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Radiological Protection During Armed Conflict: Improving Regulatory and Operational Resilience

Report of a Joint Workshop organised by the DSA in co-operation with the NEA
22-24 November 2023

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NUCLEAR ENERGY AGENCY

The OECD Nuclear Energy Agency (NEA) was established on 1 February 1958. Current NEA membership consists of 34 countries: Argentina, Australia, Austria, Belgium, Bulgaria, Canada, Czechia, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Japan, Korea, Luxembourg, Mexico, the Netherlands, Norway, Poland, Portugal, Romania, Russia (suspended), the Slovak Republic, Slovenia, Spain, Sweden, Switzerland, Türkiye, the United Kingdom and the United States. The European Commission and the International Atomic Energy Agency also take part in the work of the Agency.

The mission of the NEA is:

– to assist its member countries in maintaining and further developing, through international co-operation, the scientific, technological and legal bases required for a safe, environmentally friendly and economical use of nuclear energy for peaceful purposes;

– to provide authoritative assessments and to forge common understandings on key issues, as input to government decisions on nuclear energy policy and to broader OECD policy analyses in areas such as energy and sustainable development.

Specific areas of competence of the NEA include the safety and regulation of nuclear activities, radioactive waste management and decommissioning, radiological protection, nuclear science, economic and technical analyses of the nuclear fuel cycle, nuclear law and liability, and public information. The NEA Data Bank provides nuclear data and computer program services for participating countries.

Foreword

The conflict in Ukraine has highlighted pressing concerns regarding radiological protection and the need to enhance both operational and regulatory resilience during times of armed conflict. While the core principles of radiological protection remain sound, it is crucial for all nations to strengthen their plans and procedures to better manage emerging threats and increased uncertainty.

In response to these complex challenges, the NEA Committee on Radiological Protection and Public Health (CRPPH) and the Norwegian Radiation and Nuclear Safety Authority (DSA) co-hosted a workshop in Oslo from 22 to 24 November.

The workshop, titled “Radiological Protection During Armed Conflict”, gathered 130 experts from 28 countries, NGOs, and international organisations to share insights and explore strategies for enhancing the resilience of radiological protection (RP) in such volatile circumstances.

Featuring contributions from about 50 speakers with diverse backgrounds, the event included discussions that covered the full spectrum of radiological protection during armed conflict. In his opening remarks, NEA Director-General William D. Magwood, IV stated, "The situation in Ukraine is unprecedented. The nuclear sector has a responsibility to protect public health and safety, and this situation has demonstrated that new frameworks and approaches are needed to ensure radiological protection during armed conflict."

This report summarises the discussions and presentations, analysing the findings and proposals aimed at strengthening the international framework governing radiological protection during armed conflict. It is hoped that the knowledge gained from this workshop will benefit governments, international organisations and civil society alike.

In Memoriam

It is with profound sadness that the NEA community marks the passing of Malgorzata Sneve, Director for Regulatory Cooperation at the DSA, where she dedicated 30 years to developing major regulatory co-operation programmes with the DSA and its sister authorities. A valued member of the NEA Committee for Radiological Protection and Public Health Bureau, Malgorzata played a key role in organising the November 2023 workshop. She was deeply committed to supporting Ukrainian colleagues in ensuring the protection of workers, the public, and the environment. The success of the November 2023 workshop is a testament to her strong networks in Ukraine, as reflected in the report that follows and which is dedicated to her memory. Her contributions also extended to other NEA initiatives: the Forum on Stakeholder Confidence (FSC), the Regulators' Forum (RF), and as Vice Chair of the Committee on Decommissioning of Nuclear Installations and Legacy Management (CDLM), where her leadership was invaluable. Malgorzata will be remembered for her enduring contributions and the profound impact she had on all who knew her.

Background and acknowledgements

The NEA Committee on Radiological Protection and Public Health (CRPPH) held its annual meeting on 4-6 April 2023 at the NEA premises in Boulogne-Billancourt, France, the first to be held in person since 2020. During one of the topical sessions, the committee was briefed by an invited keynote speaker from the Ukrainian nuclear safety authority (SNRIU) who described the difficulties and challenges raised by the situation in Ukraine. The committee strongly supported the idea of a dedicated workshop by the end of 2023, hosted by the Norwegian Radiation and Nuclear Safety Authority (DSA) and co-organised with the NEA, to explore the operational lessons and practices of managing radiological protection in situations of armed conflict. The workshop was organised and held on 22-24 November 2023 in Oslo, Norway, and attracted 130 participants.

The Norwegian Radiation and Nuclear Safety Authority (DSA) and the Nuclear Energy Agency (NEA) thank the members of the workshop programme committee for their substantial involvement and contributions to the success of the workshop Radiological Protection During Armed Conflict: Improving Regulatory Resilience and Operational Applications. In particular, they recognise the efforts of the members of the programme committee, Malgorzata Sneve, Workshop Chair and Director for Regulatory Cooperation at the DSA, Thierry Schneider, Workshop Co-chair and Chair of the Committee on Radiological Protection and Public Health (CRPPH), as well as Tristan Barr, Antony Bexon, Svitlana Chupryna, Astrid Liland, Nataliia Rybalka, Katarzyna Siegien and Karen Smith.

The expertise, insights and concerted efforts that these individuals brought to the planning process were instrumental and greatly appreciated.

The workshop also owes its success to the valued contributions of the guest speakers, presenters and panellists, all of whom generously shared their time, knowledge and experience with the workshop participants. Thanks also go to the delegation of the State Nuclear Regulatory Inspectorate of Ukraine (SNRIU), whose perspectives and insights greatly enriched the workshop discussions.

Thanks are due as well to the large number of NEA standing technical committees whose collaboration and involvement enabled the workshop. These include: the Committee on Decommissioning of Nuclear Installations and Legacy Management (CDLM), the Committee on Radiological Protection and Public Health (CRPPH), the Nuclear Law Committee (NLC), the Committee for Technical and Economic Studies on Nuclear Energy Development and the Fuel Cycle (NDC), the Committee on the Safety of Nuclear Installations (CSNI), the Committee on Nuclear Regulatory Activities (CNRA), and the Radioactive Waste Management Committee (RWMC).

The report was drafted by the DSA and reviewed by participants and the NEA prior to publication. The content includes the opinions expressed at the workshop but should not be taken to represent the policy of any particular organisation.

At the NEA, both the workshop and the summary report were co-ordinated by the NEA Division of Radiological Protection and Human Aspects of Nuclear Safety (RP-HANS) under the oversight of Greg Lamarre, Head of Division, and Jacqueline Garnier-Laplace, Deputy Head of Division, with the support of Lucas Martiri, Radiological Protection Specialist, and Kerim Jaber, Junior Specialist, as well as NEA staff from divisions across the agency. We extend our gratitude to Graham Smith and Karen Smith, who, in their role as external consultants, were assigned the task of drafting this report. The efforts of all these contributors have been instrumental in the production of this report.

Table of contents

List of tables

List of figures

List of abbreviations and acronyms

AI	Artificial intelligence
ALARA	As low as reasonably achievable
ASN	Autorité de sûreté nucléaire (Nuclear Safety Authority, France)
BSS	Basic safety standards
BUEH	Bucharest University Emergency Hospital
CAF	Canadian Armed Forces
CBRN	Chemical, biological, radiation and nuclear
CDLM	Committee on Decommissioning of Nuclear Installations and Legacy Management (NEA)
CEZ	Chernobyl Exclusion Zone
CNCAN	National Commission for Nuclear Activities Control
CNL	Canadian Nuclear Laboratories
CNRA	Committee on Nuclear Regulatory Activities (NEA)
CRPPH	Committee on Radiological Protection and Public Health (NEA)
CSA	Comprehensive Safeguards Agreement
CSNI	Committee on the Safety of Nuclear Installations (NEA)
CT	Computerised tomography
DAPHNE	Diagnosis and Prognosis of Hazards in Nuclear Emergencies
DBT	Design basis threat
DCF	Dose conversion factors
DND	Department of National Defence
DSA	Norwegian Radiation and Nuclear Safety Authority
EAL	Emergency action level
EC	European Commission
ECURIE	European Community Urgent Radiological Information Exchange
EGLM	Expert Group on Legacy Management
ENSREG	European Nuclear Safety Regulators Group
EP	Emergency preparedness
EPR	Emergency preparedness and response
EPZ	Emergency planning zone
ERC	Emergency Relief Coordinator
EURDEP	European Radiological Data Exchange Platform
HERCA	Heads of the European Radiological Protection Competent Authorities

HWA	HERCA-WENRA Approach
IAEA	International Atomic Energy Agency
IACRNE	Inter-Agency Committee on Radiological and Nuclear Emergencies
IASC	Inter Agency Standing Committee
ICRP	International Commission on Radiological Protection
IEC	IAEA Incident and Emergency Centre
IFE	Institute for Energy Technology
ILO	International Labour Organization
INEX	International Nuclear Emergency Exercises
INSC	Instrument for Nuclear Safety Cooperation
IRMIS	International Radiation Monitoring Information System
IRSN	Institut de radioprotection et de sûreté nucléaire (Institute for Radiation Protection and Nuclear Safety, France)
JRC	Joint Research Centre
KINS	Korea Institute of Nuclear Safety
LOF	Location outside facilities
MHPSS	Mental health and psychological support
MoH	Ministry of Health of Ukraine
NDC	Committee for Technical and Economic Studies on Nuclear Energy Development and the Fuel Cycle (NEA)
NEA	Nuclear Energy Agency
NGO	Non-governmental organisation
NLC	Nuclear Law Committee (NEA)
NORM	Naturally-Occurring Radioactive Materials
NRA	Nuclear Regulation Authority
NSCA	Canadian Nuclear Safety and Control Act
NSOD	Nuclear Safety Orders and Directives
NRC	Nuclear Regulatory Commission
OECD	Organisation for Economic Co-operation and Development
OIL	Operational intervention level
ONR	Office for Nuclear Regulation
PAA	Poland’s National Atomic Energy Agency
PPE	Personal protective equipment
RANET	Response and Assistance Network
RDD	Radiological dispersal device
RescEU	European Reserve of Response Capabilities

RWMC	Radioactive Waste Management Committee (NEA)
SAUEZM	State Agency of Ukraine on Exclusion Zone Management
SIREN	System for Identifying Radiation in Environments Nationwide
SMR	Small modular reactor
SNF	Spent nuclear fuel
SNRIU	State Nuclear Regulatory Inspectorate of Ukraine
SSM	Swedish Radiation Safety Authority
SSE	State Special Enterprise
SSTC NRS	State Scientific and Technical Center for Nuclear and Radiation Safety
STUK	Finnish Radiation and Nuclear Safety Authority
TAR	Threat Assessment Report
TSC	Technical Support Centres
TSO	Technical and Scientific Support Organisation
UCPM EU	Civil Protection Mechanism
UAE	United Arab Emirates
UN	United Nations
US DoE	United States Department of Energy
WENRA	Western European Nuclear Regulator Association
WGE	Working Group on Emergencies (HERCA)
WGHOF	Working Group on Human and Organisational Factors (NEA)
WHO	World Health Organization
WPNEM	Working Party on Nuclear Emergency Matters (NEA)

Executive summary

Background

The war in Ukraine marks the first time in history that a country with significant nuclear and radiological capacities has been the site of armed conflict. These events raise unprecedented questions about nuclear safety and security, as well as radiological protection and public health.

From a radiological protection perspective, the challenge for any country in an armed conflict situation is twofold:

- to maintain and enhance the capability and capacity to effectively monitor, analyse and manage radiological protection and public health; and
- to continuously anticipate consequences that such conflicts will have on the implementation of radiological protection regulation and practices.

These challenges apply before, during and after situations of armed conflict.

A key question is whether the radiological protection systems and regulatory frameworks that countries rely upon to ensure safety, which have evolved over many decades and are not designed to be applied in wartime, have the resilience and flexibility to be applied to situations of armed conflict. If these frameworks cannot be adapted to such situations, then what are the gaps in the existing arrangements and what additional measures are necessary?

Building upon reflections of the Nuclear Energy Agency (NEA) Committee on Radiological Protection and Public Health (CRPPH) and the existing regulatory co-operation between the State Nuclear Regulatory Inspectorate of Ukraine (SNRIU) and the Norwegian Radiation and Nuclear Safety Authority (DSA), an international workshop was organised to address prospective issues of radiological protection in the context of armed conflict. The workshop, hosted by the DSA and organised in collaboration with the NEA, took place in Oslo from 22-24 November 2023. Participation was open to national and local government representatives, experts, regulators, operators, non-governmental stakeholders, international organisations and associations. One hundred and thirty experts from twenty-eight countries, international organisations and NGOs participated, demonstrating the importance given to the subject.

Workshop objectives and scope

The specific objectives of the workshop were as follows:

- To share the knowledge and experience of Ukrainian and other participating national regulators, as well as relevant international organisations and associations, on the operational management and regulation of radiological protection and public health during and after armed conflict.
- To identify the challenges of maintaining or restoring radiation safety, including the involvement of different stakeholders and the consideration of all hazards, as well as the application of standard emergency preparedness, response actions during wartime, and post-conflict recovery strategies.
- To develop proposals for further international collaboration in this area, including how to adapt the regulatory framework and practice for the radiological protection of workers, the public and the environment during wartime, taking into account the challenges and risks associated with armed conflict.

Of particular interest were potential radiological emergencies caused by war-related damage to nuclear and radiological facilities.

Conduct of the workshop

The workshop consisted of topical sessions on the following themes and allowed for both presentations and discussion on each topic;

- resilience practices from a human and organisational factor perspective;
- characterisation of the radiological situation and environmental monitoring systems;
- adapting emergency preparedness and response and recovery in armed conflict situations, and emergency preparedness interfaces; and
- adapting national strategies and international support for medical response.

A breakout discussion session was also organised aimed at putting lessons learnt into perspective and supporting a prospective reflection on how to manage radiological protection in situations characterised by multiple risks – notably if a major radiological risk comes into play alongside risks linked to military activities and their consequences – and if communication and stakeholder engagement are disrupted. Finally, panel discussion sessions aimed to identify key lessons learnt on managing radiological protection and potential actions to help regulators reduce radiological risks during armed conflict.

The workshop was opened jointly by Per Strand, Director General of the DSA and William D. Magwood, IV, Director-General of the NEA.

Key conclusions and actionable recommendations

International and bilateral co-operation is vital to address radiation and nuclear challenges within Ukraine, and this is likely to continue. At the same time, such international co-operation is also necessary to enhance preparedness and response in friendly neighbouring countries.

The provision of international assistance has strengthened capacity and resilience in Ukraine and has supported the Ukrainian regulatory body in navigating the significant new challenges faced as a result of the full-scale invasion.

A strong message is needed on the special status of nuclear power plants during war. The current workshop has provided the first step in developing international co-operation to address a range of identified risks and challenges.

The actionable recommendations arising from the presentations and discussions documented above are set out below in five key areas.

Area 1 - Strengthen international co-operation and reinforce international conventions

- Strengthen international and bilateral co-operation to address radiation and nuclear challenges within Ukraine. Additionally, establish such co-operation to enhance preparedness and response in friendly neighbouring countries. Consider an international/multilateral framework to co-ordinate activities on the provision of assistance (expertise, human and financial resources), on procurement of specialised equipment and other matters (including post-conflict recovery).
- Establish a small task force or team of representatives from key organisations (development of effective networks of personal contacts). This task force would

reflect on the learning and present the outcomes of their discussions, which could then be considered for implementation at an international level.

- Review and enhance conventions and/or guidance on their application to explicitly exclude nuclear installations from being targeted in attacks (e.g. by granting nuclear facilities special status beyond normal infrastructure during armed conflict, establishing exclusion zones around facilities). Although ruled out by aggressors, it could provide a basis for holding them accountable post-conflict. Co-operation protocols could then be scaled towards developing global decisions on how to act together to address nuclear facility risks into the future, essential in achieving a collective commitment for global security.

Area 2 - Build and maintain resilience nationally and beyond through flexible regulatory frameworks

- Build on information sharing mechanisms:
  - o to strengthen networks/platforms among regulators and develop national resilience when facing radiation threats;
  - o to establish protocols for mutual co-operation among all organisations that are able to support swift mobilisation of (human and logistics) resources during armed conflict;
  - o to support holistic dialogue: between different regulatory bodies in various areas of responsibility and safety issues, but also with health and welfare services; and with the military on how risks near major facilities can best be managed.
- Build more flexibility into regulatory frameworks to allow for adaptive decision making and prioritisation rather than trying to change regulations in urgent situations. A vigorous safety culture is to be encouraged within and among the operators, TSOs, regulators and other support organisations well in advance of armed conflict. This is key to support safe operations during times of limited and/or intermittent regulatory inspections and oversight, information accessibility challenges, human capacity deficiencies, etc.
- Integrate radiological protection within the overall resilience system. Relevant international organisations, including the NEA, are encouraged to prepare guidance for both the RP specialists and regulators.

Area 3 - Develop practical guidance for RP while the RP principles and policy framework apply

- Better understand what application of RP principles means in practice and how to improve the practicability of RP to ensure an appropriate level of protection.
- Revisit the justification process to recognise additional threats during armed conflict (e.g. missiles, mines) that could require prioritisation to be made on a case-specific basis. Adapt regulatory frameworks to make decisions considering other risks, while adhering to the principles already in place, namely justification and optimisation, which guide the application of the international RP system when deciding protective actions.
- Consider war scenarios within the ICRP system of radiological protection, as a country at war has not yet been considered. A war scenario could have important implications for the application of the concept of justification and selection of reference levels.

- Address the challenge of a cascade of crises occurring simultaneously during armed conflict, making optimisation difficult and complex.

Area 4 - Adopt an all-hazards approach, broaden dialogue between civil and military authorities for EPR

- Engage in dialogue with other authorities responsible for safety in other fields, including military authorities, in addition to RP and nuclear safety communities. Establish links and communication networks for the decision process to gain insights on how to operate within the objectives of military actions. Sharing the experience of different countries could be an important first step.
- Adopt a holistic view so that the focus is not solely on RP, but also security and other threats, i.e. an all-hazards approach. This includes threats associated with the availability of reliable information and how to make decisions in the absence of data, as well as establishing reliable and direct contact points for trustworthy exchange of information and ensuring security of communication channels.
- Enhance EPR analysis with release scenarios including war scenarios for nuclear installations but also for high-risk radiation installations, e.g. waste storage facilities, industrial irradiators and hospitals. From that, consider building defence and mitigation capacities and capabilities. A first step for countries could be sharing scenarios already available within national EPR programmes.
- Adjust protective actions during armed conflict and disruptive scenarios. Strive for balance between different hazards and risks; for instance, advice to shelter from shelling may conflict with advice to evacuate due to radiation situation.

Area 5 - Stakeholder engagement, critical aspects of information, communication and trust

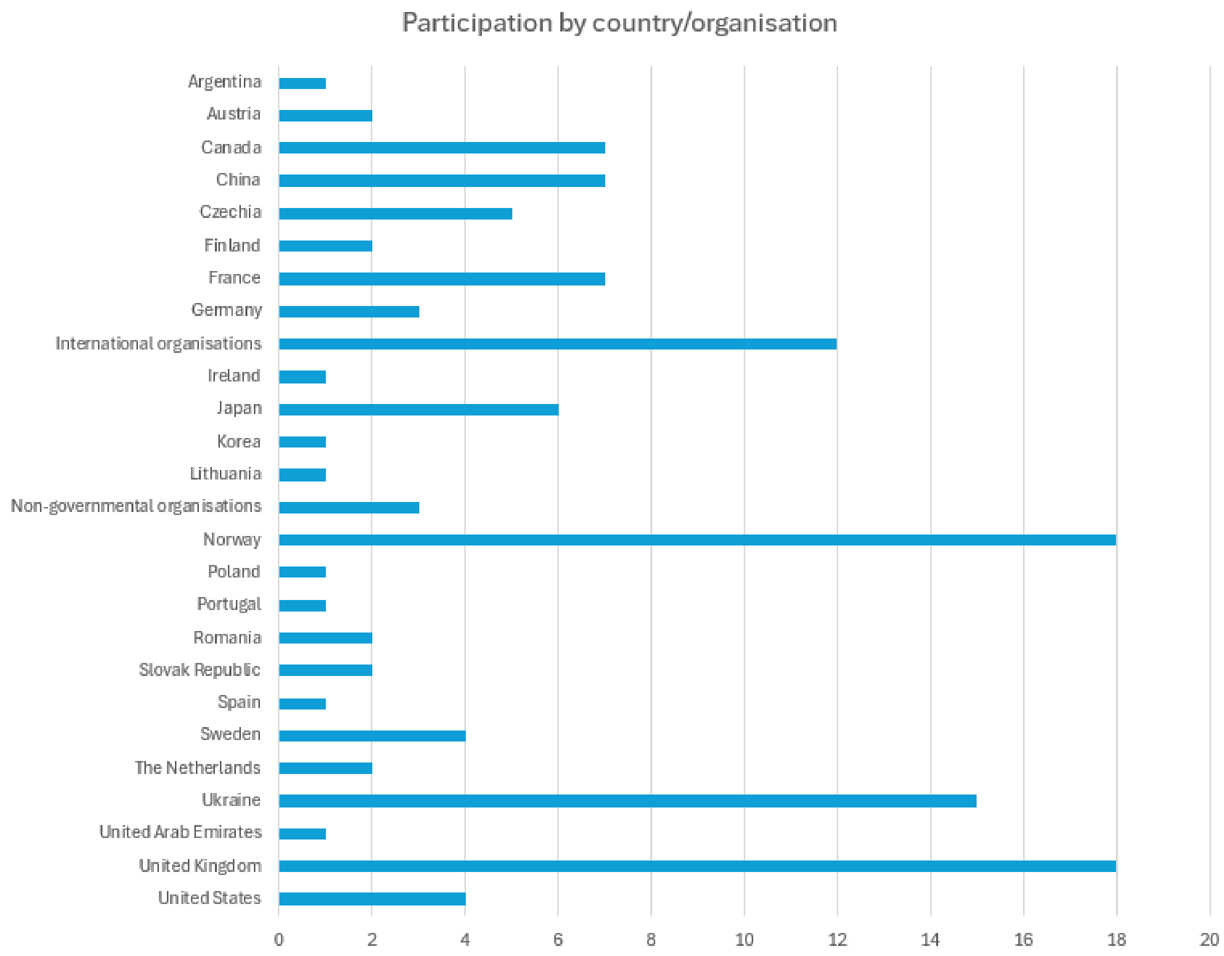
- Practice communication of information to those who need it, especially during emergency situations when electricity supplies and communication channels may be disrupted. Conduct exercises to improve co-ordination and develop the most effective communication channels.
- Leverage social scientists to address issues related to reliability, misinformation, and fake news during conflict situations. Their expertise can facilitate effective communication in emergencies.
- Engage civil society actively to build trust. Proactively implement trust-building initiatives well before conflict situations arise between operators, regulators, other stakeholders and the public in general.

1. Introduction

1.1. Participation, programme and report structure

Workshop participants included national and local government representatives, experts, regulators, operators, non-governmental stakeholders, and international organisations and associations. One hundred and thirty representatives experts from over twenty-eight countries, international organisations and NGOs participated, demonstrating the importance given to the subject.

Figure 1.1. Participation by country/organisation



The workshop, opened by the DSA Director General Per Strand and the NEA Director-General William D. Magwood, IV, consisted of technical sessions, panel discussions and "what if" exercises. It was organised into the following sessions, which are described in this report:

- Introductory session (Chapter 2);
- Session 1: Resilience practices from a human and organisational factor perspective – Focus on occupational radiological protection (Chapter 3);
- Session 2: Characterisation of the radiological situation and environmental monitoring systems (Chapter 4);
- Session 3: Adapting emergency preparedness and response and recovery in armed conflict situations (Chapter 5);
- Session 4: Adapting national strategies and international support for medical response (Chapter 6);
- Session 5: Identifying key lessons learnt on managing radiological protection during armed conflict: Improving regulatory resilience (Chapter 7);
- Session 6: "What if" conversation: Lessons from experience for a more resilient regulation and application of radiological protection in armed conflicts (Chapter 8);
- Session 7: Keynotes: Safety, security and emergency preparedness interfaces (Chapter 8); and
- Closing session: Strengthening international collaboration and establishing a list of potential actions to help regulators reduce radiological risks (Chapter 9).

Actionable recommendations and conclusions are provided in Chapter 10.

2. Introductory session

2.1. Opening words from Per Strand, Director General, Radiation and Safety Authority (DSA), Norway

Dear colleagues,

I am very pleased to welcome everyone to this international workshop on Radiological Protection during Armed Conflict: Improving Regulatory and Operational Resilience. It is jointly organised by the Norwegian Radiation and Nuclear Safety Authority and the Nuclear Energy Agency of the OECD. It therefore gives me particular pleasure to extend the welcome William D. Magwood, IV, Director-General of the NEA.

The warfare waged by Russia on Ukraine poses a very serious threat to radiation safety within Ukraine itself and within many neighbouring countries. Ukraine requires extensive assistance in bolstering its resilience to this threat during the conflict and this need is likely to continue for an extended period post-war.

Norway has steadfastly supported President Zelensky's 10-point peace plan, particularly focusing on radiation and nuclear safety. Through the 5-year Nansen Program, Norway reinforces its close collaboration with Ukraine in this area, with an annual commitment in 2023 of NOK 250 million. This support builds on the successful partnership established over previous years, notably intensified after the Russian annexation of Crimea and the destabilisation of Eastern Ukraine in 2014. Here I would like to underline the importance of our close bilateral co-operation with the State Nuclear Regulatory Inspectorate of Ukraine (SNRIU) and its technical support organisation, the State Scientific and Technical Centre for Nuclear and Radiation Safety (SSTC NRS). As regulatory authority with similar responsibilities we at the DSA fully appreciate the technical and practical challenges that SNRIU is facing every day. We also try to imagine all other difficult challenges arising from the war situation.

DSA support to SNRIU is based first on the Norwegian Plan of Action for Nuclear Safety. The main objectives are to:

1. Reduce the risk of accidents and events leading to the release of radioactive substances.
2. Minimise the risk of nuclear and other radioactive materials falling into the wrong hands.
3. Contribute to regaining regulatory control over facilities and areas directly affected by armed conflict.
4. Aid the rehabilitation of facilities and areas when feasible, post-war.
5. Disseminate information on radiation and nuclear safety and related contamination in Ukraine.

In support of these objectives, the DSA has set up a wide range of projects with SNRIU and implemented by the SSTC NRS with support from DSA staff. We will hear during the workshop about the important progress being made as well as continuing plans for projects. For now, I am pleased to highlight the work already done to restore regulatory control in areas in and around the Chernobyl Exclusion Zone that were temporarily occupied by Russian forces. In addition, significant survey work has been completed to restore the confidence of local communities.

International collaboration plays a pivotal role in supporting Ukraine and we are very happy to have such excellent joint co-operation with NEA, who jointly with us wish to focus on those challenges from international perspective. Norway will continue prioritising co-operation with NEA and other international organisations to ensure effective collaboration and avoid redundant efforts.

In conclusion, Norway remains dedicated to addressing the urgent nuclear and radiological safety needs in Ukraine during this challenging time. Through our Nuclear Action Plan and the Nansen Programme, our commitment extends beyond financial aid, encompassing tangible technical support, project development and implementation, provision of equipment, dialogue, and collaboration. Together with our international partners, we strive to make a meaningful impact and contribute to the recovery and resilience of Ukraine's radiation and nuclear safety.

2.2. Opening words from William D. Magwood, IV, Director-General, Nuclear Energy Agency (NEA).

This workshop is the culmination of a bilateral co-operation between the DSA and the NEA that was launched several months ago and came together quickly as a result of the hard work of colleagues both in the DSA and the NEA.

People working in the nuclear sector are very optimistic about the future. Technologies are advancing and nuclear power is being recognised as a critical source of energy in various countries, including developing nations, and as being central to addressing the climate crisis. Nuclear power is being accepted more and more as a means of providing clean energy with the development of small modular reactors (SMRs). The field is also forward looking in terms of potential for providing clean water and future hydrogen for transport, etc.

For most of us, armed conflict is a new subject for radiological protection with the war in Ukraine being the first time there has been armed conflict in a country with significant nuclear power. There is, therefore, a lack of experience and expertise in how to address the challenges faced. There is always a political dimension to any conflict; in this case, Russia has been suspended from the NEA.

The war in Ukraine presents a tragic situation for Ukraine and the global community. While the political aspects have been well characterised, the personal aspects have been less so, but involve significant lives lost and many are left struggling today. We are grateful to all colleagues that have travelled to share experience and knowledge, but particularly to our Ukrainian colleagues that have faced considerable challenges in travelling to attend.

In addition to political and personal aspects, there is also a practical dimension. In the nuclear sector we take pride in learning from experience and have built resilience from lessons learnt from past events, including Three Mile Island and the Chernobyl and Fukushima Daiichi accidents. A key learning point from the Fukushima Daiichi accident, however, was that we are not as resilient as we thought. Now, faced with armed conflict, we must look to learn lessons and further develop resilience. As more countries look to develop nuclear power capabilities, including countries in the Global South, the potential for armed conflict situations to arise again in the future increases. As unprecedented as the situation in Ukraine is, it is likely that similar situations could arise in other parts of the world in the future. As such, it is important that frameworks for nuclear safety are reassessed in light of the challenges being faced today and to develop these frameworks as necessary.

This workshop provides a critical first step towards carving out what the frameworks for radiological protection and nuclear safety should be and to incorporate lessons to be safe, resilient and prepared for armed conflict in countries with nuclear facilities. The workshop provides an opportunity to share knowledge and experience gained in Ukraine and to share with other regulators in order to absorb new experience and look forward by identifying challenges and developing proposals on how to address those challenges. There is also a broader perspective on risk management and incorporating new types of risks into protection frameworks. For example, it may be necessary to deploy monitoring teams to territories affected by war with increased risks from land mines, etc. It is important therefore to have a new way of thinking about risk during armed conflict. The workshop provides an opportunity to have technical discussions, but also to step back and think about responsibilities as regulators and operators of nuclear facilities.

It will be important moving forward to continue to learn as the situation continues to unfold in Ukraine and to learn lessons on how to operate under these circumstances. It is also important to recognise that there will be an end to the conflict eventually and there will be a need to think about new conventions in the light of the events that have unfolded that countries will have to commit to and abide by. The workshop also provides an important opportunity to learn more on the support that Ukraine needs from the international community and to consider initiatives for delivering support. The workshop marks the beginning, not the end, of the process of learning about this uncertain future and unprecedented situation. Our thoughts are with the people of Ukraine going forward.

2.3. Nuclear safety and security in Ukraine: Risks, threats, lessons learnt (Oleh Korikov, SNRIU)

On 24 February 2022, Russia began its invasion of Ukraine and nuclear power plants were early points of focus, with the Chernobyl Nuclear Power Plant and Chernobyl Exclusion Zone (CEZ) being occupied. This was followed in early March with shelling and occupation of the Zaporizhzhia Nuclear Power Plant and shelling of other nuclear facilities, including radon and neutron source facilities. In its presentation at the workshop, the SNRIU reported that there have been several power outages at nuclear power plants across the country as a result of the war and the Kyiv nuclear research reactor was damaged. Shelling of nuclear facilities has continued throughout the war, with damage to windows of turbine halls and monitoring systems. While radiation safety has not been impacted significantly, these actions endanger Ukraine's population and the region in general. For example, the Chernobyl Nuclear Power Plant is associated with over 21 000 spent fuel assemblies and approximately 2 500 m^3 of solid radioactive waste and 19 000 m^3 of liquid radioactive waste. The shelter housing Reactor 4 contains around 1.7 million m^3 of radioactive waste with an activity of over 7E+17 Bq.

Assistance has been provided to Ukraine through the International Atomic Energy Agency (IAEA) Response and Assistance Network (RANET). Protective and security equipment has been delivered, including decontamination units, medical equipment and information technology supplies. An IAEA medical assistance mission for operating staff at nuclear power plants helped to identify the need for critical equipment and supplies in areas including health screening and surveillance of operating staff at nuclear power plants, radiation monitoring and protection equipment, mental health support, and dose assessment and medical treatment of overexposed or contaminated patients. The preliminary cost estimate for delivery of this assistance is around EUR 15 million.

The IAEA have also undertaken safeguarding activities and have met several challenges in the implementation of safeguards, including personal security threats, personal transportation difficulties and risks associated with facilities and locations being close to active combat zones. Three special reports have so far been produced in accordance with Article 68 of the Comprehensive Safeguards Agreement (CSA):

- 25.02.2022 Special Report for Chernobyl Nuclear Power Plant;
- 04.03.2022 Special Report for Zaporizhzhia Nuclear Power Plant (9MBA);
- 05.07.2022 Special Report for Location Outside Facilities (LOFs) (3 sites).

Since July 2022, activities with nuclear material have been frozen at the Zaporizhzhia Nuclear Power Plant and the IAEA has deployed missions on site and performed remote monitoring of all reactor halls. Despite various difficulties, the IAEA was able to perform sufficient in-field verification activities in Ukraine to draw positive safeguards conclusions.

There have been several IAEA missions to Ukraine, including short-term assessment missions and permanent deployment missions to all nuclear power plants and CEZ since January 2023. All mission reports were positive in terms of nuclear safety and security, except for that for the Zaporizhzhia Nuclear Power Plant. The IAEA support and assistance mission to Zaporizhzhia Nuclear Power Plant has been ongoing since September 2022. In its presentation to the workshop, the SNRIU said that the Zaporizhzhia Nuclear Power Plant was being used as a military base and there are examples of weapon firing points being located on roofs and in nuclear power plant rooms. Unpermitted people are present on the site and emergency preparedness and response (EPR) has been degraded at the site and supply chains have been disrupted. These factors have been confirmed by the IAEA missions. In addition to occupation and direct damage to the Zaporizhzhia Nuclear Power Plant sites, the source of cooling water for the plant was targeted with the destruction of the Kakhovka hydroelectric dam.

