CHAPTER III

INDIA'S MISSILE DEVELOPMENT PROGRAMME

The third chapter entitled **India's Missile Development Programme** deals with the broad spectrum of missiles developed in India, the diversity in the composition of its missile inventory, the motivations and compulsions behind its programmes and the strategic interests behind these programmes. Further the chapter also examines briefly the country's nuclear policy and postures.

Chapter III

India's Missile Development Programme

This chapter gives a comprehensive account of India's Missile Development Programme, including the progress and achievements in the area of missiles. Further the chapter also attempts to reflect India's missile inventory which includes a sturdy arsenal of missile system and the phenomenal surges in missile technology over a period of time. The chapter attempts to briefly describe the landmarks achieved by India in its quest for missile acquisitions, highlighting the radically different choice of strategies — military and diplomatic — adopted by India to keep the respective programmes alive to enhance its security requirements as well.

India's Missile Development: The Roadmap

India's interest in missiles dates back to the time of Tipu Sultan, the ruler of Mysore during the late 18th Century. In the year 1958 the then scientific advisor to the Defence Minister D.S. Kothari opined that the ballistic missiles remained one of the greatest and most dangerous threat to the mankind for they are tipped with nuclear war heads with wider reach and destructive potential . And this prompted the setting up of Defence Research and Development in India.

The first clear indication that India was seriously considering the idea of launching the Integrated Guided Missile Development Programme came in 1979, when a committee was established, under the Ministry of Defence, with the then DRDO Director General, Raja Ramanna, as the Chair. The committee is popularly known as 'Missile Policy Committee'. Besides recommending the launching of an 'Integrated Guided Missile Development Programme (IGMDP)', the Committee recommended the "procurement, development and production of missiles for the three Services, in the short term, as also to build up the infrastructure in certain areas so as to take up projects for development of more sophisticated missiles in the long term". It was almost around the time that the Missile Policy Committee was set up to develop missiles. The Defence Research and Development Laboratory (DRDL), was responsible for developing missiles. The then DRDO Director General, Raja Ramanna suggested in 1981 that Abdul Kalam be appointed as director of DRDL, to run the missile development project. Abdul Kalam as director and his team successfully concluded the project SLV-3. By this time, a considerable amount of technological, industrial and human resources were also available. At the DRDL, a high level committee called the ‘Missile Technology Committee’ was formed. Deliberations in this body resulted in the formulation of the basic plan, which was later fine tuned, for the development of guided missiles. Abdul Kalam recently wrote that the IGMDP is a product of a ‘detailed study’ conducted in 1982 “for evolving missile systems in order to counter the emerging threats to the security of India”.

A team was formed under the chairmanship of Abdul Kalam, with Z. P. Marshal, N. R. Iyer, A. K. Kapoor and K. S. Venkataraman as members, which drew up a paper, with inputs from the three services, for the Cabinet Committee on Political Affairs (CCPA) on the development of indigenous guided missiles. Subsequently, the proposal was discussed at a presentation presided over by the then Defence Minister, Venkataraman, and finally cleared by the Cabinet. Consequently, the programme was launched on 27 July 1983 at DRDL, Hyderabad, by the then DRDO Director General, V. S. Arunachalam, amidst fanfare, in the presence of a large gathering of scientists, academicians, officers of the armed forces and production agencies. Five projects leaders were selected, one for each of the missile projects, with Abdul Kalam as the head of the entire programme.

Defence Research Development Organisation (DRDO) is the official governmental agency in India responsible for the nation’s missile development programme. DRDO was formed in 1958 from the amalgamation of the then already functioning Technical Development Establishment (TDEs) of the Indian Army and the Directorate of Technical Development & Production (DTDP) with the Defence Science Organisation (DSO). DRDO was then a small organisation with 10 establishments or laboratories. Over the years, it has grown multi-directionally in terms of the variety of subject disciplines, number of laboratories, achievements and stature. Today, DRDO is a network of 51 laboratories which are deeply engaged in developing defence technologies covering various disciplines like aeronautics, armaments, electronics, combat vehicles, engineering systems, instrumentation, missiles, advanced computing and simulation, special materials, naval systems, life sciences, trailing, information systems and agriculture. Presently, the organisation is backed by over 5000 scientists and about 25,000 other scientific, technical and supporting personnel. Several major projects for the development of missiles, armaments, light combat aircrafts, radars, electronic warfare systems, etc. are on hand, and significant achievements have already been made in several such technologies.

Brief History of India's Missile Development Programme

India's missile program is second only to China's in the developing world. The Indian space program began in early 1960s with cooperation from the United States, France, and the Soviet Union. India's missile programme can be stated to be an offshoot of its space programme, beginning 1967. The Indian Space Research Organization (ISRO) was founded in 1969. Subsequently, in 1972, Rohini- a 560 two-stage, solid propulsion sounding rocket was developed and test fired, capable of reaching an altitude of 334 km with a 100 kg payload. India first launched its small 17-tonne SLV-3 space booster (300km/40 kg) in 1979 and thereafter successfully injected the 35 kg Rohini I satellite into near-earth orbit in 1980. By 1987, an augmented booster, the 35-tonne ASLV (4,000 Km /150kg in low earth orbit), which primarily are three SLV-3s strapped together, had begun flight testing.

The much larger Polar Space Launch Vehicle was first tested in 1994 and is currently used to launch Indian remote sensing, weather, and communications satellites. India's ballistic missile program is in large part a response to China's capabilities, and is administratively separate from the civilian space program. It does, however, share a common technical origin with the civilian space program. Thus India used its commercial space launch program to develop the skills and infrastructure needed to support a ballistic missile program[1]. India initiated its Integrated Guided Missile Development Program (IGMDP) in 1983 with the aim of achieving self sufficiency in military missile production and development. The IGMDP comprises five core systems: the Agni ("Fire") series of MRBMs, Prithvi ("Earth") series of SRBMs, the Trishul ("Trident") short range SAM, the Akash ("Sky") medium range SAM, and the Nag ("Cobra") anti-tank guided missile. Appendix B contains descriptions of India's ballistic missiles.

The Defence Research and Development Laboratory (DRDL), is responsible for implementing India's missile development program. It is located in the Defence Research Complex at Kanchanbagh near Hyderabad. The Research Centre Imarat (RCI) was established in 1988 near DRDL and is dedicated to work in advanced missile technologies. Bharat Dynamics Limited of Hyderabad, a commercial defense contractor to the MOD, integrates missile components and conducts assembly. In the 1990s, the United States applied pressure on India to slow its missile development programs. This was motivated by concerns about an India-China-Pakistan arms race and the potential for India to be a proliferator of missile technology. As a result, India shelved its Agni medium range missile program.

In 1997, under the Gujral government, India restarted the Agni program after articulating its threat perceptions, and an increase in the level of horizontal proliferation between China and Pakistan. The Chinese modernization program has stimulated the development of the Agni-III intermediate range missile[2]. To date, India has displayed no inclination to export its missiles or associated technology.

By the start of the 1980's, DRDL had developed competence in the fields of propulsion, navigation and manufacture of materials. Thus, India's political and scientific leadership, which included former Prime Minister Indira Gandhi, Defence Minister R. Venkataraman and the then Scientific Advisor to the Defence Minister, V.S. Arunachalam, decided to consolidate all the relevant technologies which resulted in the birth of the Integrated Guided Missile Development Programme. Dr. Abdul Kalam, who had previously been the project director for the SLV-3 programme at ISRO, was inducted as the DRDL Director in 1983 to conceive and lead it. While the scientists proposed the development of each missile consecutively, Defence Minister R. Venkataraman asked them to reconsider and develop all the missiles simultaneously. Thus, four projects, to be pursued concurrently, were born under the

IGMDP:

- Short range surface-to-surface missile (code-named Prithvi)
- Short range low-level surface-to-air missile (code-named Trishul)
- Medium range surface-to-air missile (code-named Akash) and
- Third-generation anti-tank missile (code-named Nag).

The Agni missile was initially conceived in the IGMDP as a technology demonstrator project in the form of a re-entry vehicle, and was later upgraded to a ballistic missile with different ranges[3]. As part of this program, the Interim Test Range at Balasore in Orissa was also developed for missile testing. After India test-fired the first Prithvi missile in 1988, and the Agni missile in 1989, the Missile Technology Control Regime (then an informal grouping established in 1987 by Canada, France, Germany, Italy, Japan, the United Kingdom and the United States) decided to restrict access to any technology that would help India in its missile development program. To counter the MTCR, the IGMDP team formed a consortium of DRDO laboratories, industries and academic institutions to build these sub-systems, components and materials. Though this slowed down the progress of the program, India successfully developed indigenously all the restricted components denied to it by the MTCR.[4]

Numerous reasons have been provided for the Indian Defence Research and Development Organisation (DRDO) undertaking a high profile and stand alone project such as the IGMDP. One view instinctively links its creation to the Chinese programme which started in the late 1960s. This view tends to give credence to the security environment in which India operates, which necessitates a matching response to both Pakistan and China’s advances. But by the time the IGMDP was created in 1983, the Chinese programme had reached criticality, being several decades ahead. The second view believes that the IGMDP was solely driven by efforts of Indian scientists to indigenously develop missiles.

The 1995-96 Annual Report of the Ministry of Defence cites sale of missiles from China to Pakistan and the development of three medium and long range ballistic missiles by China, which are to become operational by "mid and late 1990s" as the compelling reasons for India "undertaking the technology demonstrator project so as to acquire a technology for future need”. In its 13-year existence, the IGMDP has earned accolades from even its most trenchant critics[5]. With a total expenditure of $260 million spread over a 15-year period[6], the IGMDP was mandated with the task of design, development and production of four missile systems. It was also given an additional charge of developing the long range Agni missile, which officially continues to remain a "technology-demonstrator".

