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Britain's hypersonic challenge: Strategic opportunities and risks

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New geostrategic thinking for a more competitive age
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Foreword

Across the world, we are seeing rapid transformation of the battlefield, with new technologies challenging the global balance of power. One such technology is hypersonic weapon systems, capable of flying at higher speeds and more manoeuvrable than conventional cruise and ballistic missiles. Hypersonic weapons have huge potential to enhance a nation's deep strike capabilities.

Alarmingly, the technological lead which Britain and other democratic nations have enjoyed since the end of the Cold War is narrowing, as a number of hostile states have started to develop cutting-edge weapons. This is true of hypersonic systems, where both Russia and the People's Republic of China (PRC) now claim to have deployable weapons. For as long as Britain lacks a comparable capability, these weapons weaken our strategic position and represent a direct threat to our national security.

Written by William Freer, an expert in national security, this Policy Paper explores what hypersonic weapons are, what systems are being developed, and why countries are acquiring them. The paper also examines why and how the UK should develop hypersonic weapons, as well as how our military might employ them to reinforce deterrence or strike the country's enemies more effectively.

This Policy Paper continues the pioneering work of the Council on Geostrategy's Strategic Advantage Cell, established to explore how Britain can induce 'strategic advantage' and strengthen its global standing in the 21st century. It helps identify how the government can enhance the lethality of our armed forces in a more contested and dangerous world.

Its conclusions and recommendations should be useful to our defence leadership and especially to those advising on the current Strategic Defence Review.

Sir Michael Fallon

Secretary of State for Defence, 2014-2017

Executive summary

- Hypersonic weapons travel at speeds greater than Mach 5 – five times the speed of sound – within the atmosphere for sustained periods, making them subject to intense physical strains. Such weapons are harder to defend against compared to less manoeuvrable ballistic missiles and slower cruise missiles. Critically, hypersonic weapons enhance deep strike capabilities, but they are very expensive to develop and produce.

- There has been growing focus on hypersonic weapons over the past few years, but interest in hypersonic technology is not new. It first began in the early years of the Cold War.

- Hypersonic weapons are not uniform; they can vary greatly in design, warhead, range, speed, launch platform, and a myriad of other factors. In terms of hypersonic missiles, there are two different types: Hypersonic Cruise Missiles (HCMs), which are essentially faster versions of supersonic cruise missiles, and Hypersonic Glide Vehicles (HGVs), which use a ballistic missile booster to reach the desired speed and altitude before the HGV separates and glides at high speed toward the target. In general, all hypersonic missiles combine, to varying degrees, high speed, long ranges, late detection (due to lower flight paths than ballistic missiles), and manoeuvrability. This combination of factors makes hypersonic weapons a potent capability, which could render even well defended targets vulnerable.

- Hypersonic weapons are starting to enter service with several of the United Kingdom's (UK) allies and adversaries. The United States (US), the People's Republic of China (PRC), and Russia are the furthest ahead in the development of hypersonic weapons – with some already in service. Broadly, the US has developed them to punch through adversaries' anti-access and area denial (A2/AD) bubbles. Russia has created them as a response to growing North Atlantic Treaty Organisation (NATO) missile defence capabilities. And the PRC has procured them to improve

the lethality of its A2/AD bubbles.

- There is a lack of clarity over the true capabilities of adversaries' hypersonic weapons. For certain, the PRC has fielded at least one type of HGV, known as the DF-ZF. Russia claims to have fielded a HGV known as Avangard and a HCM known as Zircon (which has been used in Ukraine but evidence shows Moscow has greatly exaggerated its true capabilities). The US has several different hypersonic programmes split between the Army, Air Force, and Navy with significant investments planned (around £5.3 billion has been requested for 2025). No US weapon is yet operational but several should be in service before the end of the decade; the first weapon – the Long-Range Hypersonic Weapon (LRHW) or 'Dark Eagle' – should enter service in 2025.

- There is a lack of clarity on how hypersonic weapons are best employed. One approach sees them used independently to strike deep within A2/AD bubbles; another sees them sequenced in wider strike packages – timing strikes of hypersonic and slower strike weapons to arrive at the same time. The latter negates the most significant advantages of hypersonic weapons and may not be justifiable when considering their cost, and simply acquiring less expensive strike weapons in greater quantities may yield better cost-benefit results. Considering their expense, there is also some lack of clarity on the optimal targets for hypersonic weapons – although over time, as hypersonic technology matures, costs will fall.

- The best use for hypersonic weapons, until costs fall, would be to use their improved survivability to attack well-defended components of an adversary's A2/AD bubble (such as radar installations and Surface-to-Air missile batteries). This would enable users to degrade enemy air defences faster and open up gaps in A2/AD bubbles for more vulnerable systems, available in greater quantities, to exploit.

- Future developments such as quantum technology, improved engine designs, space-based sensors, or novel means of interception, could make hypersonic weapons both more, or less,

effective. These innovations are part of the long established development and counter-development between missiles and missile defences.

- Britain plans to develop a sovereign hypersonic weapon, possibly by 2030. There is a framework in place which provides up to £1 billion of funding over seven years. Although there is a strong case for this approach, the current level of funding is trying to do too much with too little. Given the competing demands for investment within the British Armed Forces, the UK should explore options to purchase (or if possible licence produce) hypersonic weapons in the short-term. As the US is the only British ally with an advanced hypersonic development programme, this would mean looking to acquire this capability from American suppliers. Without properly resourcing sovereign development, procuring the most mature systems currently available is the optimal solution for acquiring an operational hypersonic strike capability in the short-term.

- As His Majesty's (HM) Government moves further into the Strategic Defence Review (SDR), it should include examination of the British approach to hypersonic weapons. If HM Government allocated significantly more funds for defence, the UK could pursue a sovereign hypersonic capability over the longer-term. This would also need to include significant investments into enablers and hypersonic infrastructure.

1.0 Introduction

Interest in hypersonic technology stretches back to the early Cold War. In the 1960s Britain in fact downgraded its involvement in hypersonic technology from a 'main commitment' to the 'minimum level' required for maintaining an interest in the field.[1] Interest waned because the technology was not mature enough, but was renewed following the September 11th attacks. Hypersonic weapons were seen by the US as a way to deliver prompt strikes against high-level terrorist targets, where opportunities to strike may be fleeting, anywhere in the world. But because of a combination of factors (such as cost-effectiveness), interest declined once more.[2]

As interest in the West went through this stop-start process, the PRC and Russia channelled resources in the 2010s into the development of their own hypersonic weapons.[3] A speech by Vladimir Putin, President of Russia, in 2018 announcing Russia's hypersonic weapons, shortly followed by the appearance of a Chinese hypersonic weapon in a military parade in 2019, generated a degree of alarm in free and open countries (including the UK) about falling behind.[4]

This Policy Paper is the third paper on hypersonic weapons produced by the Council on Geostrategy. This work has been developed through our Strategic Advantage Cell, dedicated to identifying and explaining how strategic advantage can be acquired. Its remit is to explore some of the most innovative and intractable questions facing British defence policy in a more contested world.

