ISSUE BRIEF
IB/23/25

CENJOWS

VYOMOTKAMPA: A HYPERSONIC ASCENT OF SASHAKT BHARAT

MR VINAYAK KUMBAR

www.cenjows.in

CENTRE FOR JOINT WARFARE STUDIES

CENJOWS

VYOMOTKAMPA: A HYPERSONIC ASCENT OF SASHAKT BHARAT

Mr. Vinayak Kumbhar is a Technical Research Assistant at the CENJOWS

Introduction

Picture yourself cycling at 100 km/h, heart racing due to adrenaline rush, experiencing thrills and a hint of anxiety causing some chills, some would term it as an adventurous yet cautious ride. Now, imagine a speed 77 times faster, surpassing the sound barrier at 1,235 km/h (761mph).[1] You are now closer to envision a missile soaring over Mach[2] 7, over 9000+ km/h – striking fear into the hearts of not so friendly nations, with unparalleled precision. Welcome to the realm of "**Hypersonic**"[3] technology, where vyoma meaning sky[4], is getting tremors – utkampa[5] from this mighty weapon rightly justifying the title. In 2025, Bharat stands tall in this elite domain, countering strategic challenges, particularly from adverse neighbours like China and its advancements in hypersonic warfare, with indigenous marvels like the K-6,[6] LRAShM,[7] and BrahMos-

II[8] missiles. These innovations not only bolster Bharat's defence arsenal but also assert its technological sovereignty in a race where global powers vie for supremacy. Through this issue brief, we unveil "Autophyes[i] Bharat", a self-reliant, self-developing nation, showcasing the strategic and technological implications of these advancements for defence, aerospace, and global ascendancy, forging a path to a "Swayam Viksit" and "Sashakt Bharat."

Arohana – A steady progress of decades

(**Fig.14** 3D art of Hypersonic LRAShM)
(**Source:** X/Kuntal Biswas)

The first ever time a mention of Hypersonic technology can be traced back to 1998[9] when DRDO initiated the studies in the same. It was carried under the guidance of one of the most revered scientists of India, **Padma Shri, Dr Prahlada Ramarao**.

---

[i] A Greek term for *Self-Reliant*

This was followed by Conceptual design of **Hypersonic Technology Demonstrator Vehicle**[10] which was later publicized in 2004. Next, in 2007 Dr A.P.J. Abdul kalam emphasised the importance of having Hypersonic weaponry.[11]

In 2009, India and Russia signed a a Memorandum of Understanding (MoU) which paved the way for what would be the final parameters of the new version of the BrahMos missile, which henceforth was to be known as BrahMos -2.[12]

In 2011, one more majestic feat was achieved when DRDO announced the successful conduct of a Shourya missile in canister mode. Designated as an sub surface to land missile, it has a range of 700km and was developed for Indian submarines.[13]

(**Fig.15** Shourya Missile testing**)**

(**Source:** Bharat Rakshak)

In the year 2016, a milestone of an extraordinary proportion, was achieved when Indian Space Research Organisation (ISRO) successfully tested the Scramjet Engine from Satish Dhawan Space Centre SHAR, Sriharikota. with hydrogen as fuel and the Oxygen from the atmospheric air as the oxidiser. This was a maiden test that was a short duration experimental one of ISRO's Scramjet engine with a hypersonic flight at Mach 6.[14] But this was followed by a setback when in 2019, Hypersonic Technology Demonstrator Vehicle (HSTDV) test failed.[15] But the resilience showed by our scientists bore a fruit in 2020 when HSTDV was successfully tested where it achieved power flight of about 20 seconds at an altitude of 31 km with Mach 6.[16]

(Fig.16 HSTDV Testing)
(**Source:** India today)

(**Fig.17** Missile Trial)
(**Source:** Janes.com)

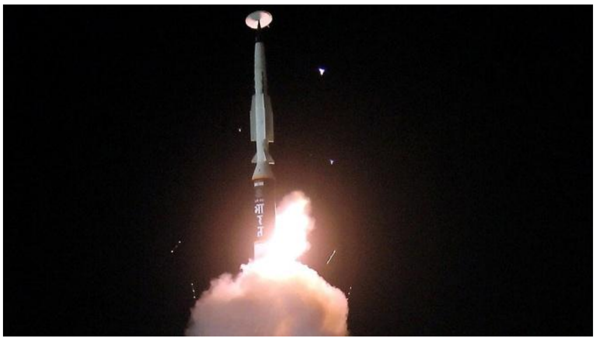
In 2020, India conducted a successful trial of the nuclear-capable Shaurya missile from a defence facility in Odisha. A canister launched, hypersonic surface-to-surface tactical missile and is developed by the DRDO, the missile can be stored without maintenance for long periods.[17]

The third test of HSTDV (Phase 3) was successfully conducted on 27 January 2023.[18] DRDO was able to achieve a controlled and sustained powered flight of 600 seconds, achieving a range of 1500 km with a warhead carriage capability of 300-400 kg.

Indo - China: The Game of Dominance

The Indo - China relationship has long been one of strategic competition or even what some may rightly call a rivalry, is of territorial disputes, and of a complicated balance of military might particularly along the **Line of Actual Control (LAC)**. In recent years, the development seen in the hypersonic technology has risen to be a critical dimension of this multifaceted competition reshaping the regional security picture. This has a significant impact on global level as well considering multiple centres of power as fantasised by few analysts in different domains. Hypersonic weapons, capable of traveling at speeds exceeding Mach 5 (over 6000+ km/h) with advanced manoeuvrability, represent a transformative leap in military capabilities, offering unparalleled speed, precision, and the ability to evade conventional missile defence systems. Both India and China having invested heavily in hypersonic technology, highlighting a need to counter each other’s growing military power and assert dominance in the Indo - Pacific region. This section is an attempt to dive into the Indo - China conflict through the lens of their individual advancements in hypersonic weaponry, examining the strategic implications, technological differences, and the broader impact on regional stability as well as on a one beyond it.

India’s swoop into hypersonic technology is a proof of its ambition to achieve strategic autonomy and boost its deterrence capabilities, particularly against China in order to have a strong as well as a straightforward say in its territorial sovereignty considering other associated rival neighbours of it with severe connections to the former one. The successful test of India’s first long range hypersonic missile, the **Long-Range Anti-Ship Missile (LRAShM),** on 16th November 2024, marked a historic milestone, placing India among an elite group of nations to having achieved such feat. Developed by the Defence Research and Development Organisation (DRDO) the LRAShM is designed to carry various payloads over ranges exceeding 1,500 km, with speeds reaching Mach 6 and the ability to execute manoeuvres while in air! making it difficult to intercept for the radars or sonars as such. It outperforms similar missiles like China’s DF-17 in terms of range and technology. The missile’s special feature is its incorporation of a **delta wing hypersonic glide vehicle (HGV)**, which allows it to follow highly complex and flexible flight paths. This capability provides greater flexibility and ensures its ability to bypass advanced air defence networks and any tracing devices such as radars. Measuring approximately 14 meters in length and weighing under 20 tons, the LRAShM is configured for launches from both land-based platforms and naval vessels, making it a versatile tool for coastal defence, anti-ship operations, and long-range precision strikes.[19]



(**Fig.28** LRAShM test launch)
(**Source:** India Today)

This missile, tailored for anti-ship roles, is seen as a potential “**carrier killer**,” similar to China’s DF-21D, and is intended to counter high value naval assets of counterparts and potential threats in the Indian Ocean Region (IOR).