India's Initial Progress in the area of Missiles

Prithvi (Earth) — a surface-to-surface battlefield missile (SSM), with a reported **range** of 40-150 km, capable of carrying a conventional payload of 1,000 kg. There have been reports that the Prithvi which has undergone extensive field trials, and has attracted the most attention because of Pakistani preoccupations with the deployment of this missile, has a second version which carries a smaller payload of 500 kg to a longer distance of 250 km. This version was also field tested recently and according to IGMDP scientists, it fulfilled all required parameters, a scientific jargon to state that the missile is ready for deployment. This version is being designed for the Indian Navy. The different variant of this missile is reflected in the given **Table 3.1.**

Missile	Type	Warhead	Payload (kg)	Range (km)	Dimension (m)	Fuel/ Stages	Weight (kg)	In service	CEP (m)
Prithvi I	Tactical	Nuclear, HE, submunitions, FAE, chemical	1,000	150	8.55X1.1	Single stage/ Liquid	4,400	1988	30–50
Prithvi II	Tactical	Nuclear, HE, sub munitions, FAE, chemical	350–750	350	8.55X1.1	Single stage/ Liquid	4,600	1996	10–15
Prithvi III	Tactical	Nuclear, HE, sub munitions, FAE, chemical	500–1,000	350–600	8.55X1	Single stage / Slid	5,600	2004	10–15

Table 3.1: Prithvi Missile System

The Prithvi is said to have its propulsion technology derived from the Soviet **SA-2** surface-to-air missile. Variants make use of either liquid, or both liquid and solid fuels. Developed as a battlefield missile, it could carry a nuclear warhead in its role as a tactical nuclear weapon. The Prithvi missile project encompassed developing three variants for use by the Indian Army, Indian Air Force and the Indian Navy. The initial project framework of the Integrated Guided Missile Development Program outlines the variants in the following manner.

•Prithvi-I - Army Version (150 km range with a payload of l000kg)

• Prithvi-II - Air Force Version (250 km range with a payload of 500kg)

• Prithvi-III - Naval Version (350 km range with a payload of 500kg)

Over the years these specifications underwent a number of changes. While the codename Prithvi stands for any missile inducted by India into its armed forces in this category, the later developmental versions are codenamed as Prithvi II and Prithvi III. The induction of Prithvi-I class of missiles happened in 1994 and the armed forces are in the process of inducting the extended range, Prithvi-II class of missiles as of 2006.

i) Prithvi-I

Prithvi-I class was a single stage liquid-fuelled surface-to-surface missile having a maximum warhead mounting capability of 1000 kg, with a range of 150 km. It has an accuracy of 10-50 metres and can be launched from Transporter erector launchers. This class of Prithvi missile was inducted into the Indian Army in 1994.

ii) Prithvi-II

Prithvi-II class is also a single stage liquid-fuelled missile having a maximum warhead mounting capability of 1000kg, but with an extended range of 250 km (155 statute miles). It was developed with the Indian Air Force being the primary user. It was first test-fired on January 27, 1996 and the development stages were completed in 2004. The Prithvi-II class of missiles are in the process of induction by the Indian Air force.

iii) Prithvi-III

Prithvi-III class (codenamed Sagarika meaning Oceanic) is a two-stage Surface-to-Surface missile in the developmental stages. The first stage is solid fuelled with a 16 metric ton force (157 kN) thrust motor The second stage is liquid fuelled. The missile can carry a 1000 kg warhead to a distance of 350 km and a 500 kg warhead to a distance of 600 km and, a 250 kg warhead up to a distance of 750 km. The design is developed while keeping the navy in mind. Sagarika is a nuclear-capable cruise missile capable of being mounted in ships or submarines. Considering the upward capability development, Prithvi class of missiles could be reclassified from a short-range ballistic missile to a medium range ballistic missile. The current codename of the operational variant Dhanush could pave way for the new codename Sagarika which was successfully tested on March 30th 2007. Sagarika is inducted into the

Advanced Technology Vessel being developed for Indian Navy. There were a number of shortcomings in the initial version of Prithvi missiles, namely high circular error probability (CEP) of around 500 meters, and volatility of the liquid-fuelled propulsion system, requiring fuelling only just before launching. These shortcomings are being overcome in the latest development versions by incorporating of Global Positioning System (GPS) in the propulsion system into the missiles to reduce the CEP to as low as 10 to 15 meters and use of solid fuel.

Thus the **Prithvi** is a surface-to surface battle field missile using a single state, twin-engine liquid propulsion system and strap-down inertial guidance, with real-time software incorporated in the onboard computer to achieve the desired accuracy during impact. Prithvi demonstrates higher lethal effects as compared to any equivalent class of missiles in the world. Prithvi could well be termed as a unique missile since it displays manoeuvrable trajectory and high level capability with field interchangeable warheads. Its accuracy has been demonstrated in the development flight trials. Flight trials for the air force has been completed and the system is now being configured for launching from ship, thereby increasing its capability as a sea mobile system.

(b) **Akash** (Sky) — a surface-to-air (SAM) missile with a range of 25 km. This system has been further refined to handle multiple targets by using phased array radars. It has new features like command guidance systems and active homing in the terminal stage. Several test flights of the missile have been conducted and the missile entered user trials in 1996. In December 2007, Indian Air Force completed user trials for the Akash missile system. The trials, which were spread over ten days, were successful and the missile hit its target on all five occasions. Before the ten-day trial at Chandipur, the Akash system's ECCM evaluation tests were carried out at Gwalior Air Force base while mobility trials for the system vehicles were carried out at Pokhran. The IAF had evolved the user Trial Directive to verify Akash's consistency in engaging targets. The following trials were conducted: against low flying near range target, long range high altitude target, crossing and approaching target, and ripple firing of two missiles from the same launcher against a low altitude receding target.[25] Following this, the IAF declared that it would initiate the induction of two squadron's strength (each squadron with two batteries) of this missile system, to begin with. Once deliveries are complete, further orders would be placed to replace retiring SA-3 GOA (Pechora) SAM systems**.** In February 2010, the Indian Air Force ordered six more squadrons of the Akash system, taking orders to eight of the type. The Indian Army is also expected to order the Akash system.

(c) **Trishul** (Trident) — a short-range surface-to-air missile, it is expected to be used by all three Services. The missile is designed to counter a low level attack with a very quick reaction time and has an all weather capability. The missile uses a single stage propulsion system with a composite propellant and command guidance. This missile has been extensively tested and has already been inducted into service. The missile has also been flight tested twice in a sea-skimming role and against moving targets. It can also be used as an anti-sea skimmer from a ship against low flying attacking missiles. The missile can engage targets like aircraft and helicopters, flying between 300 m/s and 500 m/s by using its radar command to- line-of-sight guidance. Powered by a two-stage solid propellant system, with a highly powered HTBP-type propellant similar to the ones used in the Patriot, the Trishul has necessary electronic counter-counter measures against all known aircraft jammers. Trishul, with its quickest reaction time, high frequency operation, high manoeuvrability, high lethal capability and multi-roles for three services, is state-of-the-art system providing considerable advantage to the Indian armed forces.

According to reports, the range of the missile is 12 km and is fitted with a 15 kg warhead. The weight of the missile is 130 kg. The length of the missile is 3.1m.[7] Development costs of the missile touched almost US$70 million to the taxpayers. India officially shut down the Trishul Missile project on 27 February 2008[8]. The program, one of the five missiles being developed by Defense Research and Development Organization as part of the Integrated Guided Missile Development Program, has been shelved. Defence Minister George Fernandes indicated this in Rajya Sabha (Upper House of Parliament), when he said the Trishul missile had been de-linked from user service, though it would be continued as a technology demonstrator.[9]

(d) **Nag** (Serpent) — an anti-tank missile with a range of 5 km, it is considered a third generation variant with fire-and-forget features. Like Akash, where the IGMDP scientists appear to be testing indigenously developed technologies on a wider scale compared to the Prithvi and Trishul, the Nag is designed to tackle new reactive armour and has infra-red or millimetre wave type of guidance. Like Akash, it entered into user trials in 1996.

(e) Agni (fire) – The **fifth** task given to the IGMDP related to the development of a long range missile, **Agni** was termed a "technology demonstrator", which its critics argue was meant to dilute any pressure that would have been generated from the US for developing a missile that crosses the physical threshold of security threats to India.[10] But supporters of the IGMDP in the Indian government believe that the concept of "technology demonstrator" is valid because in the case of the 2,500km range Agni missile, the several indigenously developed technologies were sought to be validated. These included manoeuvring re-entry of the re-entry vehicle (RV) structure by using multi-mode auto check systems[11] and multi-stage propulsion technology including stage separations, among others.

Agni Missile System

Missile	Project	Type	Warhead	Payload (kg)	Range (km)	Size	Fuel/ Stages	Weight (kg)	In service	CEP (m)
Agni-I	IGMDP	Strategic	Nuclear, HE, penetration, sub-munitions, FAE	1,000	700 to 1,250	15X1	Single stage solid	12,000	2002	25
Agni-II	IGMDP	Strategic	Nuclear, HE, penetration, sub-munitions, FAE	750 to 1,000	2,000 to 3,500	20X1	Two and half stage solid	16,000	1999	30
Agni-III	IGMDP	Strategic	Nuclear, HE, penetration, sub-munitions, FAE	2,000 to 2,500	3,500 to 5,000	17X2	Two stage solid	44,000 22,000 (latest version)	2011	40
Agni-IV	Agni-IV	Strategic	Nuclear, HE, penetration, sub-munitions, FAE	800 to 1,000	3,000 to 4,000	20X1	Two stage solid	17,000	Tested	
Agni-V	Agni-V	Strategic	Nuclear, HE, penetration, sub-munitions, FAE	1,500 (3–10 MIRV)	5,500 to 5,800	17X2	Three Stage solid	50,000	Tested	<10 m
Agni-VI	Agni-VI	Strategic	Nuclear, HE, penetration, sub-munitions, FAE	1,000 (10 MIRV)	8,000 to 10,000	40X1.1	Three Stage solid	55,000	Under development	

Table:3.2 Agni Missile System

The **Agni missile** (Sanskrit Agni, root of English ignites) is a family of Medium to Intercontinental range ballistic missiles developed by DRDO of India. The initial Technology demonstrator version had a range of 1500 km but was based on a solid and a liquid stage, making for long preparation before firing. Learning from this the production variants of Agni are solid fuel based to allow for swift retaliation against adversaries[12]. Indian government stated in its official press release that its nuclear and missile development programmes are not Pakistan-centric, and that the Pakistani threat is only a marginal factor in New Delhi's security calculus and Agni is at the heart of deterrence in the larger context of Sino-Indian equation[13]. Missiles of Agni series are developed by DRDO and manufactured by Bharat Dynamics Limited. The details are depicted in **Table No 3.2.**

Agni-I is a single stage, solid fuel, road and rail mobile, medium-range ballistic missile (MRBM) using solid propulsion upper stage, derived from Prithvi, essentially to prove the re-entry structure, control and guidance. The strap-down inertial navigation system adopts explicit guidance — attempted for the first time globally. Using carbon composite structure for protecting payload during its re-entry phase, the first flight was conducted in May 1989, thus establishing the re-entry technology and precise guidance to reach the specific targets. This shorter ranger missile is specially designed to strike targets in Pakistan.

