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IRSN
INSTITUT DE RADIOPROTECTION
ET DE SÛRETÉ NUCLÉAIRE

WAR IN UKRAINE:
IRSN MOBILIZED TO SERVE PUBLIC AUTHORITIES AND CITIZENS

MEMBER OF
ETSON

"Faced with an unexpected situation in emergency planification, IRSN has found innovative responses that have enabled it to be effective, consistent, and to enhance its resilience. The strength of the Institute lies in its ability to adapt to challenges and meet them by relying on a formidable emergency response asset: the multidisciplinary nature of its teams. We possess knowledge of the nuclear facilities, environmental monitoring issues, radioactivity dispersion behavior, health risks, the international situation, communication, and more. Through the synergy of all our skills, amplified by this crisis, we are able to remain in a state of readiness for the duration with regard to the Ukraine situation, covering a broad field, while preserving the Emergency Response Center's responsiveness in its daily missions."

Jean-Christophe Niel,
Director General of IRSN

On February 24th, 2022, Russian troops invaded Ukraine on four fronts and seized control of the Chornobyl site, where 20,000 spent fuel assemblies are stored. The very next day, IRSN mobilized its emergency response organization, activating its Emergency Response Center (ERC) in Fontenay-aux-Roses (Hauts-de-Seine) to carry out its technical and scientific missions to support national public authorities and international bodies. These missions involve daily monitoring of radiation levels on Ukrainian and European territories, assessing the safety of Ukrainian nuclear facilities; anticipating possible accident situations and their potential consequences for populations and the environment in Ukraine, Europe and France. IRSN was also mobilized to respond to media and civil society inquiries and produced information notes and educational materials on the situation of nuclear facilities in Ukraine in order to contribute to an understanding of the risks.

But the war continued to drag on. At various times, Ukrainian nuclear facilities were hit by artillery shellings, causing concerns as no other nuclear country had previously experienced an armed conflict of this scale[1]. Never before had nuclear power plants been used as military targets, knowing that they are not designed to withstand warfare. And the risk of a severe radiological accident had never before posed such a serious threat to Europe.

Faced with this unprecedented, evolving and often disquieting situation, IRSN emergency response teams, supported by various expert within the Institute, remain mobilized. For 10 months, they adapted their organization, mobilization and involvement as the events, solicitations and issues unfolded. Managing this crisis, different from that of Fukushima-Daiichi in Japan in 2011, led the Institute to adjust the working methods of its Emergency Response Center. Internally, it involved employees and fostered collaborative work and synergy among multidisciplinary teams. Externally, it highlighted the importance of IRSN's role as a technical expert able to provide support for the public authorities in the ecosystem of international crisis management.

As of December 31, 2022, none of the attacks directed at Ukrainian nuclear facilities or power infrastructure had caused damage to critical zones or generated any episodes of radioactive release. No abnormal increase in radioactivity had been detected by the monitoring networks, either in Ukraine or in neighboring countries. Nevertheless, major risks still persist. The Institute therefore remains mobilized on active standby. IRSN will continue to support the nuclear safety initiatives undertaken by European and international safety organizations, foremost among which is the IAEA and its Director General Rafael Grossi, to preserve safety.

UKRAINE, A COUNTRY WITH EXTENSIVE NUCLEAR FACILITIES

Ukraine is the world's seventh-largest producer of nuclear power and, in an area slightly larger than France, had a total of fifteen VVER pressurized water reactors of Russian design in operation over four production sites on February 24, 2022. In addition to these nuclear power plants, there are:

- Two research reactors;
- Six storage and disposal sites for radioactive sources and waste;
- Four RBMK reactors at the Chornobyl site, shut down since 2000: three being dismantled, one under the sarcophagus (the damaged reactor);
- Various facilities required to manage the Chornobyl accident site, including a storage pool for 20,000 spent fuel assemblies and a dry storage facility for 2,000 spent fuel assemblies.

ROBUST AND RESILIENT POWER PLANTS

Designed differently than Chornobyl, the reactors of the four Ukrainian nuclear power plants meet international nuclear safety standards. Each one was equipped from the outset with:

- A pre-stressed concrete containment (except for two Rivne[2] reactors) which also houses the spent fuel pool;
- Three independent standby emergency power generators with seven days' fuel autonomy. A single generator combined with a set of safety systems is enough to cool the core of a reactor and the spent fuel pool.

In addition, Ukraine reinforced the safety of its power plants following stress tests in Europe carried out after the Fukushima-Daiichi power plant accident. Each power plant has mobile back-up equipment, enabling it to deal with the total failure of internal and external power supply (mobile water injection heat pumps, mobile generators, with three days' fuel autonomy).

The country has also launched the rollout of a filtered containment venting system on its reactors, which limits, in the event of a severe accident, the release of volatile radioactive elements. Other provisions, such as hydrogen recombiners, have been installed to limit the risk of loss of containment.

[1] Slovenia's war of independence had led, as a precaution, to the temporary shutdown of the Krško power plant in 1991.
[2] The Rivne power plant comprises two 440 MWe reactors, older than the other VVER reactors located in Ukraine.

A LONG TRADITION OF COOPERATION BETWEEN IRSN AND UKRAINE

The safety of Ukrainian nuclear power plants, all operated by the National Nuclear Power Generation Company of Ukraine Energoatom, is controlled by the SNRIU (State Nuclear Regulatory Inspectorate of Ukraine).

Following the Chornobyl accident, IRSN forged cooperative relationships with SNRIU, within the framework of the European ICSN (Instrument for Nuclear Safety Cooperation) program, through assistance and skills transfer contracts in the field of nuclear safety and radiation protection. These cooperative relationships – particularly in the context of post-Fukushima stress tests and as part of the European FASNET project, led by IRSN, to prepare for and respond rapidly to nuclear emergencies at the international level – have enabled the Institute to acquire knowledge and data on east-European VVER reactors. Furthermore, the Institute bolstered its workforce with experts of Ukrainian nationality.