Currently, online data transmissions have been terminated to avoid data being available online. As such, data are obtained twice weekly, which limits the ability to react to situations as they arise. As the regulatory body, SNRIU closely follows the situation but said that the Russians are working in contradiction to the nuclear power plant licence conditions and international safety rules. An analysis has been undertaken of how the situation at the Zaporizhzhia Nuclear Power Plant complies with Safety Fundamentals and licence conditions with the conclusion that the site is not in compliance. The IAEA has confirmed that the presence of troops at the Zaporizhzhia Nuclear Power Plant limits implementation of Safety Fundamentals and licence conditions and confirmed a reduced level of EPR at the site as a consequence. There has also been inadequate maintenance and reduced management in the control room and among other staff at the Zaporizhzhia Nuclear Power Plant.

As a regulatory body, SNRIU is responsible for the implementation of the following international conventions:

- Convention on Nuclear Safety;
- Convention on Early Notification of a Nuclear Accident;
- Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management; and,
- Convention on the Physical Protection of Nuclear Material and Nuclear Facilities.

However, as a result of Russian occupation of the Zaporizhzhia Nuclear Power Plant and surrounding territory, SNRIU said it has not been possible to implement the full scope of provisions within the conventions. The role of Russia in preventing provisions within the conventions from being met has been fully reported. The assault, shelling and occupation of nuclear facilities by Russia are violations of international nuclear law, conventions, rules and regulations, IAEA Statute and United Nations Charter. Several IAEA resolutions have been passed, along with statements and calls for the immediate cessation of Russian hostilities against, and withdrawal from, Ukrainian nuclear facilities.

2.4. Regulatory and operational radiological protection issues and challenges in Ukraine (Nataliia Rybalka, SNRIU)

Ukraine is one of the ten largest countries in the world in terms of nuclear energy use, with nuclear power providing up to 60% of total electricity needs prior to the Russian war. As a country, Ukraine has already paid a high price for the Chernobyl accident and has therefore been working towards ensuring the highest standards of nuclear and radiation safety and security. This changed dramatically, however, due to the aggression from Russia that escalated significantly on 24 February 2022. The national laws and regulations that have been developed for the operation of nuclear power plants do not take account of the new conditions faced, which include the shelling and occupation of nuclear power plants, and there is no experience internationally of the safe operation of nuclear installations in the context of large-scale war or in the context of a post-war period.

From the beginning of the invasion there have been regulatory issues and challenges. Staff have been unable reach offices, some have joined the army, some have been evacuated and some are within occupied territories. Remote working for staff of the SNRIU and its technical support organisation, the State Scientific and Technical Centre for Nuclear and Radiation Safety (SSTC NRS) were introduced (which was helped by recent experience with the COVID-19 pandemic), but additional challenges have been faced as a result of unstable communication channels, blackouts and issues with water and heat supplies, all of which have influenced the ability to undertake activities and have contributed to high levels of stress among staff.

The invasion has affected the regulatory activities of SNRIU significantly. Scheduled inspections are no longer carried out so that only unplanned inspections take place and it has been impossible to carry out state supervision on the occupied facilities and territories. Licensing supervision activities have therefore been restricted to the facilities and territories under Ukrainian control. Human resources have also been limited, with significant resources required for information and emergency activities, international co-operation and co-ordination of other authorities and agencies for radiological protection.

Communication and information dissemination efforts have been significantly increased since the beginning of the war, with an information and emergency centre being activated and operational 24 hours a day, 7 days a week. There is continuous monitoring and analysis of the nuclear and radiation safety status and radiological consequence analysis is regularly performed. There has also been a need to provide information regularly to the IAEA Incident and Emergency Center (IEC) through the IAEA secure website and to maintain constant telephone contact with IEC response officers, particularly in the first days of the invasion. Permanent active communication was also established with the European Commission, HERCA (Heads of the European Radiological Protection Competent Authorities), WENRA (Western European Nuclear Regulators Association), ENSREG (European Nuclear Safety Regulators Group) and regulatory authorities of Ukraine partner countries and other organisations. As a result of the communication and information exchange, a number of resolutions and statements were distributed on the official websites of these organisations in support of Ukraine.

From the beginning of the invasion, operational issues and challenges were faced. On 25 February 2022, data from the automated radiation monitoring system of the CEZ indicated that gamma dose rates had increased by up to 15 times at a number of observation points compared to pre-invasion levels, with experts concluding that the increases were caused by disturbance of the upper soil layer within the CEZ by military vehicles. On 26 February, the online transfer of data from the monitoring system was lost, making control of the radiation situation in the CEZ impossible. On 9 March the external grid power supply was lost to all facilities of the Chernobyl Nuclear Power Plant, requiring emergency diesel generators to be used to maintain safety, but the limited fuel supplies meant that there was a risk of losing heat removal from the spent nuclear fuel (SNF) storage pools. Nuclear safety was therefore compromised. In addition, staff on shift at the Chernobyl Nuclear Power Plant on the day of the invasion were taken hostage. This included 92 operational personnel and around 150 national guard soldiers. For operational personnel, rotation of staff was only possible by 20 March so the 92 hostages were responsible for maintaining all systems and equipment important for safety while being held at gunpoint. Maintenance activities were not possible due to spare parts and equipment not being delivered and maintenance personnel being unable to access the site. The 150 national guards were taken prisoner on 31 March. At the current time, 106 national guards remain prisoners of Russia and no information has been made available on them to family members. Efforts continue to secure their release from captivity.

The SNRIU said that military aggression by Russia against Ukraine has included direct targeting of nuclear installations through the occupation of nuclear facilities, their sites and controlled territories and through murder, capture and imprisonment of nuclear power plant staff and security guards. There have also been indirect threats to installations through aggressive pressure and threats to nuclear power plant operational staff and threats to their families, which are still ongoing, the SNRIU said. Destruction by weapons and destabilisation of buildings and monitoring systems has also occurred along with theft of safety equipment, hardware, vehicles and PPE and damage to power lines. All of these activities increase the risk of emergencies occurring. If emergencies did occur, the ability to respond would be greatly diminished due to damaged infrastructure and limited access for emergency responders.

The Zaporizhzhia Nuclear Power Plant has been occupied since 4 March 2022. From the beginning it was necessary to stop Zaporizhzhia Nuclear Safety Inspectorate activities to focus on the evacuate of staff to safe locations and to transfer responsibilities to the central office in Kyiv. Zaporizhzhia Nuclear Safety Inspectorate work was restored (in remote mode) in December 2022. As a result, there has been a transition from direct on-site inspections to regulatory supervision through analysis of information. Licence limitation measures were implemented, with units 1 and 2 operational licences limited to “cold shutdown state” and units 3 to 6 restricted ultimately to shutdown mode. Units 3 and 4 were subject to cold shutdown mode but Russians broke the licence conditions for units 5 and 6, which were hot shutdown. The Zaporizhzhia Nuclear Power Plant operational licences were ultimately limited to the cold state due to lack of personnel, degradation of equipment and the destruction of the Kakhovka dam.

There are also increased threats and risks of sealed sources becoming damaged, orphaned or lost on territories that are out of Ukrainian control due to Russian occupation. In the State register of radioactive sources in Ukraine there are over 8 000 sealed radioactive sources registered of which around 250 radioactive sources (categories 1 to 3) are known to be out of State regulatory control as a result of the occupation of territories by Russian forces. There are also numerous generating sources used for medical purposes throughout the country and the loss of control due to escalating actions poses additional challenges for radiological protection in the country.

Healthcare institutes have also been affected by the war. Over 2 000 healthcare institutes, including hospitals, are licensed for the use of radioactive sources and many buildings have been damaged and equipment within them damaged, dismantled or stolen. As a result of the hostilities, there has been a need to move medical equipment and radiation sources from occupied and frontline territories to safer regions, and medical facilities in de-occupied territories have needed to resume activities. The conflict has also led to the evacuation to safer regions of people requiring medical care, including those requiring special treatment for COVID-19. The number of people requiring medical care has also increased significantly due to wounded military personnel, injured civilians and the wider affected population.

Key regulatory issues and challenges faced in Ukraine as a result of the war include the need to monitor the situation within the warfare area and gather information on the safety of radiation sources in these areas and in territories that are out of control of the Ukrainian authorities while also providing State supervision over licensed entities. It has been a challenge to provide the full scope of licensing activities, including increased needs for regulatory radiation safety reviews and expertise and licensing decisions, brought about as a result of the war and SNRIU therefore requested an IAEA assistance mission on the safety and security of radiation sources in Ukraine. The special mission took place in July 2023.

Prior to the war, Ukraine transported radioactive materials by road, rail, water and air. However, with the war beginning, air and sea connections were lost and the logistics of transportation were significantly challenged. The risks posed by military action are balanced against needs for medical treatments and fuel transportation for nuclear power plants, etc. Each transportation case is carefully analysed with respect to the optimisation principle, radiation risk assessment during transport and timescales. Itineraries are chosen avoiding serious threat areas and analysing the current road conditions, transportation times and the need for additional security measures. Strategic and vital transportation is carried out in accordance with all rules and regulations and after agreement with the armed forces of Ukraine. This ensures that hospitals continue to receive pharmaceuticals and radiation sources required for medical treatments and that nuclear power plants receive nuclear fuel and accumulated radioactive waste can be removed. From 2022 to 2023, more than 40 permits were issued for the international transportation of radioactive materials, including the supply of nuclear fuel, to ensure the continued safe operation of nuclear facilities in Ukraine.

The major challenge for Ukraine for the near future is to eliminate and overcome the consequences of the full-scale Russian invasion and military action towards Ukrainian nuclear installations. Continued wide and comprehensive co-operation with international partners on safety and security for nuclear installations will be important in achieving this. The SNRIU, as the regulatory authority, is responsible for co-ordinating the technical assistance and co-operation of competent Ukrainian authorities and entities with the IAEA, European Commission, United Nations, G7, ENSREG, WENRA, etc. as well as bilateral co-operations (e.g. with the DSA), which have increased significantly as a result of the war.

2.5. Overview of the NEA's radiological protection activities of interest (Jacqueline Garnier-Laplace, NEA)

The NEA provides a forum for co-operation between member countries. It was formed in 1958 and currently counts 34 member countries. The NEA consists of an overall steering committee for nuclear energy with eight standing technical committees. The eight technical committees each have a specific focal area: nuclear regulatory activities; safety of nuclear installations; radioactive waste management; decommissioning of nuclear installations and legacy management; radiological protection and public health (CRPPH); nuclear law; technical and economic studies on nuclear energy development and the fuel cycle; and nuclear science. Altogether, there are around 74 working parties and expert groups. The NEA mission is twofold:

- To assist its member countries in maintaining and further developing, through international co-operation, the scientific, technological and legal bases required for a safe, environmentally sound and economical use of nuclear energy for peaceful purposes.
- To provide authoritative assessments and to forge common understandings on key issues as input to government decisions on nuclear energy policy and to broader OECD policy analyses in areas such as energy and the sustainable development of low-carbon economies.

Some countries are members of both the NEA and OECD whereas others are members of either the OECD or NEA. Russian membership in the NEA has been suspended. Russia is not a member of the OECD.

The CRPPH is comprised of around 130 delegates from 26 countries, as well as, for committee meetings, invited experts from non-member countries: People's Republic of China, Ukraine and United Arab Emirates (UAE). The CRPPH contributes to the revision, adoption and maintenance of high standards of protection of the public, workers and the environment in support of all developments and applications of nuclear science and technology, particularly in the field of nuclear energy.

Selected activities on three strategic directions shaping the CRPPH future plan that link with the workshop theme include:

- revisiting modern radiological protection policy and its regulatory and operational application in various areas impacted by the stress of war and conflict;
- continuing to improve countries' preparedness for nuclear and radiological accidents through exercising post-accident recovery; and,
- transferring knowledge to future generations and strengthening radiological protection expertise globally.

A third stakeholder involvement workshop on optimisation in decision making was held in September 2023 in Paris. Around 15% of the 120 participants at the workshop were representatives from non-governmental organisations. The workshop took place over 2.5 days and aimed to:

- improve the common, practical understanding of what optimisation in decision making means for all stakeholders;
- support inclusive stakeholder involvement and identify tools/approaches to optimise decision making;
- identify the foundation of a generic multidimensional framework to support the optimisation process for decision makers across the nuclear sector.

Decision-making processes were discussed in plenary sessions and through the use of case studies from the nuclear sector to help develop preliminary guidelines on decisions involving stakeholders, starting from practical understanding and recognising the importance of including stakeholders in the optimisation process.

The optimisation principle is one of the fundamental principles of the international radiological protection system and workshop participants agreed that greater inclusiveness of stakeholders is required from the outset if inclusive, holistic and sustainable decisions are to be made. Decision-making processes also need to be holistic, taking account of all hazards as well as the socioeconomic impacts and benefits. The following outcomes of the workshop have an impact on the CRPPH programme of work:

- Develop further guidance on the co-development of the decision-making process (e.g. co-expertise approach, enhancing the long-term involvement of rights holders and stakeholders, and promoting citizen science where appropriate).
- Optimise societal benefits and stakeholder well-being by considering their input in decision making, as well as the link with sustainable development goals and the adoption of an all-hazards approach.
- Reflect on how to involve young people in the decision-making process and how to cope with the consequences for future generations.
- Seek equity in the balance of power among all stakeholders while ensuring diversity in geographic and cultural representation.

There are radiological protection challenges related to the deployment of small modular reactors (SMRs) and a dedicated task force was established in October 2022 to identify challenges and areas of potential work associated with SMR deployment. Among ten or so challenges identified, a few areas of potential further work were prioritised: emergency preparedness (EP) and protection strategies applicable to SMRs (including but not limited to a comparative analysis of regulatory graded approaches to EP applicable to SMRs and other related topics); occupational exposure optimisation and provision of guidance for SMR design, licensing and operation (e.g. considering significantly different operating, maintenance and support regimes); public communication and siting of SMRs and provision of related guidance (e.g. addressing communication challenges arising from the novelty of the technology, public concerns regarding unconventional siting, implementing a revised stakeholder engagement process). There is currently an ongoing analysis of opportunities for engaging with other NEA activities on SMRs.

A further important topic deals with nuclear post-accident food safety framework. An expert group has been established to look at developing high-level advice on how to develop consumer trust and confidence in food and how to facilitate national and international trade in the medium- and long-term following an accident. The expert group will also consider appropriate terminology for risk communication and stakeholder engagement to ensure transparency and clarify available international guidance and standards that are applicable, including what to use, when and where. Operational guidance will also be developed, including a scientifically-based mechanism for an independent validation of the approach taken to food monitoring and control, and advice on possible instruments to facilitate endorsement by NEA member countries and beyond.

The NEA is also working to continue improving countries' preparedness for nuclear and radiological accidents through international nuclear emergency exercises (INEX). The INEX series began in 1993 and has a long history of testing key issues associated with EPR. The next exercises (INEX-6) will run from January to March 2024 with a focus on long-term recovery. The exercises are run through topical modules focusing on aspects such as health, food safety, remediation and decontamination and waste management and provide an opportunity to test the NEA's operational guidance on post-accident recovery preparedness applicable at the national level that was published in 2022. Part 1 of the guidance focusses on key elements of preparedness for recovery and the development of a framework for recovery. Part 2 is then focused on the objectives for recovery that should be established by the government and aim to ensure health and well-being, support for the economy and protection of the environment. Part 3 focusses on how those objectives can be achieved and progress assessed. Cross-cutting themes include stakeholder engagement and building resilience. INEX-6 will help improve guidance and identify where more work is required.

Practical guidance for mental health and psychological support (MHPSS) in radiological and nuclear emergencies is also being developed. This forthcoming NEA publication will provide a comprehensive guide on how to consider mental health in protection strategies for preparedness, response to, and recovery from radiological or nuclear emergencies, building on World Health Organization (WHO) recommendations on this topic. The guidance supports an all-hazards approach and addresses unique risk factors of radiation emergencies, such as the perception of risks associated with radiation exposures. It includes a summary table of actions and 28 detailed action sheets for various themes, e.g. integrating MHPSS into needs assessments, public communication strategies, services for host communities, clinical referrals, and mental health monitoring.

For the transfer of knowledge to the next generations and strengthening of radiological protection expertise globally, the NEA ran a first edition of the nuclear risk communication training course in December 2022 in Bratislava and a second edition in November 2023 in the UAE. A fifth edition of the annual international radiological protection school was also run in 2023 in Sweden. The school is intended for early- and mid-career radiological protection professionals and provides professional development for around 50 students per year.

The current workshop provides an opportunity to start thinking about whether national regulatory frameworks for radiological protection are flexible enough to be able to adapt to armed conflict situations and to identify measures that are appropriate and the gaps in existing arrangements, and to draw up a list of preliminary actions. The outcome of the workshop will help shape future operational guidance for radiological protection during and following armed conflict, which is the topic of a two-year project that will begin in 2024 in the framework of the OECD country programme for Ukraine.

3. Session 1: Resilience practices from a human and organisational factor perspective – Focus on occupational radiological protection

3.1. Radiation monitoring in conditions of military operations and occupation of a nuclear facility (Valentyn Kostenko, Energoatom)

On 24 February 2022 a full-scale invasion of Ukraine by Russia began. From the first day, aircraft-shaped missiles were recorded over nuclear facilities, which presented new challenges and risks for ensuring the safety of nuclear power plants. With the attackers not firing exclusively on military targets and the large number of attacks, the probability of a missile hitting a nuclear site was and remains high, Energoatom said during its presentation to the workshop. There is therefore a significant probability that nuclear radiation incidents could occur at such facilities.

In the period from 24 February to 4 March 2022 there were military operations at the Zaporizhzhia Nuclear Power Plant. In agreement with the regulator, the volume of air and precipitation radiation monitoring was reduced to a critical minimum in the area of the nuclear power plants due to the risk of shelling and death of nuclear power plant personnel. On 4 March, the Zaporizhzhia Nuclear Power Plant was captured by Russian troops. Damage was sustained to the integrity of administrative and technological facilities as a result of shelling and radiation control was limited to the channels of the automated radiation control system at the site and gamma background control in the adjacent area.

On 17 May 2023, by order of the occupiers, the system for technological information transmission to the regulators server was physically disabled so both the operating company and the regulator lost access to information about the radiation safety conditions at the site. A network of autonomous radiation control posts was therefore placed to ensure appropriate radiation monitoring of the controlled territory of the Zaporizhzhia Nuclear Power Plant could continue. Furthermore, since June 2023, a mobile radiological laboratory has been in standby mode close to the Zaporizhzhia Nuclear Power Plant. The mobile laboratory is capable of monitoring radiation in air, soil and precipitation should changes in gamma background be detected or if information about unusual situations at the occupied Zaporizhzhia Nuclear Power Plant were to be received. Following destruction of the Kakhovka hydroelectric dam, measurements of Dnipro River water were also carried out.

A further risk caused by the invasion was missile strikes on Ukraine’s energy infrastructure. Long-term power outages and blackouts prevent the operation of the automatic radiation control systems due to loss of power to the equipment and disconnection of communication systems. In order to reduce risks, a system of autonomous sensors with satellite communication channels was deployed with the technical assistance of the US Department of Energy (US DoE).

Taking into account the unpredictability of the occupiers’ actions and dangers to the Zaporizhzhia Nuclear Power Plant territory, daily projections are performed of radiation accident consequences for nuclear accident and severe accident scenarios. In addition to a severe accident at the power unit, the destruction of SNF containers in a dry storage facility is used as a postulated event. For future risks, experience of the consequences of Russian occupation of radiation-hazardous facilities in Ukraine, including the Chernobyl Nuclear Power Plant’s radiological laboratory, is used. Following de-occupation of the CEZ, it was discovered that the Chernobyl Nuclear Power Plant radiological laboratory had been physically destroyed and equipment within was either destroyed or stolen. A worst-case scenario is therefore assumed for the Zaporizhzhia Nuclear Power Plant after de-occupation where radiation control systems are inoperable or destroyed, the nuclear power plant site and territory outside the site are contaminated, and critical safety equipment is missing or severely damaged. It is further assumed that there will be a severe shortage of personnel available to ensure radiation safety measures. Therefore, to eliminate potential consequences and to transition and maintain the nuclear power plant in a safe operating condition, the operating organisation is developing measures aimed at normalising the situation at the nuclear power plant and ensuring radiological protection.

The main risks for radiological protection during military operations and occupation of nuclear facilities are therefore concluded to be:

- radiation incidents caused by external impacts not foreseen in nuclear power plant designs;
- partial or complete loss of control over radiation conditions at facilities;
- decommissioning or physical destruction of radiation control equipment and the resultant loss of critical data and information for operators;
- potential radioactive contamination of territories due to violation of the requirements of non-proliferation of radioactive contamination;
- mine danger and danger during shelling for the personnel of the site; and,
- shortage of qualified personnel caused by various factors.

3.2. Adaptive decision making in nuclear emergency response: A view from the control room (Salvatore Massaiu, IFE)

Decision-making research has been undertaken over many years at the Halden Human Machine Laboratory by performing full-scale simulations of a nuclear power plant control room operation. Resilience is a broad concept and the focus of the presentation was therefore on resilience as adaptation to the unexpected. Factors causing the unexpected include unpredicted variability, multiple malfunctions and deviations from design expectations.

A meta-study on resilience engineering looked at the evolution of research from theoretical development to practical deployment (Patriarca et al., 2018) and identified five key areas of research: resilience engineering and improvisation; the need for resilience engineering; resilience engineering for modelling; defining and exploring resilience engineering; and reflecting on resilience engineering. Improvisation and reflecting on resilience engineering were the two areas where the number of studies continues to rise. Overall, resilience is considered quite a new concept and adaptation is at the core of the concept.

Within the nuclear industry, the idea is that good procedures are in place so there is no need for adaptation – operators are directed by the procedures to the appropriate response without the need to interpret information or consider possible causes, consequences, etc. However, empirical studies present a different situation. For instance, a study from Korea (Park et al., 2016) indicates that steps can be skipped due to the belief that if one step is true then previous steps must also be true. In an example from the Halden Human Machine Laboratory, in a simulated accident involving loss of coolant outside containment, there were many actions not directed by procedures that showed autonomous situation assessments and decisions, independent diagnoses, repeated actions, actions outside procedures and anticipated actions. In well-trained accident scenarios, the expected procedural progression is often seen, although different timings of actions may affect progression. With less trained, more complex accident scenarios, the procedure progressions are different from crew to crew and difficult to predict.

Within the nuclear industry, anticipation involves optimising the system and, if a person can be replaced by automation, this is often done to reduce human variability. Where this is not possible, training and procedures are provided to guide and constrain people's actions within safety boundaries. The use of technology can also help constrain people's actions. Detailed procedures for all feasible accidental scenarios are developed. At the same time, it needs to be recognised that accidents in complex systems typically deviate from expectations and plans and procedures have to be adapted to the actual situation. To allow for adaptation there should be some consideration for flexibility within the system. Procedures, training and technology should be designed to support adaptive human decision making. As it can be difficult to anticipate the exact conditions of a real accident, in addition to detailed procedures incorporating "the one best way" to accomplish the task in the most likely situation, it is necessary to know what alternative strategies the operators may use to accomplish the task and provide support to these.

The concept of designing for adaptation has been part of some engineering programmes, and particularly of cognitive systems engineering, with the main goal being to design technology, training and work processes that support decision strategies people may use when acting adaptively. There is a history within the nuclear sector of highlighting the importance of anticipating possible scenarios and this needs to continue to ensure good plans and procedures and to also continue with education and training, developing systems with appropriate interfaces, alarms and expert systems and maintaining good organisational leadership and safety cultures to implement such plans. In order to build resilience, it is also necessary to be ready for unlikely yet possible events and scenarios and to ensure that the system (people, technology, procedures) is adequately adaptive. From a systemic and functional perspective, adaptation can be seen as made up of verification and reconfiguration. Plans need to be verified to ensure they are working well: the system needs to detect and follow up anomalies and, given a tendency to explain away evidence that runs contrary to the plan, there is also a need for independent assessment (a second pair of eyes) from the main decision maker (this is why there is the shift technical advisor in the control room). Redundant checks are also a common strategy for verifying that the plans are working. For instance, plant personnel are sent outside the control room to do inspections in order to provide additional information. If current plans and procedures are not working, it is necessary to have the capacity to interrupt the existing plan, carry out new evaluations and develop new plans. The concepts of verification and reconfiguration can be applied outside the control room in any dynamic decision-making context.

3.3. Facing disruptive situations by developing resilience capacities: The experience of COVID-19 and initial perspectives of how it can be applied to a wartime context (Tania Navarro Rodríguez, NEA WGHOF)

Disruptive situations take time to be addressed and the COVID-19 pandemic provides an opportunity to consider experiences gained on how the nuclear sector responded from organisational and human perspectives and to reflect on how to manage the unexpected. The Working Group on Human and Organizational Factors (WGHOF) under the NEA Committee on the Safety of Nuclear Installations (CSNI) established a new task specific to this topic in early 2022 and is due to conclude this activity in 2025. The task group aims to consider the operating and regulatory experience in managing the pandemic from an organisational and human perspective and to look at lessons learnt with respect to organisational adaptability and resilience, including long-term impacts and future challenges that may occur as a result of response and adaptation over the long-term. The task group will also look at good practices, new potential risks and safety issues introduced by the pandemic for which new research may be needed and to consider information and learning relevant to the nuclear sector

Insights from three perspectives are considered:

- resilience of organisations in the nuclear sector;
- resilience and the experience of different sectors (beyond the nuclear sector); and
- resilience and the role of management and leadership.

The resilience of organisations in the nuclear sector, in terms of the measures taken during the pandemic and regulatory experience, identified two main points. First, adaptability within the nuclear sector is based on the industry's preparedness for large crises. Regulatory frameworks are in place concerning essential service provider status and business continuity plans and historical experience in handling emergency situations all helped in managing risks during the pandemic. Strategies were also implemented to secure workforce availability during sickness and stockpiling of goods and equipment all contributed to continued functioning within the industry and in the management of risks during that period of time. Second, regulators were pragmatic and flexible in their decision making, with the objective of enabling facilities to continue operating within a constrained situation by approving operator requests for exemptions, exceptions and deferrals. There was a minimal impact on the scope and depth of control and inspection activities, with new remote approaches being developed or activities being modified.

The availability of the workforce was crucial to the management of risks during the pandemic, but working conditions deteriorated in many nuclear facilities. From national experiences, some fundamental aspects were identified. For example, the response to the pandemic was largely based upon the reactions and co-ordination among local and national entities and the response in different countries was affected by the national history in terms of previous experience and lessons learnt in crisis management. The importance of context was also highlighted – success may be possible under certain circumstances and conditions but may not be possible with a changing context, even in the same country.

The resilience and experience in different sectors also provide learning opportunities. The task group looked at the response of the aviation industry and health sectors. Commonalities identified from these different sectors were that the pandemic highlighted pre-existing fragilities around competency loss and lack of attractiveness for certain professions. The hospital sector was the most vulnerable activity sector prior to the pandemic but had plans in place to manage exceptional workloads and practices had been tested in previous epidemic and pandemic situations. The civil aviation and nuclear industries were less vulnerable but were also less prepared to deal with the crisis due to a lack of experience. Many measures were implemented during the crisis that proved to be helpful in managing risks but did not explain the adaptation capacity of the organisations. The continuity of activities was possible due to exceptional mobilisation of personnel and adaptability of the organisations.

Six central points were identified from the cross-sectorial pandemic experience and response in terms of resilience and the role of leadership:

- know how to anticipate and react wisely;
- develop supportive management;
- adapt collectively with effective teamwork;
- encourage creativity;

- establish partnerships;
- be accompanied and guided by oversight.

The task group is looking to present proposals regarding how the COVID-19 experience could be applied in a wartime context.

One topic identified was the adaptation of organisations to ensure continuity over time. A specific feature of the pandemic was the isolation of individuals due to social distancing and this could be an object of consideration during wartime due to fear, stress and uncertain work conditions in both collective and individual perspectives. The availability of the workforce was another important characteristic of pandemic management and could also be a challenging issue under wartime circumstances. Stockpiles of goods and equipment were also critical aspects during the pandemic and, in a context in which access to nuclear facilities is limited due to war, stockpile availability could also become a crucial issue in the medium and long term. Implications in terms of organisational issues would benefit from further in-depth study, including existing EPR and lessons learnt during conflict to identify new factors that may need to be taken into account.

Concerning interdependencies of nuclear installations with respect to other critical infrastructures, such as the electric power grid, armed conflict gives rise to interconnected and at times competing issues relating to ensuring the safety of nuclear power plants, including ensuring workforce availability, which is crucial to nuclear power plant function. Nuclear power plants are crucial in supporting, but also reliant on, the electrical power infrastructure and also rely heavily on a suitable water supply as heat-sink. All such interdependencies need to be carefully considered when dealing with issues around organisational resilience in times of armed conflict.

A further topic relates to decision making and the regulatory framework. Decision making tended to be more flexible and simplified during the pandemic. In a wartime context, decision making could become unclear due to the intervention of hostile forces and unsafe working environments (e.g. conflicting messages, adaptation of communication channels) and there may also be systemic disruption that may need to be considered, including with regulatory authorities. Approaches used for inspections were adapted during the pandemic to allow for remote and/or hybrid inspections whereas different approaches (IAEA missions) have been developed in the case of war circumstances.

An important issue highlighted by the war is the need for communication between nuclear installation personnel and their families and there is an opportunity for developing and implementing internationally agreed procedures for such communication. Trade unions played an important role during the pandemic in collecting information from workers and mediating with organisations and could also play an important role in a wartime context.

Key questions arising are how to build safety in a wartime context, how to strengthen security and safety issues in a long-term unsafe context, and how to ensure protection of nuclear facilities, occupied or not, in a territory facing war.

3.4. How should a licensee integrate a more resilient approach into its management system? A regulator's view from the lesson learnt from unexpected events (Hiroko Takada, NRA)

The Japanese response to the COVID-19 pandemic has been examined. The first case reported in Japan was on 15 January 2020. The initial response to the first wave was different to that in other countries with a soft lockdown (non-enforceable) being implemented. The soft lockdown aimed to control infections through changed public behaviours while maintaining employment through sustained economic measures. The government managed, therefore, to maintain solidarity among the public and gained public co-operation for the soft lockdown. However, rising infections led to a state of emergency being declared on 8 April 2020. The state of emergency limited the actions of members of the public. The actions implemented by the state of emergency were lifted in a step-by-step approach that began on 14 May.

During the phase 1 response that ran from early February to 18 March, the government set up an expert initiative that involved external experts with experience in dealing with the influenza pandemic of 2009. The expert group was established on 14 February but had no legal authority. During this phase there were 17 expert meetings held, but there were conflicting opinions among the experts about disseminating information in a timely manner. However, an opinion was issued by the experts on 9 March committed to the message of the 3 C's (closed spaces, crowded places and close-contact settings) that had a positive impact on public reaction.

Phase 2 ran from 19 March to late April. A revised act on special measures for new infectious diseases preparedness and response took effect on 14 March and experts in the social sciences and economics were added to the expert discussion groups. To prevent a negative public reaction, there was a change from "expert opinion" to "situation analysis and recommendations" (i.e. forward learning) in the communications from this expert group. Experts recognised there was a gap in the degree of the sense of the crisis response and the government began to consider issuing a state of emergency, but the strategic objectives of the initiative first needed to be confirmed. There was conflict between experts that wanted quantitative targets for change in behaviours to be set and the government that did not. In the end, the experts discussed this directly with the Prime Minister and created the phrase of "change of behaviours" with a target of at least 70% public compliance and as close as possible to 80%. Drawing on the opinion of the experts therefore worked well in terms of government decision making.

Phase 3 involved a change to how information to the public would be disseminated and further expert panel discussions in early to mid-May took place to discuss the lifting of the state of emergency. There continued to be differences in the opinions as regards maintenance of public safety, the public sense of security and social and economic factors. There were also differences in opinion between the individual experts in the panel and the Prime Minister. In a news conference on 4 May, the Prime Minister stated that the government would consider lifting the state of emergency following an assessment to be made by 14 May and the state of emergency was lifted on that day. No further expert meetings were held after that date.

The role of the expert meetings and relationship with politicians in response to the first wave of COVID-19 infections changed in response to the evolving situation of the pandemic in Japan. The climate of trust and mutual respect fostered over time between decision makers and experts was the cornerstone in creating an effective response to the pandemic, rather than ad hoc national measures due to a lack of advance preparation. Based on this fact, perspectives on how to integrate a state of resilience within the management system are, based on the above documented experience, as follows:

- organisations should build a relationship of trust and respect between leaders and experts;
- organisations should clarify the role of experts under extreme circumstances;
- the availability of experienced personnel that can be immediately utilised should be established;

- political and resilient leadership is also important and should have systemic perspectives, such as looking at the balance between safety, economy and human/organisation; and
- organisations should consider ways of resolving disagreements in advance of the crisis situation.

3.5. Occupational radiological protection in wartime (Shengli Niu, ILO)

The International Labour Office (ILO) is a tripartite organisation with worker and employer representatives taking part in its work on an equal status with those of governments. The number of member countries currently stands at 187 and, in 1969, the ILO was awarded the Nobel Peace Prize. The mandate of the ILO is to improve conditions of labour through, among others, protection of workers against disease or injuries arising from employment. The perspective of the ILO is that everyone has the right to earn a living in an environment of freedom, dignity and security. To date, the ILO has issued close to 200 legally binding conventions around employment, social security and human rights.

There are five fundamental principles and rights at work that member countries are legally required to fulfil:

- freedom of association and the effective recognition of the right to collective bargaining;
- the elimination of all forms of forced or compulsory labour;
- the effective abolition of child labour;
- the elimination of discrimination in respect of employment and occupation; and
- a safe and healthy work environment.

