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**SPACE LESSONS LEARNED FROM
THE WAR IN UKRAINE**

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Introduction

With each passing conflict, the space industry is gaining more and more relevance in the operation command chain, especially during interstate wars. The war in Ukraine is the perfect example of this, revealing the most significant trajectories in the space domain, and highlighting flaws and rapid developments; in a nutshell, this war is shaping the future of space, especially in the military sector. The focus of this paper will be first on the Russian entanglement in the conflict, followed by an analysis of the Ukrainian rapid adaptation of the new rules in space guided by Western help, and finally, conclusions will be drawn from the very interesting evolution of the space industry in this war.

The Russian Space Industry

The invasion of Ukraine has highlighted the failure of the Russian military space programme. Indeed, one of its main issues is its lack of an efficient satellite constellation, either for positioning, communication or reconnaissance. In fact, as of December 2022, the Russian army only owns 174 satellites (Union of Concerned Scientists, 2023), of which only 15 are made for intelligence collection: eight of these are electronic intelligence satellites, five are optical imaging satellites and two are radar imaging satellites. In comparison, 20 years ago, during the war in Iraq, the United States alone possessed 30 intelligence satellites, to which we need to add commercial satellites and the satellites of the coalition of the willing (Luzin, 2022). Moreover, the Iraqi theatre was smaller and less urbanised than Ukraine: this analogy emphasises the important lag that Russia has accumulated in this sphere.

The imagery component is considered the weakest part of the Russian space sector, so weak that in November 2022 the private military company Wagner bought two high-resolution optical satellites from the Chinese giant Chang Guang Satellite Technology Co. Ltd., together with the possibility of buying imagery from their 100 satellites constellation on demand (AFP, 2023). The mercenary group had to buy those particular satellites because of the lack of intelligence offered by the Russian State. A small number of satellites means low revisit rates, which restrain Russia's situational awareness on the battlefield. With limited information, monitoring Ukrainian movements, gains, and losses becomes problematic, while missile strikes and plane missions are rendered less efficient. For example, in the early stages of the invasion, Russia unleashed salvos of missile strikes on Ukrainian territory with a total of 1,100 missiles in the first 21 days. However, this operation was not sufficient in disabling all high-priority targets, especially the anti-air defences, which is one of the reasons why the Russians failed to obtain air superiority. This failure is likely the result of a lack of satellite imagery which led to inefficient reconnaissance-strike complexes as the Russian doctrine of long-distance strike relies on near real-time intelligence (Jones, 2022). Consequently, the Russians wasted precious missile stocks on non-strategic targets.

Furthermore, the lack of precision in Russian strikes resulting from poor rocket guidance and poor target positioning reconnaissance may have occurred because of the issues encountered by their positioning, navigation and timing system (GLONASS). This system's constellation is composed of 28 ageing satellites, some of which are close to their retirement date and will be difficult to renovate given Western sanctions, as up to 90% of the electronics with which they are made are imported (Dobrynin & Krutov, 2022).

After a chaotic path of underfunding and subsequent restoration of the programme, the GLONASS system was only officially incorporated into the Russian army in 2016. This late adoption may explain the lack of GLONASS receivers in the Russian army. Ground vehicles are forced to use maps from the 1980s, while some Russian aeroplanes have been caught using American GPS receivers in the cockpit (Cozzens, 2022).

Moreover, Russia owns 46 military communication satellites, of which more than 30 have exceeded their warranted lifetime, and 37 civilian satcoms (Luzin, 2022). With an estimated 420,000 Russian soldiers in Ukraine right now (AFP, 2023), the number of Russian satcoms is not sufficient to guarantee the successful conduct of efficient operations on Ukrainian territory. In addition to this, Russian satcoms had to endure Ukrainian jamming, which further reduced their capabilities. The alternative to communication satellites i.e., the encrypted ground communication system MK VTR-01, is unlikely to be able to compensate for this lack of satellite communication (Conell, 2023). This significant scarcity of means of communication may have resulted in the use of radios and cell phones by Russian troops on the front, not only to contact their families at home but also to conduct operations despite the enormous risk of being listened to by the enemy or being spotted and targeted by missiles or artillery (Porter, 2023).

The Ukrainian Space Industry

Even though Ukraine has a noteworthy space industry, compared to Russia the Ukrainian satellite constellation is poor. In fact, Ukraine did not have any military satellites of its own at the start of the war and had to rely on the best that NewSpace had to offer.

For instance, commercial imagery showing enemy troops gathering at its border facilitated Ukraine's communication efforts and greatly helped to raise international opinion in its favour (Chance, 2021). This was also the case for the Bucha massacre, when satellite images provided by Maxar together with photos taken on the ground helped contradict claims of Russian innocence (Hern, 2022). Helping Ukraine has been a kind of trophy sought by all New Space companies to showcase their capabilities.

