from the program is that the amount of gaseous iodine released into the confinement can be actually greater than that forecasted by the models and may exacerbate the consequences of a radioactive release into the environment. These experimental results are shared by the international community by means of cross interpretation.

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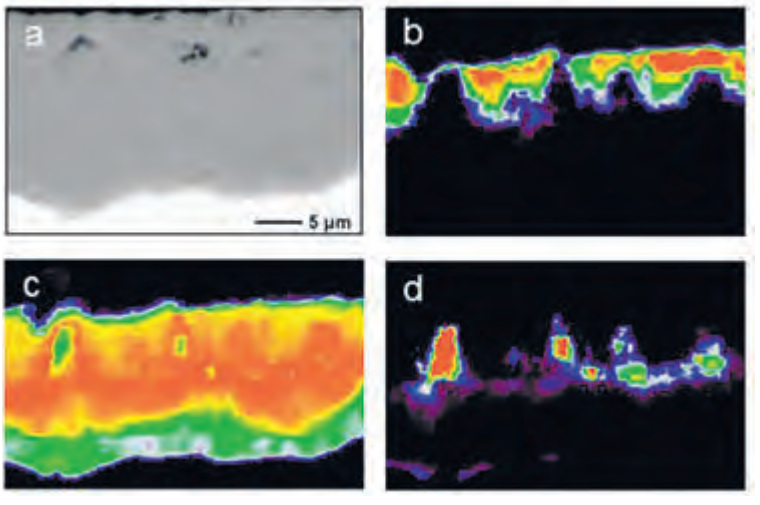
Gaseous iodine measured in core meltdown accident situations

In 2011 IRSN measured gaseous iodine in experimental systems that simulate LOCAs leading to



RAMAN imaging. (a) Optical microscope image of an oxide layer, formed when exposed to air at 800 °C on Zircaloy-4, and maps obtained using micro-Raman spectroscopy, showing the location of phases containing nitrogen – (b) Cubic zirconia – (c) Zirconium oxynitride – (d) Zirconium nitride. These phases are never alone, monoclinic zirconia predominates in all areas.

radioactive releases inside the containment building. These tests showed that the formation of gaseous iodine was limited in the presence of cesium, iodine, oxygen and hydrogen, and high in the presence of molybdenum (another chemical element released during this type of accident).
These results, used to develop and validate the chemical kinetics models in the ASTEC software used to simulate core meltdown accidents, are the product of six years spent developing a complex experimental loop known as CHIP-LP (phenomenological test line) and its associated experimental facilities.
The final phase included developing means of separating gaseous iodine from particulate iodine. These tests, which were set up to understand the high fraction of gaseous iodine measured in the containment during the PHEBUS FP tests, will be continued in order to assess the influence of elements such as boron.

Assessment of DOE and NRC work

In 2011 the DOE and the NRC contacted IRSN to review their recent work on updating the reference source term. By assessing the amount of radioactive substances that could be released into the environment during an accident, it is possible to estimate the impact of this release on human health and the environment.
IRSN assessed the NRC's work to update the reference source term for light water reactors (LWR) and evaluate, within the scope of the State-of-the-Art Reactor Consequence Analyses (SOARCA) project, the consequences of reactor meltdown accidents. In the case of the DOE, IRSN assessed the main phenomena likely to occur during accidental releases from sodium-cooled fast reactors.
IRSN emphasized the need to systematically take into account the uncertainties involved and consider such things as steam generator tube defects in order to correctly assess the risks of direct releases to the atmosphere. IRSN's recommendations were included in the final reports released to the public and will be the subject of further work.
www.nrc.gov

Experimental feasibility of debris bed reflooding

In 2011 IRSN conducted preliminary tests (the first of their kind in the world) to demonstrate the feasibility of the PEARL experimental program on large-scale reflooding of debris beds that the Institute will be launching in 2012. When a LOCA occurs in a nuclear reactor, the lead-up to a core meltdown can be slowed down – and even halted – by injecting water using any system that may be available repaired. IRSN develops debris bed reflooding experiments in order to better assess the effectiveness of injecting water into various damaged core configurations. The main technical challenges of these experiments are: a) achieving uniform high temperatures within the particle bed used to simulate debris and; b) maintaining the level of heat that would be produced inside it by radioactive decay during the repeated injections of water. At its small-scale facility for the preliminary testing of experimental reflooding of debris beds (PRÉLUDE), the Institute has developed an induction heating technique that achieves conditions representative of a core meltdown accident: a temperature of nearly 900°C and 300 W/kg of heat in the particles, representing decay heat that must be removed by the coolant for successful flooding to take place.
The results obtained will be used to validate the

IN THE WORDS OF...

MICKAEL DUBREUIL,

Head of the Office on the Analysis of Severe Accidents and Radioactive Releases, IRSN

"In 2011 we organized four training sessions for the engineers of the China Nuclear Power Engineering Co., Ltd. (CGNPC) as part of a cooperation framework agreement signed by IRSN and CGNPC in October 2010. The sessions covered two topics: the guides and means for managing core meltdown accidents, and level 1 and 2 PSAs. Three main points emerged from this experience: the Chinese engineers participated actively, they asked many pertinent questions, and the discussions held were very interesting. Despite the cultural differences and the differences in approach to the topics covered, we all share a common objective of improving safety.
In addition to transmitting the Institute's knowledge and expertise, these training sessions provided the opportunity to promote IRSN's approach to safety and its proprietary tools and methods. As a result, we are more than satisfied with this experience. And we are not alone: CGNPC plans to hold other sessions in the up coming years."

debris bed reflooding model developed by IRSN. Other tests conducted in 2011 made it possible to heat a large debris bed (500 mm in height by 500 mm in diameter) to a temperature of 900°C with a heat release rate of 220 W/kg.

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EPR configuration in the SOFIA simulator

Developed with Areva starting in 2005, the SOFIA abnormal and emergency operation simulator provides IRSN with a configuration that is representative of the Flamanville-3 EPR. This new configuration joins those already in place (900, 1300 and 1450 MWe) that are representative of the various types of nuclear power plants in operation in France. SOFIA's broad scope of thermal-hydraulic simulation will make it possible to conduct tests under all operating conditions and in all power states, including maintenance outages where the reactor vessel is opened for refueling. In a similar field, an EPR configuration incorporating the CATHARE thermal-hydraulics model – the reference in France – is currently under development.

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The SOFIA simulator is used to anticipate and improve the safety of pressurized water reactors.

ABOUT DEFENSE

ASSESSING THE SAFETY OF MILITARY NUCLEAR SYSTEMS, BASIC NUCLEAR INSTALLATIONS AND DEFENSE-RELATED TRANSPORT

IRSN's activities in this area come under a technical support agreement with the French Representative in charge of Nuclear Safety and Radiation Protection for Defense-related Activities and Facilities (DSND), operating under the aegis of the Ministry of Defense and the Ministry of Industry.

In 2011, IRSN examined the safety review documentation for the CEA's MAR 400 decladdiing unit in Marcoule in southern France.

SAFETY OF SUBMARINES, AIRCRAFT CARRIERS AND DEFENSE-RELATED MILITARY OR CIVIL FACILITIES

IRSN's safety assessment of facilities operated by the Ministry of Defense, the CEA, Areva or EADS covers their entire life cycle, from design and operation to decommissioning and dismantling. It also concerns any major modifications to these facilities brought about by changes in their activity.

DESIGN AND CONSTRUCTION

In the area of naval propulsion, IRSN examined:

- the application for a provisional operating license for the fuel storage pool at the Ile Longue naval base in Brittany, following the completion of extension work;
- the safety report and preliminary safety studies on the refurbishment of the waste treatment plant at the Ile Longue base;
- studies concerning the power supply system, centralized monitoring, seismic behavior of facilities, monitoring of civil engineering structures and the qualification program associated with the application for a provisional operating license for Dock 8 at the naval port of Brest, using fuel;
- the study of fire risks in the Cachin facilities at the port of Cherbourg in northern France in the context of modifications resulting from the Barracuda program.

IRSN also continued its examination of the application for a provisional operating license for the test reactor (RES) at the Cadarache secret basic nuclear installation (INBS) in southern France.

It also assessed the safety of several new facilities planned at

the CEA/DAM center in Valduc in eastern France:
- the planned plutonium recycling facility, with a view to obtaining a construction permit;
- the planned storage building for alpha-contaminated waste, with a view to obtaining an industrial operating license;
- two planned storage buildings, one designed to accommodate nuclear materials currently stored in the "plutonium" dedicated facility, and the other designed to take tritiated heavy water.

The Institute examined an addendum to the preliminary safety analysis report on the future nuclear materials storage facility of the nuclear propulsion fuel manufacturing plant at the CEA Cadarache center. It also analyzed the prospective study on nuclear waste management at the CEA Marcoule center, also in southern France.

OPERATION

Regarding the new programs to manufacture nuclear weapon components and fuel for nuclear-powered vessels, IRSN assessed the safety of new or renovated equipment in the "tritium" and "plutonium" dedicated facilities at the CEA/DAM center in Valduc, in the nuclear propulsion fuel manufacturing plant at the CEA center in Cadarache, and in the EADS neutron generator R&D facility.

IRSN also assessed the documentation requested from operators following safety reviews of the "tritium" dedicated facility at the CEA/DAM center in Valduc, the long-term storage areas for uranium-bearing materials at the Areva NC plant in Pierrelatte in southern France and the Marcoule Vitrification Facility, performed between 2006 and 2009.

Regarding the CEA Marcoule center, the Institute examined the following in 2011:
- the safety review documents for the liquid effluent treatment plant to decide on its continued operation, and the preliminary safety report on the discharge and cementation units, which will supplement the treatment plant's existing units;
- the safety review documents for the MAR 400 decladding unit.

Moreover, IRSN examined the safety baselines of several facilities designed for the treatment and storage of waste contaminated with tritium or alpha-emitting radioelements at the CEA/DAM center in Valduc, with a view to defining the scope of the next safety review. Regarding the Areva NC plant in Pierrelatte, IRSN examined the operator's responses to the questions raised in the construction permit for the extension of the area intended for the storage of uranium-bearing materials (P35), as well as the operating modifications made to this facility. It also examined the new water intake and discharge permit application (DARPE) for the CEA Marcoule center, as well as the acceptability of the documents submitted in support of the future DARPE at the CEA/DAM center in Valduc. Lastly, as part of its facility monitoring activities, IRSN examined the circumstances and handling of a number of incidents that occurred

6

IRSN REPORTS FOR MEETINGS OF "DEFENSE-RELATED" TECHNICAL SAFETY COMMISSIONS. **(7 IN 2010)**

IN THE WORDS OF...

BERNARD DUPRAZ,

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

"The ASND is the French nuclear safety authority responsible for monitoring defense-related nuclear activities and facilities, specifically nuclear propulsion facilities (nuclear steam-supply systems for submarines, aircraft carriers and their land-based support infrastructures), as well as CEA and Areva facilities that produce nuclear materials and manufacture weapon components and nuclear propulsion fuel. In 2011, these facilities embarked on a program of complementary safety assessments, similar to that undertaken in the civil sector. IRSN provided the ASND with technical support for this exercise and will continue to do so in 2012. IRSN's contribution mainly lies in its ability to combine the skills of nuclear defense specialists (within the Nuclear Defense Expertise Division) with those of other Institute experts involved in analyzing the complementary safety assessments of civil facilities, for example by drawing on the 'hard core' approach to safety advocated for nuclear power plants, or in order to adapt the 'rapid response force' envisaged by EDF to the needs of the French Navy. IRSN is thus helping to prevent the risk of a 'nuclear ghetto', while tailoring nuclear safety requirements to the specific features of the defense sector."

IRSN performed a safety review on Rubis-class nuclear attack submarines.

in facilities at the CEA Cadarache center, and in nuclear buildings at the CEA/DAM center in Valduc, the Areva NC plant in Pierrelatte and the CEA Marcoule center.
In the area of naval propulsion, IRSN focused on completing the safety review of the "Rubis" class nuclear attack submarines, particularly with regard to:
- internal hazards in the reactor room;
- reliability of safety-related instrumentation and control;
- the study of fire risks.

DISMANTLING

Regarding the CEA Marcoule center, IRSN examined the following:
- the preparatory documents for the dismantling of the Marcoule prototype facility;
- the documents relating to dismantling old transport casks (Cendrillon).

RADIOACTIVE MATERIAL TRANSPORT

Documentation examined by IRSN in 2011 relating to the transport of defense-related radioactive materials included:
- the new FS 110 package, designed for on-site transportation of new fuel elements for naval propulsion;
- safety options for new packages designed to transport weapon components and startup sources for naval propulsion;
- the mechanical behavior of fuel elements for naval propulsion if dropped.

IRSN also examined several requests for extension of approvals for transport on the public highway, as well as applications for the authorization of on-site transport.
Furthermore, IRSN attended meetings organized by the IAEA on changes to the regulations for the transport of radioactive materials.

ON-SITE EMERGENCY PLANS AND DRILLS

IRSN personnel were involved in developing scenarios for emergency drills at the Saint Dizier airbase and the CEA Valduc site, both located in eastern France, and the Ile Longue naval base in Brittany. The Institute also took an active part in these drills and was invited to participate in two internal French Navy drills.
IRSN issued technical notices to the DSND relating to:
- joint service training on the organization of the Ministry of Defense and action to be taken during a radiological emergency;
- the results of the examination of the operational aspects of the on-site emergency plans at Dock 8 and the Brest site in Brittany;
- the results of the examination of the operational aspects of the on-site emergency plan at the CEA's Valduc center in eastern France;
- updating of the on-site emergency plan at the CEA's Marcoule center in southern France.

95

TECHNICAL NOTICES WERE SUBMITTED TO ASND
(84 IN 2010).

•—• *Work on the SEALEX project was continued in 2011, with two new tests at the Tournemire experimental station in southern France.*

CONDUCTING ASSESSMENTS OF FUTURE FACILITIES

FUTURE WASTE REPOSITORIES

IRSN is seeking to improve its existing knowledge base on deep geological repositories for radioactive waste in order to develop the skills and tools required to assess this type of disposal facility.

Study of radionuclide transfer and seal integrity

Several joint projects involving teams from the French national center for scientific research (CNRS) and IRSN were completed in 2011 as part of the work of the TRASSE national research group, which is tasked with studying the transfer of radionuclides in soil, sub-soil and to ecosystems. The teams conducted studies designed to characterize the physicochemical interactions between argillite and concrete.

This work was carried out at the IRSN experimental station in Tournemire in southern France using systems similar to those likely to be found in a repository. The representative results, obtained for argillite-concrete contact times of 5, 18 and 125 years (the railway tunnel used was built in the late 19th century), provides IRSN with sound validation points for the simulation of these interactions.

The SEALEX project, set up to assess the long-term integrity of clay seals in a repository for high- and intermediate-level long-lived waste, continued in 2011, with two new in situ experiments being set up. Once the sealing system had been validated, the clay core was forcibly saturated with water; experimental data (relative humidity, pressure) will now be collected over a period of four to five years.

The SEALEX project was opened up to international collaborative partnerships in 2011 when a specific agreement was finalized with the Canadian Nuclear Safety Commission.

Open day at the Tournemire experimental station

On June 19, 2011, the Tournemire experimental station opened to the public for the third time.

Teams from IRSN presented the Institute's research on the safety of deep geological repositories for radioactive waste. The experimental systems installed at the station make it possible to address the main scientific questions concerning the containment capacity of the clay host rock over a very long timescale.

The fact that the event attracted 800 visitors, some of whom were openly opposed to nuclear power,

The open day at the Tournemire experimental station in southern France was a great success, demonstrating the public's interest in the safety of geological repositories for radioactive waste.

clearly demonstrates public interest in the safety of deep geological disposal of radioactive waste and in the quality of the technical information provided by the Institute based on its R&D.

REACTORS OF THE FUTURE

IRSN is researching several advanced reactors types to be able to assess the future safety nuclear reactors and their associated fuel cycle facilities.

Building up knowledge on high-temperature reactors

In 2011, IRSN continued to build up knowledge about specific safety aspects of the Generation IV high-temperature reactor (HTR) concept, mainly by participating in R&D projects funded by the European Commission. For instance, it studied the feasibility, in terms of safety, of nuclear co-generation systems (combined heat and power). This work, together with other research conducted for the EUROPAIRS project, opens the way for a European platform devoted to the development of a prototype HTR. As part of the ARCHER project, IRSN is studying various aspects relating to assessment of accidental radioactive releases from an HTR.

The Institute is also involved in an OECD project aimed at assessing the ability of numerical existing simulation software to reproduce the behavior of an HTR reactor in the event of a loss-of-coolant accident. A full-scale experiment has been carried out with the Japanese high-temperature test reactor (HTTR).

www.europairs.eu

Safety options on the new ATMEA reactor

ATMEA is a Generation III 1,000 MWe pressurized-water reactor developed by ATMEA, a joint subsidiary of Areva and Mitsubishi. IRSN has assessed safety options on this reactor with a view to its possible export. In July 2010, ATMEA and a joint ASN-IRSN task force signed a contract undertaking to complete the assessment of safety options by the end of 2011. With a view to the possible export of this reactor, the safety option assessment comprised two distinct phases:

- a preliminary assessment;
- followed by a detailed assessment, which led to five meetings of the Advisory Committee for Reactors and one meeting of the Advisory Committee for Nuclear Pressure Equipment, both of which reported their findings to the French nuclear safety authority (ASN) in November 2011.