Furthermore, in 2015, countries adopted a set of 17 sustainable development goals aimed at ending poverty, protecting the planet and ensuring prosperity for all. Each goal has specific targets to be achieved. Goal 8 is focused on sustainable development through decent work and economic growth.

Standard setting is one of the ILO’s main means of action for improving conditions of life and work worldwide and those standards are in the form of conventions (or protocols) and recommendations with the former being legally binding and requiring translation into national laws and regulations. Convention 115, adopted in 1960, is the only legally binding ILO Convention for the protection of workers from ionising radiation. The Convention, ratified by 50 countries, applies to all activities involving exposure of workers to ionising radiation in the course of their work.

Implementation of the Convention was reviewed across countries and reported to ILO’s annual International Labour Conference. Key areas examined for Convention No 115 include the system of radiological protection, application of dose limitations, protection for pregnant and breastfeeding female workers, dose limitations for persons between 16 and 18 years and for emergency workers, worker health surveillance, and discontinuation of work and alternative employment for workers with medical contraindications. The review reports indicate the implementation of requirements in the ratifying countries of the Convention.

Since the war in Ukraine, a further review of the application of international labour standards was undertaken (ILO, 2023), noting that for Convention 115, the actions of Russia with respect to the Zaporizhzhia Nuclear Power Plant had led to a deterioration in working conditions and the safety of workers. The ILO Governing Body meets approximately three times per year. After February 2022 the Governing Body met and reviewed the situation for occupational exposures for workers at the Zaporizhzhia Nuclear Power Plant. The ILO adopted a resolution in March 2022 calling for an immediate ceasefire and urging Russia to fulfil all legal obligations for the protection of workers under Convention 115, which it has ratified.

Several reports were issued on developments relating to the resolution concerning Russia's aggression against Ukraine from the perspective of the mandate of the ILO (ILO, 2022). The 2022 report summarises issues relevant to workers under armed conflict situations. Key issues identified with respect to radiological protection of workers during war include:

- Unstable electricity supply/electricity outage, persisting extremely unsafe working conditions, no access to PPE, potential increased exposure to radiation, emergency response and occupational safety and health management systems are no longer functioning effectively.
- Reduced staffing levels, increased workloads, prolonged working hours and additional shifts, psychological pressure from the ongoing military conflict.
- Absence of family members and community support.
- Employment contracts, possible situations of forced labour.
- Murder, imprisonment and aggressive pressuring of staff.
- Physical danger due to the presence of landmines, shooting, and shelling in the vicinity of the workplace.
- Destruction of safety-related equipment and radiation monitoring systems; disruptions to maintenance and security supplies; and other grievances endangering the lives and workplaces of plant workers.

The impacts of armed conflict in Ukraine are being watched closely. The obligations under Convention 115 need to be fulfilled and Russia is repeatedly urged to meet those obligations. The ILO is working closely with the Government of Ukraine and other organisations to respond to the needs of the country and is co-ordinating activities with relevant international partners including the IAEA.

3.6. Discussion

The presentations in Session 1 brought different perspectives to the issues, ranging from firsthand observations of critical human performance operational issues from the Zaporizhzhia Nuclear Power Plant operator to research and practical implementation issues raised from the NEA and national authorities based upon experiences during the COVID-19 pandemic and the ILO's perspective on legal obligations for workers in situations of armed conflict based upon current conventions. Further, discussions were focused around human organisational factors and human resiliency specific to the issue of radiological protection of workers and regulatory framework aspects relating to armed conflict situations, with the objective of identifying and prioritising gaps that need to be addressed.

It was clear that there was a need to better connect current observed operational issues due to the conflict in Ukraine with human and organisational studies drawn from lessons learnt due to COVID-19 and other recent events such as the Fukushima Daiichi Nuclear Power Plant accident. Presentations from Ukrainian participants illustrated how work needs to adapt to new situations during armed conflict situations and one learning point is that considering worst-case scenarios in advance can help in developing preparedness and resilience. It is unlikely that preparedness during peace times will reach the level necessary in wartime situations but considering different scenarios can help ensure that people and organisations are in a better position in terms of adaptability as a result of training, exercising and other preparedness mechanisms.

From an ILO perspective, workers are not soldiers and continue to have the right to work in safe environments, even in conflict situations, and all major players have obligations and duties to ensure their continued safety. Rules should continue to be applied and employers have a duty to ensure those rules are followed as workers also have a role to play in ensuring they follow those rules where possible. This is why Russia is continually asked to fulfil its obligations under Convention 115. The ILO is assisting in the development of the radiological protection system, linking the Convention to the latest ICRP recommendations and IAEA standards to ensure the Convention remains up to date and reflects the current state of the art.

The gap between decision makers and experts has been discussed regularly, particularly in light of the COVID-19 pandemic and the Fukushima Daichi Nuclear Power Plant accident. Management systems that cover off-normal extreme situations should be in place and effective use of these can assist the leadership (and worker) roles in the case of unanticipated crisis events. However, in a conflict situation, it is necessary to adapt to the situation as it relates to occupational radiological protection practices. For example, it is clear from the recent experience in Ukraine that the occupier will not in all likelihood follow prescribed rules. However, the professionalism and dedication of workers (supported by a strong safety culture) led to workers remaining on site to meet their obligations while ensuring the fundamental radiation safety objectives are adhered to in order to protect themselves, the facility and the wider population. Whether or not it is possible to maintain existing regulations under conflict situations very much depends on the occupiers and the resultant actions and decisions of the operator and regulator may need to be made based on circumstances that are not under their control. It is important, therefore, to have systems in place that allow for continued monitoring to provide the information necessary to underpin decisions. For example, in the vicinity of the Zaporizhzhia Nuclear Power Plant a mobile monitoring laboratory has been deployed to maintain awareness of the radiation situation in the vicinity of the site. Greater reliance may be placed on more passive monitoring systems during armed conflict situations. Once a facility is able to recover following occupation, detailed measures can be established to bring the facility and operations back to a normal safety stance.

For the nuclear power plants that have remained under Ukrainian control, the radiation situation has remained stable and workers continue to operate under the current radiological protection controls. The radiation situation at the Zaporizhzhia Nuclear Power Plant is currently stable, but this could change in the future due to the involvement of non-qualified workers, a lack of staff, delayed equipment repairs and maintenance, etc. It has not been possible to maintain the same controls and monitoring that were in place prior to the Russian invasion. This is, in part, due to the need to consider new (non-radiological) risks when considering radiological protection measures to be taken.

From experience gained during the COVID-19 pandemic the idea of a graded approach has been considered, noting that long-term management requires adaptation of approaches. There are some similarities between the pandemic and the war in Ukraine in terms of applying a graded approach but a key difference is that there can be very different perspectives in terms of the functions of facilities, etc., with war situations presenting many more critical unknowns for the continued safe operation of nuclear installations. From the COVID-19 experience it is clear that many installations coped as a result of having business continuation plans in place, even though initial measures needed to be adapted to take account of the situation at play and that time was an important factor that needed to be taken into account.

There is a lack of guidance and lessons learnt with respect to human performance resilience during conflict situations. The NEA provides an important network and has an important role in disseminating information and establishing connections with other programmes. It is important to continue to share and learn from experience. The war in Ukraine presents new experiences but there have been past conflicts internationally and experience in addressing radiation accident situations such as Chernobyl. It may be possible to gain valuable lessons by looking at past events and considering what has been implemented in different international contexts. Continuing to collect information on experiences gained and lessons learnt will help build resilience for future events. There can also be merit in considering whether there are lessons that can be learnt by looking back at whether additional systems in place (or adapting systems) could have helped in addressing the situations now being faced, for example if war scenarios had been considered in EPR exercise scenarios, their development and conduct. One learning point identified was that there would have been benefit in establishing more resilient radiation monitoring systems with different and possibly more robust communications channels that could help maintain and protect stable information flow.

Design basis threat assessments can be updated to take account of threats during armed conflict (e.g. drones, missiles), but the only way to ensure radiological protection and nuclear safety at installations is to protect them from illegal occupation. Safe operations can only be maintained when installations are under state control.

Where aggressors fail to meet international conventions and obligations, there are few courses of action that can be taken. Countries or parties (in the case of non-state actors) can be named and shamed, leading to a loss of international reputation. Alternatively, the International Court of Justice can be called upon.

4. Session 2: Characterisation of the radiological situation and environmental monitoring systems

4.1. Consequences of occupation for the safety and security of radiation sources of the National Scientific Centre "Institute of Metrology" (Nataliia Rybalka on behalf of Volodymyr Skliarov, National Scientific Centre "Institute of Metrology")

The National Scientific Centre "Institute of Metrology" is located in the northeast of Ukraine in Kharkiv. The institute provides metrology for society (e.g. development of measurement methods and instruments necessary for all spheres of human living and household activities) and the economy (ensuring traceability, calibration and verification of measuring instruments) and collaborates internationally with the objective of eliminating technical barriers in trade through unification of measurement systems. The Institute has established 54 national measurement standards for different measurements including mass and related quantities, time and frequency, length, thermometry, electricity and magnetism, photometry and radiometry, and ionising radiation. There are ten national measurement standards in the field of ionising radiation.

In 1992, the Scientific Centre of Quantum Measurements was established to ensure metrological accuracy for the nuclear industry in Ukraine. The building consists of four floors (two of which are underground) and is equipped with both physical and radiological protection systems. During the period from 2005 to 2008, radon-222 measurement intercomparisons were conducted and the positive results of calibrations confirmed measurement capabilities and established the national standard of the unit of volume activity of radon-222. Subsequent national measurement standards established at the institute include:

- national standards of the unit of activity of radionuclides (e.g. Cs-137 and Eu-152);
- national standard of flow unit and density of neutron flow;
- national standard of the units of absorbed and equivalent doses of neutron radiation;
- national standard of the unit of absorbed dose, power of absorbed dose of X-ray and gamma radiations;
- national standard of the units of equivalent dose, power of equivalent dose of X-ray and gamma radiations;
- national standard of the units of exposition dose, power of exposition dose of X-ray and gamma radiations;
- national standards of the units of volume activity of alpha-radiating aerosols and gamma-radiating aerosols.

Through an IAEA national project, the metrology centre received radiation therapy dosimetry equipment to increase the quality of radiation diagnostics and the safety of radiation workers and members of the public through improved accuracy and improved dosimetry practices. The equipment included an X-ray calibration system and a Co-60 source.

From 24 February to September 2022, the Scientific Centre of Quantum Measurements was in the temporarily occupied zone and buildings were occupied and appeared in the front line of military actions. The structural integrity of the building was partly damaged as a result, with damage to the roof and windows, electricity supply was lost, and flooding occurred in the lower floors. Furthermore, the licensee was unable to ensure the physical protection of the two X-ray facilities and 435 sealed radiation sources located in the building, 31 of which were categories 1-3.

The buildings and equipment within were used by occupying soldiers and the consequences for national measurement standards have been large because of damage sustained to facilities and buildings. Equipment and sources have been lost and facilities and equipment installed by the IAEA have been stolen.

As a result of the minimal distance to the border with Russia (around 7 km) there are numerous ongoing military threats, including the threat of artillery and missile attacks, mining of the territory and prevention of access to the building. Under these circumstances it has been difficult for the licensee to maintain control of radioactive sources and it has been too dangerous to carry out a physical inventory of radioactive sources and fully assess the damage caused and quantitative losses of sources. However, some urgent measurements have been made. When shelling diminished, a radiation survey of the building and its surrounding areas was conducted with the conclusion that there was no radiation contamination, but some sources were absent from designated storage areas and there was some evidence of containers having been opened. Some primary measures were also taken to increase the physical protection of the building by strengthening doors and windows to reduce the risk of further unauthorised access to the building. A decision was also made in light of the circumstances to transport the remaining radiation sources to safer locations for temporary storage. The programme consisted of two phases. The first involved preparatory work for the safe transport of sources (i.e. measures to prepare transportation packages). The second phase then consisted of a transportation programme of the sources by a licensed organisation. The programme was agreed with SNRIU.

The loss of specialised equipment during occupation has made ongoing work complicated and there is an urgent need to restore the technical equipment of the Scientific centre, including containers for sealed radioactive sources and neutron radiation sources; dosimetric and radiometric instruments such as personal electronic and wearable dosimeters; and special equipment for handling sources and containers, such as remote grippers and trolleys for moving heavy containers. A large amount of equipment was lost, including the X-ray irradiator that had been supplied through the IAEA technical assistance programme that played a crucial role in improving the quality of using ionising sources in radiotherapy. The State has therefore requested further assistance to enable the facility to be renewed and the standards laboratory recovered.

The Institute's activities have been made impossible as a result of the war. Due to the proximity to the Russian border, there remains uncertainty about future activities of the Institute in the field of ionising radiation metrology.

4.2. Findings and performance of the SURVEY project: Environmental monitoring results in areas temporarily occupied by Russia and now liberated (Svitlana Chupryna, SSTC NRS)

Since the first days of the invasion there were serious concerns about the movement of military troops in the CEZ. The CEZ received considerable contamination as a result of the 1986 Chernobyl accident and the territory, unsuitable for occupancy, has been used for radioactive waste management. The movement of heavy machinery through the CEZ posed threats to radiological well-being due to the dispersal of radioactive contamination outside of the CEZ from broken contaminated topsoil, destroyed protective barriers of historical waste storage trenches and theft of radioactive sources and samples. Considerable quantities of material on roads towards Kyiv and the risk of further spread of contamination caused public concern and the looting of laboratories further added to social anxiety. A radiation survey of liberated territories was therefore planned and a project proposal was submitted to the DSA.

The objectives of project SURVEY were:

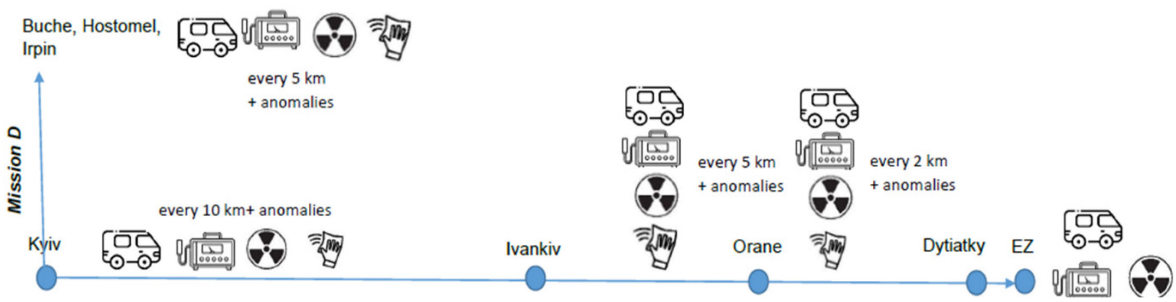
- to conduct radiation surveys in the Kyiv region;
- to reduce risks of public exposure due to contact with radioactive sources or radioactive contamination; and,
- to reduce public anxiety associated with possible radiological risks.

It was expected that the results of the project would help in communicating possible radiation risks to the public, help assess public exposures, and perform an initial assessment of the quantity of radioactive material transferred beyond the CEZ boundaries. Furthermore, the project would lead to experience being gained in conducting radiation surveys on territories liberated in the future.

The radiation situation in the CEZ changed immediately following the invasion, with the automated monitoring system within the CEZ recording gamma dose rates up to 70 times higher than the average on day 2 of the invasion before the system stopped sharing data. Following the Russian retreat, the regulator requested a physical inventory of materials and it was discovered that materials, including calibration sources and laboratory samples of contaminated media and radioactive material, were missing.

The Kyiv region that had been under occupation was selected for survey with monitoring performed using a mobile laboratory with fixed detectors. Portable hand-held detectors were also deployed. Several survey missions were undertaken, with mine hazards restricting some surveys. Surveys therefore required State emergency services to ensure mine safety. The survey strategy is illustrated in Figure 4.1.

Figure 4.1. Radiation survey strategy



Gamma dose rates and gamma-emitting radionuclides were analysed using the mobile laboratory. Manual measurements of gamma dose rates at 1 m were also taken and soils sampled for contamination analysis. Overall, the survey included 15 localities, 63 apartments, 132 private houses and yards, 130 public places and facilities and over 880 km of streets and roads. Over 300 household and military potentially contaminated items were surveyed.

The main results of the SURVEY project were that no evidence of deterioration in the radiation safety of the public was found. There were no sources of radioactivity found in homes and apartments or contamination of roads and roadsides, with dose rates being typical for the area. In some houses Cs-137 was detected in ash from furnaces due to wood contamination from the Chernobyl accident. In one school an old dosimeter was located and luminous radium was detected but there was no contamination in other rooms. Where access was possible in the CEZ, no higher levels of contamination were observed with measurements being similar to those from before the war.

Issues of public concern were addressed, with people being invited during the planning stages to request a survey of their private properties if they had concerns. Meetings with local authorities were also held to collect more information on where troops had been deployed as a means of disseminating information on the project and its results. Results were also made available on the web and broadcast on online platforms to reach a wide audience. Public lectures and webinars were also arranged to further disseminate results. An event was arranged in the town of Bucha, where residents were provided with information on the mobile laboratory and equipment demonstrated and an exhibition called “The Ruined Boundaries” was established in the Chernobyl Museum of Kyiv.

From the experience gained as a result of the SURVEY project it can be concluded that routine methodologies used for emergency response purposes do not need to be adjusted for war situations, but planning stages need to involve military administration, army and local authorities, and those conducting surveys need to focus on their own safety. Finally, communication strategies should be based on the social peculiarities of the liberated territories.

The survey of territories in Ukraine will be a long-term process as more territories are liberated, but the results of the SURVEY project will help inform future monitoring and survey activities. The preliminary assessment of radiological consequences of the hostile military occupation of the CEZ has recently been published (Balashevska et al., 2023) and the continued bilateral co-operation activities of the DSA, particularly during wartime, were gratefully acknowledged.

4.3. Source term characterisation and subsequent dispersion resulting from military activities (Luke Lebel, CNL)

Starting with an anecdote, in 2018 there was an IAEA research project on SMR emergency planning involving a lot of discussion around accident scenarios and probabilities. A scenario presented by one of the participants was an SMR being hit by a guided bomb, affecting the integrity of the reactor. The scenario was met with silence as consideration had not been given to this topic previously. Now we are facing the reality that such a scenario could occur.

CNL has undertaken an analysis of the safety of nuclear facilities in war zones, supporting efforts within the government of Canada for the department of Global Affairs, quantifying the types of hazard that might be experienced and the risks associated with those hazards. This includes risks associated with reactors being attacked directly or affected by the loss of infrastructure. Spent fuel ponds, spent fuel assemblies and low and intermediate level wastes were included as hazards to be taken into account. The analysis looked at vulnerabilities and the potential for release of radioactivity.

Reactor-related incidents have large hazards associated with them. Military activities or occupation of a site could result in loss of safety systems and barriers that could result in accidents. This could involve direct damage to reactor buildings or their power supplies or result from errors by plant staff due to hostage situations. The result could effectively be a station blackout sequence, while sabotage could result in more complex sequences, though this is considered less likely due to robust containment. The nuclear power plant may or may not be operating. If the plant is shut down, short-lived radionuclides are likely to decay away, reducing the hazard and shifting releases towards longer-lived radionuclides such as Cs-134/Cs-137.

Spent fuel ponds contain several years' worth of core inventory and may be located either inside the containment area or in an adjacent building. There are many similarities between reactor and spent fuel accidents, with similar volatile long-lived fission products releases being the main hazard. Spent fuel ponds outside of containment would be more vulnerable, but the building and pool water would still provide some degree of protection. Direct attacks could also produce explosively released fuel materials.

Dry cask-related incidents are more difficult to direct attacks against. Dry cask storage areas also contain several years' worth of core inventory, but the inventory is divided into individual casks that are passively cooled and do not rely on external safety systems. They are therefore less vulnerable to induced accidents. They are, however, located outdoors and would therefore be the most vulnerable to targeted attacks that would be associated with high hazards. Explosive events could result in aerosol releases including fuel particles with high actinide content in addition to long-lived fission products.

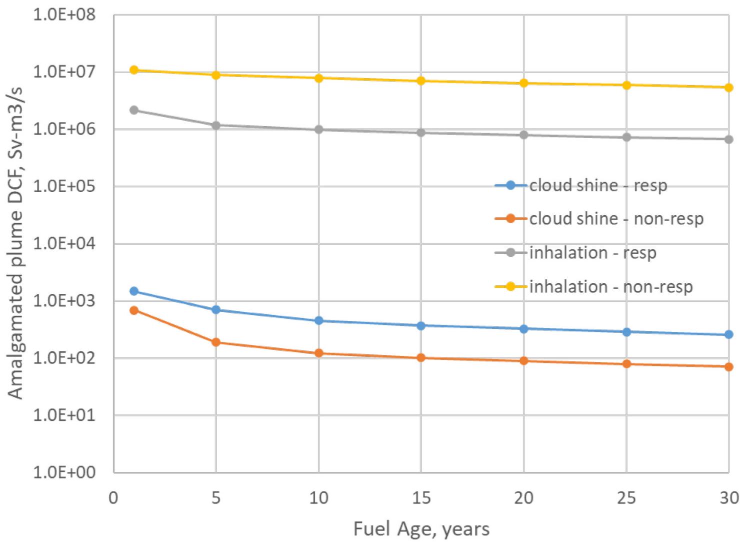
The initial dispersion characteristics were considered for an explosive dispersal scenario. The scenario and its analysis took into account past experience and experiments relating to radioactive dispersal devices (RDDs) and transport canisters to help identify what should be considered for targeted attacks.

Based on past RDD experiments, a bimodal release would be expected for an explosive dispersal scenario resulting in aerosolisation of material. The first peak is in the respirable range, with around 1% of material being aerosolised into this range. The second peak is then in the non-respirable range, with between 2 and 40% of material being released in total. During the explosion, volatile radionuclides are vaporised but then tend to recondense back onto smaller particles, resulting in enrichment relative to the initial composition. Of the volatile species released, around 40% are redeposited onto respirable particles.

Unlike a conventional nuclear power plant accident dispersion scenario where there is overheating and a release of radionuclides via a stack, an explosive scenario involves the release of radioactivity by a fireball. The initial cloud size will be linked to the explosive charge and could involve more heavy particles so deposition velocity could also be higher than a conventional release scenario. The fuel particles released from an explosive incident would be larger than for a typical nuclear power plant accident.

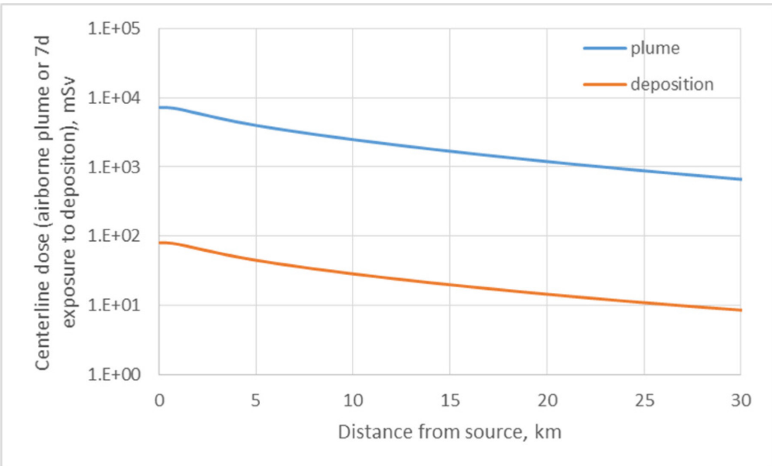
Comparing airborne concentrations with those for a typical nuclear power plant accident situation indicates a higher rate of deposition of non-respirable particles near the site. Taking all radionuclides that are assumed to be released, amalgamated plume dose conversion factors (DCF) have been generated (Figure 4.2). Since the particles are fuel fragments, they are associated with lots of actinides (respirable actinides contribute between 45 and 80% of inhalation dose). The contribution from cloud shine is negligible in comparison.

Figure 4.2. Amalgamated dose conversion factors for a dry cask explosive dispersion scenario



For a simple screening dose estimate and assuming complete dispersal of one dry casks radionuclide inventory (15% of core inventory aged to 15 years), the main risks are associated with plume exposure, with the greatest risks being associated with the inhalation pathway (Figure 4.3).

Figure 4.3. Screening dose estimate for a dry cask explosive dispersion scenario



Note: Plume exposure includes cloud shine and inhalation exposure pathways, whereas deposition exposure includes ground shine and inadvertent soil ingestion exposure pathways.

Operational intervention levels (OILs) for dispersant spent fuel were calculated and compared with IAEA OILs. Due to the presence of actinides and the high relative alpha-emitter content of the non-respirable fraction, OIL1 and OIL 2 are insufficient.

Table 4.1. Operational intervention levels for dispersed spent fuel from a dry cask explosive dispersion scenario

OIL	OIL(t,mix) for respirable particles	OIL(t,mix) for non-respirable particles	IAEA Default OIL Value	Type of Protective Action
$OIL1_{\gamma}$	1619 µSv/h	**116 µSv/h**	1000 µSv/h	urgent evacuation of those living in affected area
$OIL2_{\gamma}$	23 µSv/h	**10 µSv/h**	100 µSv/h (for <10 days) 25 µSv/h (for >10 days)	protective relocation of those living in affected area
$OIL3_{\gamma}$	7.8 µSv/h	0.61 µSv/h	1 µSv/h	urgent implementation of food restrictions to avoid ingestion of food, milk, and drinking water from an affected area
$OIL4_{\gamma}$	61 µSv/h	6.4 µSv/h	1 µSv/h	urgent protection of those with contaminated skin
$OIL7_{Cs137}$	6855 Bq/kg	355 Bq/kg	200 Bq/kg of ^{137}Cs	confirmation of extension of food, milk, and drinking water restrictions from an affected area

The radiological source terms from both induced accidents and targeted attacks are therefore essential for understanding what radiological protection frameworks need to be considered next. The risk profile for a spent fuel attack is unique with different atmospheric transport considerations (initial plume rise, larger particle size in respirable and non-respirable fractions), and radiological risk considerations (higher actinide content resulting in larger inhalation dose component). As a result of the high actinide content, the usual measurement of gamma monitoring at 1 metre above ground will be inadequate for characterising the hazard. Alternative intervention levels can, however, be calculated based on the alpha content in ground contamination.

4.4. Lessons learnt for crisis organisation, with a focus on environmental data and monitoring systems (Damien Didier, IRSN)

The IRSN is the public expert on nuclear and radiological risks in France. From 25 February 2022, the emergency response organisation was activated in response to the invasion of Ukraine by Russia. The initial response lasted several months and involved over 20 experts with daily briefing meetings being held to organise activities and share information. Key activities during this phase included assessing the safety of all nuclear installations and anticipating possible accident situations. After several months, the organisation was scaled down as initial activities were completed. A core group of experts were identified that then followed the situation on a daily basis, with daily monitoring of environmental networks and updating of radiological consequence assessments.

The situation in Ukraine was unprecedented and unforeseen, with the safety of nuclear facilities throughout Ukraine being threatened. The situation was not a regular emergency requiring a response, but rather an ongoing threat due to military attacks. This required preparedness activities at a sustained pace and under time pressure as well as emergency activities with monitoring of several facilities and seeking information on their safety and the military situation. New kinds of questions for an emergency organisation were raised as a result of the situation, including consideration of a "what if" aggression scenario and whether France could be impacted as a result (and the timescales over which impacts could occur). Questions were also asked about the availability of real-time measurement networks. New issues were also identified, such as how objective event information could be collected and how to work without any information from an affected plant as a result of a warfare situation.

At the start of the Ukraine invasion, the IRSN did not know the nuclear facilities throughout Ukraine well, so their staff worked to build a formal and informal network of international contacts to gain reliable data and, from this, develop a catalogue of standard accident sheets for each type of facility (nuclear power plant, research reactors, waste disposal sites and spent fuel pools, etc.). Based on the catalogue, potential impacts on people and the environment were assessed in terms of order of magnitude consequences for each type of accident under different meteorological conditions. More recently, such studies were extended to post-accident components to consider the marketing and consumption of foods.

A training programme was developed with the objective of maintaining experts' skills on the specific assessments and on providing advice around the Ukraine situation and on-call teams were given weekly training over several months. There were also more regular threat-phase activities developed, such as smoke plume simulations for different facilities to look at potential plume dispersion over Europe. Such activities were run daily and continue today to allow for a prompt response to any developing situation.

Monitoring of contamination was a further threat-phase activity. Available monitoring networks were identified, including TELERAY in France, EURDEP and the IAEA IRMIS platform. The team looking at monitoring systems provides daily analysis of the levels of radioactivity. Radon forecasting capabilities were also scaled up to the European level to help identify natural dose rate increases. A key issue identified with the monitoring network was that there are multiple sources of information and that each has different averaging times. Furthermore, most measurement information is not in real time, which is a major weakness for monitoring for potential contamination.

Characterisation of the radiological situation could be impacted by the war situation. Information on the impacted area may be needed to forecast consequences, with measurements ideally serving as the primary source of information on a situation, but this may be limited due to ongoing shelling activities or blackouts. In the absence of monitoring data locally, information would still be needed to inform decision makers on potential consequences and to inform wider communications. Therefore, monitoring data could be crucial to provide a more comprehensive understanding of the event. Combining measurements with modelled data could then allow gaps to be addressed. A modelling technique that proved effective following the Fukushima Daiichi accident was inverse modelling whereby measurement data and atmospheric transfer models are applied to locate an affected facility, leading to information on the source term. This can then help inform facility experts but also be applied in forward modelling using atmospheric transfer models to simulate transport and look at the anticipated spread of contamination (and timescales) and calculate potential doses. The approach does rely on measurement data being available as soon as possible, but model simulations can be improved as more measurements become available.

The main available measurements available from monitoring networks are gamma dose rates. These are very reactive and provide (almost) real-time data and have a dense spatial coverage. However, they lack the isotopic composition that is needed to provide information about a situation. The other main measurements available are of air concentrations, which do provide the isotopic composition but represent average levels over days and are usually not quickly available due to the measurement of air filters. Furthermore, such measurements tend to have coarse spatial coverage. A good mix of both gamma dose rates and air concentration data are therefore required to obtain good temporal and spatial resolution data on contamination, including the isotopic composition. Spectroscopic probes are also promising in terms of providing high temporal resolution isotopic data but are currently too rare to provide good spatial coverage.

The Ukraine war presents an unprecedented crisis that poses a high threat level over a long duration and has required adaptation in the emergency organisation to develop capabilities to respond to the ongoing situation. While emergency radiological protection risks are focused primarily on Ukraine, food contamination issues could impact many countries, potentially causing food supply difficulties.

Inverse modelling methods have an important role to play, particularly in the context of armed conflict, but access to measurement data is required to enable events to be detected effectively and to evaluate the implications throughout a crisis. A research project has been submitted alongside European colleagues to the European Partnership for Radiation Protection Research (PIANOFORTE) that calls for strengthening inverse modelling techniques for armed conflict situations.

4.5. Discussion

One of the objectives of this session was to capture knowledge around changes to best practices, etc. under challenging situations and in different environments that could help improve capacities for monitoring in situations where normal capabilities may no longer be available due to loss of power and other factors. The SURVEY project played a crucial role in developing understanding of the situation in Ukraine following occupation of territories to evaluate and minimise risks associated with military activities. It is crucial to perform such preliminary surveys straight after de-occupation to evaluate the consequences of military occupation and identify any loss of integrity to sources and changes to surface contamination. Access to monitoring equipment is therefore essential and should be applied flexibly to allow adaptation to the circumstances.

The crucial issues for the planning stages of monitoring activities are to identify routes and open dialogue with the public that survived the occupation to gain valuable information on where troops were deployed. From past emergency exercises relating to forest fires in the CEZ, the importance of combining instrument measurements with modelling to define routes for mobile laboratories has been recognised. This allows areas to be targeted for monitoring, allowing instruments to be deployed effectively and provide the data that then underpin decisions on any necessary measures. However, in an armed conflict situation, additional safety aspects must be considered to ensure the personal safety of the monitoring team and it may be necessary to work closely with the army to gain necessary permissions and passes for zones and to be accompanied by special officers to detect and address mines. Preparedness activities could therefore look at establishing relationships between the military, emergency response and monitoring teams and the public to ensure necessary connections are in place.

Consideration could be given to the available technologies for monitoring and whether flexibilities can be built into monitoring strategies as part of emergency preparedness. Some probes can be readily deployed that can provide measurements and there are some monitoring systems that can be deployed on vehicles to allow monitoring along roads rather than monitoring specific points, which may mean exiting vehicles. Airborne monitoring systems are also important and can complement vehicle-borne systems. To detect lost or stolen sources, gamma monitoring devices can be effective.

There are major gaps in the normal monitoring network for nuclear power plants and other facilities and there can be time delays in obtaining the necessary data. Gamma networks can be used to identify that something has happened, but more information is then required to understand what has happened. Furthermore, in some instances there could be a substantial alpha component to a scenario that would not necessarily be picked up through the gamma monitoring network.

In every country there can be several systems for measuring background radioactivity but often they are owned by different organisations so there is not one information system that collects all data. There are software and systems available that would allow data to be collated and shared but these are not routinely used so information that is available may not be shared. There may also be issues around sharing of data networks between different countries.

The availability of data is critical: the main limitation to responding properly to a situation is effective access to data. Without data there cannot be full situational awareness to underpin decisions around protective actions, etc. From a technical point of view it is not complicated to make data available but there is work to be done to make this happen.

It is useful to take an all-hazards approach when considering monitoring and modelling in an armed conflict scenario. The characterisation of a situation is not just about radioactivity – mines or chemical hazards could also be present. Interaction between different organisations may therefore be necessary to better characterise situations and respond to the risks faced by the affected population.

