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NEMESIS:

WITHIN THE CHALLENGE POSED TO AIR AND MISSILE DEFENCE SYSTEMS BY NEW ATTACK VECTORS

July 2026

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Focus report by:

Filippo Massacesi – Junior Fellow Defence and Security Desk

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List of Abbreviations

ABM – *Anti-Ballistic Missile*

ALBM – *Air Launched Ballistic Missile*

ARH/SARH – *Active/Semi-Active Radar Homing*

ASBM – *Anti-Ship Ballistic Missile*

A2/AD – *Anti-Access/Area Denial*

CEP – *Circular Error Probability*

C2 – *Command and Control*

DPRK – *Democratic People's Republic of Korea*

DSMAC – *Digital Scene Matching Area Correlation*

DT – *Depressed Trajectories*

EDT – *Emerging and Disruptive Technologies*

GLONASS – *Globalnaya Nvigatsionnaya Sputnikovaya Sistema*

GPS/INS – *Global Positioning System/Inertial Navigation System*

HCM – *Hypersonic Cruise Missile*

HGV – *Hypersonic Glide Vehicle*

HN – *Hong Niao*

IAMD – *Integrated Air and Missile Defence*

ICBM – *Intercontinental Ballistic Missile*

INF – *Intermediate-range Nuclear Forces*

IRBM – *Intermediate Range Ballistic Missile*

LACM – *Land Attack Cruise Missile*

LoC – *Line of Contact*

MARV – *Manoeuvrable Re-entry Vehicle*

MIRV – *Multiple Independently targetable Re-entry Vehicle*

MRBM – *Medium Range Ballistic Missile*

OWA UAV – *One-Way Attack Unmanned Aerial Vehicle*

PRC – *People's Republic of China*

RV – *Re-entry Vehicle*

SAMP/T – *Sol-Air Moyenne-Portée/Terrestre*

SRBM – *Short Range Ballistic Missile*

TEL – Transporter Erector Launcher

V2 – *Vergeltungswaffe 2*

INTRODUCTION

Over the past few years, ongoing conflicts and interstate confrontations across the international landscape have highlighted a profound transformation in the development of long-range strike capabilities. Indeed, the evolution of modern warfare has been marked by the rapid emergence and widespread adoption of increasingly sophisticated attack platforms, designed to conduct precision operations at extended ranges. In particular, both in the context of the Russia–Ukraine war and in the military operations conducted by the United States and Israel against the Islamic Republic of Iran, the role of long-range attack drones (OWA UAVs – One-Way Attack Unmanned Aerial Vehicles) has emerged as predominant, used in conjunction with ballistic and cruise missile systems to carry out saturation attacks. Overall, it is precisely within these families of delivery systems that the investments of the West's main near-peer competitors, namely the Russian Federation, the People's Republic of China (PRC), the Democratic People's Republic of Korea (DPRK) and the Islamic Republic of Iran, have converged. These nations have focused in particular on Emerging and Disruptive Technologies (EDT) such as hypersonic missiles and, more generally, manoeuvrable systems.

In this context, a clear and widespread tendency has emerged towards the development of assets belonging to different categories in terms of both capability and sophistication. Indeed, whilst on the one hand there has been a trend towards the development of increasingly advanced systems, such as manoeuvrable and hypersonic delivery vehicles, to enable them to circumvent the air defence architectures currently in service, on the other hand, there has also been a growth in investments in low-end systems, such as OWA UAVs, which can be used in conjunction with high-end assets to saturate enemy air defences. This helps illustrate the variety of capacitive segments on which the investments of the West's near-peer competitors have focused. As a matter of fact, these latter have covered both emerging technological fields with disruptive potential, such as manoeuvrable systems, gliding vehicles, hypersonic cruise missiles and OWA UAV platforms, and more traditional sectors, including ballistic and cruise missiles. From this perspective, it is evident that the threat spectrum has become increasingly diversified, encompassing a wide range of assets characterised by varying levels of sophistication and distinct operational profiles. This growing heterogeneity has, in turn, significantly increased the complexity of designing and implementing effective air defence architectures. This picture is further complicated by the fact that investment relates to systems that can be configured at multiple levels within the multi-layered framework that characterises both long-range strike capabilities and Integrated Air and Missile Defence (IAMD) capabilities. Indeed, the West's main rival powers appear to have long been focusing their attention on both short and medium-range assets and on intermediate and intercontinental-range assets. With particular regard to the latter, there has been a resurgence in investment in delivery systems equipped with Multiple Independently targetable Re-entry Vehicles (MIRVs), which possess significant manoeuvrability in the terminal phase of flight and are difficult to neutralise. This challenge is further exacerbated by the dual-capable nature of the missile systems developed, which are now systematically adapted to carry both conventional explosives and nuclear warheads with the objective of providing greater flexibility across the conflict spectrum, thereby facilitating the use of MIRV-equipped systems for conventional strike missions.

Figure 1 – Schematic representation of the submunition separation phase of a ballistic missile equipped with an MIRV warhead.

In this context, the plausible risk that the People's Republic of China might equip some of its Intercontinental Ballistic Missiles (ICBMs) with conventional warheads, thereby acquiring the capability to strike deep behind enemy lines, takes on particular significance. This possibility, however, is not an isolated case but is part of a general trend amongst the West's near-peer competitors to acquire systems characterised by significant operational ranges (long range), which enable an extension of the threat spectrum, when combined with their already substantial short and medium-range arsenals. From this perspective, the picture outlined highlights that, through the simultaneous development of assets belonging to different categories in terms of operational range, level of sophistication and scope of capability, various actors, notably the People's Republic of China and the Russian Federation, aim to simultaneously saturate all individual segments of adversarial air defence architectures, with the aim of implementing Anti-Access and Area Denial (A2/AD) strategies. Although the West's strategic competitors are investing across a broad spectrum of advanced military capabilities, several overarching trends can nevertheless be identified. The first concerns the fact that investment in the high-end segment primarily involves the Russian Federation and the PRC, and secondarily the DPRK. The Islamic Republic of Iran, on the other hand, has proved particularly prolific in the field of OWA UAV systems and short and medium-range missile systems. The latter, in particular, has been an area of great interest to the DPRK and the PRC as well, as they are fundamental in the establishment of an A2/AD bubble that would make impracticable U.S. military intervention in the area.

1. The Missile Threat

Turning to the missile domain in greater detail, hypersonic systems have emerged as the area receiving the greatest degree of attention and investment. However, these do not represent, *per se,* a significant innovation in the field of armaments: hypersonic weapons, characterised by their ability to reach speeds exceeding Mach 5, made, in fact, their official debut as early as the end of the Second World War, when Nazi Germany developed and deployed the *Vergeltungswaffe 2* (*V2*) ballistic missiles to target the United Kingdom. Over the following decades, the category of hypersonic weapons came to encompass a significant number of ballistic missiles, broadly understood as delivery systems capable of reaching speeds in excess of the speed of sound and designed to carry both nuclear and conventional warheads.