The Institute also assessed the impact on safety options of the initial lessons learned from the Fukushima-Daiichi accident.

Reference document on BORAX-type reactivity accidents in pool-type reactors

In 2011, IRSN completed a "reference document" on the subject of taking into consideration BORAX-type reactivity accidents in designing containment systems for pool-type research reactors that use aluminum- and uranium-based fuel.

The accident that occurred in the American SL-1 research reactor on January 3, 1961, together with tests carried out in the U.S. in the BORAX-1 and SPERT-1 reactors, showed that a sudden substantial addition of reactivity in the core of this type of reactor could cause a steam explosion and possibly lead to the partial or total destruction of the reactor core. The IRSN's reference document reviews the importance of various technical parameters in controlling this risk, including the thermal energy deposited in the fuel, the thermal energy transferred to the pool water, the triggering of a steam explosion, the mechanical effects on structures and equipment induced by shock waves, and the collapse of the steam bubbles formed.

www.irsn.fr

Launch of the JASMIN project

In 2011, as part of FP7, the Seventh Framework Programme for Research and Technological Development, the European Commission accepted the JASMIN project to use the ASTEC software system, developed jointly by IRSN and GRS, for severe core meltdown accidents in Generation IV sodium-cooled fast neutron reactors.

The ultimate aim of this four-year project is to develop an ASTEC-Na version, which will contribute to safety studies on this type of reactor. In addition to IRSN, there are a further eight European partners involved Karlsruher Institut Für Technologie – KIT, GRS and Stuttgart University – Germany, EDF and Areva NP – France, Ente per le Nuove tecnologie, l'Energia e l'Ambiente – ENEA – Italy, Centro de Investigaciones Energéticas, Medioambientales y Tecnológicas – CIEMAT – Spain, and the European Commission's Joint Research Centre, all of whom will contribute to validating the software by benchmarking against test results and other software.

IN THE WORDS OF...

DANIEL BLANC,

in charge of the SARGEN IV project, IRSN

"In June 2011, the European Commission approved the SARGEN IV project, proposed by IRSN as part of the Seventh Framework Programme for Research and Technological Development (FP7). The aim of this project is to draw up a roadmap for necessary safety research on sodium-cooled, gas-cooled or lead-cooled fast reactors, which are currently being studied in Europe as part of collaborative efforts to develop Generation IV reactors. The ultimate objective is to define a joint safety assessment procedure for all the reactors in question. This requires close liaison with other projects supported by the European Commission that are specific to each type of reactor.

IRSN is managing the project, which brings together 22 participants representing technical safety organizations, reactor designers, research centers and universities. Work got underway early in 2012 and will continue over the next two years.

With the SARGEN IV project, IRSN is seeking to improve its understanding of fast reactors other than those cooled with sodium and of different safety assessment approaches; this will enable it to engage in a technical dialogue with manufacturers with a view to building a reactor of this type."

SECURITY AND NON-PROLIFERATION

STRENGTHENING PREVENTION IN FRANCE AND DEVELOPING INTERNATIONAL COOPERATION

IRSN's Nuclear Defense Expertise Division (DEND) actively contributes to national and international efforts to protect and control nuclear and sensitive materials and to ensure protection against malicious acts. Besides providing assistance and support to the national authorities responsible for nuclear security and non-proliferation in France, the Institute has undertaken – under the auspices of the IAEA and in the context of bilateral relations – cooperation activities aimed at protecting nuclear facilities and materials against malicious acts. It also contributed to a peer review conducted by the IAEA in France at the end of November on how nuclear security is organized in the country, and continued to take part in reviewing regulatory texts in this area.

184 INSPECTIONS RELATIVE TO NATIONAL NUCLEAR MATERIAL CONTROL UNDER THE "DECLARATION" REGIME.
(152 IN 2010)

PROTECTION AGAINST MALICIOUS ACTS

Regulatory text reviews

In terms of regulations, 2011 saw the publication of the new regulatory framework for the protection and control of nuclear materials. The Institute was involved throughout the drafting process. The previous regulations dated back to the 1980s regarding the protection of nuclear materials against theft, and to a 1958 order regarding the protection of facilities against sabotage.

The first step in the update process was the 2005 introduction, in the French Defense Code, of legislative (article L. 1333-1 et seq.) and regulatory (article R. 1333-1 et seq.) sections on the protection and control of nuclear materials.

This was followed by the publication, on September 17, 2009, of Decree No. 2009-1120 on the protection and control of nuclear materials, facilities and transport.

The third and final step, which has just been completed, was the preparation of ten orders implementing this Decree, nine of which were published in 2011 and one in 2010: one order applies to holders of nuclear materials required by environmental regulations to file a declaration on their activities, one concerns the activities of advisory committees, one specifies the license application procedures required by the Defense Code, three are specifically aimed at nuclear material holders that come under the licensing regime (physical protection of facilities, physical monitoring and accountancy of nuclear materials, security studies), and four concern nuclear material carriers.

These texts form a coherent raft of measures ensuring the protection and control of nuclear materials that are not related to nuclear deterrence. Many

aspects of the previous regulations have been reviewed, for example the remit of the advisory committees for facilities and transport has been extended, security studies now cover the field of physical monitoring and accountancy of nuclear materials, and the risk of sabotage of nuclear facilities and shipments has been explicitly regulated.

ACTIVITIES OF THE ADVISORY COMMITTEES

The order on the composition and working procedures of advisory committees for the protection of plants and facilities containing nuclear materials and for the transport of nuclear materials was signed on April 28, 2011.
IRSN's Nuclear Defense Expertise Division provides secretariat services to these groups and presents them with the results of its analyses.

ASSESSMENT AND MONITORING OF FACILITIES

Assessment

In 2011, IRSN processed 274 requests for technical notices on the protection of nuclear materials and facilities against malicious acts.
This involved examining license applications to hold nuclear materials, analyzing any incidents or malfunctions notified by plant operators and evaluating the relevant feedback.
These assessment activities prompted IRSN to organize technical meetings with operators and consult its own safety experts, as and when necessary.

Inspections

Furthermore, Institute employees, sworn and officially appointed as "nuclear materials inspectors", are mandated by the Senior Defense and Security Official of the Ministry of Ecology, Sustainable Development, Transport and Housing to conduct inspections at facilities holding nuclear materials, at the Official's request.
They responded to 84 notifications by making 145 facility or site inspections, four of these initiated in response to security-related events. During the inspections, several exercises were carried out, some at night, to observe how local security forces implement the procedures and emergency instructions prepared by plant operators.

Some inspections are arranged with the operator in advance, while others are unannounced or initiated by the authority in response to specific situations, such as incidents or malfunctions.

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NATIONAL INSPECTIONS RELATIVE TO NUCLEAR MATERIAL CONTROL IN FACILITIES UNDER THE "DECLARATION" REGIME.
(8 IN 2010)

Nuclear material accountancy

The control of nuclear materials relies partly on the national accounting system, which centralizes all records of movements. In this context, 2011 saw the intensive final acceptance phase for the new Ar

IN THE WORDS OF...

LAURENT DEMOLINS,

Brigadier-General, Deputy Senior Defense and Security Official, Head of the Department of Defense, Security and Economic Intelligence – Ministry of Ecology, Sustainable Development, Transport and Housing

"The implementation of the ten nuclear security orders published between September 2010 and November 2011 in application of the Decree of September 17, 2009 on the protection and control of nuclear materials, facilities and transport, the success of the IAEA's International Physical Protection Advisory Service (IPPAS) mission in November 2011, and the measures taken against some civil nuclear sites in December 2011 all have a significant impact on nuclear security in France. This has prompted the nuclear security authority to step up its efforts and to ask IRSN, its technical safety organization, to help it in its task by considering ways to enhance performance.
IRSN's level of expertise, its experience and the acknowledged quality of its workforce will contribute to strengthening nuclear security, in line with the expectations of the highest State authorities and the general public."

Men control software and the early stages of the implementation of the new computer equipment used, ahead of the forthcoming rollout of this software. After the public authorities expressed a wish in 2010 to separate accounting for nuclear materials used for the deterrent policy from accounting for other nuclear materials, the Institute set up agreements with different partners in 2011 to ensure that responsibility for these materials was transferred without any loss of control.
Activities associated with the national accounting system also made it possible to identify and deal with nuclear security-related events, such as a gamma ray source stolen more than 35 years ago and found by a metal waste treatment company.
These events were managed jointly by ASN, the Senior Defense and Security Official and IRSN.

Nuclear materials management training

The Institute also contributed to training courses for Areva personnel on physical monitoring and accountancy of nuclear materials. These provide an opportunity to clarify security issues with the individuals most closely involved on the sites, as well as their managers, and thus help to inculcate a security culture. .

TRANSPORT OF NUCLEAR MATERIALS

In 2011, IRSN processed 42 requests for technical notices on the physical protection of nuclear materials during transport. This involved analyzing transport plans, applications for transport permits and applications for approval of transport methods, as well as evaluating feedback from shipments, inspections and checks.
In 2011, IRSN processed 1,722 transport requests and monitored around 1,598 domestic shipments, during which no significant incidents were reported. It also monitored international shipments, which were sometimes sensitive from a public relations perspective, such as the return of vitrified waste to Germany that had been conditioned at La Hague in Normandy, or the arrival of spent fuel from the Netherlands or Italy.
Lastly, the Institute carried out 100 technical checks on approved equipment for transportation of nuclear materials and for inspections during transport. These inspections covered all means of transport – road, rail, sea and air – but with a special focus on road vehicles.

EMERGENCY EXERCISES

At the request of the authorities, IRSN regularly organizes emergency situation inventory control exercises for nuclear material at a facility. The purpose of the exercises is to test decision-making chains as well as the coordination of those involved (operators, public authorities and so on). The exercises entail carrying out a nuclear material inventory at one or more facilities within a few hours to confirm or rule out the existence of any malicious acts, such as theft or misuse of nuclear materials, or acts of sabotage.
During 2011, the Institute organized and carried out two exercises involving the MELOX plant at Marcoule in the south of France and the FBFC facility at Romans in southeast France. Sixteen exercises of this type, usually scheduled on an almost annual basis, have already been performed. They enable the emergency procedures used by the main French nuclear operators to be tested.

SECURITY OF RADIOACTIVE SOURCES

Activities in 2011 relating to security of radioactive sources mainly centered on the launch of the ASTRA project (Assessing Tracking Systems for High-Risk Radiological Sources), set up under a contract between IRSN and the European Commission. Similarly, IRSN signed a contract with the French Ministry of Defense in 2011 to study the hazards posed by radioactive sources of French origin held abroad.
The Institute also took part in an exercise to recover radioactive sources in Morocco as part of the Global Initiative to Combat Nuclear Terrorism (GICNT).
Lastly, at the request of the IAEA, IRSN was involved

IRSN monitored the shipment back to Germany of vitrified waste conditioned at La Hague.

IN THE WORDS OF...

YANN BILLARAND,
Head of IRSN's Source Assessment Unit

"Under the Decree establishing IRSN, the Institute is responsible for the national inventory of radioactive sources, working on the basis of various documents provided by holders and suppliers of radioactive sources, such as movement forms, annual inventories, radioactive source recovery certificates and suppliers' reports. The latter consist of a quarterly statement of deliveries or receipts of sources. In response to a request from ASN, which gives priority to these reports, we took steps to encourage the transmission of these documents and the systematic use of the information they contain to improve the reliability of the national inventory of radioactive sources. This long-term process involved defining a standard report format and encouraging suppliers to use it to facilitate the input of data into SIGIS, the French information system used to manage this inventory. A practical guide for radioactive source suppliers is also available on the IRSN website. The tool is currently being improved to optimize the processing of these documents in terms of speed and quality. In 2011, on at least one occasion, 64% of suppliers sent us data that could be directly fed into SIGIS, compared with 57% in 2010."

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MISSIONS TO ESCORT INSPECTIONS INVOLVING INTERNATIONAL NUCLEAR MATERIAL CONTROL.
(52 IN 2010)

in training courses in Islamabad (Pakistan) and Obninsk (Russian Federation) for future radioactive source security instructors.

INTERNATIONAL ACTIVITIES

Relations with the IAEA

In November 2011, France welcomed a team from the IAEA's International Physical Protection Advisory Service (IPPAS) and IRSN was actively involved in the preparatory work and follow-up. IRSN experts also took part in IPPAS missions to Sweden in May and the UK in October.

Furthermore, at the request of the IAEA, the Institute was involved in courses organized in Belarus and Niger in 2011 on the principle of determining a design basis threat, in the Netherlands on potential acts of sabotage, and in China on internal threats. Two missions were carried out as part of the IAEA's working group aiming to develop a methodology for self-assessment of nuclear security regimes. The Institute was represented on the program committee for the International Conference on the Safe and Secure Transport of Radioactive Material, organized by the IAEA in Vienna (Austria) from October 17-21, 2011.

This conference, the first to address transport safety and security, laid the foundations for the IAEA's work in this field over the next fifty years. The Institute contributed to the French support program for IAEA safeguards, specifically concerning software used to determine the isotopic composition of plutonium and enriched uranium. It was also involved in a new initiative to remotely identify nuclear materials and define the requirements for a monitoring system for these materials.

Bilateral and multilateral relations

Under a cooperation agreement between the U.S. Department of Energy and IRSN on protection and control of nuclear materials, several new activities were proposed and discussed in 2011, specifically the identification of nuclear materials using portable detectors, a comparison of nuclear security regulations applicable in France and the United States, the definition of software design specifications for protection against internal threats, and a survey of the types of security exercises conducted in France and the United States, the results of which could be used as the basis for a publication in the IAEA's Nuclear Security Series.

Relations with the European Commission

IRSN provides technical support to the French authorities involved in the Ad Hoc Group on Nuclear Security (AHGNS), created in July 2011 by the

IN THE WORDS OF...

BRUNO QUAGLIA,
Head of the Euratom Technical Committee

"In its role as technical support to the Euratom Technical Committee, specifically for monitoring international nuclear material control activities, IRSN is called upon to escort a large number of inspections conducted by the IAEA or the European Commission. In doing so, the Institute fulfills a very important function in that it communicates the stance of the French authorities and supports the operators on site. This proximity at operational level is crucial, as it enables national interests to be protected and, at the same time, ensures compliance with international obligations. IRSN also makes an essential contribution to ensuring that the declarations required by the international authorities are submitted within the statutory time limits. Besides these regular activities, the Euratom Technical Committee also calls on experts from the Institute for ad hoc analysis. The responsiveness and commitment of the IRSN teams is truly impressive right across the board, as is their expertise in a field as complex as international nuclear control. Our effective and consistent collaboration will be extended in 2012 to include monitoring of the 24 bilateral agreements that France has signed with third countries on the peaceful uses of nuclear power."

European Commission. The tasks of this Group are to identify and share good nuclear security practices within the Member States of the European Union and, if necessary, to suggest possible areas for improvement.
Under a contract with the European Commission, the Institute organized a seminar in May 2011 as part of the "State response to a severe attack" (STAR) project. The aim was to exchange information with its European peers about nuclear facility security and to present a simulation tool for managing malicious acts that incorporates the safety and security aspects of such incidents.

INTERNATIONAL NON-PROLIFERATION INSPECTIONS

International inspections in the chemical field

In 2011, on behalf of the Minister of Industry, Energy and the Digital Economy under the Minister of the Economy, Finance and Industry, IRSN supported six inspections conducted by the Organization for the Prohibition of Chemical Weapons (OPCW) on French industrial sites. This level of inspection is comparable with that in 2010. During one of these missions, the OPCW took samples that were analyzed on site in IRSN's mobile laboratory unit. None of these inspections gave rise to any recommendations.
IRSN produced the French declaration of activities carried out in 2010 by the 119 French industrial plants subject to the Chemical Weapons Convention (CWC). In the second half of 2011, the Institute and the OPCW Technical Secretariat negotiated an agreement empowering the Organization to carry out sequential inspections on French territory, starting in the latter half of 2012. "Sequential inspections" are defined as two inspections that take place consecutively during the same week at two different facilities.
Furthermore, IRSN worked on the national legal framework for challenge inspections by collaborating with the Ministry of the Economy, Finance and Industry to draw up a standard court referral form. A challenge inspection is a very powerful and intrusive verification tool that can be employed, anywhere within a country's sovereign territory, at the request of another State Party to the Convention. IRSN provided technical support to the Ministry in preparing several regulatory changes to challenge inspections and the above-mentioned French declaration. Regarding challenge inspections, a draft decree that will simplify certain procedures was revised and a draft interministerial circular was finalized. With regard to the activity declarations of the industries that come under the CWC, IRSN suggested to the Ministry that several articles of the French Defense

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INTERNATIONAL MISSIONS TO ESCORT INSPECTIONS INVOLVING THE CHEMICAL WEAPONS BAN. **(7 IN 2010)**

Code should be revised to incorporate OPCW decisions. The main aim of these changes is to adjust, or even eliminate, some declaration thresholds.
IRSN organized training for companies affected by the implementation of the CWC, describing the regulatory context, detailing their obligations and rights under this Convention and explaining the verification system for French industrial sites based on the annual declarations and the response to unannounced inspections conducted by OPCW officials. The first session, held in June 2011, was attended by nine participants.

