DEFENSE & SECURITY

Zircon Hypersonic Cruise Missiles in Ukraine: A Russian First?

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The advent of hypersonic technology may well redefine the limits of military power, and Russia's recent deployment of a Zircon hypersonic cruise missile (HCM; a model also known as an HSM) over Ukraine may have opened a new chapter in the annals of modern combat. On Feb. 7, during its wide-ranging military campaign in Ukraine, Russia allegedly fired a 3M22 Zircon (SS-N-33) HCM in combat for the first time. Confirming this significant event, Oleksandr Ruvin, the director of the Kyiv Scientific Research Institute of Forensic Expertise, claimed in an interview with Vechirniy Kyiv on February 21 that initial analysis had identified the two missiles deployed in the Feb. 7 attack, which resulted in at least five deaths and over 50 injuries, as Zircon HCMs. Accompanying his statement, Ruvin shared a video on his Telegram channel allegedly showing fragments of the missile used in the incident.

Uncharacteristically, however, Russia has not yet announced that a Zircon HCM was indeed deployed in the attack. This contrasts with earlier statements, such as when President Vladimir Putin enthusiastically promoted the Zircon as a symbol of Russian military prowess and technological advancement, describing it as "invincible" and a key part of Russia's cutting-edge weapon systems. Therefore, was a Zircon used in the attack, and if so, how should it be evaluated?

HCMs and Their Significance

Hypersonic technology refers to weapons capable of traveling at speeds of more than Mach 5, five times the speed of sound. This category includes both hypersonic glide vehicles (HGVs) and hypersonic cruise missiles (HCMs), which are propelled by advanced scramjet engines that enable high-speed air-breathing capabilities. Unlike traditional ballistic missiles, which follow a

predetermined arc, HCMs are capable of maneuvering in flight, making them more elusive targets for existing defense systems due to their high speed, ability to change course, and relatively low trajectory. These characteristics give the military an upper hand through rapid, long-range strike capability against remote or heavily fortified targets, providing a strategic advantage where conventional missiles face access restrictions.

Traveling at speeds above Mach 5 causes the surrounding air to be ionized, resulting in the formation of a plasma envelope. This phenomenon, which occurs because the object's speed forces electrons away from their atoms, effectively cloaks the object in plasma, known as the fourth state of matter. Composed of ionized particles, this plasma cloud envelops the missile as it travels, absorbing radar emissions and rendering the missile almost undetectable to radar. Stealth is thus integral to HCMs.

However, the development of HCMs is not without its challenges. The extreme speeds at which these missiles operate expose them to intense atmospheric friction, heating their surfaces to temperatures above 2,200°C. Such conditions require materials and design techniques that can withstand these extreme temperatures. In addition, the very plasma cloud that provides stealth benefits also complicates missile guidance. The ionized envelope interferes with the transmission of communication signals, making it difficult to maintain control of the missile's trajectory towards a moving target.

The introduction of HCMs into modern warfare represents a transformative shift in military strategy, emphasizing the importance of speed and stealth in achieving tactical superiority. Countries with hypersonic capabilities will possess a significant strategic deterrent, influencing geopolitical dynamics and shifting the balance of power on the global stage.

Furthermore, the political implications of deploying HCMs are profound, serving as a powerful instrument of national policy. By demonstrating the ability to strike with unprecedented speed and precision, nations can deter adversaries and influence international relations without direct conflict.

Russia and HCMs

With two flagship systems, Russia is probably the most experienced operator of HCMs. As the inaugural model in this category, the Kh-47 Kinzhal represents the forefront of hypersonic missile technology. Described as an aero-ballistic missile with maneuverability, it has been in operational use since 2018, according to statements from Russian authorities. The Kinzhal can accelerate to Mach-10 during its terminal phase and is launched from either MiG-31K jets or Tu-22M3 heavy bombers. Reports indicate that its first combat deployment occurred in Ukraine on March 19th, 2023, with two subsequent uses recorded. Additionally, a smaller variant designed for the Su-57 fighter jet is reportedly under development. Despite the advanced capabilities of the Kh-47, the Ukrainian Air Force has reported success in intercepting the missiles by using Patriot air defense systems.