Since 2010, SSTC, the SNRIU technical safety organization (TSO), has been an associate member of ETSON, the European TSO network, which was created at the initiative of IRSN and Belgium and German TSO to contribute to consolidating European nuclear safety.

IN BRIEF

REACTOR SAFETY IN AN ACCIDENT SITUATION

Three conditions are essential to maintaining the safety of an operated or shut-down reactor:

- Water supply for the cooling circuits;
- Power supply to operate safety equipment and to run the water injection pumps in the reactor core or spent fuel pool and the cooling circuit pumps;
- Trained operating and maintenance personnel, who are operational and free to make their own decisions and act on them.

10 MONTHS OF ATTACKS ON UKRAINIAN NUCLEAR FACILITIES

PHASE 1 (FEBRUARY - MARCH)

DIVERSE ATTACKS

- **February 25, 2022:** Intrusion into the Chornobyl exclusion zone. Takeover of the site, occupied for 35 days. The media report on increased levels of radioactivity in the exclusion zone.
- **Night of February 26 to 27:** Attack on a waste disposal site in Kyiv, no radioactive release.
- **Night of March 3 to 4:** Attack and takeover of the Zaporizhzhya power plant, the largest in Europe.
- **March 6 and 11:** Shelling of the Kharkiv Institute of Physics Research Center.
- **March 9:** Loss of external power supply to all Chornobyl power plant facilities.
- **March 11–21:** Forest fires in parts of the Chornobyl exclusion zone generate an increase in measured radiation levels.

PHASE 2 (APRIL - JULY)

THE CONFLICT IN DEADLOCK

April 26: Arrival of IAEA mission at the Chornobyl site after the withdrawal of Russian troops.

PHASE 3 (AUGUST - MID-OCTOBER)

REPEATED OFFENSIVES NEAR AND AGAINST NUCLEAR POWER PLANTS

- **August to November:** More than twelve successive attacks (shelling) on the Zaporizhzhya site, generating major concerns about the possible consequences.
- **End of August:** Arrival of a permanent delegation of IAEA inspectors in Zaporizhzhya.
- **September 11:** Total shutdown of the last reactor still in operation at the Zaporizhzhya power plant.

PHASE 4 (MID-OCTOBER - DECEMBER)

A STRATEGY OF SHELLING ENERGY, ELECTRICITY AND WATER PRODUCTION AND DISTRIBUTION INFRASTRUCTURE

- **November 15:** Loss of one external power line at the Rivne plant. Shutdown of a reactor. Power reduction in the other three reactors. Shutdown of the two reactors at the Khmelnitskyi power plant.
- **November 23:** Loss of the national power grid. Automatic shutdown of all units at the nuclear power plants on the Rivne, Khmelnitskyi, South Ukraine and Zaporizhzhya sites.

IRSN'S INVOLVEMENT IN MANAGING THE UKRAINE CRISIS

PROVIDING SCIENTIFIC ADVICE AND OPERATIONAL ASSISTANCE TO PUBLIC AUTHORITIES

answering questions and direct requests from several ministries:
Health, Europe and Foreign Affairs, Armed Forces, Labor, Ecological Transition, etc.

MOBILIZING

02.25 TO 04.08: SETTING-UP THE EMERGENCY RESPONSE CENTER (ERC), DAILY MEETINGS

Director General, Crisis Director, Head of Emergency Assessment, "Facilities Evaluation" unit, "Radiological Consequences" unit, "Health" unit, "International" unit, "Communication" unit, "Logistical Support" unit + Ukraine pool and Operating Office of the Emergency Response Center

INVOLVING IN-HOUSE EXPERTISE ON A LARGE SCALE

Request for nine IRSN expert assessment services

ADAPTING TO A LONG-TERM CRISIS

08.22 TO 12.31: ACTIVE STANDBY

- Weekly meetings and monitoring bulletins
- Safety monitoring
- Environmental monitoring (daily monitoring)
- International monitoring
- Social network and media monitoring

CONTINUOUSLY INFORMING IN AN OPEN AND INSTRUCTIVE MANNER

PUBLICATION AND DISSEMINATION OF THE RESULTS OF EXPERT ASSESSMENTS IN THE FORM OF TECHNICAL BRIEFING NOTES, PRESS RELEASES, EDUCATIONAL MATERIALS TAILORED FOR THE GENERAL PUBLIC, INTERNAL BRIEFING NOTES:

- Three briefing notes on the "Situation of nuclear facilities in Ukraine"
- One educational notice: "Taking stable iodine tablets in emergency situations"
- Two briefing notes on the "Situation at the Chornobyl site"
- Four briefing notes on the "Situation at the Zaporizhzhya power plant"
- One briefing note entitled "Impact of the deterioration of the Ukrainian national power grid on nuclear power plants"
- Internal webinars
- Internal videos

Media: www.irsn.fr, social networks, REPERES external magazine, the IRSN newsletter, MyIRSN intranet, in-house magazine

RESPONSE TO A HIGH INFLUX OF REQUESTS:

- Media
- NGOs (Doctors Without Borders, etc.)
- Associations (CLI, ANCCLI, CRIIRAD, Greenpeace)
- Companies (France TV)
- HCTISN (High committee for transparency of information on nuclear safety)
- General public
- IRSN employees
- Parliamentarians, Elected Officials

ASSESSING THE POTENTIAL RADIOLOGICAL RISKS AND CONSEQUENCES

BUILDING A FORMAL AND INFORMAL NETWORK OF INTERNATIONAL CONTACTS to escalate and aggregate reliable assessment data (Ukrainian employees, IAEA/USIE, SNRIU, Energoatom, SSTC (Ukrainian TSO), embassies, IAEA/IEC, NNSA, NARAC)

