When Armies March – Radiological Protection During a Time of War

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Abstract

Just before dawn on the morning of February 24, 2022, Russian ground troops rushed across Ukraine's borders. This was the first time in world history when a large nuclear state (both with operating civilian nuclear reactors and nuclear weapons) invaded another country with a significant civilian nuclear power program.

Despite many fears, no major radiological threats to public health and safety have occurred. However, questions remain should a significant radiological release occur:

(1) Do the current peacetime radiological protection systems and regulatory frameworks assure adequate safety to human health and the environment during armed conflict?
(2) Do these peacetime frameworks have the required adaptability where sovereign authority over a facility and surrounding areas may not be possible whilst under the control of an invading army?

In November 2023, the Nuclear Energy Agency's Committee on Radiological Protection and Public Health (CRPPH) and the Norwegian Radiation and Nuclear Safety Authority (DSA), with support from the State Nuclear Regulatory Inspectorate of Ukraine (SNRIU), held a workshop in Oslo, Norway. This paper provides an overview of relevant discussions from the workshop, as well as areas for improvement in radiation protection frameworks and the governing body of international nuclear conventions.

Keywords: Armed Conflict, Dose Limits, International Conventions, Nuclear Liability, Nuclear Safety, Radiation Protection, Regulatory Framework, Waste Management

1.0 Introduction

Russia Invades Ukraine[1]! screamed the newspaper headlines. Just before dawn on the morning of February 24, 2022, the peace of Europe was shattered when the Russian invasion began with dozens of missiles strikes on cities all over Ukraine. Soon, Russian ground troops rushed across Ukraine's borders. The world held its breath as within a few weeks' time expansive areas of Ukraine, including the seizure and occupation of the Chernobyl Exclusion zone, as well as a nuclear plant site, were under Russian control. Constantly, the International Atomic Energy Agency (IAEA) chief Rafael Grossi continues to warn that safety and security at Ukraine's Zaporizhzhia Nuclear Power Plant (ZNPP) remain fragile as significant staffing cuts at the plant site by Russian authorities occupying the facility take their toll. While to date, no major radiological threats to public health and safety have occurred, questions and concerns are at the forefront of policy makers minds and the public regarding the realities of current radiation protection standards and legal framework's ability to continue to provide adequate protections in this regard.

In November 2023, the Nuclear Energy Agency's Committee on Radiological Protection and Public Health (CRPPH) and the Norwegian Radiation and Nuclear Safety Authority (DSA), with support from the State Nuclear Regulatory Inspectorate of Ukraine (SNRIU), held a workshop in Oslo, Norway. This workshop aimed to address prospective issues of radiological protection in the context of armed conflict - "*Radiological protection during armed conflict: Improving regulatory resilience and operational applications*". This paper provides a limited overview of some relevant discussions from the workshop and whether the current radiological protection frameworks are still relevant during a time of armed conflict at or near a civilian nuclear power plant.

2.0 Decades of Radiation Protection Development Focus - 1900 through Today

When we think of radiation protection guidance, what is glaringly apparent is there are "two distinct eras separated by World War II"[2]. Before World War II, the major areas of concern were directed at simple solutions to a specific problem (i.e., X-ray protection). From the

[1] Ellyatt, H., *Russian forces invade Ukraine*, Published Thu, Feb 24 20224:05 AM EST Updated Thu, Feb 24 202211:38 AM EST, CNBC Website, https://www.cnbc.com/2022/02/24/russian-forces-invade-ukraine.html, Accessed October 17, 2024;

[2] Kathren, R. L. (2019). Evolution of Radiation Protection Guidance in the United States. In Advanced Radiation Protection Dosimetry (1st ed., pp. 79–122). CRC Press. https://doi.org/10.1201/9780429055362-3.

moment an atomic bomb was dropped on the Japanese city of Hiroshima on August 6, 1945, the world entered a nuclear age with a new term that spread fear among the populace - radiation sickness[3]. As the public learned more about the scale of the massive destruction caused by one bomb (70 per cent of all buildings destroyed and an estimated 140,000 deaths[4]), it shocked the conscious. From 1949, when the Soviet Union detonated its first nuclear device at a remote site in Kazakhstan, the main focus of policy makers (and the public) turned to the 'immediate' destruction and illnesses caused in high-population urban centers. One lasting memory of 1950's school children in the United States (US) were the duck-and-cover drills teaching children in school what they should do when there was an atomic attack, which helped to channel the mounting "panic over an escalating arms race"[5].

By the 1960's, radiation protection had evolved to include the civilian aspects of the use of the atom. This involved the identifying and measuring the various sources of radiation exposure to the public by categorizing the potential sources of radiation exposure. These exposure scenarios ranged from releases (both minimal and major) from civilian nuclear power plants, medical uses, to the abnormally high natural radiation levels in certain regions[6], as well as from nuclear war. This potential commercial radiation dose exposure concern is shown in the Nuclear Liability Conventions[7] of the era which were adopted to ensure people were compensated for certain types of economic loss and the cost of measures to reinstate a significantly impaired environment etc. from the consequences of nuclear accidents from a commercial nuclear power plant, both within the Contracting Party and other contracting parties to the convention of a cross-boundary nature.

During the 1970's, on the military side, a new theory emerged that there was more likely to be a greater effect on the military rather than the civilian population, as it was believed a

[3] Solomon, F., Marston, F., Symposium on the Medical Implications of Nuclear War, Marston, Robert Q., & Institute of Medicine. (1986). The Medical implications of nuclear war (1st ed..). National Academy Press.
[4] The International Campaign to Abolish Nuclear Weapons, *Hiroshima and Nagasaki bombings*, https://www.icanw.org/hiroshima_and_nagasaki_bombings#:~:text=The%20uranium%20bomb%20detonated%20over,chronic%20disease%20among%20the%20survivors, Accessed August 27, 2024.
[5] History.com Website, *How 'Duck-and-Cover' Drills Channeled America's Cold War Anxiety*, https://www.history.com/news/duck-cover-drills-cold-war-arms-race, Accessed August 27, 2024.
[6] Barahona, A. (2022). Radiation Risk in Cold War Mexico: Local and Global Networks. Naturwissenschaften, Technik Und Medizin, 30(2), 245–270. https://doi.org/10.1007/s00048-022-00331-0.
[7] *Paris Convention on Third Party Liability in the Field of Nuclear Energy*, https://www.oecd-nea.org/jcms/pl_20196/paris-convention-on-third-party-liability-in-the-field-of-nuclear-energy-paris-convention-or-pc, Accessed August 27, 2024; and, *Vienna Convention on Civil Liability for Nuclear Damage*, https://www.iaea.org/topics/nuclear-liability-conventions/vienna-convention-on-civil-liability-for-nuclear-damage, Accessed August 27, 2024

