India's Hypersonic Evolution: From Concept to Capability

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In brief

India is moving closer to realising its hypersonic ambitions, which have been in the making since the 1990s. The Long-Range Anti-Ship Missile (LR-AShM) programme, in particular, had reached an advanced stage. This article traces the programme's development: initiated by the ISRO for civilian purposes (space launch vehicle), the research subsequently shifted towards military applications with the DRDO and its HSTDV demonstrator powered by a scramjet, for which tests have increased in frequency since 2019, with mixed results until a major breakthrough in May 2026. India's strategic motivation stems both from a desire to ensure technological self-sufficiency and from the need to respond to Chinese advances (DF-17, DF-21D).

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Introduction

India's hypersonic ambition is on the verge of becoming a reality. This ambition that India has harboured since the 1990s is probably going to see the light of day sooner rather than later. On 30 April 2026, the Defence Research and Development Organisation (DRDO) Chairman, Samir V Kamat, made an important reference regarding India's hypersonic ambitions. He stated that "India's LR-AShM [Long-Range Anti-Ship Missile] programme has reached an advanced stage, with initial trials expected soon.[1]" The statement carries more weight because it has come directly from the DRDO Chairman. Furthermore, DRDO is the lead agency developing India's first hypersonic weapon. The development further got a boost when several Indian media houses published a report that on 1 May 2026, India successfully carried out the second flight test of the LR-AShM.[2] This particular test, however, was not confirmed by the DRDO itself. For India, achieving hypersonic capability has become something of a national security imperative, given China's advancement in the same domain, and this also explains the pace of development, which has accelerated over the years.

From Aspiration to Reality

The initial aspiration to develop hypersonic technology was led by the Indian Space Research Organisation (ISRO). In the 1990s, the ISRO initiated various studies to develop hypersonic airbreathing technology. Their aim was to develop a cost-effective space vehicle rather than a weapon system. The first breakthrough was achieved on 26 January 1993, when the Vikram Sarabhai Space Centre (VSSC) successfully tested an air-breathing rocket, named ABR-200.[3] This was the first of many studies conducted by ISRO and other organisations in the 1990s. The following table provides an overview of other studies conducted on hypersonic technology.

Organisation	Study Name	Study Characteristics	Result
Defence Research and Development Laboratory (DRDL)	Single Stage to Orbit (SSTO)	Incorporating turbo-ram-rocket combined cycle	Defence Research and Development Laboratory (DRDL)
DRDL	Aerobic Vehicle for Transatmospheric Hypersonic Aerospace Transportation (AVATAR)[4]	The novel feature of AVATAR was its propulsion system (engine and fuel system) using a concept called FLOX. AVATAR would use a turbojet engine for take-off and landing and flight to Mach 2.5; a dual mode ramjet-scramjet engine would be used for acceleration to Mach 8 in the atmosphere; during this phase atmospheric air would be collected and liquefied, oxygen separated and stored for subsequent use in the rocket mode of flight beyond Mach 8.	Did not result in anything beyond concept study.

Overview of other studies conducted on hypersonic technology

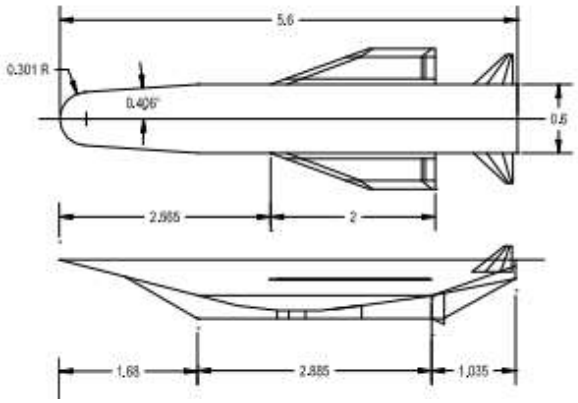
[1] 'India's LR-AShM hypersonic glide missile nears trials; DRDO chief outlines future multi-layered strike force,' ANI, 30 April 2026, https://aninews.in/news/national/general-news/indias-lr-ashm-hypersonic-glide-missile-nears-trials-drdo-chief-outlines-future-multi-layered-strike-force20260430133006/

[2] 'India carries out 2nd test of long-range hypersonic anti-ship missile off Odisha coast,' The Economic Times, 03 May 2026, https://economictimes.indiatimes.com/news/defence/india-successfully-tests-advanced-long-range-hypersonic-anti-ship-missile-off-odisha-coast/articleshow/130733635.cms?from=mdr