Additionally, India’s **Extended Trajectory Long Duration Hypersonic Cruise Missile (ET-LDHCM)**, tested in 2025, has a range of 1,500 km and a warhead capacity of 1,000–2,000 kg, capable of both **conventional and nuclear payloads**. While the ET-LDHCM represents a significant military achievement, its implications go beyond warfare. The underlying hypersonic technologies could benefit space launches, disaster response, and even boost India’s defence manufacturing ecosystem by creating jobs and opportunities for domestic industries.[20]

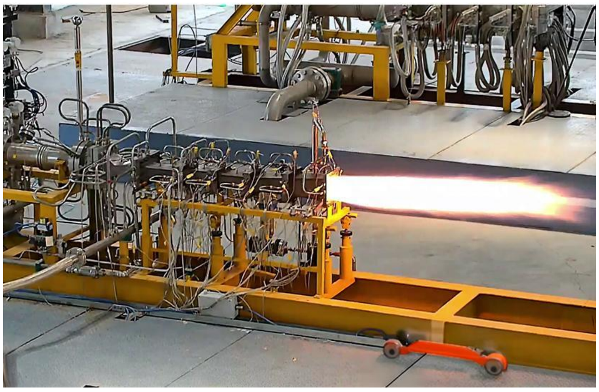
(**Fig.29** ET – LDHCM)
(**Source:** indiandefencenews)

The BrahMos-II, a collaboration with Russia, is another weapon in India's hypersonic arsenal aiming for speeds of Mach 7 - 8 and a range of approximately 600 km. Decades of research starting in 1998 under **Dr. Prahlada Ramarao** with significant milestones like the successful 2020 test of the Hypersonic Technology Demonstrator Vehicle (HSTDV) which achieved sustained flight at Mach 6 for 20 seconds,[21] and the 2023 test sustaining 600 seconds of powered flight[22] we seem to be on a perfect path in this case.

(**Fig.30** BRAHMOS – II Scale down version**)**

(**Source:** irdw.org)

India's advancements in scramjet technology, demonstrated by ISRO's 2016 test and DRDL's 2025 ground run of a subscale scramjet engine for over 1,000 seconds,[23] underscore its growing self-reliance in hypersonic propulsion systems.



(**Fig.31** Scramjet engine test run**)**

(**Source:** PIB**)**

Whereas, China has established itself too as a global leader in hypersonic technology, with a mature and diverse arsenal. China's DF-17, equipped with the DF-ZF Hypersonic Glide Vehicle (HGV), is a medium-range ballistic missile system capable of speeds between Mach 5 10 and a range of 1,800 to 2,500 km.[24] Operational since 2019 the DF-17 can carry both conventional and nuclear warheads, offering China a strategic advantage in both land attack and anti-ship roles.

(**Fig.32** DF – 17**)**

(**Source:** Deccan Herald**)**

The CM-401 hypersonic cruise missile, with speeds of Mach 6 - 8 and a range of 290 to 900 km,[25] is designed for ship and ground based launches, enhancing China's maritime capabilities.

(**Fig.33** CM – 401**)**

(**Source:** MW Stats)

The GDF 600, showcased at the 2024 Zhuhai air show, demonstrates China's technological ambition with a top speed of Mach 7 and the ability to deploy multiple payloads, including supersonic and subsonic missiles. The GDF-600 is capable of reaching speeds up to Mach 7, approximately 8,650 km/h, and can cover distances of up to 600 km, which could be on paper i.e., theoretically be extended to 6,000 km.

With a launch mass of 5,000 kg, including a payload capacity of 1,200 kg, the system can carry a range of specialized equipment, such as supersonic missiles, reconnaissance drones, and kinetic-impact projectiles. This platform is designed for rapid, effective penetrations into enemy air defences, complicating interception efforts and reducing response times.[26]

(**Fig.34** GDF 600)

(**Source:** internationaldefenceanalysis.com)

China's hypersonic advancements are supported by its strong industrial base and significant investments in research, giving it a head start over India as we have a serious concerns on defence expenditures which is MERE 0.7% of total GDP where as that of our counterpart is about 1.5%, almost double. In absolute terms this gap becomes even more wider to about 3 times!

The reported use of the CM-400AKG, a hypersonic air-to-surface missile, by Pakistan (though turning out to be a failure) against India's air defence system[27] in 2025 skirmish, is a direct and visible witness of China's role in providing hypersonic technology to its allies, indirectly attempting to hamper India's sovereignty and also challenging its defence deterrence capabilities.

The Indo-China hypersonic race is deeply linked with their much broader geopolitical tensions, particularly along the LAC as mentioned earlier, where skirmishes such as the 2020 Galwan Valley clash, have heightened the mutual averse positions. China's hypersonic capabilities, particularly the DF-17 and DF-21D, pose a significant counter to India's strategic assets including its naval forces in the IOR and military installations along the border. India's development of the LRAShM and BrahMos-II is a perfect counter to this alleged threat, aiming maintain deterrence in the IOR.

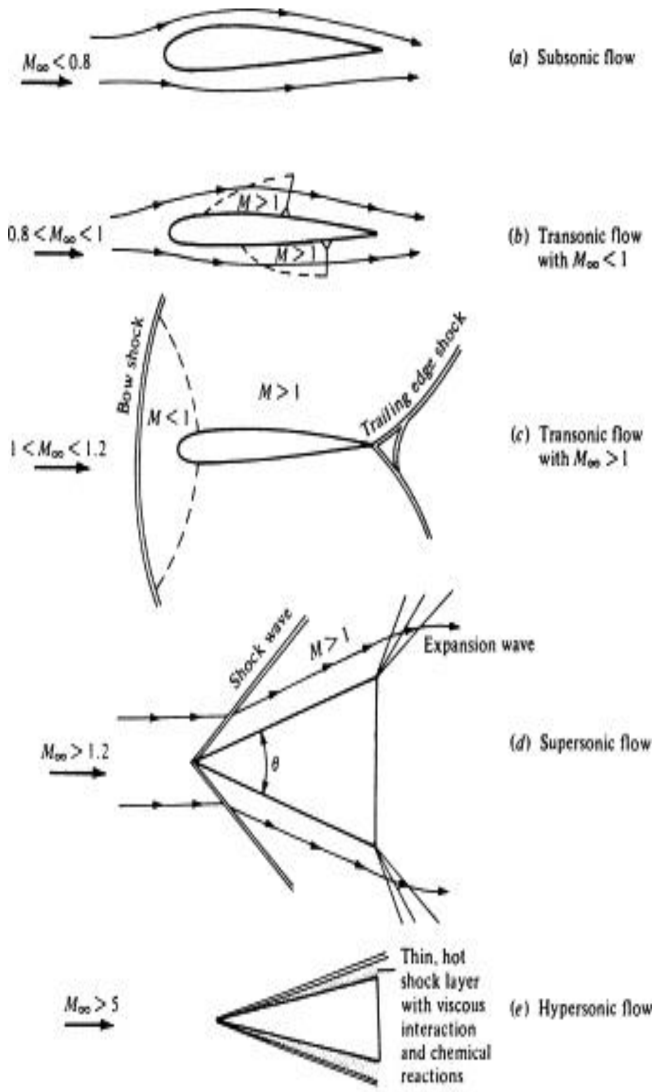
Technologically, China may hold an edge due to its earlier start and operational deployment of hypersonic systems. The extreme manoeuvring capabilities at low altitudes of Chinese hypersonic carriers makes it challenging for India's current air defence systems including the S-400, Barak-8, or for that matter for Akash to intercept but nonetheless not impossible. However, India's progress in scramjet technology and active cooling systems, as demonstrated in the 2025 DRDL tests, suggests potential to close this gap and an attempt to keep that sense of "impossibleness" a myth. India's joint venture with Russia on the BrahMos-II effectively puts to use the Russian expertise in hypersonic propulsion, such as that used in the Zircon missile which could potentially accelerate India's development timeline. Moreover, India's adherence to the Missile Technology Control Regime (MTCR)[28] ensures that its missile ranges remain constrained, potentially limiting their strategic reach compared to China's much longer-range systems like the DF-17. China's willingness to transfer hypersonic technology to Pakistan, as evidenced by the CM-400AKG and potential DF-17 transfers, brings further complications in an already strained relations.