shift in strategy was taking place towards the strategic use of nuclear weapons constrained to the battle field, more than being aimed at urban centers. At the end of the 1970's, 1979 to be precise, the most serious accident at a US commercial power plant occurred at The Three Mile Island Unit 2 reactor, near Middletown, in Pennsylvania. Although there was only "small radioactive releases [which] had no detectable health effects on plant workers or the public… sweeping changes involving emergency response planning, reactor operator training, human factors engineering, and radiation protection"[8] were brought about. Once again, there was a renewed focus on radiation protection measures surrounding the potential releases from commercial power plants rather than caused by nuclear war.

As the world approached the end of the Cold War in the 1980's, two major events brought simultaneous emphasize on radiation protection in both military and civilian applications. The first was the North Atlantic Treaty Organization (NATO) exercise 'Able-Archer' simulating a nuclear attack that brought the US and Soviet Union "to the brink of nuclear war by miscalculation"[9] and ending the détente of the 1970's. It also kicked off a renewed arms race in what has been termed the 'Second Cold War'. Second, on the civilian side, the accident at the Chernobyl Nuclear Power Plant (ChNPP) in Ukraine was a milestone event taking place on April 26, 1986. As a result of the explosion and fire in the Number Four RBMK reactor, and the resultant release of radioactive elements including plutonium, iodine, strontium and cesium into the atmosphere, it is estimated that approximately 200,000 persons had to be relocated, with some 150,000 square kilometers in Belarus, Russia and Ukraine being contaminated[10]. Furthermore, Scandinavian countries in particular were affected by the radioactive releases from Chernobyl. As a result of the Chernobyl accident two major international conventions were adopted: Convention on Early Notification of a Nuclear Accident[11] and Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency[12].

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[8] Nuclear Regulatory Commission, *Backgrounder on the Three Mile Island Accident*, https://www.nrc.gov/reading-rm/doc-collections/fact-sheets/3mile-isle.html, Accessed August 27, 2024.
[9] Radchenko, Sergey, 'The Soviet Union and the Cold War Arms Race', in Thomas Mahnken, Joseph Maiolo, and David Stevenson (eds), Arms Races in International Politics: From the Nineteenth to the Twenty-First Century (Oxford, 2016; online edn, Oxford Academic, 21 Jan. 2016), https://doi.org/10.1093/acprof:oso/9780198735267.003.0008, accessed 27 Aug. 2024.
[10] International Atomic Energy Agency, *Frequently Asked Chernobyl Questions*, https://www.iaea.org/newscenter/focus/chernobyl/faqs, Accessed August 27, 2024.
[11] https://www.iaea.org/topics/nuclear-safety-conventions/convention-early-notification-nuclear-accident, Accessed August 27, 2024.
[12] https://www.iaea.org/topics/nuclear-safety-conventions/convention-assistance-case-nuclear-accident-or-radiological-emergency, Accessed August 27, 2024.

During the 1990's, and for a period of 20 years (with the de-escalation of possible nuclear war with the fall of the Soviet Union), the international community continued to strengthen radiation protection measures and limit dose exposures in the civilian arena with renewed focus on the As Low As Reasonably Achievable (ALARA) doctrine. By the mid-2000's, there were talks of a nuclear renaissance, or a possible revival, of the nuclear power industry. A global slowdown in the construction of new nuclear projects had brought about renewed calls for an expanded energy mix driven by rising fossil fuel prices and concerns about meeting greenhouse gas emission limits. This renaissance collapsed in 2011, on 11 March, with the accident at the Fukushima Daiichi Nuclear Power Station (FDNPS).

3.0 Fukushima Accident – A Leap Forward in Radiation Protection and Response

On 11 March 2011, an earthquake of magnitude 9.0 occurred along the Japan Trench. The earthquake and resultant tsunami triggered a severe nuclear event, with these events leading to the release of radioactive material from FDNPS into the environment. While it is not the intent of this paper to comprehensively discuss this accident in detail, the lessons-learned from this accident, and the actions taken to protect life and property, not only strengthened nuclear safety culture around the world, but our radiation protection frameworks, too. Importantly, they also provide a potential template for preparing and managing radiation protection activities during armed conflict.

It should be noted that radiation protection actions were immediately employed for emergency workers. The radiation protection measures/allowable dose rates were: (1) An upper radiation exposure dose limit of 100 mSv for workers engaged in emergency works at FDNPS (immediately applied); (2) This was increased to 250 mSv on March 15, 2011; and, (3) On November 1, 2011 this limit and returned to its pre-existing value of 100 mSv for workers commencing work after November 1 and on December 16, 2011 for most other workers, with April 30, 2012 for all remaining workers[13]. In other words, radiation protection measures were adopted and changed due to shifting circumstances over the time

[13] UNSCEAR 2020/2021 Report Volume I, SOURCES, EFFECTS AND RISKS OF IONIZING RADIATION, ISBN: 978-92-1-139206-7, e-ISBN: 978-92-1-001003-0, https://www.unscear.org/unscear/publications/2020_2021_1.html, Accessed August 28, 2024.

span of one year. Flexibility is key for managing changing circumstances and for maintaining adequate levels of safety during the various phases towards recovery.

In commenting on the safety and healthy risks of these measures, the UNSCEAR 2020/2021 Report Volume I report states, "A small proportion of workers (174 workers, about 0.8%) received effective doses within the first year of 100 mSv or more, with an average of about 140 mSv. […] The Committee therefore consider[ed] that it is unlikely that an increased incidence of cancer due to irradiation would be discernible, because the normal variability in baseline rates of cancer incidence is much larger than the inferred radiation-associated cancer rates."[14] This statement does become important later in the paper's discussion when discussing proposed updates to Sweden's radiation protection legislation, as well as nuclear liability issues.