As HM Government moves further into the Strategic Defence Review (SDR), this paper explains what hypersonic weapons are, why countries are acquiring them, and what systems are currently being developed. It will provide an overview of what use the British Armed Forces might have for hypersonic weapons and will conclude with an

[1] 'Hypersonic Flight Research – Volume 765: debated on Thursday 23 May 1968', Hansard, 23/05/1968, https://hansard.parliament.uk/ (checked: 04/09/2024).
[2] David Wright and Cameron L. Tracy, 'Hypersonic Weapons: Vulnerability to Missile Defences and Comparison to MaRVs', *Science and Global Security*, 31:3 (2023).
[3] For an overview of the how the hypersonic research landscape has evolved in China see: Geoffrey Chambers, 'An Exploratory Analysis of the Chinese Hypersonics Research Landscape', China Aerospace Studies Institute, 05/12/2022, https://www.airuniversity.af.edu/ (checked: 04/09/2024).
[4] Richard Stone, 'National Pride is at Stake - Russia, China, United States rush to build hypersonic weapons', *Science*, 08/01/2020, https://www.science.org/ (checked: 04/09/2024).

exploration of the UK's current approach to developing hypersonic strike capability.

2.0 Hypersonic weapons: Definition, doctrine and defences

A previous Explainer from the Council on Geostrategy covers the background information on hypersonic weapons in more detail, but this paper will provide a brief recap.[5] There is no definitive definition of a hypersonic weapon, but there is a great deal of consensus as to the key attributes. Hypersonic speed is classified as Mach 5 and above, five times the speed of sound.[6] Yet ballistic missiles can travel in excess of Mach 5 for parts of their flight, so there are additional factors at play. The key factor is that hypersonic weapons are capable of travelling in excess of Mach 5 for sustained periods *within* the atmosphere. This is different from ballistic missiles which only achieve temporary hypersonic speeds, and many of which spend much of their flight time beyond the atmosphere. There are often other elements attached to this base definition, particularly the ability to execute complex manoeuvres.[7]

The reason that travelling within the atmosphere at such speed for a sustained period is significant is because it exposes the missile to tremendously difficult conditions. The most important of these is extreme heat due to friction with the air and the shockwaves produced.[8]

It is important to note at this point that there is no sudden change in physical conditions at Mach 5 in the way that there is at Mach 1 (i.e., the sound barrier) and that the Mach 5 classification is somewhat arbitrary. The heating effects appear before Mach 5, and it is only at temperatures of 4,000 Kelvin (roughly 3,700°C) that the heating becomes so severe a layer of plasma begins to engulf the weapon (making it hard for the missile to send or receive signals).[9]

[5] Gabriel Elefteriu and William Freer, 'Hypersonic Weapons: High Expectations', *Council on Geostrategy*, 05/12/2023, https://www.geostrategy.org.uk/ (checked: 04/09/2024).
[6] 'U.S. Hypersonic Weapons and Alternatives', Congressional Budget Office (US), 31/01/2023, https://www.cbo.gov/publication/ (checked: 04/09/2024).
[7] Kolja Brockmann and Dr Markus Schiller, 'A matter of speed? Understanding hypersonic missile systems', Stockholm International Peace Research Institute, 04/02/2022, https://www.sipri.org/ (checked: 04/09/2024).
[8] 'Hypersonic Missiles', UK Parliament Postnote: Number 696, 26/06/2023, https://researchbriefings.files.parliament.uk/ (checked: 04/09/2024).
[9] 'U.S. Hypersonic Weapons and Alternatives', Congressional Budget Office (US), 31/01/2023, https://www.cbo.gov/publication/ (checked: 04/09/2024).

The development of hypersonic weapons can be split into two different systems – Hypersonic Cruise Missiles (HCMs) and Hypersonic Glide Vehicles (HGVs). HCMs are similar to subsonic, and supersonic, cruise missiles in that they fly in a powered non-ballistic trajectory. A difficulty with designing and developing HCMs is their engines, they require either a ramjet or a scramjet to reach high speeds. The speeds ramjets are capable of are limited to around Mach 6, whereas a scramjet would enable speeds well in excess of Mach 5.[10] Both types of engines only work at high speed and require a booster rocket to get up to the necessary speed. Scramjets require higher speeds than ramjets due to the air pressure needed to function. Scramjets must also maintain an altitude of around 12.5 miles, and are highly sensitive to changes in air flow.[11] With a HGV, a glide vehicle is launched from a large booster, once it has reached the desired speed and altitude the glide body separates and glides at altitudes of 20-50 miles towards the target before diving in the terminal phase.[12]

Box 1 below explains the key advantages which hypersonic weapons have over other systems. Indeed, some (such as Putin) have claimed that hypersonic weapons are invulnerable to all existing defences.[13] However, while it is true that such weapons are more difficult to defend against, as an evolution as opposed to revolution in missile technology, they are by no means unstoppable.

Some missile defence systems already possess a nascent counter-hypersonic capability. These include the Terminal High Altitude Area Defence (THAAD), Aegis, Patriot, and Long Range Discrimination Radar (LRDR) missile defence systems originally designed to intercept ballistic missiles.[14] Upgrading existing systems and exploring new ones, particularly through the lens of Integrated Air

[10] 'Hypersonic Missiles', UK Parliament Postnote: Number 696, 26/06/2023, https://researchbriefings.files.parliament.uk/ (checked: 04/09/2024).
[11] Sidharth Kaushal, 'The Zircon: How much of a threat does Russia's hypersonic missile pose?', Royal United Services Institute, 24/01/23, https://www.rusi.org/ (checked: 04/09/2024).
[12] 'Hypersonic Missiles', UK Parliament Postnote: Number 696, 26/06/2023, https://researchbriefings.files.parliament.uk/ (checked: 04/09/2024).
[13] Robert Coalson and Carl Schrek, 'Putin's "State of the Nation" Speech', *Radio Free Europe*, 01/03/2018, https://www.rferl.org/ (checked: 04/09/2024).
[14] Alexander H. Montgomery and Amy J. Nelson, 'Ukraine and the Kinzhal: Don't Believe the Hypersonic Hype', Brookings Institute, 23/05/2023, https://www.brookings.edu/ (checked: 04/09/2024).

and Missile Defences (IAMD), will also improve the probability of detecting, tracking and successfully intercepting hypersonic weapons.[15]