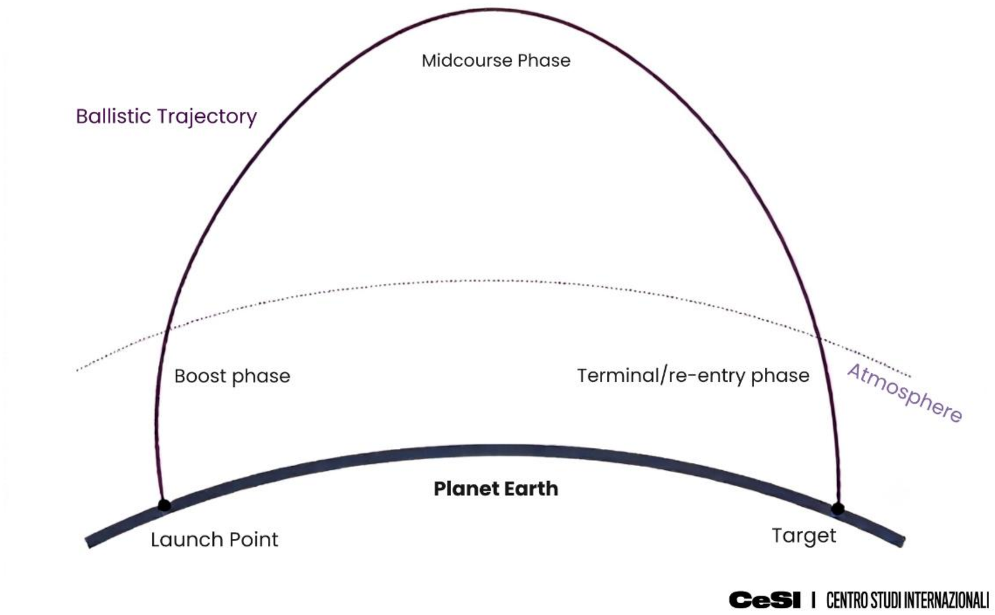

Figure 2 – Schematic diagram of the flight phases of a ballistic missile.

Such systems are indeed by definition hypersonic due to the extremely high speeds they reach both during the *boost phase*, where the peak speed is recorded, and during the midcourse and *terminal or re-entry phase* of flight, which follow a ballistic and therefore predictable trajectory. Overall, recent investments by the West's main near-peer competitors have focused quite broadly on strengthening traditional ballistic missile capabilities. These efforts have aimed both at the introduction of vectors characterised by increased operational ranges and at enhancing the quality and quantity of short-range offensive capabilities. In this regard, particular significance is given to the numerous short-range (SRBM – Short Range Ballistic Missile), medium-range (MRBM – Medium Range Ballistic Missile) and intermediate-range (IRBM – Intermediate Range Ballistic Missile) missile systems in which the DPRK and the Islamic Republic of Iran, in particular, have invested. As a matter of fact, the former has deployed the *BM-25 Musudan* IRBM and boasts a considerable number of launch vehicles in operational service, including the *Hwasong-7*, *Hwasong-9*, and *Pukguksong-2* (*KN-15*) MRBMs, and the *Hwasong-5*, *Hwasong-6*, *KN-02*, and *KN-25* SRBMs. The latter, on the other hand, possesses an arsenal that includes the *Shahab-3* MRBMs and the *Shahab-1*, *Shahab-2*, *Qiam-1*, *Tondar 69* and *Zolfaghar* SRBMs, as well as systems currently under development such as the *Emad*, *Ghadr-1* and *Khorramshahr* MRBMs. In this context, however, what distinguishes the role most recently assumed by hypersonic systems lies essentially in the combination of the high speeds they can achieve with the ability to make these missiles manoeuvrable, that is to say, capable of altering their trajectory during flight to make it more difficult for adversaries to intercept them or to increase their accuracy. This objective, in particular, has been pursued along three main lines: the development of Manoeuvrable Re-entry Vehicles (MARVs) to be mounted on standard ballistic missiles, of Hypersonic Glide Vehicles (HGVs) launchable from ballistic missiles, and of cruise missiles capable of reaching hypersonic speeds (HCMs – Hypersonic Cruise Missiles).

1.1. MARV Systems

Firstly, with regard to MARV systems, their design was intended to equip conventional ballistic missiles with the ability to manoeuvre not only during the boost phase, when the ballistic trajectory is established, but also during the terminal re-entry phase into the atmosphere. This feature is of considerable importance given that the inability to adjust the trajectory during flight makes it difficult to guide Re-entry Vehicles (RVs) to strike moving targets, such as naval vessels, as well as to evade any defensive measures that may be deployed against them. The ballistic trajectory is, by definition, predictable, which makes it easier to implement countermeasures aimed at intercepting missile vehicles if they are unable to evade them. In this sense, therefore, certain MARVs, known as *evading MARVs*, play a key role exactly in countering the anti-ballistic missile systems that may be deployed by potential adversaries (anti-ABM – anti-Anti-Ballistic Missile). This category of RVs therefore performs random manoeuvres during the terminal phase of flight, not only to prevent or hinder detection by enemy sensor systems, but also to complicate interception by ABM systems, which rely primarily on data concerning the missile's ballistic trajectory when calculating the intercept solution. With this in mind, *evading MARVs* rely extensively on inertial sensors, including gyroscopes, accelerometers and magnetometers, sometimes supplemented by a terminal guidance system, in order to execute the wide-ranging and unpredictable manoeuvres that characterise them, prioritising the vehicle's survivability at the expense of its targeting accuracy. Conversely, *accuracy MARVs*, used in particular for anti-ship missions, are designed to reduce the probability of error (CEP – Circular Error Probability) and to increase the precision of the RVs, as well as to enable them to track moving targets using sensor-based guidance systems that are activated during the terminal phase of flight. The latter, in particular, can take various forms, including radar (ARH/SARH – Active/Semi-Active Radar Homing) and electro-optical sensors, and are characterised by significant levels of sophistication necessitated by the environments in which they must operate. Indeed, these sensors must not only be incredibly fast and accurate but, above all, capable of withstanding high temperatures and pressures. Overall, however, the primary objective of this second category of MARVs is precision, which is why the trajectory they follow tends to be cleaner and more predictable than that adopted by *evading MARVs*, a fact that makes them potentially more vulnerable to ABM systems. In this context, although no initiatives in this direction currently appear to be underway, it is worth noting that the technical capabilities required to adjust a missile's trajectory during flight in order to strike a moving target could, in the future, enable the development of manoeuvring systems capable of autonomously acquiring a new target after launch and engaging it using their own onboard sensors.

Figure 3 – Illustration of an SRBM from the Iskander family in the terminal phase of flight after evading an interception attempt.