The Indo-China hypersonic arms race is one of the critical sides of their broader multifaceted strategic rivalry, driven by the need to counter each other's military capabilities and assert regional dominance and also to establish a global one eventually for the world to take note of. India's rapid progress in hypersonic technology, exemplified by the LRAShM, ET-LDHCM, and BrahMos-II, reflects its commitment to self-reliance. While China maintains a technological and operational lead India's advancements, supported by indigenous innovation and international collaboration, position it as an equally worthy contender. These dynamics will shape the Indo Pacific security environment, necessitating much needed civil and diplomatic efforts to manage tensions and prevent further escalation. As both nations continue to enhance their hypersonic arsenals, the balance of power in the region hangs by a thin thread, with hypersonic technology serving as both a deterrent and a potential booster dose the conflict might just need no matter how unfortunate that might turn out to be.

Sound Barrier – The Mach number

(**Fig. 1** An F-22 Raptor reaching a velocity high enough to achieve a sonic boom.)[29]
(**Source**: Universe Today)

In Aerodynamics, Mach number is defined as the ratio of speed of an aircraft to that of sound.[30] **M = v/a**,[31] where M is Mach number, v is the speed of the aircraft, a is speed of sound. Based on Mach number the flight regime is normally subdivided into following categories[32]



(**Fig.2** Mach regime)[33]

(**Source:** John. D. Andesron, Flight Aerodynamics)

Subsonic flow (M < 0.8)

Transonic flow (0.8<M<1.2)

Sonic flow (M=1)

Supersonic flow (1.2<M<5)

Hypersonic flow (M>5)

A Comparison of different Mach regimes[34] [35] [36] [37] [38] [39] [40]

Aspect	Subsonic	Sonic	Transonic	Supersonic	Hypersonic
Mach Number (M)	M < 1 ~(0.3 to 0.8)	M = 1	0.8 < M < 1.2	M > 1 ~ (1.2 to 5)	M > 5
Speed (v) (w.r.t. speed of sound, a)	v < a	v = a	v ~ a, with mixed subsonic and supersonic regions	v > a	v >>a
Flow Characteristics	Smooth, Almost incompressible Streamlines are continuous and smooth	Critical where flow transitions, Shock waves may form	Mixed flow coexistence of subsonic and supersonic regions , Shock waves and flow separation may occur, Significant compressibility effects	Formation of shock waves (Normal, oblique), highly compressible, sharply deflected streamlines	Extreme shock wave formation, Ionisation and air dis-association due to high temperature, Domination of boundary layer effects
Pressure and Density	Small changes in pressure and density, Flow behaves as nearly incompressible	Pressure and density changes are significant, Choked flow in nozzles	Rapid pressure and density changes, Flow can be unstable due to shock wave formation	Large pressure and density jumps across shock waves, Flow is highly compressible	Extreme pressure and density variations, Molecular dissociation alters gas properties
Temperature Effects	Minimal temperature rise due to low kinetic energy	Moderate temperature rise at critical points	Localized heating due to shock waves	Significant heating due to compression across shocks	Extreme heating leading to plasma formation and material ablation

Applications	Commercial airliners, cars, trains, Low-speed wind tunnels	Nozzles in jet engines at choke points, Critical flow in pipes,	High-speed aircraft near Mach 1, Transonic wind tunnels	Supersonic aircrafts (ex. Concorde, F-22 Raptor), Missiles, Supersonic wind tunnels, Bullets	Spacecraft re - entry (ex. Space Shuttle), Hypersonic missiles, Scramjet engines
Examples	Cessna 172 Boeing 777 Airbus 330	Throat of a converging-diverging nozzle	Boeing 747	Concorde, F-22 Raptor, SR-71 Blackbird etc.	X-43A
Challenges	Drag due to skin friction and form drag, Noise control in high-speed subsonic flows	Flow instability at transition, Precise control required	Shock-induced drag (wave drag) Flow, instability and buffet	High drag and fuel consumption, Shock wave noise -sonic boom, Material stress	Extreme thermal loads, Material erosion, Complex aerodynamics and control
Aerodynamic Design	Streamlined shapes to reduce drag, Simple air foil designs	Specialized nozzle designs ex. de Laval nozzle	Air foils designed to delay shock formation, Swept wings for stability	Sharp, slender designs to minimize shock strength, Delta wings	Blunt shapes for re-entry vehicles to dissipate heat, Advanced thermal protection systems
Wave Phenomena	No shock waves, Sound waves propagate freely	Onset of shock wave formation, Flow choking	Shock waves form locally ex. on wings (Wave drag increases)	Strong shock waves (normal and oblique), Sonic booms	Intense shock waves (Shock layer interacts with boundary layer)

Propulsion Systems	Turbofan engines, Propellers, Internal combustion engines	Converging-diverging nozzles in jet engines	High-bypass turbofans or low-bypass afterburning engines	Afterburning turbojets, Ramjets	Scramjets, Rocket engines
Material Requirements	Standard materials ex. aluminium, steel etc…	Materials to withstand moderate thermal and pressure loads	Stronger materials to handle localized stresses	Heat-tolerant materials ex. titanium, composites	Advanced ceramics, ablative materials, or refractory metals for heat resistance
Testing Facilities and flow visualisation techniques	Low-speed wind tunnels, Standard flow visualization techniques	Specialized nozzles and test sections	Transonic wind tunnels with variable Mach control	Supersonic wind tunnels	Hypersonic wind tunnels, Plasma wind tunnels for re-entry simulation
Typical Phenomena	Laminar or turbulent boundary layers, Low drag	Critical flow conditions, Mach disk in nozzles	Shock stall, Transonic buffet	Shock diamonds in exhaust, High drag due to shocks	Ionization of air, Chemical reactions in flow, Thermal ablation
Noise Characteristics	Aerodynamic noise ex. turbulence, propeller noise	High noise at transition points	Increased noise due to shock wave interactions	Sonic booms, High jet exhaust noise	Extreme noise from shock waves and high-speed exhaust

