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In 1997, the international community signed the Ottawa Treaty as a response to the humanitarian crisis caused by the global proliferation of anti-personnel mines. They agreed on banning the development, production, stockpiling, transfer and use of anti-personnel mines (International Committee of Red Cross, 1997, p.1). Twenty-six years later, these explosive remnants continue causing around 5000 casualties per year. This number is significantly rising (Landminefree, n.d., para.3). In 2020, Syria was most affected by anti-personnel mines with at least 2729 casualties. The following leading countries in this metric are Afghanistan, Burkina Faso, Colombia, Iraq, Mali, Nigeria, and Yemen (Clarke, 2021; Humanity & Inclusion, 2020).

However, with the Russian invasion of Ukraine in 2022, the latter has reached the top position of the most mined country globally (Boffey, 2023, para. 1). The extensive use of anti-vehicle mines and boobytraps has further exacerbated the situation. According to estimates, the lives of at least six million Ukrainians are under threat by minefields (Vakulina, 2023, para. 1). The purpose of this paper is to dive deeper into the strategic use of landmines in the Russo-Ukrainian war, along with examining the resulting lessons for the European defence to use advanced technology in cleaning minefields.

Types of Landmines in Ukraine

Between February 2022 and May 2023, 550 mine-related incidents have already killed at least 855 people (Doyle et al., 2023, para.22). This number is likely to increase, as landmines can cause casualties even decades after their deployment (Doyle et al., 2023, para. 23). They do not only threaten civilians, but also cause many military deaths. During the wars in Iraq, Syria, and Afghanistan, landmines or Improvised Explosive Devices (IED) caused at least 50% of the military deaths (European Defence Agency, 2020, p. 1).

What makes the Russo-Ukraine war especially threatening is the massive scale of landmine use, not seen since the Soviet invasion of Afghanistan (Doyle et al., 2023, para. 17). At least 170,000km2 are currently mined, which is six times the size of Belgium (Grynszpan & Pietralunga, 2023, para. 1). Human Rights Watch has identified the use of at least 13 types of anti-personnel mines, numerous boobytraps, and 13 anti-vehicle mines, which is twice as high since the start of the Russo-Ukrainian war (Human Rights Watch, 2023, para. 35). Russia uses many of its Soviet stockpiles but also produces new-type landmines. On the other hand, Ukraine destroyed most of its Soviet stockpiles. However, Allied partners supplement it with their own stocks (Human Rights Watch, 2023, para. 18).

Between September and December 2022, Ukrainian demining teams encountered several types of anti-personnel mines following the Russian retreat from Cherson and Kharkiv (Human Rights Watch, 2023, para. 39). The most common found types are the OZM-72 bounding fragmentation mines, the PMN-series, and the MON-series (Evans & Seddon, 2022; Human Rights Watch, 2023). Russians have further placed many boobytraps, which also serve as anti-personnel mines, such as tripwire grenades (Human Rights Watch, 2023, para. 34). Furthermore, the frontlines in Ukraine are littered with PFM-1 mines. The former is also better known as the butterfly mine. The PFM-1 mines are made of polythene plastic and contain 37 grams of liquid explosive (Doyle et al., 2023, para. 9).

Ukrainians dropped many of the PFM-1s during the battle of Izium, but they were also heavily utilised by the Russians (Human Rights Watch, 2023, para. 6). They are controversial since their remarkable leaf-like design leads often to their non-recognition as mines (Doyle et al., 2023, para.10).

Other frequent mines found on the frontline are the POM-3 mines, which are dropped out of aircrafts, launched by artillery or fired by missiles. The POM-3 contains a small parachute, and once it lands safely on the ground, it inserts a small pin directly into the ground. The pin serves as a highly sensitive sensor, which measures vibrations. As soon as it detects footsteps nearby, it will launch itself 1.5 meters up into the air, after which 100 grams of explosives will be detonated (Doyle et al., 2023, para. 12).

Finally, extensive use of anti-vehicle mines, also known as anti-tank mines, are a significant characteristic of the war in Ukraine. The most common is the Soviet TM-62, often equipped with an MVCh-62 pressure fuse. Russia and Ukraine both use the TM-62, which detonates under the minimum weight of 150 kilograms. However, some also have a magnetic proximity fuse, which detonates when in contact with any iron-containing metals (Doyle et al., 2023, paras. 13-14). Moreover, Russia uses the Soviet PTM-series, which are dropped out of helicopters or launched by artillery (Evans & Seddon, 2022, pp.26-28). Finally, reports indicate that Russia has started deploying its recently developed PTKM-1R mines. These mines launch themselves up to 30 meters into the air in order to penetrate vehicles from the top (see Evans & Seddon, 2022; Human Rights Watch, 2023).

Strategic Use of Landmines in the Russo-Ukrainian War

In early June 2023, Ukraine launched its long-awaited counteroffensive. However, it has been less successful than expected (Glover, 2023, para. 3). The many minefields constructed by Russians successfully hampered Ukrainian attempts to break through the 1,000-kilometres-long defence lines (Boffey, 2023, para. 9). On the 8 June 2023, Ukrainian forces attempted to capture Mala Tokmachka until an eventual trapping in a minefield. Russians immediately launched an artillery barrage, after which the Ukrainians abandoned 25 of their top-notch armoured vehicles, such as the Leopard 2A6, and the M2 Bradley, to save their personnel. It would eventually take them weeks to successfully recover the vehicles (Axe, 2023, paras. 10-11). Similarly in the south of Robotyne, the many Russian minefields halted the Ukrainian counteroffensive (Axe, 2023, para. 12). This initial success resulted in the Russian army shortly intensifying its landmine strategy. It did not only deepen their current minefields by between 120 to 500 metres but also increased the density (Axe, 2023, para. 2). According to estimates, Russia has currently planted around four to five mines per square meter along the front line in the South (Glover, 2023, para.5).