[3] 'India Missile Chronology,' NTI, p. 171, https://media.nti.org/pdfs/india_missile.pdf

[4] John K, Strickland, 'Current strategies towards air-breathing space launch vehicles,' The Space Review, 01 August 2011, https://www.thespacereview.com/article/1894/1

While the early efforts were primarily led by ISRO, the DRDO also ensured that its work included basic studies on weaponising hypersonic technology. To this purpose, the Defence Research & Development Laboratory (DRDL) of the DRDO initiated a technology demonstrator project, the Hypersonic Technology Demonstrator Vehicle (HSTDV) in early 2000. DRDO's hypersonic programme focused on developing a scramjet-powered vehicle. To achieve the desired results, S Paneerselvam, then project director of HSTDV, in 2007 commented on the technological trajectory DRDO followed since the early 2000s.[5] DRDO recognised the critical relationship between aerodynamics and propulsion, so the hypersonic vehicle and its engine were designed as a single, integrated system rather than as separate components. Integration is important to pre-compress incoming air before it reaches the engine and to provide the required velocity.[6] With regards to the shape of the vehicle, Panneerselvam mentioned it to be octagonal, a design favoured for better aerodynamic compression, better integration of the scramjet engine and more space for fuel tanks, avionics and other critical components. Thirdly, the aerodynamic characteristics of the hypersonic cruise vehicle have been estimated through wind tunnel tests, which were, as stated by Panneerselvam at this time carried out at the hypersonic wind tunnels available within ISRO and the Indian Institute of Sciences. Importantly, since 2007, India has received assistance from other countries, such as the United Kingdom and Israel, in wind tunnel testing.[7] The following figure shows the hypersonic vehicle configuration and flight-test details as of 2007.[8]



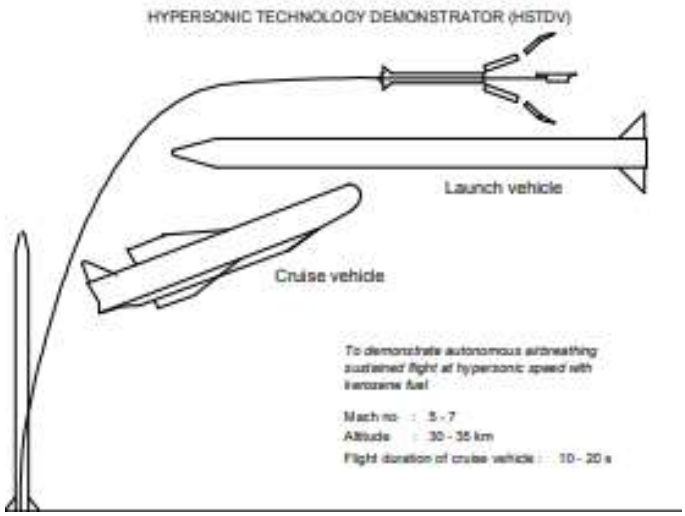
[5] '*Hypersonic vehicle configuration has been designed by considering the aerodynamics and propulsion intensive interactions. A non-circular octagonal shape of the aerodynamic configuration has been evolved in pitch yaw roll mode satisfactory stability and control characteristics in addition to positive thrust margin. Aerodynamic characteristics of the hypersonic cruise vehicle have been estimated through wind tunnel tests. Extensive CFD [Computational Fluid Dynamics] analysis has been carried out for the vehicle viz., tip to end simulation considering simultaneously the external and internal flows with heat release in the combustor and heat flux evaluation on the body and the engine. The computed results are in agreement with the wind tunnel data. Strut based combustor testing has been carried out in connect-pipe mode to ascertain its performance and suitability for the vehicles. High temperature materials have been identified and characterised for the realisation of airframe, engine and mechanisms.*'

Cited by Rajaram Nagappa, 'Hypersonic Cruise Missiles: An Overview,' 2020, pp. 6-7, http://eprints.nias.res.in/2639/1/2020-Hypersonic_Cruise_Missiles-RajaramNagappa.pdf

[6] For more information on aerodynamics and propulsion, see J. Gordon Lesihman, Introduction to Aerospace Flight *Vehicles* (Daytona Beach, FL: Embry-Riddle Aeronautical University, 2023).