In practical terms, over recent years there has been a significant increase in investment in MARV systems by the West's main near-peer competitors, particularly the Russian Federation and the People's Republic of China, which have assumed a leading position globally, but also, to a lesser extent, the Democratic People's Republic of Korea and the Islamic Republic of Iran. Firstly, with regard to the Russian Federation, the MARV systems currently in active service can be classified according to the category of missile delivery systems capable of deploying them. In particular, these include the SRBMs of the *Iskander* family, including the

Iskander-M (*9M723*), which is in service with the Russian Army, has been widely used in Ukraine and has a maximum range of 500 km, and the *Iskander-E* (*9M720*), its export version with a maximum range of 280 km. These systems are characterised by their use of depressed ballistic trajectories (DT – Depressed Trajectories), i.e. trajectories with a lower apogee than traditional ballistic ones and capable of following a flatter flight path. This practice reduces the total distance the missile must travel and acts as an anti-ABM measure, as it drastically shortens the time window available to adversaries for interception. On the other hand, however, flying at lower altitudes results in a significant increase in aerodynamic drag, which in turn leads to high fuel consumption and the need to reduce the payload capacity. In addition to DT, such systems can utilise MARV systems based on different types of sensors that incrementally improve their accuracy, ranging from a CEP of 200 m with inertial guidance to 50 m with satellite guidance (GLONASS – *Globalnaya Navigatsionnaya Sputnikovaya Sistema*) and to 20–30 m with DSMAC (Digital Scene Matching Area Correlation) terminal guidance systems, which utilise optional optical search assets for target detection. MARV capability is also a hallmark of the *Kh-47M2 Kinzhal* Air-Launched Ballistic Missiles (ALBMs), which have an estimated range of between 1,500 and 2,000 km and have been used repeatedly during the Russia–Ukraine conflict, albeit in limited numbers. These systems, in particular, although presented by the Russian media as innovative hypersonic weapons with capabilities comparable to those of HGVs, do not in fact represent a significant innovation, as they follow a standard ballistic trajectory, making them largely comparable to conventional ballistic missiles.

Figure 4 – Reconstruction of the launch phase of a Kh-47M2 Kinzhal ALBM from a MiG-31K.

To conclude, in the long-range segment, the Russian Federation has invested over the last twenty years in two ICBMs with MARV capability, both of which are currently in active service: the *Topol-M* (*SS-27 Mod 1*) and the *RS-24 Yars* (*SS-27 Mod 2*), the latter of which can be equipped with three independently targetable re-entry vehicles. MIRV capabilities, in particular, have historically been a key strength of Russia's strategic forces, which continue to invest significantly in this area. Indeed, not only is a new ICBM currently being deployed, the *RS-28 Sarmat*, capable of carrying MIRVs or HGVs and last tested in May 2026, but so too is a new IRBM with MIRV capability: the *Oreshnik*. The latter, which was probably developed following the removal of a stage from the design of the *RS-26 Rubezh* ICBM, a programme that has since been put on hold, represents a significant departure from what has been observed over the last three decades, as its existence violates the 1987 INF (Intermediate-range Nuclear Forces) Treaty. The production of the *Oreshnik* and its deployment on the Ukrainian battlefield, currently limited to three units, presumably used for demonstration and intimidation purposes, serve as a significant warning for the future of European security, which may have to prepare for the return of a class of weapons to the continent: IRBMs, which pose a significant threat, particularly when such systems can be armed, as in the case of the *Oreshnik*, with both conventional and nuclear warheads. Meanwhile, among the projects still in the early stages of development is the *Kedr* programme, aimed at replacing the *Yars* ICBMs in both mobile and fixed configurations by 2030.

The People's Republic of China, on the other hand, has in recent years focused its investments on numerous ballistic systems with manoeuvrable capabilities, a significant proportion of which fall within the short- and medium-range segment due to the nature of the relevant theatre of operations. These include, specifically, two SRBMs: the *DF-15* (*CSS-6*) and the *DF-16* (*CSS-11*). As regards the former, the *DF-15B* (*CSS-6 Mod 3*) variant, with a range of at least 725 km, is equipped with an inertial navigation system and micro-thrusters that enable trajectory corrections to be made during flight. Furthermore, its warhead is fitted with fins that enable manoeuvres during atmospheric re-entry, likely integrated with a terminal radar guidance system capable of significantly reducing the CEP. The second, by contrast, has a range of between 800 and 1,000 km and is in service in three variants, two of which are fitted with fins on the warheads and possess manoeuvring capabilities: the *CSS-11 Mod 1* and the *CSS-11 Mod 2*, which are slightly larger in size. In the medium-range missile segment, however, the PRC has the *DF-21* in active service, of which the *DF-21D* (*CSS-5 Mod 5*) variant, specialised for anti-ship (ASBM – Anti-Ship Ballistic Missile) operations and with a range of between 1,450 and 1,550 km, is equipped with a MARV and terminal guidance capabilities that enable a reduction in CEP. Additionally, the *KD-21* carrier has recently entered service; this is an air-launched variant of the *YJ-21* anti-ship missile and is plausibly equipped with terminal guidance capabilities to track moving targets. Although no technical details are available, it is believed that the *YJ-20* anti-ship ALBM, unveiled at the military parade on 3 September 2025, is also capable of manoeuvring to strike surface targets by following near-vertical terminal trajectories. Also included within this capability category is the *DF-26* IRBM equipped with a MARV, together with its anti-ship variant, the *DF-16B*, which possesses terminal guidance capabilities in line with other Chinese ASBM assets; thanks to its 4,000 km range, it provides significant coverage at intermediate range. It is interesting to note that the PRC, like the Russian Federation, has invested in recent years not only in the modernisation of its older MIRV-equipped ICBMs, the *DF-5s*, but also in two new classes of intercontinental-range launch vehicles with MIRV capability, the *DF-41* and the *DF-61*. Whilst the former are fully operational, the latter were only unveiled to the public in September 2025 and are currently believed to be in the deployment phase. This picture is further complicated by the possibility, first mentioned in a military publication in 2004, that the PRC might decide to equip some of its ICBMs with conventional warheads to acquire ultra-long-range strike capabilities against centres of gravity located deep behind enemy lines.

Although to a lesser extent, the Islamic Republic of Iran and the DPRK have also devoted resources to the development of ballistic missiles with manoeuvring capabilities. Among these actors, the former is of particular significance, having, through the operations *True Promise II* in October 2024, *True Promise III* in June 2025 and *True Promise IV* in March 2026, openly demonstrated its ability to conduct saturation attacks based on the massive deployment of medium-range ballistic missiles via mobile launchers (TEL – Transporter Erector Launcher).

Figure 5 – Illustration of an MRBM launch using a TEL.

Despite this, however, it appears that Iranian activities aimed at developing MARV systems have focused predominantly on specialised short-range assets, which are unable to reach Israeli territory. These include several variants of the *Fateh-110* missile with a range varying between 200 and 500 km, including the *Hormuz-1* and *Hormuz-2* launchers, fitted with radio-transparent radar domes and anti-radar capabilities, and the *Khalij Fars* anti-ship missiles, fitted with electro-optical seekers for terminal guidance against moving targets. At the same time, the *Fateh-313* missile, which has an operational range of approximately 500 km, is also equipped with advanced sensors for inertial and satellite navigation, as well as manoeuvring fins and, potentially, terminal guidance systems, which together significantly enhance its capability to conduct precision strikes. Finally, within the MRBM category too there have been limited attempts to develop systems equipped with MARVs, notably the *Sejjil* missile (with a range of 2,000 km), which is based on upgraded guidance systems including a strap-down navigation system and new jet vanes for vector control, and the *Fattah-1* (with an operational range of 1,400 km), announced in June 2023, deployed during the 12-Day War of June 2025 and plausibly equipped with a MARV warhead. On the other hand, its successor, the *Fattah-2* missile, although presented in November 2023 as a system combining a booster and an HGV capable of reaching speeds of up to Mach 15 and a range of 1,500 km, is believed not to be actually operational, or at any rate not to possess the stated technical characteristics.