Agni-II is an operational version of Agni-I and is an intermediate range ballistic missile (IRBM) with two solid fuel stages and a Post Boost Vehicle (PBV) integrated into the missile's Reentry Vehicle (RV) with mobile launch capability test-fired in April 1999. The range for Agni-II is more than 2000 km. Quick deployment of the Agni-II was possible, by building on the earlier Agni-TD programme that provided proven critical technologies and designs required for long range ballistic missiles. The Agni-II missile was last test fired in May 2009. A new variant of the Agni-II called the Agni-III A is presently under development.

Additionally, **Agni-III**, an intermediate-range ballistic missile was developed by India as the successor to Agni-II. Intended to be a two-stage ballistic missile capable of nuclear weapons delivery, it is touted as India's nuclear deterrent against China. The missile is likely to support a wide range of warhead configurations, with a

3,500 km range and a total payload weight of 2490 kg. The two-stage solid fuel missile is compact and small enough for easy mobility and flexible deployment on various surface/sub-surface platforms. The last development test of Agni-III was conducted in August 2009 before being handed over to the Army for user trails.

Agni-V, believed to be an upgraded version of the Agni-III is currently being worked upon by the DRDO with a range of about 5000km and above. Agni-V would be a three stage solid fuelled missile with composite motor casing in the third stage. Agni-V will be able to carry multiple warheads and would also display countermeasures against anti-ballistic missile systems.

The **Akash** system is a medium range surface-to-air missile with multi-target engagement capability. It can carry a 55-kg multiple warhead capable of targeting five aircraft simultaneously up to 25 km and is said to be comparable to the US Patriot as an air defence missile. It uses high-energy solid propellant for the booster and ram-rocket propulsion for the sustainer phase. The propulsion system provides higher level of energy with minimum mass, compared to conventional solid/ liquid rocket motor, which has better performance with minimum weight of the missile. It has a dual mode guidance, initially on command mode from phased array radar, and later, radar homing guidance with unique software developed for high accuracy. The phased array radar provides capability for multiple target tracking and simultaneous deployment of missiles to attack four targets at the same time, in each battery.

Another missile under IGMDP development is the **Nag**, an anti armour weapon employing sensor fusion technologies for flight guidance first tested in November 1990. The Nag is a third generation 'fire-and-forget' anti-tank missile developed in India with a range of 4 to 8 km. Nag uses Imaging Infra-Red (IIR) guidance with day and night capability. Mode of launch for the IIR seeker is LOBL (Lock on before Launch). Nag was successfully test fired in August 2008 marking the completion of the developmental tests and inducted. The Army urgently needs the more advanced Nag to improve kill probability as the missile used a high explosive warhead to penetrate the armour in modern tanks.

Other Developments

The expertise and technology developed through the IGMDP is also used in the new anti-ballistic missile called the Exo-atmospheric interceptor system which successfully intercepted a Prithvi-II ballistic missile. India became the fourth nation in the world to acquire such a capability and the third nation to develop it through indigenous effort even though there were a number of failures and successes. Efforts were made to expand the program in the 1990s, to develop the long range Agni missile, a ballistic missile (codenamed Sagarika), which would be the naval version of the Prithvi, and an inter-continental-ballistic-missile (codenamed Surya missile) with a range of 8,000–12,000 km[14].

In 1998, the Government of India signed an agreement with Russia to design, develop, manufacture and market a Supersonic Cruise Missile System which has been successfully accomplished by 2006. BrahMos is a supersonic cruise missile that can be launched from submarines, ships, aircraft or land. At speeds of 2.5 to 2.8 Mach, it is the world's fastest cruise missile and is about three and a half times faster than the American subsonic Harpoon cruise missile. BAPL is contemplating a hypersonic Mach 8 version of the missile, named as the BrahMos II. BrahMos II will be the first hypersonic cruise missile and is expected to be ready by 2012-13. The laboratory testing of the missile has started.[15] Further development work on Nag and Surya missiles are to continue independently.[16] In addition, the DRDO is also developing a laser-based weapon system as part of its ballistic missile defence program to intercept and destroy missiles soon after they are launched towards the country.[17] Since 2008, follow-on strategic projects are being pursued singly (e.g. the Agni project) while tactical systems could involve joint ventures with foreign partners.[18]

India is said to be in the intermediate stages of developing a new cruise missile, Nirbhay (meaning fearless). The subsonic Nirbhay is said to be 6 m in length with a 520 mm diameter, weigh 1,000 kg and have a 1,000 km range with a speed of 0.7 mach.[19] In September 2008, Indian scientists developed a path-breaking technology that had the potential to increase the range of missiles and satellite launch vehicles by at least 40 per cent. The enhanced range is made possible by adding a special-purpose coating of chromium metal to the blunt nose cone of missiles and launch vehicles. This would add-up on the stated range.[20] A new tactical missile that filled the gap between the Pinaka rocket system and the Prithvi series of missile has been developed in 2011. The 150 km range missile has been named Prahaar. Each road mobile launcher is designed to carry six missiles[21].

The Development of BRAHMOS

BrahMos is a supersonic cruise missile that can be launched from submarines, ships, aircraft or land. It is a joint venture between Defence Research and Development Organisation (DRDO) and Russian Federation's NPO Mashinostroeyenia who have together formed BrahMos Aerospace Private Limited.[22] The name BrahMos is a portmanteau formed from the names of two rivers, the Brahmaputra of India and the Moskva of Russia. It is the world's fastest cruise missile in operation.[23] The missile travels at speeds of Mach 2.8 to 3.0.[24] The land-launched and ship-launched versions are already in service, with the air and submarine-launched versions currently in the testing phase.[25] An upgraded air-launched variant of BrahMos is also being planned. India is the only country with supersonic cruise missiles in their army, navy, and air force.[26] A hypersonic version of the missile namely BrahMos-II is also presently under development with speed of Mach 7 to boost aerial fast strike capability. It is expected to be ready for testing by 2017.[27] Though India wanted the BrahMos to be based on a mid range cruise missile like P-700 Granit, Russia opted for the shorter range sister of the missile, P-800 Oniks, in order to comply with Missile Technology Control Regime restrictions, to which Russia is a signatory. Its propulsion is based on the Russian missile, and guidance has been developed by BrahMos Aerospace**.**[28]

The BrahMos missile[29] has undergone several tests from a variety of platforms including a land based test from the Pokhran range in the desert, in which the 'S' manoeuvre at Mach 2.8 was demonstrated for the Indian Army and a launch in which the land attack capability from sea was demonstrated.[30] Keltec (now known as BrahMos Aerospace Trivandrum Ltd or BATL), an Indian state-owned firm was acquired by BrahMos Corporation in 2008[31] wherein a lot of money was invested to make BrahMos components and integrate the missile systems for both the Indian army and Navy.[32]

Features of BrahMos

BrahMos has the capability of attacking surface targets by flying as low as 10 metres in altitude.[33] It can gain a speed of Mach 2.8, and has a maximum range of 290 km.[34] The ship-launched and land-based missiles can carry a 200 kg warhead, whereas the aircraft-launched variant (BrahMos A) can carry a 300 kg warhead. It has a two-stage propulsion system, with a solid-propellant rocket for initial acceleration and a liquid-fuelled ramjet responsible for sustained supersonic cruise. Air-breathing ramjet propulsion is much more fuel-efficient than rocket propulsion, giving the BrahMos a longer range than a pure rocket-powered missile would achieve.[35]

The high speed of the BrahMos is likely to give it better target-penetration characteristics than the lighter subsonic cruise-missiles such as the Tomahawk. Being twice as heavy and almost four times faster than the Tomahawk, the BrahMos has more than 32 times the on-cruise kinetic energy of a Tomahawk missile, although it carries only 3/5 the payload and a fraction of the range despite weighing twice as much, which suggests that the missile was designed for a different tactical role. Its 2.8 mach speed means that it cannot be intercepted by some existing missile defence system and its precision makes it lethal to water targets.[36]

Although BrahMos was primarily an anti-ship missile, the BrahMos Block III can also engage land based targets. It can be launched either in a vertical or inclined position and is capable of covering targets over a 360 degree horizon. The BrahMos missile has an identical configuration for land, sea, and sub-sea platforms.[37] The air-launched version has a smaller booster and additional tail fins for added stability during launch.