Also, it is valuable to note that evacuation and shelter in place measures were undertaken in a step wise basis as shown in Fig. 1, which could indicate some sort of template during time of war. Although, given fast changing conditions with moving battle fronts, evacuations on any scale may not be advisable and shelter in place is most likely the best solution. The worst-case scenario for the public is to become stuck between shifting front lines without the possibility to either complete the evacuation or return to their homes. As will be discussed later, the public will need to be better educated on dose exposure rates/limits to reduce panic and assist the public in making more informed decisions during an extremely stressful situation.

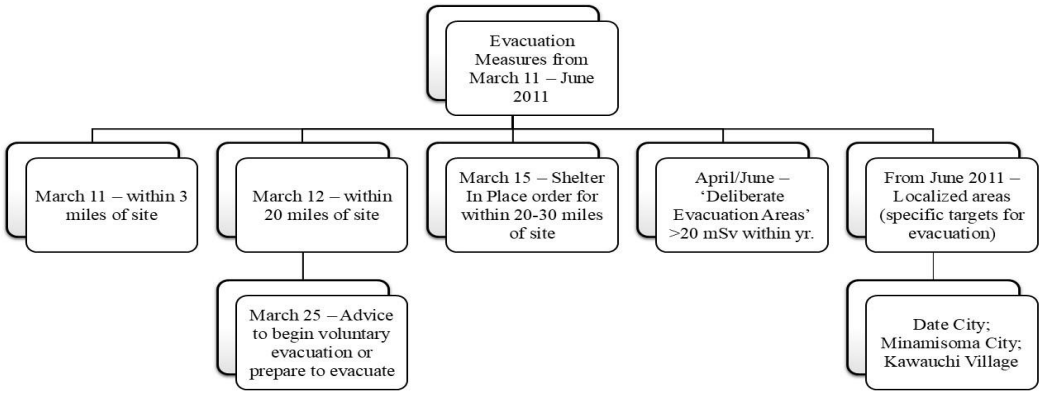

Figure 1: Evacuation and 'Shelter in Place' Orders from March 11 through June 2011

[14] *Ibid*.

3.1 Fukushima Accident Lessons-Learned and their Application during Time of War

There are a number of lessons-learned that arose from the Fukushima accident, which are appropriate with updates within the context of the paper. Do note that while all these actions and lessons-learned occurred during a peacetime accident, these lessons are useful in preparing for potential actions that could be taken during a nuclear emergency caused by a military incursion at a civilian power plant with a radiological release to the environment. The lessons-learned are taken from the IAEA 2015 Report of the Fukushima accident[15].

Lesson-learned # 1 – Radiation Protection Principles & Criteria Understandable to Non-Specialist

There is a critical need to develop better useable information and how to more simply explain the principles and criteria for radiation protection. These need to be comprehensible to non-specialists. How the protection criteria and measures are to be applied must be clearer for both political decision makers and the public. Importantly, an improved communication and education strategy is needed to convey the justification for such measures and actions to all stakeholders, including the public.

Response: This is especially vital in a nuclear emergency during time of war where communication may be limited, and where decisions might have to be taken at the local level or even within the smaller 'neighborhood' setting without consultations with central or regional government agencies. Also see lesson-learned #5.

Lesson-learned # 2 – Comprehensive & Coordinated Approach to Decision Making at All Government Levels

Arrangements need to be in place to ensure that protective actions and other response actions in a nuclear emergency do more good than harm. A comprehensive approach to decision making needs to be in place to ensure that this balance is achieved.

Response: This is a central attribute in a nuclear emergency especially during time of war where communication may be limited. Ministries and Departments must be able to flexibly delegate decision making competencies to regional and local governments. These authorities in decision making must be quickly transferred and activated, and grounded in

[15] International Atomic Energy Agency, *The Fukushima Daiichi Accident*, 2015, STI/PUB/1710 ISBN 978–92–0–107015–9 (set), https://www-pub.iaea.org/mtcd/publications/pdf/pub1710-reportbythedg-web.pdf, Accessed August 28, 2024.

pre-set administrative procedures. As an example, the Snow Chaos on the road E22 in southern Sweden January 2024 is an example of failures in delegation and quick decision-making[16].

Lesson-learned # 3 – Capability Probabilistic and Deterministic Safety Analyses

Comprehensive probabilistic and deterministic safety analyses need to be performed to confirm the capability of a plant to withstand applicable beyond design basis accidents and to provide a high degree of confidence in the robustness of the plant design.

Response: The authors would add to these particular assessments a caveat to include assessments of potential scenarios as a result of military engagements in the vicinity of a commercial power plant. The authors also refer the reader to lesson-learned #4.

Lesson-learned # 4 – Assessment of Natural Hazards Needs to Be Sufficiently Conservative

The assessment of natural hazards that might occur within the site needs to be sufficiently conservative. As was seen in the Fukushima accident, using historical data to establish the design basis of nuclear power plants needs to be weighed whether sufficient consideration regarding the wide range of potential scenarios and how to best characterize the risks of extreme natural hazards is properly considered.

Response: The authors would add, and do recommend, to this lesson-learned from Fukushima a caveat to include assessments of potential scenarios as a result of military engagements, simultaneously with credible natural hazard events in the vicinity of the commercial power plant. Additionally, simulations should be undertaken for emergency preparedness and response where a nuclear emergency occurs simultaneously with a natural hazard event.

Lesson-learned # 5 – Public Helpers & Factual Information [During Time of Nuclear Emergency]

Both ‘Emergency Workers’ and ‘Public Volunteers’ need to be defined, designated, and assigned clearly specified duties. They should each be given adequate training relative to the designated status to be properly protected during a nuclear emergency. Additionally,

[16] Hivert, A., *The chaos of the snow-covered E22 route, a symbol of 'real Sweden'*, https://www.lemonde.fr/en/international/article/2024/02/14/the-chaos-of-the-snow-covered-e22-route-a-symbol-of-real-sweden_6523901_4.html, Published on February 14, 2024, at 12:51 pm (Paris).

factual information on radiation effects needs to be communicated in an understandable and timely manner to individuals in affected areas in order to enhance their understanding of protection strategies, to alleviate their concerns and support their own protection initiatives. **Response**: This may need to include plans where trained and 'authoritative' individuals in the local community are required to provide timely information to the regulator (should normal monitoring systems go offline) or the public within their sphere of influence when communication with regulatory bodies may not be possible. Also, a more concise determination of a what constitutes 'public helpers' should be defined in a similar categorization of Emergency Workers, their training requirements and also use of PPE, with PPE supplies stored in various locations within the local community and county.