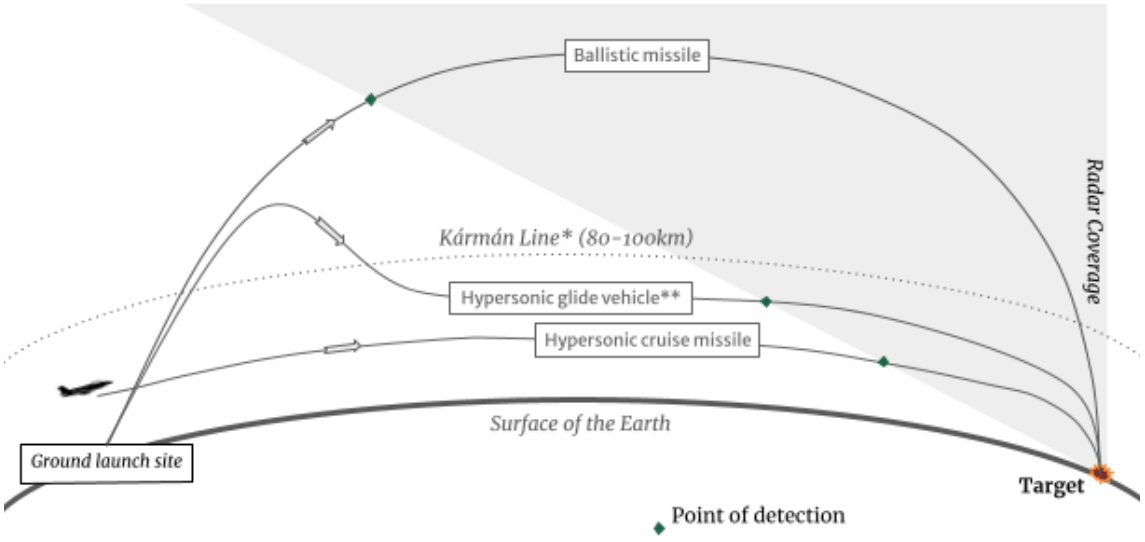
Box 1: Why acquire hypersonic weapons?

In theory, hypersonic weapons bring a slew of advantages in a single system over existing weapons (such as subsonic and supersonic cruise missiles) which explain why some states are willing to invest in them despite the high costs. Hypersonic weapons bring together the following attributes:

- **High speed:** They compress the time a target has to react. This can be useful for targets of fleeting opportunity and it makes it harder for adversaries to intercept the missile.
- **Long range:** This will not necessarily be true of all hypersonic weapons, but HGVs in particular have very long ranges.[16] Through their high speed, hypersonic weapons have the ability to overcome these long ranges in a matter of minutes, giving mobile targets less time to relocate out of range.
- **Late detection:** Owing to having a lower apogee – the highest point of the flight path – than ballistic missiles, hypersonic weapons will be detected later (see: Diagram 1), giving less time for the target to react.[17] Though this can be mitigated by layered detection systems.
- **Manoeuvrability:** Although less manoeuvrable than slower cruise missiles, hypersonic weapons are more manoeuvrable than ballistic missiles (although this can be compensated to an extent by providing ballistic missiles with Manoeuvrable Reentry Vehicles).[18] This makes it harder to track them and allows the hypersonic weapon to take unpredictable routes, generating confusion as to the intended target.

[15] IAMD is a concept which unites multiple capabilities to protect a given area against rapidly advancing air and missile threats. It requires a wide array of sensors, soft kill, and hard kill systems to be closely networked to rapidly evaluate and intercept inbound threats.
[16] James M. Acton, 'China's Ballyhooed New Hypersonic Missile Isn't Exactly a Game Changer', Carnegie Endowment for International Peace, 04/10/2019, https://carnegieendowment.org/ (checked: 04/09/2024).
[17] 'U.S. Hypersonic Weapons and Alternatives', Congressional Budget Office (US), 31/01/2023, https://www.cbo.gov/publication/ (checked: 04/09/2024).
[18] David Wright and Cameron L. Tracy, 'Hypersonic Weapons: Vulnerability to Missile Defenses and Comparison to MaRVs', *Science and Global Security*, 31:3 (2023).

Diagram 1: Example missile trajectories and radar coverage



(Diagram not to scale)
*The Kármán Line is the area of transition between the Earth's atmosphere and outer space
** The apogee of a hypersonic glide vehicle can come within the atmosphere

3.0 Existing hypersonic strike programmes: Friends and foes

Examining what allies and adversaries are pursuing can provide useful ideas as to what the UK itself could pursue. The key takeaway should be that hypersonic weapons are not uniform; there is a lot of variety (as shown in Figures 1 and 2 below) in terms of size, range, and launch platforms as well as a myriad of other factors.

3.1 US

Of all the UK's allies, the US has by far the most developed hypersonic weapons programmes. The US has long had an interest in hypersonic technology, particularly in relation to NASA activity. But in reaction to Chinese and Russian progress the US has begun to throw significant resources behind hypersonic weapons. The US Department of Defence will have invested around US$21 billion (£17 billion) on its hypersonic weapons programmes between 2020 and 2027; this is in addition to additional investment made through NASA into hypersonic R&D.[19]

This sum represents a significant commitment amidst other pressing needs, highlighting the US's intent to become a key hypersonic player. The US approach has been to spread this money between several projects, looking to cancel those which show less promise and feed lessons into the more promising projects. The key US hypersonic weapons in development include:

- **ARRW (Air-launched Rapid Response Weapon):** An air-launched HGV with a range in the region of 620 miles.[20] It has been designed to be launched from the B52 strategic bomber, but there were also discussions to adapt the F-15 fighter to carry it. The

[19] 'US Hypersonic Weapons and Alternatives', Congressional Budget Office (US), 31/01/2023, https://www.cbo.gov/publication/ (checked: 04/09/2024).
[20] *Ibid.*

status of the programme remains unclear; Congress cut funding in 2023, but since then further tests have taken place.[21]

- **CPS (Conventional Prompt Strike):** A US Navy missile designed to carry the Common Hypersonic Glide Body (C-HGB) HGV. It is designed to be launched from naval platforms, with initial plans to launch it from large Vertical Launch System (VLS) cells on the Zumwalt class destroyers, with testing due to take place in 2025.[22] It is estimated to have a range in the region of 1,700 miles.[23] CPS is expected to become operational after 2027 and the development phase could total over US$9 billion (£7 billion).[24]
- **LRHW (Long-Range Hypersonic Weapon):** The LRHW shares the C-HGB with the CPS, but is being designed for the US Army for ground-based launchers.[25] The LRHW is the closest to operational deployment of all the American hypersonic projects and the development phase will have cost approximately US$5.3 billion (£4.2 billion), with unit costs for All Up Rounds (AURs) estimated to be around US$41 million (£32 million).[26] The US plans to field six batteries of four transporter-erectors each carrying two missiles.[27]
- **HALO (Hypersonic Air Launched Offensive, Anti-Surface):** A HCM under development with the US Navy. It is designed to provide a medium/long range anti-surface missile that can be launched from carrier-based aviation. It is expected to enter service later this decade and the focus for now is on developing technologies which allow for increased range.[28] However, the US Navy has recently commented that it may not cross the Mach 5 threshold.[29]

[21] Zuzanna Gwadera, 'The end of the US Air Force's ARRW hypersonic programme', International Institute for Strategic Studies, 30/11/2023, https://www.iiss.org/ (checked: 04/09/2024).
[22] Kelley M. Sayler, 'Hypersonic Weapons: Background and Issues for Congress', Congressional Research Service (US), 09/02/2024, https://sgp.fas.org/ (checked: 04/09/2024).
[23] 'US Hypersonic Weapons and Alternatives', Congressional Budget Office (US), 31/01/2023, https://www.cbo.gov/publication/ (checked: 04/09/2024).
[24] *Ibid.*
[25] Kelley M. Sayler, 'The U.S. Army's Long-Range Hypersonic Weapon (LRHW)', Congressional Research Service (US), 15/09/2023, https://crsreports.congress.gov/ (checked: 04/09/2024).
[26] *Ibid.*
[27] *Ibid.*
[28] Lee Willet, 'HALO Programme Accelerates US Navy Hypersonic Capability Drive', *Naval News*, 05/09/2022, https://www.navalnews.com/ (checked: 04/09/2024).
[29] Jon Harper, 'Navy's future HALO "hypersonic" missile might not actually be hypersonic', *Defense Scoop*, 03/04/2023, https://defensescoop.com/ (checked: 04/09/2024).