[7] 'In Their Own Words: Hypersonic Vehicle Technology,' China Aerospace Studies Institute, June 2024, p. 26, https://www.airuniversity.af.edu/Portals/10/CASI/documents/Translations/2024-06-24%20ITOW%20Hypersonic%20Vehicle%20Technology.pdf

[8] K. P. J. Reddy, 'Hypersonic Flight and Ground Testing Activities in India,' 16th Australasian Fluid Mechanics Conference, 02-07 December 2007, p. 33, https://people.eng.unimelb.edu.au/imarusic/proceedings/16/Reddy.pdf



Hypersonic Technology Demonstrator Vehicle Configuration and Flight-Testing Details (Credits: K.P.J. Reddy, 2007)

In 2007, the former president of India, APJ Abdul Kalam, also mooted the idea of having a Mark-II version of the BrahMos hypersonic cruise missile. To this end, in 2009, a Memorandum of Understanding (MoU) was signed between India and Russia.[9] The new version was named BrahMos-2 and paved the way for certain specifications, such as a weapon system based on hypersonic scramjet technology.[10] The rationale for developing this weapon was to target deeply buried enemy nuclear bunkers and heavily protected locations, and all three defence services of India would be utilising it.[11] However, little was achieved under this MoU, and India continued developing the technology on its own. To enhance its scramjet capabilities, India tested in 2019 and 2020 the indigenously developed HSTDV. The 2019 test did not achieve the desired result and was deemed a failure.[12] However, on 7 September 2020, India announced a successful test of its scramjet technology. The 2020 test allowed for the scramjet engine to burn for about 20 seconds, operating the vehicle beyond Mach 5. The 2020 tests ushered India's hypersonic ambitions into a new era, and since then, the development programme has been successful in many ways. The ambition to acquire hypersonic weapons, particularly HCM, got a boost on 21 December 2022 when India's Defence Minister stated that "*In order to maintain a minimum credible deterrence, we have to immediately think about hypersonic cruise missile development. It will be a revolutionary step in our defence sector and we all have to put our efforts into it.*[13]" Since the 2020 test and the Defence Minister's assertion, India further advanced scramjet technology, and in January 2023, it again tested the HSTDV's scramjet engine. The 2023 test, however, did not go as planned and was deemed only partially successful. There was no official word from the DRDO about it, but the subsequent reports published in the media noted that "*The initial launch and take-off were successful. But there are question marks on the subsequent performance of the scramjet engine of the HSTDV for which the data has*

[9] 'India, Russia to develop new hypersonic cruise missile,' Indian Express, 09 October 2009, https://indianexpress.com/article/india/latest-news/india-russia-to-develop-new-hypersonic-cruise-missile/

[10] Javed Alam, 'India's Hypersonic Ambitions: Tracking the Progress,' Centre for Aerospace Power and Strategic Studies, 24 February 2024, https://capssindia.org/indias-hypersonic-ambitions-tracking-the-progress/

[11] 'India to develop MrahMos-II missile,' BrahMos Aerospace, 03 August 2009, https://www.brahmos.com/press-release/95

[12] Rajat Pandit, 'India's maiden hypersonic technical demonstrator vehicle flops,' The Times of India, 12 June 2019, https://timesofindia.indiatimes.com/india/indias-maiden-hypersonic-technical-demonstrator-vehicle-flops/articleshow/69762552.cms

[13] Rajat Pandit, 'Rajnath Singh asks DRDO to fast develop hypersonic weapons,' 15 December 2021, https://timesofindia.indiatimes.com/india/rajnath-singh-asks-drdo-to-fast-develop-hypersonic-weapons/articleshow/88285554.cms

to be analysed in detail.[14]" However, in a major breakthrough, the DRDL of DRDO conducted on 9 May 2026 an extensive long-duration test of 'Actively Cooled Full Scale Scramjet Combustor.[15]' The test ran for over 1,200 seconds. The following table provides an overview of tests conducted over the years to develop a supersonic combustor.

