



Hypersonic Systems 2023 Key Developments Report



By

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Overview

There is continued and growing interest in the development and or acquisition of hypersonic systems, in particular missiles (either hypersonic glide vehicles – HGV, or cruise missiles – HCM), and air vehicles. The latter include the US Hermeus' Darkhorse,¹ the Canadian Space Engine Systems' Hello-1X,² and the Chinese MD-22.³ Although there is considerable uncertainty with regard to the status of the MD-22,⁴ it is reflective of the ambition and developing technological base underpinning China's efforts to develop and deploy hypersonic systems. As will be discussed below, China may arguably be the world leader in hypersonic capabilities, with at least two additional hypersonic weapons emerging in the past 12 months, the DF-27, and air-launched variant of the YJ-21 respectively.

Russia continues to pursue the development of multiple hypersonic weapons, although such efforts, as with wider military development and production, may be constrained by the impact of the war against Ukraine. Conversely, it is likely that Russia will prioritise hypersonic weapons, given the capabilities that they provide. Russia's use of the 9-A-7760 Kinzhal air-launched ballistic missile (ALBM) in Ukraine has perhaps fallen short of expectations, with Ukraine successfully intercepting a number of missiles launched at Kyiv in May 2023.⁵ The Kinzhal, a derivative of the Iskander-M, reflects a lower-risk and more accessible approach to the development of a hypersonic weapon, as Eugene Saad and Adam Mount note with regard to ALBMs: 'The velocity of a ballistic missile provides a relatively simple means of creating a hypersonic strike option that can provide a prompt means of holding mobile or transient targets at risk...'.⁶

1. Hermeus, 'Darkhorse', <https://www.hermeus.com/darkhorse>.
2. Steve Trimble, 'Canadian Firm Built Hypersonic Vehicle, Scraps 'Sexbomb' Name', *Aviation Week*, 23 June 2023, <https://aviationweek.com/shownews/paris-air-show/canadian-firm-built-hypersonic-vehicle-scraps-sexbomb-name>; Space Engine Systems, <https://www.spaceenginesystems.com/products>.
3. Akhil Kadidal & Akshara Parakala, 'Update – Airshow China 2022: New Reusable Hypersonic UAV Displayed', *Janes*, 10 November 2022, <https://www.janes.com/defence-news/news-detail/update-airshow-china-2022-new-reusable-hypersonic-uav-displayed>.
4. Joseph Trevithick, 'All the Air Combat Developments Out of China's Massive Air Show (Updated)', *The War Zone*, 7 November 2022, <https://www.thedrive.com/the-war-zone/all-the-air-combat-developments-out-of-chinas-massive-air-show>.
5. Steve Trimble, 'The Weekly Debrief: Is Kinzhal Merely a Dagger of the Mind?', *Aviation Week*, 8 May 2023, <https://aviationweek.com/defense-space/missile-defense-weapons/weekly-debrief-kinzhal-merely-dagger-mind>.
6. Eugene Saad and Adam Mount, *Air-Launched Ballistic Missiles*, FAS, 2019, p. 7.

Whilst constituting a highly potent threat, the Kinzhal does not have the same combination of speed, endoatmospheric manoeuvrability, and with it, unpredictability of trajectory, and lower flight altitude that characterises HGVs and HCMs.⁷ It also means that the missile can be intercepted by systems designed to counter ballistic missile threats, such as the Patriot PAC-3.

In this regard, the US Congressional Budget Office has, in a 2023 study on U.S. Hypersonic Weapons and Alternatives, stated that hypersonic missiles 'would probably not be more survivable than ballistic missiles with maneuverable warheads in a conflict', in particular over shorter ranges.⁸ Hypersonic weapons would offer advantages over longer-ranges and in the face of mid-course ballistic missile defence capabilities. However, hypersonic weapons would cost more than similar ballistic missiles, but 'would provide a niche capability, mainly useful to address threats that were both well-defended and extremely time-sensitive (requiring a strike in 15 minutes to 30 minutes)'.⁹ Ballistic missiles also travel at hypersonic speeds, and as Kolja Brockmann and Dmitry Stefanovich explain, HGVs and HCMs are 'typically slower than ballistic missiles' and 'it is not speed itself but rather the combination of speed with endoatmospheric [that is, within the atmosphere] manoeuvrability that distinguishes HGVs and HCMs from other missile systems'.¹⁰ Manoeuvrable re-entry vehicles (MaRVs), which equip some ballistic missiles (for example, the Chinese DF-15, DF-16, DF-21 and