- **HACM (Hypersonic Attack Cruise Missile):** A HCM which is a successor to the Hypersonic Air-breathing Weapon Concept (HAWC) and the Southern Cross Integrated Flight Research Experiment (SCIFiRE – a joint US-Australian project). The project is in its very early stages and, with the cut to funding for the ARRW, is the only US Air Force hypersonic programme still in development. The HAWC programme was focused on the development of scramjet technology.[30]
- **Mako:** Unveiled by Lockheed Martin in April 2024, the Mako is a solid-rocket motor-powered ground attack hypersonic weapon.[31] It is small enough to fit within the internal weapons bays of F35A and F35C variants of the Lightning II Joint Combat Aircraft and is compatible with essentially any aircraft with 30 inch lugs. The possibility of launching Mako from the Vertical Launch Systems (VLS) on warships is also being explored. In using a solid rocket motor propellant, Mako should be considerably more affordable than other hypersonic weapons (ramjet/scramjet engines are a key cost driver). Further details, such as on range and speed, are yet to be publicly revealed.

3.2 PRC

The PRC's focus on hypersonic weapons is part of a desire to increase the lethality at range of the Chinese A2/AD bubble and a reaction to the strength of US missile defences. The PRC's hypersonic weapons are primarily designed to provide long-range strike with improved chances of penetrating defences – compared to the PRC's already impressive ballistic missile arsenal – against hostile bases and naval forces operating in the western Pacific. Key programmes include:

- **DF-ZF:** a HGV first tested in 2014 and deployed in 2019. It is estimated to have a range of 1,200 miles when launched from the DF-17 and somewhere in the region of 3,100-4,900 miles when launched from the DF-27 (and even further if launched from the DF-41 which is reportedly being tested): the DF-17, DF-27, and

[30] 'US Hypersonic Weapons and Alternatives', Congressional Budget Office (US), 31/01/2023, https://www.cbo.gov/publication/ (checked: 04/09/2024).
[31] Thomas Newdick, 'The Lowdown On Lockheed's Newly Revealed Mako Hypersonic Missile', *The Warzone*, 11/04/2024, https://www.twz.com/ (checked: 04/09/2024).

DF-41 being ballistic missiles.[32] The DF-ZF has been monitored executing complex manoeuvres.[33] The PLA has claimed the DF-ZF is capable of reaching speeds of Mach 10 and can hit slow moving targets.[34] It is launched by truck-based canisters hidden across the PRC.

- **DF-100:** It is not clear whether the DF-100 is a hypersonic weapon. It is evidently a new long-range cruise missile under development which some have described as a 'hypersonic, regional level anti-ship missile.'[35]
- **YJ-21:** It is also unclear as to what exactly the YJ-21 is. All that is known for certain is that it is ship and air launched (it has been monitored launching from the Type 055 Renhai class cruiser, and the H-6K bomber has been photographed carrying one) and is most likely an anti-ship weapon.[36] Various observers have termed the YJ-21 as a ballistic missile or a hypersonic weapon.[37]

[32] Kartik Bommakanti, 'Advances in Chinese missile defence and hypersonic capabilities', Observer Research Foundation, 19/06/2023, https://www.orfonline.org/ (checked: 04/09/2024).
[33] Kelley M. Sayler, 'Hypersonic Weapons: Background and Issues for Congress', Congressional Research Service (US), 09/02/2024, https://sgp.fas.org/ (checked: 04/09/2024).
[34] 'Today's missile threat: China', Missile Defense Advocacy Alliance, 13/01/2023, https://missiledefenseadvocacy.org/ (checked: 04/09/2024).
[35] Larry M. Wortzel, 'Hypersonic weapons development in China, Russia and the United States: Implications for American Security Policy', Association of the United States Army, 23/03/2022, https://www.ausa.org/ (checked: 04/09/2024).
[36] Zachary Williams, 'Takeaways From China's Zhuhai Air Show 2022: Real gains were shown in China's missile, radar, unmanned systems, and fighter technology', *The Diplomat*, 21/11/2022, https://thediplomat.com/ (checked: 04/09/2024).
[37] Tayfun Ozberk, 'China Test-Fires New YJ-21 Hypersonic Missile', *Naval News*, 20/04/2022, https://www.navalnews.com/ (checked: 04/09/2024).

3.3 Russia

Russia's pursuit of hypersonic weapons is also a reaction to the sophisticated missile defences it faces. The Russians envision hypersonic weapons as a way both to improve their ability to strike well defended targets and increase the range at which they can hold valuable assets at risk of strike: a continuation of their doctrine of 'Active Defence.'[38]

It is important to note at this point that many analysts term the Kinzhal missile as a hypersonic weapon (because the Russians themselves do) but, although it shares some characteristics with hypersonic weapons, this is not the case; it is an aero-ballistic missile – an air-launched variant of the Iskander-M.[39] Russia's programmes include:

- **Avangard:** A HGV, which Russia claims has entered service. It is deployed on the SS-19 Intercontinental Ballistic Missile (ICBM), but Russia plans to deploy it on the more modern Sarmat ICBM.[40] The Kremlin intends to generate two missile regiments (of around 10 launchers per regiment).[41] Russia has made bold claims about the Avangard, which it says has a top speed in excess of Mach 20 and a range of 3,700 miles.[42] Considering it has allegedly been in service for several years, and no one has actually ever seen one beyond an artist's impression, it is fair to say that these claims are either false or greatly exaggerated.[43]
- **Zircon/Tsirkon:** An anti-ship HCM with secondary land-attack capabilities. It has been used against Ukraine and it is deployed on several surface warships. Russia is trialling them with the new Yasen and older Oscar class submarines; combining the stealth of submarines with the high-speed of the missile and compressing

[38] William Freer, 'The hypersonic threat to the United Kingdom', Council on Geostrategy, 25/01/2024, https://www.geostrategy.org.uk/ (checked: 04/09/2024).
[39] John T. Watts, Christian Totti, and Mark J. Massa, 'Primer on Hypersonic Weapons in the Indo-Pacific Region', Atlantic Council, 15/08/2020, https://www.atlanticcouncil.org (checked: 04/09/2024).
[40] Roger Mcdermott, 'The role of hypersonic weapons in Russian Military Strategy', The Jamestown Foundation, 04/02/2022, https://jamestown.org/ (checked: 04/09/2024).
[41] *Ibid.*
[42] Steve Brown, 'Russia Demonstrates Avangard Hypersonic Missile – Here's What You Need to Know', *Kyiv Post*, 16/11/2023, https://www.kyivpost.com/ (checked: 04/09/2024).
[43] *Ibid.*

reaction time for potential targets even further.[44] Once more, however, Russian claims are excessive.[45] The Kremlin claims the Zircon has a top speed of over Mach 9 (and it has claimed to have developed an operational scramjet to reach these speeds) and a range of over 600 miles.[46] However, there are several factors to consider when evaluating these claims. Initial test footage shown by the Russians was later found to be an older missile – the P-800 Oniks.[47] In addition, more than once images of wreckage have emerged such as the footage posted by the Kyiv Scientific Research Institute of Forensic Expertise.[48] Interestingly, there are no indications of a scramjet, and in the Zircon in fact looks very similar to the Oniks; it is now clear the Zircon is not scramjet-powered, as claimed, and is potentially a derivative of the Oniks (capable of Mach 2.6). As such, the Zircon may be capable of exceeding Mach 5 (which could be achieved through a long and shallow dive), but is very unlikely to reach anywhere near Mach 9.