PRODUCTION OF "ATYPICAL" ASSESSMENTS FOR A BETTER ANTICIPATION

- Safety assessment of Ukrainian power plants
- Catalog of standard accident sheets for each family of Ukrainian nuclear facilities
- Worse-case scenario of radiological releases and consequences
- Risk studies

ANTICIPATING A POST-ACCIDENT SITUATION

Assessment of the consequences of a serious accident in Ukraine (possible restrictions on food marketing and consumption)

ANTICIPATING

The European theater of the crisis in Ukraine and the kinetics of events have challenged IRSN with unprecedented situations. To increase its responsiveness and enable the Government to anticipate the protective measures to be taken in France in the event of a severe radiological accident in Ukraine, the Institute has taken the initiative to broaden the scope of the assessments it usually carries out in emergency situations. It has worked in real-time on scenarios to anticipate serious events across Ukraine, adapting its tools and methods, and mobilizing targeted competences.

A STANDARD EMERGENCY RESPONSE ORGANIZATION TO START WITH

As soon as the Emergency Response Center (ERC) was activated, at midday on February 25, the IRSN emergency response organization's technical units were set up and running at the crisis director's request. Media demand for information intensified. The supervisory authorities requested an analysis of the situation in Ukraine and advice on protective actions to be considered. The Institutes teams were immediately set to work in the various units, including "Facilities Evaluation", "Radiological Consequences", "Health", "Communication", "International" and "Logistical Support". Within the first few hours, they conducted an analysis of the events, making it possible to produce and disseminate a preliminary briefing note on the "Situation of nuclear facilities in Ukraine".

During the first six weeks of the conflict, marked by a constantly changing and particularly unsettling situation, the ERC remained mobilized, most frequently during working hours. Gradually, a "Ukraine pool" of around thirty team members was formed to manage the crisis on an ongoing basis. It receives assistance when needed from specialized support units. Every morning, and as required, the crisis manager organizes a situational briefing, and decides what assessment work needs to be launched, and which methods and resources mobilized. He serves as the contact person for the public authorities.

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TEAM MEMBERS FORM THE "UKRAINE POOL"

A WIDE RANGE OF FRONTS, UNPRECEDENTED ISSUES

From the end of February to mid-March, the "Ukraine pool" was called upon to focus its assessments on highly mobile fronts: the Chornobyl site located less than 150 km from Kyiv, the capital of Ukraine, to the north; Zaporizhzhya, Europe's largest power plant, to the south-east; a waste disposal site near Kyiv; an experimental reactor in Kharkiv, to the north-east; then Chornobyl once again... The crisis team must adapt to the diverse types of nuclear facilities across the vast territory of Ukraine and the many radiological issues associated with them.

Rapidly, specific problems emerged which the teams had not encountered while managing the previous international nuclear crisis, that of the Fukushima-Daiichi power plant in 2011: .

- **How can objective event information be collected** when the military conflict in Ukraine is accompanied by an "information warfare" that requires the deciphering of not only technical but also political and strategic situations?
- **How can reliable technical information be reported and centralized** to guarantee the quality of IRSN's assessments on the radiological consequences of attacks on Ukrainian power plants? IRSN is not in direct contact with Ukrainian operators, as they are with EDF in France; in Chornobyl and Zaporizhzhya, Ukrainian operatives work under the constraints of the Russian army.
- **How is it possible to characterize** spent fuel storage sites and research reactors on which IRSN has no data? It is difficult to accurately calculate potential radioactive releases when parameters are missing.
- IRSN has more knowledge at its disposal concerning the **four Ukrainian VVER power plants** because their technology is close to that of French power plants; the results of their European post-Fukushima stress tests provide useful information. Nevertheless, many questions remain: have maintenance operations been carried out? What is the status of the safety provisions? What is the condition of the emergency power generators, and what is their reliability over time? How badly have working conditions deteriorated for the Ukrainian personnel working under constraint?

This anticipatory questioning is bound to continue throughout the crisis. Over the course of events, new topics of investigation have emerged, such as the ability of the power stations and their backup systems to get through the winter, or the risks linked to the destruction of the Dnieper dams upstream and downstream of the facilities.

LOSS OF ELECTRICAL SOURCES: A SENSITIVE SUBJECT QUICKLY SPOTLIGHTED

"As early as February 25, we diagnosed a critical threat in our safety analysis: the shelling of the Ukrainian electric grid could lead to the loss of power to nuclear facility safety systems. Very quickly, IRSN decided to develop expertise on this complex topic. For months, we collected and consolidated information on the Ukrainian power generation and distribution grid and retrieved or established power plant connection diagrams. To do this, we mobilized power distribution specialists and had discussions with SNRIU and the IAEA, who had dispatched a mission on site. This work helped us better assess the situation and risks for each episode of power line loss. We even anticipated a widespread grid incident that would lead to the automatic shutdown of all plants. This is an issue that has remained a constant concern throughout the crisis. However, it should be emphasized that, over the course of the year, the Ukrainian energy companies have always been able to repair damage to the power grid to maintain the safety of the facilities."

Emmanuel Raimond,
Leader of the "Facilities Evaluation" unit, Head of the Reactor Emergency Operating Department and Probabilistic Safety Studies

360° SUPPORT FOR THE PUBLIC AUTHORITIES

"This unprecedented context of an international crisis has confirmed IRSN's pivotal role in supporting national public authorities and international bodies. This war, which erupted at the very threshold of Europe and posed serious radiological threats on the continent, has led those responsible for handling crises at the highest levels of Government to look beyond the national frame of reference. The French Ministries of Ecological Transition, Health, Foreign Affairs, the Armed Forces, and Labor, and the State operators approached us directly, as a public expert on nuclear and radiological risks, for expert assessments and operational support with increasingly extended scope.