4.0 Radiation Protection – It All Changes with Major War in Europe (2022)

On February 24, 2022, Russia's invasion of Ukraine began with dozens of missiles strikes on cities all over Ukraine. Over the next weeks, Russian ground troops moved in quickly and within a few weeks were in control of large areas of Ukraine. In what was a surprisingly shocking move, the Russian army seized and occupied the Chernobyl exclusion zone. Adding insult to injury, a Russian assault on the Zaporizhzhia Nuclear Power Plant (ZNPP), which began on 3 March 2022, captured the power plant by the next day. Still this year (2024), the United Nations declared, "that the first-ever war to be fought amid the facilities of a major nuclear power programme is bringing the prospect of nuclear accident "dangerously close"[17].

As a starting point, to begin international discussion on these serious events and impact to radiation protection programs and legislative frameworks, between November 22-24, 2024 a workshop titled '*Radiological protection during armed conflict: Improving regulatory resilience and operational applications*' was held in Oslo, Norway. The workshop had three aims, which are shown in Figure 2.

Without going into full detail of each presentation in the workshop, the goal here is to provide some basic relevant information and consider a war's impact on the functioning of

[17] United Nations, 9604th Meeting (PM), *Prospect of Nuclear Accident 'Dangerously Close' at Zaporizhzhia Power Plant in Ukraine, International Atomic Energy Agency Chief Warns Security Council*, April 15, 2024, https://press.un.org/en/2024/sc15662.doc.htm, Accessed September 2, 2024.

international nuclear conventions. Three key regulatory issues and challenges[18] were mentioned in context of the War in Ukraine:

1. National laws and regulations have been developed without taking into account shelling conditions or occupation of nuclear installations.
2. There is no experience anywhere in the world of the safe operation of a nuclear installation in the context of large-scale war.
3. There is no experience of nuclear regulation in the context of large-scale war and for recovery and the re-start of the regulatory body control/work in a postwar period.

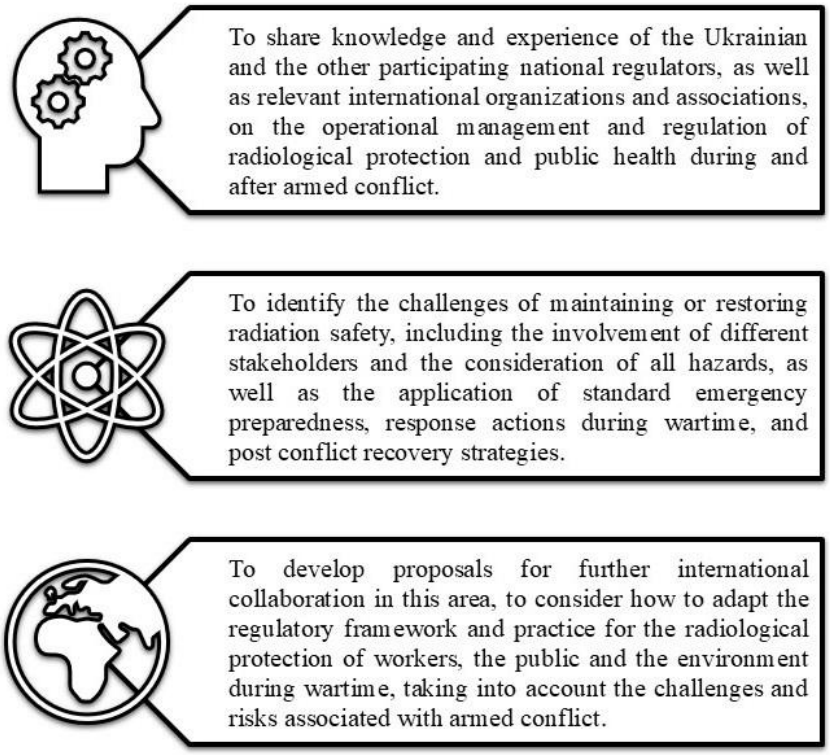

Figure 2: The Three Aims - NEA's Radiation Protection During War Workshop (2023)

[18] See PowerPoint Presentation from the Workshop: Regulatory and Operational Radiological Protection Issues and Challenges in Ukraine, NATALIIA RYBALKA - Director of the Department for Safety of Radiation Technologies and Radioactive Waste Management – Deputy Chief State Inspector for Nuclear and Radiation Safety of Ukraine. Presentations may be found at: https://www.oecd-nea.org/jcms/pl_82793/radiological-protection-during-armed-conflict-improving-regulatory-resilience-and-operational-applications

5.0 Radiation Protection Example during War - Sweden: A Case Study

During the workshop, a presentation by Sweden[19] was given which is used as a case study for this paper. Sweden is currently conducting a review of its radiation protection legislation and framework to consider how appropriate they would still be during a heightened state of alert and war. The two guiding doctrines for their review are:

1. Develop a framework for radiation protection in connection with emergency exposure situations during a heightened state of alert and war as part of a complete protection strategy.
2. Propose the necessary changes to the Swedish legislation in order to implement the framework.

One main concern for Sweden in its review is: 'what constitutes a worker involved in an Emergency Response'? Sweden is reviewing this question in context with the European Union Basic Safety Standard for an emergency worker, '*which means any person having a defined role in an emergency and who might be exposed to radiation while taking action in response to the emergency*'[20]. Workers, though, not designated as emergency workers are treated as members of the public with regards to radiation protection in emergency exposure situations. However, some of these workers, though ancillary, would still need to participate in vital societal functions. Therefore, Sweden seeks to propose the following solution:

+ *The redesignation of non-emergency workers as "workers in an emergency exposure situation" and their being treated as emergency workers.*

The argument Sweden wishes to put forward in its 'worker' redesignation justification is that such a change in the Swedish legislation would ensure adequate regulation of radiation protection for these emergency ancillary workers during a time of heighten alert, as well as for peacetime emergencies. This would also ensure that responsibilities and individual rights