Beyond the US, the PRC and Russia, several other countries have begun to explore hypersonic weapons. France (conducting the first test of its VMAX HGV in June 2023), India, Japan (conducting the first test of its Hyper-Velocity Gliding Projectile in 2024), South Korea, North Korea and Iran are often seen as states in pursuit of hypersonic programmes.[49]

[44] Roger Mcdermott, 'The role of hypersonic weapons in Russian Military Strategy', The Jamestown Foundation, 04/02/2022, https://jamestown.org/ (checked: 04/09/2024).
[45] *Ibid*.
[46] Evan Braden Montgomery and Toshi Yoshihara, 'Speeding towards instability: Hypersonic weapons and the risks of nuclear use', Centre for Strategic and Budgetary Assessments, 28/04/2023, https://csbaonline.org/ (checked: 04/09/2024).
[47] Sidharth Kaushal, 'The Zircon: How much of a threat does Russia's hypersonic missile pose?', Royal United Services Institute, 24/01/23, https://www.rusi.org/ (checked: 04/09/2024).
[48] 'Kyiv Scientific Research Institute of Forensic Expertise confirmed the use of the Zircon hypersonic missile during Russia's missile attack on Kyiv', *Militarynyi*, 12/02/2024, https://mil.in.ua/ (checked: 04/09/2024).
[49] 'Hypersonic Flight Research – Volume 765: debated on Thursday 23 May 1968', *Hansard*, 23/05/1968, https://hansard.parliament.uk/ (checked: 04/09/2024).

Figure 1: US ARRW under the wing of a B52 in Guam (left) and Figure 2: NASA's X-43 experimental scramjet powered hypersonic vehicle (right)

Source: Defence Visual Information Distribution Service. The appearance of US Department of Defence visual information does not imply or constitute DoD endorsement.

4.0 The future of hypersonic weapons

Given the advances to date hypersonic weapons, and counter-hypersonic capabilities, will mature over time. Some of these developments may render hypersonic weapons more effective, overcoming key drawbacks (such as the plasma effect or the difficulties of introducing a reliable scramjet), but they may also do the opposite and render hypersonic systems less effective (for example novel means for interception or improved satellite detection and tracking).[50]

If the current problems which hold back scramjet designs (e.g., ensuring the airflow is stable for prolonged flight, particularly if the missile is executing manoeuvres) can be overcome and costs reduced, then scramjet powered HCMs capable of over Mach 6 (the rough ceiling for ramjet powered missiles) would be more feasible.[51] However, although the improved speed would have some benefits – time to target and the extra difficulty for 'kill vehicles' to hit the missile being the most obvious – there would be limitations. Supersonic and subsonic cruise missiles, with their ability to hug the terrain (though this requires a much greater level of mission planning which takes time), could prove similarly hard to detect for far less cost, particularly if they have stealth features.

Other developments could come from computing improvements. Quantum technology, though still in its infancy, may help hypersonic systems to hit moving targets. The sheath of plasma which envelopes the missile at higher speeds (particularly from around Mach 10 and over) makes it very difficult for sensors, and communications, to work through the plasma layer. Quantum technology could aid in rapid target acquisition. Quantum technologies could also reduce the ability of stealth aircraft and submarines to go undetected, in which case the ability to strike within A2/AD bubbles would become more reliant on long-range missiles.[52]

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[50] Tom Karako and Masao Dahlgren, 'Complex Air Defence: Countering the Hypersonic Missile Threat', Centre for Strategic and International Studies, 06/02/2022, https://csis-website.com/ (checked: 04/09/2024).
[51] 'Hypersonic Weapons: DOD Could Reduce Cost and Schedule Risks by Following Leading Practices', United States Government Accountability Office, 25/07/2024, https://www.gao.gov/ (checked: 04/09/2024).
[52] Michiel van Amerongen, 'Quantum technologies in defence & security', *NATO Review*, 03/06/2021, https://www.nato.int/ (checked: 04/09/2024).

Counter-hypersonic capabilities will continue to develop alongside hypersonic weapons and could render them vulnerable. Already, certain existing air and missile defence systems possess some ability to intercept hypersonic weapons and these systems will be upgraded over time. Developments could come from faster interceptors, better radars, more layered defences, and the introduction of more and improved space based sensors (which the US has been investing in recently with their Hypersonic and Ballistic Tracking Space Sensor network).[53] Over time, novel means for interception could prove cost-effective, for example Directed Energy Weapons (DEW) could be one such avenue: lasers of around 50-100 kW are capable of engaging uncrewed aircraft systems, of around 300 kW could engage cruise missiles, and lasers of 1 MW could potentially engage ballistic missiles and hypersonic weapons.[54]

Proliferation is also an important consideration. There was a time, during the Cold War, when ballistic missiles were the sole remit of the richest and most advanced countries, but today many states – and even some non-state actors as seen with the Houthis – possess ballistic missiles. Over time, there will be a proliferation of hypersonic weapons; in the very least, this would necessitate investment by the UK in counter-hypersonic systems, especially through the lens of IAMD. Britain should not fall behind in IAMD in the way it did on Ballistic Missile Defences (BMD). The Royal Navy's Type 45 destroyers are only now receiving limited BMD capabilities, more than two decades after the US introduced the BMD Aegis Combat System.[55]

[53] Masao Dalghren,'Getting on Track: Space and Airborne Sensors for Hypersonic Missile Defence', Centre for Strategic and International Studies, 18/12/2023, https://csis-website.com/ (checked: 04/09/2024).
[54] Kelley M. Sayler, 'Defence Primer: Directed-Energy Weapons', Congressional Research Service (US), 07/05/2024, https://crsreports.congress.gov/ (checked: 04/09/2024).
[55] 'Upgrading the Royal Navy's Type 45 Destroyers', *Navy Lookout*, 04/04/2022, https://www.navylookout.com/ (checked: 04/09/2024).

5.0 Strategic advantage: The case for British hypersonic weapons

Developing hypersonic weapons is a costly, high risk and long-term commitment. This begs two questions: Does the UK need such weapons in the first place? And in what scenarios might they provide enough utility to justify the costs of development and procurement?

Due to their speed and survivability, hypersonic weapons would certainly provide the UK with a weapons system to help deter aggressors. They would contribute to maintaining a strong armed forces to continue providing a centre of gravity to allies. Something which Britain can leverage to assert leadership and shape the international order in accordance with its own interests.