Internationally, we have had technical discussions with the IAEA, which has played a central role in disseminating the information it has centralized to the UN Member States as well as in managing this crisis, highlighting repeatedly the challenges this represents for nuclear safety. We have also had direct contact with SNRIU and shared assessment intelligence with our counterparts in the USA, Canada, Norway, Finland, and Germany.

Lastly, the Ukraine crisis has given rise to a network of crisis actors within ministries and international bodies. It has federated a new national community which has further extended internationally. As is often the case, an emergency situation has been an accelerator of organizational development."

Louis-Michel Guillaume,
Deputy Director General of the Defense, Security and Non-Proliferation Division

PRODUCING ATYPICAL ANTICIPATION ASSESSMENTS IN EMERGENCY SITUATIONS

As attacks on Ukrainian nuclear facilities continued, so did the questions raise in the media and referrals issued by the State. In response, IRSN experts have produced numerous calculations of possible consequences for populations and the environment. These assessments have been part of a process of preparing for and anticipating a radiological event. They have resulted in the drafting of technical briefing notes distributed to the public authorities and the media, before being laid out for public.

In the space of a few days, with the support of other IRSN departments, the "Ukraine pool" produced the following:

- A catalog of Standard Accident Sheets for each family of Ukrainian nuclear facilities: the 1,000 MWe and 440 MWe VVER operated reactors, research reactors, waste disposal sites, and spent fuel pools. The "Facilities Evaluation" unit identified the scenarios that could occur at the different facilities and the atmospheric releases into the environment associated with these scenarios. Then, the "Radiological Consequences" unit assessed the consequences for populations and the environment under different meteorological conditions. These sheets provide an order of magnitude for each typology of accidental release.
- Assessments for obtaining an order of magnitude of iodine releases for different accident scenarios at the Ukrainian power plants and for determining whether dose levels justifying the administration of stable iodine could be exceeded on French territory. This work has provided operational responses for the public authorities.
- In November, IRSN extended its studies on the start of the post-accident component in order to assess any actions to limit the consumption and marketing of certain foodstuffs that may prove necessary to comply with regulations in force and taking into account the impact of contamination on territories across Europe.

EVERYONE MOBILIZED, EVERYONE INVOLVED IN A CROSS-FUNCTIONAL CHALLENGE

"To produce our studies on Ukraine, we called on experts from two specialized services from IRSN's nuclear safety division: from Fontenay-aux-Roses and Cadarache where they were based, experts from the Neutron Physics Department for Criticality Risks (SNC) and from the Major Accidents Department (SAM) took up the subject. Using more sophisticated calculation resources than those of the ERC – which relies on simplified tools to enhance its reactivity – they have developed data sets representative of Ukrainian power plants, enabling us to perform radioactive release calculations using complex models that will be extremely useful in the event of actual releases in Ukraine. Throughout the crisis, the ERC has relied on internal expertise from many departments: for assessment of safety against malicious acts, nuclear safety studies, the safety of transport and fuel cycle facilities, the power grid, the safety of nuclear research facilities, atmospheric dispersion and the radiological consequences, severe accidents, healthcare and the environment, VVER experts, the IT department, purchasing, etc. This peripheral network has brought a great deal of added value, shedding light on certain subjects, and allowing progress to be made on others. The ERC has helped the Institute to innovate and develop new skills. It has stimulated collaborative work and team spirit. Mobilizing skills outside the "hard core" of the ERC crisis organization is an example of our target mode of organization. This unprecedented experience strengthens our conviction that crisis management is a cross-functional subject. Not only does it mobilize many multidisciplinary skills, it also involves a broad spectrum of the Institute's employees, who take an interest in what their company produces in this crisis so that they too can provide objective insight into stressful events."

Philippe Dubiau,
Executive Director for Emergency Preparedness and Response

MONITORING

Monitoring is at the heart of IRSN's emergency response expertise. It is based on a 24/7 operational warning system that guarantees the rapid acquisition of data in order to assess the risks as quickly as possible and protect the health of populations. To remain effective and reactive to numerous and diverse events occurring outside French borders, in a context where it has been difficult to recover reliable information, IRSN has extended its reach beyond its standard frame of reference. The Institute has adapted its monitoring organization and broadened the usual scope of its monitoring systems by deploying them in four areas: media, international, safety, and Europe-wide environmental monitoring.

ORGANIZED MONITORING SYSTEMS

Faced, on the one hand, with a lack of readily available technical data on the design of nuclear facilities in Ukraine and, on the other, with the difficulty of accessing reliable event-based information on the shelling that have occurred, the need to implement four monitoring systems became quickly apparent. During the six weeks of ERC activation, these organized watches produce daily – sometimes twice or three-times daily – situation reports, making it possible to review and decide on actions at the morning crisis meeting. They also feed into the regular flow of information that IRSN passes on to the public authorities.

This monitoring, which was scaled down on April 8, resumed at a more sustained pace on 22 August, when repeated strikes against the Zaporizhzhya power plant led IRSN to reactivate its crisis organization in the form of "active standby", punctuated by meetings and situation reports, which were no longer daily but weekly.

MEDIA WATCH

In order to be able to detect weak signals and to inform the ERC's technical teams in real time of events taking place in Ukraine, the "Communication" unit activated a media watch in France and abroad starting from February 25. Building on the Communication Department's tools, this watch is based on:

- Monitoring of all social networks, via hashtag-keywords (themes, nuclear sites that could be attacked, etc.) programmed on search engines. This monitoring includes Telegram – an alternative to WhatsApp –, which is hugely popular in Ukraine and has been used by the Ukrainian authorities to disseminate information since they were deprived of other means of communication.
- A watch of all conventional media (agencies, radios, TV, print media) to produce a daily IRSN "Ukraine special" press overview summarizing around 100 press clippings.