DF-26), can also perform in-flight manoeuvres, although as Karako and Dalhgren note 'MaRVs may also pull high-G turns at hypersonic speeds even though they do not sustain hypersonic flight or possess the same aerodynamic lift characteristics as HGVs'.¹¹

In addition to the use of hypersonic technology as a means of conducting high-speed strike, it can also be applied to anti-air missiles, such as the Russian R-37M (AA-13 Axehead), and as the technology matures, to aircraft. Canada, China, France, the UK and US are developing hypersonic uncrewed air systems for a variety of roles, including intelligence, surveillance and reconnaissance (ISR), strike, and operationally-responsive space launch. The latter would be a particularly valuable capability especially as space becomes more contested, and the need for space-based ISR architectures, including to detect and track hypersonic threats (for example, the US Hypersonic and Ballistic Tracking Space Sensor (HBTSS) system¹²), continues to grow. In this context, 'responsive launch is the ability to be able to deploy

assets into the space domain with pace and flexibility, responding to real-time events'.¹³ Moreover, a 'horizontally launched spaceplane concept, powered by innovative high-Mach/hypersonic air-breathing propulsion technology, is an important part of the solution. The aircraft-like operational characteristics of spaceplanes align well with the prospective requirements of responsive launch and would add the operational flexibility seen in the aviation domain'.¹⁴ As Reaction Engines state, hypersonic technology is critical to a responsive launch capability:

...the propulsion system of a spaceplane must be able to operate in air-breathing mode to high air speeds, typically to Mach 5 and above. By using air from the atmosphere for the early part of the ascent trajectory, a large fraction of the mass associated with a conventional rocket-based system (typically greater than 75%) can be eliminated...After delivering the payload to orbit (or transfer orbit) the vehicle would return to Earth and land horizontally on a conventional runway.¹⁵



Credit: raytheon-missiles-and-defense-1664212219

7. For in-depth discussion of the types and characteristics of hypersonic weapons, see James Bosbotinis, *Hypersonic Defence 2022*, Defence IQ/IDGA.
8. Congressional Budget Office, U.S. Hypersonic Weapons and Alternatives, January 2023, 'At a Glance', <https://www.cbo.gov/system/files/2023-01/58255-hypersonic.pdf>.
9. Ibid. p. 1.
10. Kolja Brockmann and Dmitry Stefanovich, *Hypersonic Boost-Glide Systems and Hypersonic Cruise Missiles: Challenges for the Missile Technology Control Regime*, SIPRI, April 2022, p. 4.
11. Tom Karako and Masao Dahlgren, *Complex Air Defense: Countering the Hypersonic Missile Threat*, CSIS, February 2022, p. 9.
12. Theresa Hitchens, 'Congressional Concern Re-Emerges on Fate of MDA's Hypersonic Missile Tracking Sensors', *Breaking Defense*, 11 May 2023, <https://breakingdefense.com/2023/05/congressional-concern-re-emerges-on-fate-of-mdas-hypersonic-missile-tracking-sensors/>.
13. Reaction Engines, *Preparing for Lift-Off*, July 2022, p. 7.
14. Ibid.
15. Ibid. p. 8.

Key Developments

The following is not exhaustive and is intended to highlight key trends and the implications for defence and industry.



AUSTRALIA

In December 2021, Hypersonix Launch Systems, a Brisbane based start-up, 3D printed the SPARTAN scramjet out of high temperature alloys under a grant program of the Federal Australian government which was completed in March 2022. The Spartan is a hydrogen-fuelled scramjet, manufactured using 3D printing, and designed to operate at speeds of Mach 5 to 12; it is intended to power the DART AE multi-mission hypersonic UAV, also being developed by Hypersonix and employing additive manufacturing in its construction.¹⁷ The Manufacturing pilot of the high temperature composites version of the SPARTAN scramjet engine were received in June 2023. In March 2023 Hypersonix Launch systems won the HyCAT solicitation of the Defense Innovation Unit (DIU) in the US in March 2023. In September 2022, the United States Air Force (USAF) selected a Raytheon and Northrop Grumman team to continue development of the Hypersonic Attack Cruise Missile (HACM – see below),¹⁸ this builds on the collaborative Australia-US Southern Cross Integrated Flight Research Experiment (SCIFIRE). SCIFIRE is included within the AU\$9.3 billion assigned to high-speed long-range strike and missile defence in the Force Structure Plan 2020, and intended to result in an air-launched, scramjet-powered hypersonic cruise missile for the Royal Australian Air Force and equip aircraft such as the F/A-18E/F Super Hornet, F-35A and P-8 Poseidon.¹⁹



CANADA

A Canadian company, Space Engine Systems, has built an optionally crewed hypersonic air vehicle, which may fly as early as February 2024.²⁰ The company is looking to develop hypersonic systems for both responsive space launch and military applications.