The DPRK, meanwhile, much as has been observed with the People's Republic of China, has focused its efforts on SRBM and IRBM systems, probably due to the nature of its operational theatre. The first category includes, above all, two variants derived from the *Scud* missile family: the *KN-18*, with an operational range of 450 km, and the *KN-23*, with a range of over 700 km. Whilst the former, about which there has been no definite information since the sole recorded test dating back to 2017, and which is presumed to be part of North Korea's arsenal constitutes a modified version of the

Scud featuring the addition of a MARV with specialised fins, the latter appears to be a missile distinct from the *Scud*, although equally derived from it. Furthermore, the *KN-23* bears striking similarities to the Russian *Iskander-M*, itself a descendant of the *Scud*, in terms of both physical appearance and capabilities, to the extent that it is believed to have been developed with foreign support. Among the distinctive features of the *Iskander-M* replicated by the *KN-23* is, in particular, its ability to follow low-angle ballistic trajectories and to perform climb manoeuvres during the terminal phase of flight to make interception more difficult, capabilities that have been directly put to the test through their use by the Russian Federation in the war in Ukraine. Also in the SRBM segment, the DPRK has in recent years developed the *KN-24* missile, which has a range of approximately 410 km and is equipped with a MARV; like the *KN-23*, it is reported to have been supplied in support of Russian military efforts, albeit in limited numbers.

Figure 6 – Comparison of the main variants derived from the Scud missile family.

In the IRBM category, on the other hand, North Korea has in recent years developed and plausibly incorporated into its arsenal two missile delivery systems, the *Hwasong-8* and the *Hwasong-16*, whose respective variants, the *Hwasong-12A* and *Hwasong-16A*, are equipped with manoeuvring capabilities. Specifically, it is worth noting that the *Hwasong-8*, developed by removing one stage from the *Hwasong-12* IRBM, appears to have been specifically designed as a ballistic vehicle for launching an HGV. Although, following the only known test, which took place in September 2021, it is known for certain that the system possesses significant manoeuvring capabilities and is capable of following low-angle trajectories, it remains unclear when the system will enter active service, given that, according to South Korean intelligence, the warhead did not reach hypersonic speeds. At the same time, however, the DPRK has maintained its commitment to the development of missile launchers for hypersonic glide vehicles. During a military parade in July 2023, several missiles capable of carrying HGVs, designated *Hwasong-12B*, were displayed; these could be variants of the *Hwasong-8*, such as the *Hwasong-12A*, or, given the numerous similarities, renamed versions of the latter. Furthermore, in April 2024, a variant of the *Hwasong-16* missile, known as the *Hwasong-16B*, was tested; this too is capable of carrying HGVs, demonstrating the North Korean regime's ongoing interest in this category of weaponry. More recently, in October 2025, a new version of the *Hwasong-11* SRBM, known as the *Hwasong-11E*, was unveiled; this too can be equipped with an HGV.

1.2. Hypersonic Glide Vehicles

Overall, hypersonic glide vehicles represent an innovative means of delivering a nuclear or conventional payload at extremely high speeds, whilst offering the ability to manoeuvre in flight to evade enemy defence systems. Their operation consists of two phases: in the first, the vehicle is brought to a specific altitude using a rocket or a launcher, whilst in the second, the warhead utilises aerodynamics to glide out of the atmosphere without propulsion before re-entering and striking the target. More specifically, ballistic missile boosters, sometimes with certain stages removed, are often used for launch operations, as they are already optimised for such missions. Following separation from the booster and once the predetermined altitude and peak velocity have been reached, the HGV begins its glide phase through the atmosphere, during which it must cope with the challenges of deceleration and heating caused by friction with the air, whilst attempting to reach a predetermined target without propulsion and as accurately as possible.

Figure 7 – Artistic rendering of a hypersonic glide vehicle during atmospheric re-entry.

To achieve this objective, HGVs operate along non-ballistic atmospheric re-entry trajectories that involve lower angles than those of traditional ballistic missiles, thereby enabling a significant reduction in peak temperature and spreading it over a prolonged period of time, thus indirectly affecting deceleration. From this perspective, although the technical details are classified, it is believed that the most plausible re-entry trajectories for military HGVs currently under development are those known as glide trajectories, namely skip-glide and steady glide. The principle underlying both is to utilise RVs with an aerodynamic configuration and equipped with control surfaces to glide between the mesosphere and the stratosphere (at altitudes between 30 and 60 km), where the atmosphere is dense enough to generate lift but rarefied enough to limit excessive heating. From a capability perspective, specifically, the chosen re-entry technique has a decisive influence on the potential applications of HGVs. Firstly, steady glide involves the RV entering the atmosphere at low angles of attack and then remaining constantly in the upper layers of the atmosphere, minimising thermal peaks and maintaining a fairly flat trajectory (glide phase). Consequently, this allows HGVs to maintain considerable stability and a high level of lateral manoeuvrability, factors which enhance their precision and suggest that the use of this technique by military systems currently under development is highly plausible. Secondly, skip-glide replicates within the atmosphere what skip trajectories do between the atmosphere and space, namely, exploiting the lift generated by gliding flight to gain altitude (pull-up phase) through 'bounces' (skips). These 'skips' can be repeated a variable number of times before the glide stabilises, and help to reduce the drag experienced by the HGV through rhythmic movement towards altitudes where the air is thinner; this results in a further reduction in the heating experienced by the RV and allows for an overall extension of the vehicle's range. Overall, therefore, skip-glide makes it possible to maximise range and increase the difficulty of interception, whilst preserving the aerodynamic control and manoeuvrability that characterise steady glide; these factors make its adoption in military HGVs a plausible prospect. In this context, the development of a warhead capable of withstanding the significant mechanical and thermal stresses to which it is subjected, particularly on its vulnerable control surfaces, is of paramount importance.