This development is in line with the traditional Soviet mine-laying doctrine, successfully implemented during the Battle of Kursk. The Red Army laid down millions of anti-tank and anti-personnel mines to halt the German advance (Miller, 2023, para. 16). This doctrine found further application during the Afghanistan and Chechen wars. Nowadays, it again became relevant during the invasion of Ukraine (Mittal, 2023, para. 5). However, there is an apparent downside to Russia's extensive mine-laying strategy. Since their stockpiles are reducing faster than expected, minefields can differ in depth (Axe, 2023, para. 15). Once Ukrainians cross the first defence line, the size and density of minefields ahead of them drastically thin out (Axe, 2023, para. 16).

As Brigadier General Tarnavskiy stated, Russia has allocated 60% of its efforts and resources to the first line of defence and only 20% each to the second and third defence lines (Axe, 2023, para. 16). The Russians try to compensate for their shortages by placing anti-vehicle mines in a tight formation to ensure that a single blast immediately destroys armoured vehicles (Axe, 2023, para. 15). However, once the Ukrainians break through the first defence line, it becomes increasingly easier to exploit their gains (Axe, 2023, para. 16). Thus, the greatest challenge of the Ukrainian counteroffensive is not only breaking through the initial minefields, but also to immediately penetrating the following defence lines before Russia lays down new minefields (Miller, 2023, para. 25).

Mine Clearance: From Mechanical Methods to Advanced Technology

Demining complete minefields is time-consuming and would slow down the Ukrainian counteroffensive. Therefore, mine-clearing units need to make use of rapid and resolute methods to create a safe passage for the Ukrainian advance (Doyle et al., 2023, para. 29). One of these methods is the US-supplied M58 MICLIC. It is an armoured vehicle system capable of launching 110-meters-long line into minefields. The line is charged with explosives which are triggered remotely or with a timer. Following a detonation of the line, a path up to six meters is cleared of mines (Miller, 2023, para. 11).

Another standard method is the use of armoured demining vehicles, such as the Armtrac 400 and the GCS-200, which plough through the ground in order to trigger mines (Doyle et al., 2023; Miller, 2023). However, Russian reconnaissance drones closely monitor any such units due to the flatland location of most minefields. Thus, they are often subject to missiles and artillery attacks, hindering the deployment of such mine-clearing methods in the first place (Hrabchuk & Khurshudyan, 2023, para. 15).

As a Ukrainian officer stated in an interview with the Washington Post, "When the enemy sees even a Leopard tank in front of him and special engineering equipment, he will destroy the special equipment [mine-clearing vehicles] first. […] Because without it, all the others will not pass" (Hrabchuk & Khurshudyan, 2023, para. 18). This pattern explains why many Ukrainian mine-clearing units increasingly resorted to conventional methods like removing mines manually (Hrabchuk & Khurshudyan, 2023, para. 19). The demining operations mainly start at twilight due to the high visibility of units during the day or easy detectability in the dark by night-vision cameras (Hrabchuk & Khurshudyan, 2023, para. 19).

In hopes of speeding up the demining processes, Ukrainians increasingly rely on advanced mine detection technologies. An example of such is the usage of thermal imaging drones to detect PFM-1 mines, discovered by geophysicists from the University of Binghamton (Technology, 2023, para. 19). They observed that the butterfly mine heats up and cools down at a different rate throughout the day with its surrounding habitat (Technology, 2023, para. 19). Flying above the minefield at a ten meters height allowed the team to directly scan a 300m2 surface within three and a half minutes (Technology, 2023, para. 21). Furthermore, the team turned to computer technology to analyse the images rather than relying on the human eye, which sped up the detection rate by 90% (Technology, 2023, para. 20).

This group of geophysicists further cooperated with the University of Maryland and Oklahoma State to test thermal imaging on other types of mines, which allowed them to improve the detection method further (Technology, 2023, para. 26). The UN even invited the team to visit a testing ground near Chernihiv in northern Ukraine. They successfully captured 15,000 images from 62.5 acres of land, which they analysed within 15 minutes by using algorithm programmes (Technology, 2023, para. 55). They eventually found at least 76 mines and unexploded devices (Technology, 2023, para. 55). On a final note, many recently developed devices find their usage in the demining process, such as drones equipped with magnetometers detecting irregular patterns in magnetic fields (Heslop, 2023, para. 6).

Conclusion

The Russo-Ukrainian war has shown that the strategic use of landmines still plays a significant role in modern warfare. This imposes a great burden on the Ukraine counteroffensive and causes many casualties among military personnel (Doyle et al., 2023, para. 29). Ukrainian demining units have turned to advanced methods, such as thermal imaging drones, in order to speed up the demining process (Technology, 2023, para. 55). These methods require significant improvements in order to deploy them under differing weather conditions, as well as several types of vegetation and soil (Heslop, 2023, para. 10). Nevertheless, it is important to the European defence industry to closely monitor and develop new landmine detection technologies. The arms race has already begun, as landmines become ever more technological advanced. In order to push the modernisation of European armies further, it is vital to understand how this shift will affect future warfare.

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