CHINA

In July 2022, it was announced that a team of engineers at the Northwestern [sic] Polytechnical University, had successfully test-flown the Feitian 1 hypersonic air vehicle, which utilised a combined-cycle engine and was powered by kerosene.²¹ An H-6K bomber carrying two missiles, bearing the stencilling '2PZD-21', was displayed at Airshow China 2022, held in Zhuhai in November 2022; this is the air-launched version of the YJ-21.²² Notably, a model of the H-6K armed with two YJ-12 supersonic anti-ship missiles and two YJ-21s was included as part of the Aviation Industry Corporation of China display at the Paris Air Show 2023.²³ A reusable, hypersonic unmanned air vehicle concept demonstrator was also exhibited at Airshow China: the MD-22 is stated to have a range of 8,000 km and speed of Mach 7.²⁴ Such a system could, for example, provide a penetrating ISR capability. Leaked US intelligence reports have confirmed that a new Chinese long-range ballistic missile equipped with an HGV, the DF-27, believed to have a range of 5,000-8,000 km, has been successfully tested,²⁵ with Chinese sources reporting the missile has been deployed.²⁶ It is also believed that China possesses an air-launched ballistic missile with an HGV payload.²⁷

16. Adam Thorn, 'Brisbane-Based Hypersonix Takes Delivery of Scramjet Engine', Defence Connect, 9 June 2023, <https://www.defenceconnect.com.au/key-enablers/12133-brisbane-based-hypersonix-takes-delivery-of-scramjet-engine>.
17. Robin Hughes, 'Team Sport', Janes Defence Weekly, Vol. 59, No. 33, 17 August 2022, pp. 18-24.
18. Richard Scott, 'Raytheon/Northrop Grumman Team Selected For HACM Hypersonic Weapon', Janes Defence Weekly, Vo. 59, No.40, p. 5.
19. Hughes, 'Team Sport', p. 23.
20. Trimble, 'Canadian Firm Built Hypersonic Vehicle, Scraps 'Sexbomb' Name'.
21. Zhang Tong, 'Chinese University Sanctioned By US Declares Success of Hypersonic Test Flight', South China Morning Post, 5 July 2022, <https://www.scmp.com/news/china/science/article/3184229/chinese-university-sanctioned-us-declares-success-hypersonic>.
22. Mike Yeo, 'China Displays Air-Launched Hypersonic Missile at Air Show Near Taiwan', C4ISRNET, 10 November 2022, <https://www.c4isrnet.com/battlefield-tech/2022/11/10/china-shows-off-air-launched-hypersonic-missile-at-airshow-near-taiwan/>.
23. Mark Wagner, 'Part 2: A Look at China's Display From The Paris Air Show', Aviation Week, 20 June 2023, <https://aviationweek.com/aerospace/part-2-look-chinas-display-paris-air-show>.
24. Kadidal & Parakala, 'Update – Airshow China 2022: New Reusable Hypersonic UAV Displayed'.
25. Zuzanna Gwadera, 'Intelligence Leak Reveals China's Successful Test of a New Hypersonic Missile', IISS, 18 May 2023, <https://www.iiss.org/online-analysis/online-analysis/2023/05/intelligence-leak-reveals-chinas-successful-test-of-a-new-hypersonic-missile/>.
26. Minnie Chan, 'China's Advanced DF-27 Hypersonic Missile Which Can Strike Parts of US Has Been in Service For Several Years, Source Says', South China Morning Post, 20 May 2023, <https://www.scmp.com/news/china/military/article/3221198/chinas-advanced-df-27-hypersonic-missile-which-can-strike-parts-us-has-been-service-several-years>.
27. Bradley Perrett, 'A Guide to China's Bomber Fleet', Aviation Week, 11 January 2023, <https://aviationweek.com/defense-space/aircraft-propulsion/guide-chinas-bomber-fleet>; and for background, see Thomas Newdick, 'This is Our Best Look Yet at China's Air-Launched "Carrier Killer" Missile', The War Zone, 19 April 2022, <https://www.thedrive.com/the-war-zone/this-is-our-best-look-yet-at-chinas-air-launched-carrier-killer-missile>.