Thus, Ukraine has been able to rely on commercial space services with numerous satellites from the early stages of the war, allowing for a very high revisit rate. For example, Planet Labs has more than 200 optical satellites, while Maxar has over 285 satellites. Besides that, in August 2022 the Ukrainian government, due to fundraisers and donations, managed to purchase the "people's satellites", a synthetic aperture radar from the Finnish ICEYE company, accessing their 27 satellite constellation (Werner, 2022).

All these constellations separately provide up to 15 revisits a day, while Russia can acquire one revisit every three days at best (Luzin, 2022). Moreover, Ukraine only ordered footage pertinent to the war, thus spending less money. This easy accessibility to commercial data and the help of Western intelligence agencies (Lindley-French, 2023) has given Ukraine an enormous advantage over Russia.

However, what made the most headlines in the media was the entry of Starlink's mega constellation into the conflict. On the first day of the invasion, the Russians managed to hack thousands of Viasat's modems from the KA-SAT network with wiper malware (Groll & Vasquez, 2023). The Ukrainians relied on this service for their military communications and thus, when additional Russian strikes hit other communication facilities, the Ukrainian military command was left disorganised (Howel O'Neill, 2022). The Ukrainians quickly turned to Starlink for help: the company provided receivers and granted its service for little cost in the beginning but it has now been taken under the wing of the US Department of Defense, as Starlink declared not being able to afford losing 20 million a month (Roulette & Stone, 2023).

Starlink has been a great help for civilians and the military. Nonetheless, it has now a monopoly on Ukrainian communications, and this dependency endangers Ukrainian strategy. For example, Starlink decided to not back up any assault operations on Russian territory which includes the Crimean Peninsula. Parts of the Ukrainian operations are under the rule of the US government and sometimes must comply with the will of Elon Musk (Lyngaas, 2023).

Finally, for positioning and navigation purposes Ukraine can rely on proven GPS and Galileo with plenty of cheap compatible equipment such as small drones. At first, Russia did not make much use of its jamming capabilities, either because Ukraine had an overwhelming majority of Soviet-era GPS-less equipment, or because the Russians were relying too much on GPS systems themselves (Goward, 2022). However, with the increasing arrival of Western equipment which are GPS and Galileo guided, Russia has intensified its signal jamming operations (Axe, 2023).

Conclusion

The war in Ukraine has showcased the tools and different opportunities offered by New Space. The intelligence offered by Western space programmes and private space companies has played an enormous role in Ukraine's successful resilience. The growing reliance on the private market when state-owned space equipment is lacking is the main trajectory drawn by both sides in the conflict.

Even though Russia is maintaining a constant budget for its space programmes while also planning ambitious projects such as the launch of 600 Sfera satellites (Comsat) over the next few years (Connell, 2023), the war in Ukraine has brought to light underlying issues in the Russian space sector. Considering the recent troubles and failures of both civilian and military programmes, the future of Russian space might not be so bright: especially if we take into account the recent Western sanctions, which might be the final blow to this dying space giant (Privalov & Vidal, 2023).

However, Russia is well aware of its position behind the Americans, Europeans, Chinese and now Indians. A weak Russia in space is even more unpredictable as Russian doctrine recognises the importance of hindering the enemy's space capabilities when entering a conflict. In a hypothetical scenario where Russia continue their space downfall, and in the worst-case contingency of a wider conflict with NATO, which has the ability to lean on unmatched proprietary and commercial space assets, Russia will have much to gain and almost nothing to lose from the opening of a new front in space. No matter the space debris and equipment self-destruction it might result in, in such a scenario, Russia's top strategic priority could well be blinding NATO forces by mobilising the full strength of its countermeasure arsenal (Connell, 2023). In general, disrupting Western satellites is likely in the plans of other probable future adversaries such as China too (Penent, 2023).

Russia may already be prepared for this scenario as they have maintained Chayka, the radio terrestrial navigation system (Cozzens, 2022) that can still work in a space-devastated world. Simultaneously, the West is recklessly relying on satellite positioning. Indeed, space dependence has long been considered a weakness, thus making the disruption of satellites the perfect target to massively impact specific military operations and the Western economy more generally.

New Space's proposed solution to this threat is an increase in the number of satellites, which is intended to reduce the significance of any single one (Borowitz, 2022). In fact, in a mega constellation, the strategic importance of every satellite loss is diluted, which means that a potential adversary could well waste its missile stocks and still not endanger the capabilities of the constellation.

Should it choose to follow this path, Europe must bear in mind that relying too heavily on a large non-European private company implies putting operational plans in the hands of a foreign private actor supervised by its own government. Therefore, it is crucial for the European Union to push even more to foster domestic space entities.

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