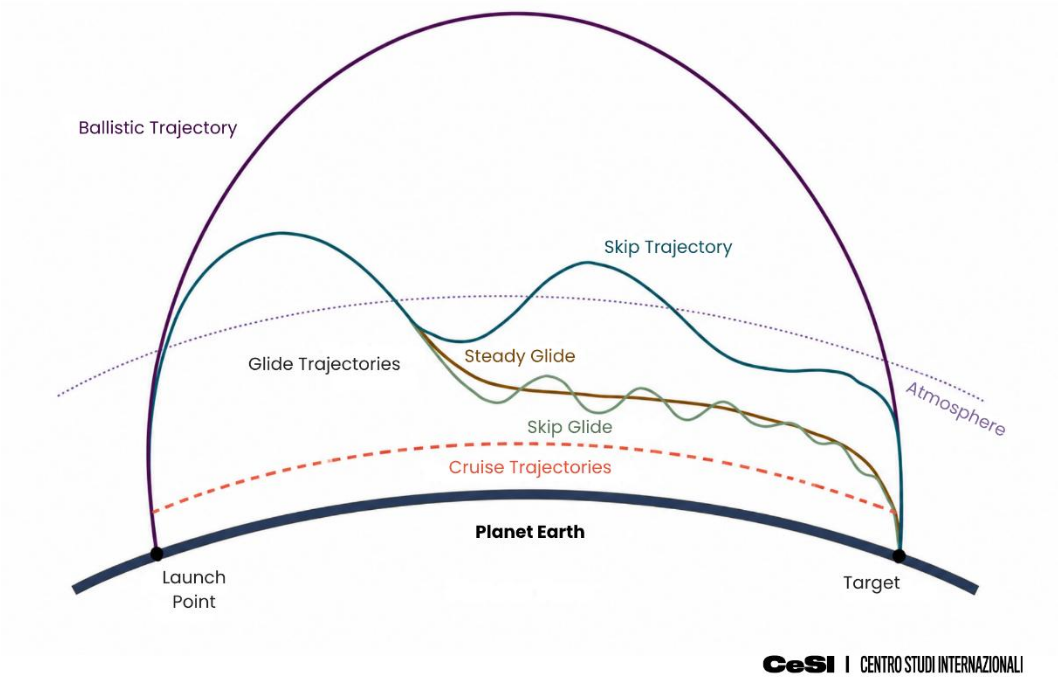

Figure 8 – Comparative diagram of the different trajectories that missile effectors can follow.

In practical terms, apart from the DPRK's efforts already outlined, over the last few years, the main investments in the field of hypersonic glide vehicles by the West's near-peer competitors have been made by the Russian Federation and, above all, by the People's Republic of China. The former, first and foremost, can claim to have had, since 2019, one of the few operational HGVs in the world in active service, albeit in limited numbers: the *Avangard*. This system relies on an initial boost phase currently provided by the *UR-100* (*SS-19 Stiletto*) ICBM, although it is expected to be replaced in future by the *RS-28 Sarmat* ICBM, and is characterised by a significant range of over 6,000 km, which makes it superior in this respect to its Chinese counterparts. The PRC, on the other hand, has the *DF-ZF* (*WU-41*) HGV in service, which has a range of approximately 1,900 km and has reportedly been capable of performing extreme manoeuvres. The warhead can be deployed both from the specially developed *DF-17* MRBM, which has an operational range of between 1,800 and 2,500 km, and, from 2023, from the *DF-27* IRBM, capable of reaching targets at ranges of 5,000–8,000 km. The latter, in particular, is reportedly also available in anti-ship variants, which would make it a potentially lethal 'carrier killer'. From this perspective, it is also worth considering the *YJ-17* anti-ship ALBM, unveiled to the public for the first time during the military parade on 3 September 2025 and equipped with an HGV. Furthermore, it is reported that the *DF-41* ICBM could also be compatible with HGVs, if suitably modified. At the same time, the People's Republic of China is also developing the *Xing Kong-2* (*Starry Sky-2*) HGV, which, according to some reports, may have become operational in 2025. Its distinctive feature lies in the fact that it is a waverider, namely a vehicle capable of generating a shock wave in front of it and utilising its pressure to increase lift. This would enable it not only to achieve a more favourable lift-to-drag ratio at high speeds, but also to manoeuvre more effectively in the upper layers of the atmosphere. Another vehicle in the same category is the *YKJ-1000* HGV system, produced by the private Chinese company Lingkong Tianxing Technology and announced in November 2025. With a range of between 500 and 1,300 km and capable of reaching speeds of between Mach 5 and Mach 7, the system, comprising a booster and a glider, has been described as having relatively low costs, which would make it potentially capable of being produced on a larger scale than traditional hypersonic systems.

1.3. Hypersonic Cruise Missiles

Despite their high speed and manoeuvrability, HGVs have some significant performance limitations. Firstly, as they lack any form of propulsion, they tend to gradually lose energy and speed during the glide phase due to air resistance, an effect that is even more pronounced when manoeuvres are performed. In this context, the role of hypersonic cruise missiles becomes particularly important. These are characterised by their ability to maintain constant hypersonic speeds thanks to their propulsion system, which enables them to compensate for the energy that would otherwise be lost when changing course during flight. This allows for significant levels of manoeuvrability and unpredictability, making it more difficult to calculate potential interception trajectories. Furthermore, HCMs differ from both HGVs and ballistic missiles in their ability to fly for extended periods at low altitude, which reduces the detection time available to enemy radars and makes their neutralisation more challenging. However, HCMs also present significant inherent challenges, such as their extreme technological complexity. Indeed, their operation relies on a propulsion system capable of achieving supersonic speeds (at least Mach 4) in an initial phase (boost phase) and hypersonic speeds in a second phase (cruise phase), which must be maintained constantly throughout the flight until the deceleration preceding target impact. The initial propulsion phase is not technically novel, as it relies on the use of missile carriers or airborne launchers for the deployment of the vehicle: equipped with a booster of variable power depending on the launch method adopted, the vehicle thus achieves a stable aerodynamic regime, as well as the minimum useful speed and the optimal altitude for the transition to the cruise phase. During this phase, the booster is jettisoned and the scramjet engine, the beating heart of the HCM, is ignited. Its operation, much like that of a ramjet, relies on exploiting the extremely high speeds at which it operates to forcibly compress the incoming airflow before combustion. Unlike the ramjet, however, the scramjet does not use inlet cones to slow the air to subsonic speeds, but is able to operate even with supersonic airflow without overheating, thus making prolonged hypersonic flight within the atmosphere possible. From this overview, however, it is clear that the technological challenges associated with such missiles also extend to the materials used in their manufacture, which must be capable of withstanding extremely high temperatures and mechanical stresses due to the friction caused by the density of the air in the lower layers of the atmosphere. In light of this, there are significant technological barriers to entry for the development of the fundamental components of HCMs, which is why, at present, only a very small number of states have any either in operational service or at an advanced stage of development.

Figure 9 – Graphical representation of a Zircon-class hypersonic cruise missile in low-altitude flight over sea level.

In particular, the global landscape is dominated by the West's two main near-peer competitors: the Russian Federation and the People's Republic of China. Firstly, since the end of 2022, the Russian Federation has officially deployed the *3M22 Zircon* HCM, which has a range of 1,000 km, is capable of carrying both nuclear and conventional warheads, and can be launched from naval vessels such as frigates and submarines. Furthermore, this system is the only hypersonic cruise missile to have been deployed directly in a combat environment, although only a few units were used during the Russia–Ukraine conflict. In the terminal phase of flight, it has proven vulnerable to high-end air defence systems such as the *MIM-104 Patriot* and the *Sol-Air Moyenne-Portée/Terrestre* (*SAMP/T*). The PRC, on the other hand, had already publicly displayed a prototype HCM known as the *Lingyun-1* as early as 2018; over the following years, it was widely believed to be under development, despite the lack of further information on the matter. However, with the military parade on 3 September 2025, the picture changed drastically as two new hypersonic cruise missile systems specialising in anti-ship missions were unveiled, with their deployment confirmed in February 2026: the *YJ-19* and the *CJ-1000*. The latter, in particular, due to its significant size, is believed to have a range of several thousand kilometres, which would enable it to bridge the gap between intermediate-range and intercontinental missiles.