FRANCE

The French defence research agency Onera, unveiled the Espadon, a concept model for a hypersonic fighter aircraft, at the Paris Air Show in June 2023.²⁸ The Espadon program is intended to 'to anticipate post-2050 threats, work out the types of missions that could be carried out to nullify these threats and then develop the required technological solutions. Onera is working jointly with the French Air Force on this project'.²⁹ Again at the Paris Air Show, MBDA revealed its Aquila interceptor, intended to counter hypersonic threats, and under development as part of the Hypersonic Defence Interceptor Study (HYDIS2); this is in competition with the Spanish-led HYDEF study, both of which are components of 'Timely Warning and Interception with Space-based Theater surveillance', or Twister programme.³⁰

Aquila is intended to complement the Aster family of surface-to-air missile systems, which have a limited counter-hypersonic capability, and will likely include a ship-launched version with the navies of France, Germany, Italy and the Netherlands expressing interest.³¹ The European Defence Fund is also funding a programme, Odin's Eye, which is intended to develop an autonomous European ballistic and hypersonic missile early warning capability.³²

On 26 June 2023, France conducted the first test of its V-MAX HGV demonstrator. The V-MAX was developed by the ArianeGroup, also responsible for France's submarine-launched ballistic missiles,³³ the V-MAX was launched by a sounding rocket, and as Timothy Wright suggests, 'The glider tested may simply be a smaller scale and experimental version of the ultimate design... it is conceivable that V-MaX may be used for conventional rather than nuclear missions, given that France already

possesses a theatre-range and very high-speed nuclear-delivery system', and may ultimately be intended as a 'theatre-range system'.³⁴



INDIA

It was reported in August 2022 that the India-Russia BrahMos II HCM will likely have similar performance to, and use technologies developed for, the Tsirkon.³⁵ It was also stated by the CEO of BrahMos Aerospace that the BrahMos II will be very expensive;³⁶ due to the materials required and manufacturing processes involved, it is likely that hypersonic weapons will be expensive (a point raised in the above-mentioned CBO report).



IRAN

On 6 June 2023, Iran revealed the Fattah, a medium-range ballistic missile (MRBM) with a range of 1,400 km and equipped with a re-entry vehicle powered by a thrust-vectoring nozzle enabling it to manoeuvre in flight.³⁷ The use of a powered MaRV would constitute a more challenging target for missile defence systems, such as the US Terminal High Altitude Area Defense system (THAAD) and the Israeli Arrow-3.



ISRAEL

Rafael unveiled the Sky Sonic counter-hypersonic interceptor at the Paris Air Show in June 2023. Employing a two-stage configuration, the interceptor is designed to counter high-speed, manoeuvrable threats, as part of a layered integrated air and missile defence system.³⁸

28. Tim Martin, 'Onera, France's DARPA, Bets on Espadon Hypersonic Fighter Concept for 2050 Flight', Breaking Defense, 19 June 2023, <https://breakingdefense.com/2023/06/onera-frances-darpa-bets-on-espadon-hypersonic-fighter-concept-for-2050-flight/>.

29. Helen Chachaty, 'French Aerospace Lab Onera Presents FCAS, Hypersonic Research', Aviation Week, 22 June 2023, <https://aviationweek.com/shownews/paris-air-show/french-aerospace-lab-onera-presents-fcas-hypersonic-research>.

30. Tony Osborne, 'MBDA Details Aquila European Hypersonic Interceptor Concept', Aviation Week, 20 June 2023, <https://aviationweek.com/shownews/paris-air-show/mbda-details-aquila-european-hypersonic-interceptor-concept>.

31. 'AQUILA: MBDA's new Hypersonic Threats Interceptor', Naval News, 27 June 2023, <https://www.youtube.com/watch?v=cewdBLLIZvA>.

32. Osborne, 'MBDA Details Aquila European Hypersonic Interceptor Concept'.

33. Tony Osborne, 'France Flies V-MAX Hypersonic Demonstrator', Aviation Week, 27 June 2023, <https://aviationweek.com/defense-space/aircraft-propulsion/france-flies-v-max-hypersonic-demonstrator>.

34. Timothy J. Wright, 'France Conducts its First Hypersonic Glide Vehicle Test', IISS, 29 June 2023, <https://www.iiss.org/online-analysis/online-analysis/2023/06/france-conducts-its-first-hypersonic-glide-vehicle-test/>.

35. Naval News Staff, 'Hypersonic BrahMos-II Missile May Include Tech From Tsirkon Missile', Naval News, 2 August 2022, <https://www.navalnews.com/naval-news/2022/08/hypersonic-brahmos-ii-missile-may-include-tech-from-tsirkon-missile/>.

36. Ibid.

37. Jeremy Binnie, 'IRGC Displays Fattah 'Hypersonic' Ballistic Missile', Janes Defence Weekly, Vol. 60, No. 24, 14 June 2023, p. 12.