[19] Jan Johansson, Peder Kock, Anders Axelsson, Alireza Sadeghi Shahriary, Anna Maria Blixt Buhr, Jonas Lindgren, Jonas Boson and Simon Karlsson, *Development of a Swedish framework for radiation protection during a heightened state of alert and war*, Strålsäkerhetsmyndigheten (Swedish Radiation Safety Authority), November 2023.
[20] Council Directive 2013/59/Euratom of 5 December 2013 *laying down basic safety standards for protection against the dangers arising from exposure to ionising radiation*, and repealing Directives 89/618/Euratom, 90/641/Euratom, 96/29/Euratom, 97/43/Euratom and 2003/122/Euratom, Article 4, Definitions, (31), https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A02013L0059-20140117, Accessed October 16, 2024.

are adequately regulated for these emergency ancillary workers. This, at least, is the technical protection justification. Sweden also proposes drastic changes from current guidance for 'Occupational Exposure in Emergency Exposure Situations' and 'Reference levels for the Public in Emergency Exposure Situations'. These are shown in Figures 4 and 5.

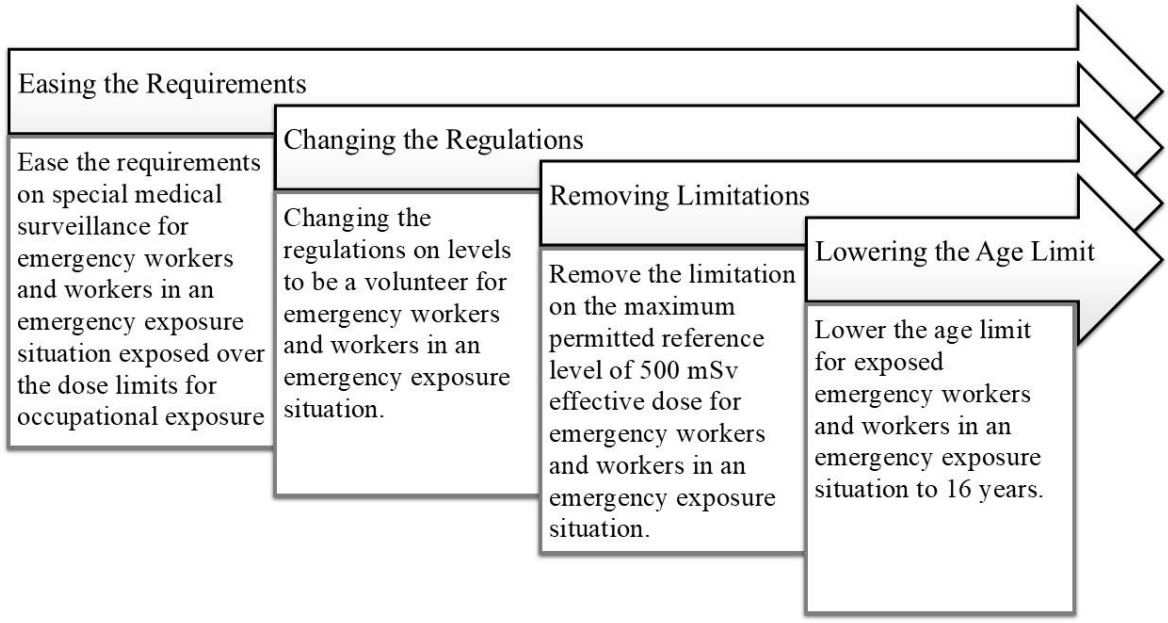

Figure 3: Sweden's Proposed Changes for Occupational Exposure in Emergency Exposure Situations

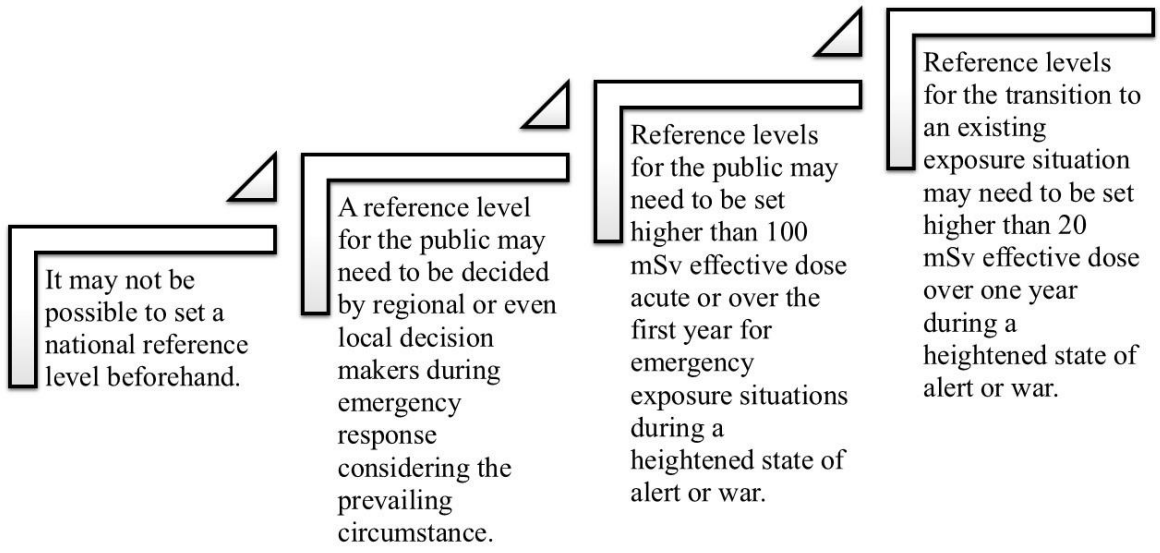

Figure 4: Regarding Reference Levels for the Public in Emergency Situations (Sweden)

We foresee two challenges with implementing these approaches.

Challenge 1: Removing the permitted reference level of 500 mSv.

A strong technical justification would have to be presented and explained as in this instance one is moving into the moderate dose exposure range and out of the questionable risk to health category[21]. Further, and importantly, Article 51, 2. (b) states: "*in exceptional situations, in order to save life, prevent severe radiation-induced health effects, or prevent the development of catastrophic conditions, a reference level for an effective dose from external radiation of emergency workers may be set above 100 mSv,* ***but not exceeding 500 mSv***.[22]" As this in European Union (E.U.) directive, and the foundational goal of the E.U. is to bring about harmonization in legislation, it is not clear how this change in permitted dose exposure would be applied, especially should other E.U. member states send emergency workers to assist in a nuclear emergency in Sweden. Would two tiers apply - one allowable limit for Swedish Emergency Workers and another for other E.U. Emergency Workers?