There is experience of creating national monitoring systems and a pilot project was run around the Zaporizhzhia Nuclear Power Plant to install an independent monitoring system under the environmental protection ministry. The idea was to work towards covering all territories around facilities using radioactivity with small monitoring systems, with information then being collected in a national centre. The deployment has not yet occurred but a scientific manager has been appointed and a small training centre for the operators and technical support set up. Work is ongoing to create an automatic radiation monitoring station and to try to combine with the different smaller scale systems to produce a single monitoring system. The work is currently in the conceptual development stage. Building one overall system for monitoring in the country would allow for a more rapid reaction to any event, inside or outside Ukraine. In the absence of a fully functioning CEZ monitoring system following the occupation, it was helpful that mobile equipment, provided by the United States, was made available.

In Germany, a database has been developed for the collection of monitoring data. Once data are approved, they are made publicly available on an accessible website. Activity concentrations in groundwater, drinking water, food and fodder are all published. For public environmental monitoring systems to contribute to building trust during war or occupation situations, the data need to be associated with trustworthy organisations.

There may be instances where the provision of data should be stopped. For example, if monitoring stations are threatened by military activities. However, probes and similar material could be deployed elsewhere to continue providing data from surrounding areas.

5. Session 3: Adapting emergency preparedness and response and recovery in armed conflict situations

5.1. Restoring regulatory control to overcome the consequences of Russian military occupation of the Chernobyl Exclusion Zone (Nataliia Rybalka, SNRIU)

At the beginning of the Russian military aggression against Ukraine on 24 February 2022, the Chernobyl Nuclear Power Plant site and facilities and the CEZ were invaded and seized. Heavy military equipment and weapons were placed on the nuclear power plant site and the CEZ was turned into a military base. The occupation lasted more than a month until the military occupiers left the CEZ on 31 March 2022. During the period of occupation, regulatory control of nuclear and radiation safety at the Chernobyl Nuclear Power Plant site and CEZ was impossible. Units 1 to 3 of the Chernobyl Nuclear Power Plant are under decommissioning. The new safe confinement building, storage facilities and a new dry storage facility are operational, with ongoing transfer of waste from old to new facilities. Additionally, a new facility for the management of solid and liquid radioactive waste is being commissioned. Within the CEZ there is a vector complex with facilities for radioactive waste management and disposal, a centralised SNF storage facility and disposal facilities for emergency radioactive waste that were developed during the initial response measures following the Chernobyl accident. Within the town of Chernobyl there are a few enterprises that use radioactive sources.

Occupation of the CEZ had several consequences:

- there were no safe access routes for facility staff due to bridges and roads being destroyed and mines remaining throughout the territory;
- logistical routes for the delivery of equipment, spare parts and materials necessary for the safe operation of facilities as well as medical supplies had been broken;
- specialised vehicles had been stolen or destroyed;
- computer, office and server equipment and databases had been destroyed, disabled or stolen;
- dosimetry and environmental monitoring equipment had been damaged or stolen;
- houses and offices in Chernobyl town were damaged or spoiled; and,
- the central analytical laboratory for radioactive waste characterisation had been completely destroyed and equipment had been broken or looted.

As a result, the Chernobyl Nuclear Power Plant, centralised radioactive waste management enterprise, and enterprises using radioactive sources could not ensure compliance with safety and security regulations and licensing conditions due to a lack of qualified operational and emergency staff, equipment and materials. This meant that it was not possible to ensure the safety and physical protection of facilities or to implement radiation dosimetry controls and environmental monitoring to the required frequencies. Furthermore, accounting and control of radioactive waste and radiation sources were impaired, along with the ability to provide adequate emergency response. On the basis of information received from licensees, SNRIU concluded that licensees were unable to fully comply with licence conditions and requirements for nuclear and radiation safety. As a result, in April 2022, a decision was made to terminate a number of licences. These included licences for decommissioning units 1 to 3 of the Chernobyl Nuclear Power Plant, conducting activities in radioactive waste management facilities, including the new safe confinement, and the use of radioactive sources. This decision was not made lightly but was deemed necessary due to the "force majeure" circumstances arising from the temporary occupation and seizure of the CEZ territory by Russian military forces, rather than any fault of the licensees.

There was no prior experience in the safety regulation of nuclear and radiation facilities under military occupation or after de-occupation, nor was there international experience or recommendations on safety regulation in such circumstances. Therefore, a decision was made by the SNRIU, with the support of the DSA, to develop specific regulations for restoring nuclear and radiation safety in CEZ facilities that had been temporarily occupied. Two regulatory documents were developed and approved by the SNRIU Board:

- "Recommended approach to state regulation of safety of nuclear and radiation facilities located in Chernobyl Exclusion Zone, which was affected by hostilities".
- "Recommended procedure for restoring level of safety of nuclear and radiation facilities located in Chernobyl Exclusion Zone, which was affected by hostilities".

The first document, regarding the recommended approach for restoring safety, defines the approach, scope and application of safety principles, including licensee obligations for ensuring safety, radiological protection, security, human factor and prevention of the self-sustaining fission chain reaction, among others. For each topic, efforts were made to provide frameworks that could be applied or not, depending on the challenges faced with respect to occupancy and hostilities. The second document, which covered procedures for restoring the safety of facilities, established a step-by-step approach for checking and assessing:

- the presence and condition of SNF, radioactive waste, radiation sources and other radioactive materials;
- the functioning of management systems and staffing sufficiency;
- the safety status and operability of facilities, systems and equipment;
- the sufficiency of radiation and dosimetry control and monitoring;
- the security status of facilities, radioactive materials, radioactive waste and radiation sources;
- the identification of safety deficiencies; and
- the development and assessment of well-grounded decisions for elimination of safety deficits if identified.

Importantly, all relevant inspections and measures would be implemented following the elimination of military risks.

In line with these recommendations, licensees implemented measures to restore compliance with safety requirements. The first step was to exclude all military risks to staff by ensuring the absence of explosive devices in objects or on sites, etc. The operational capacity of important safety systems and equipment, including radiation control and monitoring systems, was then restored and checks made of the compliance with the inventory of radioactive materials, radioactive waste and radiation sources. Where possible, logistical challenges related to staff and equipment delivery were addressed and shift work patterns were restored. Emergency preparedness systems were also restored. As a result of these measures, the SNRIU restored in August 2022 the licences that had been previously suspended, but with additional conditions to perform further checks based on the recommended procedures document. For the Chernobyl Nuclear Power Plant, the additional checks and assessments required, included:

- assessing the safety level and operability of structures, systems and equipment of facilities, including units 1 to 3;
- providing additional radiation monitoring and control of air contamination in personnel residential areas at the nuclear power plant site;
- updating emergency planning documentation; and
- providing a survey and safety assessment of the Shelter Enclosure Structure to expand its operational period beyond the design period set up after stabilisation.

These activities were carried out between August 2022 and February 2023. During the same period, the Centralized Radioactive Waste Management Enterprise:

- assessed databases, material, technical and financial resources;
- verified radioactive waste availability in facilities;
- conducted additional radiation surveys of the waste facilities;
- checked the state and operability of stationary radiation monitoring systems and equipment; and
- updated emergency planning documentation.

The SNRIU, with support from the EC Instrument for Nuclear Safety Cooperation (INSC) project UK/TS/58, undertook evaluation of licensees' documentation, including documentation on the survey and safety assessment of the Shelter Enclosing Structure to extend its operation beyond the design period. Staff residential areas were also organised for the Chernobyl Nuclear Power Plant since connection routes between the nuclear power plant and the city were disrupted. Living quarters were therefore provided on the site and radiation monitoring controls were provided for those residences to ensure staff safety. Emergency plans were also updated to take account of conditions of martial law and changes in access to facilities as well as the shelter and evacuation of personnel staying in residential areas of the nuclear power plant site.

5.2. Activity of State Special Enterprise "Association Radon" in wartime: Challenges and achievements (Oleksii Zhyvotenko, SSE Association Radon)

The State Special Enterprise (SSE) "Association Radon" is responsible for the receipt and temporary storage of radioactive waste, recycling of radioactive waste, transportation of radioactive materials, participation in the liquidation of radiation accidents and accounting of the state repository cadastre and radioactive waste register. The enterprise falls under the management of the State Agency of Ukraine on Exclusion Zone Management and has five branches. The central branch is located in Kyiv, with four regional branches being located in Dnipro, Lviv, Odesa and Kharkiv. Since the 1960s, storage facilities for solid and liquid radioactive waste and stores for radioactive sources have been built, with the most recent having been constructed in 2013. Additionally, a decontamination station is in operation, and the enterprise has a special transport cargo truck and packing containers for storage and transportation of radioactive waste and sources. The enterprise carries out activities in accordance with state requirements and holds licences issued by the SNRIU for the recycling and storage of radioactive waste, for the transport of radioactive materials and the use of ionising radiation sources. Monitoring systems are in place at each facility to measure gamma dose rates and aerosols. Each facility operates independently. Overall, there are over 4 200 tonnes of solid radioactive waste and around 790 m^3 of liquid radioactive waste stored. Furthermore, there are a large numbers of spent radiation sources and around 780 tonnes of NORM as radioactive waste stored.

Since February 2022 several challenges were faced. Solutions were needed to ensure the continuation of activities during wartime and to strengthen physical protection and radiation controls of facilities. The main task for the enterprise prior to the war was the receipt of radioactive waste. From the beginning of the war, the main focus has been on physical protection and radiation control at facilities. A central management headquarters for the enterprise was established at the Kyiv facility. The enterprise continued its activities in the management of radioactive waste and the transportation of radioactive materials several months after the beginning of the full-scale invasion of the Russian Federation troops on the territory of Ukraine. Some of the main challenges faced were as follows.

- Military forces attacked territories close to the Kharkiv facility, leading to difficulties for staff in reaching the facility and endangering workers' lives. Blackouts were also experienced as a result of targeting of electrical supplies. However, the facility itself was not damaged, and from September 2022, de-occupation of the surrounding territories has allowed the situation to become stabilised. Nevertheless, the danger of further attacks remains.
- On 27 February 2023, there was a rocket attack near the Kyiv facility. As a result, the radiation monitoring system failed and mobile connections were lost. Inspections confirmed that storage facilities were undamaged and the radiation situation was confirmed to be stable. The radiation monitoring system has since been restored.

  Rocket attacks have targeted the Ukraine energy system, resulting in blackouts at all facilities, thereby interrupting radiation monitoring systems and the functioning of physical protection systems. During these times, physical radiation monitoring has been performed and the levels of physical protection of facilities has been increased. To restore electrical supplies, diesel generators have been deployed.
- From the start of the war, transportation of radioactive materials was ceased to mitigate potential threats related to military actions. Short-distance transportation was subsequently allowed from April to May 2022, along with transportation of radioactive material removed from illegal circulation. Instructions for transportation that includes limitations were developed and interactions were strengthened with the State Atomic Energy Regulatory Authority in the exchange of information regarding the transportation of radioactive materials. Further information exchange prior to transportation has been limited to mitigate risks. Since October 2022 there has been renewed transportation of spent sources from Radon facilities to storage facilities built in the CEZ.

The main achievements during the war have been updating functioning radiation control systems and improving the physical protection of facilities, as well as renewing activities for radioactive waste management and radioactive material transportation since May 2022. Additional instructions for the transportation of radioactive materials and for emergency response have also been developed and co-operation with the SNRIU has been strengthened. Two licences for recycling and storing radioactive waste have also been extended and seven certificates for containers have been issued by the SNRIU. There has also been renewed transportation of radioactive waste and transfer of spent sources from all Radon facilities to the central storage facility in the CEZ. Further activities have included assessing the condition of radioactive waste storage containers and production of containers to increase the potential for radioactive waste storage. Participation in liquidation of radiation accidents and removal of radioactive materials from illegal circulation has also resumed.

There has been no warfare on radioactive waste storage facility territories or occupation of those territories. Control has not been lost over radioactive waste and stores have not been damaged. Activities for radioactive waste management and radioactive material transportation have continued and radioactive monitoring and the provision of physical protection of facilities have been achieved. The tenacity of employers and staff has been a key factor in reestablishing activities.

Since the start of the war, the international community has supported Ukraine and helped to improve the stability of the physical protection and radiation monitoring systems. Continued co-operation is needed to develop solutions for radioactive waste management, including the supply of equipment for radioactive waste management and recycling and the manufacture and delivery of containers, etc. As illustrated in Table 5.1, the war has impacted the transfer of radioactive waste from SSE Association Radon storage facilities to the central storage facility in the CEZ. Transfer rates are, however, increasing and work continues to look for safe solutions for reducing the accumulation of radioactive waste at facilities. New containers for the transport and storage of solid radioactive waste were produced in 2022 and have been certified. A decision on issuing transport certification of these containers by the SNRIU is awaited (updated - in December 2023, the SNRIU issued a certificate for transportation).

Table 5.1. Transfer of spent sources and solid radioactive waste from SSE Associate Radon facilities to CEZ storage

transferred in	2018	2019	2020	2021	2022	2023	TOTAL
Spent Sources, units	264	19 108	100	186	48	423	**20 129**
Solid RW, t	188,8	147,3	80,4	42,6	0	0	**459,3**

5.3. Development of a Swedish framework for radiation protection during a heightened state of alert and war (Jan Johansson, SSM)

The Swedish peacetime legislation on radiological protection also applies during a heightened state of alert and war. However, the Swedish framework for radiological protection in emergency exposure situations has been developed for peacetime events and circumstances. A review of the radiological protection framework is necessary to assess whether it remains appropriate in all situations that can arise during a heightened state of alert and war. The overall goals are to review and develop the framework as necessary for a heightened state of alert and war as part of a complete protection strategy and to propose any changes to Swedish legislation needed to implement the framework. A two-year project to be completed by December 2024 has been established. The work plan is inspired by the steps proposed by the IAEA to develop a protection strategy for peacetime nuclear and radiological emergencies.

A first area of concern is workers not involved in emergency response. According to the EU Basis Safety Standards (BSS), an emergency worker is any person having a defined role in an emergency situation and who might be exposed to radiation while taking action in response to the emergency. Other workers in an emergency exposure situation are treated as members of the public. However, some workers not taking part in emergency response need to continue working to protect vital societal functions and critical infrastructure or to perform their duties in military and civil defence and therefore cannot follow recommendations on protective actions intended for the general public. Consideration therefore needs to be given to the regulation of such workers in emergency exposure situations. One solution that would apply both in peacetime and during a heightened state of alert or war would be to designate those workers as “workers in an emergency exposure situation” and treat them as emergency workers. This would ensure adequate regulation of radiological protection, including responsibilities and individual rights for these workers.

A second area of concern is occupational exposure in emergency exposure situations. A few possible changes to national legislation to make it appropriate during a heightened state of alert and war have been identified within the project. Considered changes include lowering the age limit for emergency workers and workers in an emergency exposure situation to 16 years. Every person between the age of 16 and 70 years has a duty to participate in military or civil defence in Sweden. Given other risks associated with these duties, there is no reason to exclude exposure to radiation. It is also considered to remove the limitation on the maximum permitted reference level of 500 mSv effective dose for emergency workers and workers in an emergency exposure situation. Considering other risks and duties that these workers may face in emergency exposure situations during a heightened state of alert or war, this limitation may not be reasonable. Changes are also considered to the regulations to be a volunteer in emergency exposure situations. In Sweden, the level to be a volunteer is linked to the dose limit for occupational exposure, i.e. 20 mSv annual effective dose. However, workers in military and civil defence are not volunteers during a heightened state of alert and war, nor is it voluntary to perform the assigned tasks even if they constitute a life-threatening hazard. The easing of requirements on special medical surveillance for emergency workers and workers in an emergency exposure situation exposed over the dose limits for occupational exposure is also being considered. During a heightened state of alert and war, it may not be reasonable to perform medical surveillance following exposure to such low radiation doses.

A third area of concern is reference levels for the public in emergency exposure situations. Reference levels are useful for emergency response planning, both in peacetime and during a heightened state of alert or war. However, reference levels are unlikely to be useful as benchmarks to assess the effectiveness of the implemented protection strategy during emergency response in a heightened state of alert or war. This would require radiation doses received by different groups of the population to be estimated with a sufficient level of precision to be compared with the reference level, which is unlikely to be possible in situations where both resources and information are scarce. Furthermore, the values for the reference level and their establishment may also have to be different for emergency exposure situations during a heightened state of alert or war. Reference levels may need to be set higher than a 100 mSv effective dose when comparing the risks posed by the exposure to other risks that may be present. Also, it may not be possible to set a national reference level beforehand; instead, a reference level for the public may need to be decided by regional or even local decision makers considering the prevailing circumstances. Moreover, reference levels for the transition to an existing exposure situation may need to be set higher than a 20 mSv effective dose over one year during a heightened state of alert or war.

A fourth area of concern is the transition from an emergency exposure situation. The conditions to make a transition from an emergency exposure situation to an existing or planned exposure situation need to be clarified, both in peacetime and during a heightened state of alert or war. The need to take urgent actions to avoid or mitigate exposure is the key condition to categorise an exposure situation as an emergency exposure situation. To avoid delays in making the transition, it is important to distinguish between actions needed to terminate the emergency exposure situation and actions needed to terminate the emergency as a whole. The emergency and the emergency exposure situation may start at the same time, but it is not certain that they are terminated at the same time. Furthermore, guidance is needed on time frames to make the transition once conditions are fulfilled. Since the tolerated doses are higher in emergency exposure situations compared to existing exposure situations, it is important that the transition take place as soon as the necessary conditions are fulfilled.

In addition to the work on reviewing and revising the radiological framework for workers and the public in emergency exposure situations during a heightened state of alert and war, a report has recently been published on the radiological consequences of fallout from nuclear explosions (SSM, 2023). The report presents an analysis of the potential radiological consequences of fallout from nuclear explosions at distances up to 300 km from the explosion and explores the effect of various protective actions to help inform emergency response planning.

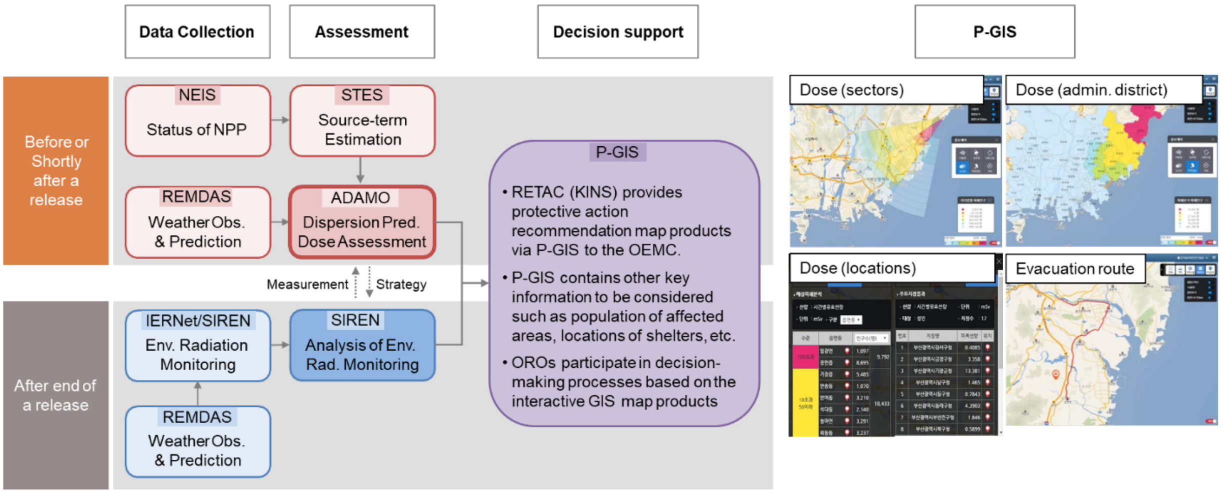
5.4. Overview of emergency response in Korea and its potential challenges during armed conflict situations (Kyuwon Choi, KINS)

There are five operating nuclear power sites in Korea with a total of 25 reactors and three more reactors are under construction. The current nuclear power plants generated 30% of Korea's electricity in 2022. The objectives of emergency response actions are to prevent severe deterministic effects and to reduce stochastic effects. The emergency classification system is used as a primary basis for decision making in the urgent response phase. Site-specific, predetermined criteria for emergency action levels (EALs) are used for declaring emergencies that trigger predetermined protective actions within emergency planning zones (EPZ). To reduce stochastic effects, model predictions are used as a secondary measure to adjust and optimise initial protective actions implemented by emergency classification during the early phase. Environmental monitoring is used as the basis for longer-term responses and recovery. For the five major nuclear power plant sites, EPZs have been established. However, two sites are in close proximity and therefore share an EPZ.

There are two areas to each planning zone. In the zone immediately around the nuclear power plant there can be a few thousand to a few tens of thousands of permanent residents, whereas the larger zones can contain up to a few million residents. Protecting populations during an emergency therefore poses large challenges.

A decision support system has been developed that relies on real-time data from nuclear power plants and determines the actions needed. Each nuclear power plant has a fixed monitoring system to provide data, with a wider range of data being available from around 230 monitoring points throughout the country. Data are consolidated into a single decision support system that includes a GIS system that helps inform on the implementation of protective actions and discussion on where to focus resources during an emergency. The decision support system is illustrated in Figure 5.1.

Figure 5.1 Emergency decision support system.



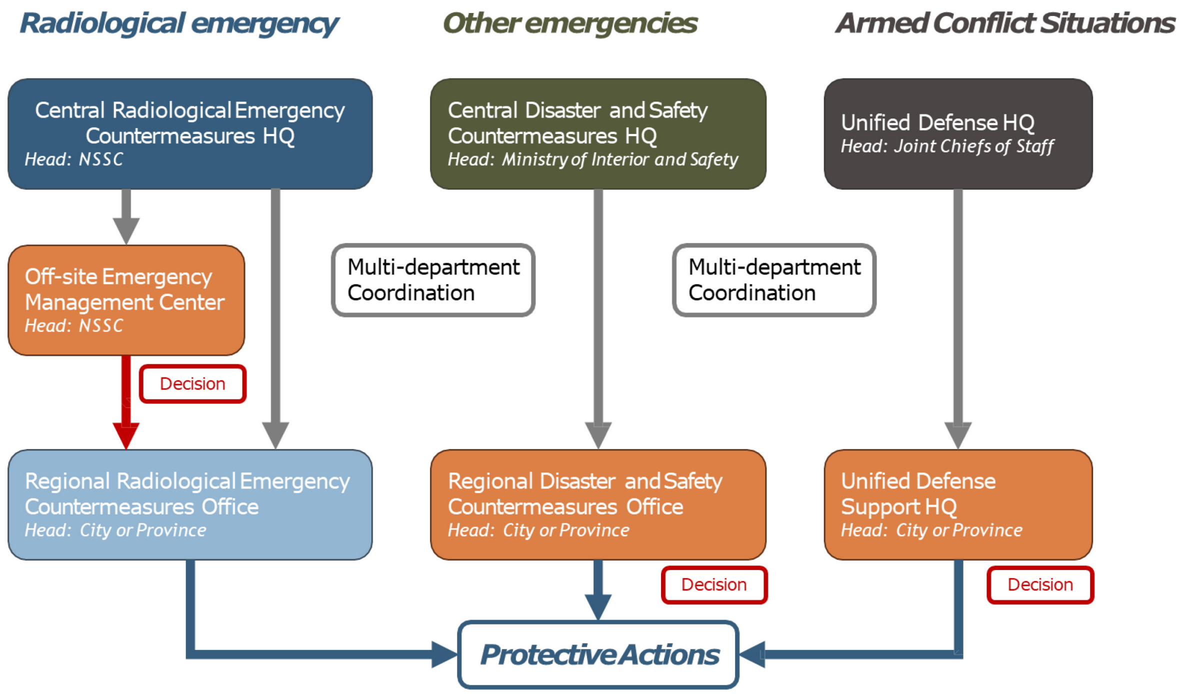
In addition to the fixed monitoring points, several other environmental monitoring resources are available, including aerial, marine and vehicle-based monitoring resources. The monitoring data are then fed into the System for Identifying Radiation in Environments Nationwide (SIREN). The Korea Institute of Nuclear Safety (KINS) leads the national radiological monitoring and assessment centre during an emergency, but resources are heavily reliant on other organisations, including the military and meteorological institutes and local authorities.

During a combined emergency, including those arising from potential armed conflict situations, several challenges arise, including the questions of:

- who decides on the overall public protective actions;
- what kind of criteria would be used; and
- whether resources would still be working and available as planned and prepared.

Within the country, response frameworks are individually legislated for radiological emergency, other disasters and armed conflict situations. In addressing a combined emergency situation, which could be military or natural hazards (e.g. typhoon) combined with a radiological emergency, multi-department co-ordination ensures that views from other key response organisations are heard (Figure 5.2). Establishment of a clear unified command and control system for emergency response under an all-hazards approach can be key to effective responses to a combined emergency.

Figure 5.2. Concept of operations for response to a combined emergency situation



In a combined emergency situation, it would be necessary to adopt a flexible approach to the application of generic criteria. In practice, generic criteria have generally been developed to achieve doses caused by a radiological emergency to as low as reasonably practicable. However, in applying such criteria to a combined emergency, consideration would need to be given to the other hazards presented. For example, consideration would need to be given as to whether it is safe to evacuate people or, during a release of radioactive materials, whether it is safe for the public to shelter if the area is under attack. Decisions will therefore need to take account of the prevailing circumstances, including perceived risks to the public from the different hazards.

Another key aspect to responding to a combined emergency is the availability of resources. Resources available in peacetime emergency response planning may not be available during a combined emergency involving armed conflict, etc. For example, key resources for on-site and off-site monitoring may be used to respond to other hazards, response personnel may not be available for radiological emergency response or key resources such as shelters, roads and vehicles may be lost due to attacks.

Therefore, to have a unified response system, an all-hazards approach needs to be established at the preparedness stage and generic criteria need to be flexibly applied to account for non-radiological consequences. Essential resources also need to be clearly specified during the preparedness stage and assured during armed conflict situations. Finally, international support and assistance are key to ensure radiological protection for people and the environment.

5.5. Actions taken by Poland's National Atomic Energy Agency and the Radiation Emergency Centre in the context of the conflict in Ukraine (Dawid Frencel, PAA)

The Radiation Emergency Centre is one of the departments of Poland's National Atomic Energy Agency (PAA). The department consists of two units – an emergency preparedness and response unit and a monitoring and prognosis unit. The centre acts as the national warning point and operates 24 hours a day, 7 days a week with duty officers working between two 12-hour shifts. The centre provides the emergency service of the president of the PAA together with the central laboratory for radiological protection.

The Radiation Emergency Centre is responsible for co-ordination of the network of measurement stations and facilities, of which there are two types of monitoring – nationwide and local. Measurements made by monitoring stations form the early warning network for radioactive contamination. There are 52 permanent monitoring stations nationwide that provide continuous monitoring of ionising radiation levels throughout the country. They measure the ambient dose equivalent rate and the gamma ray spectrum of radioactivity in air and on the ground, as well as basic weather parameters such as precipitation and ambient temperature. Additionally, there are 13 atmospheric aerosol sampling stations that continuously collect atmospheric aerosols on filters, which are changed and analysed by spectrometric determination of radioisotopes on a weekly basis. Following the start of the Ukraine war, the frequency of analysis was increased to twice weekly. Throughout the country there are also nine monitoring stations belonging to the Institute of Meteorology and Water Management that measure gamma dose rate and the activity of atmospheric aerosols and total fallout and 13 stations belonging to the Ministry of National Defense that continuously monitor gamma dose rates. In 2022, 13 new permanent monitoring stations were installed, and the plan is to have 150 monitoring stations by 2033 that will provide both gamma and spectrometry measurements. The number is being gradually increased with older stations also being replaced.

In co-operation with the nuclear safety and security department, source terms for Ukrainian nuclear power plants are being created to allow for appropriate prognosis of potential releases to the atmosphere as a result of military activities. Different emergency scenarios were considered, including for severe accidents leading to loss of containment. For each scenario, prognosis of releases considered both prevailing meteorological data and the worst-case scenario. Hypothetical release scenarios were also performed for the actual atmospheric conditions on the day of scenario analysis.

The Radiation Emergency Centre has co-operated closely with the SNRIU, with duty officers maintaining contact for exchange of information relating to the safety of the nuclear power plants, and the SNRIU has provided prompt responses to any requests for information. The information received has been used to underpin hazard analysis and assessment of the radiation situation as well as forming the basis for developing messages to the public both in terms of preparing for a potential radiation event and addressing fake information and misinformation.

The Radiation Emergency Centre has participated in a number of international working groups, including the HERCA Ukrainian support task force, and in WENRA expert group meetings in the area of modelling specific accident scenarios associated with consequences of the war in Ukraine. The centre also participated in the Visegard Group meeting on the modelling of accident scenarios related to the war in Ukraine.

One of the largest challenges has been public communication. Public opinion has been hampered as a result of the handling of the Chernobyl accident so there remains mistrust and fear in society, which is not helped by fake news. The centre is therefore doing its best to release as much information as required by the public by releasing frequent messages on social media channels and providing information on websites to explain aspects of nuclear safety as well as holding press, TV and radio interviews. Since the start of the war, interest in the PAA by the public on social media channels has increased fivefold. The war has demonstrated that people still vividly remember the history of the Chernobyl accident and continue to fear the reoccurrence of such an event.

Discussion

From the beginning of the war in Ukraine, one of the first decisions made was to activate co-operation channels to provide information to international partners and agencies. Decisions made in response to specific events were often challenging. In the case of the occupation of Chernobyl and impacts on licensees, a step-by-step approach was taken to address the issues. The occupation of territories around Chernobyl was brief, allowing actions to be implemented to restore operations and bring the radiation situation back under licensing controls. The situation faced by the Institute of Metrology posed greater difficulty on determining the best course of action. While the immediate removal of radiation sources could have been considered for security reasons, the military risks were high so the decision was made to first eliminate military risks before addressing radiological protection issues. For the Institute of Metrology, this has been shown to have been the right decision, with the focus being on removing the risk of unauthorised access to the facility before the removal of radiation sources.

With respect to the application of reference levels in an armed conflict situation, consideration needs to be given to whether to apply at the regional or local levels depending upon the areas occupied and whether to adjust reference levels in light of the prevailing circumstances. Information may be lacking in an armed conflict situation, so regulatory systems need to allow for flexibility. While national reference levels may be available, it may be appropriate to set reference levels at a local level to account for the specific situation, including balancing the different risks. For example, it would not be appropriate to insist on actions to minimise doses by implementing evacuation measures if this increased risks from armed conflict. Consideration also needs to be given to the availability of safe places and the availability of safe routes to access those places. Such considerations would apply not just to armed conflict situations but also to other combined hazard situations that could lead to infrastructure damage (earthquakes, volcanic eruptions, etc.).

From presentations during the session, it is evident that slight extensions, refinements and revisions to current regulations can help address armed conflict situations, enabling regulatory frameworks to be flexible and adaptable to different circumstances. By allowing flexibility in terms of worker exposures in emergency situations, radiological risks can be balanced against other risks, including risks to life as a result of military action. By revising the legal framework in advance, plans can be made and operational resilience can be strengthened.

Safety assessments and emergency planning for nuclear power plants and other radiation facilities have typically not considered war situations, but the events in Ukraine have demonstrated the need for such considerations. It is clear from presentations and discussions that some countries are also considering EPR in relation to the potential use of nuclear weapons as a result of Russian hostilities towards Ukraine.

There is currently no international guidance available on the application of radiological protection and nuclear safety principles and related standards in armed conflict situations. However, care needs to be taken to avoid building legal frameworks for war situations that could legitimise war. Reference levels are often perceived as limits, but that is not the intention. Rather, they are reference points around which there should be optimisation.

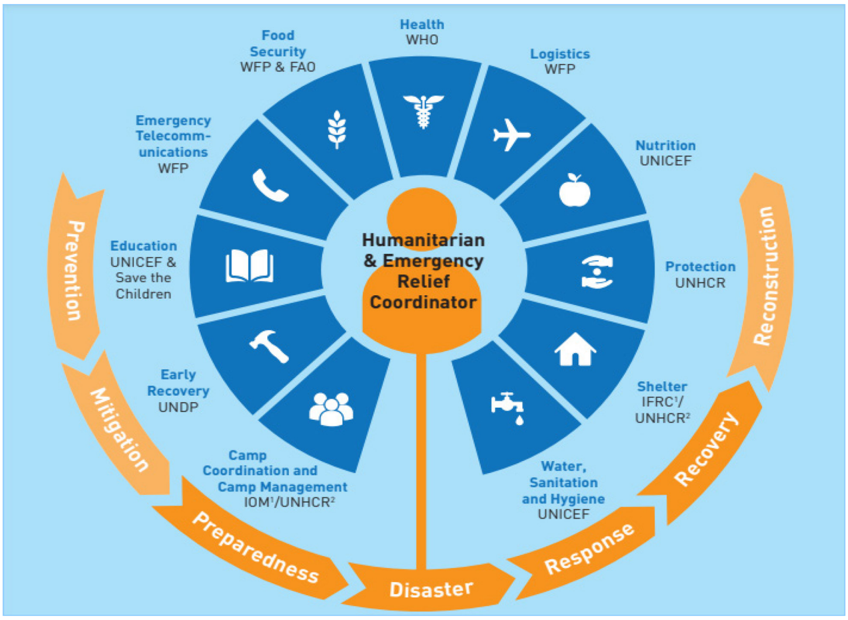
Continuing to share experience around the review and refinement of national legal frameworks for radiological protection in light of the war in Ukraine will help in building resilience internationally.