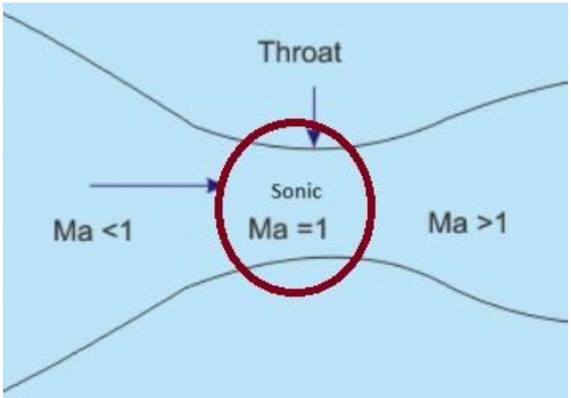
Mathematical Modelling	Incompressible flow equations ex. Bernoulli's equation, Navier-Stokes with low Mach approximation	Isentropic flow relations, Critical flow equations	Compressible Navier-Stokes, Shock capturing methods	Compressible flow equations, Shock relations (Rankine-Hugoniot)	Non-equilibrium thermo - dynamics, Navier-Stokes with chemical reactions

(**Table:** Comparison of Different Mach Regime characteristics)

(**Source:** Compiled by Author from books and websites mentioned in end notes)

(**Fig. 3** Boeing 777 a subsonic regime aircraft)

(**Source:** Boeing)



(**Fig. 4** Sonic condition at the throat of a convergent – divergent nozzle)[41]

(**Source:** NPTEL)

(**fig. 5** Boeing 777 flying at transonic speed)[42]
(**Source:** Supercarblondie)

(**Fig. 6** F32 Raptor flying supersonic)[43]
(**Source**: The avionist)

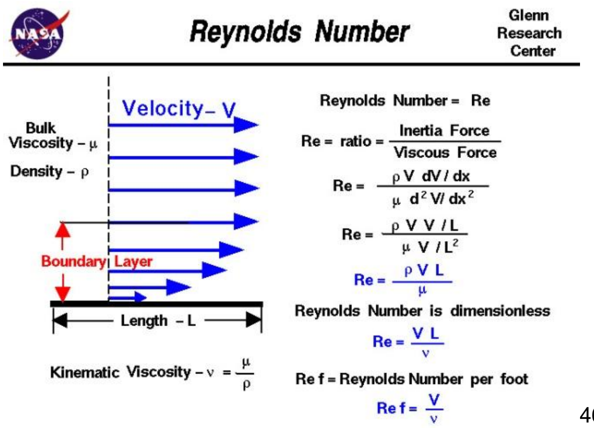
(**Fig. 7** Atmospheric Re-entry)[44]
(**Source:** Payloadspace)

In this issue brief, the focus has been kept on Hypersonic flow regime and its application, challenges, recent developments and India's latest triumphs in the same

Before we dive into the realm of Hypersonic speed, there are few basic terminologies one needs to be familiar with in order develop a basic essence of what lies ahead.

Mach number - As stated earlier Mach number is the ratio of speed of an aircraft to that of sound. M = v/a, where M is Mach number, v is velocity of aircraft and a is speed of sound.

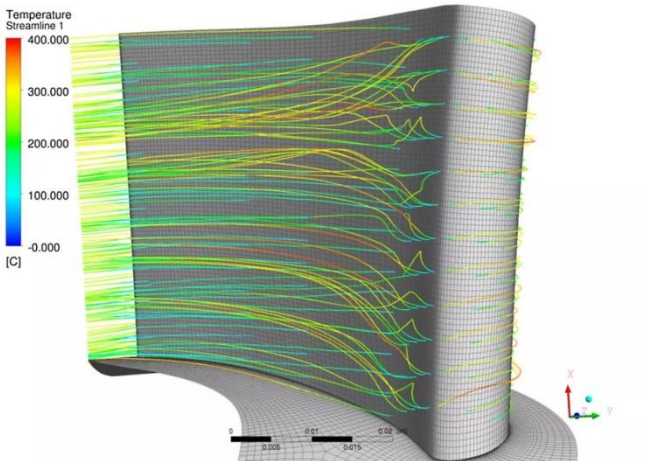
Reynolds number (Re) – It is defined as ratio of Inertial force to that of Viscous force. Re = Inertial force/viscous force. It is a dimensionless quantity which is of crucial importance for studying flow properties and characteristics and to determine whether the fluid flow is laminar or turbulent.[45]



[46]

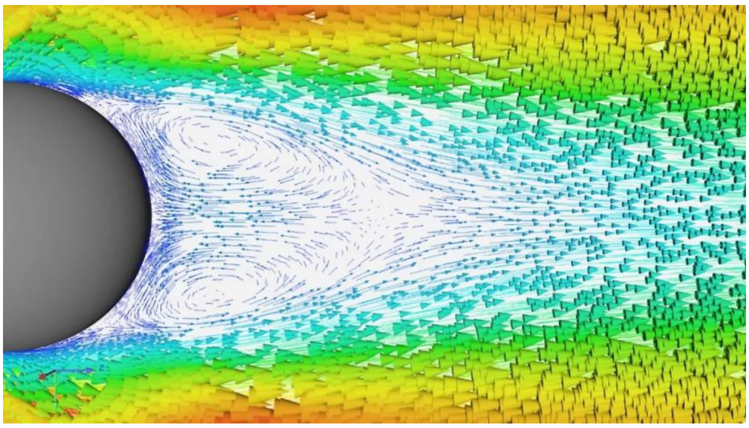
(**Source:** NASA)

Laminar flow - Laminar flow, also called streamline flow, is a flow regime in which the particles in a fluid move in smooth, parallel layers. In this viscous forces in fluid flow dominate the internal kinetic forces. Laminar flow is most common in viscous fluids flowing at a relatively low flow rate.[47]



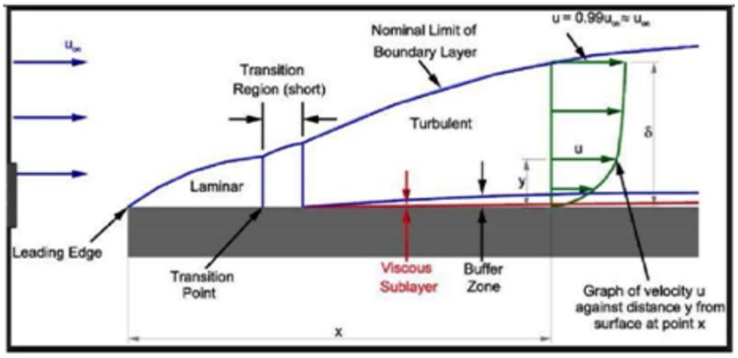
(**Fig. 8** CFD analysis of a turbine blade showing laminar flow)[48]
(**Source:** ANSYS)

