

Problem Statement

The ongoing conflict between Russia and Ukraine raises key concerns about the possibility of another nuclear accident in the region. Specifically, direct military action and unexploded ordnance (UXO) near Ukraine's nuclear infrastructure present clear risks that demand near term mitigation. As seen during the Chernobyl incident in 1986, nuclear accidents can have widespread and sustained consequences that impact public health, the global economy, and the environment.

Given the catastrophic consequences of a nuclear incident in Ukraine, the international community, alongside the Ukrainian government, must take action to safeguard at-risk nuclear infrastructure. Unexploded ordnance near Ukrainian nuclear sites presents the most immediate (and actionable) threat. Russian ordnance used in Ukraine has an estimated 10 – 30 percent dud rate, leaving untold unexploded hazards dangerously near nuclear infrastructure and increasing the likelihood of a radiological incident. Although numerous for-profit corporations and humanitarian organizations specialize in large-scale demining, these entities lack the knowledge and expertise to safely address UXO threats near nuclear infrastructure. This problem requires a unique solution.



Background

Ukraine has a long history with nuclear power, which has provided up to 52% of the country's energy needs through its civil nuclear power plants. Four operational nuclear power plants – Khmelnytsky (KNPP), Rivne (RNPP), South Ukraine (SUNPP), and Zaporizhzhya (ZNPP) – use water-cooled, water-moderated (VVER) type reactors to generate electricity. Ukraine also has the Chernobyl facility, which had high-power channel-type reactors (RBMKs) that have been permanently shut down. Chernobyl also has a wet and dry spent fuel storage facility, ISF-1 and ISF-2, respectively. In addition to these sites, nuclear material is also used and stored at the Kharkov Institute of Physics and Technology (KIPT) Neutron Source installation in Kharkiv and the research reactor at the Institute for Nuclear Research in Kyiv. At the onset of hostilities in 2022, the Kharkov facility was put into a deep subcritical state, while the fuel of the research reactor in Kyiv was unloaded and stored in a spent fuel storage facility on-site.

Since the start of the Russian invasion, several of Ukraine's nuclear power plants and other nuclear-related facilities have been damaged by direct military attack. It is assumed that key equipment, vital to the safety and security of the plants, has been damaged, but better assessments are needed. Additionally, given the volume of unexploded ordnance, these facilities are at risk of additional damage from UXO scattered on or near critical nuclear power plant infrastructure.



IAEA Intervention

Based on their acknowledgement of the risks to nuclear infrastructure in Ukraine, the International Atomic Energy Agency (IAEA) proposed seven pillars to ensure nuclear safety and security in armed conflicts in 2022. The measures were in direct response to Russian military activities at the Chernobyl and Zaporizhzhia facilities. To date, these pillars have been used to assess the safety and security situation at nuclear facilities in Ukraine, focusing on the most urgent conditions necessary for safe and secure nuclear power operations. The first four pillars offered by the IAEA cover the most pressing near term needs to mitigate the risk of a nuclear incident:

Pillar 1: Physical integrity of the site: In nuclear power generation, containment is key. Reactors, fuel ponds, radioactive waste storage areas, support equipment buildings, and administrative/control rooms all require structural integrity and containment to prevent a nuclear incident. As hostilities continue, there is an increasing risk that UXO, in the form of rockets, bombs, artillery shells, landmines, and submunitions, will weaken or destroy key structural and containment features necessary to safely operate the plant and prevent radiological contamination.

Pillar 2: Safety and security systems and equipment: In addition to the direct risks posed by explosive ordnance to the key structural and containment nodes of the facility, indirect risks – including kinetic effects to plant control rooms, plant operation alarm systems, and necessary safety systems such as mobile feedwater pumps and nitrogen-oxygen stations – could result in a nuclear incident. Specifically, blast effects and fragmentation damage from UXO to plant safety and security equipment are key concerns that must be mitigated to lessen the risk of incident in Ukraine.