The focus on developing assets with enhanced range has also led to the creation of another *sui generis* cruise missile system, this time subsonic, by the Russian Federation: the *9M730 Burevestnik* nuclear-powered cruise missile. This is a system currently unrivalled worldwide, characterised by its virtually unlimited range. Indeed, thanks to a built-in miniaturised nuclear reactor, the missile is capable of sustaining prolonged flights, limited only by the ability of the system to withstand air resistance over significant durations. This characteristic, combined with the fact that the *Burevestnik* is suited solely to carrying nuclear warheads due to the nature of its propulsion system, makes it particularly well-suited for deterrence tasks, especially as it is optimised to ensure the capability to carry out a nuclear second strike.

1.4. Conventional Cruise Missiles

Beyond the niche field of HCMs, it is worth noting that all the West's main near-peer competitors continue to invest significantly in the traditional cruise missile segment. Such assets, indeed, retain considerable importance in many respects. Firstly, from an economic perspective, these assets fall midway between OWA UAV systems and hypersonic missiles (both ballistic and non-ballistic), a fact which makes them particularly well-suited, as demonstrated by the course of the Russia-Ukraine conflict, for carrying out long-range precision strikes in massive, concentrated salvos at sustainable costs. Secondly, cruise missiles are of particular importance as they are capable of reaching targets located between a few hundred and several thousand kilometres away whilst flying at low altitude, meaning they maintain a profile that is difficult for enemy air defence systems to identify and neutralise, especially when accompanied by OWA UAVs or decoys. In this context, in particular, there is a general trend towards increasing the range of cruise missiles, so that they can be deployed in conjunction with ballistic systems and other low-end assets as part of saturation attacks across individual capability segments. The distinctive feature that sets the deployment of cruise missiles apart from ballistic missiles in this respect lies in the fact that the former possess outstanding manoeuvrability. This capability is systematically exploited to optimise the already significant impact of their characteristic low-altitude flight by plotting pre-programmed routes, allowing the missiles to pass through specific waypoints designed to minimise the chances of detection. These waypoints constitute intermediate stages between the launch point and the designated target, intended to ensure that the missile follows unpredictable trajectories, utilising low-altitude flight, the characteristics of the terrain and any information on the deployment of enemy defence systems, so as to facilitate penetration into the enemy's airspace. This is, of course, made possible by the presence of integrated sensors and various types of guidance systems, ranging from GPS/INS (*Global Positioning System/Inertial Navigation System*) to electro-optical systems.

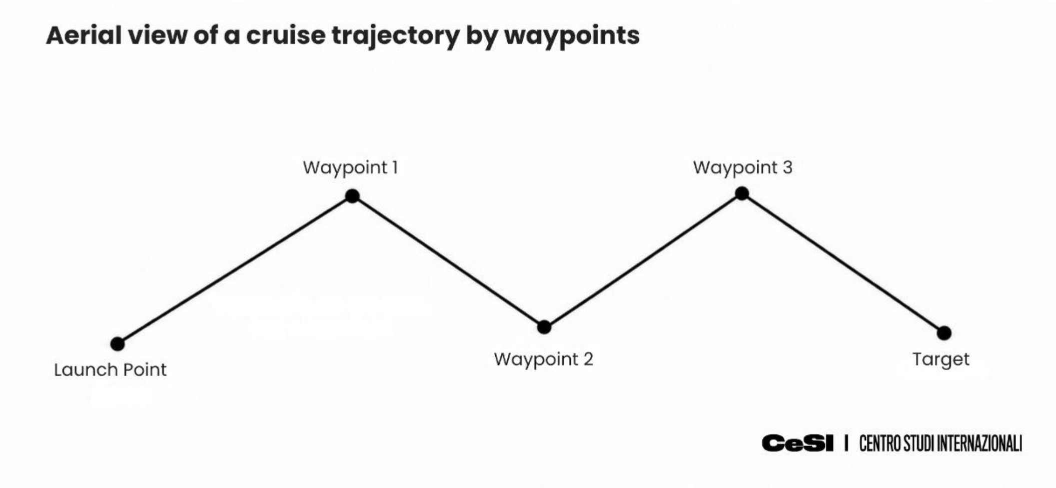

Figure 10 – Schematic representation of waypoint-based cruise trajectory guidance.

The high manoeuvrability of these platforms is ensured by the presence of control surfaces, often actual wings, and by their relatively low speed compared to hypersonic systems, which allows these vehicles to be classified as subsonic or supersonic. Whilst the former, equipped with turbofan propulsion systems capable of reaching speeds of 800–900 km/h, clearly represent the majority segment, the latter, which utilise ramjet systems to fly at speeds between Mach 2 and Mach 4, constitute a niche segment. Indeed, the latter are currently in service with the West's main near-peer competitors in only a few models, the most significant of which are the variants of the Russian *P-800 Oniks* anti-ship cruise missile, which is equipped with secondary ground-attack capabilities and has been used, albeit in limited numbers, in the Russia-Ukraine conflict. This variant was developed as the successor to the *P-270 Moskit* (*3M80*) ramjet-powered ASCM, which, however, remains in Russian arsenals. At the same time, the People's Republic of China also has two supersonic systems in service, both developed primarily for anti-ship roles and secondarily for ground attack: the *YJ-12*, in service since 2011, and its successor, the *YJ-15*, which was unveiled to the public at the military parade on 3 September 2025. Overall, it is worth noting that supersonic systems equipped with ramjets tend to be designed primarily to perform anti-ship functions. This stems from the specific operational conditions that characterise the use of cruise missiles against naval targets. These include, firstly, the fact that naval vessels are equipped with built-in defensive systems: in this context, the high engagement speeds of supersonic systems reduce the time available for their identification and neutralisation. Secondly, the waypoint navigation that characterises the use of cruise missiles and maximises their effectiveness is compromised in maritime contexts, where it is impossible to exploit the terrain to conceal the approach of the missiles, a fact that gives an advantage to systems capable of travelling at high speeds.

As regards subsonic cruise missiles, on the other hand, the widespread interest in them is evidenced not only by their prevalence in the arsenals of the West's near-peer competitors, but also by the fact that they continue to be deployed directly in various conflict zones, most notably the Russia–Ukraine conflict. The Russian Federation, indeed, regularly employs a significant variety of delivery systems belonging to this category; among these, the *Kh-101/Kh-102* ALCMs stand out for their frequency of use and the number of units deployed. Introduced to replace the *Kh-55/Kh-555* ALCMs, which, however, remain in service, they are equipped with a stealth profile which, combined with their impressive range of 2,000–2,500 km, makes them particularly well-suited to neutralising enemy air defences, including through low-level flight. These assets have also been supplemented by the *Kh-59* ALCMs and their stealth variant, the *Kh-69*, albeit in limited numbers. Another cruise missile system widely used by the Kremlin in Ukraine is the ground-attack version (LACM – Land Attack Cruise Missile) of the *3M-14 Kalibr* ship-launched missile, which has an operational range of between 1,500 and 2,500 km. Finally, among the most widely deployed systems are the *SSC-7* (*9M728*) and *SSC-8* (*9M729*) cruise missiles, the latter of which has a range of over 2,000 km and can be deployed using modified launchers from the Iskander system, known as *Iskander-K*.