Turbulent flow - when the particles in the fluid start to move perpendicular to the dominant or mean flow direction and exhibit chaotic changes in direction, flow velocity, and pressure. This perpendicular, often circular movement is referred to as an eddy or swirl.[49]



(**Fig. 9** CFD Analysis showing turbulent flow)[50]
(**Source:** ANSYS)

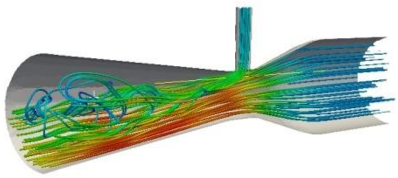
Boundary layer - As the fluid moves past the object, the molecules right next to the surface stick to the surface. The molecules just above the surface are slowed down in their collisions with the molecules sticking to the surface. These molecules in turn slow down the flow just above them. The farther one moves away from the surface, the fewer the collisions affected by the object surface. This creates a thin layer of fluid near the surface in which the velocity changes from zero at the surface to the free stream value away from the surface i.e., The boundary layer.[51]



(**Fig.10** Various layers in a flow past a surface)[52]

(**Source:** Skill lynk)

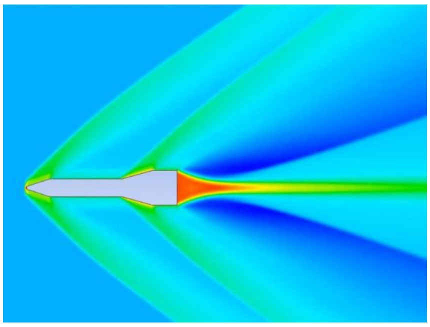
Incompressible flow - incompressible flow refers to a flow in which the density remains constant in any fluid parcel, i.e. any infinitesimal volume of fluid moving in the flow.[53]



(**Fig.11** Incompressible flow inside a ventury tube)[54]

(**Source:** Simscale)

Compressible flow – The flow at velocities that are comparable to, or exceed, the speed of sound. At such velocities the variations in density that occur as the fluid moves from place to place are too significant to be ignored.[55]



(**Fig.12** Incompressible flow)
(**Source:** Brittanica)

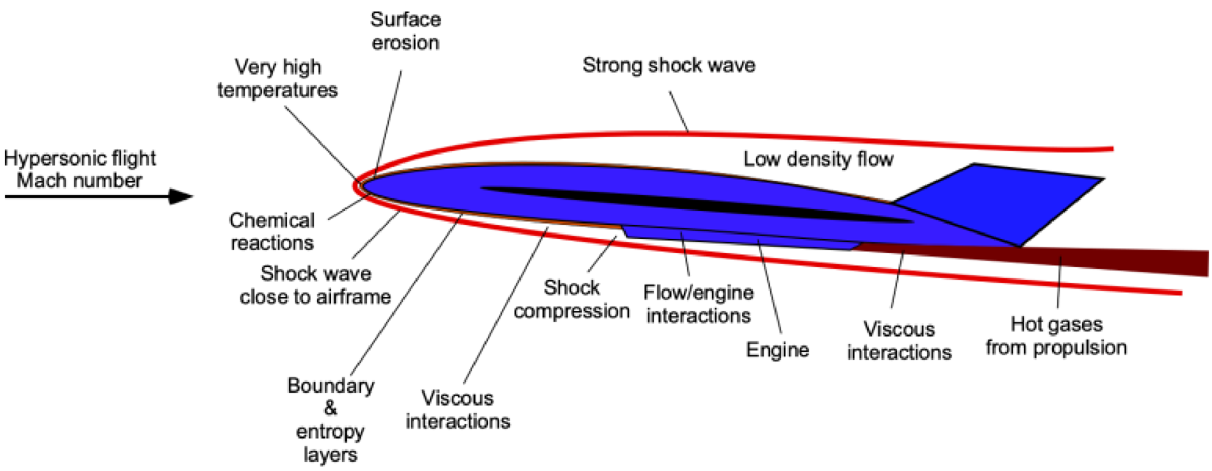
Shock wave - When an airplane reaches the speed of sound and catches up to its own pressure waves, the air ahead of it receives no warning of the plane's approach. The airplane blows through the air, creating a shock wave which can be understood as an accumulation of molecules in an intense concentration.

(**Fig.13** An aircraft with a visible shockwave developed)
(**Source:** Deccan Herald)

Now let's dive into the majestic realm that is "Hypersonic". As mentioned in the beginning, an object is said to have reached hypersonic velocities if it reaches a speed that is as much as 5 times more than that of sound in the same medium. This comes up to about a magnificent 9000+ km/hr! Imagine travelling from Kashmir to Kanyakumari in about 20 - 25 minutes! Aren't that thrilling? When an aircraft or a missile travels through such speed it literally can be seen as tearing the sky and moving ahead causing tremors and instilling fear into the hearts of what one may call as enemies and hence the name “Vyomotkampa.” As we move further into the details one can appreciate the sheer amount of efforts and scientific prowess Indian scientists have put into make the dominance is visible globally. Before heading to the missiles, aircrafts and latest inventions and innovations, milestones we need to first make ourselves completely familiar with the concept of Hypersonic flow in a bit more elaborate way.

Aerodynamics behind Hypersonic technology

The main characteristic of hypersonic technology is that the temperature generated around the aerial body is extremely high and hence study of the chemistry of the gas is of great importance. At low hypersonic speeds, there is a vibration of molecular bonds, which changes the magnitude of the forces experienced by aircraft because of air. At higher hypersonic speeds, there is creation of plasma because of the breaking apart of these bonds. There is a large variation in air density and pressure caused by shock waves, and expansions. There is a presence of very thick boundary layer along the surface of hypersonic vehicles and missiles causing a high heat transfer to the surface.[56]

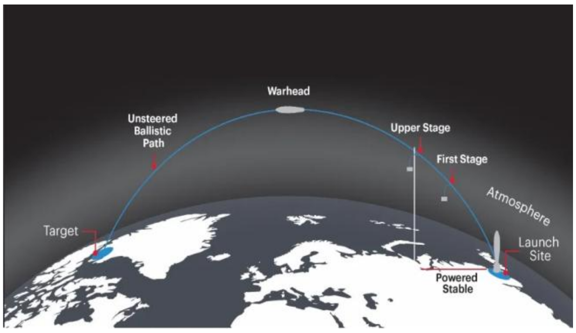


(**Fig 18.** Boundary layer around an aircraft)

(**Source:** NASA)

The initial research related to hypersonic flight began when post-WWII ballistic missile development when the necessity of vehicles in the Mach regime of over 5 became evident. In order to achieve intercontinental range, these missiles had to exit the atmosphere and re-enter it near the target location.