Surface-Launched, Block I

- Ship-launched, anti-ship variant (operational)
- Ship-launched, land-attack variant (operational)
- Land-launched, land-attack variant (operational)
- Land-launched, anti-ship variant (In induction, tested on 10 December 2010)

Surface-Launched, Upgraded Variants

- BrahMos Block II land-attack variant (Operational)[38]
- BrahMos Block III land-variant (being inducted)[39]

- Anti-aircraft carrier variant (tested in March 2012) - the missile gained the capability to attack aircraft carriers using the supersonic vertical dive variant of the missile that
- could travel up to 290 km.[40]

Air-Launched

- Air-launched, anti-ship variant (under development)
- Air-launched, land-attack variant (under development)[41]
- Air-launched, miniaturised variant (under development)[42]

Submarine-Launched

- Submarine-launched, anti-ship variant - Tested successfully for the first time from a submerged pontoon on 20 March 2013.[43]
- Submarine-launched, land-attack variant (under development)[44]

India and Russia intend to make 2,000 BrahMos supersonic cruise missiles over the next ten years through their joint venture company, and nearly 50% of them are expected to be exported to friendly countries.[45]

BrahMos I Block-I

The BrahMos I Block-I for the Army was successfully tested with new capabilities in the deserts of Rajasthan, at a test range near Pokhran in December 2004 and March 2007.[46]

Brahmos I Block-II

On 20 January 2009, BrahMos was tested with a new navigation system but it failed to hit the target. "The missile performance was absolutely normal until the last phase, but the missile missed the target, though it maintained the direction," and" the problem was in the software, not hardware."[47] The Defence Research and Development Organization (DRDO) said that there were "small hitches" in the last stage of the test firing, which was attributed to the US GPS satellites, which were switched off on that day as Barack Obama was sworn in as the President of the United States. The missile travelled for 112 seconds instead of the slated 84 seconds and fell 7 km away from the target.[48] However the missile, tested again in 2009,[49] was deemed successful.[50] BrahMos successfully hit the intended target in two and a half minutes of launch. India is now the only nation in the world with this advanced technology"[51] setting a high standard of accuracy[52]. The Indian Army too confirmed that the test was extremely successful and the army is absolutely satisfied with the missile. This marked the completion of the development phase of BrahMos Block-II, and ensured it was ready for induction.[53]

The testing of BrahMos on 5 September 2010 created a world record for being the first cruise missile to be tested at supersonic speeds in a steep-dive mode. With this launch, the army's requirement for land attacks with Block-II advanced seeker software with target discriminating capabilities was met. BrahMos became the only supersonic cruise missile possessing advanced capability of selection of a particular land target amongst a group of targets, providing an edge to the user with precise hit.[54]

BrahMos I Block-III

The missile under block III was successfully test-fired by India on 2 December 2010 with advanced guidance and upgraded software, incorporating high manoeuvres at multiple points and steep dive from high altitudes. The steep dive capability of the Block III enables it to hit targets hidden behind a mountain range. The missile will be deployed in Arunachal Pradesh and can engage ground targets from an altitude as low as 10 meters for surgical strikes without any collateral damage. Further the missile is also capable of being launched from multiple platforms like submarines, ships, aircraft and land based Mobile Autonomous Launchers (MAL).[55] The missile was again test fired on 12 August 2011 by ground forces meeting all the mission parameters.[56] The missile was test-fired by an Indian Army Unit again on 4th March 2012 at the Pokhran range in Jaisalmer to operationalise the second regiment of the weapon system in the army.[57] With this test, the second BrahMos unit of the Indian Army became operational.[58] Several tests were conducted to evaluate more than 25 sub-systems of the missile which were produced by the Indian industry, like the power systems, materials for air frame components, guidance scheme and various electric systems. The test data was sent for analysis and used for large-scale indigenous production of the missile.[59] The analysis revealed that except for one subsystem, all other subsystems and components had performed as per the requirement. The malfunction of one subsystem resulted in increase in velocity of the missile, which crossed the limit and the mission was aborted. The defect was rectified and further development flight tests were announced to develop self-reliance.[60]

Indian Air Force

The air-launched version for the Indian Air Force was ready for testing in 2008.[61] An expert committee from the DRDO and the Indian Air Force (IAF) had ruled out any structural modifications to the Sukhoi Su-30MKI to carry the missile.[62] In January 2009, two Indian Air Force Su-30MKI fighter jets were sent to Russia for a retrofit program that would enable them to launch the missile.[63] A new take-off engine for launching of the missile in air and at extreme high altitudes had been developed, and the initial test firing of the missile would be undertaken from the Su-30 MKI. The air-launched version of BrahMos is being developed. This version of the BrahMos missile will use air breathing scramjet propulsion technology and would be more fuel efficient than a traditional rocket-powered missile.[64]

The purchase of over 200 air-launched BrahMos supersonic cruise missiles for the IAF was cleared by Cabinet Committee on Security (CCS) on 19 October 2012, at the cost of ₹6000 crore (US$918 million). This would include funds for the integration and testing of the BrahMos on Su-30MKI of the IAF. As per this plan, the first test of the air-launched version of the missile was to be conducted by December 2012. Two Su-30MKI of the IAF would be modified by the HAL at its Nashik facility where they will also be integrated with the missile's aerial launcher.[65] The trial is now expected to happen in early 2014.[66] A new, smaller variant of the air-launched BrahMos is also under development. This variant would arm the Sukhoi Su-30MKI, Mirage 2000, future inductions such as the 126 Dassault Rafale, and the Indian navy's MiG-29K.[67] A model of the new variant was showcased on 20 February 2013, at the 15th anniversary celebrations of BrahMos Corporations. The miniaturized version would also have a range of 290 km, but it will be shorter by three metres as compared to the present missile. The Sukhoi SU-30MKI would carry three missiles while other combat aircraft would carry one each.[68]

BrahMos 2

Preliminary work has also begun for the development of a hypersonic BrahMos 2 missile capable of flying at a speed between 5 and 7 Mach using a scram jet engine. An agreement to develop the new missile was reached during a visit by Russian Defence Minister Anatoly Serdyukov to India in 2009 and the missile will be ready within the next five years.

When compared with other weapon systems of its class, BrahMos continues to remain the most cost effective option. It is plausible to assume that cruise missiles constitute an important element of the military arsenals for many nations including India owing to the costs, both absolute and in comparison with other aerial weapons. Thus the contribution of the BrahMos to India’s defence is fundamentally significant in a quest to maximise its firepower potential to counter a future military attack. In fact, India is the only country in the world to have inducted the supersonic land attack cruise missile in its army.

Yet another milestone in cruise missile technology is the **Nirbhay** 2007—a subsonic missile with a range of 1000 km. Capable of being launched from multiple platforms on land, sea and air, the missile was developed in 2009. Nirbhay will be a terrain hugging, stealth missile capable of delivering 24 different types of warheads depending on mission requirements and will use inertial navigation system for guidance. In fact, Nirbhay will supplement BrahMos in the sense that it would enable delivery of warheads farther than the 300 km range of BrahMos, according to reports. The missile was primarily designed to match the capabilities of the Tomahawk, and Pakistan’s missile variant Babur. In 2008, New Delhi announced the end of the IGMDP with the focus now shifting towards serial production of missiles developed under this programme. Notwithstanding that the need for a systematically planned long-term doctrine has to be underlined, given that future wars would be autonomous and network centric, India needs more BrahMos like weapons systems which has emerged as the perfect strike weapon with a fine combination of speed, precision, power, kinetic energy and reaction time attributes.

Delhi has also taken steps toward achieving submarine launched ballistic missile capability, with the first test of the K-15 (Sagarika) taking place in February 2008 from a submerged barge with a range of 750 km. Moreover, a land based variant of the K-15 Sagarika named **Shaurya**, which can be stored in underground silos for longer time and can be launched using gas canisters as booster was successfully test-fired in November 2008. This nuclear-capable missile aims to enhance India's second-strike capability. Sagarika missile is being integrated with India's nuclear powered Arihant class submarine that began sea trials in July 2009.

Also under development is the sea-based **Dhanush**, which has been tested several times in recent years and is believed to be a short-range, sea-based, liquid-propellant ballistic missile - perhaps a naval variant of the Prithvi series. According to reports, the possibility of a two stage version, the first being solid fuelled and the second liquid fuelled is expected - thus providing the missile with a maximum range of approximately 300 km.

It would be apposite to conclude by stating that India's missile programme represents an iconic image demonstrating sovereignty and self-reliance vis-à-vis its technological achievements. Resultant of nearly three decades of research, India's guided missile programme has assumed a self-sustaining character and become fundamentally crucial to New Delhi's proposed minimal deterrent.[69]

The past decades have witnessed phenomenal surges in missile technology and intrusions into outer space. India however did not have a credible missile programme by means of which it could boast of a sturdy arsenal of missile systems of that point. The Indian missile arsenal boasts a range of systems and the current thrust areas of the DRDO include Internal Ram Rocket Engines, Multi-target tracking capability, homing guidance using seeker and networking of radars. Concurrently, the DRDO has consistently worked towards enhancing and upgrading the following missile system further: Significant additions also include the Multi-Barrel Rocket System **Pinaka**, an area weapon system to supplement the existing artillery gun at ranges beyond 30 km, having quick reaction time and high rate of fire which has been accepted by the user after extensive trials.

Type	Name	Missile / Propulsion	Warheads	Pay load Weights (kg)	Range (km)	Nos
SRBM	Prithivi -I / SS 150	Ballistic / Liquid fuel	Conventional / Nuclear	1000	150	75 - 90
	Prithivi - I I / SS 250	Ballistic / Liquid fuel	Conventional / Nuclear	500	250	25
	Dhanush / Prithivi -III / SS 350	Ballistic / Liquid fuel	Conventional / Nuclear	NK	350	15
	Agni I	Ballistic / Solid fuel	Nuclear	1000	700 to 800	NK
	Shourya	Ballistic/ Solid / Canisterized	Conventional / Nuclear	>500	600	NK
MRBM	Agni (TD)	Ballistic / 2 Stage / Hybrid	Nuclear	1000	1200 to 1500	10 - 20
	Agni - II	Ballistic / Solid fuel	Nuclear	1000	2000 to 2500	NK
IRBM	Agni -III	Ballistic / Solid fuel	Nuclear	NK	3,500 – to 4000	
	Agni – V	Ballistic / Solid fuel	Nuclear	NK	5000	
SLBM	K- 15 Sagarika	2 Stage SLBM	Conventional	500	700	

Table 3.3 : India's **Missile Inventory**

The **Table 3.3 India's Missile Inventory** highlights missile variants, the warheads, payload, range and number in possession.

Role of DRDO

In what could be described as a 'decisive shift' in missile development plans, the missile capability of Indian armed forces received a major fillip from Defence Research and Development Organisation (DRDO) following the launching of the Integrated Guided Missile Development Programme (IGMDP) in 1983. The principal aim was to develop a family of strategic and tactical guided missiles based on local design and development for three defence services. DRDO accorded particular priority to development of sophisticated guidance technology. The IGMDP, and other defence projects, is managed by the Defence Research and Development Organisation (DRDO) whose long-time Head and Secretary was our former President of India, Dr.