6. Session 4: Adapting national strategies and international support for medical response

6.1. The work of WHO in support of preparedness to radiation emergencies during the war in Ukraine (Zhanat Kenbayeva, WHO)

The world of radiological protection and nuclear safety does not exist in a bubble so it is appropriate to reflect on the global response to the war in Ukraine. There are three main levels of humanitarian response: the Emergency Relief Coordinator (ERC) chairs the Inter Agency Standing Committee (IASC) and is responsible for oversight of all emergencies requiring United Nations (UN) humanitarian assistance. The ERC also acts as the focal point for governmental, intergovernmental and non-governmental relief activities. The IASC is an inter-agency forum for co-ordination, policy development and decision making that involves both UN and non-UN humanitarian partners. The IASC was established in 1992. Global clusters are then groups of UN and non-UN humanitarian organisations active in each of the main sectors of humanitarian action (e.g. health, water, logistics). Global clusters are designated by the IASC and have clear roles for co-ordination. There are 11 clusters operating at the global and national levels and covering the various sectors of humanitarian response throughout an emergency, from prevention to recovery and reconstruction. The WHO is responsible for the Global Health Cluster (Figure 6.1).

Figure 6.1. The role of WHO in the global humanitarian response to an emergency



The Global Health Cluster consists of over 30 international humanitarian health organisations that have been working together since 2005, under the leadership of the WHO, to build partnerships and mutual understanding and to develop common approaches to humanitarian health action. In Ukraine, there are nearly 200 health partners working together, under the leadership of the WHO, to deliver various health services across the country, reaching some 9 million people in 2023, ensuring people receive essential health care.

The WHO published a report (WHO, 2023a) in March 2023 detailing the work undertaken in the first year of the war and lessons learnt. Situation reports are also published regularly that provide important graphics. The situation report for 17 November 2023 (WHO, 2023b) indicates that over 1 358 attacks on health care have been reported and there have been over 25 000 civilian casualties. Around 14.6 million people are in need and over 3.6 million people have been displaced as a result of the war in Ukraine.

Since the start of the war, the WHO has donated 600 000 tonnes of medical supplies to the Ukrainian Ministry of Health (MoH), including medications, hospital equipment, ambulance vehicles, decontamination equipment and PPE. Consultation with MoH ensures that prioritised needs are met, based on the current needs, and taking account of dynamic changes in the frontlines to ensure those most at need receive what is needed. Capacity building through training medical departments in regions at risk and supply of necessary equipment and medical supplies go hand in hand and were begun promptly since the start of the war.

From the outset there was concern around chemical, biological, radiation and nuclear (CBRN) security threats. From a public health perspective, these threats are taken seriously by WHO. So far there have been no reports of deliberate targeting of military or civilian populations with CBRN agents, but the potential for loss of control of radioactive sources and military operations close to industrial facilities, including the Zaporizhzhia Nuclear Power Plant, leave the population at risk of chemical, radiological and nuclear hazards. There are also concerns related to the potential risk of tactical nuclear weapons or improvised nuclear devices being used. WHO monitors closely all information shared by the national authority in Ukraine and IAEA press releases relating to the ongoing situation at the country's nuclear power plants and in the CEZ and provides technical support with regards to capacity building in the health sector, managing potential health risks from the various hazards, conducting risk assessments, and supporting risk communication.

In response to a request from the MoH, the WHO led a fact-finding mission in September 2022 to review the preparedness of the health sector for a radiological or nuclear emergency and to identify areas of improvement and recommendations for strengthening the sectors' capacity to respond to an emergency. The mission also aimed to review contingency plans for protecting UN staff in the field from radiation risks in the case of a nuclear emergency. A follow-up mission is planned for January 2024. The mission involved meeting with regional health departments and national authorities and holding briefings with organisations in the field and involved over 28 hours of travel through the country by car. Key findings for the mission were that the Chernobyl accident legacy has resulted in technical expertise being well represented in various sectors, including emergency response, but that there was a need to strengthen the legislative basis for co-ordinated preparedness and response to a nuclear emergency. It is clear that national nuclear power plant operators could cover on-site emergency response, but response to other emergencies such as the use of nuclear weapons was less clear and more discussion and preparation is needed in this area. It will be important to discuss and strengthen civil and military co-operation in the first response to an event. Furthermore, responsibilities for environmental and individual monitoring have become fragmented and there is low throughput due to use of old devices. As a result of meetings with medical services in the affected regions it is clear that there is a need for training of health workers on the front line and for designated hospitals.

Public health preparedness and response, including interventions and medical evacuation arrangements, are key areas where the WHO has provided input. Emergency evacuation arrangements are complex as no airport services are available. Medical evacuation has therefore been considered for the transport of patients requiring immediate care outside of Ukraine. However, there are concerns around the radiation safety of air pilots and crew and of the contamination of planes in a radiological/nuclear emergency. It would not be feasible to move the most critical of patients so there would be time available to allow for the decontamination of patients prior to transport to alleviate worries. However, some form of official certification confirming that patients have been checked and that there is no residual contamination risks for aircraft and crew may be required.

Issues were encountered in procuring radiation detection and monitoring equipment for emergency responders and the public due to a lack of knowledge and experience of the certification standards for such equipment, which has led to some delays with external consultants being brought into support. Another issue encountered was with the provision of some medical countermeasures and critical supplies to some hospitals. For example, cytokines can be used as a first response countermeasure for treating acute radiation exposure but are not legally permitted for use in some countries. They are also expensive and have only a short shelf life, so some countries maintain inventories where such medications are available and put in place arrangements to rapidly acquire supplies if needed. It has not yet been possible to put such arrangements in place in Ukraine, but the procurement of cytokines has been added to the national stockpile list and case management protocols and guidelines have been translated to Ukrainian.

Another important initiative to support Ukraine has been the planning and launching of mental health and psychosocial support to address the needs of people affected by war. This has required the development and provision of training courses for health workers, including modules on nuclear emergencies and many resources have been made available (WHO, 2022). A framework for prioritised multi-sectoral mental health and psychosocial actions has also been developed and the WHO has supported 60 community mental health teams and trained over 700 specialists in the management of stress-related mental health conditions in challenging new circumstances. The WHO has also been involved in risk communication and community engagement activities, including distribution over 800 000 copies of a Ukrainian booklet detailing simple to follow safety measures for chemical and radiation emergencies, with a particular focus on those communities in areas affected by the conflict. Infographics have also been made available in Ukrainian as part of public information dissemination on topics including self-decontamination, iodine thyroid blocking and advice for pregnant women in a radiation emergency. A health sector capacity building training programme on radiation and nuclear EPR has also been developed and rolled out with a first training course being held in Kyiv in June 2022. Training courses have been provided online as well as in person in different regions. A dedicated website on technological hazards and health risks in Ukraine has also been established (WHO 2024).

The key lessons learnt from a year of response to the war in Ukraine are as follows:

- The perceived risk of health emergencies caused by the deliberate or accidental exposure to chemical or radiological/nuclear hazards has increased.
- Despite established existing preparedness in the region, this increase in perceived risk has revealed significant co-ordination, capacity and capability gaps.

- Preparedness and response to these risks requires extensive collaboration between local, national and international stakeholders, involving all humanitarian and development partners, which will be critical to the successful assessment, planning, implementation and monitoring of response interventions and, ultimately, meeting the needs of the affected population.
- The strengthening of national health systems should be a priority for country preparedness to promote resilience to shocks including those involving refugee influx; this ensures continuity of services even as capacity is built to respond to emerging needs.
- It is vitally important to maintain health services in war-affected areas in the short term and to invest in longer-term post-war health system recovery and transformation.

6.2. The interdisciplinary NATO workshop "Regional strategy for medical response as part of the disaster management in case of radiation emergency caused by the war in Ukraine" – Reflections (Cosmin Dugan, BUEH)

The Bucharest University Emergency Hospital (BUEH) has been operating for 45 years. The hospital contains 1 100 beds distributed in 24 medical and surgical specialties arranged in 29 departments. It is the largest emergency hospital in Romania and played a crucial role in the national response to the COVID-19 pandemic, treating the greatest number of patients of any hospital in Romania. In November 2022, BUEH was notified by the Ministry of Health that it had been designated as a hospital for the medical response for the civilian population in the event of a nuclear or radiological emergency. Irradiated patients had never been treated at the hospital so it was necessary to develop action plans (internal regulations, specialised material base, human resources and training); hence, a meeting was held with the National Commission for Nuclear Activities Control (CNCAN) that led to the development of an initial training programme extended over a period of 3 years. The first training course, which was supported by the US DoE within the framework of the International Radiological Assistance Programme "Training for Emergency Response", was held over a week in March 2023.

BUEH also participated in a national exercise, Valahia, that was held in October 2023 and simulated a severe accident scenario at the Cernavodă Nuclear Power Plant. Over 50 medical personnel were directly involved in the training exercise, which focused on the medical procedures involved in the management of two seriously injured people transported by helicopter (one case requiring transfer outside the country) and 19 ambulatory patients that were realistically simulated.

In addition to the training exercise, a decision was made with CNCAN to help realise an advanced NATO workshop on a "Regional strategy for medical response as part of the disaster management in case of a radiation emergency caused by the war in Ukraine". The workshop was organised by BUEH in partnership with the State University of Moldova and was sponsored by the NATO Science for Peace and Security programme. The workshop was held 19-23 September 2023 and considered risks, vulnerabilities, scenarios and solutions in the case of an incident associated with the conflict in Ukraine, including local, regional and European reactions. It was attended by specialists from a wide range of countries, including those most likely to be affected by the war in Ukraine as well as from international organisations such as the WHO. Ukraine was also represented via remote participation.

A broad range of topics were covered, including contingency planning for haematologists in radiological and nuclear events, leading to a Nuclear Accident Committee task force being organised on the topic of blood and bone marrow transplants following radiation and nuclear emergencies. On the third day, the Ambassador of Japan in Romania and the Ambassador of Korea in Romania hosted a panel on strategies for reducing the risk of a radiological disaster or conflict with weapons of mass destruction. The presentations during the event included a talk about a physician's 10 years of experience following the Fukushima Daiichi Nuclear Power Plant accident. Plausible scenarios for the Ukrainian conflict were also presented.

Several future actions for BUEH have been identified as a result, including the need for capacity building for the medical management of radiation injuries, which will be synergistic with planned development of medical capabilities including the development of a nuclear medicine department and of transplant capabilities. The response to the COVID-19 pandemic highlighted the importance of having good public communication and psychological resilience strategies, which will be needed to deal with any radiological or nuclear incident, covering both the psychological impact on patients and medical staff responding to a large influx of patients.

The NATO workshop was useful but is only one step in the development of capabilities and capacities for treating patients affected by radiological and nuclear emergencies. Continued national and international co-operation is needed in the scientific field, as well as in training exercises and simulations.

6.3. Regulatory strategies for acceptance of medical equipment: New challenges (Yevheniia Kudriashova, SSTC NRS)

Since the beginning of the war, 1 697 X-ray machines for X-ray diagnostics have been registered in Ukraine, bringing the total as of November 2023 to 15 612. The X-ray machines, which include mammographs, computed tomography (CT), dental and conventional X-ray diagnostic devices, have an important role to play in medical practices and diagnostics. While the number of diagnostic devices has increased since the start of the war, the Ukrainian population has reduced, from 43.5 million in 2021 to between 28 and 34 million in 2023.

The increase in registered machines is attributed to an increase in the number of procedures. The COVID-19 pandemic has led to an increase in the number of X-ray examinations and CT scans, as well as a relaxation of controls on the importation of diagnostic equipment. Subsequently, and as a result of the war, Ukraine has received a large amount of humanitarian aid but radiation safety has been neglected and the number of qualified personnel has fallen. A number of problems therefore need to be solved, including establishing clear treatment protocols and training personnel to ensure equipment is applied consistently, that image quality is optimised relative to patient exposure, and that diagnostic information is made available in a predictable and reliable way. There also needs to be appropriate judgement on the benefits of diagnostics versus consequences for those trying to heal, which requires functional and modern equipment to be in operation. The use of older outdated machines leads to the risk of patients receiving much higher doses than needed. It is also necessary to put in place safeguards to protect patients from unnecessary diagnostic procedures involving radiation exposure and to ensure the safety of radiation sources.

The invasion of Ukraine has put a severe strain on the healthcare system. There is higher demand from citizens and military personnel as a result of trauma injuries. Since the start of the conflict, hospitals have tried to maintain services, but there have been numerous direct attacks by Russians on the healthcare infrastructure, with 1 156 attacks being recorded by November 2023. Russian forces have also been implicated in the destruction of medical equipment and attacks on the power infrastructure have affected the ability of healthcare system to maintain services, including diagnostics. Continued provision of quality healthcare is vital to support the affected populations.

Since late 2021, the SSTC NRS has worked collaboratively with the DSA to develop criteria for the acceptance of medical diagnostic equipment. Criteria and acceptance testing, commissioning, periodic performance testing and proper decommissioning of medical diagnostic equipment will be established. Diagnostic equipment, like any other devices, are subject to breakdowns and malfunctions over time, which can lead to a loss of diagnostic function. Hence, conducting regular tests on critical parameters of X-ray diagnostic equipment is imperative, enabling timely detection of degradation or changes in equipment operation. The qualification of people undertaking checks on equipment is critical and there needs to be a clear framework for responsibilities to ensure that potential safety issues with equipment are identified before they can cause harm to patients. It is expected that, as a result of projects implemented with expert support from the DSA, significant improvements in the regulatory framework will be achieved. The projects will involve the development of regulatory documents on providing services related to the acceptance, commissioning, periodic testing, and decommissioning of medical diagnostic radiological equipment. The primary focus of these documents extends beyond optimising doses for patients, also emphasising the need to obtain adequate diagnostic information.

There are a number of challenges ahead, including creating an evidence-based safe environment for patients during diagnostic procedures, which includes ensuring that diagnostic reference levels are met and that diagnostic equipment is of appropriate quality. In addition to meeting diagnostic reference levels, it is crucial to establish a method for computing patient doses. Ensuring there is a sufficient supply of qualified medical and technical staff is also essential – general purpose X-ray machines are being used many times per day in Ukraine as a result of trauma injuries to military personnel and members of the public, so it is essential that there is sufficient qualified staff available to operate the diagnostic equipment safely. Regular training is also required to maintain equipment. Licensing requirements and safety conditions also need to be updated.

In armed conflicts, safety rules must continue to be applied, even in situations where hospitals are turned into shelters. It is necessary to continue to provide medical services to the public and to the country's military forces as they work to defend and protect the population.

6.4. Discussion

One of the main objectives in ensuring that health services continue to function under armed conflict situations is to create a safe environment for medical personnel to work in and to provide psychological support to people who have been displaced as a result of the conflict. Issues can also arise in the provision of necessary pharmaceuticals and other supplies in occupied regions. It is also important to standardise procedures to reduce the time needed for military personnel and civilians to receive the medical care they need.

To help countries build resilience, training exercises based on appropriate scenarios can be run to develop expertise and improve capabilities. It is not possible to prepare for all eventualities. Nonetheless, the healthcare sector is now better prepared as a result of the recent experience of the COVID-19 pandemic and lessons can be learnt. For example, emotions ran high among medical personnel during the pandemic and strong leadership was needed. The understanding that everyone is facing the same situation and the existence of strong leadership can help people to continue providing the care that is needed. A further lesson learnt was the need to consider the resources that might be needed for different scenarios and to have access to specialised expertise to help prepare and respond rapidly.

From the perspective of the WHO, in supporting Ukraine and in other conflict situations, it is necessary to develop and strengthen close co-operation and co-ordination between the different sectors involved in responding to emergencies. In a conflict situation, staff operate in challenging, difficult and dangerous environments and good co-ordination is needed. The attacking of healthcare facilities, as seen in Ukraine, goes against international conventions and laws and those laws must be respected in times of war.

There has been concern from citizens in Dnipro about the potential risks from an emergency situation arising at the Zaporizhzhia Nuclear Power Plant. From a health sector preparedness point of view, it is important to recognise that even in a worst-case scenario there will be time to communicate with the public on mitigation measures such as sheltering or taking iodine tablets. However, if a tactical nuclear weapon were to be deployed, a very different scenario would arise. The use of a tactical nuclear weapon could lead to a high impact, mass casualty event with hundreds to thousands of casualties. While it is hoped that no such situation arises, the question of how the burden of clinical care can be addressed is being considered by working with UN member states bordering Ukraine to train health care workers, etc.

The WHO noted that its mission in Ukraine was unusual, requiring travel in a bullet-proof vehicle for long periods between cities. It said that the resilience of Ukrainian health workers on the front line, dealing with wounded people and recounting horrific stories, was impressive and inspiring.

7. Session 5: Identifying key lessons learnt on managing RP during armed conflict: Improving regulatory resilience

7.1. Regulatory threat assessment: Methodology for review and strategy to address changed and new threats (Oleksandr Pecherytsia, SSTC NRC)

The approach to regulatory threat assessment was established through a co-operation agreement between the SNRIU and the DSA. The co-operation agreement was signed in November 2014 and was aimed at enhancing and developing radiation and nuclear safety in Ukraine. A transparent approach to activities was implemented (Figure 7.1) involving periodic assessment of regulatory threats and development of priority actions. The overall objective was to conduct a comprehensive and detailed analysis of regulatory activities, including an assessment of progress made since the previous one, and identifying vulnerabilities/gaps for which measures to eliminate or mitigate threats identified from the regulatory perspective could be developed.

Figure 7.1. Method for review and strategy to address regulatory threats in Ukraine

A Threat Assessment Report (TAR) was produced that details the comprehensive analysis and identification of critical vulnerabilities. Sections 1 to 8 of the report describe emerging developments in the nuclear sector and identify and present the threats and their implications. The report then systematises the threats and identifies and justifies ways of addressing the threats. From this a roadmap for the next phase of co-operation between the DSA and SNRIU was developed and presented (Figure 7.2).

Figure 7.2. Main elements of the Threat Assessment Report

There are several main elements of co-operation projects, with gap analysis of the national framework in the relevant area being key. Following gap analysis, best international practices are reviewed and new regulatory requirements and guides developed as required.

The first regulatory threat assessment was undertaken in 2015, with the resultant TAR being published in 2016 (DSA, 2016). The assessment identified several priority areas for improvement of the regulatory and legal framework, including:

- safety of nuclear installations;
- radioactive waste;
- emergency preparedness and response;
- transport of radioactive materials;
- remediation of legacy sites; and
- radiological protection.

In 2017, a second regulatory threat assessment was performed (Siegen et al., 2018) that covered all areas of the agreement and again developed a roadmap for the next phase of co-operation. The latest threat assessment was undertaken in 2021 (Sneve et al., 2022) with both the SNRIU and the DSA recognising significant achievements in improving the state of nuclear safety regulations in Ukraine as a result of the steps taken to improve the legal framework. New challenges were also identified in the 2021 TAR.

To date, 41 projects have been completed or are ongoing, covering a range of topics that include medicine, radioactive waste, EPR, decommissioning and transport, including a project to enhance the framework for radioactive waste management that, despite the invasion of Ukraine by Russia, has continued. Furthermore, the overall number of projects since the start of the invasion has increased five-fold compared with before the invasion, with the DSA being the first to provide assistance to Ukraine in addressing the challenges faced as a result of the Russian invasion. Two phases of project SURVEY (see section 4.2) have been successfully completed, as well as three projects that focused on the development of priority regulatory documents to ensure safety regulation when restoring control over nuclear hazardous facilities and sites affected by the hostilities. Project ZONE I focused on facilities in the CEZ, ZONE II focused on restoring state safety regulation for operation on the Zaporizhzhia Nuclear Power Plant, and ZONE III focused on developing an action plan to renew and complete licensing of the Neutron Source facility, taking into account long-term shutdown and damage resulting from Russian shelling of the facility. Two further projects have also been completed:

- Project EQUIPMENT, which had the objective of strengthening the regulatory capacity of the SNRIU by providing monitoring equipment; and
- Project KNOWLEDGE, which had the objective of developing training modules on a range of topics related to potential accidents as well as the potential use of nuclear weapons. Topics including the assessment of radiation consequences, modelling of atmospheric dispersion, ensuring radiation safety of armed forces when working in contaminated territories during hostilities, and issues of decontamination and radiation surveys.

The projects have also aimed to provide public information and help build trust through visibility and dialogue as well as helping develop relationships between people affected through occupation, etc. and the regulatory bodies. For example, an exhibition was organised on the results of the radiation survey around Kyiv with over 1 000 people attending. The event was also covered widely in the media.

The approach implemented in the bilateral co-operation agreement between the SNRIU and the DSA was recognised as good practice by the European Commission and European regulators and TSOs are willing to engage and contribute to the development of the ongoing co-operation between the SNRIU and the DSA.

As a result of the invasion of Ukraine by Russian forces, there is a need to further update the TAR to address newly changing circumstances and work is ongoing. It is anticipated that the next TAR will be finalised in early 2024. The co-operation between the SNRIU and the DSA is anticipated to continue using the established project-oriented approach to further enhance and develop the regulatory framework on nuclear and radiation safety, with a focus on the following:

- assessment of radiological impacts on the public in situations of uncertainty associated with force majeure, with a view to better inform the public on the threats;
- communication of the safety-related information to the public on territories affected by occupation, increasing awareness of media representatives with respect to nuclear and radiation threats;
- closer dialogue with other relevant authorities and stakeholders at the national and international levels, including joining procedures and activities that increase co-ordination and performance;
- further increasing the visibility of the SNRIU-DSA co-operation at the national and international levels through event-based dissemination, scientific publications, conferences and workshops.

The systematic and transparent approach developed by the SNRIU and the DSA to implementing bilateral activities, based on identification of the threats and challenges that adversely affect the SNRIU's functions, have provided an effective and sustainable basis for planning, co-ordination and timely implementation of projects aimed at addressing the key challenges. The approach has proved to be efficient and the working relationship between the SNRIU and the DSA is expected to allow for further co-operation.

7.2. War in Ukraine – European Commission support activities in nuclear safety and radiation protection (Pascal Daures, European Commission)

When Russia invaded Ukraine, the EU reacted with the adoption of sanctions against Russia. The unprovoked aggression presented an unprecedented situation for the international nuclear community. On 26 April 2022, the 36th anniversary of the Chernobyl accident, the EU released a declaration calling on the international community to reflect on how to improve existing international instruments or whether new instruments may be necessary to protect nuclear sites in the context of war.

The Chernobyl Nuclear Power Plant and CEZ were occupied by Russian military forces from the early hours of invasion until their withdrawal on 31 March 2022. Following the withdrawal of troops, many items were found to be missing or damaged, with damage within the CEZ estimated to be of the order of EUR 80 million. Administrative and laboratory buildings were also extensively damaged and equipment stolen. The Zaporizhzhia Nuclear Power Plant has also come under the occupation of Russian military forces and remains under Russian control, with the situation becoming increasingly tense and challenging. Reactors are in shutdown but security and safety issues continue from shelling, the precarious supply of external power to the site, destruction of the Kakhovka dam, pressure on staff and reduced scope of maintenance.

The European Commission has co-ordinated support for Ukraine, identifying what support is needed and co-ordinating the delivery of that support, which has included material assistance, supply of medical countermeasures, support to the SNRIU and financial, political and diplomatic support.

European civil protection and humanitarian aid operations under the EU Civil Protection Mechanism (UCPM) involve all 27 EU member states plus 9 participating states. Since the establishment of the UCPM, over 600 requests for assistance have been received. The UCPM aims to strengthen co-operation between EU countries and participating states on civil protection to improve prevention, preparedness and response to emergencies (nuclear or other) and provides a mechanism for countries to request assistance when national response capabilities are overwhelmed. Both frontline support and external support services can be provided. In 2019, a new European Reserve of Response Capabilities (RescEU) was established to strengthen disaster risk management. RescEU has capabilities within several areas of action (or pillars) that include aerial forest firefighting, medical, shelter, transport and logistics, emergency energy supplies and CBRN. The reserves and pillars continue to be strengthened with the supply of more equipment. The emergency energy supply pillar was relevant following the targeting of Ukraine's power infrastructure in the winter of 2022. With the exception of aerial forest firefighting, RescEU capacities are labelled as high-impact, low-probability.

Altogether, 32 countries have provided support to Ukraine via RescEU, with around EUR 760 million provided. Support has included the medical evacuation of people for treatment outside of the Ukrainian health system, provision of over 93 000 tonnes of equipment, including power generators, and establishment of four logistical hubs at border points that help deliver what is needed to where it is needed. The delivery of support to Ukraine has been the largest operation undertaken by RescEU to date.

The co-ordination group INSC was established to identify support needs and priorities. Under the INSC, a co-ordination group led by the State Agency of Ukraine on Exclusion Zone Management (SAUEZM) was established, focusing on the Chernobyl Nuclear Power Plant and CEZ to restore automatic radiation monitoring capacities, recover the functionality of the Centralized Analytical Laboratory and procure laboratory equipment for the damaged laboratory at Chernobyl that had originally been provided by the EU and others.

The INSC has also refocused activities to provide direct material assistance to nuclear facilities. Of the EUR 16.4 million available in the 2022 INSC action plan, EUR 3.4 million was allocated to support IAEA assistance to Ukraine, EUR 5 million was directed to restoring analytical capabilities in the CEZ, with support being co-ordinated with the DSA, and EUR 8 million was contributed to the International Chernobyl Co-operation Account managed by the European Bank for Reconstruction and Development. An additional EUR 10 million was proposed under the 2023 action plan and has been enacted.

There are two main systems for emergency preparedness - the European Community Urgent Radiological Information Exchange (ECURIE) and the European Radiological Data Exchange Platform (EURDEP). Information from monitoring stations throughout Europe is gathered and, if radioactivity is detected following an accident within or outside the EU, the ECURIE system is activated and provides vital information throughout the network. Together, these systems provide for a continuous online exchange of radiation monitoring data, with data being updated at least hourly during an emergency. Ukraine is not currently part of the ECURIE system but has been invited to join.

The EC has also provided support to Ukraine through ENSREG, the European Nuclear Safety Regulators Group, which provides direct support to the regulatory authority through co-operation with other European regulators, with ENSREG arranging emergency meetings and statements. A WENRA technical group on Ukraine has also been established to develop position papers and undertake assessments, including modelling of accident scenarios. Both ENSREG and WENRA provide dedicated support to SNRIU and its TSO (SSTC NRS) through provision of financial support and through transfer of expertise to maintain nuclear regulatory oversight.

One of the flagship projects triggered by the Russian invasion is the project implemented to restore the Central Analytical Laboratory in the CEZ that was destroyed and looted by Russian troops. The project aims to restore the infrastructure for radioactive waste management in the CEZ and is undertaken in co-operation with the DSA and with additional funding from the United Kingdom and United States. The project is a good example of how the pooling of resources can lead to efficient delivery, with equipment replacement beginning in autumn 2022.

The INSC previously contributed to the establishment of a national training centre for nuclear power plant management and maintenance. The Zaporizhzhia Nuclear Power Plant training centre was targeted during the first shelling by Russian forces and has also been looted. The EC stands ready to participate and support Ukraine in re-establishing the training centre to restore the same nuclear and security capabilities when the situation allows.

7.3. Roundtable discussion of key lessons

A roundtable discussion session focused on identifying key lessons on managing radiological protection during armed conflict that could improve regulatory resilience. While discussions focused primarily on Ukraine specifics, more general issues were also considered. The panellists included a range of experience and expertise, as follows:

- Oleh Korikov, Acting Chair of SNRIU, Ukraine
- Andrzej Głowacki, President of PAA, Poland
- Géraldine Pina, Commissioner, Nuclear Safety Authority (ASN), France

- Per Strand, Director General, DSA, Norway
- Gareth Thomas, Lead for regulation of radiation protection, Office for Nuclear Regulation (ONR), United Kingdom
- Petteri Tiippana, Director General, Radiation and Nuclear Safety Authority (STUK), Finland

Key points arising in discussions are summarised below.

During an armed conflict situation, radiological protection and nuclear safety organisations must continue to do their jobs to the best of their abilities under the circumstances they are faced with. Roles during conflict situations may change so it is necessary to be able to adjust, adapt and make decisions under challenging circumstances, including by balancing the radiation safety risks against the other risks faced by society. Communication between organisations is crucial in responding to radiological protection and nuclear safety risks during armed conflict situations.

From experience gained during the COVID-19 pandemic, it may be possible for some activities to be deferred or for them to be performed remotely and the same could apply in an armed conflict situation. However, armed conflict poses more varied and serious dangers and challenges, including the potential for communications tools to be affected, so additional measures and greater adaptation may be needed.

During the COVID-19 pandemic there were discussions in Norway on what would happen if there were to be a nuclear accident during the pandemic and how the two situations would impact each other. Adaptation can be prepared for to an extent by considering several crises occurring at the same time, or one crisis leading to simultaneous crises. The principle of justification remains relevant even in a war situation, but it may be necessary to consider how justifiable actions to address one crisis could impact another. War scenarios have not commonly been considered for radiological protection, and the conflict in Ukraine has shown a need to consider such scenarios further in threat assessments, alongside nuclear safety and security in these circumstances.

In making operational decisions, it is necessary to consider not just the risks of accidents occurring, but also any negative impacts on society associated with ceasing activities, again applying the justification principle to ensure actions do more good than harm. Such decisions should be made at the political level as the decision will need to consider any implications on the ability of the country to fight the aggressor and of any actions on the population and the crisis as a whole. For example, from a radiological protection and nuclear safety point of view, it may be preferrable to shut down a nuclear power plant, but energy supply can be critical to the supply of vital services. The actions to be taken will be national policy decisions, but while factoring in nuclear safety in those decisions, along with consideration of the consequences for the rest of society. The consequences of not taking an action should also be considered, including the consequences of any accidents resulting from not taking actions.

To make decisions, information is needed, but in a war situation, information may come from different angles and there may be challenges in obtaining necessary information, which could lead to hesitancy around making decisions. Development of a policy framework at the international level could provide high-level guidance for armed conflict situations on what radiation and nuclear safety activities should be continued and list the activities that could be stopped, taking into account the circumstances faced. Decisions would still need to be made on the basis of information available and national requirements (e.g. energy requirements). There may also be requirements for decisions to be regularly revisited. For example, nuclear power plants may remain operational to ensure energy requirements are met, but shutdown may be necessary if the conflict encroaches on nuclear power plant territories and requires evacuation of workers. Nonetheless, consideration can be given to the safety culture at nuclear power plants and to plan for what may need to be changed or adjusted, with that plan being built upon depending on the circumstances faced. It is also important to be honest and transparent, recognising that it may be preferable to take one action but admitting that it is not possible to do so under the circumstances.

A key lesson learnt from the Ukraine situation is the need for a strong safety culture to be in place. If there is a strong safety culture, people will tend to do the right thing even when unexpected circumstances arise. This requires that people have sufficient training and have access to the right tools. The DSA is continuing to work closely with Ukraine to build on lessons learnt and to act within the regulatory framework as required.

It is clear from Russian military actions that in a war situation, aggressors may not implement nuclear safety fundamentals, follow nuclear safety principles or follow international conventions. Every war situation will be different in terms of the scenarios faced and will depend on factors such as economic development, availability of resources and infrastructure. It is a challenge to develop a template of actions that will suit all circumstances. Furthermore, emergency response strategies will need to be able to adapt to changing circumstances and the availability of resources on which those strategies are reliant (e.g. shelters and roads). There will also be a need to consider the consequences of planned actions to account for the new circumstances faced. For example, the evacuation of an affected population as a result of a nuclear power plant incident will increase population density in the areas to which the population is evacuated. Military strikes to those areas would then have higher consequences. A case-by-case approach will therefore be necessary for any nuclear power plant situation to compare the risks and benefits of the different actions and to take additional or alternative actions based on necessity.

Nuclear facilities are subject to design basis threat assessments as part of EPR, but military aggressors are not usually within the scope. There is a need to consider external threats a lot more than they have been considered to date. This includes not only aggressors but also external threats from natural phenomena, as evidenced by lessons learnt from the Fukushima Daiichi accident, and threats associated with climate change, etc. The extent of challenges faced should also be considered, including whether support from neighbouring countries may be required. However, if a severe incident were to occur, support from neighbours may not be feasible as they may be responding themselves to the challenges faced within their own country resulting from the incident. The implications of neighbours being unable to provide assistance should therefore be considered. From the Fukushima Daiichi accident a key lesson learnt was that nuclear power plants need to be made more secure by ensuring power supplies for cooling water systems can be maintained under threat scenarios. Nuclear power plants should be as robust as reasonably achievable to the threats that could be faced, but it will not be feasible to plan for every eventuality – prior to the Ukraine war, planning controls would not have considered taking account of scenarios around missile strikes to nuclear power plants and loss of control of facilities as a result of military conflict.

Communication between organisations is crucial in responding to radiological protection and nuclear safety risks during armed conflict situations. However, if nuclear weapons were to be deployed, a very different situation would be faced. Responses would be targeted to areas outside the physically impacted area to implement protective actions for the population that may become exposed to the plume. This does not differ substantially from taking protective actions for the wider population following a nuclear incident so there is scope for planning. There would be a need to model how the plume will respond to prevailing weather conditions and to consider what this means in terms of the transport and dispersion of radioactivity and the need for protective actions. Where the radiation comes from is therefore less important for considering actions, but the political and regulatory implications would be much larger as a result of the use of nuclear weapons.

ICRP Task Group 120 is looking at radiation emergencies and malicious events to update guidance. The scope of radiation emergencies and malicious events is large and initially did not consider tactical nuclear weapons. Following the start of the armed conflict in Ukraine, this topic came to the forefront to consider public protection. Work is continuing, including protection of first responders involved in rescue missions, etc. Guidance on how to respond to alerts and what to do during the initial stages of an incident has been translated into 15 languages (ICRP, 2024).

In Norway, about 55% of the population is concerned about the potential use of nuclear weapons. Currently the use of tactical weapons in other countries (including Ukraine) and the implications for Norway are the focus of interest. Other countries are also considering EPR scenarios involving the use of nuclear weapons – if preparedness activities include war, it is natural to also consider the use of nuclear weapons. While the first response to the use of nuclear weapons would be to protect the public from radiation, protecting society from other hazards also needs to be considered. How to maintain regulatory functions under situations involving the use of nuclear weapons should also be considered. The ability to obtain timely and accurate information will be important in responding to such events and building, implementing and improving national strategies for monitoring capabilities can help build resilience. Educating the public on radiation impacts prior to any crisis occurring is also important, as is building public trust so attention is paid to instructions following an incident.