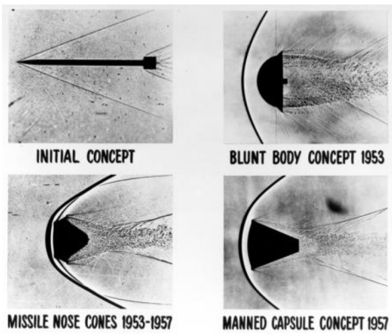
The missiles tested were based on a highly pointed German V2 design. They experienced intense aerodynamic heating and shock wave compression, leading to structural failure. It often melted entirely during its descent.



(**Fig.19** Ballistic Trajectory)
(**Source:** Medium.com)

(**Fig.20** German V2 design-based rocket)
(**Source:** 3djake.uk)

A blunt and rounded nose design for the same was suggested by H. Julian Allen and Alfred Eggers, which created a shock wave that stood off the nose and caused a boundary layer to flow over the nose cone's surface, preventing the excessive heat of re-entry from melting the structure.[57]



(**Fig.21:** Shockwave ahead of sharp and blunt shaped bodies)
(**Source:** Leishman, J. Gordon. 2023. "Hypersonic Flight Vehicles.)

List of countries which possess Hypersonic technology

<table>
<tr><td>China</td></tr>
<tr><td>Hypersonic Glide Vehicle **DF-ZF (with DF-17)**</td></tr>
<tr><td>


(**Fig.22** DF-ZF with DF-17)
(**Source:** National Herald)
</td></tr>
<tr><td>Hypersonic Cruise Missile **CM-401**</td></tr>
<tr><td>


(**Fig.23** CM – 401)
(**Source:** cgtrader)
</td></tr>
<tr><td>Russia</td></tr>
<tr><td>Hypersonic Glide Vehicle **Avangard**</td></tr>
</table>

 (**Fig.24** Avangard) (**Source:** Sputnik India)

Hypersonic Cruise Missile **Zircon**
 (**Fig.25** Zircon) (**Source:** Russia beyond)
Air Launched Hypersonic Missile **Kinzhal**
 (**Fig.26** Kinzhal) (**Source:** CAT/UXO)
United States
Hypersonic Glide Body **(LRHW/CPS)**

(**Fig.27** LHRW/CPS)
(**Source:** Naval News)

(**Table:** countries which possess Hypersonic technology)
(**Source:** Compiled by Author)

A comparison: Where does India stand Globally?

Country	Missile System	Speed	Year of Initiation	Year of Completion	Length	Warhead Capacity	Range	Launch Platform
India	ET-LDHCM	Mach 8	2007	2024	~8 m	1,000 - 2,000 kg (conventional or nuclear)	1,500 km	Air, Sea, Land
China	DF-ZF (with DF-17)	Mach 5–10	Early 2010s	2019	~10–12 m	500 - 1,000 kg (conventional or nuclear)	1,800 - 2,500	Ground (TEL), potentially Air
China	CM-401	Mach 6–8	Mid-2010s	2018	~6–8 m	~300 kg (conventional)	290 - 900 km	Ship, Ground
Russia	Avangard	Mach 20–27	2004	2019	~2–3 m	~2,000 kg (nuclear, up to 2 Mt)	6,000 km	Silo (Sarmat ICBM)

Country	Missile System	Speed	Year of Initiation	Year of Completion	Length	Warhead Capacity	Range	Launch Platform
Russia	Zircon	Mach 8–9	2011	2022	~8–10 m	300 - 400 kg (conventional or nuclear)	1,000 - 1,500	Ship, Submarine, potentially Air
Russia	Kinzhal	Mach 10–12	2010s	2017	~8 m	480 kg (conventional or nuclear, up to 500 kt)	1,500 - 2,000	Air (MiG-31, Tu-22M3)
United States	Hypersonic Glide Body (LRHW/CPS)	Mach 5–10	2017	2023	~3–5 m	500 - 1,000 kg (conventional)	2,775 - 3,000	Ground (Army), Ship (Navy)

(**Table:** India’s position in Global order)

(**Source:** Compiled by Author)

Project VISHNU

The Extended Trajectory Long Duration Hypersonic Cruise Missile (ET – LDHCM) is designed to deliver precision strikes with conventional and also nuclear warheads weighing 1 to 2 tonnes.[58] It is a flagship project under the DRDO’s hypersonic missile development program. It offers a strategic flexibility by being able to be launched from Air, Sea as well as from land[59] targeting enemy command centres, radar installations, naval assets, bunkers and more. Having the ability to perform mid flight course corrections and to be able to operate at low altitudes[60] it enhances India’s deterrence capabilities by being less susceptible to be detected by conventional radar systems.

(**Fig.35** India’s new Hypersonic Missile)
(**Source:** Indian Defence Research Wing)

Way Forward

As India strengthens its position in the hypersonic domain through the LRAShM, ET-LDHCM, and BrahMos-II, the need of the hour is a sustained innovation, strategic integration, and geopolitical scheming to ensure a long lasting dominance. Firstly, research and development (R&D) needs to be boosted with sufficient funding and hence creating necessary infrastructure. The government should increase the allocation to the defence R&D sector up from the current <1% of our GDP, to bridge the gap with our counterparts as well as the adverse neighbours. This funding will accelerate indigenous programs under DRDO, ISRO and other such institutions focusing on development and induction of advanced materials, use of AI in optimizing the trajectory, modern propulsion systems such as those combining scramjets with rockets for extended ranges beyond the present ones to assert dominance. Collaborations with private sectors can foster a vibrant ecosystem encouraging the former’s participation and thus creating skilled manpower and hence high tech jobs and eventually reducing import dependency in years to come.

While the BrahMos-II is a joint venture with Russia, India should look for ways to enhance its ties with nations compliant with Missile Technology Control Regime order to be a beneficiary of the technology transfers in hypersonic testing facilities. As India is an active member nation of the Quadrilateral Security Dialogue (Quad), the I2U2, there can be an active participation in joint exercises to exchange best practices to effectively counter hypersonic threats, hence leading to a more effective interoperability against the them. However, Atmanirbharata needs to be prioritised. Policies like the Defence Acquisition Procedure 2020, in order to boost local manufacturing needs to provide suitable incentives, that could push indigenous content in future projects without having to compromise desired quality as well.

Challenges that are associated with Hypersonic weapons needs to be addressed as well. These weapons while being a destructive ones for adversaries, also ask for robust countermeasures. Hence investing in directed energy weapons and radar systems and integrating quantum technology to effectively neutralize the threats from adversaries becomes an important issue that needs attention. Environmental considerations such as minimizing sonic boom's impact on civilian areas should also be considered during testing protocols. Specialized programs at academic institutions focused in Aerothermodynamics (ATD) and Computational Fluid Dynamics (CFD) could build a skilled workforce.

On the other front, India could advocate for global norms on hypersonic arms control to prevent proliferation. Diplomatic efforts could push for transparency in testing, reducing escalation risks in the sensitive areas using multilateral forums with nations that think on the same lines. Integrating hypersonic into multi domain operations, integrating them with cyber and space assets will enhance deterrence capabilities, ensuring rapid response to non-conventional threats.