Date	Test Name	Organisation	Time Achieved
28 August 2016	Captive Test	ISRO	5 seconds at Mach 6
7 September 2020	Flight Test	DRDO	20 seconds at Mach 6
January 2025	Ground Test (Full Scale)	DRDO	120 seconds
25 April 2025	Ground Test (Sub-scale)	DRDO	1,000 seconds
10 January 2026	Ground Test (Full Scale)	DRDO	720 seconds
9 May 2026	Ground Test (Full Scale)	DRDO	1,200 seconds

Overview of tests conducted to develop a supersonic combustor. Source: Compiled by the author

In terms of flight-testing, India made significant progress in its hypersonic technology on 16 November 2024 with the successful trial of a long-range hypersonic missile. The test marked an important step in the country's pursuit of advanced missile capabilities. The missile test and subsequent official press release provided much information about where the programme is heading.[16] The government mentioned in this communication that India's hypersonic missile has been developed and designed to carry various payloads for ranges greater than 1,500 km. This was an important announcement with regards to the kind of warhead India intends to mount on its hypersonic platform. The terminology "various payloads" can mean many things, but in all probability, it must refer to both conventional and nuclear warheads. India's missile inventory is generally classified by whether it is intended for a conventional payload or a nuclear payload. The Agni, Prithvi, and Sea-launched ballistic missile series, designed to deliver nuclear warheads, fall under the operational domain of the Strategic Forces Command (SFC), the primary agency responsible for executing nuclear missions. Missiles such as BrahMos are under the operational domain of India's three defence services, and are meant to deliver only conventional warheads.

[14] Rajat Pandit, 'India conducts another test in a bid to develop hypersonic weapons,' 28 January 2023, https://timesofindia.indiatimes.com/india/india-conducts-another-test-in-a-bid-to-develop-hypersonic-weapons/articleshow/97389386.cms

[15] 'Major breakthrough in Hypersonic Missile development: DRDO conducts extensive long-duration test of Actively Cooled Full Scale Scramjet Combustor,' Ministry of Defence, 09 May 2026, https://www.pib.gov.in/PressReleasePage.aspx?PRID=2259482&reg=3&lang=1

[16] Ministry of Defence "DRDO carries out successful flight-trial of India's first long-range hypersonic missile off the Odisha coast," PIB,17 November 2024, https://www.pib.gov.in/PressReleasePage.aspx?PRID=2073994&reg=48&lang=2

An image of the Long-range Hypersonic missile test conducted on 17 November 2024. Credits: Government of India[17]

While there is therefore ambiguity on the type of warhead that India intends to couple to its hypersonic systems, the characteristics and information gathered from the recent test report of the HGV make it likely that this system at least will be designed as a conventional weapon. This point can be ascertained from the way DRDO is showcasing the weapon development and end-user arrangements. The DRDO's showcasing of LR-AShM at a military parade on 26 January 2026 and the newsletter published shortly thereafter specified the LR-AShM role, and stated that "*the weapon system is designed to meet the coastal battery requirements of the Indian Navy*[18]." Given that the end-user of the LR-AShM, as per the DRDO newsletter, is the Indian Navy rather than the SFC, it is safe to assume that the weapon will remain conventional. The LR-AShM essentially uses a two-stage solid-propulsion rocket motor system, in which Stage-1 separates after the burn-out, and the vehicle then travels as an unpowered glider. The second and most recent development is the DRDO test conducted on 1 May 2026. This particular test has been reported only by several Indian media houses, and no official confirmation has come from the DRDO.

[17] 'DRDO carries out successful flight-trial of India's first long-range hypersonic missile off the Odisha coast,' Ministry of Defence, 17 November 2924, https://www.pib.gov.in/PressReleasePage.aspx?PRID=2073994&reg=3&lang=2

[18] 'REPUBLIC DAY 2026: DRDO SHOWCASED ITS PATH BREAKING INNOVATIONS AT KARTAVYA PATH AND BHARAT PARV,' DRDO Newsletter, Vol. 46, Iss. 2, February 2026, p. 4, https://drdo.gov.in/drdo/sites/default/files/publication-document/NL_Feb2026.pdf

India's LR-AShM with Launcher was showcased on 26 January 2026. Credits: DRDO

While not much is known about the future features and warheads of India's HCM, the following details are known:

Length	5.6m
Mass	1,000 kg
Cross section	Octagonal with rectangular-shaped air intake
Materials	Titanium alloy, Aluminium alloy, Niobium and Nimonic alloys

HSTDV Specifications[19]

The LR-AShM, on the other hand, follows a quasi-ballistic trajectory, meaning that it will follow a low trajectory and will be able to perform manoeuvres. The former DRDO chairman also explained the major technological features of the HGV and stated that *"The HGV follows a quasi-ballistic trajectory, reaching speeds of up to Mach 10 and maintaining an average speed of around Mach 5 with multiple skips. It is equipped with indigenous sensors to engage moving targets in the terminal phase.*[20]*"*