Where hypersonic weapons may have particular utility is in the way they may generate 'strategic advantage' for the UK. Strategic advantage was the third element of the Integrated Review Refresh (IRR) framework; first mentioned in the Integrated Review of 2021, it was unpacked in the IRR as: 'the UK's relative ability to achieve our objectives compared to our competitors' by 'cultivating the UK's strengths.'[56] Taking this term as a starting point, the Council on Geostrategy has built on the IRR's definition to develop this understanding further (see: Box 2).[57]

[56] *Ibid*.
[57] Gabriel Elefteriu, William Freer and James Rogers, 'What is strategic advantage?', Council on Geostrategy, 23/11/2023, https://www.geostrategy.org.uk/ (checked: 04/09/2024).

Box 2: Strategic Advantage

In the Primer entitled 'What is strategic advantage?', the Council on Geostrategy defined strategic advantage as:

The ability to induce catalysts to help secure, more efficiently and effectively, national objectives. It is derived from catalysing the resources and instruments at the country's disposal, in other words, its national strengths, to generate a strategic effect which is more potent than if the catalysts had not been devised.[58]

This definition is further expanded by a typology which divides strategic advantage into four forms, which are not mutually exclusive:

- **Amplifiers**, which increase strategic effect;
- **Multipliers**, which broaden strategic impact;
- **Accelerators**, which speed up strategic success;
- **Extenders**, which further strategic reach.

5.1 Deterring adversaries

There is growing debate over how hypersonic weapons are best employed. For example, one approach could be to sequence hypersonic strikes with a wider attack where a well defended enemy is saturated by other threats, allowing the hypersonic weapon to charge through and deliver the killing blow. However, using this approach hypersonic weapons would not generate strategic advantage: in this case, slower weapons already in the UK's arsenal would amplify (make more potent) the capabilities of hypersonic systems rather than vice versa. More mass to overwhelm the target would have the same (and likely a more cost-effective) result. And given how close launch platforms would have to be to enable shorter range strike weapons to be sequenced, and the dangers of venturing too deep within A2/AD bubbles, this approach would not allow hypersonic weapons to make the most of their capabilities.

[58] *Ibid.*

An alternative approach, one which would generate strategic advantage, would be to launch hypersonic strikes at range to try to evade defences and strike high value targets, particularly at the outset of hostilities. In this way, hypersonic strikes against key A2/AD assets themselves such as radars, missile launchers and air/naval bases would then open up the way for more vulnerable platforms and weapons to exploit the initial gaps created. This would accelerate considerably the efforts to suppress enemy A2/AD networks.

As per the IRR, the UK faces two systemic competitors: Russia in the Euro-Atlantic and the PRC in the Indo-Pacific, although Russia has a Pacific presence and the PRC is growing its presence in the Euro-Atlantic. Both have demonstrated the resources and will to pose a threat to the prevailing international order. Hypersonic weapons could provide the UK with an additional means to deter them, while simultaneously maintaining the credibility of Britain's Armed Forces in the face of the growing capabilities of adversaries.

In the case of the Indo-Pacific, it is almost impossible to imagine that Britain would find itself in a serious conflict in the region apart from alongside the US. In such a scenario,the UK best aids efforts to maintain deterrence by working closely with regional allies and partners.

A key element of this would be the ability to hold the PLA Navy (PLAN) at risk were it to leave port during a conflict, as PLAN warships themselves form a key part of the PRC's A2/AD strategy. However, given the fact that the PLAN has a relative deficiency in anti-submarine warfare (ASW) capabilities, it is likely that nuclear-powered submarines would provide the optimal solution in the near to medium term, contributing to deterrence by denial by threatening the ability to degrade the PLAN at sea.[59] Of course, hypersonic missiles capable of being launched by submarines would amplify the already potent threat of stealthy and long-endurance nuclear powered submarines themselves. Yet the PLAN will improve its ASW capabilities over time, and therefore investing in ship-launched hypersonic weapons to provide the Royal Navy with long-range punch when operating in the Indo-Pacific may be one way of hedging against this potential development.

[59] Andrew S. Erickson, 'Chinese undersea warfare: Development, capabilities, trends', *Andrew Erikson blog,* 05/05/2023, https://www.andrewerickson.com/ (checked:04/09/2024).

Ground based launchers in the region, in theory, could make a similar contribution to deterrence by denial, but this would require basing rights with local countries. This could prove very difficult to negotiate and even if these basing rights could be negotiated, there is no guarantee the host nation allows you to fire the weapon from their territory should the need arise.

When it comes to deterring Russia, there is an even stronger case for the utility of British hypersonic weapons. The potential for conflict between NATO and Moscow is the highest it has been since the Cold War, and many officials have warned that there is a real risk of war in the next few years.[60] Although, due to the 'Pax Atomica' (the relative peace established due to the threat of nuclear annihilation) these warnings may be alarmist.

The addition of hypersonic weapons to the British arsenal would amplify the conventional deterrent. Unlike in the Indo-Pacific scenario, Russia's A2/AD bubble by virtue of geography is 'forward deployed' and extends over NATO territory. In the event of a war it could prove costly for NATO to punch its way through or dismantle Russia's air defences. In such a conflict, hypersonic weapons could perform three useful functions in terms of delivering strategic advantage. The first would be to extend Britain's striking reach by holding high-value strategic targets (such as air bases or command centres) at threat, even deep within Russia. The second would be to launch hypersonic strikes from a safe distance on well defended and/or time-sensitive targets deployed close to the frontline (such as headquarters and supply dumps) to blunt the initial combat capability of Russian land forces before their A2/AD bubble has been adequately degraded. The third, and most important, would be to accelerate the degradation of Russia's A2/AD bubble for more vulnerable systems to exploit.

The need for the UK to acquire hypersonic weapons will grow over time as the US will focus more on the Indo-Pacific, reducing the likelihood of the US deploying its hypersonic weapons in Europe (or in significant numbers). The US does plan to deploy 'long-range fires' to Germany from 2026 which will include 'developmental hypersonic weapons' (presumably meaning at least one LRHW battery), but these plans can change.[61] British hypersonic weapons would increase the UK's

[60] Nicolas Camut, 'Putin could attack NATO in "5 to 8 years," German defence minister warns', *Politico*, 19/01/2024, https://www.politico.eu/ (checked: 04/09/2024).
[61] Jen Judson, 'US to send Tomahawks, hypersonics, other long-range fires to Germany', *DefenseNews*, 10/07/2024, https://www.defensenews.com/ (checked: 04/09/2024).

influence within NATO and provide the alliance with a more resilient hypersonic strike capability to deter Russia even if the US focuses its own hypersonic weapons on a PRC contingency. Though it must be recognised that the needs of rebuilding Britain's stockpiles of other, less expensive, long-range weapons would need to be factored into any decision made.