Figure 11 – Kalibr-family land-attack cruise missiles en route to the mainland following launch from naval platforms.

In parallel, subsonic cruise missile capabilities have also been developed by the PRC, which has prioritised the creation of anti-ship missiles, including the *YJ-18*, *YJ-62* and *YJ-83*, the first two of which are also capable of carrying out ground-attack missions. At the same time, the People's Republic of China has also devoted considerable resources to the development of LACMs, such as the *CJ-10* variants, derived from the Russian *Kh-55*, and their successors, the *CJ-20* and *DF-100* (*CJ-100*), all characterised by operational ranges of more than 2,000 km. Of particular interest is the PRC's long-standing trend towards developing ground-attack systems with ever-greater ranges. In this regard, it is worth noting the technological evolution of the *Hong Niao* (*HN*) missile family. Whilst, on the one hand, the *HN-1*, which entered service around 1996, is capable of striking targets up to 600–650 km away, on the other hand, its successors, the *HN-2* and *HN-3*, which entered service in 2002 and 2007 respectively, have maximum ranges of 1,800 and 3,000 km.

Much like the PRC, the Democratic People's Republic of Korea has also invested in ASCMs, albeit to a limited extent, and has developed two variants: the *KN-01*, which for a long time was its only missile in this category, and the *Kumsong-3* (*KN-19*), a variant of the Russian *Kh-35* anti-ship missile (at present in service with the Russian Federation) currently under development, possibly featuring supersonic capabilities, which is expected to completely replace the outdated *KN-01* in North Korean arsenals. The focus on the anti-ship cruise missile segment could be interpreted as a response to the threats facing Pyongyang in its operational theatre, potentially posed by naval units and maritime expeditionary forces deployed by the United States, Japan or other states aligned with them. Nevertheless, the *Hwasal-1* and *Hwasal-2* strategic cruise missiles have also been introduced recently; these have been tested on several occasions since 2021 and are likely to further strengthen the DPRK's capabilities in terms of nuclear-capable assets.

Similarly, over the last few years, the Islamic Republic of Iran has invested in the *Ra'ad*, *Nasr-1*, *Noor* and *Qader* ASCMs, the latter being an upgraded version of the *Noor*, using Chinese missiles in several cases (the *C-802* for the *Noor* and the *C-704* for the *Nasr-1*) as the basis for these systems. At the same time, however, it has also channelled resources into the development of assets with ground-attack capabilities. These include variants of the *Soumar* missile family, derived from the Russian *Kh-55* and having a range of 2,000–3,000 km, including the *Hoveyzeh* and *Paveh* variants, and the *Ya-Ali* missile, capable of striking targets up to 700 km away. The *Soumar* missiles, in particular, are of significance as they are potentially capable of reaching Israeli territory.

2. Long-Range Attack Drones

Beyond the missile domain, another category of attack platforms with long-range stand-off strike capabilities has also taken on crucial importance in recent times: OWA UAVs. These are unmanned aerial vehicles equipped with an integrated explosive warhead and capable of travelling along a pre-programmed route for distances of up to several thousand kilometres to strike targets deep behind the Line of Contact (LoC) through direct impact. This operation is carried out with no prospect of recovering the aircraft, which takes on the characteristics of a true suicide drone, dedicated solely to delivering an explosive device to its target before sacrificing itself to ensure its destruction. Added to this is the low-end nature of OWA UAV systems, which makes it possible to mass-produce them at significantly lower costs than any type of missile. These platforms are, indeed, designed to be easily manufactured on a large scale, thanks in part to the use of technological solutions characterised by mechanical simplicity and low costs. From this perspective, it is significant that the most widely adopted propulsion systems in such UAVs are internal combustion engines, particularly piston engines or *Wankel* rotary engines, used to drive a propeller located at the rear of the fuselage, capable of maintaining a cruising speed of approximately 180-200 km/h. The cost-effectiveness of these airframes is further enhanced by the use of composite materials, including plastics and light metals, which make their rapid production in large numbers considerably more sustainable. This final factor, in fact, constitutes the real strength of OWA UAVs, which, due to their low level of sophistication and the relatively low speeds they can achieve, are most effective when deployed in saturation attacks, characterised by the simultaneous deployment of a large number of platforms. Overall, however, their operational methods are consistent with those already observed in the case of cruise missiles, characterised by low-altitude flight, aimed at hindering the detection of the assets by enemy radar systems, in conjunction with the use of waypoints to define the engagement route.

Figure 12 – Illustration depicting a formation of Shahed-136 drones in flight.

In this specific capability segment, the main investments by Western near-peer competitors have been made by the Russian Federation and the Islamic Republic of Iran, which have come to occupy a leading position globally in this field. With regard, first and foremost, to the Russian Federation, an analysis of the course of the conflict with Ukraine reveals the key role assigned to OWA UAV systems for long-range targeting operations, which remains complementary to that played by missile systems. Indeed, these UAVs are deployed on a daily basis to strike both rear-area targets near the LoC and strategic targets deep within enemy territory. For the second category of operations in particular, the Iranian-designed *Shahed-131* and *Shahed-136* systems, whose production has been outsourced to Russia, are widely used, as are their Russian variants, the *Geran-1* and *Geran-2*. Although these are essentially the same platforms, it is worth noting that the latter feature slight technical modifications compared to the former and are equipped with GLONASS navigation systems rather than GPS systems. The distinctive feature of all four systems mentioned lies in their significant range, amounting to approximately 900 km for the *Shahed-131* and *Geran-1*, and 2,500 km for the *Shahed-136* and

Geran-2, which effectively enables their use for strategic attacks in conjunction with various types of missile systems. In doing so, however, it is necessary to stagger the launches to take account of the flight times required by the various categories of assets, given their respective speeds (time-on-target synchronisation): very short for hypersonic missiles, moderate for cruise missiles and much longer for OWA UAVs. The role played by the Iranian *Shahed-238* system is also noteworthy, as it has been adopted by the Russian Federation in Ukraine under the name *Geran-3* after relatively minor technical modifications were made, as in the cases already mentioned. This platform is characterised by a turbojet propulsion system, which enables it to reach high speeds but also increases the overall cost of the system, whilst reducing its range to 1,000-1,200 km.

Figure 13 – Comparison between the Shahed-136 and Shahed-238 platforms, equipped with turbofan and turbojet propulsion systems respectively.