A.P.J. Abdul Kalam. DRDO functions as the nodal agency for the execution of major development programs of relevance to the MOD through integration of research, development, testing and production facilities with national scientific institutions, public sector companies and other agencies. India views medium and intermediate range missiles as being almost exclusively for nuclear weapons delivery. All systems are mobile and rely on covertness to survive a first strike and retaliate. Like China, Indian missiles would not routinely be on a high level of alert (e.g., dispersed in the field with nuclear warheads mounted). India seems to view short range missiles as primarily for conventional warhead delivery with a secondary role for nuclear weapons. The Army views the Prithvi-I missiles as a conventional means to hit targets behind an advancing enemy formation or to disrupt and disperse troop concentrations (held in reserve or being shifted between fronts). A potential nuclear role for the Prithvi was defined after its conventional mission and was advocated by the civilian research establishment.[70] The Indian Air Force views the Prithvi-II missiles as conventional weapons to attack airfields and air defense sites.[71]

Drivers for India	**1946-1974** [72]		**1975-1998**		**1999 - Present**	
	%	Rank	%	Rank	%	Rank
Head of State pressure	35	1	20	1	10	6
Nuclear and missile scientists' pressure	30	2	15	2	15	1
International Prestige	15	3	10	4	10	5
China threat and its Nuclear Posture	15	4	15	3	15	2
Anti-Americanism	5	5	10	6	10	8
Pakistan terrorist threat	0	6	10	7	15	4
Nuclear balance with Pakistan and its Nuclear Posture	0	7	15	5	15	3
Bureaucratic politics within the military	0	8	5	8	10	7

Table 3.4: Drivers for India

The catalyst from the Indian perspective for accelerating the missile race is region specific, with continued Chinese assistance to Pakistan and the failure of the

US to impose sanctions under Missile Technology Control Regime (MTCR) provisions being the principal causes. The main drivers of India are reflected in the **Table 3.4.**

India's Cruise Missile Programme

India has at least three reported cruise missile development programs: the Lakshya, the Coral, and the Sagarika.

• The Lakshya is based on the design for a pilotless target aircraft, which first flew in 1985. The cruise missile variant is believed to use INS and GPS mid-course guidance with radar or IR terminal seekers. The system is thought to have a 600-km range carrying a 450kg warhead. An Indian turbofan engine was flight tested on this vehicle in 1995. An unconfirmed report in 1997 suggested that this system could have a range objective of 2500km.

• The Coral program is designed to produce improved Russian Moskit (Sunburn) anti-ship cruise missiles for deployment on Indian destroyers. The existence of this program indicates that India likely has some Sunburn anti-ship cruise missiles.

• The Sagarika program is believed to cover the development of both a ballistic and a cruise missile for deployment on its nuclear submarine when it completes development. The cruise missile part of this program reportedly is focused on providing a land- attack cruise missile system that uses a turbojet engine to provide the missile with a planned range of 300 km. The system is expected to incorporate terrain contour matching, INS, and GPS guidance systems. It will be able to carry nuclear or conventional warheads, and a follow-on version is planned that will have a 1000-km range. The *Club* cruise missiles India procured from Russia are being deployed on its *Kilo (Sindhurashtra* class) submarine fleet. The *Club* missile is produced in four variants to include land-attack and anti-ship/submarine versions. Currently, India has only purchased the anti-ship version; India's second *Kilo* submarine departed a Russian shipyard in August 2000, modified to carry this missile system. There are indications that India may be planning on fitting cruise missiles on other warships for land-attack missions.

Since the early 90s, India has faced the threat of ballistic missile attacks from Pakistan and China, against which it has fought multiple wars in the past. With the heightening of tensions in the region, and in response to Pakistan's deployment of M-11 missiles bought from China, in August 1995, the Indian Government procured six batteries of Russian S-300 surface-to-air missiles to protect New Delhi and other cities. In May 1998, India for the second time (since its first test in 1974) tested nuclear weapons, followed by Pakistan with its first ever nuclear test. With Pakistan's testing of nuclear weapons and missile delivery systems, this threat intensified.

In 1999, the Kargil War between India and Pakistan became the first direct conflict between two declared nuclear powers. As the war progressed, the first hint of the possible use of a nuclear weapon was on May 31, when Pakistani foreign secretary Shamshad Ahmad made a statement warning that an escalation of the limited conflict could lead Pakistan to use "any weapon" in its arsenal. This was immediately interpreted as an obvious threat of a nuclear retaliation by Pakistan in the event of an extended war. The leader of Pakistan's senate noted that "the purpose of developing weapons becomes meaningless if they are not used when they are needed." Some experts believe that following nuclear tests in 1998, Pakistani military was emboldened by its nuclear deterrent cover to markedly increase coercion against India. Development of an anti-ballistic missile system began in late 1999, suggesting that India initiated the program in light of Pakistan's eschewing of a nuclear No First Use policy and heightened tensions during the Kargil war including a possibility of full scale nuclear war.

India-Israel Cooperation

India was interested in acquiring the Arrow-Il Missile System, which had been jointly developed by US and Israel. However, the deal fell through due to US refusal to approve the sale of the missile and the Yellow Citron control system. India and Israel jointly developed the Swordfish Long Range Tracking Radar (LRTR), which is the target acquisition and fire control radar for PAD Missile System. The LRTR radar has the capability to detect multiple targets. It was reported in December 2009 that the latest upgraded version of Swordfish Long Range Tracking Radar, already developed by DRDO in collaboration with Israel was capable of detecting very small targets in the 600 km - 800 km range and can spot objects as small as a cricket ball. The DRDO plans to upgrade the capacity of Swordfish to 1,500 km (930 mi).

Nuclear Deterrence and the Role of Ballistic Missiles

There is a clear linkage between nuclear deterrence and ballistic missile capability.[73] George Fernandes, the Indian Defense Minister, made the following statement on April 23, 1999[74]:"The acquisition of a missile system capable of delivering conventional or nuclear warhead bridges a key gap in the nuclear deterrent profile of the country. The double distinction of being nuclear-capable and a possessor of the means of delivery, means that India can hold its head high without fear of being bullied in a hostile security environment. China with its vast nuclear arsenal, Pakistan with its nuclear weapons and delivery system capability, America perching in Diego Garcia and eight other Asian countries possessing missiles is quite a grim security scenario."

In the formative stages of the US-Soviet nuclear competition, deterrence theorists identified a *stability-instability* paradox associated with the acquisition of offsetting nuclear weapon capabilities. The essence of this paradox was that nuclear weapons were supposed to stabilize relations between adversaries, and to foreclose a major war between them. At the same time, offsetting nuclear capabilities might well increase instability by encouraging provocations and conflict at lower levels – precisely because nuclear weapons would presumably provide protection against escalation.[75]

The India-Pakistan dynamic is different and in some ways more volatile than the historic United States-Soviet Union rivalry. Sagan notes that India and Pakistan have more in common than the Americans and the Soviets, who were on opposite sides of the globe and viewed each others as mysterious, often unpredictable adversaries. In contrast to the subcontinent, the U.S. and Soviet rivalry was ideological without disputed territory and a history of armed conflict[76]. Many observers of South Asia have accepted Kenneth Waltz's position (summarized in Sagan's paper[77]) and have argued for the nuclear weapons forces of India and Pakistan to adopt a more cautious, less bellicose approach toward each other. In their view, the possibility of large-scale, deliberate conventional conflict between the two states has lessened considerably, and nuclear deterrence ultimately compelled restraint, de-escalation, and disengagement on both sides[78]. Other scholars in India, Pakistan and the U.S. have argued that nuclear and missile arsenal proliferation will increase the likelihood of crises, accidents and nuclear war[79].

India's nuclear policy since the mid-1960s has been driven by China with the Pakistani threat as secondary.[80] Pakistan's entry into the nuclear club has not brought a period of détente and stability between India and Pakistan. Although there was a brief period of détente represented by the Lahore summit of February 1999, the "spirit of Lahore" was crushed by the Kargil conflict of May-June 1999 and disputes have grown more intense and more frequent and more dangerous since then. The Kargil crisis seems to indicate that Pakistan is losing the fear of retaliation central to the concept of deterrence because it now has nuclear weapons. Pakistan has never declared a No-First-Use policy, and there is a growing concern in India about the threshold at which Pakistan might use nuclear weapons in a limited war. During the 2002 crisis, India felt itself sufficiently handicapped to prevent any policy decisions with regard to 'hot pursuits' in Pakistan-controlled Kashmir despite a number of provocative Pakistani actions.[81] Hence, Kenneth Waltz's argument does not appear to be applicable within the context of India and Pakistan. It is likely that both countries will continue to test each other's limits, with the resultant risk that the nuclear threshold may be crossed.

India's Nuclear Programme and Nuclear Policy

Although India was alleged to have a nuclear weapons program since its nuclear test in May 1974, India demonstrated to the world that it is a de facto nuclear power by conducting its second nuclear test in May 1998. Pakistan, which has a contentious relationship with India, quickly followed suit with tests of its own at the end of May. The nuclear tests by both countries were carried out in face of the strengthening and universalization of the Nuclear Non-Proliferation Treaty (NPT) regime.

History of India's Nuclear Programme

India's nuclear development has been gradual and reactive as shown in **Figure 3.1.** Chinese nuclear testing and the acquisition of nuclear capability by Pakistan are factors that pushed the development of India's nuclear capability on to the next stage. However, India has not sought to achieve security through nuclear weapons in a straight, single-minded manner due to its domestic politics. Some domestic elements strongly commit to nuclear disarmament while others are concerned about the financial cost of nuclear development. India's democratic system does not allow nuclear development simply out of military interests. Nuclear non-proliferation and disarmament issues are interwoven with India's domestic politics, and thus India's nuclear development was correlated to the negotiation process of the NPT in 1967-68 as well as its review and extension process in 1995.[82]

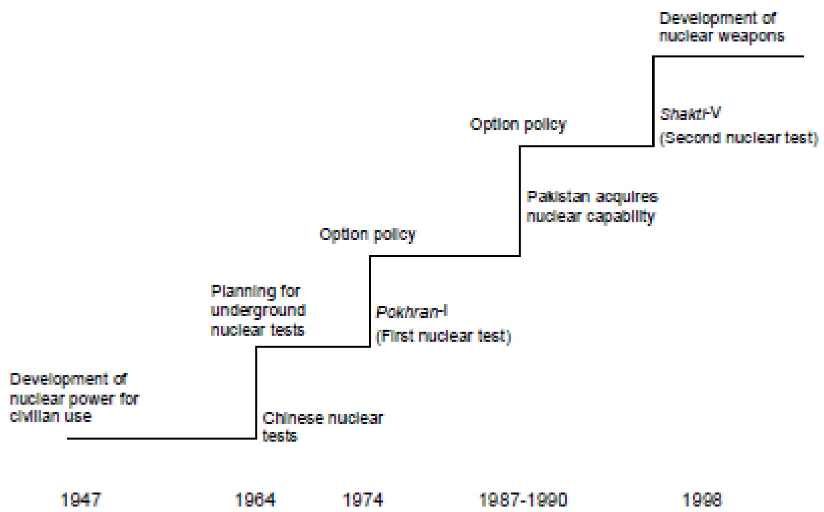

Figure 3.1 India's Nuclear Development[83]

The nuclear test conducted by China in 1964 became a major factor in motivating India to conduct an underground nuclear test of its own. Given the time lag of ten years between the Chinese nuclear test and the *Pokhran*-I of 1974, domestic politics as well as technical constraints appear to have affected the decision to conduct nuclear tests.[84] With India's defeat in a border clash with China in 1962, politicians in northern India who had strong anti-Chinese feelings, and atomic energy scientists with strong techno-nationalistic intentions, insisted that India should carry out nuclear tests of its own to counter the nuclear tests conducted by China. However, the Gandhian principle of non-violence and Nehruvian orientation for international cooperation had a strong influence on intellectuals and the ruling party, the Indian National Congress. They believed that exercising self-restraint with respect to nuclear tests would put India in a position of moral superiority vis-à-vis China in the international community.