A US which was less focused on NATO could also impact the nuclear balance in Europe. Russia possesses the largest nuclear weapons stockpile in the world, including significant tactical delivery options.[62] Without the US, it is possible (though unlikely) Russia might change its calculations on nuclear deterrence if it was left to the smaller British and French arsenals. Investing in nuclear armed hypersonic weapons with improved chances of surviving missile defences could be one way to amplify the UK's nuclear deterrence and rebalance this calculation. But, in terms of strategic nuclear deterrence this is not worth pursuing. Russia is unlikely to make this calculation in the first place given it only takes a very small number of nuclear weapons to make it through to deliver devastating – and crucial for effective deterrence, *unacceptable* – destruction. There is also a risk in mixing nuclear strategic nuclear weapons with multiple and dual-use delivery systems, it makes it difficult for the adversary to know if they are under nuclear attack and heightens the risk of miscalculation. It would be more cost-effective for the UK to amplify its deterrence by expanding the current number of warheads deployed on Trident missiles. Initially, it was believed hypersonic weapons could have a significant impact on strategic nuclear deterrence but this thinking is being challenged.[63]

Hypersonic systems could, however, amplify nuclear deterrence in a different way. They could make for an effective delivery system for 'tactical' nuclear weapons should HM Government decide to re-acquire this capability, to close the current gap on the escalation ladder.[64]

[62] Claire Mills, 'Overview: Where are all the world's nuclear weapons?', House of Commons Library (UK), 28/07/2022, https://researchbriefings.files.parliament.uk/ (checked: 04/09/2024).
[63] For some of the latest thinking along these lines see: Evan Braden Montgomery and Toshi Yoshihara, 'Speeding towards instability: Hypersonic weapons and the risks of nuclear use', Centre for Strategic and Budgetary Assessments, 28/04/2023, https://csbaonline.org/ (checked: 04/09/2024).
[64] The UK currently lacks tactical nuclear weapons delivery systems, but its adversaries possess them. This could result in a situation where, in response to an adversary deploying a tactical nuclear weapon, Britain's only response option would be to employ a strategic nuclear delivery system (Trident). Even if only one warhead was used, as Trident can carry multiple warheads, the target country may read this as the beginning of a larger strategic nuclear attack.

However, this paper is not the right place to explore Britain's lack of tactical nuclear weapons and a discussion on whether or not it should re-acquire them will not be explored here.

In sum, there is a case for Britain acquiring long-range conventionally armed hypersonic weapons. They would generate strategic advantage primarily via their ability to degrade the A2/AD bubbles of adversaries, but also through their ability to hit high-value targets within them, and by holding long-range targets at increased risk.

5.2 Recent hypersonic developments in the UK

HM Government has already recognised the growing need for hypersonic weapons. A 'Hypersonic Technologies and Capability Development Framework' (which this paper will refer to as the Hypersonic Framework from now on) has been developed.[65] The key details include up to £1 billion of funding to cover the period 2023-2030, with the work being divided into three possible strands of: Buy a HGV via AUKUS; Collaborate into existing or new international development projects; and Develop UK sovereign HCM capability. The focus, for now, will be on the develop and collaborate strands. The framework has ambitious plans to use this funding to develop industrial capacity, infrastructure, academia and expertise – all with the aim of building internationally recognised hypersonic expertise in the UK. It is a well designed framework, giving HM Government an array of options through which to pursue hypersonic capabilities and developing the UK's hypersonic infrastructure now will place Britain in a better position in the future to develop its own weapons or be a valued partner for collaborative projects. However, funding does not match ambition. When looking at how much the US has been investing in its own hypersonic programmes – around £5.3 billion has been requested for 2025 alone, and it must be remembered this budget builds on decades of investment in prerequisite hypersonic R&D and infrastructure – this £1 billion is likely not enough to meet expectations.[66]

[65] 'Hypersonic Technologies & Capability Development Framework', Ministry of Defence (UK), 08/12/2023, https://www.find-tender.service.gov.uk/ (checked: 04/09/2024).
[66] Kelley M. Sayler, 'Defence Primer: Hypersonic Boost-Glide Weapons', Congressional Research Service (US), https://crsreports.congress.gov/ (checked: 04/09/2024).

For comparison, in 2014 the US identified 48 critical hypersonic test facilities and mobile assets. Since then the Department of Defence, NASA, and others have invested significantly in expanding this infrastructure; such as the construction of a one kilometre long Mach 10 wind tunnel in Texas.[67] The UK lacks similar levels of existing hypersonic infrastructure. Britain has five wind tunnels classified as hypersonic (although the maximum flow speed of one is limited to roughly Mach 3.5) though this was achieved on an initial 2014 'shoestring' budget of just £13.3 million to upgrade existing wind tunnels.[68] In addition, the UK may struggle to test any hypersonic weapon it develops (long-distance test ranges and the ability to monitor the flight of the weapon being two primary issues) whereas the US already has strong testing capabilities and even then plans to invest an additional £1.2 billion to 2028 in its test infrastructure to meet demand. Though, of course, Britain could request access to US support to test its weapons but would be subject to availability dependent on the schedules of US programmes.[69]

How the current approach could be adapted depends on one crucial issue, that of defence investment. The current budget for the Hypersonic Framework of £1 billion, with most of the focus for now going on the development strand may prove insufficient. Given the well advertised gap in defence spending (including a £17 billion gap in the Ministry of Defence's equipment plan for 2023-2033 and the needs for investment in personnel) this raises questions as to the best approach to acquiring hypersonic weapons.[70] The new government has committed to spend 2.5% of GDP but has given no timeline. The previous government set a timeline for 2030 for reaching 2.5% of GDP which would have seen an extra £20 billion (not the £75 billion touted) over the next five years.[71] A timeline for getting to 2.5% of GDP would be

[67] Kelley M. Sayler, 'Hypersonic Weapons: Background and Issues for Congress', Congressional Research Service (US), 14/08/2024, https://crsreports.congress.gov/ (checked: 04/09/2024).
[68] 'Our facilities', The National Wind Tunnel Facility, no date, https://www.nwtf.ac.uk/ (checked: 04/09/2024).
[69] 'Hypersonic Weapons: DOD Could Reduce Cost and Schedule Risks by Following Leading Practices', United States Government Accountability Office, 25/07/2024, https://www.gao.gov/ (checked: 04/09/2024).
[70] 'The Equipment Plan 2023-2033', National Audit Office (UK), 04/12/2023, https://www.nao.org.uk/ (checked: 04/09/2024).
[71] 'PM announces "turning point" in European security as UK set to increase defence spending to 2.5% by 2030', 10 Downing Street (UK), 23/04/2024, https://www.gov.uk/ (checked: 04/09/2024).

very welcome, but it still leaves little room for what more is needed, let alone for hypersonic programmes.

The potential extra £20 billion (assuming the new government sets a similar timeline) will be quickly absorbed by other needs such as the equipment plan gap, personnel needs – especially now that HM Government has committed to a sorely needed headline figure 6% pay increase for the Armed Forces – and support for Ukraine.[72] In addition, there should be a balanced approach to building up the UK's inventory of long-range munitions which ensures 'mass' is not lost when developing more 'exquisite' systems. Hypersonic missiles should complement rather than seek to replace lower cost weapons and in order for any investment in hypersonic missiles to be cost-effective there must be a large number of other weapons available to exploit any successes strikes by hypersonic weapons might achieve.

[72] 'Armed Forces awarded largest pay increase in decades to "renew nation's contract with those who serve"', Ministry of Defence (UK), 30/07/2024, https://www.gov.uk/ (checked: 04/09/2024).