Also, it would be advisable, where possible, to have a two-tiered definition of Emergency Worker with differing allowable dose exposures relevant to certain training requirements and availability of PPE, which would be in line with the general concepts found in Council Directive 2013/59/Euratom of 5 December 2013. The following is suggested:

(1) Emergency Worker - Radiological (e.g., power plant staff, trained emergency workers (fire, police, doctors/nurses), and
(2) Emergency Worker – Public Helper (e.g., Red Cross Volunteer, ancillary hospital staff, etc.).

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[21] See: Swedish emergency preparedness for nuclear energy accidents (Pamphlet – Public Release), Räddnignsverket (Swedish Rescue Services Agency), 2001, ISBN 91-7253-147-9, https://rib.msb.se/Filer/pdf%5C20844.pdf, Accessed September 4, 2024. Also see: M.C. Sanders and C.E. Sanders, "Three Blind Mice – Low-Dose Radiation, Epidemiology and the Law", Proceedings of the International Nuclear Law Association Inter Jura 2022, Washington D.C., USA, October 24-27, 2022, https://www.researchgate.net/publication/364142820_Three_Blind_Mice_-Low-dose_Radiation_Epidemiology_and_the_Law.

[22] Council Directive 2013/59/Euratom of 5 December 2013 *laying down basic safety standards for protection against the dangers arising from exposure to ionising radiation*, and repealing Directives 89/618/Euratom, 90/641/Euratom, 96/29/Euratom, 97/43/Euratom and 2003/122/Euratom, Article 4, Definitions, (31), https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A02013L0059-20140117, Accessed October 16, 2024.

Should one proceed along this route, it is recommended that proposals are developed how different exposure levels could be applied over a set time frame, the training requirements as well as Personal Protection Equipment use, etc., which would be applied for each 'worker' category – 'Emergency Worker' or 'Public Helper' ("Emergency Worker").

In conjunction with this particular challenge, consideration should be directed to Sweden's nuclear liability law, Law (2010:950), Law on Responsibilities and Compensation in the Event of Radiological Accidents[23]. In 11 § it states: "*This law does not apply to injuries as the result of a radiological accident that is directly caused by acts of war or similar acts during armed conflict, civil war or rebellion*". A better connection to the State's managing abilities (i.e., who the decision makers are and their authorities listed), State's actions ensuring the public is compensated, etc., should be provided now in the event of war. The public would need to be able to have adequate information available on claims processes and limitations applied. In short, where one turns for assistance needs to be given in advance. Other changes in the law might include a potential carve out for special compensation allowance for Emergency Workers (e.g., ≥ 250 mSv) and Public Helper Worker (e.g., ≤ 250 mSv but ≥100 mSv) in situations where dose exposure from a civilian power plant exceed certain regulatory limits[24]. In Table 1, the exposure criteria during a Radiation Emergency in the US are provided as a point of reference.

Table 1: Emergency Radiation Exposure Criteria in the US

Emergency Radiation Exposure Criteria – 10 CFR 835.1302

Dose Limit	Activity	Conditions
50 mSv	ALL	ALL
100 mSv	Protect Major Property	Lower dose not practical
250 mSv	Lifesaving or protection of large populations	Lower dose not practical
>250 mSv	Lifesaving of protection of large populations	Only on a voluntary basis to personnel fully aware of the risks involved

[23] Lag (2010:950) om ansvar och ersättning vid radiologiska olyckor, "Denna lag gäller inte skador orsakade av en radiologisk olycka som är en direkt följd av en krigshandling eller en liknande handling under väpnad konflikt, inbördeskrig eller uppror " https://www.riksgalden.se/globalassets/block---gemensamma/karnavfall/lag-2010-950-om-ansvar-och-ersattning-vid-radiologiska-olyckor.pdf, Accessed, September 4, 2024.

[24] Article 53 3. Provides for a 100 mSv limit. "Member States shall ensure that emergency workers who are liable to undertake actions whereby an effective dose of 100 mSv may be exceeded are clearly and comprehensively informed in advance of the associated health risks and the available protection measures and undertake these actions voluntarily".

Challenge 2: Increased Reference Levels for Public to ≥ 100 mSv

Any change to reference levels for the public would require a massive coordinated education campaign and stakeholder engagement. It would also have to be better explained/justified why the disparity in the current peacetime allowable release of 1 mSv per annum from an operating nuclear power plant to ≥ 100 mSv for public exposure in a nuclear emergency during war time situation is acceptable. A major stumbling block is that there is a chasm of understanding by the public between a regulatory limit of 1 mSv per annum dose exposure from a civilian nuclear power plant during normal operation and what is a safe limit of dose exposure. The public and other stakeholders have mistakenly applied the line between what is safe and what is not safe to the 1 mSv per year regulatory limit. Further, the stakeholders should be educated that the ALARA principle is not being turned on its head from its current application, but rather will still be applied but from another vantage point.

Also, the lowering of the age limit for emergency workers in a nuclear emergency will be problematic as this goes against the current E.U. directive[25]. This should also be considered in view of the legal age in Sweden, when one is considered an adult, which is 18 years of age. In 2024, Sweden changed its laws so a person can change their legal gender at age 16, but they need approval from their parents, a doctor, and the National Board of Health and Welfare. Consider too, the legal drinking age in Sweden is set at 18 years old. Despite this, purchasing alcohol from Systembolaget, the government-run liquor store, requires individuals to be at least 20 years old. Further, in Sweden, people are generally treated as adults for criminal purposes once they reach the age of 15. However, there are special rules. So, whilst there are different standards applied for different situations, which could be used to justify the lowering of the age limit for emergency workers, perhaps, similar to the gender change law, parents' approval for a 16-year-old to participate as a worker in a nuclear emergency might be needed – though it could be difficult to properly manage. It is suggested, should this change occur, that the government consider mandating radiation protection training and use of PPE in the school curriculum from the age of 16 with follow-up training each succeeding year during high-school.