38. Tony Osborne, 'Rafael Says Sky Sonic Interceptor To Enter Full-Scale Development', Aviation Week, 19 June 2023, <https://aviationweek.com/shownews/paris-air-show/rafael-says-sky-sonic-interceptor-enter-full-scale-development>.



JAPAN

In June 2023, the Japanese Ministry of Defence awarded two contracts relating to the development of hypersonic weapons, one concerning its hypersonic anti-ship weapon, the other relating to the Hyper Velocity Gliding Projectile (HVGP), a tactical HGV.³⁹ The hypersonic anti-ship weapon, or Scramjet-powered Hypersonic Weapon (SHW), formerly known as the Hypersonic Cruise Missile, is intended to provide a tactical HCM, and although there are no formally announced plans for an operational system, it is believed that the missile will eventually be acquired.⁴⁰ Production of the HVGP is due to commence in Fiscal Year 2023, and will provide a ground-launched, tactical anti-ship HGV.⁴¹ It was also announced in March 2023 that the US and Japan are looking to collaborate on the former's development of the Glide Phase Interceptor, building on Japan's contribution to the SM-3 block IIA interceptor.⁴²



KOREA, DEMOCRATIC PEOPLE'S REPUBLIC OF (NORTH KOREA)

North Korea continues to develop HGVs, and claims to have undertaken three successful tests of the Hwasong-8 thus far, although Janes states that 'developing a reliable and credible hypersonic capability is likely to take several years and many more tests'.⁴³ However, there is uncertainty as to whether the Hwasong-8 tests involved HGVs as claimed, or a MaRV.⁴⁴



KOREA, REPUBLIC OF (SOUTH KOREA)

In October 2022, Korea Aerospace Industries disclosed efforts to develop a carrier-borne version of the KF-21 fighter aircraft, and notably, the model shown at the DX Korea 2022 exhibition included hypersonic long-range air-to-surface missiles reported to be under development by the Agency for Defence Development.⁴⁵ In April 2023, the Defence Project Promotion Committee approved a development plan, worth 2.71 trillion-won (US\$2.03 billion) for the Long-range Surface to Air Missile (L-SAM) II system, which will include a glide phase interceptor to counter hypersonic threats.⁴⁶



POLAND

Poland has expressed interest in joining the South Korean KF-21 programme, and procuring the air-launched variant of the Hycore HCM that would equip the aircraft.⁴⁷



Credit: Raytheon

39. Takahashi Kosuke, 'Japan Awards Kawasaki Heavy Industries \$243 Million Contract for Homegrown Version of Tomahawk Missile', The Diplomat, 7 June 2023, <https://thediplomat.com/2023/06/japan-awards-kawasaki-heavy-industries-243-million-contract-for-homegrown-version-of-tomahawk-missile/>.
40. Jon Grevatt, 'ATLA Ramps Up Hypersonic Anti-Ship Weapon Project', Janes Defence Weekly, Vol. 60, No. 13, 29 March 2023, p. 8.
41. Jon Grevatt, 'Japan Set to Start Producing Hypersonic Glide Vehicles', Janes Defence Weekly, Vol. 60, No. 13, 29 March 2023, p. 10.
42. Jen Judson, 'US, Japan Exploring Partnership on Hypersonic Missile Interceptor', Defense News, 20 March 2023, <https://www.defensenews.com/pentagon/2023/03/20/us-japan-exploring-partnership-on-hypersonic-missile-interceptor/>.
43. Cristina Varriale, 'Strike Action', Janes Defence and Intelligence Review, Vol. 2, No7, July 2023, pp. 52-57.
44. Jon Grevatt, 'Raising Stakes', Janes Defence Weekly, Vol. 59, No. 40, 5 October 2022, pp. 18-25.
45. Jon Grevatt, 'KAI Outlines Development Plan for Carrierborne Version of KF-21N', Janes Defence Weekly, Vol. 59, No. 40, 5 October 2022, p. 16.
46. 'S. Korea Approves Development of Advanced Missile Interceptors', Korea Times, 25 April 2023, https://www.koreatimes.co.kr/www/nation/2023/04/205_349774.html.
47. Kim Minseok, 'Poland Expresses Interest in KF-21 Program', Aviation Week, 8 May 2023, <https://aviationweek.com/defense-space/aircraft-propulsion/poland-expresses-interest-kf-21-program>.