6.0 Conclusion

One of the key dimensions of HM Government's SDR is to examine the 'opportunities for modernisation and transformation' of the British Armed Forces.[73] The introduction of hypersonic weapons would modernise and transform British forces. While these weapons are still maturing, key allies and adversaries are investing in them now. The case for the UK to acquire hypersonic strike capabilities, in terms of their ability to generate strategic advantage by amplifying the British Armed Forces' ability to hit key targets within and degrade enemy A2/AD bubbles, is a strong one. Despite their higher cost, hypersonic weapons would help ensure lower-cost, more vulnerable systems are likely to survive in greater numbers as they seek their targets. But the current approach is trying to do too much with too little.

Until HM Government is willing to invest more into hypersonic technology they should, in the short-term, shift the focus towards the 'buy' strand of the Hypersonic Framework. Laying the groundwork for the UK's hypersonic infrastructure should be seen as a secondary objective until more funding becomes available. This logic is further reinforced if it is deemed that the risk of deterrence failure in the next few years is high and hypersonic strike is needed as soon as possible; there are quicker routes to acquiring the capability. An added benefit of this approach would be that once hypersonic strike has been acquired, Britain would be better placed to contribute towards spiral developments in the future. Section 6.1 below outlines what options would be available if the buy strand of the Hypersonic Framework were the new priority.

6.1 Policy recommendations

Given the US is the ally furthest ahead in the development of hypersonic weapons, this would mean purchasing American systems. In the short-term there are essentially two options, the LRHW which is nearing operational status and the Mako (though further details are yet

[73] 'Strategic Defence Review 2024-2025: Terms of reference', Ministry of Defence (UK), 17/07/2024, https://www.gov.uk/ (checked: 04/09/2024).

to be revealed) which has been described as 'ready now'.[74] The estimated cost for a single AUR of the LRHW is in the region of £32 million (roughly equivalent to 16 Storm Shadow subsonic cruise missiles), the cost of Mako has not been announced, and in addition to purchasing the actual missiles money would also be required for the launchers and other support elements needed to operate them. This raises a difficult question as to which missiles and which launch platform would be the best short-term option for the UK. Essentially there are three routes:

- **Air launched:** The LRHW is not designed to be launched by aircraft, but there could be an option for a 'Rapid Dragon' system.[75] This involves air dropping a palletised missile from the back of a transport aircraft. Given the long range of the LRHW this could be done from a safe distance to the target. It would also allow for a good degree of redeployability (to any UK or allied air station), albeit only to air stations a safe distance from the striking range of an adversary as large transport aircraft are hard to hide. Other drawbacks include the ability for an adversary to monitor aircraft taking off, potentially warning of a strike; another drawback is the extra time it takes for the aircraft to take off and reach the desired altitude to deploy the missile – the RAF's limited transport fleet is also in high demand and using them in this way reduces strategic lift capacity. Mako however could be deployed on any aircraft with 30 inch lugs, but unfortunately is too large for the F35B Lightning II Joint Combat Aircraft's internal weapons bay.
- **Ground launched:** The LRHW can be launched from canisters carried by trucks. This would make rapid redeployment of the system over long-distances difficult. But it would be hard for Russia, at range, to find and destroy the launchers. One only has to look at how hard the Russians have found it to destroy Ukraine's HIMARS launchers, which have a far smaller range.[76]

[74] Aaron-Matthew Lariosa, 'Lockheed Martin's New Mako Hypersonic Missile Breaks Cover', *NavalNews*, 10/04/2024, https://www.navalnews.com/ (checked: 04/09/2024).
[75] 'Rapid Dragon', Air Force Research Laboratory (US), https://afresearchlab.com/ (checked: 04/09/2024).
[76] 'Attack On Europe: Documenting Ukrainian Equipment Losses During The Russian Invasion Of Ukraine', *Oryx*, https://www.oryxspioenkop.com/ (checked: 04/09/2024).

- **Sea launched:** The CPS (the naval version of LRHW) will be integrated with the US Navy's Zumwalt class destroyer and then the Virginia class submarine. The issue is that the CPS is large and the Zumwalt class will receive larger VLS systems to accommodate it, known as Growth VLS (G-VLS).[77] Refitting G-VLS on existing Royal Navy warships would be a serious undertaking and not worth the time. G-VLS could be designed into future Royal Navy warships, such as the potential Type 83 class destroyer, but these would not be ready until at least the mid-2030s. The Mako may be able to be deployed in Mk41 VLS cells. Presently, the Royal Navy does not use the Mk41, but the Type 26 and Type 31 class frigates (to enter service later this decade) will. The advantage of a ship-launched hypersonic weapon would be that the launch platform can steam anywhere across the globe providing greater mobility (and therefore strategic reach); and also protection via the warship's own defences.

Based on the factors outlined above, two alternative options for the quickest route to capability present themselves. One would be to purchase a battery of LRHW through AUKUS as outlined as an option within the Hypersonic Framework. This would provide the British Armed Forces with a short-term solution to acquiring hypersonic strike, and reduce the need to spend on development; it would also help reduce the unit cost of LRHW AURs. A second option would be to purchase Mako missiles for the RAF and, when the Mk41 enters service, also for the Royal Navy.

The UK could even explore the feasibility of establishing production of the Mako in Britain in a similar way to how other operators of foreign missiles have established domestic production (for example, Australia recently announced a £435 million investment into a factory to build Kongsberg's Naval Strike Missile in Australia).[78] A potential issue with these options could be that of the US's International Traffic in Arms Regulations (ITAR), but Congress is working on overcoming potential ITAR barriers to allow AUKUS Pillar 2 to work effectively. Either of these acquisitions would also provide

[77] Aaron-Matthew Lariosa, 'Lockheed Martin Developing New, Larger VLS For DDG(X)', 14/04/2023, https://www.navalnews.com/ (checked: 04/09/2024).
[78] 'Local factory to boost ADF strike power', Australian Government: Defence, 22/08/2024, https://www.defence.gov.au/ (checked: 04/09/2024).

hypersonic strike to NATO in the event the US does not deploy its own systems to Europe itself, helping to add to the conventional deterrent against Russia as it would have to factor in the increased vulnerability of its high-value assets in the event of a conflict.

If defence spending is increased significantly (i.e., above 2.5% of GDP), a more ideal approach could be taken. With more funding available, the UK could still follow the path outlined above, but in addition to this, it could invest more heavily in a sovereign hypersonic weapons capability over the long-term, better tailored to its specific requirements. HM Government could multiply the effort by looking to collaborate on development, either through AUKUS or European partners (although they are further behind than the US). HCM designs should be prioritised, especially if made capable of being carried internally in the F35B Lighting II and later the Tempest combat aircraft, in addition to the launch systems of surface warships and submarines.

About the author

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About the Council on Geostrategy

The Council on Geostrategy is an independent non-profit organisation situated in the heart of Westminster. We focus on an international environment increasingly defined by geopolitical competition and the environmental crisis.

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Our vision is a united, strong and green Britain, which works with other free and open nations to compete geopolitically and lead the world in overcoming the environmental crisis – for a more secure and prosperous future.

Notes

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