International inspections in the nuclear field

In 2011, IRSN supported 47 Euratom and IAEA inspections on behalf of the Euratom Technical Committee, roughly the same number as in 2010. It also devoted considerable effort to analyzing documents and agreements in preparation for discussions between the French authorities and the European Commission. In this respect, it is worth highlighting the negotiations on the content of lists of items in stock, during which the Euratom Technical Committee put forward a number of legal arguments at Euratom's request; the creation and scope of the joint Euratom-France working group on the transmission of safeguards data to Luxembourg; and the exchanges on the Euratom-recommended implementation of unannounced inspections of EDF reactors.
At the request of the Euratom Technical Committee, IRSN performed multiple analyses of the operations involved in transferring nuclear materials from an activity subject to Euratom safeguards to one not subject to these safeguards, and vice versa, in order to inform the discussions on the draft decree concerning the stewardship of nuclear materials required for defense purposes, which was published on November 18, 2011.
At the request of the Directorate General for Energy and Climate (DGEC), IRSN also helped to update the fuel cycle report by the French high committee for transparency and information on nuclear safety by checking data submitted by operators regarding imports and exports of nuclear materials in 2010.
As a result of the changes to the French regulations on governmental control, IRSN initiated negotiations with the CEA/DAM and the Euratom Technical Committee during the second half of 2011 for a protocol on the transmission of information relating to the implementation of Euratom and IAEA safeguards at relevant facilities. Computer applications used to produce IRSN declarations were also optimized this year. Another notable event was the launch of the PIMENT Internet portal for declaring nuclear material movements at EDF nuclear power plants.

•–• *The George-Besse II plant in Pierrelatte in southern France passed its first LFUA inspection in August 2011.*

On the inspection front, the George Besse II plant at Pierrelatte in the south of France completed its first LFUA-type inspection (Low Frequency Unannounced Access) in August 2011, conducted jointly by the International Atomic Energy Agency and the European Commission. This type of inspection is a key aspect of the safeguards strategy of gas centrifuge enrichment plants. This LFUA inspection, the first of an expected ten a year, involved significant preparatory work on the part of IRSN and the operator, including carrying out an exercise

RADIATION PROTECTION – ENVIRONMENT AND HUMAN HEALTH

GREATER KNOWLEDGE FOR GREATER PROTECTION

Radiation protection – protecting people and the environment from the harmful effects of ionizing radiation – is a vast area of research and expertise requiring the deployment of significant human and technical resources within IRSN. To give some examples of progress made in 2011, the Institute rolled out a new generation of Teleray environmental monitoring probes; as part of a survey of uranium mining sites or radioactively contaminated sites, it conducted field-work such as MIMAUSA or the radium operation; and in the area of radioecology, it launched the first joint European experiment to study the effects of chronic exposure to gamma radiation on non-human species. Similarly, IRSN began or continued work on various research programs to assess the health effects of chronic exposure to low doses of ionizing radiation, an area that remains largely unknown. In this context, the Institute runs the European MELODI platform (Multidisciplinary European Low Dose Initiative), which aims to share research resources in this field, and contributes to national programs such as the French Birth Cohort Study (ELFE) involving 20,000 children. It also made progress with its research programs aimed at finding out more about the causes of complications in radiotherapy patients and at protecting medical staff, for example those working in interventional radiology.

226 MONITORS (INCLUDING 219 TELERAY) IN THE NATIONAL REMOTE MONITORING NETWORK.
(171 IN 2010 INCLUDING 164 TELERAY)

ENVIRONMENTAL AND POPULATION EXPOSURE

IRSN is responsible for general monitoring of environmental exposure to ionizing radiation and, to this end, is constantly improving its measuring equipment.

ENVIRONMENTAL MONITORING

Rollout of new Teleray probes

In 2011, IRSN began upgrading and redeploying the Teleray radiological alert network (see glossary) to ensure better coverage across France.
Nine new-generation probes were installed around the EDF Fessenheim power plant, and eleven around the Cattenom plant, both in northeastern France.
A further 33 existing probes were replaced with new-generation probes in the Paris region and in the south east of the country.
The rollout also included the installation of new-generation probes in France's overseas départements and territories in response to the Fukushima-Daiichi accident; this was possible due to the active cooperation of the National Gendarmerie.

METROLOGY

IRSN is conducting research to improve the measurement of different radioactive substances in the environment.

New tritium measurement technique

In terms of activity, tritium is the main radionuclide discharged into the continental and marine environment.
Current environmental radioactivity monitoring strategy and ongoing radioecological studies have to take into account an increase in very low-level tritium analyses, associated with the commissioning of new reactors and the startup, in the medium term, of

The deployment of new Teleray probes began in overseas France. Illustrated above is the beacon installed in Saint-Claude in Guadeloupe to monitor atmospheric gamma radioactivity.

the ITER fusion facility. To meet this demand, IRSN began developing a new, more effective measurement technique, using mass spectrometry; organically bound tritium is determined by measuring its decay product, helium-3.
The corresponding equipment, set up in an IRSN laboratory at the Orsay campus of Paris-Sud University, was developed in 2011 in collaboration with the Laboratory of Climatological and Environmental Sciences (CEA/CNRS/Versailles Saint-Quentin-en-Yvelines University).

Analysis of water supply samples

In 2011, in collaboration with the regional health agencies, IRSN conducted a water potability study, funded by the Directorate General for Health. The radiological analysis method for drinking water involves measuring total alpha and beta activities, which must be less than 0.1 and 1 Bq/l respectively to comply with regulatory requirements.
An analysis of 168 water samples, selected for their potentially high concentration of natural radionuclides (lead-210, radon-222, uranium), found that 22% had significant lead-210 activity. The study thus confirmed that the measurement techniques generally used to analyze total beta activity do not detect the presence of lead-210, with the resulting risk of underestimating the integrated dose received from drinking this water. According to the study's findings, this risk concerned less than 2% of the water analyzed.

Radon: transposition of French standards into international standards

The process of transposing French standards (AFNOR) into international standards on measuring radon and its decay products in air was successfully concluded in 2011. IRSN set the ball rolling in 2007 during a meeting of the Nuclear Energy Committee of the International Standardization Organization (ISO). The ISO members voted to approve the eight French texts as a new working topic; they were subsequently discussed over a four-year period by a working group comprising experts from Europe (the UK, Germany, Spain, Switzerland, the Netherlands, Norway and France), North America (the United States and Canada) and Asia (Japan and Korea). The consensus reached makes it likely that the ISO standards will be officially published in early 2012. IRSN has initiated a similar process for the transposition of AFNOR standards on radon measurement in water.

POLLUTED SITES AND SOILS

At the request of plant operators and the authorities, IRSN conducts studies to assess the impact of industrial activities, both past and present, on the environment and the general population.

Consolidation of data on former uranium mines

As part of the MIMAUSA program, conducted at the request of the public authorities with the aim of

compiling, updating and publicizing detailed information about former uranium mines, IRSN carried out "second-level" inspections in 2011 at former uranium mining sites in central, south-central and east-central France.
The purpose of this exercise is to compare the information in the MIMAUSA database with new measurements and observations in the field, and to check the results and the information in environmental reports produced by Areva NC in implementation of a circular of July 23, 2009. In addition to visual observations, gamma dose rates are measured on the sites and in the surrounding area, and samples of water and sediment that may have been affected by mining operations are analyzed.

Preliminary results of the radium operation

IRSN continued to play an active part in the national "radium diagnostics" operation, launched in the Île-de-France region around Paris in October 2010. The aim is to identify and, where necessary, rehabilitate any radium-contaminated sites formerly accommodating medical or craftwork activities (e.g. watch making) in the first half of the 20th century. Under the auspices of the State, IRSN is carrying out its diagnostic campaign on sites now used for residential or business purposes. In 2011, the Institute investigated ten buildings in Paris, i.e. more than 100 premises ranging from apartments, shops and basements to two houses in the suburbs. Six places were found to be contaminated with radium, usually restricted to just one or two rooms in a building. IRSN has drawn up and implemented a protocol for carrying out final tests after cleanup to ensure that the contamination has been completely removed. The Institute has also proposed radiation reference levels for residential areas in Île-de-France, which will be useful for defining cleanup objectives.

Decontamination of part of the Feursmétal site

On May 26, 2010, during an operation carried out by IRSN and Cegelec on the Feursmétal site in central France to retrieve a radioactive source that was trapped in the guide tube of a gamma ray source, a workshop and six people involved in the operation were slightly contaminated.
Following the incident, at the request of Feursmétal, the Court of First Instance of Paris ordered an expert assessment to determine the respective responsibilities of each of the three parties and the harm caused by the incident.

The first STAR experiment to understand the effects of chronic exposure to gamma radiation on the nematode C. elegans was performed in 2011.

To settle the dispute and to commence cleanup of the contaminated site as soon as possible, the three parties negotiated an agreement in 2011, under the aegis of the Directorate General for Risk Prevention and the Interministerial Committee for Industrial Restructuring, and signed it on September 27, 2011. Under this agreement, the part of the Feursmétal industrial site that has been radioactively contaminated will be transferred to IRSN for decontamination, scheduled to start in 2012. Once the cleanup operation has been completed, ownership of the site will revert to Feursmétal.

900

AMBIENT DOSE RATE MEASUREMENT POINTS. **(900 IN 2010)**

RADIOECOLOGY

IRSN is conducting research to improve understanding of radionuclide behavior and radionuclide transfer mechanisms in ecosystems.

First experiment for STAR

The partners in the STAR network, which comprises eight European organizations jointly engaged in radioecology research, conducted their first pilot experiment in 2011 to understand the effects of chronic gamma irradiation on the nematode C. elegans. The aim is to determine whether irradiation alters the distribution of energy required for the basic metabolism, growth or reproduction of these organisms.
During the study, which was conducted in IRSN's laboratories, the partners in the STAR network pooled their expertise, protocols and test results, demonstrating the willingness of European research teams to integrate and share resources.

Report on the Red Forest site: radionuclide migration after 25 years

In 2011, in collaboration with its Ukrainian (IGS, UIAR) and French (CNRS, universities) partners, IRSN reviewed the research conducted since 1999 on the experimental Red Forest site, located within the Chernobyl exclusion zone (Ukraine). This work studies the influence of bio-physico-chemical conditions and the key role of vegetation on the mobilization and environmental fate of radionuclides buried in waste trenches, focusing on a trench containing fuel particles, contaminated soil, irradiated tree trunks, etc. Researchers have identified the development, between 1999 and 2008, of a trail of strontium-90 stretching about ten meters from this trench, in the direction of groundwater flow, indicating migration of this radionuclide.
Twenty-five years after the accident, this trench no longer contains any UO_2+x-type soluble particles (complex uranium oxides), as they have been dissolved and have released most of the radionuclides they contain, particularly strontium and plutonium

IN THE WORDS OF...

PER STRAND,

Head of the Department for Emergency Preparedness and Environmental Radioactivity, Norwegian Radiation Protection Authority (NRPA)

"A few years ago, eight organizations involved in radioecology research – including the Norwegian Radiation Protection Authority – decided to create the European Radioecology Alliance with the aim of coordinating their research efforts more effectively and ensuring that their discipline enjoys greater visibility. The changing global environment, marked by the major nuclear accident in Japan and the potential threat of terrorist attacks using radioactive materials, prompted the Alliance partners to integrate their activities and resources to an even greater extent, within a research platform called STAR. Its first task was to define a strategic agenda based on new approaches such as the study of multistressors, i.e. the effects of chronic low-dose exposure combining nuclear and chemical stressors. Last year saw the first experiments on nematodes and the development of radioecology courses intended for young Master's-level scientists. We cannot afford to wait for another major accident in order to maintain and expand our radioecology expertise. This is why STAR plays a vital role in ensuring that the scientific organizations involved have a sound scientific knowledge base to help them in their task of supporting the teams responsible for defining the regulations to protect human health and the environment."

Work carried out in trench 22 of the "Red Forest" experimental site in Ukraine showed the development of a strontium-90 plume covering ten meters between 1999 and 2008.

Monitoring of the contaminated St-Maur-des-Fossés site

Since November 5, 2010, IRSN has been measuring tritium concentration in water, air and vegetation samples taken in the vicinity of a building belonging to the company 2M Process in St-Maur-des-Fossés, near Paris, which was accidentally contaminated following the use of a molecular sieve provided by the CEA and subsequently found to contain tritium. With more than 350 results obtained during 21 sampling campaigns, the Institute has detailed knowledge about the variation in tritium concentration around this site over space and time. The general downward trend observed throughout 2011 is related to the decontamination operations conducted by the CEA, which in turn have led to a sustained reduction in the need for monitoring. By the end of 2011, tritium was no longer quantifiable, except in the immediate vicinity of the contaminated building. The Institute also analyzed urine samples for tritium to identify individuals exposed during this accidental contamination, and assessed the radiation dose received by anyone who tested positive. A total of 134 people were tested: 55 workers at 2M Process or neighboring companies and 79 local residents (including pupils and teachers at the nearby Pissarro high school). A dose assessment was required for 44 workers and 7 local residents. The latest tests, conducted in June 2011, revealed that contamination was below detection limits.

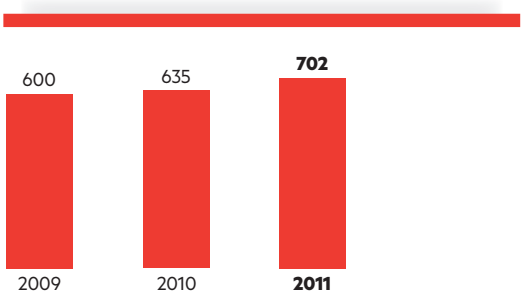
www.irsn.fr

Improving quantification of chronic low-dose exposure

IRSN is conducting epidemiological studies that will contribute to the assessment of the health risks associated with chronic exposure to ionizing radiation. A PhD thesis, defended in 2011, concerned the cohort of nearly 37,000 CEA and Areva NC workers (isotopes 239, 240 and 241), into the soil water solution. All that remains are particles of UO_2 (simple uranium oxide) and ZrUyOx (complex zirconium), which dissolve very slowly.
Several articles on the subject have been published in peer-reviewed international journals.

RADIATION PROTECTION IN THE WORKPLACE

IRSN carries out research and analysis to prevent and assess the exposure of workers to ionizing radiation.



SAMPLING POINTS FOR RADIOACTIVITY MONITORING THROUGHOUT FRANCE

monitored between 1950 and 2004, specifically the reconstruction for their cumulative external exposure. The mortality rate of these workers was found to be lower, on the whole, than that of the general population; this result classical in occupational studies, is denominated as the "healthy worker effect". Conversely, excess incidence of lung and skin cancer was observed, unrelated to the doses received by the workers in question.
No significant link with dose was revealed for deaths from solid cancers or cardiovascular disease. On the other hand, a link was established with the dose received in the case of deaths from leukemia. An extended study combining the cohort studied with other cohorts of nuclear workers will enable more accurate quantification of the risks associated with chronic low doses.
www.irsn.fr

Cataract risk among interventional cardiologists

In 2011, IRSN published the results of its epidemiological study, O'CLOC, the purpose of which is to assess the risk of radiation-induced eye lens opacities among interventional cardiologists exposed to X-rays. About a hundred interventional cardiologists and a control group (not exposed) of IRSN employees volunteered to take part in the study between October 2009 and April 2011.
The results show that posterior subcapsular lens opacities occurs nearly four times more often among interventional cardiologists than in the control group. This excess risk gives cause for concern, even though the information collected in the professional questionnaire indicates that the people examined for the purposes of the study did not make optimum use of radiation protective equipment. These initial findings are consistent with those of other studies conducted in the medical community and form the basis for strongly recommending systematic use of the X-ray protective gear made available to interventional cardiologists, e.g. lead eye glasses, to reduce this risk.

Radiation protection of medical staff: learning more about doses

Between 2008 and 2011, IRSN participated in the collaborative European project ORAMED, which aims to develop methods for better assessing exposure of medical staff to ionizing radiation. In the process, an enormous amount of data concerning doses received at in the extremities and at lens eyes of operators has been collected from several interventional radiology and nuclear medicine units in Europe. This database provides information on dose distribution as a function of practices and on the relevance of protection equipment.

18,806

ENVIRONMENTAL SAMPLES TAKEN FOR RADIOLOGICAL MEASUREMENTS.
(20,414 IN 2010)

IN THE WORDS OF...