[25] Article 8, Age limit for exposed workers, "*Member States shall ensure that subject to Article 11(2), persons under 18 years of age may not be assigned to any work which would result in their being exposed workers"*.

6.0 Russia's Invasion of Ukraine: Impacts to International Nuclear Conventions – Changes Needed!?

There are several key conventions that form part of the international nuclear legal framework and provide for stability with regards to safety, liability, and security. Russia's unlawful occupation of the ZNPP has raised questions among experts and the international community how suitable the conventions are in their current form and how potentially these are affected during armed conflict.

6.1 Nuclear Liability [**green light**]

- Nuclear Liability Conventions - Vienna Convention on Civil Liability for Nuclear Damage, https://www.iaea.org/topics/nuclear-liability-conventions/vienna-convention-on-civil-liability-for-nuclear-damage
- Convention on Supplementary Compensation for Nuclear Damage, https://www.iaea.org/topics/nuclear-liability-conventions/convention-supplementary-compensation-nuclear-damage

A very good recent article in the Nuclear Law Bulletin No.111 by Nathalie L.J.T. Horbach and Omer F. Brown, II[26] performs an outstanding job of discussing various challenges in the texts to the liability conventions and some recommendations. Generally, though, the nuclear liability conventions provide good assurance of compensation and assistance to victims from accidents caused by military hostilities. One that needs to be considered is should a nuclear accident occur at a Ukraine nuclear power plant, most likely Ukraine would be liable and would have to provide compensation to victims in Ukraine and other countries, including Russia. How would these payments occur given Ukraine's financial situation? Most likely, western nations would have to pony up to assist Ukraine to meet its obligations.

Simply, one could find oneself in a situation where one Party would be liable to pay and would not have the means to do so, especially if nuclear insurers cancelled coverage before the event (e.g., Ukraine), and another Party who could be found liable but refuses to

[26] Please see: Nathalie L.J.T. Horbach and Omer F. Brown, II, Nuclear liability in respect of Ukraine's nuclear installations under Russian military control, Nuclear Law Bulletin No. 111, Volume 2024/2, https://www.oecd-nea.org/jcms/pl_95469/nuclear-law-bulletin-no-111-volume-2023/2?utm_source=mnb&utm_medium=email&utm_campaign=JustPublished, Accessed September 2, 2024.

compensate victims or delays compensation by legal maneuvering (e.g., Russia). Some minor edits and updates to definitions in the texts are recommended. Discussions may be advisable around a threshold or reference dose when compensation during a time of war is warranted. Example: dose exposure is ≥20 mSv.

6.2 Nuclear Safety [**yellow light**]

- Convention on Nuclear Safety, https://www.iaea.org/topics/nuclear-safety-conventions/convention-nuclear-safety

The Ukraine experience has shown difficulties in being fully compliant with Article 9 "Responsibility of the License Holder", Article 10 "Priority to Safety" and Article 16 "Emergency Preparedness". It should be pointed out that the preamble states: "*Reaffirming that responsibility for nuclear safety rests with the State having jurisdiction over a nuclear installation*". Therefore, as jurisdiction and actual control are two separate issues and definitions, some tweaks to the Convention on Nuclear Safety will be needed to take into account these issues.

6.3 Radioactive Waste and Spent Fuel Management [**yellow light**]

- Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management (Joint Convention), https://www.iaea.org/topics/nuclear-safety-conventions/joint-convention-safety-spent-fuel-management-and-safety-radioactive-waste

The Joint Convention is primarily a civilian sector convention. It also applies to spent fuel and radioactive waste from military or defense programs if such materials are transferred permanently to and managed within exclusively civilian programs, or when declared as spent fuel or radioactive waste for the purpose of the Convention by the Contracting Party concerned.

The war in Ukraine has shown quite a large impact on Ukraine's ability to maintain obligations under the Joint Convention, which are listed below. However, the easiest solution here may be to designate in the Joint Convention that civilian spent fuel and radioactive waste facilities/disposal sites are areas of special protection which should be

excluded from active military operations. Additionally, should an aggressor nation occupy such a site, then the obligations of the Joint Convention are encumbered on that nation to protect and preserve undisturbed any such facilities and wastes stored there.

- Due to unauthorized configuration change of the facility design (unauthorized modification) committed by Russia, operational license of the Dry Spent Fuel Storage Facility on ZNPP site was limited. **Affected - Articles 8, 21**

- On March 9, 2022 the external grid power supply was fully lost; diesel generators have limited amount of diesel fuel - the situation could lead to a loss of heat removal from the ChNPP SF-1 pools. **Affected - Article 4 (i)**

- Logistical chains for staff rotation, equipment supply, spears, materials, medicals etc. were disrupted at ChNPP. **Affected - Articles 22 (i), 26, 16 (iii) (iv)**

- Radiation control system in the ChNPP Exclusion Zone (EZ), which serve radwaste management facilities and monitor the contaminated territory of the EZ incurred significant damage during the Russian occupation and need to be restored. **Affected - Articles 17 (iii), 24 (iii)**

- Radiological and Radioactive Waste characterization laboratories in the EZ and within the town of Chornobyl have been damaged. **Affected - Article 16 (v)**

- From April to August 2022, the regulator suspended a number of the licenses of facilities and activities in the EZ due to inability of the licensees to fully comply with regulations on nuclear and radiation safety, physical protection, and license conditions. **Affected - Article 19, point 2 (ii)**

- An adequate emergency response is impossible due to the limitation of access of emergency staff (at the currently occupied ZNPP site and at the ChNPP site during its occupation and recovery period). **Affected - Articles 1, 25**

- The military actions significantly increased the threat and risk for sealed radiation sources to be damaged. Also “orphan” or lost sources, which due to military

invasion, have become out of the control of Ukraine and can be significantly damaged. **Affected - Article 28 (1)**

6.4 Notification of Nuclear Accident [**red light**]

- Convention on Early Notification of a Nuclear Accident, https://www.iaea.org/topics/nuclear-safety-conventions/convention-early-notification-nuclear-accident

This convention requires States to report the accident's time, location, nature, and other data essential for assessing the situation. Notification is to be made to affected States directly or through the International Atomic Energy Agency (IAEA), and to the IAEA itself. Reporting is mandatory for any nuclear accident involving facilities and activities listed in Article 1.