CROSS-REFERENCING AND VERIFICATION: A CONSTANT CONCERN

"The information war waged between Ukraine and Russia since day one is an extremely complex component of this war. It puts our ability to analyze, cross-check and verify information to the test. Beside the facts, and sometimes even before the facts, there are comments, influencing and fake news across the social networks. It is very difficult to distinguish information from disinformation. The communicators spend a lot of time sorting through and analyzing the content and information in order to qualify them before passing them on to the technical experts of the ERC to contribute to the analyses."

Marie Riet-Hucheloup,
Communication Director

INTERNATIONAL WATCH

At the same time, international monitoring has been set up. The "International" unit teams collect the information published by IRSN's historical international partners, from their respective websites: the crisis centers for technical support (TSO) and safety authorities in European countries as well as international organizations such as NNSA (National Nuclear Security Administration) and NARAC (National Atmospheric Release Advisory Center). They also cull the key elements of diplomatic news in relation to Ukraine and Russia. The teams publish a monitoring bulletin covering recurring themes that provide insight into the position of the various States and international agencies: how these are reacting, what preparations they are making, how they organize themselves, why they have decided to break off relations with Russia, etc.

SAFETY WATCH

As for the "Facilities Evaluation" unit experts, they have been collecting information on safety, first at the Chornobyl site, then at the Zaporizhzhya power plant, then at all the other facilities located across Ukraine. The challenge is to rapidly calculate the orders of magnitude of potential radioactive releases and the radiological consequences of possible accident situations. Knowledge about each reactor must be consolidated in order to anticipate accidental scenarios and provide an opinion on the seriousness of a situation very promptly, when one occurs.

With the support of Ukrainian colleagues who speak the language and are familiar with facility designs, the teams enter into direct contact with SNRIU and other local actors. The teams seek first-hand information to ensure that they correctly interpret the information provided by Energoatom about the situation. They also discuss situations and release calculations with their contacts from foreign safety organizations: GRS and BfS in Germany, STUK in Finland, SSM in Sweden, DOE in the USA. They have technical discussions with the IAEA Incident and Emergency Center (IEC).

THE ENVIRONMENTAL MONITORING SYSTEM IN UKRAINE AND NEIGHBORING COUNTRIES: A KEY TO IRSN'S VALUE CREATION DURING THE CRISIS

The monitoring system implemented by IRSN crossmatches and aggregates data from 1,100 sensors belonging to different monitoring networks:

In Ukraine:

- Data from the Teleray radiation station of the French Embassy in Kyiv and the IRSN station installed in Lviv when the Embassy was relocated;
- Data from the Ukrainian national network via the European EURDEP platform;
- Data from Ukrainian nuclear operators and the Ecocentre (Ukrainian Public Agency for the Management of the Chornobyl Exclusion Zone) via the IAEA web-based tool, IRMIS;
- Data from accessible web-based aggregation sites such as SaveEcoBot (aggregation of data from the Ecocentre, Ukrainian nuclear operators, and the Ukrainian HydroMet network).

In neighboring European countries:

- Data from national monitoring networks via the European EURDEP platform.

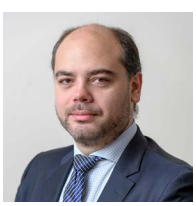
This system automatically provides real-time, clear visualization of the dose rate evolution over a wide area.

In France, permanent nationwide radiological monitoring is carried out by:

- The Teleray network operated by IRSN (440 radiation monitoring stations in metropolitan France and overseas territories that transmit an ambient dose rate measurement every 10 minutes);
- The IRSN OPERA-Air network (50 air sampling stations in metropolitan France);
- Operator monitoring networks (EDF, CEA, ORANO La Hague): 550 radiation monitoring stations.

ENVIRONMENTAL MONITORING EXPANDED TO EUROPE

"The taking of the Chornobyl site and the rise, measured on certain radiation monitors and reported by press agencies, in the level of radioactivity at the time of the Russian offensive, raised the question of environmental monitoring in Ukraine from day 1 of the war. How can you get to grips with the radiological situation in a distant country in order to put in place an expert assessment? On February 24, IRSN could rely only on one single, and vulnerable, tool which was exposed to the shelling: the equivalent dose rate radiation stations deployed by the monitoring networks of various countries, such as the French Teleray network radiation monitor installed on the French Embassy in Kyiv.
The solution was to organize remote monitoring. Very quickly, we put in place a system allowing us to analyze the radiological situation in Ukraine on a daily basis and inform the public authorities. This system collects radiation stations data from the various Ukrainian monitoring networks, in particular the data automatically transmitted to the European EURDEP network, and that of the IRMIS platform of the IAEA. Our monitoring has been expanded to include all neighboring countries of Ukraine, with a dual objective of backup and warning: detecting a radiological event that Ukrainian radiation monitors, inoperative due to shelling or power outages, for example, would be unable to detect; and being able, if necessary, to inform the French Ministry of Foreign Affairs about protection measures for French nationals present in Eastern Europe. This monitoring provides a snapshot of the radiological situation in Ukraine.
We also talk about the data with our counterparts, who pass on the intelligence to their own national authorities.
Second, with the help of IRSN's environmental data specialists, we have optimized the efficiency of this monitoring, which aggregates a huge amount of information, with some radiation stations transmitting a measurement every 10 minutes. This included setting up a dedicated database and easy-to-use interoperable interfaces for crisis teams and radiological remote monitoring teams who are on call around the clock. This automated system enables us to perform a rapid and precise analysis and interpretation of any abnormal increase in radioactivity levels, which are not necessarily linked to an incident at a nuclear facility. Such a spike may be due to natural events (storms, rain, drought), or a failure of the radiation stations."