ISABELLE FITTON,

radiology physicist and radiation protection specialist at Georges Pompidou European Hospital in Paris

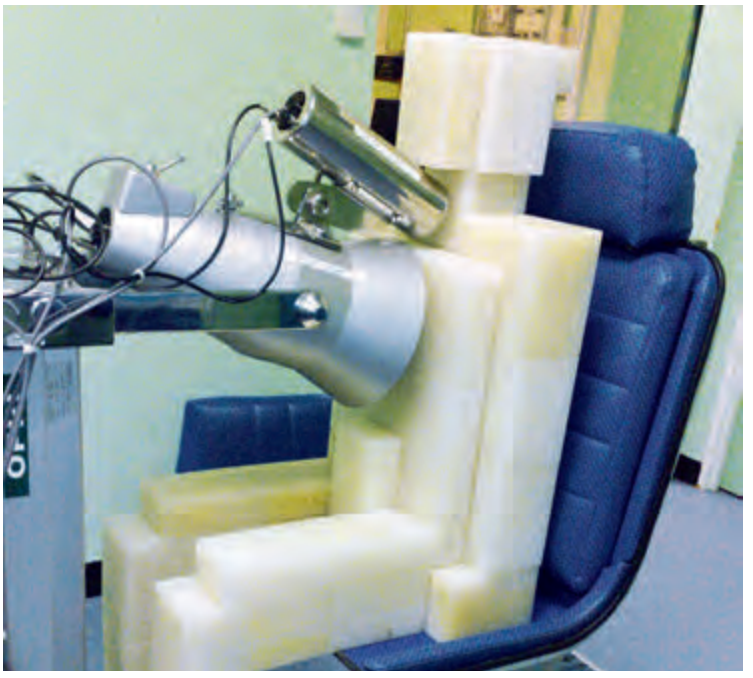
"Being involved in the working group to improve the structure and presentation of the annual report on worker radiation protection has been a valuable experience. It has given us the opportunity to exchange information with other professionals on our practices and expectations, which vary depending on the field considered. Even though the version of the report sent to us in 2011 is not in its final form, we have been able to clarify the presentation of the document and simplify access to the information of interest to us. A more structured format and more practical information, such as workstation studies, have made the report easier to use, for instance in the training courses we give to professionals.
The frequent exchanges with IRSN have also led to our involvement in radiation protection workshops organized by the Institute to inform high school seniors about the subject. These events have provided an opportunity to meet with motivated, interested young people."

Furthermore, a new dosimeter for monitoring exposure of the eye lens has been developed and successfully tested in the workplace.
Lastly, the performance of nine operational dosimeters was studied under real-life conditions used in interventional radiology (pulsed field) to improve their use in this area. All the findings and analysis results were presented at a conference organized by IRSN in Barcelona (Spain) from January 20-22, 2011, and an article was published in November 2011 in a special issue of the scientific journal Radiation Measurements.

www.upc.edu/inte/oramed/

MORE ABOUT

INTERCOMPARISON OF EDF WHOLE-BODY, LUNG AND THYROID COUNTERS



IGOR, the anthropomorphic phantom used for testing whole body counters used at EDF facilities.

Under the Order of December 6, 2003, IRSN is required to organize intercomparison exercises for radiation dose measurements in the three configurations usually tested: whole body, lungs and thyroid. In 2011, at the request of EDF, the Institute launched an intercomparison campaign for "whole body" and "thyroid" measurements covering all radiation dose counters at EDF power plants.
These intercomparison exercises enable the participating laboratories to assess their performance against the criteria defined in the NF ISO 12790-1 standard. Failure to meet these criteria leads to corrective actions, e.g. a review of measurement calibrations or protocols. All EDF equipment tested under these conditions complied with regulations.

More realistic radiation dosimetry for women

In 2011, research work carried out at IRSN as part of a doctoral dissertation, jointly funded by Areva, led to improvements in radiation dosimetry.
While whole body counting radiation dosimetry is still considered the ideal method for identifying and rapidly quantifying X and gamma radionuclides in the body, it had, until now, one significant drawback for women working in the nuclear industry, namely the use of anthropomorphic phantoms based on the male anatomy.
In order to improve radiation monitoring of female workers, IRSN researchers set out by developing a library of numerical models of the female thorax, reproducing the most common sizes and morphologies. This library was then used for numerical calibration on the counting system of the medical analysis laboratory at the Areva NC La Hague plant. In addition, a series of look-up tables defining counting efficiency variations according to energy and morphology was proposed and validated. These tables can be directly applied by Areva NC occupational health teams.

Neutron metrology intercomparison

As an associate laboratory of the French National Metrology Institute, IRSN holds the national references for fluence and dosimetric quantities in neutron fields. These references are regularly tested during international comparisons between national metrology institutes. In 2011, a new ten-yearly comparison (CCRI-K11) relating to the neutron fluence for four energies, involved Germany, the UK, France, the European Commission, Russia, China and the United States. It was carried out at IRSN's AMANDE facility from September 5, 2011 to January 27, 2012, with IRSN managing the exercise and also acting as participating host laboratory. The measurements and their uncertainties were determined independently by each participant. The overall deviation from the mean value gives the degree of equivalence of the national references.

Radiation protection events and incidents: an essential survey

After creating a database in 2010 to centralize information on radiation protection events and incidents, IRSN developed in 2011 a method to analyze these data. The results of this analysis and consequent statistics provide an assessment of the quality of

radiation protection measures implemented in the various fields where ionizing radiations are used. The aim is to prioritize radiation protection actions in light of feedback.
The method of analysis was tested on 60% of the 400 events known by the institute in 2010 and was found to be robust, taking into account the quantity and quality of the information available. This first analysis highlights the potential advantages of a more systematic contribution to this database by the organizations responsible for collecting information.

EFFECTS OF CHRONIC EXPOSURE

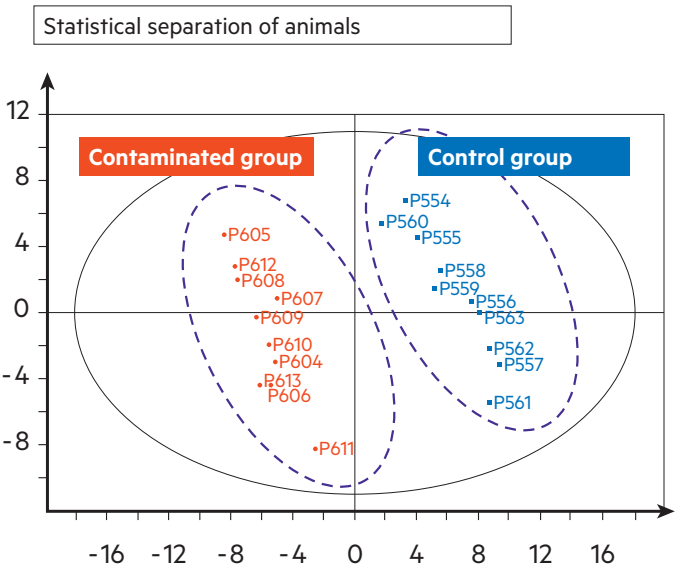
Contribution to the French Birth Cohort Study (ELFE)

IRSN contributes to the French Birth Cohort Study (ELFE), which is coordinated by a joint INSERM/INED unit (see glossary) and aims to identify and analyze the effects of environmental (air pollution, water pollution, UV, chemicals, ionizing radiation, etc.) and social factors on children's development, health and socialization.
This is the first general study on such a scale in France. The Institute is examining exposure to ionizing radiation to determine more accurately the doses received by children. Following a pilot phase in 2007, the ELFE study was extended in 2011 to a cohort of 20,000 children, who are being tracked from birth to the age of 18.
A questionnaire compiled by the Institute was sent to parents to identify the various radiological examinations their children have undergone during their lifetime. A cancer risk assessment will be carried out for this cohort of children, recruited between April and December 2011 from all over metropolitan France.

www.elfe-france.fr

Consensus conference on the non-cancerous effects of ionizing radiation

Within the framework of the European network of excellence on low-dose research, DoReMi, IRSN organized a consensus conference (September 19-23, 2011) on crystalline lens opacity potentially caused by professional exposure to ionizing radiation. Based on state-of-the-art knowledge, 28 experts from 11 countries identified the most promising avenues for research.
This conference will therefore contribute to updating the Strategic Research Agenda on low doses. It followed a previous conference organized in December 2010 on radiation-induced vascular effects and precedes another that will examine the effects on the central nervous system, which is planned for the second half of 2012.



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Discrimination between the 2 groups (contaminated/uncontaminated)

A metabolomic approach was tested as a new analytical tool in the field of radiotoxicology. In this case, statistical analysis is used to discriminate between animals that have been contaminated by cesium and those that have not.

ENVIRHOM PROGRAM

Metabolomic fingerprint of cesium-137 contamination

Metabolomics is a comprehensive analytical approach used in biology to identify all metabolites (carbohydrates, lipids, proteins, vitamins, etc.) produced by a living organism when subjected to a given stimulus. Within the framework of the ENVIRHOM program, IRSN has undertaken a metabolomic study of rats, enlisting the specific skills of an INRA/INSERM unit at the University of the Mediterranean.
The aim of the study is to detect the presence of specific markers in blood and urine, associated with chronic ingestion of cesium-137.
The findings were published in 2011 and are very promising, since they show that it is possible to identify animals contaminated with low doses of cesium-137 based on "metabolomic fingerprints" measured in their urine. Under the same contamination conditions, measuring blood levels of biochemical markers used in human clinical medicine does not enable this distinction to be made between contaminated and uncontaminated animals.
Compared with more traditional biochemical methods, this kind of approach opens up new avenues in radiotoxology by making it easier to detect the effects of cesium contamination on living organisms.

MORE ABOUT

ADOPTION OF THE STRATEGIC RESEARCH AGENDA ON LOW DOSES

The MELODI association is a European platform dedicated to studying the health effects of chronic exposure to low doses of ionizing radiation. During its third international workshop, held in Rome (Italy) in November 2011, the association adopted its Strategic Research Agenda on low doses, which was prepared by an IRSN-led working group and is aimed at integrating international R&D efforts in this field. The agenda will be submitted to the wider scientific community for discussion and comments. The main research priorities will be the study of non-cancerous pathologies (cardiovascular disease, cataracts and neurological disorders), work relating to individual radiosensitivity and advanced epidemiological studies integrating monitoring of cancer biomarkers.

www.melodi-online.eu

Chemical toxicity of uranium

Sources of drinking water naturally contain a variable concentration of uranium. To study the chemical toxicity of uranium, IRSN conducted an experimental study on rodents chronically contaminated with uranium added to their drinking water, as part of its ENVIRHOM program. The results of this research, completed in 2011, describe the effects on several organs (liver, kidneys, brain, etc.) of a wide range of uranium concentrations in drinking water (0.2 to 120 mg/l).

The study did not reveal any deleterious – either structural or functional – in any of the organs examined including, at a uranium concentration of 120 mg/l. In view of the equivalence coefficients applied in pharmacology, it can be estimated that there will be no effect in humans at concentrations below 1.25 mg/l in drinking water.

This new experimental data supplements the epidemiological data in the literature, and suggests that the chemical toxicity of uranium in the kidneys

The chemical toxicity of uranium is studied as part of the ENVIRHOM program at IRSN.

would only have a adverse effect at values at least 10 times higher than the WHO recommendation of 30 µg/l.

Effects of tritium

Besides the effects on human health, it is important to study the impact of radioelements on the different compartments of the environment. Within this context, IRSN embarked on several studies in 2011 to acquire new data on the effects of tritium in non-human organisms.

The focus was on DNA damage and its consequences on the embryonic development of a fish chosen as a vertebrate model. This research proved that internal exposure of fish to tritiated thymidine (organic tritium) would lead to DNA damage, vertebral malformations and delayed hatching at dose rates above 100 mGy per day.

PROTECTION IN HEALTHCARE

Overexposure during radiotherapy at Angers University Hospital

An accident involving overexposure of a patient at Angers University Hospital in western France during an interventional radiology procedure was declared to ASN in January 2011.

At ASN's request, IRSN experts visited the hospital and rapidly determined that the patient had suffered a severe skin lesion. IRSN then carried out physical measurements on the radiology equipment used and estimated, by reconstruction, that the patient's skin had received a dose of approximately 25 Gy. It made recommendations for the health monitoring of the patient in question.

Lastly, to prevent recurrence of such an accident, the Institute also formulated recommendations concerning equipment and practices in interventional radiology used for therapeutic purposes.

Initial results of the ROSIRIS research program

IRSN's experimental ROSIRIS research program aims to discover more about the side effects of radiotherapy with a view to reducing patient risk and optimizing treatment protocols.

One of the areas the program focuses on is establishing a link between early biophysical events at cellular level and their later consequences at cellular or tissue level. The experiments done in 2011 indicated a cause-and-effect relationship between the topology of energy depositions in the cell nucleus and DNA damage. Energy depositions were evaluated by numerical simulation using transport codes for particles in matter and DNA damage was revealed by DNA double-strand break markers.

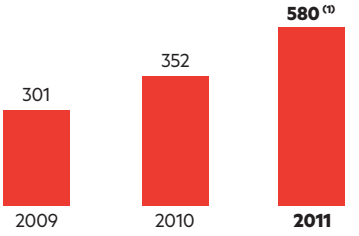
IN THE WORD OF...

PROF. ÉRIC LARTIGAU,

Head of the Radiotherapy Department at the Oscar-Lambret Center in Lille and President of the French Society of Radiation Oncology

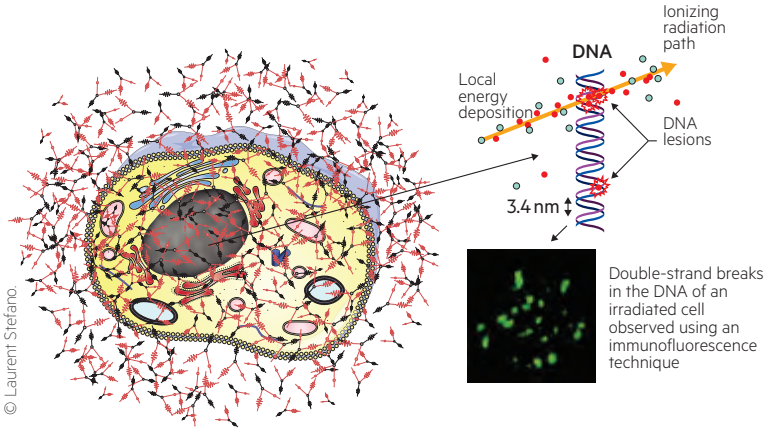
"The IRSN report on radiation therapists facing the challenge of improving treatment safety is a highly relevant analysis of the situation we have been dealing with for the past few years in response to governmental measures designed to improve the safety of cancer treatment. The various exchanges with the Institute have been particularly constructive and have culminated in a document that indicates a significant improvement in treatment, assuming a correct diagnosis, albeit at the cost of greater constraints being placed on professionals and institutions.

We hope that this report will be the starting point for a collaborative venture with our main contacts, i.e. the French Nuclear Safety Authority, the French National Authority for Health and the French National Cancer Institute. IRSN will continue to provide methodological support for the implementation of its recommendations."



WHOLE-BODY RADIATION COUNTS FOR WORKER MONITORING.

(1) 104 using mobile equipment.



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The ROSIRIS program is based on the working assumption of a causal relation between early radiation-induced effects and their consequences in tissue.

Another line of research aims to determine the biological mechanisms underlying the toxicity of radiotherapy treatments to healthy tissue. Conducted in partnership with teams from the University of Évry-Val-d'Essonne near Paris, this work has clarified the role of the vascular system. Using new broad-spectrum biological techniques (proteomic studies), IRSN's research has made it possible to describe an initial network of molecular interactions, specific to the early response of some vascular components to irradiation.

Progress of research on radiological burns

For the past three years, with financial assistance from EDF, IRSN has been pursuing research aimed at better predicting the development of radiological burns and improving treatment of these lesions by cellular therapy.

Radiological burns, sustained by accident or during radiotherapy treatment, are a cause of great concern in the field of radiopathology. Over the past few years, thanks to the efforts of the Institute, diagnosis has become easier, mainly due to the use of dosimetric reconstruction tools and improved recognition of clinical symptoms. The extent and severity of the damage likely to develop in the long term are still difficult to predict, however.

The results of IRSN's research were published in 2011. Using a preclinical model of radiological burns, a large-scale proteomic analysis of mouse proteins has made it possible to predict the severity of radiation-induced damage before the initial lesion even appears.

IRSN also demonstrated the effectiveness of endothelial progenitor stem cells (EPCs) in the treatment of radiation-induced lesions. These stem cells concentrate in the area of the skin lesion and accelerate the healing process after irradiation. The results show that the use of EPCs for therapeutic purposes is promising for the treatment of radiological burns, as are mesenchymal stem cells.

Collaboration with the World Health Organization

In July 2010, IRSN was designated as a World Health Organization (WHO) Collaborating Center for radiation protection, for a period of three years.

In this context, WHO calls upon the Institute for technical support in various fields of human radiation protection, particularly management of radiological accidents, biological dosimetry, risk assessment and medical radiation protection. Furthermore, the organization relies on IRSN to promote and disseminate a radiation protection culture in the medical and scientific community.