From the Ukrainian perspective, the data transfer from ARMS (ASKRO) was blocked, as part of the information exchange between the Nuclear Power Plant crisis centers and the State Nuclear Regulatory Inspectorate of Ukraine (SNRIU). Also, the transmission of this data in real time to the Decision Support Systems (JRODOS) and the IAEA International Radiation Monitoring System (IRMIS[27]) has been interrupted. Additionally, 11 stationary reporting posts are out of working condition and cannot be repaired. Because of the absence of direct communication between the regulator and the ZNPP operator, timely receipt of a notification from ZNPP in the event of an accident and verification of the reliability of information of conditions are impossible.

Compliance with the requirements of Articles 2 and 5 of the Convention becomes problematic not only for Ukraine, as a party to the Convention, but also for the IAEA to perform its functions. Further Article 4 of the Convention id hampered, since the tools for verifying the authenticity of information that can be broadcast from the site of the occupied ZNPP. Thus, changes to the convention should be made to ensure that interference by an aggressor nation on reporting requirements and equipment of the responsible operator/national authority are not severed.

[27] See Presentation - Nuclear Safety and Security in Ukraine Risks, Threats, Lessons Learned, Oleh Korikov Acting Chairman – Chief State Inspector on Nuclear and Radiation Safety. https://www.oecd-nea.org/jcms/pl_82793/radiological-protection-during-armed-conflict-improving-regulatory-resilience-and-operational-applications

6.5 Physical Protection - Nuclear Material [**red light**]

- Convention on the Physical Protection of Nuclear Material (CPPNM), https://www.iaea.org/publications/documents/conventions/convention-physical-protection-nuclear-material-and-its-amendment

In the CPPNM, legal obligations are established for Parties regarding the physical protection of nuclear material used for peaceful purposes. This is for (1) during international transport, (2) the criminalization of certain offences involving nuclear material; and (3) international cooperation, (example: theft, robbery or any other unlawful taking of nuclear material or credible threat thereof). The 2005 amendment[28] expanded the scope of the original treaty to cover physical protection of nuclear facilities and nuclear material used for peaceful purposes in domestic use, storage and transport. However, observe how the language waffles/excludes considerations for the activities of armed forces during an armed conflict.

Article 2, 4 (b) – "*The activities of armed forces during an armed conflict, as those terms are understood under international humanitarian law, which are governed by that law, are not governed by this Convention, and the activities undertaken by the military forces of a State in the exercise of their official duties, inasmuch as they are governed by other rules of international law, are not governed by this Convention*."

Certainly, changes are warranted in this context given the experiences in Ukraine. The physical protection of nuclear material must be respected by '*military forces of a State in the exercise of their official duties*' given the amount of destruction and damage caused by Russian military forces to various laboratories, hospitals, health clinics and other nuclear sites across Ukraine. Further, criminal liabilities should be prescribed for military commanders and/or soldiers in the field for breach and failing to adhere to these obligations.

Impacts on Ukraine's ability to meet obligations of the convention are:

- FUNDAMENTAL PRINCIPLE A: Responsibility of the State

[28] Amendment to the Convention on the Physical Protection of Nuclear Material (2005) https://www.iaea.org/sites/default/files/publications/documents/infcircs/1979/infcirc274r1m1c.pdf, Accessed September 2, 2024.

- ♦ FUNDAMENTAL PRINCIPLE C: Legislative and regulatory framework
- ♦ FUNDAMENTAL PRINCIPLE D: Competent authority
- ♦ FUNDAMENTAL PRINCIPLE E: Responsibility of the license holders

6.6 Assistance During Nuclear Emergency [**red light**]

- Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency, https://www.iaea.org/topics/nuclear-safety-conventions/convention-assistance-case-nuclear-accident-or-radiological-emergency

The Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency, adopted in 1986 following the Chernobyl nuclear plant accident sets out an international framework for co-operation among State parties and with the IAEA to facilitate prompt assistance and support in the event of nuclear accidents or radiological emergencies. What has been shown in the case of Ukraine, should a nuclear accident occur, that it could be difficult for the affected Party and other Contracting Parties to adequately respond to requests for assistance.

Major changes and updates to the convention should be undertaken to include:

- → Safety corridors to allow Contracting Parties to bring material and personnel unhindered into the affected area when requested under the convention.
- → Requirement for the establishment by the military authorities of safe-passage and evacuation routes for the civilian population, when needed.
- → When a nuclear emergency has been declared and determined to be a reality by the IAEA, an agreement to cease military operations within a > X-mile radius from the impacted nuclear facility or site.

7.0 Conclusion & Final Thoughts

What is shown, the peacetime Radiation Protection standards and guidance that have been employed for the past 60-80 years provide adequate protection for the public and nuclear workers. As can be seen from the Sweden example, using current guidelines provide a reasonable basis for setting expanded directives with an increasingly allowable dose exposure during a nuclear emergency during a time of war. As was mentioned, there are going to be challenges to re-explain radiation exposure safety principles in conjunction with established regulatory limits, as current guidelines are a mixture of scientific findings and societal judgments in the development of acceptable radiation dose limits, with societal judgments weighing heavily on these pronouncements.

Further, lessons-learned from the Fukushima accident could serve as a template for preparation and coordinated responses to a radiological emergency during a time of war. That being said, the international nuclear conventions and national laws/regulations do need to be revised taking into consideration the experiences from the Russian invasion of Ukraine and how an active military incursion near a commercial nuclear power plant could impact the functioning of nuclear legislation and regulatory agencies. Furthermore, the international community will have to begin discussions how the international nuclear framework/conventions and national law can be strengthened to better protect civilian nuclear power plants, waste disposal and storage facilities, laboratories and hospitals/health clinics (where radioactive sources are used), as well as the public and environment. Of course, gaining international consensus on any changes will be a high hurdle to overcome.

Finally, as nations, such as Sweden, work to amend their radiation protection legislation to consider higher reference dose exposure, a realization must be made that this will necessitate a huge public relations/education campaign with wider stakeholder involvement. Given financial challenges during war, discussions on what exposure levels that would allow for compensation under national law and the liability conventions (e.g., ≥20 mSv), might also need to be on the table for open debate.

Authors' notes: The thoughts and opinions in this paper reflect those of the authors. They are not to be considered the opinions of any other person/organization, including the International Nuclear Law Association.

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