However, when the NPT came into being in 1968, China was privileged as a nuclear-weapon state status, while India was not. When India sought security assurances from both the U.S. and the Soviet Union in the event of a Chinese nuclear attack, it was rejected, which led in turn to India’s decision not to participate in the NPT.[85] Though India justified its non-participation in the NPT by reason of the “inequality” between nuclear weapon states and non-nuclear-weapon states; it had maintained a vague position on whether or not to produce nuclear weapons. The nuclear test had demonstrated that India retained the potential to develop nuclear weapons in the future, but the Indian government also made it clear that it had no intention of producing nuclear weapons at that time. This is what is commonly referred to as the “option policy.”

India’s option policy was predicated on going ahead with weaponization in the event of the emergence of a new strategic threat, and this condition was fulfilled around 1987 by Pakistan’s nuclear development. It is not possible to use official data to corroborate at what point Pakistan acquired nuclear capability and how India evaluated Pakistan's nuclear capability and linked this to its own nuclear development. Several research works conclude that it was in the late 1980s that nuclear factors became visible during the small-scale armed conflicts between India and Pakistan over Kashmir[86]. India had the option of carrying out a preventive attack against Pakistan’s nuclear facilities during the India-Pakistan crisis that occurred between late 1983 to early 1984.[87]

While the risk of military conflict was rising in 1987, triggered by “Operation BRASS TACKS,” a military exercise conducted by India, several comments from Pakistan hinted at the possible use of nuclear weapons. Once the crisis was over, President Mohammad Zia-ul-Haq of Pakistan declared that the country had indeed embarked on a program of nuclear development.[88] In order to counter Pakistan's nuclear capability, India moved a step closer to the weaponization stage of its own nuclear option. It is said that Indian Prime Minister, Late Rajiv Gandhi, ordered the development of nuclear weapons in 1988.[89] It was around this time that India began full-scale development of delivery systems, and in 1989 India carried out its first tests of the Agni intermediate-range ballistic missile.

The nuclearization of Pakistan served to accelerate nuclear development in India. However, one could find the military doctrine of the Indian army towards Pakistan shift from one of deterrence by conventional arms to one based on nuclear deterrence. Rather it would be more correct to say that the Indian army tried to enhance its conventional arms capability so that it would not be offset by the nuclear capability of Pakistan. The pursuit of nuclear development by India is not logically tied to its military doctrine vis-à-vis Pakistan.[90] Thus the progress of India's nuclear development has been a reactive response to circumstances, of which Pakistan's nuclear development is thought to be one such "circumstance."

The indefinite extension of the NPT in 1995 and the conclusion of the negotiation of the Comprehensive Test Ban Treaty (CTBT) in 1996 were factors that finally pushed India's option policy towards nuclear testing. Indian strategists and nuclear scientists were alarmed at the dooming effect of the CTBT on the option policy. It was obvious to them that without nuclear tests, it would not be possible to secure credible nuclear deterrence. Such security concerns articulated by strategists prompted a policy decision that led to India's refusal to sign the CTBT. There was no strong opposition against this decision from proponents of nuclear disarmament in Indian society. The reason for this was because India's proposal for time-bound nuclear disarmament was rejected during the CTBT negotiations. As a result, these proponents for disarmament were also dissatisfied with the NPT and CTBT.[91]

As mentioned above, the finalization of the CTBT resulted in a weakening of the leverage held by Indian proponents of nuclear disarmament. It also boosted nationalist sentiment among those who engaged in nuclear development. However, the final decision on nuclear testing would not have been possible without the inauguration of the BJP-led government. The Bharatiya Janata Party (BJP), which publicly advocated the option of "inducting" nuclear weapons, acquired the largest number of seats in the Lower House (Lok Sabha) general election of 1998, and formed a government with allied parties. The BJP has been transforming the Nehruvian diplomacy of the Congress Party and has been seeking for major power status through power politics in the international arena. Also, some of the ideologues in the BJP have an antagonistic mindset toward China.[93] Immediately following the nuclear test of May 1998, Prime Minister Atal Behari Vajpayee wrote a letter to President Clinton implying that China posed a threat, stating that "we have an overt nuclear weapons state on our borders, a state which committed armed aggression against India in 1962".[94] However, the attempt to justify nuclear testing in light of a "China threat" invited criticism both at home and abroad. As a result, the government revised its line on the China threat and assumed the official view that it was not China's nuclear arms that were so much the cause for concern, but rather the transfer of nuclear and missile technology from China to Pakistan that contributed to a deterioration of the security environment of India.[95]

India started to develop nuclear weapons in earnest after the nuclear tests of 1998. The development of a nuclear capability until then had proceeded gradually in response to circumstances. In contrast to this, India clearly referred to "credible minimum nuclear deterrence" in its draft nuclear doctrine released in 1999. The *Agni* development program that had been suspended under pressure from the United States in 1994 was also resumed, with tests taking place in April 1999 and January 2000. Today, the Indian government and strategists maintain that nuclear weapons are necessary in order to overcome pressure from the nuclear non-proliferation regime and to maintain the autonomy of decision making in diplomacy and security policy, and further, in order not to have to submit to nuclear threats made by China.

Nuclear Weapons and the Nuclear Doctrine in India's National Security[96]

India published its "Draft Report of the National Security Advisory Board on Indian Nuclear Doctrine" (hereafter referred to as "Draft Nuclear Doctrine") in August of 1999. The National Security Advisory Board, a sub-organization of the newly established National Security Council, drafted this doctrine. The doctrine is yet to be authorized as an official government document. Though initially scheduled for adoption by the National Security Council followed by approval by the cabinet, it currently represents the best compromise among the many disparate views within India. The reason why the doctrine is still in draft form might be found in the criticism it has encountered both at home and abroad. Pakistan claimed that India's nuclear policy would fuel an arms race[97].

The U.S. Department of State also expressed its disappointment, stating that the maintenance of a nuclear deterrence was a move in the "wrong direction."[98] Various Western nations expressed concern because India's nuclear policy appeared to be too ambitious, given its stipulation of a "nuclear triad" and the lack of any clear indication of an upper limit on its nuclear capability. Within India, further criticism was targeted at the motive for releasing the Doctrine at that particular time when the Parliament had been dissolved. It was suspected that announcing the nuclear policy was aiming to gain votes for the incumbent administration in the upcoming elections The Draft Nuclear Doctrine consists of eight sections, namely: 1) Preamble, 2) Objectives, 3) Nuclear Forces, 4) Credibility and Survivability, 5) Command and Control, 6) Security and Safety (of Nuclear Weapons), 7) Research and Development, and 8) Disarmament and Arms Control. Indian analysts take the view that the Chinese principle of No-First-Use is only applicable to non-nuclear states.[99] The fourth point concerns nuclear force structure. The Draft Nuclear Doctrine has designated a triad of aircraft, mobile land-based missiles, and sea-based assets.[100] While admitting that sea-based forces are ideal from the perspective of survivability, the moderate group regards the establishment of sea-based assets as a long-term objective, something more for the future than the present. They put priority on the Agni-II intermediate-range ballistic missile, which requires further development, mobility, dispersion and deception.[101] Those who advocate maximum deterrence argue that the development of inter-continental ballistic missiles (ICBM), submarine-launched ballistic missiles (SLBM) and cruise missiles should be promptly advanced.[102] This debate, however, reflects the organizational interests of the different branches of the military. For example, retired naval officers advocate sea-based missiles[103], while those of the air force emphasize an airborne nuclear force.[104] Tactical nuclear weapons are considered unnecessary except for a minority within the advocates of maximum deterrence. This is because the recessed deterrence group and the moderate group do not base their premises on a nuclear war, while those in favour of maximum deterrence do not assume deterrence vis-à-vis Pakistan.

The fifth point concerns command and control. Since the middle group does not envisage a nuclear war, it considers it sufficient to centralize command and control in the hands of the Prime Minister. Those who advocate maximum deterrence believe that nuclear weapons should be integrated into the military operation plan, and that the authority for the control and use of nuclear weapons needs to be transferred to the armed forces in a severe crisis, as was once the case with the U.S. and Soviet nuclear deterrence policies.

Building a Deterrent Capability

The Minimum Nuclear Deterrence, as was previously mentioned, cannot be a perfect guide for the future of the nuclear weapon program. The biggest challenge that India might face would be how to develop a stable deterrence policy vis–à–vis Pakistan and China. Two questions are at hand. First, what kind of weapons should be developed and deployed? Second, how will nuclear weapons affect the stability of the India-China border? On the first question of the choice of weapons, while predicated on an assessment of Pakistan and Chinese nuclear strategy, research so far has been only fragmentary both at the governmental level and among the strategic community. Since it is difficult to evaluate and predict China's intentions, research has focused on the configuration as well as the deployment of Pakistan and China's nuclear capabilities.