In this area, IRSN took major action in three areas in 2011:

IN THE WORDS OF...

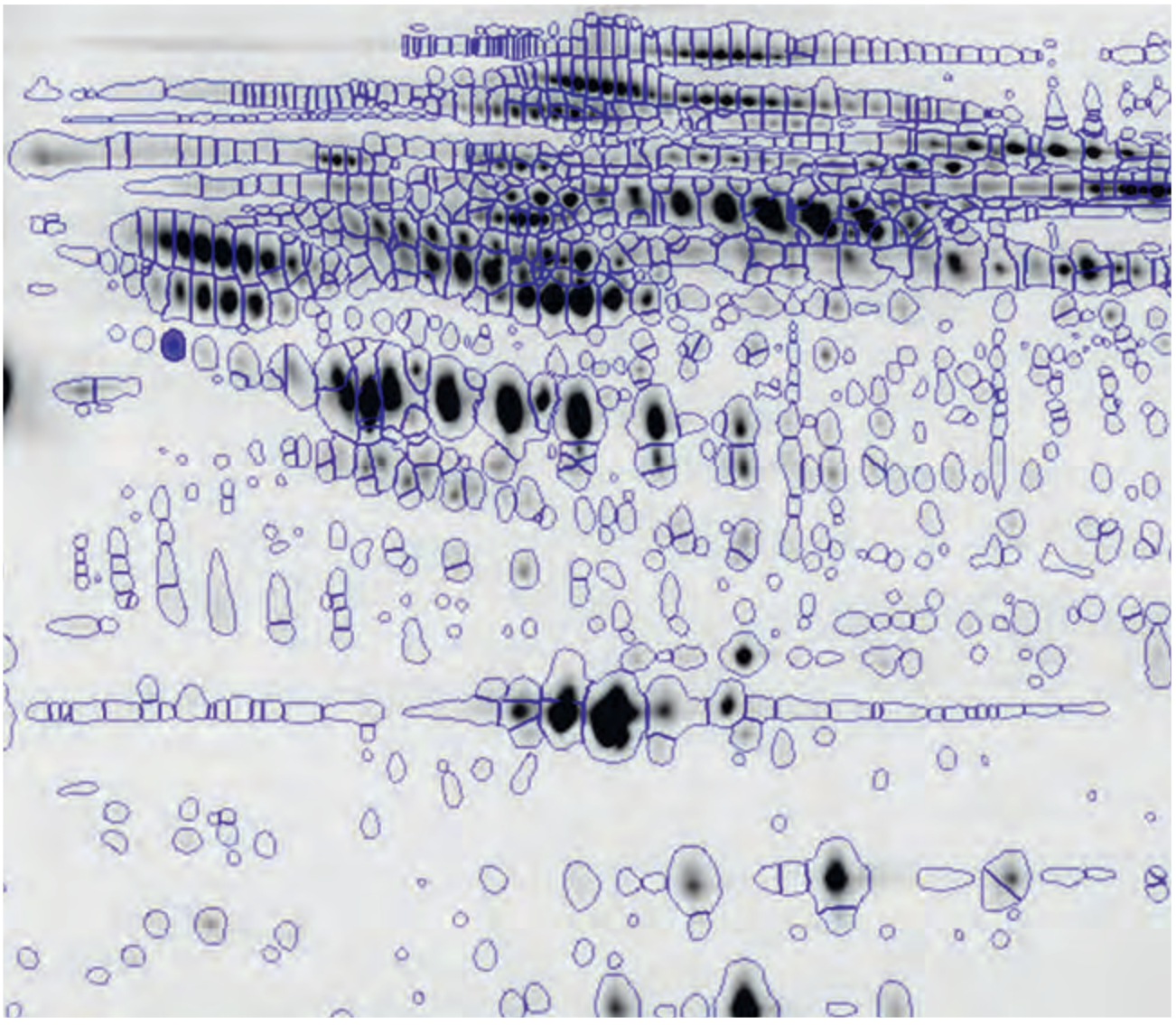
VINCENT PLAGNOL,

Radiation physicist and radiation protection specialist at SCM Coradix

"At the beginning of the year, IRSN launched a new online application for direct registration of data linked with the DRLs (diagnostic reference levels) for the procedures we carry out.
I signed up fairly quickly to be able to access this web-based DRL database. As with any new application, I had a few problems initially and passed them on to IRSN. I was impressed with how responsive their technical people were: they quickly addressed my comments and modified the application accordingly. I still think there's room for improvement, for instance in the accuracy of the information in the e-mail confirming registration of our data.
This kind of application enables IRSN to compile statistics more easily and on a large scale. From the users' point of view, it would be useful, in the medium term, to have a local version, showing doses over time, of the national DRL analysis that IRSN performs."

• in the aftermath of the Fukushima accident, WHO called on experts from the Institute to define the dose assessment method required to set up an epidemiological study for the purpose of evaluating the health impact of the accident on the Japanese population;
• IRSN participated in the conference of the WHO/REMPAN network (Radiation Emergency Medical Preparedness and Assistance Network), organized in Nagasaki (Japan) from February 16-18, during which an IRSN radiopathology expert was appointed president of the International Association of Radiopathology (IAR);
• participation in the international WHO BioDoseNet project, which aims to set up a global network of biological and physical dosimetry laboratories that will be fully operational in cases of large radiation emergency events.
IRSN's involvement as collaborating center is proof of its international reputation in the field of radiation protection.

•–• *Proteomics contributes to the search for biomarkers for predicting the severity of radiological burns. Shown below, irradiated mouse serum proteins viewed on a 2D electrophoresis gel.*



EMERGENCY AND POST-ACCIDENT SITUATIONS

SPEED, ACCURACY AND INFORMATION

As in most accident situations, the action taken during the first few hours following a nuclear or radiological accident is crucial in terms of managing the emergency and its potential consequences for human health and the environment. For this action to be effective, the nature of the accident and its radiological impact must be identified rapidly and accurately, in order to provide the relevant public authorities with reliable decision support. IRSN demonstrated the validity of this approach during two incidents in 2011: an irradiation accident that occurred in a Bulgarian industrial plant and the accidental explosion of a furnace at the Marcoule Centraco facility in southern France. The Institute also continued to prepare for radiological emergencies, specifically by validating a semi-automated biological dosimetry method to enable rapid triage of exposed and unexposed individuals during a large-scale radiological event.

Another key aspect of emergency and post-accident management is information. The accident at the Fukushima-Daiichi power plant led, for example, to IRSN implementing its CRITER tool, which centralizes the results of continuous measurements from radiation monitors in the remote environmental monitoring networks in the event of an emergency; the results are available in real time on the Institute's website.

3 ACTIONS TAKEN BY THE EMERGENCY RESPONSE CENTER:
– MARCH 11: FUKUSHIMA-DAIICHI ACCIDENT,
– SEPTEMBER 12: EXPLOSION AT THE CENTRACO FACILITY IN SOUTHERN FRANCE,
– DECEMBER 16: ONSITE SAFETY PLAN ACTIVATED AND FLOOD AT THE BLAYAIS PLANT IN SOUTHWEST FRANCE.
(3 IN 2010)

RADIOLOGICAL INCIDENTS AND ACCIDENTS

In the event of a radiological accident or incident, IRSN is called upon to assess the consequences for irradiated individuals and the environment, and to help decide on the most appropriate course of action.

Radiological accident in Bulgaria

An irradiation accident occurred on June 14, 2011 in Bulgaria when employees of a company mistakenly handled hight activity cobalt-60 sources used for sterilization purposes.

At the request of the IAEA, IRSN immediately sent two experts to Bulgaria, a medical doctor and a radiopathologist, to carry out an initial assessment of the medical consequences. The five victims were then swiftly transferred to the hemotology department of the Percy Military Hospital near Paris. The Institute assisted the medical team, in particular in assessing the doses received by the victims. The following analyses were performed: biological dosimetry by counting chromosome aberrations in the blood; dosimetric reconstruction by simulation with a Monte Carlo code, which enabled the victims to be modeled in their environment; and retrospective dosimetry on tooth enamel samples, taken specifically and analyzed using electron paramagnetic resonance.

The dosimetric data obtained were crucial in determining the right treatment for each of the victims. The most severely irradiated among them were successfully treated by injecting growth factors, in accordance with the European medical consensus reached at the Les Vaux-de-Cernay conference near Paris.

Explosion in a metal waste furnace at Marcoule

On September 12, 2011, an explosion occurred in a furnace used to melt down very low-level radioac-

The cobalt source storage container at the sterilization facility was the cause of the accident in Bulgaria.

tive metal waste at the SOCODEI plant in Marcoule in southern France. IRSN quickly intervened to assess the potential impact on the environment and the local population. The Institute's Emergency Response Center was set to work and soon reached the initial conclusion that there was unlikely to be any risk to the public.
A team from Cadarache sought to corroborate this view by means of direct environmental measurements and to quantify the environmental impact of this event by sampling and analyzing vegetation. The samples were taken to the metrology laboratories, where they were subjected to more extensive analysis the same day. By the next day, the Institute was able to confirm that the radioactivity released was not quantifiable, even using the most advanced metrological equipment.

Release of iodine-131 in Hungary

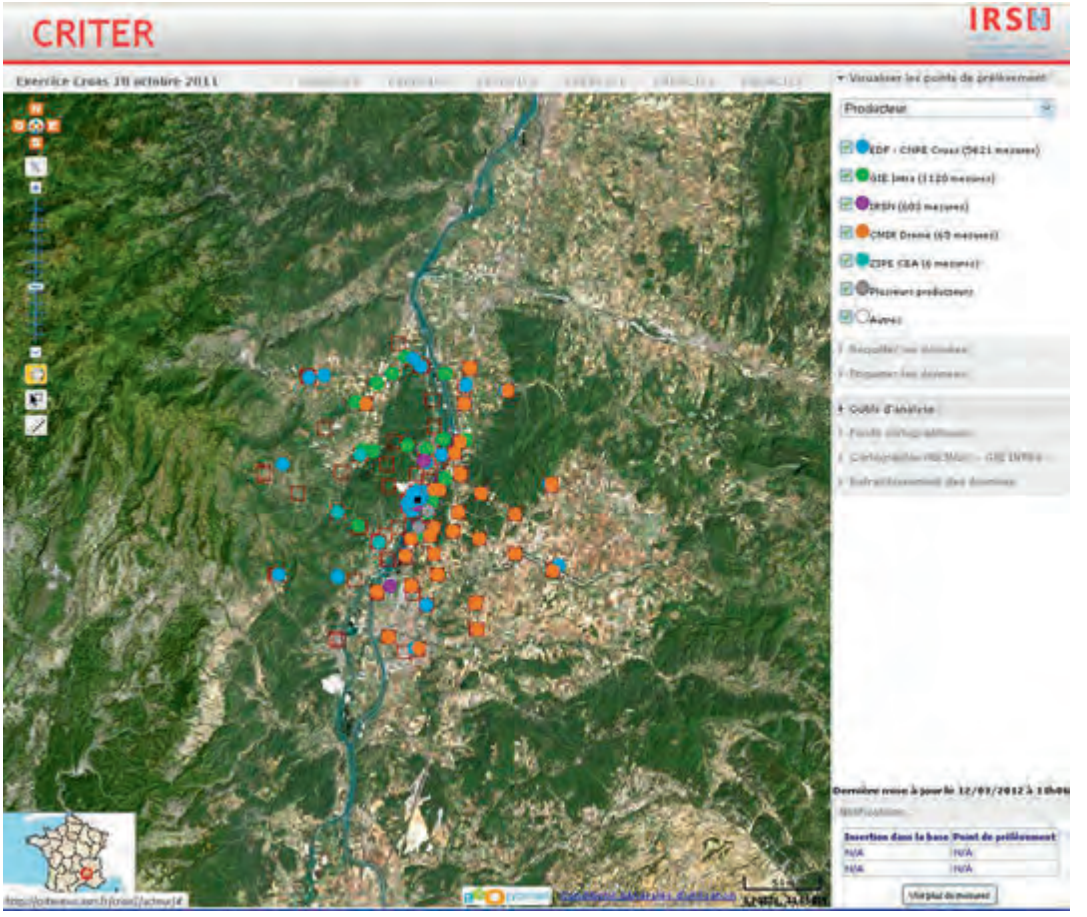
Early in November 2011, IRSN learned that airborne traces of iodine-131 had been detected in several countries in Central Europe. The Institute rapidly undertook the analysis of samples of aerosols and gaseous iodine to check whether this radionuclide could be detected in France. The analysis revealed the presence of iodine-131, mainly between November 5 and 10, at concentrations of no more than a few µBq/m³, a value very close to the detection limits of the measuring equipment, and which presents no risk to public health. Since the origin of this radioactive pollution was a release to the atmosphere from the Isotope Institute in Budapest (Hungary), IRSN also estimated the radiological impact within a 20 km radius of the site of the institute, which pointed to very low doses, even for "unprotected one-year-old children". According to the Hungarian authorities, the release occurred between September 8 and November 16; the cause has yet to be determined.

TOOLS AND RESOURCES

To be able to suggest the most appropriate course of action in an emergency, IRSN is working on ways of improving its dosimetry equipment and developing tools to centralize and provide access to environmental data.

9

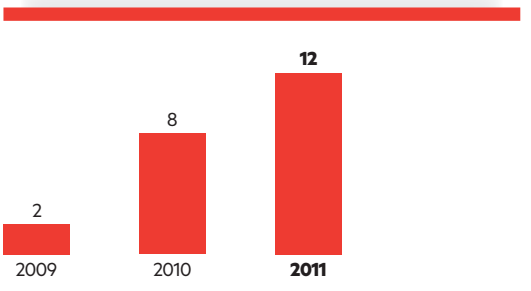
NATIONAL NUCLEAR EMERGENCY EXERCISES EXCLUDING DEFENSE-RELATED ACTIVITIES. **(5 IN 2010)**



The CRITER system is designed, in the event of emergency, to rapidly provide decision-makers with an overview of the environmental measurement results obtained by all the organizations on the site. Opposite is an illustration of measurements taken as part of the Cruas exercise.

Taking dietary habits into account in dosimetric assessments

In 2011, IRSN conducted a dietary survey in the area surrounding the Gravelines nuclear power plant in northern France, with the support of the local information commission and in collaboration with the French environment and energy management agency. The Institute would like to have data on the dietary habits of local residents in order to refine its dosimetric assessments around industrial sites. Data currently available at national level could be modified based on knowledge of specific local conditions. Furthermore, recent national surveys do not consider locally grown food, a key factor in ensuring accurate dosimetric assessments, as this produce may be the most contaminated. After Tricastin (2004-2005), Chinon (2008) and Marcoule (2010), the 2011 survey focused on a seaside site for the first time.



IONIZING RADIATION DOSE ASSESSMENTS BY BIOLOGICAL DOSIMETRY.

Faster analysis for biological dosimetry

In 2011, IRSN validated a semi-automated dosimetric method to enable rapid triage of irradiated and unirradiated people in the event of a radiological accident likely to have affected a large number of individuals. The method optimizes the use of the current biological dosimetry reference technique, which is based on counting chromosome aberrations, thereby reducing sample analysis time by a third, while guaranteeing the same accuracy of results. It is now possible to retrospectively estimate the irradiation dose received by an individual and assess the heterogeneity of exposure more quickly. The operational capability of this new method will

shortly be tested on a sample of 50 people during an emergency exercise.

Assessment of the CRITER tool

The concept and functionalities of the CRITER tool were assessed during exercises organized throughout 2011. Designed to deliver information to the various stakeholders in the event of an emergency, this tool will be used to centralize and provide access to the results of environmental measurements. Using CRITER, the results of measurements carried out using IRSN probes in the Teleray network, as well as EDF measurements, can be disseminated in real time; dose rate measurements from systems belonging to the French Navy, the CEA, the INTRA Group (focusing on the use of remote-controlled equipment in accident situations) or Areva have made it possible to gradually refine the tool over successive emergency exercises.
Development of the tool also enabled IRSN to give real-time online access to the results of measurements from remote environmental monitoring networks just as contaminated air masses from the Fukushima-Daiichi power plant in Japan were passing over France.

New decision support tool in the event of pollution in the Mediterranean

In 2011, IRSN completed the multi-partner CLARA 2 project, co-funded by the French national research agency (ANR) with the aim of developing a decision support tool for use during marine pollution incidents. One of the Institute's tasks was to map the sensitivity of the French Mediterranean coast from an ecological point of view (in particular, protected areas or species) and from a socio-economic perspective (tourism, aquaculture, fishing and other activities directly or indirectly linked with water quality).
In the event of an incident, the operational tool developed as part of this project would be used to cross-reference this information against dispersion forecasting of hazardous substances to rapidly determine the most vulnerable areas, which should be dealt with first.

3

NATIONAL NUCLEAR EMERGENCY EXERCISES INVOLVING DEFENSE-RELATED FACILITIES.
(6 IN 2010)

CLARA2 is a decision-making aid in the event of marine pollution. Below, an illustration of the Mediterranean coastline.