A well-prepared international framework for ensuring nuclear safety and radiological protection is in place and countries have responsibilities for implementing the safety fundamentals, principles, rules and requirements. One of the important lessons learnt from the war in Ukraine is that ownership is key. Where there is ownership, safety fundamentals, rules and requirements can be implemented (although the infrastructure needs to be maintained to make available necessary resources). However, under armed conflict situations, if control of a facility is lost, it is no longer possible to take responsibility for that facility and aggressors may not follow rules and conventions. The focus then becomes how to protect the facility and how to co-operate with neighbouring countries in the face of uncertainties. The role of international organisations in this area is important.

Where aggressors violate rules, international co-operation is needed to evaluate the actions of the aggressor and consider the application of sanctions. This might include a range of measures, such as the freezing of assets or refusing to accept passports, etc. A strong response mechanism is required to act as a deterrent to any potential aggressor.

8. Session 6: "What if" conversation: Lessons from experience for a more resilient regulation and application of radiological protection in armed conflicts

Session 6 focused on lessons learnt for more resilient regulation and the application of radiological protection in armed conflicts. After a presentation summarising key activities under the NEA Working Party on Nuclear Emergency Matters (WPNEM), a "what if" session began with presentations related to two topical areas:

1. radiological protection management in armed conflict situations; and
2. communication and stakeholder engagement in situations where daily life is disrupted.

The presentations aimed to provide context and background information on the selected topics to ensure that participants had a good understanding of the subjects prior to breakout discussions. The presentations, discussion scenario and feedback from the discussion groups are presented below.

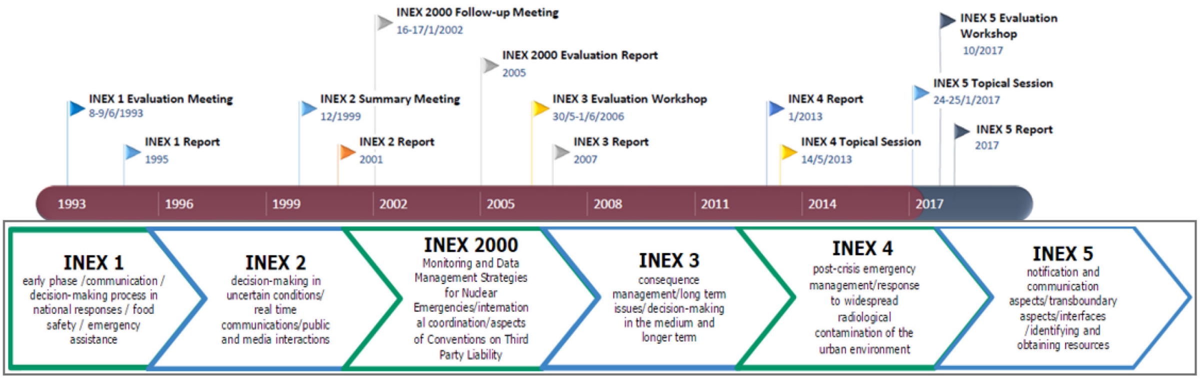
8.1. Key activities of the Working Party on Nuclear Emergency Matters (WPNEM): A focus on INEX-6 (Jacqueline Garnier-Laplace, NEA, and Tristan Barr, WPNEM)

The NEA WPNEM serves as the CRPPH vehicle to address nuclear emergency matters. The WPNEM was established in 1993 with the mission to enhance nuclear emergency management systems in member states and to provide a forum for sharing knowledge and experience on all aspects of planning, preparedness and response for all phases of a nuclear or radiological emergency, including recovery actions. The WPNEM has a membership of 117 delegates from 28 NEA countries, along with invited countries. A key pillar activity is to prepare international emergency exercises in the INEX series. INEX series exercises have been organised by the NEA since 1993. The NEA develops, organises, evaluates and analyses the exercises to improve nuclear and radiation emergency management systems and identify best practices for response and recovery following an emergency. Each exercise addresses the needs of the participants, and participation is voluntary. Exercises can be table-top or field-based. There is always an evaluation event held to capture lessons learnt from the exercises. The exercise structure functions as a loop where there is an exercise, debrief and analysis to identify gaps that could improve the process. The topic for the next exercise is also agreed upon. These exercises are important for advancing emergency preparedness at the national and international levels, and feedback from INEX exercises is the primary input into the WPNEM's programme of work. INEX exercises are held every five to six years and have addressed various topics, including:

- early phase communication issues, real-time communications and interactions with the public and the media;
- consequence management and decision making in the medium and longer term;
- response to contamination in the urban environment; and
- transboundary aspects of notification and communication.

The timeline of events is illustrated in Figure 8.1.

Figure 8.1. Timeline of INEX exercises and topics addressed



Key outcomes from INEX 5 that have helped shape the WPNEM programme of work fall into three key areas:

- Communication and information sharing with non-accident countries and international partners with a focus on real-time communication platforms. The working group is reviewing how communication platforms that can be used to facilitate cross-border and regional information exchange and co-ordination of countermeasures can be improved. A report on this topic will be published in early 2024.
- Two areas of improvement have been identified on the topic of cross-border and international co-ordination of protective actions: sharing of dose projection outputs based on the same (or very similar) accident inputs can help improve dose prognosis in emergencies; and updating the WPNEM member country Protective Measures Handbook. Publications from both will be made available early in 2024.
- Long-term aspects to be better integrated in early decision making and preparedness has been a topical work area focused upon over the last four years. A practical guide on how to consider mental health and psychosocial support in protection strategies for preparedness, response to, and recovery from radiological or nuclear emergencies was due to be published in December 2023 or early 2024. Recommendations for building nationally adapted recovery frameworks in NEA countries was published in 2022 (NEA, 2022).

INEX-6 will help continue improving countries' preparedness for nuclear and radiological accidents, focusing for the first time on long-term recovery. INEX-6 will run from January to March 2024 and will involve four table-top modules focused on different aspects of long-term recovery including health, food safety, remediation and decontamination, and waste management. Cross-cutting issues across the four modules include stakeholder engagement, communications, international co-operation and socioeconomics. The aim is for each country to run a common scenario independently and then evaluate across all countries to further develop preparedness plans that include the recovery stage. The INEX-6 scenario has been developed as a question-driven exercise aimed at challenging participants to apply existing policies and plans to determine protective actions and links directly with the NEA publication "Building a framework for post-nuclear accident recovery preparedness: National-level guidance" (NEA, 2022). As such, some guidance is available to participants on building and applying recovery plans. Each participating country has been asked to put together a national planning committee to oversee the planning, delivery and post-exercise review for their national exercise.

Key participants for INEX-6 national exercises include emergency planners, responders and technical decision makers from national authorities, local authorities (where relevant for recovery), and governmental and non-governmental stakeholders relevant to the exercise objectives. Furthermore, countries may opt to include neighbouring countries as observers. The extent of participation is at the discretion of each country. Twenty-five countries/territories and the EC and IAEA have signed up to participate in INEX-6.

Exercise evaluation will be conducted in two parts. First, participants will be provided with an evaluation questionnaire to be completed by a designated exercise evaluator responsible for observing and recording discussions and decisions and for seeking feedback from other participants on successes and areas for improvement. A post-exercise review workshop will then be held towards the end of 2024 or in early 2025. A post-exercise report will be prepared, focusing on international comparisons. Feedback on the exercise will be incorporated into the next programme of work in the WPNEM.

The exercise is based around a fictitious incident scenario with a source term focused on long-lived radionuclides. The scenario describes the situation 12 months after the event and includes cross-border impacts, e.g. with the plume extending to neighbouring countries that include both nuclear and non-nuclear states. Most emergency plans consider the early phase of response to an incident, but the longer-term phase response will likely involve the same people and include additional stakeholders. The participants are expected to understand that the scenario begins 12 months following the incident, rather than focusing on initial actions to be taken. In instances where the effects of an emergency cross national borders, it is vital to align national government protective actions and communications strategies to gain public trust.

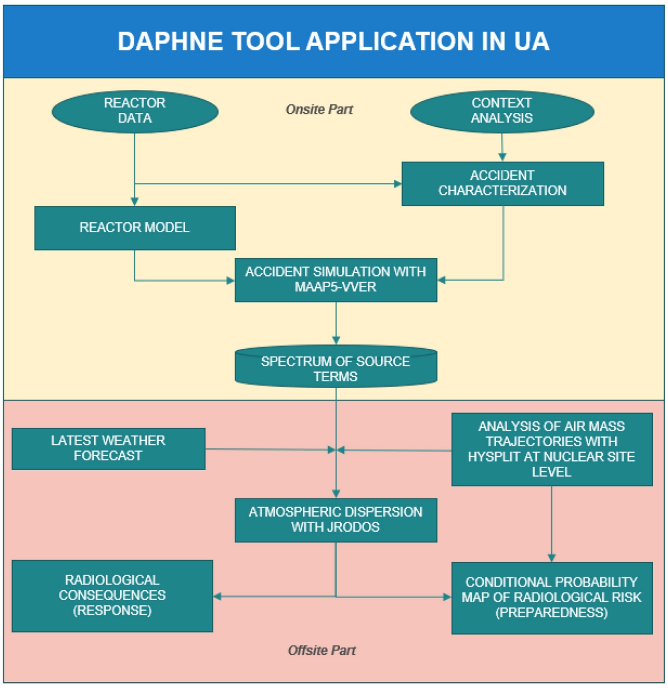
8.2. Topic 1: Radiological protection management in armed conflict situations

8.2.1. DAPHNE application in Ukraine for accident assessment and benchmarking of radiological consequences (Juan Carlos de la Rosa Blul, EC JRC)

Prior to the war in Ukraine, the EC Joint Research Centre (JRC) was asked, partly in response to the Fukushima Daiichi accident, to set up an approach for the Diagnosis and Prognosis of Hazards in Nuclear Emergencies (DAPHNE). DAPHNE is an EC in-house numerically based methodology to perform severe accident simulations based on surrogate reactor models for computing the source term followed by atmospheric dispersion, deposition and calculation of radiological consequences.

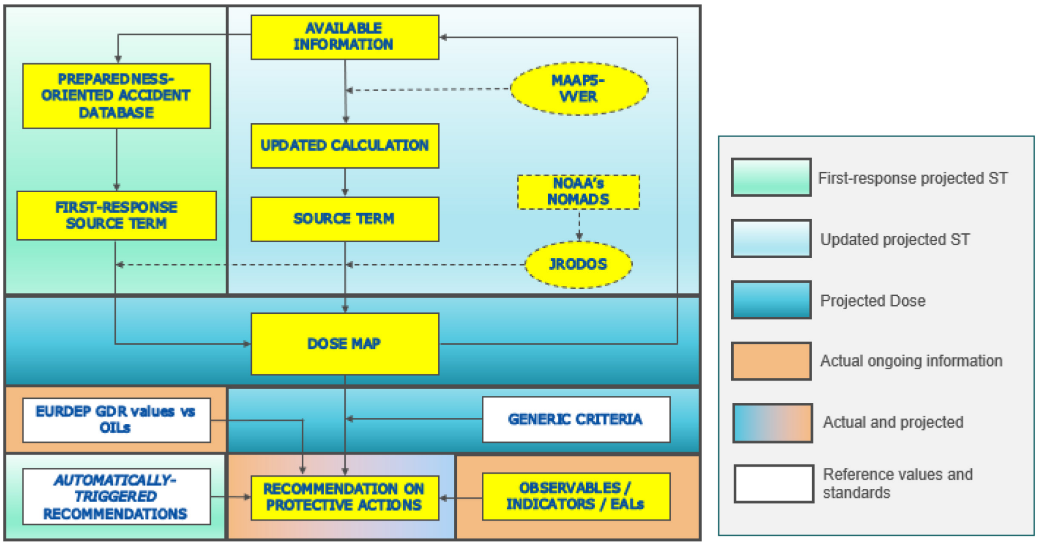
DAPHNE has been applied to the situation in Ukraine. There are a number of uncertainties to address in order to establish a numeric-based model for different nuclear facilities, different accident sequences and their potential radiation consequences. In applying DAPHNE to the situation in Ukraine (Figure 8.2), a surrogate model for each existing nuclear power plant design in Ukraine, namely VVER-1000 and VVER-440/213, was used and, in terms of potential accidents, the situational context was taken into account to identify extreme yet reasonable events. Accident simulations within the MAAPS-VVER code then generated a spectrum of source terms. These source terms then provided the basis for off-site emergency preparedness and response simulations. For emergency preparedness, thousands of different air trajectories for nuclear sites in Ukraine were used with clustered meteorological data to represent the most relevant trajectories and, from this, to derive conditional probability maps of radiological risk. For emergency response, atmospheric dispersion is modelled using the latest weather forecast to look at radiological consequences.

Figure 8.2. Overview of the DAPHNE tool application in Ukraine



A dedicated method has been developed for the computation of radiological consequences from nuclear accidents through a preparedness-oriented accident database for nuclear power plants throughout Europe. As information comes in, projected dose maps can be generated and recommendations made on protective actions. The approach is illustrated in Figure 8.3.

Figure 8.3. DAPHNE emergency response flowchart



Several critical questions for emergency preparedness and response have arisen as a result of the conflict situation in Ukraine, such as whether existing emergency plans at the nuclear power plants are suitable for wartime conditions and what the radiological risk would be at the geographical level due to the war. There was also a need to consider how to distribute EPR resources which should be based on risk prioritisation. DAPHNE was therefore applied to help answer some of these questions. The geographical regions affected by the radiological consequences of a set of representative nuclear accidents from an emergency preparedness standpoint were evaluated, with results presented as maximum distances from the damaged nuclear power plant reaching a damage threshold, set at a 96-hour cumulative effective dose of 50 mSv. In looking at potential radiological consequences, a wide range of possible accident scenarios were considered, ranging from loss of electricity to feasible yet severe scenarios such as loss of containment and damage to facilities outside of containment (e.g. spent fuel ponds and dry storage areas) and an all units fail (reactors and spent fuel ponds) scenario.

The analysis of representative accident scenarios did not replicate the emergency preparedness planning in place prior to the war and the emergency zones set as a result of that planning since many potential accidents considered for a war situation had not been previously considered. Data sets for the nuclear power plants are therefore being updated and emergency zones reevaluated with locations with a probability that is higher than 5% of exceeding the dose threshold indicated above. For Zaporizhzhia Nuclear Power Plant, the geographical radius around the site based on the radiological risk results was 20 km (96-hour cumulative effective dose of 50 mSv). For the same threshold value being reached in 24 hours, the radius is reduced to 15 km.

Dose projection tools informing decisions on implementing protective actions of the public against ionising radiation feature uncertainties that deserve dedicated analysis. Benchmarking is a useful tool for strengthening collaboration and increasing harmonisation in approaches for emergency preparedness and response. Within the ECURIE and HERCA working group, benchmarking has been used to compare and analyse radiological consequence figures used to support and orient decision making during a nuclear emergency response and to identify discrepancies in the outputs of different dose projection tools. The focus has therefore been on the practical use of dose projection tools, but with the exercises also strengthening collaboration and co-ordination between the HERCA/ECURIE organisations and promoting the sharing of information. Even in normal emergency situations there can be issues regarding lack of information and the information that is provided may not be completely clear or arrive promptly. The most important information driving dose projection results for emergency response is the source term.

Two emergency-preparedness-driven benchmarking scenarios have been considered, with one involving limited releases occurring over a 30-day simulation and the other having significant releases occurring over a 7-day simulation. In the first exercise, participants were provided with the source term as a fixed variable whereas in the second exercise there was freedom to perform individual source-term calculations. Different release scenarios were considered, ranging from a limited release at a site where reactors had been shut down to reactor-vessel scale incidents. Five participating organisations in the second exercise computed the source term. Significant discrepancies arose when the source term was computed individually by participants, even though the scenario was known. The results of the simulations showed a greater correlation in dose projection tools close to the release point for the first exercise compared to the second, with greater variation being observed downwind.

The benchmarking exercise served to increase awareness of the limitations of the use of radiological consequence/dose projection tools and highlighted the importance of the source term in validating the results of any radiological consequence assessment. Given the significant discrepancies among the existing results, information on the accident plant and scenario is key to compute an appropriate source term, which is also an important reason for promoting the early sharing of information and the need for strengthening trans-border co-ordination. It is recommended that a guide to best practices and recommendations on the use of radiological consequence tools be developed and agreed. The guide should cover topics such as dealing with the use of the source term, grid cell size, computational grid, atmospheric model suitable for the scenario, weather data resolution, etc. It should be recognised, however, that even if model results are aligned and fall within a perfect match, this does not guarantee that the real world will align with those results.

The exercise also emphasised the important role played by radioactivity monitoring networks in emergency preparedness and response, especially in situations where information is lacking. This is likely to be of increasing importance in an armed conflict situation.

8.2.2. Dose control levels and other radiation protection strategies applicable to Canadian Armed Forces personnel during emergencies and military operations (Roger Hugron, Canadian Department of National Defence)

The Canadian Nuclear Safety and Control Act (NSCA) came into effect in 2000. The Act led to the creation of the Canadian Nuclear Safety Commission, which is responsible for regulating all uses of nuclear substances in the country, with the exception of the Department of National Defence (DND), which was granted an exclusion from the NSCA and associated regulations due to differences required for military operations. Although the Canadian Armed Forces (CAF) are exempt from the Act, the Minister of National Defence was required to establish and maintain requirements consistent with the regulations as far as practicable. For peacetime activities, the DND regulations are therefore consistent with those of the NSCA, with the same annual dose limit being applied. However, different requirements were established for military operations and emergencies.

Directorate of Nuclear Safety is a small directorate that has two sections. One is responsible for compliance and standards and the other focuses on radiation studies, analysis and investigations, including overseeing the Royal Canadian Navy Nuclear-Powered Vessels Visits Safety Programme. The Nuclear Safety Orders and Directives (NSODs) are the safety regulations for the DND and the CAF. The NSODs apply to any country or territory in which CAF activities are conducted. As such, military units conducting nuclear activities resulting in controlled occupational exposures are required to have a radiation safety programme and a radiation safety authorisation, similar to those in Canada, but the Director Nuclear Safety has the authority to modify requirements to account for mission specific needs. For example, in an armed conflict situation, it may be justifiable for troops to be exposed to higher radiation doses in defence of the country or to enter territories to make measurements to identify protective measures that may be needed. Where military operations could result in operational exposures, the principles of justification, optimisation and dose limitation are applied to maintain exposures to as low as reasonably achievable. However, compared to peacetime activities, it is recognised that it may not be possible to study exposure situations and plan in detail and on-the-spot decisions may be needed. In an armed conflict situation, the most important factors are the mission and whether forces are under fire. Under such situations, radiological protection measures will not be the most important factors and dose control via reduced exposure time, increasing distance to the source and increased shielding, etc., may not be possible, particularly in large contamination areas. The use of PPE or of shielded vehicles may be possible, but their use needs to be balanced against other risks, including heat exhaustion.

Dose limits have been established in the NSOD for operations and emergencies. The normal dose limit can be exceeded when justifiable up to 50 mSv, with the decision to permit exposures above this level and up to 100 mSv being taken by the commanders in charge. Further increases are possible, but the authority of the person required to authorise such increases also escalates. For example, at level 2, the dose limit can be raised to 250 mSv under approval of the Formation Commander. A level 3 increase to 500 mSv requires authorisation by the Commander of Canadian Joint Operations Command or the Commander of the Canadian Special Operations Forces Commander and a Level 4 increase above 500 mSv requires authorisation by the Chief of Defence Staff – the highest officer in the armed forces. The dose limits do not apply to someone acting voluntarily to save a life.

In the opinion of the author, the ICRP exposure situations (planned, existing and emergency) are considered relevant under armed conflict situations and no new category specific to armed conflict situations is considered necessary. Depending on the circumstances, any of the exposure categories could apply. For instance, entering a known contamination area would be a planned exposure situation, while being downwind of a radioactive plume and requiring protective actions would be considered an emergency situation. An existing exposure situation could arise if there was a need to operate within a contaminated area for a period of time. For each situation, radiological protection principles need to be applied and the dose control concept applies to all military and emergency situations irrespective of the context.

8.2.3. Report of the HERCA-WG Emergencies (WGE) Task Force supporting Ukraine and neighbouring countries (Gareth Thomas, ONR)

HERCA is a voluntary association in Europe comprised of 47 competent authorities from 29 countries. Meetings are held every six months to discuss common issues and practical solutions to those issues. The goal is to achieve a high level of radiological protection throughout Europe.

The HERCA Working Group on Emergencies (WGE) is one of four working groups. WGE was established in 2011 with the aim of sharing knowledge and experience of EPR in Europe in order to promote consistent and compatible EPR arrangements throughout Europe and to improve cross-border co-operation and communication.

An international exercise was undertaken previously to look at protective actions based on a hypothetical event occurring in Slovenia. Different countries adopted different protective actions in response to cross-border releases, with some countries taking no action. Differences in cross-border protective actions can cause confusion and concern among the public and could lead to the public following advice from another country where that is deemed to be safer. The aim, therefore, is to move towards a more harmonised and co-ordinated approach to emergency planning. Different countries will have different factors to consider, such as demographics, that could affect the actions taken. Where differences in actions can be explained, this can build trust with the public. This needs to be done during EPR planning stages.

In 2014, HERCA-WENRA published an approach for better cross-border co-ordination of protective actions during the early phase of a nuclear accident (HERCA and WENRA, 2014). The approach is presented in two parts. Part 1 begins with planning for co-ordination between countries, including establishing appropriate communication channels and builds to what to do in the early phase of a nuclear accident. Part 2 then considers what to do in the first few hours of a severe accident while little is known about the situation. Essentially, the approach guides countries to follow the actions of the country in which the accident has occurred in the first few hours until more data become available to inform national actions. By following the actions of the country in which the accident has occurred, this ensures a consistent approach for the public, until informed country-specific decisions can be made.

In addition to the HERCA-WENRA Approach (HWA) (HERCA and WENRA, 2014), various additional supporting documents are available, including:

- HERCA Guidance on HWA - Supplementary Glossary (Oct 2019)
- HERCA Guidance on HWA - Strategies for extension of urgent protective actions (May 2019)
- HERCA Guidance on HWA - Additional protective actions (May 2019)
- HWA guide to developing Memorandums of Understanding with neighbouring countries (2015)
- HERCA-WGE distant accidents recommendations report (2013)

From the beginning of the war in Ukraine, the WGE looked to provide support and a WGE Task Force was formed with a mandate that included identifying HERCA documents relevant to the situation, identifying pragmatic needs not covered by existing documentation, seeking common positions on how or when protective actions may be applied or are unlikely to be required, identifying emergency centres and co-ordination mechanisms and identifying the relevant information to be shared, and creating a fora for discussion between Ukraine and bordering countries within the HERCA framework related to emergency preparedness.

The first meeting of the task force took place not long after the war began and most of the mandate objectives were completed quickly. Two regional communication mechanisms were established for Tier 1 and Tier 2 countries where Tier 1 countries were those immediately bordering Ukraine (excluding Russia and Belarus) and Tier 2 countries were the rest of Europe. A paper was also rapidly prepared and published that focused HERCA publications on the events and nuclear facilities in Ukraine to avoid the need to go through all documents. It was also established that there were not many cross-border emergency preparedness co-ordination mechanisms in place and efforts were focused on establishing and identifying new mechanisms for co-ordinated planning on cross-border protective actions.

There have been regular meetings with Tier 1 and Tier 2 countries, with Tier 1 countries meeting eight times to date and Tier 2 countries meeting four times. Several documents have been produced, including "War in Ukraine: WENRA and HERCA conclusions on the consequences of a nuclear accident" (WENRA and HERCA, 2022) and "HERCA/WENRA approach Ukraine Crisis" (HERCA, 2022), both of which are available from www.herca.org/documents/. Fact sheets have also been prepared and made available on the website that describe the nuclear facilities, EPR arrangements, and responsible authorities in all European countries.

The Task Force produced a report on application of the HWA to Ukraine. The report was compiled in recognition of its urgency and reflecting the changing situation in Ukraine. Comments were invited from all WGE member countries and the Ukraine regulator. The report was published in May 2022. The purpose of the report was to set out practical considerations in the application of HWA to support the Ukraine crisis under different circumstanced, including:

- before any emergency is declared;
- if abnormal observations are detected by national environmental monitoring networks;
- if an emergency (not general emergency yet) has been declared;

- if a general emergency is declared (in the early phase); and
- if a general emergency is declared (beyond the early phase).

The clear structure is aimed at providing relevant information on actions for each circumstance and provides information relevant to Ukraine and both Tier 1 and Tier 2 countries. Tables describe the HERCA/WENRA status of neighbouring countries to Ukraine and provide details on the Ukrainian nuclear power plants and their emergency planning zones for sheltering and protection measures. Maps are provided that detail the planning zones to help inform what actions should or should not be taken, noting that if actions are taken that should not have been, this can upset action plans in neighbouring countries. Informing what not to do is therefore as important as informing what to do.

Tier 1 countries have shared important parts of their national emergency plans, and a contacts directory has been established and will be maintained for emergency planners and emergency operation centres. A questionnaire has been developed to help identify key aspects of emergency plans to allow countries to see where there are differences in emergency plans and to consider how harmonisation could be achieved. Responses have been received from Hungary, Poland, Romania, the Slovak Republic and Ukraine and, at the request of Tier 1 countries, a comparison analysis was undertaken by the Task Force with result being provided to Tier 1 countries to consider. In addition, Ukraine requested public messaging information (e.g. public information/media statements) in the case of nuclear disasters and this information was provided by a number of Task Force member countries. The information can be used by Ukraine to support preparation of national statements should they be required. Messaging to mobile phones can be really useful in an emergency situation, but it can be slow to roll out such communication strategies in countries. Where they are available, however, they can be an important means of disseminating emergency information quickly.

The Task Force will continue to meet with the frequency of meetings depending on the changing situation in Ukraine. Tier 1 countries continue to focus on sharing information on national emergency plans and seeking ways to co-ordinate plans where possible and to overcome language issues. A new Task Force has also recently been established to look at other nuclear emergency events, including nuclear weapons and protective actions.

There will continue to be differences in emergency action plans between countries and there will be different reasons for the approaches taken. For example, differences were seen in national responses to the COVID-19 pandemic. It is important to accept that while there will be differences, that does not stop efforts being made to harmonise approaches by developing understanding of why differences have arisen. For example, if there is a high population density in one country, it may not be possible to evacuate, whereas a bordering country may have a lower population density, making evacuation feasible. As noted previously, understanding the reasons behind differences in EPR can help in communication and avoid mistrust among the public.

8.3. Topic 2: Communication and stakeholder engagement in situations where daily life is disrupted

8.3.1. How to prepare for the worst? Communication and stakeholder engagement during armed conflict (Karim Peltonen, STUK)

There is a long tradition of national defence in Finland, with civil preparedness being ingrained in the nation and a certain level of awareness of the possibility of war throughout the population.

For nuclear EPR around Finland's nuclear power plants there are a large number of stakeholders ranging from the local to national levels involved in the management of emergencies and protection of the population from the consequences of radiation exposure. Emergency protection zones and rescue plans are in place for each nuclear power plant site and the main risk scenarios (during peacetime) are nuclear power plant accidents. STUK is responsible for assessing any accident at a nuclear power plant and for providing recommendations on protective actions. STUK is also responsible for international notifications and provides support for crisis and incident management as well recommendations concerning protective actions such as evacuations. In an emergency situation there is engagement with civil society, with the population being considered an asset and included in the response system. In principle, communications are the responsibility of the competent authority, but the reality is more complex.

Several key learning points have been identified as a result of real incidents and crises, including the COVID-19 pandemic.

- Nuclear and radiation safety is an essential part of comprehensive security of society; nuclear safety is paramount to maintaining vital functions, as 40% of the nation's electricity depends on nuclear power. There is a need, however, to consider population resilience and whether nuclear power is perceived as safe.
- Situational awareness and effective communication are key requirements for STUK, requiring action to be taken even in response to rumours of an incident to prevent potentially hostile actors responding and causing panic. The underlying premise of all activities consists of reliability and trust and the aim, therefore, is to build trust around communications during normal times so that the trust is in place prior to any emergency. This can be achieved by preparing for the unexpected and co-ordinating and exchanging information with domestic stakeholders and co-operating with international partners. Planning is essential, but organisational resilience and flexibility are paramount. There is a need to anticipate, adapt and respond to scenarios. It is important to recognise that emergency situations are dynamic, so flexibility is key to responding to emerging circumstances.

Two real-life cases were introduced to help inform deliberations in the breakout discussion groups.

The first case was a plant emergency at Olkiluoto 2 in December 2020, during the COVID-19 pandemic, that required a full emergency response to be launched. STUK had a central role in communications during the emergency response, but the flow of information did not follow the rules and some emergency response actors were not initially made aware of the situation, leading to a delay in response. Finland is a large country and communications need to be in at least two languages (three if English is included). The need for a system for round-the-clock multi-channel and multi-language communications was recognised, as well as for improved co-ordination among authorities. Following the incident there was an extensive post-event survey and one of the most valuable findings was that citizen trust had not been lost as a result of the incident. The survey also provided an important insight into the audience of a nuclear emergency with the audience falling into different groups based on perceptions. The focus in an emergency should be on those that fall into the uncertain group and remain undecided. A small portion of the population fell into the category of those who cannot be convinced and on which there is therefore no point in focusing.

The second case focused on false information and misinformation. In the spring of 2023 there had been a false claim in the media that there was a radiation cloud over Europe resulting from the destruction of depleted uranium ammunitions in Ukraine. Timely communications and co-operation with the media enabled the issue to be quickly resolved.

This was an example of a new type of threat being faced. It was a well-co-ordinated campaign aimed at fostering uncertainty, fear and mistrust in the public. In the light of "no danger" responses, experts were targeted to build doubt around their expert status to try and foster further uncertainty on whether information on the situation was being hidden and could potentially be much worse than the public were being told.

Conflict today is more than just "armed conflict". What makes a conflict depends on the circumstances and the environment, but it generally involves a hostile entity trying to take advantage of weaknesses. Hybrid warfare has lowered the threshold for hostilities. For example, the border between Finland and Russia had to be closed in response to pressure from Russia and the large numbers of Russian migrants crossing the border. Additionally, cyberspace has emerged as a new conflict zone.

In considering how emergency responses could change during an armed conflict situation, thought should be given to the different scenarios that could be anticipated and the diversification of risks. Planning should take account of the different actors and their roles and responsibilities, and of capacities available. The resilience of society should also be considered to look at what factors could increase or reduce resilience by, for example, taking into account concerns when daily life is disrupted.

8.3.2. DSA operations in Norway during the war in Ukraine (Astrid Liland, DSA)

The DSA has a long-standing bilateral co-operation with Ukrainian organisations, including the SNRIU and SSTC NRS, which enabled it to continue co-operation activities when the war began. From first speculation that an invasion was likely, the DSA was prepared to disseminate information on the different facilities in Ukraine and possible risks. When the war started on 24 February 2022, a first message was sent to the DSA with over 100 messages having since been sent to the crisis committee and others with a response role in Norway. A key focus of activities since the war began has been on gathering information and verifying that information. The gathering of reliable information was challenging as a result of the war, but verification was helped as a result of having good points of contact in place with Ukrainian colleagues.

Atmospheric dispersion modelling has also been an important daily task for each of the nuclear power plants in Ukraine. While initially a daily task, it has recently been possible to reduce atmospheric modelling activities to twice a week, but these activities can be increased again if needed. Results of atmospheric modelling have been reported to the Ministry of Foreign Affairs and to the Crisis Committee of the DSA as well as to offices around the country and neighbouring countries, to assist them in preparing for a potential release.

Daily tasks since the war began also included source-term considerations and zones for protective actions. Daily atmospheric dispersion results were analysed to evaluate how far zones for protective actions such as iodine tables and sheltering would extend. It was clear from the atmospheric dispersion results that protective actions would not be needed in Norway due to the distance between the nuclear power plants and the Norwegian border, as well as the radioactive decay of short-lived radionuclides before a plume could reach the border. However, Norway received a significant amount of Cs-137 fallout from the Chernobyl accident as a result of the circumstances and weather conditions at the time, and Cs-137 remains measurable in the environment to this day. Therefore, while protective actions would not be required, there remained concern around the potential for radioactivity to reach Norway following an accident. Worst-case scenarios for the Ukrainian nuclear power plants were therefore considered and, under worst-case meteorological conditions, atmospheric dispersion modelling indicated that a radioactive plume could reach Norway in around 16 hours, though it would more likely take between 24 and 48 hours. This is consistent with the Chernobyl accident, in which two plumes occurred, one after 24 hours and a second after 48 hours. Additionally, daily tasks in response to the war included public communication, responding to questions, and giving media interviews.

On the night of 4 March 2022, the officer on duty received a call informing them of a fire at the Zaporizhzhia Nuclear Power Plant, with firemen unable to access the fire due to active firing on the territory by Russia. The fire was extinguished around 3 hours later, but the message had been shocking to receive and led to intensified international work and increased contact with Ukrainian colleagues. The event triggered increased international co-operation for Ukraine, resulting in the shipment of equipment that was delivered by the end of March. There have been continued efforts since then to support Ukrainian colleagues and organisations. Nationally, work also intensified, with increased national reporting activities and crisis meetings held regularly. Worst cast scenarios continued to be considered, including accidents at SNF stores and the tactical use of nuclear weapons. Plans have been revised and new and revised guidelines issued, including for food safety. New actors entered the scene, including the immigration authority, voluntary rescue services and the directorate for education, to consider scenarios such as actions to take if people arriving in the country were contaminated, what to do for people working outdoors in the case of radiation fallout and what to do if sheltering were advised during the school day.