RUSSIA

In July 2022, it was announced that Russia was developing a new intermediate-range ballistic missile (IRBM), the Zmeyevik, which will have a range of around 4,000 km and be equipped with an HGV; the Zmeyevik is intended to provide an anti-ship ballistic missile capability akin to the Chinese DF-21D and DF-26.⁴⁸ A new variant of the MiG-31 was displayed at the Army-2022 military-technical forum held in August 2022 at the Patriot Park Exhibition Centre, Alabino training range, and Kubinka airbase. The MiG-31I features a new avionics suite which will 'allow the orbital launch of small satellites and for anti-satellite weapons as well as the use of the Kinzhal missile' and 'should integrate and not replace' the current Kinzhal carrier, the MiG-31K.⁴⁹ In addition to the Kinzhal ALBM, Russia is employing the hypersonic long-range air-to-air missile, the R-37M, in operations over Ukraine. The R-37M, or AA-13 Axehead, is believed to have a maximum speed of Mach 6, a range of around 300 km, and is carried by the MiG-31BM and Sukhoi Su-35.⁵⁰

Russia is also believed to be close to completing development of a new high-speed missile, the Kh-MT ('multiple targets'), which will likely be designated Kh-41, and provide a 'tactical and theater-level air-to-surface missile...compatible with any Russian platform. Russia plans to use it on multirole fighters, bombers, surface ships, submarines and coastal launchers... [and] is intended to fight surface ships as well as some ground and air targets, such as early warning aircraft'.⁵¹ The speed of the Kh-MT has not been disclosed, but it is believed to be powered by a scramjet and 'is very likely' to be hypersonic.⁵² Another air-launched hypersonic missile, 'Ostrota', is also reportedly under development; it is scramjet-powered and sized to fit within the internal bay of the Sukhoi Su-57.⁵³ Following on from the US stating in March 2022 that the Tsirkon had been operationally deployed,⁵⁴ and President Putin's announcement at the Main Naval Parade in July 2022 that deliveries of the missile would commence in August 2022, the Russian Navy declared in December 2022 that

the frigate Admiral Gorshkov had been equipped with the Tsirkon missile ahead of its January 2023 deployment.⁵⁵ It is likely that the Tsirkon had already been operationally deployed, most probably onboard the Yasen-class submarine, Severodvinsk, which had been used for trials of the Tsirkon (as had the Admiral Gorshkov). It was also reported in November 2022 that a contract for additional Tsirkon missiles, due for completion by the end of 2023, had been agreed, and involves 'several dozen' missiles.⁵⁶



UNITED KINGDOM

In July 2022 at the Farnborough Airshow, the UK unveiled the Hypersonic Air Vehicle Experimental (HVX) programme, led by Rolls Royce and Reaction Engines, together with the Royal Air Force's Rapid Capabilities Office, Defence Science and Technologies Laboratory and National Security Strategic Investment Fund.⁵⁷ The aim of the HVX programme is 'to rapidly mature technologies to deliver a step-change in the cost of developing a reusable high-Mach/hypersonic air vehicle',⁵⁸ and will use a:

combined-cycle engine...[consisting of] a gas turbine core integrated with the Reaction precooler system. The turbine will propel the vehicle from a standing start on the runway to a mode transition speed—likely up to the Mach 4 range—after which the engine will be cocooned and thrust will be provided by a ramjet/ramburner.⁵⁹

If successful, an operational capability, for example, providing a hypersonic ISR system, could be available in the 2030s.

48. Thomas Newdick, 'Russia Developing Anti-Ship Ballistic Missile: Report', The War Zone, 13 July 2022, <https://www.thedrive.com/the-war-zone/russia-is-working-on-a-new-anti-ship-ballistic-missile-report>.

49. Daniele Faccioli and Giovanni Colla, 'Russia Flexes its Muscles', Air Forces Monthly, November 2022, pp. 72-81.

50. Miko Vranic, 'Combat Experience', Janes Defence Weekly, Vol. 59, No. 47, 23 November 2022, pp. 28-29.

51. Piotr Butowski, 'Russia is Close To Launching New High-Speed Air-Launched Missile', Aviation Week, 13 April 2023, <https://aviationweek.com/defense-space/missile-defense-weapons/russia-close-launching-new-high-speed-air-launched-missile>.

52. Ibid.

53. Ibid.

54. Statement of Charles A. Richard, Commander United States Strategic Command, Before the House Armed Services Committee on Strategic Forces, 1 March 2022, <https://www.stratcom.mil/Portals/8/Documents/2022%20USSTRATCOM%20Posture%20Statement%20-%20HASC-SF%20Hrg%20FINAL.pdf?ver=TqVMLA9r8HHTNTJ-5t4hmQ%3D%3D>.

55. Tomasz Grotnik, 'Russian Frigate Sails To The Atlantic With Hypersonic Missiles', Naval News, 9 January 2023, <https://www.navalnews.com/naval-news/2023/01/russian-frigate-sails-to-the-atlantic-with-hypersonic-missiles/>.