Maxime Morin,
Leader of radiological monitoring in Ukraine, in neighboring countries and in France, and Head of the Environmental Metrology Analysis Department

IN TIMES OF WAR, TRUTH IS GAUGED BY ENVIRONMENTAL MONITORING STATIONS RESULTS

"In a country at war, where the battle of communication requires a highly critical approach to understanding the information disseminated by the belligerents about the nature of the damage, the only way to know whether a nuclear facility has released radioactivity into the environment is to take measurements around the facility under attack. The monitoring of radioactivity in Ukraine has made it possible to objectively gauge the safety assessments of the "Facilities Evaluation" unit, which had very little information to work with at the start of the conflict. This monitoring indicated whether the firing and shelling might have hit a safety-critical area. Thanks to the professionalism and training of the environmental monitoring teams, IRSN is able to accurately interpret any variation in radioactivity levels and indicate whether this can be explained by weather conditions, the failure of a radiation monitoring station, or some other cause."

Éric Cogez,
Head of Crisis Expertise,
Head of the Radiological Intervention and Environmental Monitoring Department

MONITORING WITH AN OPERATIONAL EMPHASIS

These four "watch units" set up by IRSN are not only used to provide a daily or weekly snapshot of developments in the situation. They also constitute four action levers:

- They help the Crisis Director decide on work to be launched or initiatives to be taken to solve problems or anticipate solutions to emerging issues.
- They provide the "Facilities Evaluation" and "Radiological Consequences" units with a sum of verified knowledge and data, to consolidate and reinforce the reliability of the assessments they carry out.

A SUCCESSION OF SAFETY AND RADIATION PROTECTION ASSESSMENTS IN DIFFERENT LOCATIONS

After each event on a nuclear site, IRSN's diagnostics shed light on the situation. These diagnostics provide objective scientific insight into the nature of the actual damage and associated risks in a context where information is difficult to obtain and validate. The expert assessments provide input for technical briefing notes written up for the public authorities and, when appropriate, for elected representatives and associations, and published on the IRSN website.

Events	IRSN expert assessments
Increase in the radioactivity level measured by certain radiation stations in the Chornobyl exclusion zone	After exchanges with its European partners and the IAEA, the "Radiological Consequences" unit tends to favor the explanation of a technical malfunction of the radiation stations, without excluding the hypothesis of Russian tanks disturbing radioactive dust by driving through the area.
Power supply cut off for all Chornobyl power plant facilities. Evoking the risk of a "new Chornobyl"	The "Facilities Evaluation" unit dismissed a dewatering risk of the assemblies in the spent fuel pool, based on post-Fukushima studies and its own calculations. It assesses the site's other issues: risks associated with direct shelling of the sarcophagus and of the spent fuel pools.
The first shelling of the Zaporizhzhya power station indicating damage to the containment	The "Radiological Consequences" unit confirmed the absence of releases. The "Facilities Evaluation" unit, based on a study of the power plant design and its power supply resources, assessed the robustness of the power plant and confirmed approximately 10 days of autonomy in the event of total loss of external power supply, provided that the site teams remain operational.
Forest fires in the Chornobyl exclusion zone leading to an increase in measured radioactivity	The "Radiological Consequences" unit combined the data from its monitoring in Ukraine with the measurements of aerosol filters from other European countries and its OPERA-Air network, which detects minute traces of radioactivity in the air. No abnormal increase in radioactivity was observed.
Month-long shelling at the Zaporizhzhya power plant, which give cause for concern	The "Facilities Evaluation" unit approached the Energoatom operator to assess the extensive damage. The "Radiological Consequences" unit measured no increase in radioactivity. IRSN alerted the authorities to the degraded situation of the power plant and detailed the site's vulnerabilities: areas identified as safety-critical with regard to radiological risks and the main safety issues.
Loss of power supply to the South-Ukraine power plant, then systematic shelling of the Ukrainian power grid leading to the automatic shutdown of all reactors at the four power plants	The "Facilities Evaluation" unit assessed the means and time required to gradually rebuild the power grid in order to restart the reactors. IRSN stressed the need to reconstruct the national power grid to guarantee a sustainable power supply for nuclear site safety systems.
Arrival of winter	The "Facilities Evaluation" unit carried out a preventive assessment of the capacity of Ukrainian power plants (in particular Zaporizhzhya) to manage the winter season. The unit validated with the operator the implementation of thermal protection for the emergency power generators.

10
TECHNICAL BRIEFING NOTES FOR THE PUBLIC AUTHORITIES

- Three briefing notes on "The situation of nuclear facilities in Ukraine"
- Two briefing notes on "The situation at the Chornobyl site"
- Four briefing notes on "The situation at the Zaporizhzhya power plant"
- One briefing note on "The impact of deterioration of the Ukrainian national power grid on the nuclear power plants"

+ 1
EDUCATIONAL NOTICE ON "THE TAKING OF STABLE IODINE TABLETS IN AN EMERGENCY SITUATION"

ADAPTING

IRSN demonstrated agility throughout the 10 months of war in 2022. It has undergone a transformation, by reaching beyond its traditional emergency response "procedures", poorly suited to the situation in Ukraine. Innovation has enabled it to adapt its organization, mobilization, involvement, methods, and tools to address the specific features of the Ukraine crisis: highly fluctuating events and demands, intense periods, no accidents but a permanent risk, continuous tension, and a long crisis with no end in sight.

FLEXIBLE EMERGENCY RESPONSE CENTER ORGANIZATION

During the ERC's set-up period, the crisis organization went beyond its traditional frame of reference, while remaining true to its main principles. To adapt to highly fluctuating events and demands, the crisis units and mobilized workforce vary from day to day, and often over the course of the same day, depending on what has to be dealt with. They work in hybrid mode: some on site, others remotely.

The work is carried out mainly during working hours by the "Ukraine pool" team representing the key functions. These experts, mobilized from the start of the crisis, have access to the history of all the actions carried out by the ERC. At night and on weekends, the on-call team members ensure monitoring activities, ready to alert the Emergency Response Director, carry out initial assessments, and, in the case of a major event, call on the "Ukraine pool" team members to assist.