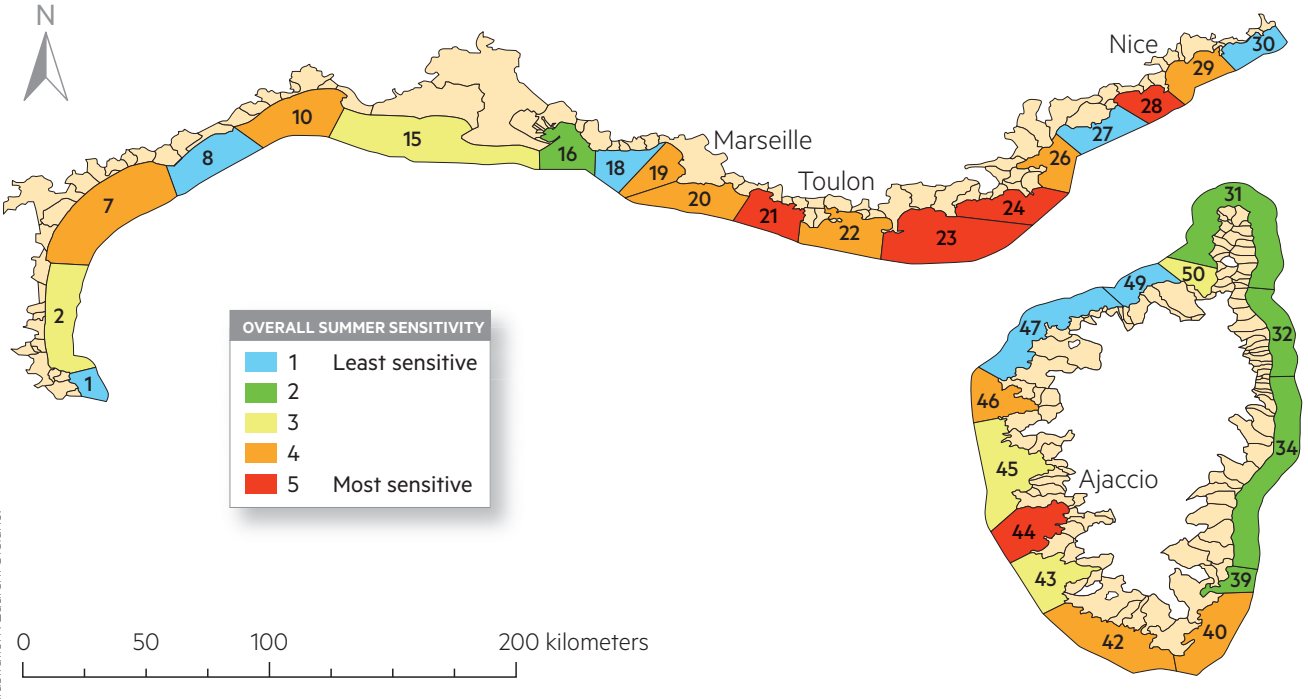


Illustration : Laurent Stefano.

04/

SACLAY – ESSONNE (September 19)

THE INSTITUTE TOOK PART IN THE SCIENCE FAIR BY OPENING UP ITS LABORATORIES AT SACLAY, IN COOPERATION WITH CEA.

EFFICIENCY

CONTROL AND OPERATION

RESOURCES SUPPORTING THE WORK OF THE INSTITUTE

2011 was a year of decisions taken by IRSN's supervisory ministries to enable it to carry out its tasks even more efficiently. The Institute can thus continue its efforts to improve safety and radiation protection in the face of ongoing changes in the nuclear industry and take into account the lessons learned from the Fukushima-Daiichi accident.

Operators' annual contribution

To meet the growing demand for expert assessment services, particularly in new nuclear projects, the French parliament voted to introduce a fixed annual contribution payable by operators of nuclear facilities to IRSN. This decision reflects the commitment of the Institute and its supervisory ministries to tailor IRSN resources more closely to these changing needs, as part of the Contract of Objectives for 2006-2009.

Estimated to be worth €30 million when it was introduced, this contribution replaced part of the grant allocated to IRSN in 2011. This will ensure that the Institute has access to flexible funding based on demand for expert assessment, while guaranteeing that it remains totally independent in all its operations.

Increase in number of full-time equivalents

For the past few years IRSN has had to cope with the growing expectations of the public authorities in matters relating to expert assessment. In this context, and to meet new needs identified in additional safety assessments carried out in the wake of the March 2011 accident at Japan's Fukushima power plant, the public authorities decided in June 2011 to create 44 extra IRSN jobs, 22 of which for staff on assignment to the French nuclear safety authority, ASN.

Interministerial arbitration on IRSN's property project

By prohibiting "other government bodies" (ODAC) from taking out a credit institution loan for longer than 12 months, the Public Finance Programme Act for 2011-2014 called into question the principle of IRSN borrowing to finance its property project. After several months of discussions, an interministerial meeting reached a decision on June 16, 2011 regarding a new legal and financial arrangement: demolition and reconstruction of buildings 02 and 44-23 at the Fontenay-aux-Roses site near Paris using a third-party investor (temporary occupation permit in return for lease arrangement); reconstruction of building A on the nearby Le Vésinet site within the context of the Public Project Contracting Act; and allocation of the proceeds from the transfer of the State's stake in the Le Vésinet site to finance part of the project. At the same time, the State land tenure arrangements for the Fontenay-aux-Roses and Le Vésinet sites were settled at the end of 2011 under a utilization agreement between the State and IRSN.

MORE ABOUT

A NEW STRATEGY, DEVELOPMENT AND PARTNERSHIPS DIVISION

The Strategy, Development and Partnerships Division was created in January 2011 as a result of a merger between the Science Division and the Strategy, Development and External Relations Division. This new division has been set the task of strengthening the scientific base of IRSN's strategy, stepping up its strategic planning and improving coordination of assessment or research projects, without losing sight of budget realities.

It is also responsible for developing more structured relations with IRSN's partners, specifically those involved in research and higher education, as well as continuing to promote the Institute's skills and strengthen dialogue with all stakeholders. Within the Institute's restructured functional organization, the Scientific Director now reports to the Director General, with responsibility for scientific assessment, coordination of the college of experts and exploratory research.

A STRONG COMMITMENT TO SUSTAINABLE DEVELOPMENT

The year 2011 saw the launch of a number of significant environment-related activities such as the signing of the Sustainable Development Charter, the decontamination of the Le Vésinet site, and the removal of radioactive sources.

Signing of the Sustainable Development Charter

On April 8, 2011, Agnès Buzyn, Chair of the IRSN Board of Directors, signed the Sustainable Development Charter together with 20 other public corporations and institutions, thereby demonstrating the Institute's willingness to go beyond its statutory obligations and responsibilities to society. Specifically, IRSN undertakes to hold strategic discussions on sustainable development, translate the findings into policies, projects and management practices, draw up a strategic document on sustainable development, prepare an action plan, and report annually on the social and environmental impact of its activities. It thus becomes one of 40 organizations in the sustainable development "club" of Charter signatories.

Decontamination of Le Vésinet site

IRSN undertook the substantial task of soil decontamination at its Le Vésinet site near Paris in 2011. Contamination occurred in 2003 when some 7,000 l of fuel oil was accidentally spilled while the boiler tank was being filled. After an initial cleanup operation in 2005, a second was required because of the depth of the contamination (13 m) and its proximity to a drinking-water catchment area. The work carried out in 2011 involved demolishing and replacing the boiler then using complex shoring techniques in order to excavate 4,500 t of contaminated earth. Analyses performed during and after the work confirmed that the soil had been thoroughly decontaminated. This analysis work will continue during 2012.

Removal of NUMEC sources

In 2011, IRSN removed eight plutonium-beryllium neutron sources stored in its laboratories at Fontenay-aux-Roses near Paris and Cadarache in southern France. NUMEC, an American company that has since gone into liquidation, had supplied these sources to the CEA in the 1960s and they were subsequently transferred to IRSN when it was set up. Once the U.S. government had agreed to take them back, IRSN started removal operations as part of a joint project with the CEA. The work proceeded in two stages: the sources were first placed in American transport casks by personnel from Los Alamos National Laboratory (LANL) before being transported by road and sea. They left France in June 2011.

MORE ABOUT

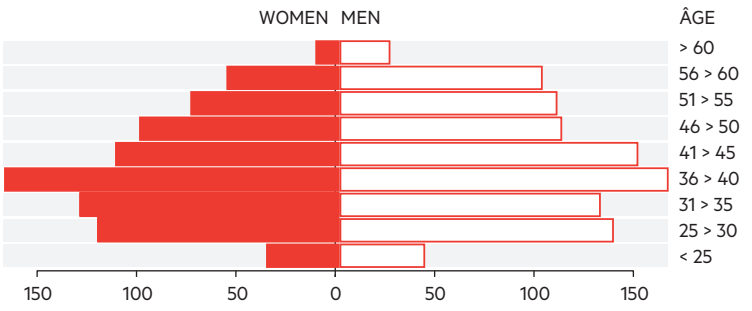
WORKING TOWARDS A SINGLE QUALITY, SAFETY AND ENVIRONMENTAL MANAGEMENT SYSTEM

In order to meet its sustainable development objectives while honoring its safety and quality commitments, IRSN decided, in 2011, to develop a single quality, safety and environmental management system, certified according to ISO 9001, ISO 14001 and OHSAS 18001 standards. This will eventually result in a better understanding of the risks to human health and the environment arising from the Institute's activities, enabling it to pursue its quest for continuous improvement even more effectively.

HUMAN RESOURCES

ANTICIPATING NEEDS AND ENSURING SKILLS DEVELOPMENT

In the area of human resource management, 2011 saw an analysis of internal systems and HRM tools with a view to updating them by tailoring them to IRSN's current needs. The action plan on quality of life at work and prevention of psychosocial risks was also implemented.



AGE PYRAMID **(AS % BY GENDER).**

1.34 **€M** MILLION SPENT ON TRAINING. **(1.67 EN 2010)**

Internal mobility system

Having introduced skills and professional specifications in 2010, which have been brought to employees' attention and explained more fully during annual appraisal interviews, the Institute decided it needed to incorporate them into its internal mobility system more effectively.

First of all, employees seeking alternative employment within IRSN are invited to the HR department to identify the kind of assistance they need to progress in their career. Depending on how well articulated their own goals are, they are offered either a counseling and mobility interview to guide and support them in their dealings with the various units, or a more in-depth career interview for the purpose of mapping out a new career path. In 2011, 110 counseling and mobility assessments were made, and 20 career assessments.

Secondly, the internal mobility procedure has been reviewed and now functions in the same way as the external recruitment procedure, i.e. the most suitable candidate for a vacancy is selected based on the applicants' profiles. The HR department is therefore involved in all kinds of recruitment: assessing candidates' suitability, advising the units in the event of several applicants for the same vacancy and guiding employees towards available positions that best match their skills and requirements.

Feedback on the implementation of collectively agreed wage structures

In 2011, IRSN assessed the implementation of the wage structure for managerial staff during the previous three years, as provided for in the relevant agreement, signed in 2008. This involved examining the situation of the different managerial categories: novices, i.e. individuals with less than two years' professional experience, and seasoned managers.

The assessment compared career development with how it used to be under the pre-2008 system and found that, overall, the new system is conducive to more regular pay progression. This progression is of course slower for people in the early stages of their career, but is offset by a higher starting salary based on reassessment of qualifications in monetary terms, as set down in the agreement. Moreover, ten-year projections show that early-career employees will earn slightly more than under the former system.

The situation will need to be reviewed, however, to improve continuity in the range of individual salary increases proposed for each pay band, to examine the pace of progression within the range and to rethink the terms used to assess employee performance. The wage structure assessment was presented during an extraordinary meeting of the Career Committee.

The social partners agreed, in principle, to negotiations in 2012 with a view to improving the system. The Institute has also carried out an initial analysis of the collectively agreed wage structure for non-managerial staff, one year after it was put in place. This assessment, which found the system to be satisfactory overall, highlights greater flexibility in calculating the individual measures for all employees on a yearly basis.

Assessment of the agreement on assisting the disabled to secure employment

Signed in February 2009, the first agreement in support of helping disabled people to find employment set a number of specific objectives, i.e. to promote employability, to keep the target group in employment and to increase staff awareness. Three years on, the assessment of this agreement is positive in several respects. First, six information sessions were organized during the period 2009-2011 to promote greater employee awareness; this exercise is linked with 12 employees being declared disabled workers.

At the same time, the Institute largely achieved its subcontracting objectives with the sheltered employment sector. The aim was to have five beneficiary units by the time the agreement expires, and the first survey of contracts awarded to this sector, as at December 31, 2011, indicates that this figure has been exceeded (6.5 beneficiary units). These encouraging results are primarily due to the signing of two service contracts, one for a telephone helpline and the other for printing work.

On the other hand, some progress can be made in the area of recruitment, since the ambitious objectives have not yet been achieved, mainly due to a lack of suitable candidates. During the period of application of the agreement, IRSN:

- recruited one disabled person in 2009 on a fixed-term contract for a period of 13 months;
- employed two disabled temporary staff in 2009 and 2010 for a period of 13 and 15 months for the purpose of data capture and archiving;
- recruited one disabled person in 2011 on a one-year work experience contract.

As part of efforts to retain disabled workers in employment during the 2009-2011 period, 12 meetings were convened with the Occupational Health Department and the social services department responsible for preventing disabled people being declared unfit for work. The participants took part in nine workstation studies, four with the help of an ergonomics specialist, contributed to adapting seven workstations, and helped seven disabled employees to improve their working conditions.

MORE ABOUT

ACTION PLAN ON QUALITY OF LIFE AT WORK AND PREVENTION OF PSYCHOSOCIAL RISKS

Following the signing of the second agreement on stress prevention and quality of life at work in December 2010, and the implementation of an action plan to prevent psychosocial risks in the summer of 2010, IRSN launched a number of initiatives. Specifically, these included training organized on the Institute's main sites to promote greater staff awareness, with the content finalized by an interdisciplinary working group. Five awareness sessions were held at the Fontenay-aux-Roses and Le Vésinet sites near Paris and at the Cadarache site in southern France, involving more than 250 employees. The working group also helped prepare training material on the same topic, specifically targeting management, HR and medico-social personnel, employee representatives and members of the health, safety and working conditions committees. Two pilot sessions were organized in 2011. At the same time, IRSN's Occupational Health Department devised a questionnaire specifically focused on these risks, which the occupational health physician uses during medical examinations. This anonymous questionnaire is routinely offered to employees and all replies are confidential. The data obtained is used for statistical analyses on the quality of life at work. A psychosocial risk unit has also been set up. In the event of a critical individual or collective situation, and at the request of the IRSN Inspector General, this unit conducts a diagnostic analysis and submits its findings to the Director General, who decides on a plan of action that is then monitored by the HR department. Lastly, the HR department contributed to driving change by taking part in discussions on the Institute's operational reorganization. It also helped prepare for this major undertaking by ensuring that all staff were kept properly informed and by being available to employees who wished to express their views on the subject in strict confidence.

GLOSSARY

A

AERES French Evaluation Agency for Research and Higher Education.
AFNOR French standards association.
ALPHA RADIATION (SYMBOLIZED AS "α") A highly ionizing form of particle radiation with low penetration consisting of helium-4 nuclei. A simple sheet of paper can prevent its propagation.
AMANDE Accelerator for dosimetry metrology and neutron applications (Cadarache).
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.
ASAMPSA2 Advanced Safety Assessment Methodologies: Level 2 Probabilistic Safety Assessment.
ASN French nuclear safety authority.
ASND French nuclear safety authority for defense-related facilities and activities.

B

BECQUEREL (Bq) Official international unit of measure used for radioactivity. The becquerel is equal to one transformation per second.
BEL V Technical safety organization of the Belgian Nuclear Safety Authority.
BETA (SYMBOLIZED AS "β") Radiation consisting of electrons with a positive or negative charge. Propagation can be stopped by leaving a space of a few meters around the source or providing a barrier using a simple sheet of aluminum foil.

C

CABRI CEA test reactor used by IRSN to study nuclear fuel safety.
CAMARI Aptitude certificate for operating industrial radiology equipment.
CHROMOSOME ABERRATION An irregularity in the number or structure of chromosomes.
CLI Local information commission.
CONTROL ROD ASSEMBLY A set of mobile interconnected rods containing neutron-absorbing material, which is inserted into the core of a nuclear reactor. It increases or decreases core reactivity depending on its position.
CPW Chemical Weapons Convention.
CRITICALITY (RISKS) Risks associated with uncontrolled fission phenomena in fissile materials.
CSA Complementary Safety Assessment.
CTE Euratom technical committee.

D

DOE/NNSA Department of Energy (USA).
DOSIMETRY Assessment or measurement of the dose of radiation (radioactivity) absorbed by a substance or an individual.
DRL Diagnostic reference level.
DSND Representative in charge of Nuclear Safety and Radiation Protection for Defense-related Activities and Facilities.