56. Naval News Staff, 'Russia Orders Additional Tsirkon Hypersonic Missiles', Naval News, 15 November 2022, <https://www.navalnews.com/naval-news/2022/11/russia-orders-additional-tsirkon-hypersonic-missiles/>.



UNITED STATES

As part of its fiscal year (FY)2024 budget request, the US Department of Defense has requested \$11 billion for hypersonic and long-range subsonic missiles.⁶⁰ Whilst in late January 2023, the Defense Innovation Unit, expanding its work on hypersonic technologies, launched a Commercial Solutions Opening for the Hypersonic and High-Cadence Airborne Testing Capabilities (HyCAT II) initiative, which will focus on four areas: manufacturing and materials; communication systems and components; propulsion; and alternative navigation and control systems.⁶¹ The Hypersonix DART AE will contribute to the HyCAT II programme.⁶² However, a combination of supply chain issues and inconsistent demand have contributed to a significant lag in US hypersonic weapons development and deployment, as set out in a May 2023 report by the Emerging Technologies Institute, '...the DoD has often wavered in its commitment to fielding hypersonic systems at scale. Some years, it has been a clear priority while other times, the commitment has been ambiguous'.⁶³

As Steve Trimble, writing for Aviation Week, highlights, 'soaring production costs' have driven the estimated unit cost of the US Army's Long Range Hypersonic Weapon (LRHW) and US Navy Conventional Prompt Strike (CPS) missile to 'nearly \$60 million by fiscal 2028', and test failures have put the USAF's previously-planned production of the AGM-183A into limbo, with the result that production of hypersonic weapons for the USAF may not commence until FY2027.⁶⁴ Moreover, as Wostenberg et al., highlight, 'the current supply chains, including the manufacturing base, supply of critical materials, testing

infrastructure, and workforce are incapable of supporting DoD's ambitious plans'.⁶⁵ In addition, the DoD has not yet 'established any programs of record for hypersonic weapons, suggesting that it may not have approved either mission requirements for the systems or long-term funding plans'.⁶⁶ This is reflected in the Defense Advanced Research Projects Agency (DARPA)-led OpFires ('Operational Fires') programme, which has successfully developed a medium-range (thought to be somewhere between 500 and 1,800 km) two-stage hypersonic missile system, that can be transported by a C-130 Hercules and carried on US Army and Marine Corps logistics trucks. Neither the Army nor Marine Corps have plans to invest in it.⁶⁷

It is uncertain whether the USAF plans to acquire the AGM-183A Air-Launched Rapid Response Weapon,⁶⁸ but it may nonetheless utilise 'four residual missiles from the operational prototyping program' to declare an early operational capability by the end of 2023.⁶⁹ The focus for the USAF will be on developing and deploying HACM, the contract, worth US\$985 million, for which was awarded to Raytheon and Northrop Grumman in September 2022, and is intended to result in delivery by 2027. HACM will be a scramjet-powered HCM, compatible with tactical aircraft and the rotary launchers of US bombers such as the B-52 and B-1.⁷⁰ The USAF has also awarded a contract to Leidos for the development of the Mayhem Hypersonic Multi-Mission ISR and Strike UAV system. Mayhem will utilise a standardised payload interface, and may also be linked to advanced propulsion system designs, such as dual-mode ramjets and turbine-based combined cycle engines.⁷¹