The second technology of this class, Russia's 3M22 Zircon (also known as SS-N-33), is a high-profile HCM notable for its scramjet propulsion system. It boasts speeds of up to Mach 9 and a potential range of 1,000 kilometers. The Zircon underwent testing from two naval platforms: the *Admiral Gorshkov* frigate and the *Severodvinsk* submarine, with launches occurring in 2020 and 2021. In January 2023, the *Admiral Gorshkov* frigate became the first ship officially commissioned to serve with the Zircon system.

The International Significance of HCMs

Russia's deployment of HCMs such as the Zircon not only marks a significant technological milestone but also reshapes the strategic landscape of military engagement and international security. The unprecedented speed and maneuverability of these missiles challenge existing defense mechanisms, forcing nations around the world to reassess their security doctrines and defense capabilities. In a military context, the introduction of HCMs changes the dynamics of deterrence, as the traditional metrics of missile defense based on intercept capabilities become less effective. This shift could lead to an acceleration of the arms race as states seek to develop or acquire comparable technologies to maintain strategic parity.

From an international security perspective, the use of HCMs thus extends beyond the battlefield, affecting global power balances and diplomatic relations. The ability to deliver strikes with unprecedented precision and speed could destabilize regions and lead to new

alliances and defense cooperation. Moreover, the deployment of such advanced systems in contested areas, such as Eastern Europe or the Asia-Pacific region, could escalate tensions and make diplomatic resolution of conflicts more difficult. The international community may need to negotiate new arms control agreements to address the proliferation of hypersonic technologies and ensure that their deployment does not lead to increased global instability.

By integrating HCMs into their arsenals, nations gain not only a formidable military tool but also increased leverage in international diplomacy as the possession of such cutting-edge technology becomes synonymous with strategic dominance. The use of HCMs is therefore not just a reflection of military innovation but also a factor that could reshape the very foundations of international security and geopolitics.

The US Perspective on Russian HCMs

The US is pursuing a comprehensive and urgent response to the growing threat posed by hypersonic missiles. The US Department of Defense (DOD) has worked on integrating tracking capabilities across space-, ground-, and sea-based radars to counter hypersonic threats. This integration aims to enhance the detection, tracking, and engagement of hypersonic weapons across multiple phases of their flight path, including the challenging glide phase, where these missiles maneuver unpredictably.

The Space Development Agency (SDA) has furthermore initiated the deployment of satellite constellations, starting with the Tranche 0 satellites, to improve the detection and tracking of hypersonic missiles. These satellites aim to address the shortcomings of current early warning systems by detecting the dimmer infrared signatures of hypersonic missiles, which are difficult for traditional systems to track due to their low flight paths and maneuverability.

In addition, the Missile Defense Agency (MDA) is developing missile interceptors capable of engaging hypersonic threats. Such efforts include the Enhanced Hypersonic Missile Defense system, which seeks to achieve kinetic kills against maneuvering hypersonic missiles. These interceptors leverage existing missile defense architectures, such as the Command & Control, Battle Management & Communications (C2BMC) system, forward-based radars, and Aegis ships, to cue acquisition and launch capabilities against incoming threats.

Overall, the US recognizes the transformative nature of hypersonic weapons technology and is investing heavily in the capabilities needed to defend against this emerging threat.

Conclusion

While Zircon hypersonic missiles (HSMs) represent a strategic deterrent for Russia, the initial reports on their combat usage came from Ukraine, not Russia itself. This suggests that Russia may have been testing the Zircon under combat conditions with less-than-satisfactory results, and this may be why Russia has not officially confirmed their use. Ordinarily, a nation would publicize the deployment of a strategic asset for deterrence and strategic communication. The lack of information regarding Russia's Zircon stockpile, production capacity, reliance on foreign components, and deployment across naval vessels poses difficulty in predicting the Zircon's future usage against Ukraine. However, Russia might employ Zircon HSMs in an attempt to overwhelm or circumvent Ukrainian air defenses when it is targeting high-value objectives.

While it is odd that no statements have issued from Russia, there are plausible reasons underlying Ukraine's disclosure of Zircon deployment in the February 7th attacks. With ongoing debates about US arms aid to Ukraine, demonstrating the threat posed by Russian HSMs could bolster Ukraine's case for receiving advanced missile defense systems, like the SM-3 or SM-6, capable of intercepting hypersonic threats. The US may also benefit from this information, gaining valuable field data on the effectiveness of these systems against HSMs. Ultimately, developing air and missile defense capabilities to counter the hypersonic threat will soon become paramount.