NORSAR is a Norwegian seismic array foundation specialising in seismology and seismic monitoring. Automated seismic monitoring around nuclear power plants will detect any explosions within 100 km of nuclear power plants, with the DSA being notified on the location, distance to nuclear power plants and the magnitude of the explosion. Accurate information has been provided rapidly on incidents as a result of this monitoring network.

The DSA has produced a significant amount of information on the situation in Ukraine, with regular updates made to the DSA website as well as the development of plans, guidance and reports. Information dissemination has also been carried out through Podcasts and media interviews. Information has been made available in 20 different languages.

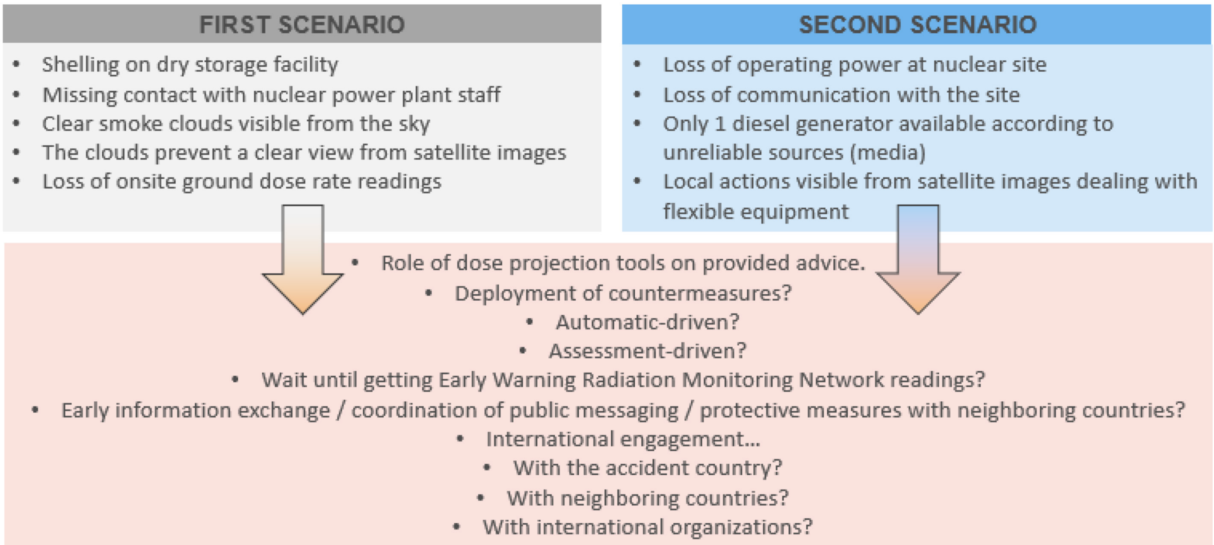
Emergency plans have been developed for the screening of refugees arriving in Norway or returning Norwegians in the event of a nuclear accident, with training on the rollout of monitoring stations being undertaken.

Norwegian support for nuclear safety in Ukraine has also involved the hosting of an international meeting for co-ordination of support to Ukraine in Oslo in April, including an Information Sharing Initiative, and working on President Zelensky's peace plan with a focus on nuclear safety. Financial support has also been donated to Ukraine through the Nansen Programme, with EUR 6.5 billion being provided to date to support military and humanitarian actions. In 2023, Nansen funds to the value of EUR 22 million were provided in support of nuclear safety and security in Ukraine with some funds directed through the DSA and some through the IAEA. The Nansen Programme aims to contribute towards Ukraine's ability to protect its territories and population from the Russian invasion and to sustain critical infrastructure and reduce human suffering.

8.4. Breakout discussion groups: Scenarios and group feedback

Workshop participants were divided into small breakout groups to foster discussion and to encourage the sharing of experience related to the topics. The aim was to brainstorm and discuss possible solutions to the challenges presented in the two topical areas. Participants were encouraged to think critically and creatively to come up with viable solutions or approaches based on two hypothetical scenarios (Figure 8.4).

Figure 8.4. Hypothetical scenarios for the breakout group discussions



For each topic, discussion groups were provided with a series of questions to consider in the context of the proposed scenario. Questions and summarised feedback from discussion groups are presented below. Summarised feedback is presented from the perspective of the country in the conflict and from the perspective from a neighbouring country for each question.

8.4.1. Discussion Topic 1: Identify best practices and areas for improvement (gaps) in national planning for the application of radiological protection during armed conflict.

Question 1: Are the factors considered in optimisation changed during military conflict to take account of the differences from usual circumstances? For instance, would it be helpful to recognise radiation exposures arising directly from the conflict as existing exposure situations (rather planned exposure situations)? What advice can be prepared in advance concerning appropriate radiological criteria (e.g. reference levels), or should such decisions be left until the situation arises?

Perspective from the country in the conflict

Adherence to ALARA principle: Emphasise the continued relevance of the ALARA (as low as reasonably achievable) principle. Acknowledge that dose values (e.g. reference levels) may change, thresholds may be altered, or may not be applicable in the context of armed conflict.

Increased training for non-radiation workers: Recognise the necessity for enhanced training (notably on radiological protection) to ensure the safety of non-radiation workers in the unique conditions of armed conflict.

Adaptation of optimisation: Highlight that the application of optimisation, although not initially designed for armed conflict situations, must be adapted to consider different factors during such circumstances. Acknowledge that the optimisation process must become more pragmatic in armed conflict situations, requiring: (1) faster decision making in the face of rapidly evolving challenges; and (2) consideration of all risks, whether or not they are linked to radiation.

Addressing information gaps: Address the challenge of inadequate information, stressing the importance of being aware of potential or real emergencies during armed conflict situations.

Effective triage processes: Implement triaging protocols for symptoms where necessary, ensuring a systematic approach to prioritising and managing cases in the context of armed conflict.

Perspective from a neighbouring country

Prudent initial action: Recognise that a good initial action may entail no immediate action. Decisions should be made based on factual information, with preliminary actions undertaken to verify plans and ensure readiness.

Deploy mobile units to the border: Consider dispatching mobile units to the border as part of an initial response.

Utilise international networks for data: Leverage international networks for environmental monitoring and meteorological data to enhance the collection of comprehensive and reliable information regarding the incident.

Worst-case scenario calculations: Conduct calculations based on a worst-case scenario to adequately prepare for potential challenges and establish a robust response strategy.

Triage at outer borders: Focus on implementing triage procedures at the outer borders of the detonation point.

Question 2: Are there issues (or gaps) with the existing regulatory frameworks that should be considered in an armed conflict, such as on environmental monitoring (e.g. if not practical due to military conflict, or if new needs arise) or on monitoring of operating limits and conditions?

Perspective from the country in the conflict

Understanding aggressor motives and capabilities: Account for the motives and capabilities of the aggressor, incorporating considerations of opposing force actions and reactions into comprehensive planning strategies.

Military-civilian collaboration: Establish frameworks that prioritise close military-civilian collaboration, emphasising clear definitions of roles within the joint effort to ensure seamless co-ordination.

Information protection: Highlight the critical importance of information protection, recognising that human resources in nuclear power plants and central government data can be valuable information for the enemy.

Preparedness: Emphasise the strategic significance of preparedness. Regulatory frameworks should account for the risks of military conflicts, enabling advanced planning for managing nuclear or radiological emergencies during armed conflict.

Scenario-based planning: Promote the preparation of a generic list of scenarios, allowing for comprehensive planning against armed conflict threats.

Perspective from a neighbouring country

Operational emphasis in armed conflict: During armed conflict, the operational framework takes precedence over the regulatory framework. Prioritise assessing risks, focusing on those directly affected, and verifying the operability of critical equipment and capabilities.

Assessment of assistance needs: Pose the question: What assistance is needed? Base actions on the results from the monitoring network, ensuring a targeted and effective response.

Task prioritisation: Recognise the importance of task prioritisation, given the potential hindrances to normal procedures. Efficient prioritisation is essential to better understand how to handle radiological protection during armed conflict.

HERCA approach for information gaps: Adopt the HERCA approach in the absence of information from the affected country. However, note that the effectiveness of the HERCA approach depends on the availability of actionable information from the affected country.

8.4.2. Discussion Topic 2: Identify best practices and areas for improvement (gaps) in communication plans for nuclear emergencies during armed conflict

Question 1: How should existing communication plans be adapted to the unique challenges posed by armed conflict? Do they need to be tailored to the complexities of a conflict situation at the local, national and international levels?

Perspective from the country in the conflict

Governance: Integrate the communication plan into the state and military's framework to establish one official voice.

Familiarity: Ensure public awareness of the designated channels and senders to foster trust. Build this trust and familiarity during peacetime.

Technology risk: Implement contingency measures for communication channels, considering potential interference or disruptions during conflict situations.

Rationale for actions: Emphasise the importance of explaining the reasons behind actions rather than merely providing instructions.

Adaptability in armed conflict: Incorporate provisions for alternative communication channels in the communication plans for times of armed conflict.

Effective communication strategies: Prioritise concise messaging and utilise radio as the primary medium for optimal communication efficacy.

Perspective from a neighbouring country

Shortcomings in communication planning: Address the tendency of communication plans to focus solely on short-term needs. Anticipate and carefully consider aspects that should not be communicated.

Potential misinformation: Recognise the possibility of misinformation from the aggressor, where inducing panic might be the intended outcome.

Collaborative communication: Advocate for joint communication efforts with various services, including the military, to enhance coherence and effectiveness.

Secure communication channels: Emphasise the necessity of restricting communication channels and transmitting information through secure systems to safeguard sensitive information.

Resilient national warning systems: Develop plans for resilient national warning systems capable of transmitting messages to regional or local levels. Include strategies for communication in case the primary system is incapacitated.

Question 2: Are there different communities (e.g. emergency responders, conflict evacuees, voluntary rescue personnel) that need to be considered in communication plans during armed conflict?

Perspective from the country in the conflict

Military personnel: Recognise the unique communication needs of military personnel.

Indigenous communities: Ensure communication reaches Indigenous communities.

Religious groups and leaders: Engage with religious groups and leaders, acknowledging their influence and considering cultural nuances to foster trust and co-operation.

Refugees (internal and external): Address the additional communication needs of refugees, both internal and those who have left the country, by providing targeted information and support.

Public guidance: Offer "self-help" instructions to members of the public, empowering them with essential information to navigate situations independently.

Cultural awareness: Acknowledge the importance of cultural awareness; tailor communication strategies to suit diverse preferences—some may prefer direct instructions, while others require more detailed explanations to trust the message.

Citizen science and community empowerment: Encourage the involvement of non-governmental organisations, educators and academics in citizen science initiatives.

Perspective from a neighbouring country

Civil-military co-operation: Ensure awareness and co-ordination between civil and military authorities regarding communication plans to prevent conflicts and ensure a seamless response.

Considerations for conflict evacuees: Address the unique needs of conflict evacuees, including considerations for interpretation, cultural sensitivity, and specific information requirements.

Mental health and psychosocial support: Prioritise mental health and psychosocial support, recognising the profound impact of armed conflict on public well-being. Provide necessary resources to alleviate fear and anxiety.

Managing false rumours and misleading information: In situations with false rumours and misleading information, emphasise the importance of delivering accurate and targeted information to the public. Counter misinformation with clear and reliable messaging to maintain public trust.

Question 3: What strategies and mechanisms can countries implement to enhance cross-border co-operation in aligning public communications around protective actions?

Perspective from the country in the conflict

Adherence to international guidelines: Follow the guidelines set by and co-ordinated through the IAEA IEC for standardised and effective communication.

Utilisation of informal communication channels: Leverage informal communication channels, such as professional networks, to promptly seek advice and share information efficiently.

Preparation for cross-border situations: Plan in advance for the cross-border application of protective actions and communications. Anticipate and co-ordinate responses that may extend beyond national borders for a comprehensive and collaborative approach.

Preparation for loss of communication: Plans for alternative communication should be made available in the case of loss of internet or mobile communication services.

Perspective from a neighbouring country

Co-ordinated prepared messages: Develop prepared messages in collaboration with neighbouring countries, ensuring co-ordination and agreement to facilitate a unified response in times of emergencies.

Preparedness for emergencies: Authorities should proactively prepare for emergencies to cultivate a shared level of trust and understanding. This readiness fosters effective cross-border collaboration.

Establishment of hotlines: Establish hotlines with close neighbours and bilateral bases to facilitate swift and direct communication in critical situations, enhancing the efficiency of information exchange.

Implementation of ECURIE and IAEA systems: Implement ECURIE and IAEA systems, ensuring the seamless sharing of monitoring data for a comprehensive and collaborative approach.

Bilateral agreements and common criteria: Strengthen bilateral agreements and establish common criteria for implementing protective actions with neighbouring countries.

9. Session 7: Safety, security and emergency preparedness interfaces

9.1. Security-Emergency Preparedness Interface in the US Nuclear Regulatory Commission Regulations (Todd Smith, NRC)

The terrorist attacks of 11 September 2001 on the United States demonstrate that resilient communities are able to respond to threats and hazards that are outside of their experience and planning. There are many stories of what happened on the day and how people came together to help each other. One such example is the story of the spontaneous evacuation of lower Manhattan following the terror attacks. In response to the attacks and subsequent collapse of the towers, the public needed to evacuate, but roads were closed for security reasons, so the public began to gather *en masse* to the waterfront. A call was made for all available boats to assist in the evacuation of Manhattan Island, and soon they started to arrive. Overall, more than 100 boats answered the call and converged on lower Manhattan. Those responding did so with no knowledge of the dangers they faced; they only knew that people were in need and that they could help. It is estimated that somewhere between 300 000 and 500 000 people were evacuated in just nine hours. All of this was achieved with no pre-planning.

On that day, the US Nuclear Regulatory Commission (NRC) also quickly realised they needed to act. For many, it was only when the second plane crashed into the towers that it was understood this was an attack and not an accident. As soon as the attack was recognised, the NRC issued a notice recommending that licensed facilities move to the highest level of security and to remain vigilant, as at that time it was not known if there would be more attacks.

Nuclear power plants are some of the most secure and resilient facilities, and they are designed to withstand severe external hazards and to protect against design basis threats (DBTs), including theft and sabotage of nuclear materials. However, an attack directly against a nuclear facility was a new threat. Facing this new threat environment, nuclear power plants were subsequently ordered to enhance security. For example, more barriers were used to slow access to the site and the number of security patrols were increased. Security event consequences were also looked into, with the conclusion that events caused by security incidents would not result in larger releases than those events already planned for within emergency preparedness for nuclear power plants. The focus then was on how to prepare for hostile actions and to enhance the interface between security and radiological emergency preparedness and response.

A hostile action is defined as an act towards a nuclear power plant or its personnel that includes the use of violent force to destroy equipment, take hostages, and/or intimidate the licensee to achieve an end. In 2011, the NRC published enhancements to its emergency preparedness regulations to address hostile action against nuclear power plants and the interface between emergency preparedness and security. The enhancements to regulations establish capabilities and provide the means to develop resilience in decision making for radiological protection in the face of hostile actions. These enhancements include requirements for adequate on-shift staffing, emergency action levels (EALs) for hostile action, alternative facilities to act as staging areas, protection actions for workers and the public, and hostile action-based drills and exercises.

From the start of an emergency, on-shift staff may face emergencies that require urgent response, such as fires. In responding to incidents, it is important that emergency plans can be implemented without staff involved in the emergency response having competing responsibilities. Similarly, it is important that key staff functions are not lost to emergency actions. The regulatory enhancements therefore required sites to look at design basis accidents, hostile actions and other events and consider emergency preparedness functions that would need to be met and to take necessary measures to prevent issues arising as a result of competing priorities.

Declaring an emergency is important for initiating response activities. Threat environments are constantly monitored in the United States and, if there is a credible threat, nuclear power plants are quickly notified so they can declare an emergency and prepare for hostile action. For security-initiated events, the emergency classification level depends on how close a hostile action is to creating the potential for a significant radiological release. Emergency action levels (EALs) for hostile action were developed to provide for anticipatory response and timely notification of federal, state and local agencies. The EALs range from Unusual Events (i.e. confirmed security condition or threat) to General Emergency, where a hostile action could result in the loss of physical control of the facility. It is vital to recognise a hostile action at an early stage as this initiates the necessary co-ordination between the onsite and offsite response organisations and law enforcement and helps ensure radiation safety is placed in the context of the hostile action.

During the Three Mile Island accident it was recognised that plant operators needed to be relieved from the emergency response to allow them to focus on plant operations. Technical Support Centers (TSC) are often located close to control rooms to achieve this purpose by providing a dedicated response facility and staff to implement emergency plans. However, in a hostile action scenario, access to the site, including access to the TSC, may be restricted. Therefore, alternative facilities—away from the site—need to be identified to muster key staff and to provide essential EP functions. These alternative facilities protect staff from immediate danger and ensure response staff are staged and ready to promptly enter the site when access is restored.

Under a hostile action scenario, it may not be possible to evacuate a site. As such, more strategic thinking is required about how to protect workers on site while ensuring safety critical functions are maintained. For example, staff with key capabilities for plant operations and maintenance should not all be located in the same area and teams should be prepared on how to move through the site. Co-ordination with security teams may be required to provide protection for staff where risks remain onsite. Under hostile action scenarios, sheltering may be the best action for the public, allowing security response personnel to contain hostile people.

Under the enhanced regulations, sites are required to perform a hostile action exercise to demonstrate that EP plans are adequate and that interactions between emergency preparedness and site security and local law enforcement are effective. The drills and exercises are intended to be challenging, both in terms of challenging decision-making and testing capabilities in response to events that go beyond the DBT.

In addition to physical security, cybersecurity plans are required to protect critical digital assets that perform EP functions, including emergency call-out and offsite notification and communication systems. Where digital functions are relied upon for emergency response, independent back-up systems may be required and people relying on these functions should be proficient in their use in the event of an emergency. Furthermore, all equipment that is susceptible to cyber-attack must be periodically checked to ensure it is performing its intended function.

The NRC has been considering the emergency preparedness–security interface for decades and several resources are available with respect to hostile actions, including:

- Hostile Action Based Emergency Preparedness Drills: www.nrc.gov/about-nrc/emerg-preparedness/respond-to-emerg/hostile-action.html
- Emergency Preparedness in Response to Terrorism: www.nrc.gov/about-nrc/emerg-preparedness/respond-to-emerg/response-terrorism.html
- Frequently Asked Questions About NRC's Response to the 9/11/01 Events: www.nrc.gov/security/faq-911.html
- Post 9/11 Information: www.nrc.gov/security/post-911.html

Nuclear plants are required to defend against and respond to the DBT and to hostile actions. For postulated attacks by adversaries with capabilities exceeding the DBT (e.g. those carried out by a Nation State), NRC licensees would rely on support from state and federal resources. The NRC does not require licensees to maintain specific response plans and capabilities to protect against events beyond the DBT, and such planning is not a prerequisite to have reasonable assurance of adequate protection of public health and safety. The responsibility and capability to prevent, mitigate, and respond to attacks beyond the DBT reside with other US agencies and within our national defence and is not the role of the regulator or regulated community. In the United States, preparedness is a shared responsibility, and roles and responsibilities are clearly defined. The US national preparedness goal defines what it means for the whole community to be prepared for all types of disasters and emergencies. Experience from the 11 September 2001 terrorist attacks shows that the concept of the whole community response is achievable. Disasters are not things that can be managed with plans but are a series of events that unfold that must be addressed. By looking at the lessons and experience from past events it is evident that resilient communities will do what needs to be done. The responsibility to maintain capabilities to implement the emergency plan in an unknown security state achieves an adequate level of preparedness and builds resilient communities able respond to all threats and hazards. These capabilities are demonstrated in Hostile Action-Based drills and exercises, in which onsite and offsite response organisations are able to effectively implement radiological emergency plans and make sound decisions to protect workers and the public health and safety, even amidst the uncertainty of an unknown security state on site.

9.2. IAEA response and assistance to Ukraine during armed conflict (Svetlana Madjunarova, IAEA)

Since the start of events in Ukraine, the IAEA has been monitoring the situation and assessing it against the seven pillars for ensuring nuclear safety and security during an armed conflict. The IAEA has also shared information with the public and international community through press releases, public reports and briefings and has provided technical support and assistance, with a primary focus on in-person missions and delivery of equipment to help maintain safety and security and assess consequences.

Armed conflict in close proximity to nuclear power plants poses risks to nuclear and radiation safety and has required that the ways of assessing the situation be tailored to the context of armed conflict and continually changing circumstances. From the outset, the ability to identify the most pressing and important aspects of maintaining safe and secure operations at facilities was based on the unfolding events and what could be foreseen for the near future. This led to the derivation of seven pillars for use during armed conflict (Figure 9.1). The pillars are aligned with the IAEA safety standards and nuclear security guidance and have been in use since early March 2022 to assess the situation with respect to nuclear safety and security in Ukraine.

Figure 9.1. The seven pillars for maintaining nuclear safety and security

In response to the difficult and challenging situation at the Zaporizhzhia Nuclear Power Plant, five concrete principles were developed to help stabilise the situation, protect the nuclear power plant from attack and ultimately prevent a nuclear accident from occurring. The principles were established by the IAEA's Director General in May 2023 and are as follows:

- Principle 1: There should be no attack of any kind from or against the plant, in particular targeting the reactors, spent fuel storage, other critical infrastructure or personnel.
- Principle 2: The plant should not be used as storage or a base for heavy weapons (i.e. multiple rocket launchers, artillery systems and munitions, and tanks) or military personnel that could be used for an attack from the plant.
- Principle 3: Off-site power to the plant should not be put at risk. To that effect, all efforts should be made to ensure that off-site power remains available and secure at all times.
- Principle 4: All structures, systems and components essential to the safe and secure operation of the Zaporizhzhia Nuclear Power Plant should be protected from attacks or acts of sabotage.
- Principle 5: No action should be taken that undermines these principles.

IAEA mission staff providing technical support and assistance at the Zaporizhzhia Nuclear Power Plant monitor the ongoing situation at the site, assess the needs and report back with fact-based and impartial information on each of the seven pillars and compliance with the five concrete principles.

The IAEA Comprehensive Assistance Programme has been ongoing since early February and is linked to the major issues faced in Ukraine. An objective appraisal of the situation helps identify needs and the delivery of nuclear safety and security-related equipment has helped address some challenges resulting from the destruction or theft of equipment and to provide spare parts for maintenance. The delivery of equipment has been challenging.

New assistance programmes under the Comprehensive Assistance Programme were announced in April and June 2023.

- Since the start of the conflict, nuclear power plant personnel have been working under stressful situations and have been forced to live in temporary living conditions. A medical assistance programme has therefore been established to help maintain health and fitness for duty by building capacity for medical care and mental health support for nuclear power plant operating personnel.
- The destruction of the Kakhovka dam had implications for securing cooling water for the Zaporizhzhia Nuclear Power Plant but also affected the population downstream of the dam as a result of flooding. An assistance programme to the Kherson Oblast to help manage consequences of the dam destruction is planned.

The Assistance Programme is fully supported financially by extra budget contributions and in kind contributions from member states and organisations, including the European Union. There is a need for strong co-ordination at the national and international levels to deliver efficient support to Ukraine that is focused on priority areas and avoids duplication of effort.

The first IAEA in-person nuclear safety and security mission to Ukraine took place in March 2022 and there have been over 80 in-person missions in total to look at essential nuclear safety and security issues. Since September 2022 there has been a continued IAEA presence at the Zaporizhzhia Nuclear Power Plant to monitor and observe compliance with the five concrete principles. It has been an extensive undertaking to maintain information on the situation on the ground as a result of the armed conflict and the missions help to monitor and assess the situation through independent measurements, documenting the situation and reporting back to headquarters, where information is prepared and shared through regular IAEA updates and reports issued on the nuclear safety and security situation in Ukraine.

The seven pillars were used to assess the situation at all Ukrainian nuclear power plants in February 2023, with a colour coding system being used to report on the key threats and concerns. For most nuclear power plants the main threat related to pillar 4 (off-site power supply) with pillars 3 (operating staff) and 5 (logistical supply chain) also being of concern. For the Zaporizhzhia Nuclear Power Plant there were threats and concerns relating to all seven pillars with physical integrity (pillar 1) and operating staff (pillar 3) being of highest concern. Regular updating of assessments relative to the seven pillars helps ensure major impacts and concerns continue to be identified.

The delivery of equipment to Ukraine is based on official requests from Ukraine and from needs identified during in-person missions. There have been lots of competing priorities and the focus has been on trying to address safety and security needs arising as a result of armed conflict rather than improving organisational capabilities that can be addressed at a later date. Since the start of the conflict there have been 32 deliveries made, requiring extensive logistics and procurement processes.

The new medical assistance programme aims to help ensure that operating staff are fit for duty to ensure safe and secure operations and to provide mental health support. Operational staff are not only working in high stress environments, but are also facing increased workloads due to loss of staff to the military and as a result of evacuations, etc. Medical assistance aims to support mental health and provide regular health checks and screening to minimise human error risks. Medical equipment and supplies have also been provided to nuclear power plant medical facilities and local hospitals and work is ongoing to procure additional equipment and supplies that are needed. Mental health support has been initiated through a series of consultations and workshops.

The assistance programme to the Kerson Oblast has begun with remote consultations to identify support needs.

There has also been interest from member states for the IAEA to look into issues of maintaining nuclear safety and security during armed conflicts, to identify the main challenges and lessons learnt with respect to applying safety standards in armed conflict situations and to identify whether additional standards are needed. A review of the challenges in applying the safety standards in armed conflicts was initiated in 2022 based on knowledge and experience gained as a result of the Ukraine war. The preliminary findings from the review are that there is no need to revise existing safety standards and nuclear security guidance, but that development of additional technical guidance would be beneficial. An IAEA technical document on the issues and challenges faced at nuclear facilities in terms of the practical application of the IAEA safety standards and nuclear security guidance during armed conflicts is therefore under development. It is envisaged that the document will include detail on the application of the seven pillars in the context of armed conflict and the challenges faced in the practical application of safety standards. An all-hazards approach in responding to an emergency situation is being considered. The aim is to publish the document towards the beginning of 2024.

The next steps in providing technical support and assistance to Ukraine will involve continued monitoring and assessment of the ongoing situation against the seven pillars and continued observation of compliance with the five concrete principles for protecting the Zaporizhzhia Nuclear Power Plant. Assistance will also continue to be delivered through the deployment of missions, provision of equipment and supplies and delivery of training, with a systematic approach being employed to identify urgent needs and assign priorities so that technical assistance is provided as funding is made available. There will also be continued co-operation with member states and international organisations to ensure efficient and effective delivery of assistance, avoiding duplication.

9.3. STUK's response to the War in Ukraine (Petteri Tiippana, STUK)

Following the Russian invasion in Ukraine, safety concerns grew with the occupation of the CEZ and with threats from Russia on the use of nuclear weapons and dirty bombs. STUK followed developments in Ukraine and undertook safety assessments to provide information to the decision makers, public and media. Support to Ukraine was also initiated and STUK began participating in international activities, including within the auspices of WENRA and HERCA. It is important in addressing concerns to receive information directly from the country affected by a conflict, especially from the regulators, and for that information to be as accurate as possible to ensure the right guidance is disseminated. Co-operation throughout the Nordic countries has also been very important.

A national risk assessment was published in February 2023 detailing the most significant threats and their potential impacts on Finland. National risk assessments are updated on a regular basis, but the Ukraine conflict led to an expedited update to address new concerns. The assessment provides the basis for Finland’s preparedness and response on state, regional and organisational levels to threats. A range of generic threat scenarios are addressed, including disruptions to energy supply, cyber-attack, pandemic, terrorist acts and use of military force in Finland. The threat scenarios have been used by STUK as the basis for its own preparedness and response planning, in addition to traditional radiation and nuclear threats.

Response capabilities were evaluated for the different threats and the ability to also respond to radiation threats. Key considerations were whether there were enough people in terms of the numbers, skills, training and motivation; whether there were secure and available information and communication systems; and whether there was sufficient leadership and management to plan and form situational awareness and make decisions. For some scenarios there was good preparedness but for others there was a need to enhance or develop action plans. As a result of the evaluations, communications between different ministries and government agencies are improved and more effective.

A programme to enhance situational awareness for improved resilience and response capability began in response to the COVID-19 pandemic and continued as a consequence of the Ukraine war and considered events that could affect Finland. Meetings involving around 20 participants were held on a weekly basis to discuss the situation, developments and information on topics such as domestic and neighbouring nuclear power plants, waste and nuclear materials; environmental radiation monitoring; information and cyber security; international environment (including the war on Ukraine); media environment; and emergency exercises . The information gained was shared within STUK and with interested parties within government. As a result of the weekly meetings, the potential use of nuclear weapons was identified as a concern and a safety evaluation was initiated and communicated to the media.

An update to STUK’s strategic goals was being prepared when the war on Ukraine began, leading to some revisions. For example, the changed global security situation and enhancements to resilience were included and related mostly to the Ukraine war. Two societal-level goals have also been adopted:

- having responsible operators and well-functioning regulatory services; and,
- the overall security of society and sense of safety.

STUK previously had a role in both supporting and encouraging operators to be responsible and accountable for safety and in supporting the resilience of citizens and society, but that role became more meaningful as a result of the war in Ukraine.

Supporting Ukraine is a top priority of Finland’s government. As soon as the war began, Finland started to support protection measures through the provision of necessary radiological protection equipment. Regular meetings have been held throughout the war between STUK, the DSA and the Swedish Radiation Safety Authority (SSM) to co-ordinate actions and brainstorm further actions. Denmark has also recently joined the co-ordination meetings.

One of the latest efforts has been to establish a Joint Nordic Strategy for Radiation and Nuclear Safety Cooperation with Denmark, Norway, Iceland and Sweden. The strategy group is focused on the Nordic and Baltic environment, with the overall objective of exploring the impact of changes in the operating environment to Nordic co-operation by presenting the state of the co-operation and anticipated future needs, defining specific goals and practical measures for implementation, and compiling master documents to reflect strategic goals to enhance co-operation. A framework and action plan are scheduled for implementation in 2024. The strategy group gets together once per year to discuss changes and consider the strategy for co-operation over the next few years. Concrete actions are established to ensure effective and efficient co-operation.

STUK is also a key partner in RescEU and has stockpiled protective equipment, devices for identification and monitoring, supporting equipment and medical countermeasures for responding to CBRN incidents in co-operation with the Ministry of Interior and government agencies. Finland also holds the presidency for the Council of the Baltic Sea States, hosting weekly meetings at which the situation in Ukraine is a cross-cutting theme. A Ukraine forum was scheduled for November 2023 to share both knowledge on how to assist Ukraine and lessons learnt from Ukrainian colleagues on what is happening in the country.

A spectrum of threats needs to be prepared for and the spectrum is now much wider than in the past and includes combined threats. Sharing awareness helps to build resilience and prepare for more effective responses and the Nordic co-operation has resulted in improved awareness of regional response capabilities. Radiation and nuclear safety in Ukraine is a top priority for STUK and the authority now also plays a large role in societal safety as a result of the war. Continued Nordic co-operation activities on radiation and nuclear safety will further enhance the effective and efficient delivery of support to Ukraine from the Nordic countries.

9.4. Discussion

In an emergency situation, response is part of a shared culture between nuclear power plant operational and response personnel. The culture at a nuclear power plant site is to act but training through emergency response drills helps ensure awareness for personal protection in different situations. For IAEA in-person mission staff, emergency planning is the same as for nuclear power plant personnel, so in an emergency they would comply with instructions from authorities with respect to protective measures. Advice is given to staff prior to missions on how to evacuate in a medical emergency but otherwise, in an emergency situation, they would comply with national/regional authorities' instructions and would be treated as members of the public.

When the Zaporizhzhia Nuclear Power Plant was first attacked, the IAEA activated a full response model to look at implications of escalation or an accident occurring. One of the main challenges faced was language, with information being received in Russian. At the IAEA it is possible to find people talking most languages so it was possible to process the information received but this can cause delays. Another challenge faced was that contact points are usually within the competent authority of the member state, but in Ukraine those contact points were on the front line, which affected their ability to respond rapidly to information requests. However, in this instance it was possible to receive information directly from the nuclear power plant, which greatly improved the timeframe for obtaining necessary information. In applying the seven pillars for nuclear power plants in operation in Ukraine-controlled territories it was important to use real data for the affected sites. The infographics presented to summarise the situation at the nuclear power plants are underpinned by detailed assessments against each pillar, with references provided. As new information becomes available there are regular reassessments against the pillars, with publicly available reports issued on a regular basis.

In the event of an armed conflict situation, good communications are needed between all relevant bodies to ensure that national security response organisations can be contacted quickly to trigger deployment of the necessary skills to address the situation. In the United States, the NRC ensures that different plans are in place for different contingencies, to ensure continuity of operations and plans for, and means of, interacting with security response organisations are in place. Emergency exercises ensure that nuclear power plant personnel are familiar with the different plans and who to communicate with and how.

Emergency response exercises are vital for preparedness. By participating in exercises, the way people act in an emergency becomes more habitual. This applies not only to on-site workers but also members of the public. Exercises that involve communicating simple messages on actions, such as instructions to stay indoors and stay tuned for updates, helps develop awareness and preparedness in the population and the learnt responses may apply to a range of different emergency scenarios.

For all IAEA missions in Ukraine there was an opportunity for staff to meet with WHO representatives to be informed of actions for medical assistance, including provision of information on nearby hospitals. In the most recent mission this was expanded to include the type of assistance that can be provided and the means of contacting different organisations as needed. There has been a long history of co-operation between the WHO and the IAEA, with both organisations reaching out to the other as needed. The IAEA missions in Ukraine were more focused on the health needs of staff of nuclear power plant facilities and their families whereas the WHO has been operating more on supporting the health needs of the population. There are uncertainties about the ability of different health facilities to diagnose signs of radiation sickness and for this to alert to a situation. There is greater preparedness at nuclear power plants due to emergency exercises bringing awareness to staff of appropriate actions than there would be if a nuclear detonation occurred or if radiation sources were present at other locations. Medical first responders may not be familiar with radiation injuries and the different medical assistance that may be required. It would therefore be beneficial to establish links between regional hospitals and health facilities at nuclear power plants to help in co-ordinating actions and establishing dialogue on radiation injuries.