E

EEIG European Economic Interest Grouping.
EFFECTIVE DOSE A physical variable used in the field of radiation protection, where it serves to assess the impact of exposure to ionizing radiation on biological tissue. It takes into account the sensitivity of the affected tissues and the type of radiation. The sievert (Sv) is the unit of effective dose.
ENSREG European Nuclear Safety Regulators Group
ENSTTI European Nuclear Safety Training and Tutoring Institute.
ENVIRHOM Research program that studies the processes involved in radionuclide accumulation and the biological effects induced by this accumulation in flora, fauna and humans in a chronic exposure situation.
EOLE CEA research reactor used for exploring the physical properties of light-water nuclear reactor cores. It is designed in particular for studying new reactor core designs.
EPR European Pressurized-water Reactor.
ETSON European Technical Safety Organisations Network.
EURATOM European Atomic Energy Community.

F

FLUENCE Number of particles intercepted by a detector per unit area (particles/cm^2).
FNR Fast neutron reactor.
FOUNDATION RAFT Thick, reinforced concrete foundation providing stable support.
FP European Union Framework Programme for research and technological development.
FUEL ASSEMBLY Bundle of fuel rods assembled in a metal structure, used in nuclear reactors.

G

GAMMA RADIATION (SYMBOLIZED AS "γ") Electromagnetic radiation with high penetration but low ionization, emitted during the transformation of radionuclides. Protection is provided by concrete or lead screens.
GRS Gesellschaft für Anlagen- und Reaktorsicherheit (German technical safety organization).
GWJ/T Fuel burnup unit. Gigawatt-hours per metric ton of fuel. Commonly used unit of measure giving the level of irradiation of fuel assemblies, expressed as energy output by the assembly in the reactor per ton of initial uranium.

H

HCTISN French high committee for transparency and information on nuclear safety.
HDR Accreditation to supervise research.
HFDS Ministry of Energy Senior Defense and Security Official, the authority in charge of nuclear material protection and control in France.
HILW-LL High level and intermediate level long-lived waste.
HTTR A Japanese high temperature test reactor.

I

IAEA International Atomic Energy Agency.
ICRP International Commission on Radiological Protection.
IFSTTAR French institute of science and

technology for transport, development and networks.
IGS Institute of Geological Sciences (Ukraine).
INB Basic nuclear installation.
INBS Secret basic nuclear installation.
INED French national institute for demographic studies.
INERIS French national institute for the study of industrial environments and risks.
INRA French national institute for agricultural research.
INSERM French national institute of medical health and research.
InVS French national institute for health surveillance.
ISOTOPES Elements whose atoms have the same number of electrons and protons, but a different number of neutrons. Designated by the same name, they display the same chemical properties. There are currently 325 known natural isotopes and 1,200 artificial isotopes.
IRSTEA French research institute for agricultural and environmental engineering.
ISTP International Source Term Program.
ITER International Thermonuclear Experimental Reactor – an international program set up to demonstrate the viability of nuclear fusion as a new source of energy.

J

JAEA Japan Atomic Energy Agency.
JNES Japan Nuclear Energy Safety Organization.

K

KV kiloVolt.

L

LOCA Loss Of Coolant Accident.

M

M5 Type of PWR fuel cladding.
MEDDTL French Ministry of Ecology, Sustainable Development, Transport, and Housing.
MELODI Multidisciplinary European Low Dose Initiative, a European governance instrument set up to organize research into risks relating to low-dose radiation exposure.
MGY Milligray – Unit of radiation absorbed dose used in the international system.
MIMAUSA Program on the heritage and impact of obsolete uranium mines in France, created for analysis and archival purposes..
MINEFI French Ministry of Economy, Finance and Industry.
MINERVE Experimental reactor used for neutronics studies on fuel networks in various nuclear reactor series. The main purpose of this research is to improve knowledge of basic nuclear data.
MOX Fuel made from (natural or depleted) uranium and plutonium oxide.
MSV Millisievert – Unit of effective dose used in the international system.
MWE Megawatt electric, unit of electric power produced. In a pressurized water reactor, the thermal power released is about three times greater.

N

NPP Nuclear power plant.
NRC United States Nuclear Regulatory Commission.
NRG Nuclear Research and Consultancy Group – a nuclear service provider in the Netherlands.

O

OECD Organisation for Economic Co-operation and Development.
OPCW Organisation for the Prohibition of Chemical Weapons.
ORAMED Optimization of Radiation Protection of Medical Staff.

P

PCR Radiation protection specialists.
PSA Probabilistic Safety Assessment. Level 2 probabilistic safety assessments (PSA2) serve to quantify the probability of fission product release in the event of a severe accident.
PUI On-site emergency plan.

R

RADIOELEMENT Natural or artificial radioactive element.
RADIONUCLIDE Radioactive isotope of an element.

S

SARNET Severe Accident Research NETwork of excellence, a European research project to study core meltdown accidents in water reactors.
SGDSN French General Secretariat for Defense and National Security.
SIGIS Information and management system for the French national inventory of sources of ionizing radiation.
SNA Nuclear attack submarine.
SNETP Sustainable Nuclear Energy Technology Platform.
SNRIU State Nuclear Regulatory Inspectorate of Ukraine.
SOFIA Emergency operation observation simulator.
SOURCE TERM Radioactive release to the environment in the event of a core meltdown accident in a water reactor.
STAR Strategy for Allied Radioecology – a European network of excellence set up to pool its partners' knowledge, infrastructure and research activities in the field of radioecology.
SYLVIA Name of a fire and ventilation computer code coupling system developed by IRSN.

T

TELERAY French national automatic gamma air monitoring network. It also emits a warning in the event of unusually high ambient dose rates.
TTRASSE French national research grouping (IRSN-CNRS) focusing on the subject of radionuclide transfer to the ground, subsoil and ecosystems.
TSN French act relative to Transparency and Security in the Nuclear Field.
TSO Technical Safety Organisation.

U

UIAR Ukrainian Institute of Agricultural Radiology.

V

VVER (OR WWER) Vodo-Vodianoy Energetichesky Reactor or Water-Water Energetic Reactor. Russian-designed reactors that operate in a similar way to western pressurized-water reactors.

W

WENRA Western European Nuclear Regulators' Association.
WHO World Health Organization.

Z

ZIRCALOY-4 A zirconium alloy used for making fuel tubes for uranium oxide fuel pellets.

For further information, consult the glossary on the IRSN website at www.irsn.fr

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ET DE SÛRETÉ NUCLÉAIRE

Enhancing nuclear safety

FINANCIAL REPORT

2011

RESEARCH EXPERTISE 10 YEARS

CONTENTS

MANAGEMENT REPORT

GENERAL OUTLOOK

Significant events in 2011:

- the Fukushima accident was the reason for a release of €5.5 million in reserves from Budget Program 190 to support the Institute's action to deal with the crisis and to contribute to the funding of complementary safety assessments of all nuclear power reactor units in France;

- a cost-saving measure was applied at the end of the fiscal year, which reduced the level of the grant from €1.4 million to €210.8 million;

- the Institute's self-generated revenue from the co-funding of research and from industrial and commercial operations suffered as a result of teams being allocated as a priority to actions undertaken in the wake of the Fukushima accident;

- the 2010 full-employment situation deteriorated during the year, slipping back by 37 employees (full-time equivalent worked);

- the dispute that followed the incident at the Feursmétal industrial site was resolved with the signature of a settlement agreement, the financial consequences of which are reflected in the accounts for 2011 as a provision of €11.1 million and a payment of €7.9 million;

- the work begun in 2010 on Le Vésinet site, following an environmental accident, was completed;

- €2.9 million was paid out from the special dismantling fund to cover the cost of works carried out in 2010.

Budget execution in 2011 involved a vast investment program totaling €36 million after incorporation of operations carried over from the previous year, including the Institute's property project. This amount was increased during the year by a transfer of €2.8 million from the operating budget, due to a change in the nature of the expenditure relating to refurbishment of the restaurant belonging to CEA.

Not all of these investments were completed during the fiscal year, and a proposal to carry over €21.7 million for operations in progress will be put forward in the first revision (DM1) of the projected revenue and expenditure statement for 2012.

Furthermore, not as much work financed out of the operating budget (CABRI) was done as originally planned and so a proposal to carry over €8.2 million of this expenditure will also be made.

BUDGET BALANCE

Execution (in €M)	2011	2010	Difference 2011/2010
Total resources	**292.1**	316.3	– 7.7%
Total expenditure	**282.0**	312.8	– 9.9%
BALANCE	**+ 10.1**	**+ 3.5**	**+ 188.6%**

Budget execution in 2011, as in previous years, shows a budget balance that appears to be amplified by the €19.7 million in investments carried over. Appropriate recalculations give the following results:

Recalculated execution (in €M)	2011	2010
Actual balance	**+ 10.1**	+ 3.5
2009 carryover	**–**	+ 14.5
2010 carryover	**+ 19.2**	– 19.2
2011 carryover	**– 29.9**	
RECALCULATED BALANCE	**– 0.6**	**– 1.2**

The year 2011 can be characterized as follows:

- results match the balance figures given in the projected revenue and expenditure statement approved by the Board of Directors;
- a budget execution rate of 87.2% (compared with 93.4% in 2010), i.e. a difference of €41.4 million, of which €29.9 million corresponds to delays in the execution of certain investments or specific expenditure. If these delayed items were excluded, the budget execution rate would be 96.4% compared with 99.2% in 2010. The remainder is split between a reduction in revenue (€6.3 million) and a contribution to the working capital (€5.2 million).

INCOME STATEMENT ANALYSIS

REVENUE

Execution (in €M)	2011	2010	Difference 2011/2010
Sales	**36.2**	39.2	– 7.6%
Operating grant	**198.9**	230.6	– 13.7%
Other income	**48.0**	8.1	493.0%
Operating income subtotal	**283.1**	**277.9**	**1.9%**
Investment income	**0.8**	0.3	131.5%
Extraordinary revenue	**11.6**	11.2	+ 22.1%
TOTAL	**295.5**	**289.4**	**2.1%**

Operating revenue rose by €5.2 million (1.9%) compared with the previous fiscal year, reaching €283.1 million, with:

- €194.0 million from the public service grant paid by the Ministry of Ecology, Sustainable Development, Transport and Housing. The total in government grants received under Budget Program 190 amounted to €210.8 million of which €16.8 million was recorded as a capital grant. The reduction in this grant is compensated for by the creation of the operators' contribution;
- €3.4 million from the agreement signed with the Ministry of Defense as part of Budget Program 212, which is stable compared with the previous year;
- €1.5 million in other grants, including from local government authorities, which is stable compared with 2010;
- €36.2 million of self-generated revenue from consultancy services, co-funding of research programs, or other services, representing a 7.6% reduction on the previous year.

Revenue (in €M)	2011	2010
Catalog services	**12.4**	11.7
R&D and co-funded research	**9.6**	11.7
Services and non co-funded research	**9.1**	10.0
Other services	**5.1**	5.8
TOTAL	**36.2**	**39.2**

Self-generated revenue scan be broken down into four main categories:

- catalog services, amounting to €12.4 million, of which €10 million was from the activity of IRSN's Dosimetry Laboratory, €0.9 million came from radiotoxicology analyses and €0.9 million was generated by training;
- co-funding of research, amounting to €9.6 million, the main partners in which are EDF (€4 million), Areva (€2.3 million) and the European Commission (€1 million);
- services and non co-funded research, amounting to €9.1 million, €2 million of which is from services performed for Riskaudit, €0.9 million for Areva, €1 million for CEA and €0.7 million for EDF;
- other services, amounting to €5.1 million, 96% (€4.9 million) of which is for invoicing for seconded personnel.

€48.0 million in other operating income, compared with €8.1 million in 2010. This amount mainly includes income from contributions paid by nuclear operators (€33.4 million), fees paid for industrial property (€1.1 million, up on 2010), and write-backs on depreciation and provisions (€13.1 million, up on 2010).

Investment income, which amounted to €0.8 million, was up compared with 2010 (by €0.5 million).

Extraordinary revenue was stable at €11.6 million, compared with €11.2 million in 2010. Capital grants of €10.2 million, recorded in the income statement, accounted for most of this amount.

Revenue grew by 2.1% (€6.1 million) overall.

EXPENDITURE

Execution (in €M)	2011	2010	Difference 2011/2010
Purchases	**112.9**	136.6	– 17.3%
Personnel	**125.9**	124.2	1.4%
Taxes	**7.1**	13.3	– 46.4%
Depreciation & provisions	**42.1**	29.4	43.3%
Other expenses	**4.4**	2.2	100.3%
Operating expenses subtotal	**292.5**	**305.6**	**– 4.3%**
Financial charges	**0.9**	1.2	– 25.0%
Extraordinary charges	**8.4**	0.5	1,606.0%
TOTAL	**301.7**	**307.3**	**– 1.8%**

Operating expenses for the year amounted to €292.5 million, a fall of €13.1 million or 4.3%. This variation was concentrated mainly in purchases and taxes, and breaks down as follows:

- Personnel expenses rose by 1.4% to €125.9 million. The average number of employees over the year 2011 was 1647 (full-time equivalent worked) for a budget of 1684. At the end of 2010, there were 1677 employees (full-time equivalent);
- Taxes amounted to €7.1 million, down by €6.2 million, due to mainly to the alignment of the method of calculating employment tax with the method of calculating VAT;
- Depreciation and provisions rose to €42.1 million (up by €12.7 million on 2010), mainly due to a provision of €11.1 million being set aside for forthcoming remediation costs as a result of the agreement signed in connection with the radiological incident at the Feursmétal site. A provision of €6.6 million was also set aside to cover the risk associated with the Individual Right to Training scheme;
- Purchases of goods and services fell by €23.7 million (or 17.3%) to €112.9 million, due mainly to a reduction of €15.3 million in core activity subcontracting (of which €14.6 million was in respect of CEA) and a reduction of €3.1 million in general subcontracting. The drop in activity connected with CEA is partly explained by the delay in doing some of the work on the CABRI experimental reactor (€8.2 million) but also to a drop in the projected budgets (down €3.5 million between 2010 and 2011).

The limitation of servicing/maintenance expenditure (down by €1.6 million), the use of temporary workers (down by €1.4 million) and travel costs (down by €0.9 million) also had an impact.

Other expenses represented €4.4 million, compared with €2.2 million in 2010. Fees (€2.7 million) accounted for much of this amount.

Financial charges fell by 25% to €0.9 million. They were mainly for interest paid on loans to finance the head office, the new dosimetry technology and the current property project.

Extraordinary charges rose by €7.9 million. They represent the payments made under the agreement settling the dispute with Feursmétal.

RESULTS AND FINANCING

Results and financing (in €M)	2011	2010	Difference 2011/2010
Profit (+) / loss (–)	**– 6.2**	– 17.9	11.7
Cash provided by operations (+) / (–)	**12.5**	– 5.6	18.1
Variation in working capital	**10.1**	3.5	6.6

The net balance for the year 2011 showed a deficit of €6.2 million, compared with a loss of €17.9 million in 2010 and a loss of €20.8 million in 2009. The difference between the revised forecast in the second budget amendment, predicting a deficit of €14.8 million, and the accounts at closing on December 31, 2011 is €8.6 million, which is explained by a combination of:

- An increase of €2.1 million in the estimated income;
- A decrease of €6.5 million in the estimated charges;

including a reduction of €23.4 million in disbursable costs (purchases, staff costs, etc.);
and an increase of €16.9 million in non-disbursable costs (depreciation and provisions).

Cash provided by operations, budgeted at -€5.3 million in the second budget amendment, reached +€12.5 million, a positive difference of €17.8 million.

This difference in relation to the second budget amendment is explained by the

reduction of €23.4 million in disbursable costs, partially compensated for by a reduction by €5.5 million in collectible income.

This cash provided by operations was completed by the portion of the public service grant paid by the Ministry of Ecology, Sustainable Development, Transport and Housing allocated to capital grants (€16.8 million) and a below-forecast reimbursement by the special dismantling fund of €2.9 million.

The resulting total resources paid for jobs and a €10.1 million contribution to the working capital against a planned withdrawal of €25.1 million in the second budget amendment. This variation was mostly due to a sum of €21.7 million carried over as part of the investment program and by the delay in work on the CABRI project, amounting to €8.2 million..

MANAGEMENT BALANCES

The following table shows the variation in working capital, cash, and working capital requirements:

In €M	Difference 2011/2010	2011 level	2010 level
Working capital	10.1	**35.4**	25.3
Working capital requirement	6.1	**– 53.6**	– 59.7
Cash	3.9	**88.9**	85.0

VARIATION IN WORKING CAPITAL

The projected variation in working capital in the second budget amendment of 2011 was due to a withdrawal of €25.1 million, broken down as follows:

- Write-back on Feursmétal dispute provision ..... 3.5 €M
- Write-back on fuel oil dispute provision ..... 0.8 €M
- Investments carried over from 2010 ..... 19.2 €M
- Write-back on profit-sharing provision 2010 ..... 1.1 €M
- Write-back on sources ..... 0.5 €M

The contribution to working capital at the end of 2011 amounted to €10.1 million, an increase of €35.2 million compared with the figure in the second budget amendment. The difference can be broken down as follows:

- investments not completed in 2011, proposed to be carried over to 2012 ..... +21.7 €M
- CABRI work not done in 2011, proposed to be carried over to 2012 ..... + 8.2 €M
- provision for profit-sharing plan 2011 ..... – 0.6 €M
- difference in funding via special fund ..... – 0.6 €M
- other operating savings ..... + 6.5 €M

Expenditure relating to investments and specific projects not completed in 2011 is the subject of a carryover proposal in the first budget amendment for the 2012 budget. The payment of dismantling expenses via the special fund is delayed because of the way the fund works (expenditure is reimbursed after the event on presentation of documentary evidence).