[19] Rajaram Nagappa, 'Hypersonic Cruise Missiles: An Overview,' 2020, p. 8, http://eprints.nias.res.in/2639/1/2020-Hypersonic_Cruise_Missiles-RajaramNagappa.pdf

[20] The LR-AShM, is reported to be about 14 meters long and weigh less than 20 tons. "India's LR-AShM hypersonic missile nears trials, DRDO outlines capabilities" Business Standard, 30 April 2026, https://www.business-standard.com/external-affairs-defence-security/news/india-s-lr-ashm-hypersonic-missile-nears-trials-drdo-outlines-capabilities-126043000590_1.html

LR-AShM section at DRDO (Screenshot from India TV report, Credits: @Archit_Ch)[21]

Strategic Rationale and Future of India's Hypersonic Programme

To understand India's interest in hypersonic technology, two considerations require attention: one relates to hedging against technological development, and the second concerns China's rapid development in the same domain. For India, hypersonic technology is a dream that has been in the making for a fairly long time. As argued earlier, the ambition first arose from the technology's civilian use and subsequently became tied to the national security requirement. The recent advancement in India's hypersonic capabilities is tied to China's development in the same domain. China currently operates the DF-17 medium-range missile equipped with an HGV. China also deploys the medium-range DF-21D anti-ship missile. While the DF-17 is essentially an HGV meant to bypass adversaries' ballistic missile defences, the DF-21D is designed to attack ships at sea, thus the name "carrier-killer," and has a manoeuvrable warhead. The DF-21 D is essentially a ballistic missile and cannot be utilised as an HGV per se. India has made sure to follow suit, but unlike China, which developed the so-called carrier-killer early and then followed up with the HGV, India has been developing both the HCM and the HGV almost simultaneously. Another important dimension would require more information regarding India's hypersonic weapon. While China has made sure to develop its hypersonic capabilities in a dual-capable form, it remains to be seen whether India will also make that choice. The 2021 observation by the Defence Minister of India shed light on how India wants to weaponise its HCM.[22] Given this observation, India may proceed to develop its HCM as a potential launcher for its nuclear deterrence, while the HGV will remain conventional. This, however, is a guess based on current developments.

There is another important dimension regarding the hypersonic weapons that India might seek in the near future. India has been considering establishing an Integrated Rocket Force since 2021, and the most recent announcement on the matter came from the Indian Chief of Army Staff.[23] To fulfil the mandate, India might deploy its hypersonic weapons and the recently tested Pralay missile into the Integrated Rocket Force, which

[21] Adithya Krishna Menon, 'India showcases first Hypersonic Anti-Ship Missile System in national parade,' Naval News, 29 January 2026, https://www.navalnews.com/naval-news/2026/01/india-showcases-first-hypersonic-anti-ship-missile-system-in-national-parade/

[22] Rajat Pandit, 'Rajnath Singh asks DRDO to fast develop hypersonic weapons,' 15 December 2021, https://timesofindia.indiatimes.com/india/rajnath-singh-asks-drdo-to-fast-develop-hypersonic-weapons/articleshow/88285554.cms

[23] Abhishek De, 'India plans rocket-missile force with eye on Pak. What it can learn from Iran,' India Today, 14 January 2026, https://www.indiatoday.in/india/story/india-rocket-missile-military-force-eye-on-pakistan-china-what-is-it-2851767-2026-01-14

will be conventional in nature as hinted recently by the former DRDO chairman.[24] India has developed the Pralay missile, a quasi-ballistic surface-to-surface tactical ballistic missile for conventional roles. The whole purpose of establishing such an institution would be to provide India with a greater firepower with speed and precision in stand-off warfare capabilities against both Pakistan and China. To do so, the hypersonic weapons, both the HGV and HCM, might eventually play a bigger role as conventional weapons rather than as nuclear ones.

[24] "India's LR-AShM hypersonic missile nears trials, DRDO outlines capabilities" Business Standard, 30 April 2026, https://www.business-standard.com/external-affairs-defence-security/news/india-s-lr-ashm-hypersonic-missile-nears-trials-drdo-outlines-capabilities-126043000590_1.html

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THE HAGUE CODE OF CONDUCT

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