However, the 2,500-km range[105] Agni-II is not able to reach Beijing or other cities in eastern China. It is in light of this that an argument in favour of the early development of ICBMs has surfaced even among the authors of the Draft Nuclear Doctrine.[106] Theoretically, this would be possible if India's space development technology were utilized. In 1980, India became the seventh nation in the world to acquire satellite-launch capability. Although the early space-launch vehicle had a launching capability of only a 35- to 40-kilogram satellite to low earth orbit, the polar space launch vehicle (PSLV) that was successfully launched in 1994 has a launching capability of three tons to low earth orbit. It was around this time that India's ICBM "*Surya*" development program was first reported. The PSLV is a four-stage rocket that uses solid fuel in the first and third stages, and liquid fuel in the second and fourth stages. In April 2001, India succeeded in launching a Geosynchronous Space Launch Vehicle (GSLV) using a cryogenic rocket engine in the fourth stage.

India had purchased this engine from Russia, and though initially it had intended to use technology transfer, it switched to acquiring the completed product because of the sanctions imposed upon India and Russia in May 1992 by the United States for violating the guidelines of the Missile Technology Control Regime (MTCR).[107] The launching of the PSLV and GSLV was aimed at entering the global communications space business in the fields of communications satellites and earth observation, but if they were to be converted to military use, they could realize a range of more than 5,000 kms. Dr. A.P.J. Abdul Kalam, who had been in charge of nuclear development in India, declared, "An ICBM is technically feasible. Once India makes a decision, it will be produced shortly."[108] However, as Dr. Kalam himself admits, because a cryogenic rocket requires time for fuel supply and an enormous facility, it is not suited for missiles. It has also been pointed out that it is difficult to make the huge bodies of a PSLV and GSLV mobile, and that their survivability is questionable.[109] Right now the Indian government is keen on developing ICBMs, which is a key decision.

Sea-based Deterrence

The second challenge is building sea-based deterrence. Although sea-based deterrence is generally discussed in relation to the objective of enhancing survivability, India is in the process of acquiring nuclear submarines, and building a highly survivable sea-based deterrence programme which will be time-consuming and expensive. India's advocacy of sea-based deterrence could be seen in the context of China and US and threat of terrorism.

Developmental Stages of the Indian Navy's Ballistic missile capability

The various stages of the Indian Navy's ballistic and cruise missiles are given below. The first on-board test firing of the Dhanush short-range surface-to-surface ballistic missile, a naval version of the Prithvi, was conducted in April 2000.[110] With an estimated range of 250 kms, the Dhanush is considered to be an anti-ship missile.[111] Regarding cruise missiles, in April 1998 the New York Times revealed a secret program with Russian cooperation involving the submarine-launched cruise missile Sagarika. Although Minister for Defence George Fernandes admitted the existence of the program, it cannot be verified because of contradictory information coming from various sources.[112] In marked contrast to the controversy over the Sagarika program, the purchase of the Club naval cruise missile system from Russia in September 1999 passed unnoticed. Though it is not clear which type has been purchased by India, if it is a 3M54E (SS-NX-27) with 220-km range, it would be an effective anti-ship attack weapon as it flies at supersonic speeds.[113] A Kilo-class submarine fitted with the Club missile system was brought to India in July 2000 and commissioned under the name INS Sindhushastra[114]. It is thought that these weapons will be fitted to three Krivak-class frigates as well as three Kilo-class submarines currently undergoing a refit in Russia.[115]

India's intense efforts to obtain ballistic missiles and cruise missiles with a range of less than 300 kms might be a manifestation of India's strong desire to influence Chinese and US activities in the Indian Ocean. In December 1998, in the face of the presence of nuclear submarines and ballistic nuclear submarines of China and the United States in the Indian Ocean, in which India has a vital stake, the House Standing Committee on Defence recommended to the government to "review and accelerate its Nuclear Policy for fabricating or for acquiring nuclear submarines to add to the deterrent potential of the Indian Navy." The recommendation was noted by the government in October 2000.[116]

This recommendation urged the government to accelerate its efforts to promote the Advanced Technology Vessel (ATV), the project for indigenous nuclear submarines that was started in the 1970s. In 1988, India set out to introduce nuclear reactor technology by leasing a *Charlie*-I-class nuclear-powered cruise-missile submarine (SSGN), but technical problems such as scaling down the size of the 190Mw nuclear reactor remain unresolved.[117] The construction of a prototype vessel is over but however the missile capability is yet to be achieved[118]

As can be inferred from the above equipment plans, the "sea-based deterrence" in India's nuclear doctrine means nuclear powered submarines, not nuclear missiles. It may be interpreted as putting nuclear submarines loaded with ballistic missiles or cruise missiles with conventional warheads into service with the objective of acquiring the capability to deny Chinese and US naval activity in the Indian Ocean. Even though if in the long term it does proceed with its nuclear-capable SLBM program, for the present time sea-based deterrence is at the very least aimed at nuclear deterrence vis–à–vis China and is more an issue of military balance in the Indian Ocean.

Deterrence and Limited War against Pakistan

The third challenge is securing strategic stability, which is a more urgent issue for relations with Pakistan than with China. As compared to India-China border disputes, the conflict between India and Pakistan over Kashmir comprises national identities and, therefore, is likely to intensify. In addition, it is suspected that Pakistan has not given up on the option of challenging the status quo through use of force.

In examining the strategic stability between India and Pakistan, it is necessary to go back to 1987 when Pakistan is thought to have acquired nuclear capability.[119] The period from 1987 to 1990 witnessed a number of events that reflected a lack of both crisis stability and arms-race stability between India and Pakistan. First, in response to the Soviet Union's withdrawal from Afghanistan, Pakistan was seen to shift its strategies to another front, Kashmir. It was around this time that Pakistan started supporting Islamic militant groups in Jammu and Kashmir, which is on the Indian side of the Line of Control (LOC).[120]

As a result of acquiring nuclear capabilities, the incentive increased for Pakistan to carry out nuclear first-use in cases where India escalated situations into conventional warfare, something that concerned India's military intelligence agencies and some researchers in the United States[121]. Second, an India-Pakistan missile development race accelerated in the same period. In response to India's first flight test of the short-range ballistic missile Prithvi in February 1988, then Pakistan displayed both Hatf-I (range: 80 to 85 kms) and Hatf-II (range: 300 kms [122]) missiles in March 1989. India in turn conducted the first test of the intermediate-range ballistic missile Agni-II (range: 2,000 kms) the following May. Although its action may not have been intended to provoke Pakistan, the effect was to induce a Pakistani reaction.

The United States responded quickly to these strategic instabilities. In the early 1990s, many high-level US government officials raised alarm over the intensification of the nuclear and missile development race between India and Pakistan. Something that must not be overlooked is that these remarks were not only aimed at promoting the US non-proliferation agenda by putting pressure on both India and Pakistan, but that the intentional leaking of information by the US side was intended to promote strategic stability. The objective of the United States toward the arms race was to bring about an immediate freeze in nuclear development by India and Pakistan with an ultimate goal of eliminating nuclear weapons and capping missile development.

United States imposed sanctions against Russia's export of cryogenic rocket engines to India in 1992, and China's export of M-11 missiles (DF-11/CSS-X-7 range: 300 km) to Pakistan in 1991 and 1993, for not complying with the guidance of the MTCR. However, these sanctions could only slow the pace of the arms race. After China demonstrated a more positive approach to non-proliferation by reaffirming its pledge to the MTCR in October 1994, Pakistan then turned to North Korea as a supplier of missiles. It is thought that the intermediate-range (1,300 to 1,500 km range) ballistic missile Ghauri-I tested in April 1998 was based on the North Korean No Dong missile. As for the crisis stability, the US adopted a more low-key approach, and this has been successful to a certain degree. When India and Pakistan came close to war emanating from military exercises in 1990, there was serious concern in the Bush administration over the possibility of nuclear war. The United States took on a mediating role in an attempt to avoid a crisis.[123] This led to several confidence-building measures including the Agreement on Prevention of Air Space Violations (April 1991)[124], the Agreement on Advance Notice of Military Exercises, Manoeuvres and Troop Movements (April 1991)[125], the extension of the hotline between the two countries (December 1990), and the exchange of instruments of ratification for an agreement on the non-attack of nuclear facilities in January 1991. India also proposed its No-First-Use policy in 1994.

Even after this series of confidence-building measures, the question of the stability of the virtual nuclear deterrence between India and Pakistan continued to be debated among researchers in the United States. Those who argued that nuclear deterrence lacked stability pointed out several factors, including the possibility of war between the two countries over Kashmir, deployment of short-range ballistic missiles, insufficient intelligence capabilities and fragile command and control systems.[126]

The Kargil crisis, which lasted for two months from May 1999, was the first test of crisis stability after the nuclear tests. It started with Islamic militants crossing the LOC from the Pakistan-side and making an incursion into Indian Territory, followed by Pakistani forces occupying strategic posts on the Indian side. Subsequently it developed into an armed conflict between the regular military forces. After India's air campaign, the Indian armed forces gained superiority in the end. Nawaz Sharif, Prime Minister of Pakistan, asked Clinton for mediation, in vain, and had to accept a virtually unilateral cease-fire.[127] Strong persuasion by the US Commander-in-Chief of the Central Command to the Pakistan Chief of Army Staff also facilitated the end of the Kargil crisis. This episode is one more indication of the structure whereby the United States provides the communication channel between India and Pakistan.

It is a matter of significance to look at how both governments are interpreting the Kargil crisis in the context of nuclear deterrence. The Pakistani government's opinion is that India's restraint in not crossing the LOC was the effect of Pakistan's deterrent capability.[128] This view is somehow shared with the Indian side. The Kargil Review Committee Report, published by India, reveals a view held by India's Joint Intelligence Committee a few years back that Pakistan was conducting low intensity conflict under a nuclear umbrella, and that Pakistan's nuclear capability had made it difficult for India to escalate the conflict into a conventional war.[129] Even if a Kargil-type crisis occurs in the future, India is not likely to go beyond deterrence by conventional forces. After the submission of the Kargil Review Committee Report, India's strategic community started to discuss the concept of a limited war.[130]

According to India’s Minister of Defence, George Fernandes, a limited war is a war that is “limited to a geographical area,” something that is considered inevitable in the future.[131] It seems that India is trying to raise the “nuclear threshold” between India and Pakistan through a buildup of its conventional forces. However, the doctrine of limited war would not be able to eliminate the possibility of the use of nuclear weapons by Pakistan if India fails to clearly convey its political objectives in Kashmir. As India’s declared policy is that Kashmir as a whole, including Pakistani-held Kashmir, belongs to India,[132] if India were to launch even a small counter-attack on the Pakistani side of the LOC, it is possible that Pakistan could misunderstand it as being an intention of seizing the whole of Kashmir.