57. Guy Norris, 'UK Unveils HVX Hypersonic Demonstrator Plan', Aviation Week, 22 July 2022, <https://aviationweek.com/shownews/farnborough-airshow/uk-unveils-hvx-hypersonic-demonstrator-plan-0>.
58. Gareth Jennings, 'UK Unveils Concept V Hypersonic Aircraft in HVX Portfolio', Janes Defence Weekly, Vol. 59, No. 30, 27 July 2022, p. 12.
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61. Gerrard Cowan, 'Pentagon's DIU to Test New Hypersonic Weapons Technology', Janes Defence Weekly, Vol. 60, No. 10, 8 March 2023, p. 5.
62. Courtney Albon, 'Defense Innovation Unit Eyes First Flight of Hypersonic Testbed', C4ISRNET, 2 June 2023, <https://www.c4isrnet.com/battlefield-tech/2023/06/02/defense-innovation-unit-eyes-first-flight-of-hypersonic-testbed/>.
63. Rebecca Wostenberg, Wilson Miles, Jordan Chase, and Samantha Beu, Hypersonics Supply Chains: Securing the Path to the Future, Emerging Technologies Institute, National Defense Industries Association, May 2023, p. 5, <https://www.ndia.org/-/media/ndia-eti/reports/hypersonics/hypersonics-supply-chain-report-final.pdf?download=1>.
64. Steve Trimble, 'U.S. Hypersonic Push Exposes Deep Industry, Testing Gaps', Aviation Week, 17 May 2023, <https://aviationweek.com/defense-space/missile-defense-weapons/us-hypersonic-push-exposes-deep-industry-testing-gaps>.
65. Wostenberg, et al., Hypersonics Supply Chains, p. 5.
66. Executive Summary in Kelley M. Saylor, 'Hypersonic Weapons: Background and Issues for Congress', Congressional Research Service, R45811, Updated 13 February 2023, <https://crsreports.congress.gov/product/pdf/R/R45811>.
67. Ashley Roque, 'Any Takers? DARPA Eyes Service to Continue OpFires Hypersonic Missile Development', Janes Defence and Intelligence Review, Vol. 1, No. 11, November 2022, pp. 8-9.
68. Michael Marrow, 'Air Force Cracks Open Door on Hypersonic ARRW, Weeks After Indicating it Was Shut', Breaking Defense, 28 April 2023, <https://breakingdefense.com/2023/04/air-force-cracks-open-door-on-hypersonic-arrw-weeks-after-indicating-it-was-shut/>.
69. Steve Trimble, 'U.S. Hypersonic Testing Shows Mixed Results In Pivotal Year', Aviation Week, 2 May 2023, <https://aviationweek.com/defense-space/missile-defense-weapons/us-hypersonic-testing-shows-mixed-results-pivotal-year>.
70. Zach Rosenberg, 'HACM Undergoing Subsystem Ground Testing and Beginning Fabrication', Janes Defence Weekly, Vol. 60, No. 22, 31 May 2023, p. 6.
71. Joseph Trevithick, 'Mayhem Hypersonic Strike-Recon Jet Contract Awarded To Leidos', The War Zone, 16 December 2022, <https://www.thedrive.com/the-war-zone/mayhem-hypersonic-strike-recon-jet-contract-awarded-to-leidos>.

Delays in testing the CPS at sea may result in a delayed deployment of the weapon onboard the US Navy's Zumwalt-class destroyers, which were initially planned to first deploy with CPS in 2025; this is together with a slip from 2028 to 2030 of the Virginia-class submarines deploying with CPS.⁷² As part of efforts to develop the next-generation destroyer, DDG(X), Lockheed Martin is developing the Growth Vertical Launch System (G-VLS), which will enable the stowage of larger missiles than the MK41, for example, hypersonic weapons.⁷³ In March 2023, the US Navy awarded Lockheed Martin and Raytheon Missiles and Defense contracts for the development of the Hypersonic Air-Launched Offensive Anti-Surface (HALO) missile system.⁷⁴ This will be compatible with carrier-based aircraft and provide an anti-ship missile that 'is faster-flying, has greater range, and is otherwise more capable than the existing LRASM', and be in service by 2029.⁷⁵ As part of continued efforts to develop counter-hypersonic capabilities, work on the Glide Phase Interceptor continues, with it being reported in March 2023 that hardware development will commence 'shortly'.⁷⁶ The Missile Defense Agency also intends to attempt to shoot down an HGV target in 2024 using an 'upgraded version' of the SM-6 Block 1A interceptor.⁷⁷ Finally, the US Navy is developing an experimental HGV under the Multiservice Advanced Capability Hypersonics Test Bed (MACH-TB) programme.⁷⁸

The US Army intends to deploy its first operational LRHW, or Dark Eagle, system in FY2023, despite there not yet being a 'successful test of the combined Common Hypersonic Glide Body (CHGB) and two-stage booster', and accepting 'deliveries of the CHGB Block 1-equipped Dark Eagles even as Lockheed Martin, the LRHW booster supplier and integrator, and Dynetics, the CHGB manufacturer, continue finalizing the design'. Further, as Trimble highlights, whilst 'the Navy plans to buy 64 CPS missiles through fiscal 2028, neither service has committed to production of the missiles beyond the six-year Future Years Defense Program'. Potentially adding to the LRHW's problems is a limited supply of ammonium perchlorate, a critical ingredient in solid rocket fuels, and a further reflection on supply chain constraints and their impact on US hypersonic weapons plans.



Credit: Raytheon

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76. Theresa Hitchens, 'Glide Phase Interceptor for Hypersonic Defense About to Enter 'Hardware Phase': MDA Director', Breaking Defense, 24 March 2023, <https://breakingdefense.com/2023/03/glide-phase-interceptor-for-hypersonic-defense-about-to-enter-hardware-phase-mds-director/>.
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