In view of the above, the level of working capital at December 31, 2011, estimated at €0.2 million according to the second budget amendment, is actually €35.4 million.

CASH VARIATION

The cash level stood at €88.9 million at the end of 2011, compared with the projected €58.5 million in the second budget amendment.
It was stable compared with the year-end level for 2010 (€85.0 million), due to the combined effects of the increase in working capital (by €10.1 million) and the increase in the working capital requirements (by €6.1 million).

Like the working capital, cash was affected by the delay in reimbursing the cost of remediation and dismantling operations via the special fund. Expenditure of €5.2 million for the PHEBUS dismantling costs was executed and will be reimbursed via the special fund on presentation of documentary evidence, when the 2012 budget is executed. Because of the way in which the special remediation and dismantling fund works, the cost of pre-financing dismantling operations is met from cash and working capital.

VARIATION IN WORKING CAPITAL REQUIREMENTS

Working capital requirements stood at -€53.6 million at the end of 2011, compared with a projection of -€58.3 million in the second budget amendment. The €6.1 million decrease in working capital requirements compared with 2010 is because fewer operations were being carried over at the end of 2011. This is reflected in a reduction of €13.2 million in trade notes and accounts payable of €61.9 million.

BALANCE SHEET ANALYSIS

LIABILITIES

■ With a recorded loss of €6.2 million, the net position dropped to €31.3 million, compared with €37.5 million in 2010. The capital grant saw a €6.6 million increase, rising from €75.5 million to €82.1 million. Furthermore, contingency and loss provisions rose by €6.6 million, reaching the figure of €77.6 million on December 31, 2011. This significant increase was the result of an allowance of €19.7 million being set aside in particular as provisions for the remediation of the polluted Feursmétal site and for employees' right to training on the one hand, and the use of €13.0 million on the other. The Institute's long-term capital rose, reaching €191.0 million compared with €184.1 million in 2010.

■ Debt fell to €123.7 million compared with €135.4 million in 2010. This was due to the combined effect of the fall in long- and medium-term debts (down by €4.0 million) and especially to the fall in short-term trade payables (down by €13.2 million).

ASSETS

■ Fixed assets fell to €175.9 million (down by -€7.0 million) due to depreciation expenses (up by €22.1 million) progressing faster in 2011 than fixed asset acquisitions (up by €15.1 million).

■ Current assets remained almost stable at €138.9 million compared with €136.6 million in 2010, with a reduction in accounts receivable (down by €1.9 million) benefiting cash, which rose to €88.9 million at December 31, 2011 compared with €84.9 million at December 31, 2010.

OVERALL CONCLUSION

The 2011 budget was executed within the forecast budget balance presented to the Board of Directors.

A €10.1 million contribution was paid into the working capital, which stood at €35.4 million at year-end 2011. The amount withdrawn from working capital for 2012 was €33.9 millions. This was to cover the profit-sharing plan, the carryover of investment projects in progress, the carryover of expenditure related to CABRI and an adjustment to the special dismantling fund.

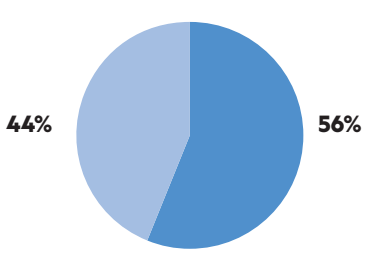
The available working capital balance is €1.5 million.

BALANCE SHEET

ASSETS

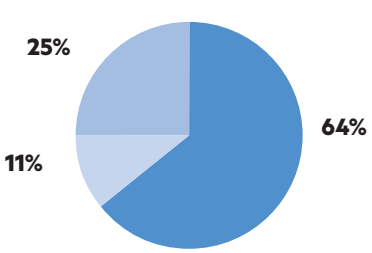
In €	Gross	Depreciation and provisions (to be deducted)	Fiscal year 2011 Net	Fiscal year 2010 Net	Fiscal year 2009 Net
Intangible assets	22,134,261	16,523,524	5,610,738	5,402,088	5,152,255
Tangible assets	315,577,347	151,706,343	163,871,004	168,230,969	166,660,722
Financial assets	6,394,644	–	6,394,644	9,273,133	12,264,531
Fixed assets	**344,106,251**	**168,229,867**	**175,876,385**	**182,906,190**	**184,077,508**
Inventory and work in progress	–	–	–	–	–
Prepayments and advances on orders	179,280	–	179,280	128,585	626,922
Accounts receivable	49,800,117	51,996	49,748,121	51,477,077	43,650,600
customer receivables	*34,938,185*	*51,996*	*34,886,189*	*34,803,062*	*28,411,055*
related receivables	*14,861,932*	–	*14,861,932*	*16,674,015*	*15,239,544*
Other receivables	–	–	–	–	3,690
Investment securities	77,416,860	–	77,416,860	76,706,174	77,925,874
Cash	11,506,485	–	11,506,485	8,244,314	7,403,786
Prepaid expenses	–	–	–	–	–
Current assets	**138,902,743**	**51,996**	**138,850,747**	**136,556,151**	**129,610,872**
GRAND TOTAL	**483,008,994**	**168,281,862**	**314,727,132**	**319,462,340**	**313,688,380**

Assets



Fixed assets **175.9 M€**
Current assets **138.9 M€**

Current assets

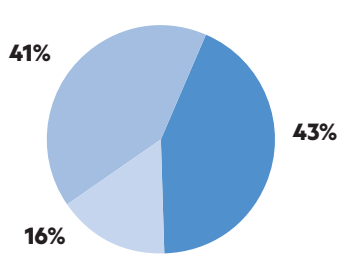


Cash **88.9 M€**
Customer receivables **34.9 M€**
Other receivables **15.1 M€**

LIABILITIES

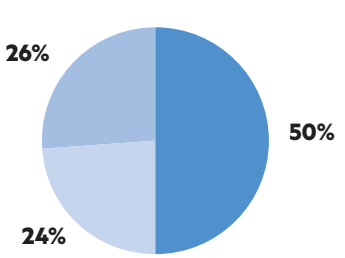
In €	Fiscal year 2011	Fiscal year 2010	Fiscal year 2009
Allowances	4,183,946	4,183,946	4,183,946
Reserves	90,783,098	90,783,098	90,783,098
Retained earnings	– 57,454,515	– 39,524,210	– 18,724,288
Fiscal year profit or loss	– 6,237,293	– 17,930,305	– 20,799,922
Net position	31,275,237	37,512,529	55,442,834
Capital grants	82,111,360	75,534,368	67,282,861
Equity	**113,386,596**	**113,046,898**	**122,725,695**
Contingency provision	–	6,052,934	2,666,100
Provision for taxes due	95,000	–	–
Loss provision	77,552,646	64,951,818	69,321,702
Contingency and loss provision	**77,647,646**	**71,004,752**	**71,987,802**
Bank borrowings	20,143,157	24,101,128	11,056,526
Various debts and liabilities	–	–	191
Prepayments and advances on orders	–	–	–
Trade notes and accounts payable	61,930,294	75,129,357	71,948,637
Tax and social liabilities	30,180,005	27,383,714	26,111,320
Other operating liabilities	105,393	–	–
Trade notes and accounts payable	5,556,600	4,650,730	6,045,394
Other liabilities	5,777,440	4,145,763	3,812,816
Prepaid expenses	–	–	–
Liabilities	**123,692,889**	**135,410,691**	**118,974,883**
GRAND TOTAL	**314,727,132**	**319,462,340**	**313,688,380**

Long-term capital



Capital grant **82.1 M€**
Provisions **77.6 M€**
Net position **31.3 M€**

Liabilities



Trade payables **61.9 M€**
Tax and social liabilities **30.2 M€**
Other liabilities **31.6 M€**

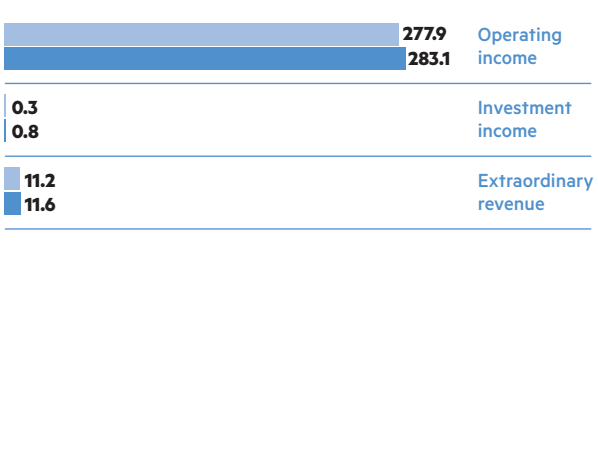
INCOME STATEMENT

In €	Fiscal year 2011	Fiscal year 2010	Fiscal year 2009
Research work	9,648,996	11,743,489	13,569,471
Service contracts	21,503,291	21,667,148	18,145,983
Other services provided	5,080,365	5,797,320	5,996,864
Net revenue	**36,232,652**	**39,207,957**	**37,712,318**
Operating grants	198,903,976	230,576,638	216,500,738
Operators' contribution	33,375,000	–	–
Write-backs on depreciation and provisions	13,065,756	7,326,896	6,835,490
Capital grants recorded in income statement	10,249,909	9,748,492	7,928,750
Expense transfer	204,125	98,756	147,682
Other income	1,336,405	665,373	596,142
Operating income	**257,135,170**	**248,416,156**	**232,008,803**
Outside expenses for the fiscal year	112,890,120	136,551,173	132,765,002
Taxes, duties, and similar payments	7,110,599	13,264,085	12,795,271
Personnel expenses	125,945,952	124,213,013	119,962,166
Depreciation and provisions	42,097,667	29,385,527	25,143,506
Other expenses	4,421,370	2,205,995	1,582,253
Operating expenses	**292,465,707**	**305,619,793**	**292,248,199**
OPERATING INCOME	**902,115**	**– 17,995,680**	**– 30,455,829**
From controlled entities	–	–	–
Other interest income	19,157	21,154	26,886
Foreign exchange gains	17,554	95,672	92,326
Gains on sales of short-term investments	717,159	208,779	1,243,942
Investment income	**753,870**	**325,605**	**1,363,154**
Interest expense	861,160	882,065	471,602
Foreign exchange losses	23,828	298,457	17,845
Losses on sales of short-term investments	–	–	–
Financial charges	**884,988**	**1,180,522**	**489,447**
FINANCIAL INCOME	**– 131,118**	**– 854,917**	**873,706**
INCOME BEFORE EXCEPTIONAL ITEMS	**770,997**	**– 18,850,597**	**– 29,582,122**
Gains on sales of assets	12,788	73,041	–
Capital grants strictly for the period	6,598	–	–
In operations	1,304,183	1,339,208	1,211,821
Extraordinary revenue	**1,384,569**	**1,412,249**	**1,211,821**
In operations	8,392,859	372,640	316,224
Book value of assets sold and other capital losses	–	119,316	42,147
Extraordinary charges	**8,392,859**	**491,956**	**358,370**
EXTRAORDINARY INCOME	**– 7,008,289**	**920,292**	**8,782,200**
Income tax	**–**	**–**	**–**
FISCAL YEAR INCOME	**– 6,237,293**	**– 17,930,305**	**– 20,799,922**

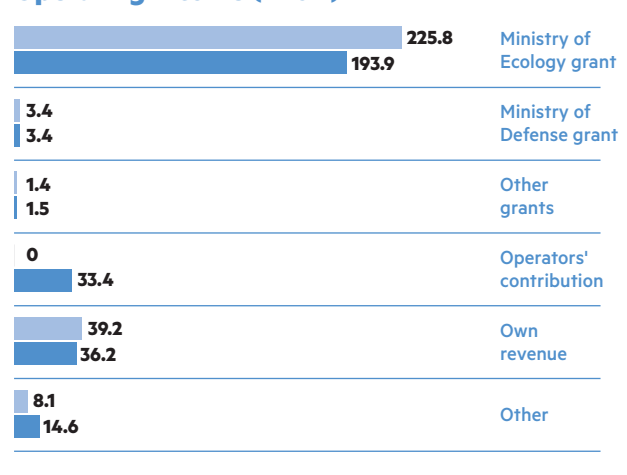
INCOME STATEMENT SUBTOTALS

In €	Fiscal year 2011	%	Fiscal year 2010	Fiscal year 2009
Sales	36,232,652	13.49	39,207,957	37,712,318
+ Operating grants	198,903,976	74.08	230,576,638	216,500,738
+ Operators' contribution	33,375,000	12.43	–	–
FISCAL YEAR PRODUCTION	**268,511,628**	**100.00**	**269,784,595**	**254,213,056**
– Outside expenses	112,890,120	42.04	136,551,173	132,765,002
ADDED VALUE	**155,621,508**	**57.96**	**133,233,422**	**121,448,054**
– Taxes	7,110,599	2.65	13,264,085	12,795,271
– Personnel expenses	125,945,952	46.91	124,213,013	119,962,166
OPERATING INCOME BEFORE INTEREST	**22,564,957**	**8.40**	**– 4,243,676**	**– 11,309,384**
+ Write-backs, expense transfer	13,269,881	4.94	7,425,652	6,983,173
+ Other income	1,336,405	0.50	665,373	596,142
– Depreciation and provisions	42,097,667	15.68	29,385,527	25,143,506
+ Write-back on capital grants	10,249,909	3.82	9,748,492	7,845,143
– Other expenses	4,421,370	1.65	2,205,995	1,582,253
OPERATING INCOME	**902,115**	**0.34**	**– 17,995,680**	**– 22,610,686**
+ Investment income	753,870	0.28	325,605	1,363,154
– Financial charges	884,988	0.33	1,180,522	489,447
INCOME FROM CONTINUING OPERATIONS BEFORE INCOME TAXES	**770,997**	**0.29**	**– 18,850,597**	**– 21,736,979**
+ Extraordinary revenue	1,384,569	0.52	1,412,249	1,295,428
– Extraordinary charges	8,392,859	3.13	491,956	358,370
EXTRAORDINARY INCOME	**– 6,237,293**	**– 2.32**	**– 17,930,305**	**– 20,799,922**
– Income tax	**–**	**–**	**–**	**–**
FISCAL YEAR RESULT	**– 6,237,293**	**– 2.32**	**– 17,930,305**	**– 20,799,922**

Income in detail (In €M)



Operating income (In €M)



BUDGET VERSUS ACTUAL REPORT

INCOME STATEMENT (In €)	2011 budget	2011 actual
REVENUE		
Service contract sales	44,436,390	36,232,652
Government grants	199,393,570	198,903,976
Other operating revenue	33,875,000	37,107,584
Internal operations	15,672,070	23,262,050
TOTAL REVENUE	293,377,030	295,506,262
EXPENDITURE		
Personnel expenses	141,795,600	125,945,952
Other operating expenses	141,231,560	133,699,935
Internal operations	25,150,000	42,097,667
TOTAL EXPENDITURE	**308,177,160**	**301,743,554**
RESULT (PROFIT)	–	–
RESULT (LOSS)	*14,800,130*	*6,237,293*
TOTAL INCOME STATEMENT BALANCE	**308,177,160**	**301,743,554**

TRANSFER OF RESULT TO CASH PROVIDED BY OPERATIONS (In €)	Budget 2011	Réel 2011
RESULT (LOSS)	**14,800,130**	**6,237,293**
+ Loss on sale of assets	–	–
+ Depreciation and provisions	25,150,000	42,097,667
– Gains on sale of assets	–	12,788
– Gains from offsetting depreciation	–	–
– Portion of grants recorded in result	3,500,000	10,249,909
– Write-backs on depreciation and provisions	12,172,070	13,065,756
CASH PROVIDED BY OPERATIONS	**– 5,322,200**	**12,531,923**

SUMMARY STATEMENT OF CHANGES IN FINANCIAL POSITION (In €)	Budget 2011	Réel 2011
CASH PROVIDED BY OPERATIONS	**– 5,322,200**	**12,531,923**
Government capital grants	16,826,900	16,826,900
Other sources (excl. internal operations)	200,000	3,013,806
Increase in long-term debt	3,513,000	105,393
TOTAL SOURCES OF CASH	**20,539,900**	**32,478,021**
Acquisition of tangible and intangible assets	36,020,270	18,213,037
Financial assets	100,000	122,529
Long-term debt paid	4,220,000	4,063,363
TOTAL USES OF CASH	**45,662,470**	**22,398,929**
CONTRIBUTION TO WORKING CAPITAL	**– 25,122,570**	**10,079,092**

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meanings