REGULAR OPERATIONAL TRAINING FOR ON-CALL TEAM MEMBERS

In order to build on-call team members' awareness of the real risks to Ukrainian nuclear facilities, training sessions are regularly organized. These operational exercises are based on the theoretical anticipation carried out by their colleagues in the "Ukraine pool": the Standard Accident Sheets for each family of Ukrainian nuclear facilities and the pre-calculated worse-case scenario. Based on the values of an accident scenario and the day's meteorological data from *Météo France*, the on-call team members practice making calculations across the entire operational chain: assessment of the accident situation, calculation of the release, estimation of the spread of the plume over Europe, identification of zones that would require protection measures for the populations, drafting of the ERC external message of information for the public authorities. These training sessions, implemented before summer 2022, were reactivated in mid-November on a weekly basis. They promote knowledge sharing and relaying of information between the "Ukraine pool" team members, who are at the front line of crisis management, and the on-call team members pool, further away from the heat of the action. These sessions reinforce the engagement of the Institute's employees and help to ensure the reactivity of all crisis pool teams in case of a serious event in Ukraine.

THE ACTIVATION OF AN INNOVATIVE "ACTIVE STANDBY" ORGANIZATION

On April 8, 2022, IRSN scaled back its watch system, while remaining available for its contacts. There were several reasons for this choice: the conflict was becoming entrenched and the tension around the Ukrainian nuclear sites, including Zaporizhzhya, was decreasing. The teams that had been highly involved over these weeks were also mobilized on national or international topics. IRSN's approach had to be a long-term one.

In August, the Zaporizhzhya power plant was subject to particularly worrying repeated shelling. On August 22, IRSN decided to remobilize the team members of the "Ukraine pool". It chose an innovative "active standby" format that was not envisaged in its organization. The objective was to mobilize the teams by setting up regular consultation meetings based on the situation briefings established by the four reactivated monitoring mechanisms (media, safety, environmental monitoring, international). Since then, every Monday, the Crisis Director has invited the facilitators of the "Ukraine pool" units as well as the main on-call team members who may be called upon "on the spot", to give an overview of the week's current events, to give briefings on the work in progress, to define the directions to take, the work to be initiated, and the documents to be produced in order to inform the public authorities and to keep the media and civil society in the loop. This simplified system has enabled IRSN to demonstrate a high level of reactivity when faced with six real events successively in less than 30 days in France, from September to mid-October, and to implement its program of crisis exercises and visits (see chapter: Crisis and Post-Accident of the 2022 Annuel Report).

THE UNPRECEDENTED SET-UP OF AN "INTERNATIONAL" UNIT

An "International" unit created after the Fukushima-Daiichi power plant accident, rarely called upon in the context of national exercises, set themselves up at the ERC on February 25 to help collect and cross-check information for an objective insight into events. This unit is responsible for international ties with two types of contacts: the network of IRSN's historical technical partners and the network of institutional contacts.

It first organized and produced a daily international monitoring report, then a weekly one. After each attack on a nuclear facility, it closely monitored the situational self-appraisal information posted by SNRIU on two platforms administered by the IAEA: USIE, the unified system for the exchange of information in the event of an incident or emergency, and IRMIS, the international radiological control information system. It reported on the press conferences of IAEA Director General Rafael Grossi.

THE UKRAINE CRISIS HAS STRENGTHENED THE NEED FOR EXCHANGES WITH OUR TECHNICAL COUNTERPARTS AND OUR INSTITUTIONAL CONTACTS ABROAD

"For many years, and especially since the Fukushima-Daiichi accident, IRSN has been working with its counterparts in Europe and around the world to build common emergency response expertise, involving common risk assessment, technical assessment methods, and shared tools for assessments and release prognostics, etc. With a strong international presence in crisis management, the Institute has established partnerships with major emergency centers of technical bodies and safety authorities. It is therefore quite natural that, from the start of the events in Ukraine, we have established regular exchanges with our historical partners: GRS and BfS in Germany, US-DOE NNSA, as well as the US-NRC in the USA, STUK in Finland, SSM in Sweden and BelV in Belgium. The challenge was to understand everyone's levels of mobilization and preparedness, and to all be able to build a common assessment framework in order to support decisions of the public authorities in Europe should an event occur. These contacts led us to share technical products that we had not previously exchanged, and to check that everyone could use the technical data into their workflow.

We established the same type of exchanges with the IEC, the IAEA emergency center, although our relations had not yet been formalized. The IAEA had specific technical questions about the risks associated with the Ukraine situation. The Institute provided it with safety analysis data.

Also in the context of the Ukraine crisis, we have had discussions with WENRA, the association of safety authorities in Western European countries, chaired in 2022 by the ASN. We participated in meetings with the European Commission, giving rise to an inter-comparison report of expert capacities on a European scale to achieve enhanced integration."

Olivier Isnard,
Deputy Executive Director, interfacing with the international information networks

INFORMING

As part of a process of transparency and openness to society, IRSN has been heavily involved in responding to media requests and the specific queries of other stakeholders in civil society. The Institute has published educational, technical, and scientific briefing notes and news briefs. New in-house communication initiatives enable employees to stay informed of the situation and of the actions taken by the Institute.

A COMMUNICATION TEAM IN A STATE OF ALERT

From the start of the conflict, IRSN's communication department was on alert. The teams set up a media watch on the threats of a war. Media pressure was stepped up on February 24. To respond to these initial requests, IRSN decided to activate the crisis organization in standby mode before officially setting up the ERC on February 25. Immediately, the "Communication" unit put in place the "Ukraine special" media watch mechanism, integrating all social networks and conventional media in France and abroad. To keep the ERC teams updated on events, it produced one or more daily summaries, depending on the current situation. Highlighting areas of concern among elected representatives, associations, the workforce and citizens, this media watch guided IRSN's decision-making on technical assessments to be launched or thematic language elements to be developed.