Pillar 3: Operating staff- Experienced and qualified operating staff are key to ensure safe and reliable nuclear power generation. Globally, the nuclear power workforce is a low-density career field – in Ukraine, this personnel challenge is further strained by the war with Russia. Therefore, protection of Ukraine's nuclear power workers from UXO on or around nuclear facilities is a critical step in maintaining safe nuclear power operations. UXO clearance and mitigation of plant access roads and support sites must occur to preserve the Ukrainian nuclear workforce and ensure future operations.

Pillar 4: Off-site power supply- It is essential for all nuclear sites to have a secure off-site power supply from the grid. Lack of redundant power supply – which is at risk through damage to power supply lines or emergency diesel generators – jeopardizes safe nuclear power operations and could result in a nuclear incident. Off-site power configuration and equipment must be assessed, cleared of existing UXO, and hardened to ensure safe operation and mitigate downstream radiological risks.



Reducing the Risks – A Path Forward

The risks posed by the nexus of unexploded ordnance and nuclear infrastructure is a unique problem that requires a unique solution. Traditional UXO clearance organizations, both commercial and non-profit, lack understanding and experience in nuclear power operations and radiological hazards. Conversely, nuclear industry experts typically do not have a background in explosive hazard clearance operations. The niche nature of this problem requires expertise from focused counterproliferation and counter-weapons of mass destruction experts. Specifically, a deep understanding of the nuclear fuel cycle, nuclear power generation, unexploded ordnance, and explosive hazard mitigation are critical to safely addressing the UXO / Nuclear Infrastructure threat space.

Though complex, near-term activities to mitigate the risks to Ukrainian nuclear infrastructure are possible through a phased, networked, and expert-driven approach. Initial assessments and stakeholder engagements would allow for necessary deconfliction and prioritization. Follow on site surveys to accessible nuclear sites would offer more comprehensive threat characterization and refine UXO clearance prioritization. Once assessed, coordinated, and prioritized, UXO clearance could occur at specific sites as conditions in Ukraine allow.

Once the immediate threats to Ukraine's nuclear infrastructure are abated, additional actions would be necessary to mitigate future risks. Until hostilities cease, it is assumed that more Russian attacks (and unexploded ordnance) will continue to endanger Ukrainian nuclear sites. Given this likelihood, the establishment of a persistent, UXO response capability for nuclear sites should be considered. Timely response to exigent explosive hazards could also be enhanced through additional nuclear site intelligence, surveillance, and reconnaissance. Finally, near term hardening measures for critical nuclear site equipment should also be assessed as a standing mitigation until the war with Russia ends.

Post-Conflict – Safeguarding Continued Nuclear Investment

Despite the ongoing war with Russia and the associated nuclear incident risks, future nuclear infrastructure investments in Ukraine are expected. Given growing energy demands and an uneasy dependence on Russian energy, the European Union (EU) views Ukraine (along with other countries) as key nodes in a broader energy security strategy. In considering future EU autonomy and economic stability, investment in future nuclear power infrastructure in Ukraine makes sense – particularly when coupled with EU decarbonization goals.

Westinghouse and Energoatom have recently solidified a proposal aimed at meeting some of the EU's energy goals through the construction of Small Modular Reactors (SMRs) in Ukraine – the plan is aggressive, with specified goals in the 2027 timeframe. Although the strategic importance is clear, the continued need for bespoke, expert UXO clearance in executing this plan is equally obvious. Regardless of when or how active conflict in Ukraine ceases, the country will be littered with explosive remnants of war. As SMRs are planned, constructed, and put in to operation, specific UXO clearance, aimed at safeguarding this nuclear infrastructure must occur.

Conclusion

The threats posed by UXO to Ukrainian nuclear infrastructure are of strategic significance and demand near term mitigation efforts. Though this is a unique problem, future conflicts could also present equally challenging scenarios as we enter a Nuclear Renaissance based on global energy needs and an emphasis on decarbonization. At BVG & Company, we are in a unique position to both identify this problem and offer tailored solutions to answer it. We are a Counterproliferation and Counter-Weapons of Mass Destruction firm, founded by Navy Explosive Ordnance Disposal Technicians, and possess the unique expertise and network to solve this problem.