Faster space launches and high-speed transport, potential economic spinoffs of hypersonic could boost GDP contribution from the sector through dual use applications. India can look into opportunities to export hypersonic systems to friendly nations generating revenue as well as establishing strategic ties that are need of the hour considering the volatility that exists presently. This approach will transform Vyomotkampa from a defensive tremor to a symbol of offensive thunder, helping turn into reality the dream that Bharat aspires to achieve in aerospace and defence domain.

Conclusion

In the high weighted arena of hypersonic technology, India has emerged as a front runner, countering strategic challenges from its adverse neighbours while also asserting technological sovereignty. From the foundational studies in 1998 to the successful tests of the HSTDV in 2020 and 2023, the groundbreaking LRAShM in 2024, and the most recent Project VISHNU, India's journey exemplifies resilience and innovation. These advancements along with BrahMos-II, not only enhance precision strikes at higher end Mach speeds but also fortify deterrence in the Indo-Pacific, addressing potential threats from the adversaries.

The hypersonic race underscores broader implications: enhancing defence autonomy, fostering economic growth through job creation and exports, and influencing global power dynamics by asserting dominance in this domain. India's indigenous scramjet prowess and international collaborations position it to close the gap that exists in operational capability and funding ensuring regional stability amid various tensions be it along the land borders and in the maritime ones.

"Vyomotkampa" symbolizes India's ascent to "Swayam Viksit Bharat" a progressive nation through self-reliance. By exploiting the hypersonics for peace and progress, India can deter aggression, inspire innovation, and lead in a multipolar world, where speed precision and intensity redefine security.

DISCLAIMER

The paper is author's individual scholastic articulation and does not necessarily reflect the views of CENJOWS. The author certifies that the article is original in content, unpublished and it has not been submitted for publication/ web upload elsewhere and that the facts and figures quoted are duly referenced, as needed and are believed to be correct.

References

---

[1] "Speed of Sound." n.d. https://www.grc.nasa.gov/www/k-12/BGP/sound.html.

[2] "Mach Number." n.d. https://www.grc.nasa.gov/www/k-12/airplane/mach.html.

[3] Bonsor, Kevin, and Sascha Bos. 2023. "Hypersonic Speed Explained: How Hypersonic Planes Work." HowStuffWorks. September 27, 2023. https://science.howstuffworks.com/transport/flight/modern/hypersonic-plane.htm#:~:text=Sources-,What%20Is%20Hypersonic%20Speed?,it%20travels%20through%20the%20atmosphere.

[4] ———. 2025. "Vyoman, Vyoma: 31 Definitions." March 15, 2025. https://www.wisdomlib.org/definition/vyoman#:~:text=2)%20%5Bnoun%5D%20the%20gaseous%20envelope%20surrounding%20the%20earth;%20atmosphere.

[5] www.wisdomlib.org. 2022. "Utkampa: 9 Definitions." May 31, 2022. https://www.wisdomlib.org/definition/utkampa.

[6] ———. 2025b. "Former BrahMos Scientist Reveals DRDO's K-6 SLBM Development With 8000km in Works - Indian Defence Research Wing." Indian Defence Research Wing. June 25, 2025. https://idrw.org/former-brahmos-scientist-reveals-drdos-k-6-slbm-development-with-8000km-in-works/#:~:text=Its%20hypersonic%20speed%20of%20Mach,K%2D4%20trials%20in%202020.

[7] Admin. 2025a. "DRDO's LRAShM Hypersonic Glide Weapon Hits Mach 10, Surpassing Expectations - Indian Defence Research Wing." Indian Defence Research Wing. March 3, 2025. https://idrw.org/drdos-lrashm-hypersonic-glide-weapon-hits-mach-10-surpassing-expectations/.

[8] Desk, Web. 2025. "India to Deploy 12 Hypersonic Missiles: Project Vishnu, BrahMos-II to Power Next-gen Scramjet Strike Arsenal." Organiser, July 3, 2025. https://organiser.org/2025/07/03/300844/bharat/india-to-deploy-12-hypersonic-missiles-project-vishnu-brahmos-ii-to-power-next-gen-scramjet-strike-arsenal/.

[9] capsnetdroff. 2024. “India’s Hypersonic Ambitions: Tracking the Progress.” CAPS India. February 24, 2024. https://capsindia.org/indias-hypersonic-ambitions-tracking-the-progress/.

[10] Ibid
[11] Ibid
[12] “India, Russia to Develop New Hypersonic Cruise Missile :: BrahMos.com.” 2015. Brahmos.com. 2015. https://www.brahmos.com/newscenter.php?newsid=102.

[13] PIB. 2016. “Successful Flight Testing of ISRO’s Scramjet Engine Technology Demonstrator.” Pib.gov.in. 2016. https://www.pib.gov.in/newsite/PrintRelease.aspx?relid=149271.

[14] Manu Pubby. 2019. “Hypersonic Vehicle Programme to Be Back on Track Soon.” The Economic Times. Economic Times. June 18, 2019. https://economictimes.indiatimes.com/news/politics-and-nation/hypersonic-vehicle-programme-to-be-back-on-track-soon/articleshow/69835671.cms.

[15] Reporter, Imr. 2020. “DEFENCE RESEARCH: Hypersonic Cruise Vehicle Tested Successfully.” IMR. November 8, 2020. https://imrmedia.in/defence-research-hypersonic-cruise-vehicle-tested-successfully/#:~:text=Hypersonic%20flying%20vehicles%20have%20potential,times%20the%20speed%20of%20sound.

[16] “India Test-Flies Hypersonic Technology Demonstrator Vehicle.” 2023. Default. February 2, 2023. https://www.janes.com/osint-insights/defence-news/defence/india-test-flies-hypersonic-technology-demonstrator-vehicle.

[17] Javaid, Arfa. 2020. “K Missile Family of India: Here’s Everything You Need to Know.” Jagranjosh.com. Jagran Josh. October 6, 2020. https://www.jagranjosh.com/general-knowledge/k-missile-family-1601983618-1.

[18] “India’s March towards Achieving Hypersonic Capability.” 2023. Vifindia.org. 2023. https://www.vifindia.org/print/11260.

[19] Du Fretay, Halna. n.d. “India Successfully Tests First Long-Range Hypersonic Missile LRAShM.” https://armyrecognition.com/news/army-news/army-news-2024/india-successfully-tests-first-long-range-hypersonic-missile-lrashm.

[20] Staff, OpIndia. 2025. “India’s ET-LDHCM Hypersonic Missile, developed under Project Vishnu, Outpaces BrahMos by Nearly 3 Times with Mach-8 Speed.” OpIndia. June 18, 2025. https://www.opindia.com/2025/06/indias-et-ldhcm-hypersonic-missile-developed-under-project-vishnu-outpaces-brahmos-by-nearly-3-times-with-mach-8-speed/.

[21] “DRDO Successfully Flight Tests Hypersonic Technology Demonstrator Vehicle.” 2020. Pib.gov.in. 2020. https://www.pib.gov.in/PressReleasePage.aspx?PRID=1651956.

[22] "India Test-Flies Hypersonic Technology Demonstrator Vehicle." 2023b. Default. February 2, 2023. https://www.janes.com/osint-insights/defence-news/defence/india-test-flies-hypersonic-technology-demonstrator-vehicle.