OPEN AND EDUCATIONAL INFORMATION IN RESPONSE TO MEDIA PRESSURE

Over the next few days, journalists' questions came in thick and fast. Two spokespersons were chosen: one to answer questions relating to safety, and the other to address radiation protection/health issues. Their number was deliberately kept to a minimum due to the volatility of the events, which required in-depth knowledge of a subject in constant evolution.

The Communication team managed the technical information produced by the ERC to answer as clearly and simply as possible the questions that kept recurring: What nuclear facilities exist in Ukraine? What is the condition of these power plants (technology, robustness, safety status, etc.)? What is the radiological situation? Is there a risk? If so, what kind of risk?

Once the ERC produced a briefing note, the Communication Department disseminated it and promoted it internally and, where appropriate, in the media and on the Institute's website (irsn.fr).

The press office investigated all media requests and, in conjunction with IRSN experts, followed up on them.

Once established, this process continued: producing, transmitting, publishing, informing, and answering media questions.

Media pressure peaked on several occasions. The experts were particularly solicited for the events of February 24, March 4 and March 9, in an unprecedented context of information warfare, then again in August and early September when the IAEA mission to Zaporizhzhya submitted its inspection report.

PROCESSING MANY OTHER REQUESTS

The communication department also received requests from other actors, sent directly or via other IRSN departments. These requests came from the HCTISN (High Committee for Transparency and Information on Nuclear Safety), from associations (CLIs, ANCCLI, CRIIRAD, Greenpeace, etc.), from NGOs, and even from companies that want to know what radiation protection measures and equipment are needed for their employees. Here are a few examples:

- *Médecins Sans Frontières*/Doctors Without Borders (MSF) requested training support for its teams departing for Ukraine.
- *France Télévision* asked for recommendations on the equipment of its journalists and filming teams who were shooting the evening news in the city of Lviv, in Ukraine.
- CRIIRAD asked questions about IRSN's assessments.

Each time, the ERC studied the request, defined the Institute's position, and determined which expert contact to assign for the response.

300
PRESS REQUESTS THAT LED TO INTERVIEWS IN THE WRITTEN PRESS, ON THE WEB, RADIO AND TELEVISION

REINFORCED INTERNAL COMMUNICATION TO LEVERAGE COLLECTIVE STRENGTH

As soon as the ERC was activated, an internal message informed all employees of the situation. It announced the setting up of the crisis organization, explained that the Institute had been called upon and mobilized for the war in Ukraine, and that it had moved into operation to produce expert assessments and provide support to the public authorities within the framework of its missions.

The internal communication teams reported statements, as well as the media coverage. This regular flow of information allowed employees to be given insight into the events.

Nevertheless, the war continued to rage. IRSN needed to strengthen its internal communication. If a serious event occurred in Ukraine, all employees would serve as spokespeople for the Institute with regard to their family, circle of acquaintances, and the outside world.

In addition, the management of this long-term crisis required more and more employees – not always members of the crisis pool – to carry out expert assessments. IRSN wanted to promote this new cross-functional and collaborative dynamic. To do so, the Institute launched two new initiatives in September:

- **Two internal webinars.** These Teams conferences were attended by almost 500 employees. The presenters explained the nature, depth, and scope of IRSN's work as part of its missions, with a focus on safety assessments of Ukrainian facilities, the problem of losing power supply, the environmental monitoring system in place, exchanges and modes of cooperation with SNRIU, and investment in communication.
- **Four internal videos: "Everyone mobilized"!** These short films showcased the first-hand accounts of experts invested in crisis management, even though they are not part of the on-call team of IRSN's crisis organization. By showing multifaceted mobilization, the films promoted the Institute's collective strength and the power of collaborative work.

AND AFTERWARDS...

The Ukrainian crisis, on the European continent, pursuing a dynamic that no scenario had envisaged, is very different from that of the Fukushima-Daiichi power plant which, in 2011, had driven IRSN to set up the ERC around the clock for a period of several weeks. The Japanese crisis, unlike other major international crises in the history of civil nuclear power and safety, was linked to a severe accident that simultaneously affected several reactors on the same site. In Ukraine, no reactor suffered critical damage in 2022. Nevertheless, a latent radiological risk, linked to acts of war targeted against facilities scattered over a large territory or against the energy infrastructure, has left a lasting threat over Ukraine and neighboring countries. This led IRSN to remain mobilized or on active standby for 10 months in 2022: an unprecedented situation. Given that the war is ongoing, the Institute will continue to monitor the nuclear facilities and the environment in Ukraine, Europe, and France for as long as necessary in 2023.

At the same time, feedback from this atypical crisis is already forthcoming. Indeed, the analysis of events affecting nuclear facilities always teaches us important lessons for improving safety and crisis management. Repeated attacks on the Ukrainian nuclear sites, along with the recent Covid-19 health crisis, once again prove that the reality of a crisis challenges the imagination, and that crisis management plans, while very useful for organizing quickly in the event of an alert, can never predict everything. Nevertheless, even though the safety improvements for nuclear facilities implemented in Europe – and more specifically in Ukraine – following feedback from the Fukushima-Daiichi disaster were not designed to protect these facilities in wartime, they have contributed directly to the robustness of the power plants during this year of armed conflict. They have reduced the risk of a severe accident caused by the loss of external power supply.

The exceptional situation of the crisis in Ukraine has also led IRSN to seek outside-the-box responses to build its resilience by drawing on the ability of its multidisciplinary teams to adapt their efforts to the challenges. Internally, within the Institute, this crisis has been a catalyst for adaptation and transformation. Externally, it has reaffirmed the importance of IRSN's role as a technical expert providing support to the public authorities in the context of international crisis management.

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