India's Nuclear Doctrine

India declared a policy of No-First-Use of nuclear weapons in August 1998. Prime Minister Vajpayee emphasized India’s self-restraint but did not state the official policy of a “minimum, but credible, nuclear deterrent” until December 1998.[133] Early official statements did not assert a specific nuclear threat to India. In August 1999 the Indian Government issued the Draft Report on Indian Nuclear Doctrine that reiterates the policy of credible minimum deterrence against any state or entity.[134] The report was not official policy but included several descriptive statements:

- “India’s nuclear forces and their command and control shall be organized for very high survivability against surprise attacks and for rapid punitive response.” This statement appears to forgo a strategy of delayed second strike.
- “India’s peacetime posture aims at convincing any potential aggressor that any threat of use of nuclear weapons against India shall invoke measures to counter the threat.” This statement implies that actions by conventional as well as nuclear forces might be initiated against the threat.
- It calls for India’s nuclear forces to be based on a “triad of aircraft, land-based mobile missiles, and sea-based assets.” This statement implies that Indian nuclear stockpile will be larger than a few dozen weapons. The report does not distinguish between tactical and strategic nuclear weapons.
- “India will not resort to the use or threat of use of nuclear weapons against states which do not possess nuclear weapons or are not aligned with nuclear weapons powers.” India’s No-First-Use may be more flexible (or subjective) than its initial unconditional statements.

India updated the draft nuclear doctrine in January 2003 adding several features:[135]

- A posture of "No-First-Use" nuclear weapons will only be used in retaliation against a nuclear attack on Indian territory or on Indian forces anywhere.
- Nuclear retaliation to a first strike will be massive and designed to inflict unacceptable damage.
- Nuclear retaliatory attacks can only be authorized by the civilian political leadership through the Nuclear Command Authority.
- Non-use of nuclear weapons against non-nuclear weapon states.
  However, in the event of a major attack against India, or Indian forces anywhere, by biological or chemical weapons, India will retain the option of retaliating with nuclear weapons.
- A continuance of strict controls on export of nuclear and missile related materials and technologies, participation in the Fissile Material Cut off Treaty negotiations, and continued observance of the moratorium on nuclear tests.
- Continued commitment to the goal of a nuclear weapon free world, through global, verifiable and non-discriminatory nuclear disarmament

The Indian Strategic Forces Command (SFC), sometimes called Strategic Nuclear Command, forms part of India's Nuclear Command Authority (NCA). It is responsible for the management and administration of the country's tactical and strategic nuclear weapons stockpile.[136] It was created on January 4, 2003 by Vajpayee Government.[137] Air Marshal Teja Mohan Asthana became its first commander-in-chief.[138] It is the responsibility of the Strategic Forces Command to operationalize the directives of the NCA under the leadership of a Commander-in-Chief who is a three-star rank officer. It will have the sole responsibility of initiating the process of delivering nuclear weapons and warheads, after acquiring explicit approval from the NCA. The exact selection of the target area shall be decided by the SFC through a calibrated, cumulative process involving various levels of decision-making, and with formal approval by the NCA.[139]

The SFC manages and administers all strategic forces by exercising complete command and control over nuclear assets, and producing all contingency plans as needed to fulfil the required tasks. Since its inception, the SFC's command, control and communication systems have been firmly established, and the command has attained a high state of operational readiness.[140] The Agni-I and Agni-II ballistic missiles are operational under the SFC,[141] while the Agni-III missile is being inducted.[142] The Hindu reported in September 2012 that Agni-III missiles were operational under the Strategic Forces Command and a user test of rail mobile Agni-III was carried out 21 September 2012.[143] The SFC carried out the second user trial of rail mobile Agni-III missile on 23 December 2013.[144]

The Prithvi missile inducted into India's Strategic Forces Command in 2003, the first missile to be developed under India's prestigious IGMDP strengthened India's nuclear deterrence A missile unit of the elite Strategic Forces Command (SFC) successfully launched a Prithvi missile on 7 January 2014 from the test range at Chandipur.[145]

It was reported by *Hindustan Times* on 12 September 2010 that to increase its lethal power, India's tri-services strike force is planning to acquire 40 fighter planes capable of delivering nuclear weapons. The SFC has submitted a proposal to the Defence Ministry for setting up two dedicated squadrons of fighter aircraft which will act as a mini-Air Force. This will be the first time that the SFC, which at present depends on the Indian Air Force for delivering nuclear weapons under its command, will have its own aerial assets.[146]

India has often been accused of lacking in strategic vision, and as many Indians believe, not entirely without reason. Although there has been a recent increase in the general discourse in matters concerning security and strategy, the amount of attention that the Indian polity devotes to these vital aspects needs to be far greater than it is. India has identified its threats in general terms as emanating from the possession of nuclear weapons by both its neighbours and their active mutual collusion. It has, accordingly, embarked on a program to be able to retaliate against an attack by China, though the progress is rather slow. To meet its perceived threats, India needs not large numbers, but adequate missiles with the capability to cause unacceptable damage at a range of between 4,000 and 5,000 km. This perception has led naturally to the development of SRBMs, medium-range ballistic missiles (MRBMs), and, as recently announced, the 5,000-km range Agni.

Most of India's operational missiles are of short range, which might lead one to the conclusion that its main preoccupation is with Pakistan. However, this must be looked at as being more due to the developmental process than an indicator of India's strategic priorities. India’s progress can be flagged by the steady increase in the ranges of its missiles, and the preponderance of SRBMs is only partially due to its perceived requirements. This proportion is likely to change as the longer-range missiles are improved, and their serial production gathers momentum. A major reason for India’s missile inventory not yet reflecting its strategic imperatives is the narrow design and engineering base for military armament production. This is restricted to just one government organization, which is responsible for the design and the development of short-, medium-, intermediate- and long-range missiles, cruise missiles, submarine-launched ballistic missiles (SLBMs), and missile defence. The planned Indian missile force architecture is rational and in line with strategic needs, but it is a few years behind the stage where it could have been, because of inadequate human and material resource utilization; the private sector has still to be brought meaningfully into the design and production chain.

Ballistic Missile Defence (BMD) System

Defence Research and Development Organization (DRDO) is developing a Ballistic Missile Defence (BMD) system to be deployed by 2015. The system will be based on radar technology for tracking and fire control which the DRDO developed jointly with Israel and France. In Phase I the BMD system will be implemented as a two tiered terminal phase interceptor system comprising of:

- Prithvi Air Defence (PAD) exo-atmospheric interceptor missile for intercepting targets outside the atmosphere.

- Advanced Air Defence (AAD) endo-atmospheric interceptor missile for intercepting targets up to an attitude of 30 kms. The seven-metre long AAD interceptor is a single stage solid rocket propelled guided missile, equipped with an inertial navigation system, a hi-tech computer and an electro-mechanical activator totally under command by the data up-linked from the sophisticated ground based radars to the interceptor, sources said.

- ‘Swordfish’ Long Range Tracking Radar (LRTR). The Swordfish LRTR has been developed from the Green Pine early warning and fire control radars imported by India from Israel in 2001-2002.

BMD Tests

India has conducted three successful intercepts using the Phase 1 system against non manoeuvring targets in 2006, 2007 and 2009. On March 6, 2008 a PAD missile successfully intercepted a modified Dhanush surface-to-surface missile, fired from INS Rajput anchored inside the Bay of Bengal at 1620 hours, towards Wheeler Island, simulating a target "enemy" missile with a range of 1,500 km. On November 27, 2006 a PAD missile intercepted a Prithvi ballistic missile at 48 km altitude. In December 2007 an AAD missile intercepted a target missile at an altitude of 15kms. India is also developing two new missiles, AD-1 and AD-2, as part of the ABM system. These Phase II missiles are being developed to intercept ballistic missiles with the range in excess of 5000 km and probably represent elements of a mid-course interception system.

Upcoming Test

DRDO will carry out another test in 2014 to enhance the capabilities of AAD endo-atmospheric missile, which is used to intercept missiles at altitudes up to 15 km. Sources say that if the tests prove successful, the DRDO will go ahead and deploy the system by 2015.

Boost Phase Missile Defence

The Laser and Science Technology Centre (LASTEC) is also reported to be developing lasers to take out enemy missiles during their boost phase, when they are most vulnerable. "It's easier to kill a missile in boost phase as it has not gained much speed and is easier to target. It cannot deploy any counter measures and it is vulnerable at that time," DRDO's Air Defence Program Director V K Saraswat told PTI in January 2009. "In LASTEC, we are developing many of these technologies. We have to package these technologies on aircraft like the Americans have done on their systems," he added. "It is an involved process and not just about producing lasers. We have to put in many systems like the surveillance and tracking systems together for such a system to work. It will take another 10-15 years before we talk of integrating all these elements," he said. A Boost Phase Missile defence system will need to rely on a space based launch detection system like the SBIRS satellite constellation being deployed by the US. Unlike the SBIRS, 'which is global in scope, India would require a more limited system to monitor Pakistan and China. India could also buy into the US' SBIRS while developing its own limited constellation.

The sustained hostility between India and Pakistan has existed since the two countries became independent, and the reasons are deep-rooted. However three major seminal events — the accession of Kashmir to India, Pakistan's loss of its eastern territory, and the overwhelming defeat in the war (which ended with 90,000 Pakistani troops in Indian prisoner-of-war camps) — have deeply affected the national psyche, which now blames Indian Government for all the nation's problems. As the years passed, the differences between the two countries widened. India exploded several nuclear devices and declared itself a nuclear weapons state. The arms race implies that India's military expenditure is determined in an action-reaction framework with Pakistan's military expenditure in the long run. Also, this arms race has brought about an arms rivalry-missile rivalry between the two. **Hence, the first hypothesis is that there is an enduring missile arms race and missile rivalry between India and Pakistan.**

Pakistan followed suit and one can see not only the rivalry continuing, but also find the arms race existing between these two countries whether it be conventional or nuclear. Therefore the next chapter attempts to examine **Pakistan's Missile Development Programme**.

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