10. Closing session: Strengthening international collaboration and establishing a list of potential actions to help regulators reduce radiological risks

10.1. Summary of the workshop findings and discussion with participants

Key points from each session were summarised by session rapporteurs and questions were invited from workshop participants. The key points and associated discussion are detailed below.

10.1.1. Session 1: Resilience practices from a human and organisational factor perspective – Focus on occupational radiological protection

Important issues and lessons learnt from responding to the COVID-19 pandemic and challenges faced by Ukrainian colleagues in ensuring nuclear safety and maintaining resilience and radiological protection frameworks in the context of armed conflict were presented and there were a number of key takeaway messages and learning points.

There are substantial challenges when dealing with human and organisational factors during armed conflict situations, and on the resilience of organisations. Workers at occupied nuclear power plants face major challenges and working conditions can be extremely difficult, including long hours, heavy workloads, lack of PPE, destruction of equipment, absence of family members and community support, as well as threats of torture, murder and imprisonment. Workers are essentially operating under forced labour conditions. The only available international framework to address this would be to refer the aggressor to the International Court of Justice. As evidenced by the ongoing situation, the aggressor may nevertheless continue with their actions. Robust frameworks are needed that will stand up to such actions.

In armed conflict situations, challenges are not only faced in occupied areas. Facilities in unoccupied territories can also face challenges as a result of workforce availability, disruption to supply chains, and interdependence with other infrastructure. While some experience was gained around business continuity as a result of responding to the COVID-19 pandemic, such as the necessity for organisational adaptability and focusing on essential services, the situations faced due to armed conflict are much more difficult to address. The ability to remain adaptable is crucial to resilience and extends to the control room as it is difficult to proceduralise appropriate responses for armed conflict events. Trust and adaptability in safety culture are key to building resilience and robust training programmes and exercises can help prepare people to respond to the unexpected.

10.1.2. Session 2: Characterisation of the radiological situation and environmental monitoring systems

It is evident from the presentations that a range of facilities can be affected by armed conflict situations, from standards laboratories to nuclear power plants. Rapid surveys may be required to characterise the situation and radiation sources may need to be transported to safer areas. Flexible emergency response capabilities are therefore required and may need to adapt in the face of monitoring equipment limitations.

Surveys are of high interest after military activity to address concerns around disturbed environmental contamination, stolen sources, damage to protective barriers, etc. Rapid communication of survey outcomes is needed to address public concern both within the country and internationally, as well as to address misinformation. Information from the public in affected areas can also be an important resource for characterisation and surveying, providing information on military movements and observed actions.

In an armed conflict situation, it may be necessary to consider potential radiation sources in a different context, such as the use of explosives against fuel casks and to develop capabilities for rapid assessment in the event of such attacks to evaluate potential consequences. Releases under attack scenarios could differ from a normal accident scenario, such as particulate releases with high alpha activities. Existing criteria such as operational intervention levels (OILs) may not be suitably protective and may need to be applied flexibly to allow optimal resource allocation and ensure actions do not cause more harm than good.

Armed conflict presents a high threat situation that can be of a prolonged duration that may require adapted methods of working. There may also be gaps in monitoring networks due to disruption of power and data transmission networks or as a result of damage or theft of monitoring equipment. Environmental dispersion modelling of radioactive releases may be required to address some data gaps, or inverse modelling may need to be carried out. Modelling can also be used in optimising the deployment of monitoring resources by identifying areas for survey teams to target.

The conflict in Ukraine has also highlighted areas where additional planning for resilience could prove useful, such as building relationships with the military in relation to physical protection of survey teams and monitoring equipment and for potential development of integrated and shared monitoring systems that cut across civil, military and border force data sources. Data security is also important for EPR, and data integrity and risks from data being obtained and used by an aggressor should be considered.

10.1.3. Session 3: Adapting emergency preparedness and response and recovery in armed conflict situations

Information was presented on events that occurred in the CEZ during and after occupation and how the licensing process was adapted to take account of the changing circumstances. Presentations described the facilities impacted during the occupation of territories and the need to restore movement of radioactive waste and for international collaboration to help address the many issues faced following occupation. Presentations also discussed emergency preparedness activities in different countries, including the review and modification of legislative frameworks to incorporate additional flexibility that could be required under armed conflict situations. It was evident from the various presentations that there is increasing interest in the concept of combined emergencies and how countries prepare and respond to such events. Experience shared from Ukraine showed that decisions in the initial phase were complex and fast paced and had to be taken with no prior knowledge or experience of how to deal with such a situation. Balancing radiation and other risks in combined emergencies can be challenging.

There is potential for artificial intelligence (AI) to be used to support remote operations and modelling/assessment within EPR arrangements. However, if AI is to be embraced, it needs to be applied under robust ethical practices and security controls.

There was general consensus that the current framework for radiological protection and nuclear security is generally effective, but flexibility is required in applying the framework to allow adaptation in the face of changing circumstances and to allow multiple hazards to be addressed proportionately. Adaptation of regulations to provide for protection of people and the environment in the face of multiple hazards can be an significant challenge, however, with uncertainties and confusion around the application of relevant criteria, etc.

within national strategies. National exercises considering armed conflict situations around nuclear power plants have indicated that it is necessary to work towards an optimised level of protection for the public in complex situations, based on consensus and understanding among decision makers with clear and effective messages being given to the public to achieve an optimal level of protection. Further discussion around this topic may be warranted.

10.1.4. Session 4: Adapting national strategies and international support for medical response

One of the main obstacles to ensure that health services continue to be available is to create a safe environment for medical personnel, including providing psychological help. The active presence of effective leadership is also required, as evidenced from experience of providing medical responses internationally in the COVID-19 pandemic.

It is not easy to prepare for armed conflict situations but establishing international co-operation can help in building resilience for medical management and response capabilities when there is a risk of transport routes being lost (e.g. airports and ports) and where extremely challenging situations are faced. From examples presented from Ukraine it is evident that the delivery of medical care has been resilient, with medical response remaining safe and effective in the face of multiple challenges both in the field and at the frontline.

In both Ukraine and Japan in response to the Fukushima Daiichi Nuclear Power Plant accident, there are lessons to be learnt on how the medical systems have adapted to new challenges. Medical needs should be regularly reassessed in light of the ongoing situations and challenges faced, including the availability of medical staff. Continued provision of medical response can be challenging during the active response stage and during the recovery phase, and there is scope for further exchange on this topic in terms of experience with adaptation and lessons learnt.

10.1.5. Session 5: Identifying key lessons learnt on managing radiological protection during armed conflict: Improving regulatory resilience

Safety culture is key to regulatory resilience and is important not only for prevention of accidents, but also for armed conflict situations, with this theme being highlighted on several occasions. The situation in Ukraine has shown that prevention is an ongoing task, so safety culture needs to be ingrained. Nonetheless, safety culture can be difficult to maintain in an active armed conflict situation when there may be competing physical and psychological demands. For example, societal needs for electricity may compete against safety culture. However, it is important to recognise that if physical protection of a facility cannot be controlled, the ability to run the facility may also be in doubt and it may be necessary to put some operations aside, particularly where there are life safety concerns. There can be advance planning for what activities could be adjusted or stopped in a conflict situation, and change processes should be included in regulatory documents and feature in the radiation safety framework.

Every action has consequences and the message to ensure that actions do not do more harm than good came through again in several presentations. It is also important that lessons learnt are not then forgotten.

Following a natural disaster, the recovery phase can be long but there is awareness that there will be an end. However, as evidenced by the war in Ukraine, armed conflict can last for years without knowledge of when the situation will end. While the international framework for radiation safety and nuclear security still holds up under an armed conflict situation, it is clear from experience in Ukraine that planning in areas that would not have been considered previously may be necessary and flexibility is required. While the framework holds up, it may be appropriate to reassess high-level policy and actions. For example, it may be appropriate to revisit design basis threats and review national regulatory policy. Where changes to regulatory policy are warranted, regulatory bodies should be the top level players, but it is imperative they then follow their own advice and also include relevant stakeholders in the process.

From the presentations and discussions at the workshop, it is clear that a few countries are starting to think and plan around possible nuclear detonations. While the probability of such an occurrence is low, in the United States there has been planning for events involving improvised nuclear weapons following the events of 11 September 2001.

Co-operation across the international community to provide support during and after an armed conflict is vital. Even in times of peace there can be challenges to supply and demand and the availability of a prepared workforce.

There may therefore be conflict between actions that local authorities would want to take and what occupying forces will permit. For example, training within the EPR framework undertaken at Ukrainian controlled nuclear power plants illustrated that it would be possible to implement the full scope of measures and protective actions but at occupied nuclear power plants it would not be possible to implement measures due to a lack of capacity and capabilities in the occupied regions. Nonetheless, Ukraine would be responsible under the international convention on nuclear safety as the legal owner of the nuclear power plants, so illegal occupation of sites presents real challenges when trying to make assurances that obligations can be fulfilled.

Resilience in data and information sharing is also required. Different national dialects and differing points of view can be challenging from an international perspective and there may be merit in establishing a task force to look at standards for the state of the art in communicating and to address security issues faced with respect to data.

10.1.6. Session 7: Safety, security and emergency preparedness interfaces

There is a lot of debate in the international community on the topic of safety, security and emergency preparedness interfaces and how far to go in terms of design basis threats, etc. The example of the boat evacuation convoys of 11 September 2001 illustrates how, in an emergency situation, response can come together both promptly and effectively.

The 11 September 2001 terrorist attacks in the United States forced the NRC to consider EPR planning for hostile events. Determined adversaries with enough resources could overwhelm arrangements to address design basis threats and this resulted in the concept of hostile action and hostile action levels linking security-related criteria to protective actions, including off-site actions as required. Different responders may be required for hostile events than for normal plant EPR and different actions may be required such as site shutdowns, the mustering of people, or bringing onsite additional response support, including from military and federal organisations. The importance of holding EPR exercises for hostile actions was emphasised, along with the need for maintaining flexibility in responses to allow for adaptation to the circumstances faced. However, it is not just physical hostile actions that need to be prepared for, but also potential cyberattacks that could affect the sites and the ability of emergency response organisations to respond to situations. At the outset of a cyberattack, it will not be known whether the source is a systems hacker or the deliberate targeting of a site by foreign military interference. Further consideration may be merited on cybersecurity with respect to safety standards, design basis threats and EPR guidance.

The IAEA has a role to play in EPR in monitoring situations, sharing information and supporting countries in responding to emergencies. Seven pillars of nuclear safety and security and five concrete principles for preventing nuclear accidents as a result of armed conflict have been developed in response to the events in Ukraine since February 2022 and the application of those pillars were described. Examples were provided of how the IAEA has supported Ukraine through the deployment of staff to nuclear power plants to provide safety assurance were presented, along with examples of logistical arrangements for providing supplies and medical support, including psychological support, to help maintain safety at nuclear power plants. The IAEA has also conducted a review of the challenges in applying the safety standards and nuclear security guidance in armed conflicts and no revisions were deemed necessary, but the need for additional guidance was identified and a TECDOC is being prepared and is expected to be published early in 2024.

10.2. Discussion

A roundtable discussion session completed the workshop, with the aim of facilitating the development of proposals for further international collaboration in the field of radiological protection and nuclear security in armed conflict situations. The discussion panel was comprised of Oleh Korikov (SNRIU), Malgorzata Sneve (DSA), Thierry Schneider (NEA-CRPPH), Pascal Daures (EC), Anne Nisbet (ICRP Committee 4), and Anastasios Zodiantes (ILO). Discussions were centred around two questions, with panellists invited to give their views before opening discussions more widely to workshop participants.

10.2.1. What needs to change in national or international frameworks based on the workshop experience?

A number of questions and issues arose as a result of presentations and discussions. One of the key challenges to be addressed relates to the human dimension, both in terms of having sufficient availability of people to carry out necessary functions during armed conflict situations and the challenges faced by workers. Without adequate human resources it is difficult to continue day-to-day activities and respond to circumstances as they arise, and it is important to recognise that the status of workers can change significantly in armed conflict situations. For example, Ukrainian personnel at the Zaporizhzhia Nuclear Power Plant are no longer workers but captive workers. They continue to operate to the best of their abilities under very challenging circumstances in order to protect the nuclear power plant and Ukraine in the wider context. It is not possible for people to effectively and reliably work under extreme stress, with high workloads over prolonged periods and when subject to forced labour conditions, and these are real issues faced in Ukraine at the Zaporizhzhia Nuclear Power Plant. Workers in unoccupied territories also operate under challenging conditions, with supply chains and infrastructure damaged, affecting the ability to maintain equipment, etc. Safety culture is key to preparedness and the information shared around safety culture will help in better understanding the challenges and in building resilience.

The international community plays an important role in providing the necessary support to facilitate activities, including provision of equipment and logistics to fulfil nuclear safety requirements. It is not just armed conflict situations where such resources may be required, but also following natural disasters such as that which occurred in Japan in 2011 and led to the Fukushima Daiichi Nuclear Power Plant accident. It was useful to learn from presentations and discussions of the collaborative work and divergent support being provided to Ukraine through international organisations and as a result of bilateral arrangements and it will be important going forward for such arrangements to be continued in a co-ordinated way to ensure optimised and appropriately prioritised support is delivered.

Continued development of capabilities at the international level will therefore be required to facilitate rapid mobilisation of needed resources. Co-operation and co-ordination in the supply of equipment, logistics, etc. will not only be required during the conflict, but also once the conflict has ended to support recovery: there will be many resource requirements to bring the range of facilities affected by the war back into safe operation and to replace equipment and resources that have been destroyed or stolen. Continued co-ordination should be managed internationally under the leadership of the IAEA and WHO, as appropriate.

International conventions and frameworks, are in place, but one of the most worrying lessons learnt so far in the Ukraine conflict is that these conventions and frameworks are not followed by aggressors, leading to unacceptable nuclear safety situations. Conventions have aimed to bind countries to appropriate conduct with respect to nuclear safety, but it has become clear that the conventions are not fully effective in armed conflict situations as compliance depends on the willingness of the parties involved in the conflict to abide by the relevant articles. This does not mean that conventions and frameworks are not needed, as they can be used to hold aggressors to account for their actions, but it may be useful to consider how the integrity of conventions and frameworks can be strengthened. For example, it may be appropriate for nuclear power plants to be given special status as infrastructure facilities beyond normal infrastructure with exclusion zones established under armed conflict situations. Conventions should make clear that nuclear power plants should not be targeted and it may be appropriate to consider adjustments to conventions to prevent or reduce the likelihood not just of attacks on nuclear power plants but also occupation.

The adoption of new or revised national regulations in times of peace can take months or years within a normal democratic process but, as evidenced by the situation faced in Ukraine, may require rapid action to be taken in an armed conflict situation. Regulated processes, as opposed to ad hoc knee-jerk reaction, may need to be introduced to allow this.

There may be merit therefore in looking at how conventions can be made to be more effective instruments under the IAEA. However, due to the number of member states and the range of different interests and foci, this may be seen as overly ambitious. It may be appropriate to start discussions in smaller groups to promote and develop stepwise arrangements among countries with similar interests and contexts. Such progress could then be consolidated more broadly. The NEA may support a constructive platform for beginning such dialogue. The development of any recommendations or guidance should take account of lessons learnt from the Ukraine situation, including the need to consider war as a possible threat assessment scenario and to look more holistically so the focus is not just on radiation safety but also security and other elements that need to be included in threat assessments.

The ICRP, as an independent international organisation that operates as a charity, currently has more than 250 people contributing to activities from around 35 different countries. Recommendations from the ICRP provide the basis for radiological protection standards and practice worldwide. The presentations and discussions, including those in breakout groups, as well as the key lessons from the workshop will help inform the ongoing and future work of the ICRP, including lessons to be learnt on building capacity and capabilities and the need for flexibility in EPR plans and for adaptive decision making and prioritisation. Building flexibility into plans and adaptive decision making and prioritisation moves towards a need for an all-hazards approach, which is a topic that has gained interest both with the ICRP and the IAEA. The ICRP has been working on justification and optimisation and there have been significant conversations relating to all-hazards approaches. ICRP Task Group 120 on radiological protection for radiation emergencies and malicious events will need to revisit justification in light of armed conflict to take into account the additional risks (missiles, land mines, etc.) that may change priorities and justification. In an armed conflict setting it will not be feasible to achieve what would be achievable in peacetime so prioritisation will be needed on a case-by-case basis. Various ICRP task groups are considering the justification principle and there may be a need to extend considerations to take account of armed conflict – key lessons from the workshop will be used to inform activities of the Task Groups in this respect.

In addition to international approaches, it is also important to look at national procedures for ensuring safety on the ground with both top-down and bottom-up analysis of procedures. There has been work ongoing for many years in the bilateral framework between the DSA and Ukraine to look at regulatory threats and prioritise actions to address those threats. In some instances, it has been possible to address threats quickly through updates to procedures, but for regulatory updates the timescales tend to be longer.

A further challenge that has been noted several times during the workshop is how to provide and maintain good access to reliable information. It is not possible to make good decisions without reliable data. It is important to develop direct contacts and develop trust and have means of communicating on the condition of facilities without having to rely on the aggressors for information. Securing communication channels and improving defence of nuclear power plants and other facilities is key.

A recurring theme throughout discussions was the need for flexibility and adaptability. While radiological protection principles still apply in an armed conflict situation, what this means in practice is less clear and there would be benefit in sharing more around the experience of armed conflict situations (and other relevant scenarios) and implications for radiological protection practices. From this, it may be possible to improve the practicability of the principles of radiological protection and ensure a good level of protection and optimisation in light of non-radiological risks.

An example was shared of adaptation of nuclear regulations in light of unforeseen national challenges and the consequences. During the coal miners' strike in the United Kingdom in the 1980s, Magnox nuclear-powered reactors ran at full capacity to generate electricity to mitigate the reduction in generation by coal-powered power stations. As a consequence, spent nuclear fuel was generated at a rate greater than could be reprocessed and longer on-site storage of spent fuel was necessary. The UK regulator allowed for some relaxation of normal site procedures to allow on-site storage and, ultimately, nuclear legacies were increased as a result. There will be other examples internationally demonstrating regulatory changes to address national challenges and the consequences that have resulted and there would be merit in sharing information and lessons learnt on adaptation in the face of national challenges to support discussions around furthering regulatory resilience in the face of military or other pressures.

Armed conflict is a special situation affecting decision-making processes, bringing more complexity. It may be necessary to articulate with the military and consider how military operations could affect optimisation. While military response is not part of the radiological protection framework, actions will be part of the decision-making framework. It was brought up during the workshop that there can be a hierarchy for decision making depending on the circumstances. Armed conflict situations may therefore challenge perspectives and it may be appropriate to consider whether the radiological protection framework should evolve to accommodate extremely low-probability events with high potential consequences, including armed conflict and whether there is a point at which the radiological protection framework would end to give precedence to another decision-making framework.

A number of challenges have been identified for further consideration on how they can be addressed. Continued discussion will help identify ways forward and priorities for the future. It may not be possible to address all challenges in this way and there may need to be acceptance that in exceptional circumstances it may be necessary to adapt and operate outside of radiological protection frameworks for short times. The extent to which it is acceptable to work outside of the framework will depend on the circumstances, but resilience should ensure that frameworks can be put in place once again when circumstances allow.

International collaboration has been important in the case of the Ukraine war and building partnerships between countries during peaceful times provides a strong basis for effective multilateral co-operation in challenging times. Collaborative projects with the DSA, STUK, Poland, EC, IAEA, WHO and other organisations and international bodies have allowed the Ukrainian regulatory body, SNRIU, to navigate the significant challenges caused by the invasion by Russia and has enhanced governance during critical campaigns. Further development of mechanisms for sharing information would help strengthen co-operation between regulators internationally on radiation and nuclear security threats. There would also be benefit from training and capacity building through workshops and similar events to help harmonise regulatory standards and enhance expertise in mitigation of radiation threats.

There may also be merit in exploring the scope for unusual assistance protocols; establishing protocols for mutual support could provide a means for delivering swift resource mobilisation during conflict situations. Routine joint assessments/exercises could also help develop competence in line with international standards and support resource pooling initiatives that could help optimise capabilities in managing radiation risks. This could be a scalable initiative, moving towards a more global arrangement on how to act together during conflict situations and address nuclear facility risks in the future.

10.2.2. What should be done together on multinational frameworks that is not being done already?

There are many facilities in Ukraine that have been impacted to different degrees as a result of the conflict. Some have been directly attacked and sustained damage and others have not been tangibly impacted. Radiation safety principles have stood fast for all facilities, irrespective of the damage. The principles have also stood firm at nuclear power plants that are not occupied by Russian forces and safety performance has continued. Hospitals and other medical facilities that have been targeted have been able to recover and continue providing medical support. However, for the occupied nuclear power plant, hardware will need to be rebuilt to meet the requirements of the radiological protection framework. While many challenges have been faced, the radiological protection framework has stood firm and continues to be the correct approach to apply.

It may be useful as a next step to perform a gap analysis of the international framework for radiological protection within the scope of what is aimed to be achieved and, from this, look at developing a proposal to address any gaps. In order to be efficient, it would be appropriate for a small team with legitimate interests to look at this and communicate to the wider community. Consideration can then be given as to how to implement recommendations internationally. This approach was taken in the aftermath of the Fukushima Daiichi Nuclear Power Plant accident to consider necessary changes to the framework, with a team spending a few years looking at the framework and making recommendations that were then analysed before any decisions were reached.

As was mentioned a number of times during the workshop, different risks and hazards can be present at different times and, in a war situation, radiological protection is unlikely to be the most important. How to take a holistic approach to addressing the different challenges faced needs more international focus and co-operation, with dialogue between the authorities responsible for different aspects of safety being opened up.

Information is key to decision making but it can be challenging in a war situation to discern between real and fake information and to address gaps in information, for example when data flow is interrupted by electricity outages. Further consideration of how to make decisions based on potentially limited information may be beneficial. Furthermore, countries depend on each other internationally to provide good and accurate information and data and information exchange policies have been established. However, such policies were developed during times of peace and there may be merit in reflecting on how they have held up in a war situation and to consider adaptations and enhancements that could improve data security and exchange.

The 2007 Recommendations of the ICRP are in the process of being updated. This provides an opportunity to identify themes that should best be taken forward over the next decade. Special liaison groups and committees ensure international co-operation with the EC, NEA, etc. and efforts are made to engage internationally at every step when updating recommendations. ICRP task groups routinely include representatives from other working groups (e.g. the NEA Expert Group on Legacy Management [EGLM] and CRPPH) that also consider risks from non-radiological hazards and advocate for an all-hazards approach to risk management. It will be important going forward to continue engaging with symposia and workshops, including interim online webinars to engage with a wider audience to gain insights into the issues and challenges. Greater engagement with those working in the security field would also be beneficial.

Information and lessons learnt from this workshop will also be disseminated to NEA working groups (e.g. CRPPH) to inform on key points and areas where there could be improvement, such as the need for adaptable and resilient regulations, and to discuss possible activities that could form a next step. Many organisations have shown concern around the topic of resilience in regulations and further discussion could help identify missing elements that could lead to improved application of the system for radiological protection.

Presentations and discussions have also highlighted the importance of capacity building, safety culture and communications that could also be taken forward within the context of the challenges of armed conflict situations. The important roles that citizen scientists can play have been highlighted and more thought could be given to how to reach out and communicate effectively via social media, etc., to gain fresh perspectives in the event of an emergency, particularly in the early stages of response. Further discussion around these topics would be useful in establishing the best way to proceed, along with continued interaction with Ukrainian colleagues to gain further insights into challenges faced and lessons learnt.

From the perspective of the SNRIU, there would be benefit in having international exchanges on the supervision and regulation of nuclear reactors, etc. by different national authorities. This could also help foster and fortify international collaboration between nuclear regulators and to work towards synergy and a collective commitment for global security and well-being.

Emergency preparedness tends to focus on nuclear power plants, but there are other safety-important facilities that can have high radiological risks associated with them, including storage and disposal facilities and hospitals. It could be beneficial to look at different scenarios that should be evaluated to identify critical points and initiating events that could inform on building appropriate defences. A good starting point would be to share information on scenarios that are already available that could help others in building their own safety assessments relevant to their circumstances and this could be taken forward within the CRPPH Working Party on Nuclear Emergency Matters (WPNEM). It would also be useful to consider guidance on the frequency of emergency exercises for facilities and local authorities for EPR for armed conflict situations consistent with guidance available for emergency exercises for nuclear accidents.

Ongoing within the ICRP is a re-evaluation of what justification means in terms of optimisation and the application of reference levels. In a war situation, justification also plays an important role. What justification means for the application of reference levels and dose limits could be evaluated by considering armed conflict scenarios to see whether current advice is appropriate or whether revisions would be appropriate. Scenarios considered to date have included the Litvinenko poisoning and use of RDDs, but a country at war completely changes the justification concept so would merit specific consideration. Recommendations arising from the re-evaluation will be open to international critical review before being finalised.

In going forward, the focus should not be solely on nuclear emergencies; it will be important to recognise that there could be concurrent emergencies that could give rise to conflicting protective actions. For example, and as noted previously, during an emergency situation advice could be for people to shelter together, but if the emergency occurred concurrently with the COVID-19 pandemic, that advice would go against measures to protect against the pandemic. This experience should be taken into account when looking to develop or revise guidance to ensure an all-hazards approach is applied when responding to emergency situations. Within ICRP guidance on reference levels and optimisation, it will be recognised that other factors at play should also be taken into account rather than focusing solely on protection from radiation. It was noteworthy that the workshop is one of the only times that protection of the environment from radiation has not been an additional focus area, illustrating armed conflict gives a very different perspective, that of saving lives.

The Russian war on Ukraine has seen nuclear power plants being used as weapons of war with direct threats to nuclear power plants being used to scare society as a whole. A strong message needs to be made for nuclear power plants to be given special status in armed conflict. This could be taken forward by the NEA with the OECD council requesting that governments adopt this as a formal position and potentially resulting in new conventions.

There was only limited participation at the workshop by representatives with a fully military perspective. A more significant presence from this group could have contributed to sharing valuable insights on armed conflict situations, including command control and communications during difficult operations and civil protection when infrastructure is damaged. The presence of military stakeholders would also have allowed for discussions around opponent motivations and aims during armed conflict, on planning and anticipating what opponents might be planning and how they might react to mitigating actions, and challenges in dealing with chaotic opponents (i.e. where there is no clear plan or objective). Efforts were made to involve military stakeholders, but there were no direct lines of communication available. As such, it was necessary to rely on third parties, but this led to communication issues around workshop aims and objectives, etc. This highlights some of the challenges going forward. The radiological protection community has not previously worked on radiological protection issues from the perspective of armed conflict and networks and lines of communication need to be established. Lines of communication will be essential in an armed conflict situation to support decision making in the context of military action objectives. Sharing of experience from different countries on engagement between radiological protection and nuclear safety authorities and national defence organisations/military could be a useful first step to brainstorming around the application of the system for radiological protection in an armed conflict perspective.

There is an Inter-Agency Committee on Radiological and Nuclear Emergencies (IACRNE) to facilitate and co-ordinate inter-agency co-operation in case of an emergency, but the effectiveness of this committee, particularly at the start of the Ukrainian war, was apparently limited. In moving forward, there may be benefit in considering how more effective support could be provided by, for example, clarifying and co-ordinating within the committee the assistance that can be provided by each agency and working to improve the effectiveness of mechanisms for providing detection devises and equipment, which currently requires tenders and selection of suppliers.

Prior to the Russian invasion of Ukraine, the threat of nuclear power plants being directly targeted during armed conflict had not been recognised. Now the threat is recognised and, with nuclear power increasing internationally, it is possible that such threats could occur more often into the future.

10.3. Closing remarks and acknowledgements

The workshop was the culmination of the first collaborative bilateral project between the NEA and the DSA and the information shared and discussed by workshop participants will help inform long-term efforts to address how radiological protection and nuclear safety frameworks and decision-making processes may need to adapt to improve regulatory and operational resilience for armed conflict situations. Actions will be taken on many dimensions and continued support from the international community in moving forward will be appreciated.

Finally, the efforts of colleagues from Ukraine in attending the workshop in person to share with the international community insights and information, knowledge and experience of the situation faced in Ukraine as a result of Russia's aggression was gratefully acknowledged. As a result of the descriptions of events since the war began, it is possible to get a greater understanding of the reality of the situation and what is at stake. This knowledge will assist countries internationally to enhance nuclear security and safety. The events and situations described during the course of the workshop are of great concern, with threats still ongoing that challenge the resilience of the radiological protection system. It will be important to ensure that the knowledge of events is not lost and that lessons are learnt from the real challenges faced in Ukraine.

11. Key conclusions and actionable recommendations

International and bilateral co-operation is vital to address radiation and nuclear challenges within Ukraine, and this is likely to continue. At the same time, such international co-operation is also necessary to enhance preparedness and response in friendly neighbouring countries.

The provision of international assistance has strengthened capacity and resilience in Ukraine and has supported the Ukrainian regulatory body to navigate the significant new challenges faced as a result of the full-scale invasion.

A strong message is needed on the special status of nuclear power plants during war. The current workshop has provided the first step in developing international co-operation to address a range of identified risks and challenges.

The actionable recommendations arising from the presentations and discussions documented above are set out below in five key areas.

Area 1- Strengthen international co-operation and reinforcing international conventions

- Strengthen international and bilateral co-operation to address radiation and nuclear challenges within Ukraine. Additionally, establish such co-operation to enhance preparedness and response in friendly neighbouring countries. Consider an international/multilateral framework to co-ordinate activities on the provision of assistance (expertise, human and financial resources), on procurement of specialised equipment and other matters (including post-conflict recovery).
- Establish a small task force or team of representatives from key organisations (development of effective networks of personal contacts). This task force would reflect on the learning and present the outcomes of their discussions, which could then be considered for implementation at an international level.
- Review and enhance conventions and/or guidance on their application to explicitly exclude nuclear installations from being targeted in attacks (e.g. by granting nuclear facilities special status beyond normal infrastructure during armed conflict, establishing exclusion zones around facilities). Although ruled out by aggressors, it could provide a basis for holding them accountable post-conflict. Co-operation protocols could then be scaled towards developing global decisions on how to act together to address nuclear facility risks into the future, essential in achieving a collective commitment for global security.

Area 2- Build and maintain resilience nationally and beyond through flexible regulatory frameworks

- Build on information sharing mechanisms:

  1. to strengthen networks/platforms among regulators and develop national resilience when facing radiation threats;

  2. to establish protocols for mutual co-operation among all organisations that are able to support swift mobilisation of (human and logistics) resources during armed conflict; and

3. to support holistic dialogue: between different regulatory bodies in various areas of responsibility and safety issues, but also health and welfare services; and with the military on how risks near major facilities can best be managed.

- Build more flexibility into regulatory frameworks to allow for adaptive decision making and prioritisation rather than trying to change regulations in urgent situations. A vigorous safety culture is to be encouraged within and among the operators, TSOs, regulators and other support organisations well in advance of armed conflict. This is key to support safe operations during times of limited and/or intermittent regulatory inspections and oversight, information accessibility challenges, human capacity deficiencies, etc.
- Integrate radiological protection within the overall resilience system. Relevant international organisations, including the NEA, are encouraged to prepare guidance for both the RP specialists and regulators.

Area 3- Develop practical guidance for RP while the RP principles and policy framework apply

- Better understand what application of RP principles means in practice and how to improve the practicability of RP to ensure an appropriate level of protection.
- Revisit the justification process to recognise additional threats during armed conflict (e.g. missiles, mines) that could require prioritisation to be made on a case-specific basis. Adapt regulatory frameworks to make decisions considering other risks, while adhering to the principles already in place, namely justification and optimisation, which guide the application of the international RP system when deciding protective actions.
- Consider war scenarios within the ICRP system of radiological protection, as a country at war has not yet been considered. A war scenario could have important implications for the application of the concept of justification and selection of reference levels.
- Address the challenge of a cascade of crises occurring simultaneously during armed conflict, making optimisation difficult and complex.

Area 4- Adopt an all-hazards approach, broaden dialogue between civil and military authorities for EPR

- Engage in dialogue with other authorities responsible for safety in other fields, including military authorities, in addition to RP and nuclear safety communities. Establish links and communication networks for the decision process to gain insights on how to operate within the objectives of military actions. Sharing the experience of different countries could be an important first step.
- Adopt a holistic view so that the focus is not solely on RP, but also security and other threats, i.e. an all-hazards approach. This includes threats associated with the availability of reliable information and how to make decisions in the absence of data, as well as establishing reliable and direct contact points for trustworthy exchange of information and ensuring security of communication channels.
- Enhance EPR analysis with release scenarios including war scenarios for nuclear installations but also for high-risk radiation installations, e.g. waste storage facilities, industrial irradiators, hospitals. From that, consider building defence and mitigation capacities and capabilities. A first step for countries could be sharing scenarios already available within national EPR programmes.

- Adjust protective actions during armed conflict and disruptive scenarios. Strive for balance between different hazards and risks; for instance, advice to shelter from shelling may conflict with advice to evacuate due to radiation situation.

Area 5- Stakeholder engagement, critical aspects of information, communication and trust

- Practice communication of information to those who need it, especially during emergency situations when electricity supplies and communication channels may be disrupted. Conduct exercises to improve co-ordination and develop most effective communication channels.
- Leverage social scientists to address issues related to reliability, misinformation, and fake news during conflict situations. Their expertise can facilitate effective communication in emergencies.
- Engage civil society actively to build trust. Proactively implement trust-building initiatives well before conflict situations arise between operators, regulators, other stakeholders and the public in general.

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