[23] "DRDO Achieves Significant Milestone in Scramjet Engine Development." 2025. Pib.gov.in. 2025. https://www.pib.gov.in/PressReleasePage.aspx?PRID=2124415.

[24] "DF-17." 2024. Missile Threat. April 23, 2024. https://missilethreat.csis.org/missile/df-17/.

[25] Chin, Jeremy. 2018. "Cm-401 Archives." Missile Threat. 2018. https://missilethreat.csis.org/tag/cm-401/.

[26] Du Fretay, Halna. n.d. "China Expands Hypersonic Capabilities With GDF-600 Boost-Glide Vehicle for Missile and Drone Deployment." https://armyrecognition.com/news/army-news/army-news-2024/china-expands-hypersonic-capabilities-with-gdf-600-boost-glide-vehicle-for-missile-and-drone-deployment.

[27] admin. 2025. "Pakistan's Failed Attempt to Use CM-400AKG Supersonic Missile against Indian S-400 System - Indian Defence Research Wing." Indian Defence Research Wing. May 15, 2025. https://idrw.org/pakistans-failed-attempt-to-use-cm-400akg-supersonic-missile-against-indian-s-400-system/#google_vignette.

[28] India's Membership of the Missile Technology Control Regime – Peace Research Institute Oslo (PRIO)." 2019. @PRIOresearch. 2019. https://www.prio.org/comments/200.

[29] ———. 2023b. "How Fast Is Mach One?" Universal-Sci. December 21, 2023. https://www.universal-sci.com/headlines/2017/7/11/how-fast-is-mach-one.

[30] "Mach Number - Activity." n.d. https://www.grc.nasa.gov/www/k-12/BGA/Corrine/mach_number_act.htm.

[31] "Isentropic Flow Equations." n.d. https://www.grc.nasa.gov/www/k-12/airplane/isentrop.html.

[32] Anderson, John D. 2003. "Flight (Aerodynamics)." Encyclopaedia of Physical Science and Technology, 1–21. https://doi.org/10.1016/b0-12-227410-5/00915-7.

[33] Ibid.
[34] Anderson, John. 2016. "Introduction to Flight Eighth Edition Introduction to Flight." https://aerospace.gdgoenka-university.com/wp-content/uploads/2023/10/introduction-to-flight-8th-edition-pdf-free.pdf.

[35] ———. 2017. "Fundamentals of Aerodynamics." https://aviationdose.com/wp-content/uploads/2020/01/Fundamentals-of-aerodynamics-6-Edition.pdf.

[36] Anderson Jr., John D . n.d. "Hypersonic and High-Temperature Gas Dynamics Second Edition." https://gymkhana.iitb.ac.in/~scp/scp/ocw/aerospace/AE%20624%20-%20Hypersonic%20flow%20theory/Hypersonic%20and%20high-temperature%20gas%20dynamics%20-%20John%20David%20Anderson.pdf.

[37] J. Bertin., John , and Russel M. Cummings. n.d. Aerodynamics for Engineers. 2nd ed. Upper saddle river: Pearson Prentice Hall.

[38] “NASA Technical Reports Server (NTRS).” n.d. Ntrs.nasa.gov. https://ntrs.nasa.gov/search.

[39] Guest. 2019. “Gas Dynamics John Keith - PDFCOFFEE.COM.” Pdfcoffee.com. PDFCOFFEE.COM. 2019. https://pdfcoffee.com/gas-dynamics-john-keith-pdf-free.html.

[40] “Home | AIAA Aerospace Research Central.” 2015. Aiaa.org. 2015. https://arc.aiaa.org/.

[41] “Objectives template.” 2025. Nptel.ac.in. 2025. https://archive.nptel.ac.in/content/storage2/courses/112104118/lecture-40/40_4_nozzle.htm.

[42] https://supercarblondie.com/china-airlines-boeing-777f-826-mph/

[43] Daolio, Andrea. 2024. “The Aviationist.” The Aviationist. November 7, 2024. https://theaviationist.com/2024/11/07/lockheed-martin-f-22-raptor/.

[44] Parsonson, Andrew, and Andrew Parsonson. 2023. “Europe’s Privately Funded Space Capsule Startup Nabs €40.5M in Funding.” Payload. February 2, 2023. https://payloadspace.com/europes-privately-funded-space-capsule-startup-nabs-e40-5m-in-funding/.

[45] Simscale. 2024. “What Is the Reynolds Number?” SimScale. July 31, 2024. https://www.simscale.com/docs/simwiki/numerics-background/what-is-the-reynolds-number/.

[46] https://www.grc.nasa.gov/www/k-12/airplane/reynolds.html

[47] Ansys. 2025. “What Is Laminar Flow? | Ansys.” Ansys.com. 2025. https://www.ansys.com/simulation-topics/what-is-laminar-flow.

[48] Ibid.

[49] ———. 2025b. “What Is Turbulent Flow? | Ansys.” Ansys.com. 2025. https://www.ansys.com/en-in/simulation-topics/what-is-turbulent-flow.

[50] Menter, Florian. 2025. “Laminar vs. Turbulent Flow: Difference, Examples, and Why It Matters.” Ansys.com. Ansys Inc. January 6, 2025. https://www.ansys.com/blog/laminar-vs-turbulent-flow.

[51] Benson, Tom. 2021. “Boundary Layer.” Www.grc.nasa.gov. NASA. May 13, 2021. https://www.grc.nasa.gov/www/k-12/BGP/boundlay.html.

[52] Benson, Tom. 2021. “Boundary Layer.” Www.grc.nasa.gov. NASA. May 13, 2021. https://www.grc.nasa.gov/www/k-12/BGP/boundlay.html.

[53] “What Is Incompressible Flow?” 2020. SimScale CAE Forum. November 6, 2020. https://www.simscale.com/forum/t/what-is-incompressible-flow/70493.

[54] SimScale. 2023. “What Is Incompressible Flow?” SimScale CAE Forum. October 31, 2023. https://www.simscale.com/forum/t/what-is-incompressible-flow/70493#p-83055-related-topics-7.

[55] Faber, Thomas E. 1998. “Fluid Mechanics | Definition, Equations, Types, & Facts.” Encyclopedia Britannica. October 26, 1998. https://www.britannica.com/science/fluid-mechanics/Waves-on-shallow-water#ref611712.

[56] “Hypersonic Aerodynamics Home.” n.d. https://www.grc.nasa.gov/www/BGH/index.html.

[57] Leishman, J. Gordon. 2023. “Hypersonic Flight Vehicles.” Introduction to Aerospace Flight Vehicles. January 1, 2023. https://eaglepubs.erau.edu/introductiontoaerospaceflightvehicles/chapter/hypersonic-flight-vehicles/.

[58]———. 2025d. “DRDO’s Hypersonic Missile Program: ET-LDHCM Under Project Vishnu Nears Testing, Awaits MoD Funding - Indian Defence Research Wing.” Indian Defence Research Wing. July 15, 2025. https://idrw.org/drdos-hypersonic-missile-program-et-ldhcm-under-project-vishnu-nears-testing-awaits-mod-funding/.

[59] Ibid.

[60] Ibid.