The Russian Federation has also developed and deployed further suicide UAVs on the Ukrainian front, of which the *Gerbera* system is particularly noteworthy, boasting a considerable range of approximately 300-600 km. The Islamic Republic of Iran, on the other hand, has not only the *Shahed-131*, *Shahed-136* and *Shahed-238* in service, but also other OWA UAVs from the same family, such as the *Shahed-107*, unveiled in 2024 and characterised by a range of 1,500 km. In addition to this, assets derived from the *Kian-1* and *Kian-2* suicide drones, currently in service and with operational ranges of approximately 1,000 km, are also being deployed. These include the *Arash 2*, an upgraded version of the *Kian-2* that entered service in 2020 and features an increased range of 2,000 km. Overall, however, it is worth noting that Iran has also carried out operational deployments of OWA UAV systems, against targets in Israel, US military bases in the Middle East and the Arab states of the Persian Gulf in large-scale attacks involving different families of platforms, conducted as part of Operations *True Promise I, II, III* and *IV*. Against this backdrop, the West's other two major near-peer competitors, the People's Republic of China and the Democratic People's Republic of Korea, have so far played a secondary role, although they are actively investing in the field of OWA UAVs. The PRC, first and foremost, has attracted attention for its recent efforts to create a replica of the Iranian *Shahed-136*, characterised by a further reduction in production costs per unit. The result of these efforts is the *Feilong-300D*, unveiled in early November 2025 and capable of striking targets up to 1,000 km away at a unit cost of just $10,000, factors which make it a significant threat given its ease of mass production. In conclusion, however, although the DPRK is devoting increasing resources to the development of suicide drones, no details are currently available regarding any long-range OWA UAV assets that are operational or under development.

Conclusions

Overall, the picture that emerges highlights the significant variety and scale of investment that the West's main near-peer competitors have devoted to the development of broad-spectrum long-range strike capabilities. These capabilities are, in fact, being structured with very careful consideration of various specific capability segments, ranging from hypersonic missiles to cruise missiles, and including OWA UAV systems, which, when integrated, have the potential to provide both general and selective saturation firepower capable of overwhelming modern integrated air defence and missile defence architectures. From this perspective, the tactics and methods of employing the aforementioned assets take on particular significance, as they have the potential to maximise and optimise their actual effectiveness.

A further element that emerges clearly from the analysis conducted concerns the stratification of emerging delivery systems by cost and performance categories, which is driven by a strategy of multi-level saturation of enemy defences. On the one hand, there is a proliferation of low-end assets, characterised by low production costs that allow them to be deployed in large numbers and, consequently, to generate swarms capable of depleting stocks of interceptors and overloading the adversary's Command and Control (C2) systems through the sheer volume of their attacks. On the other hand, we are witnessing the parallel development of high-end assets, highly specialised and technologically sophisticated, designed not for quantity but for the ability to selectively breach the most advanced and best-protected layers of IAMD architectures.

From this perspective, the variants of high-end assets under consideration, including MARVs, HGVs and HCMs, are particularly significant, as they highlight a now well-established trend towards the development of delivery systems capable of circumventing existing defences precisely in the highest tiers of the threat spectrum, traditionally considered the most resilient. These are systems which, by exploiting combinations of hypersonic speed, terminal manoeuvrability and non-ballistic or unpredictable trajectories, drastically reduce the reaction windows available to defence systems, imposing on the latter an interception cost that is disproportionately higher than the cost of developing and deploying the offensive delivery system itself. This economic asymmetry, whereby the burden of interception ends up weighing far more heavily on the defender than on the attacker, constitutes one of the most significant and worrying aspects of the current competitive dynamics, as it risks eroding, over time, the very sustainability of integrated defence architectures, regardless of their technological sophistication. In this context, cruise missiles continue to represent an intermediate and, in some respects, irreplaceable element within the threat spectrum, striking a balance between low-end and high-end delivery systems. Although they lack the extreme speed and manoeuvrability typical of hypersonic assets, they retain a high degree of operational effectiveness thanks to their precision, flexibility of deployment and ability to fly at low altitude, elements that allow for their synergistic integration with both swarms of low-end delivery systems and advanced high-end assets, thereby helping to form a complex, layered threat spectrum that is difficult to neutralise in its entirety.

It is precisely in this direction, moreover, that the stratification by cost bracket outlined thus far seems to naturally extend: the simultaneous availability of low-end, intermediate and high-end assets does not amount to a mere coexistence of alternative options, but rather to the possibility of their deliberate and coordinated combination within a single attack plan. Indeed, there is a growing trend towards the integrated use of various long-range delivery systems, through the synchronised or closely timed launch of ballistic and cruise missiles alongside swarms of OWA UAVs, to create an extremely complex threat picture that is difficult for enemy C2 systems to identify and respond to effectively.

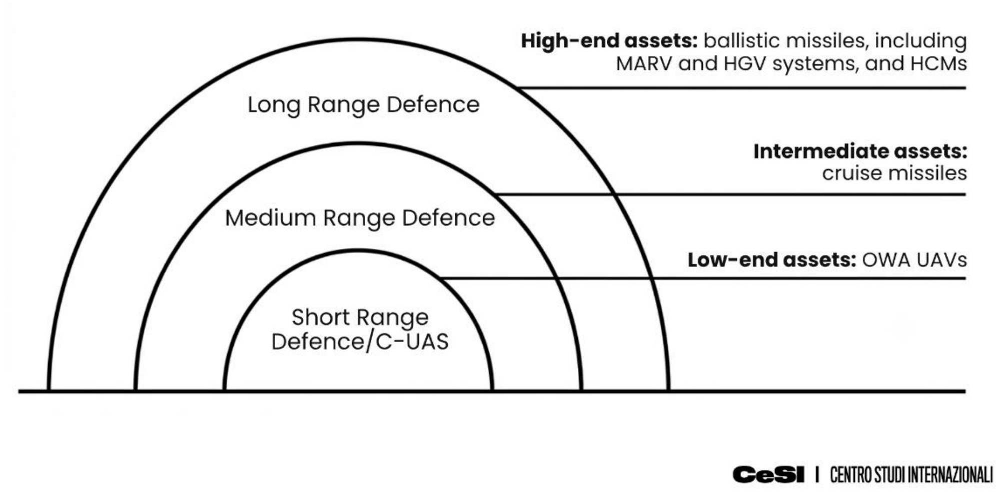

Figure 14 – Conceptual illustration of the diversification of attack vectors and the resulting implications for defensive architectures.

The emergence of this integrated operational paradigm ultimately has implications that go beyond the purely tactical level to encompass the strategic and doctrinal spheres as well. First and foremost, it requires a review of the principles governing the allocation and prioritisation of defence resources, which can no longer be planned based on single or homogeneous threat scenarios, but must necessarily take into account the simultaneous management of multiple and highly heterogeneous threat profiles. At the strategic level, the ability to plan and conduct combined multi-domain attacks requires a level of integration between the various components of the armed forces that represents a significant evolution from more traditional and sector-based operational models. The overall picture that emerges, therefore, seems to indicate that the true source of competitive advantage lies not exclusively in the technical performance of individual platforms but rather in the ability to synergistically orchestrate a diversified portfolio of offensive capabilities, capable of generating cumulative effects greater than the simple sum of the individual components deployed.

Author

Filippo Massacesi – Junior Fellow at the Defence and Security Desk of CeSI. Currently enrolled in the Master's Degree program in Global Security Policies at the University of Roma Tre, he earned his Bachelor's Degree in Strategic and Security Studies with honors at SUISS – Interdepartmental University School of Strategic Studies, University of Turin. After spending a period at the Theresan Military Academy in Wiener Neustadt (Austria), he successfully completed numerous national and European courses, including Common Modules at the Italian Army School of Application and advanced training programmes.

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