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India's Nuclear Triad

A Net Assessment

Ajey Lele and Parveen Bhardwaj

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Institute for Defence Studies & Analyses

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Mirage 2000 (http://vayu-sena.tripod.com/pix/mirage2000-3.jpg)

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Arihant Nuclear Submarine (http://2.bp.blogspot.com/-hwSpUtr9uM0/T3_hFgzu6wI/AAAAAAAADKc/MrphIZheKLA/s1600/INS+CHAKRA+03.JPG l)

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Abstract

As per the Treaty on the Non-Proliferation of Nuclear Weapons (NPT) there are five "official" nuclear-weapon states in this world - the United States (US), the United Kingdom (UK), Russia, France and China. India, Pakistan, Israel and North Korea are in the possession of nuclear weapons outside the ambit of NPT. India carried out its first nuclear test in 1974. Subsequently, in 1998 India had carried out a series (five in total) of nuclear tests and now India is known to have weaponries of nuclear technology. The process of weaponisation is a complicated engineering activity and could involve various activities form deciding on the yield necessity, device design, and material acquisition and processing and many other processes. All these activities would heavily depend on the type of weapon to be produced which in turn would depend on the nature of the weapon delivery system. The warhead would be essentially designed based on the weapon system which ultimately would deliver the munitions on the target. Alternatively, the modern day warheads are compressed in size and hence in a position to offer different options for the delivery systems too. Basically, all such warheads could be delivered from ground, aerial or submarine based platforms. This paper discusses such delivery mechanisms commonly known together as nuclear triad in the Indian context. The paper has four major parts. The first part attempts to set the context for the overall discussion. The second, third and fourth parts deals with the evaluation about missile forces, aerial platforms and submarine based platforms for nuclear weapon delivery on the targets.

List of Acronyms

ASW	Anti Submarine Warfare
AAA	Air-to-Air
AWACS	Airborne Warning And Control System
CBCP	Case Bonded Composite Propellant
CEP	Circular Error Probable
CLCP	Cartridge Loaded Composite Propellants
ECM	Electronic Counter Measure
EW	Electronic Warfare
FMCT	Fissile Material Cut-off Treaty
GLONASS	Global Navigation System
GPS	Global Positioning System
HTBP	Hydroxyl Terminated Ploy Butadiene
ICBM	Intercontinental Ballistic Missile
IGMDP	Integrated Guided Missile Development Program
IFR	In-Flight Refueling
INS	Inertial Navigation System
Isp	Specific Impulse
JDAM	Joint Direct Attack Munition
MAD	Mutual Assured Destruction
MIRV	Multiple Integrated Re-entry Vehicle

NEPE	Nitrate Ester Plasticized Polyether
NFU	No First Use
NPT	Non-Proliferation Treaty
RV	Re-Entry Vehicle
SLCM	Submarine Launch Cruise Missile
SLBM	Submarine Launch Ballistic Missile
SSN	Nuclear Powered Submarine
SSBN	Nuclear Powered Ballistic Submarine
TERCOM	Terrain Contour Matching
TEL	Transport Erector Vehicle
TNT	Trinitrotoluene
VLS	Vertical Launch System

Context

Nuclear Triad essentially has three major components-the strategic bombers, Inter Continental Ballistic Missiles (ICBMs) and Submarine Launched Ballistic Missiles (SLBMs) for the purpose of delivering a nuclear weapon. The reason for having such three-branched capability is to significantly reduce the possibility of the destruction of the entire nuclear architecture of the state in the first nuclear strike by the enemy itself. The triad provides the potency to the country which has been under the nuclear attack to respond swiftly by nuclear means. Such system essentially increases the deterrence potential of the state's nuclear forces.

This triad fundamentally represents the three basic deliveries platform for nuclear weapons, such as system like Vertical Launch Systems (VLS), Transporter Erector Launcher (TEL), Rail-mobile launcher etc. for land based fighters and strategic bombers for air-based and under water submarines for sea based.[1]

It is important to appreciate the nature and lethality quotient of nuclear munitions before debating the nuclear triad. On August 6, 1945, the United States attacked Hiroshima, the Japanese city with an atomic weapon. This bomb was the equivalent of 20,000 tons of Trinitrotoluene (TNT), a yellow, crystalline compound used mainly as an explosive which flattened the city, killing tens of thousands of civilians[2]. The first thermonuclear ("hydrogen") bomb test released the same amount of energy as approximately

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Authors are grateful to Gp Capt Vivek Kapur, Cdr SS Parmar, Maj Gen SL Narasimhan and Mr. Sudhanshu Sharma for valuable suggestions

1 WMD411 - Case Studies: The New Triad". *Nuclear Threat Initiative*. 2010-04-06, (Accessed December 07, 2012)

2 At http://history1900s.about.com/od/worldwarii/a/hiroshima.htm, (Accessed December 08, 2012)

10,000,000 tons of TNT[3]. A modern thermonuclear weapon weighing may be 1000 kg to 1,100 kg can produce an explosive force comparable to the detonation of more than 1.2 million tons (1.1 million tons) of TNT. Even a small nuclear device can devastate an entire city by blast, fire and radiation.

In spite of major investments being done in the nuclear weaponry field it is a reality that there is a difficulty in coming up with practical ways nukes that could conceivably be applied on the battlefield. It is rare to find a target that can't be struck just as well by conventional weapon[4]. Hence, actual usage of nuclear weapons (if someone is 'stupid' enough to use it) would be only for the political reasons. Hence, states are bound to have an inevitable dependence on second strike capability just in response to a nuclear attack. Such a need highlights the importance of the different modes of delivery systems. Such triad would help complicate the adversary's nuclear planning.

In the Cold War, nuclear weapons were central to the deterrence strategy for the then superpowers, the US and the erstwhile Soviet Union. The US had deployed a wide variety of systems that could carry nuclear warheads. These included nuclear mines; artillery; short, medium, and Long Range Ballistic Missiles (LRBM); cruise missiles; and gravity bombs. The US had deployed these weapons with its troops in the field, aboard aircraft, on surface ships, on submarines, and in fixed, land-based launchers. It was a complex strategy adopted by the US that consisted of detailed operational plans that would guide the use of these weapons in the event of a conflict with the Soviet Union and its allies.[5]

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[3] WMD411 - Case Studies: The New Triad". *Nuclear Threat Initiative*. 2010-04-06. (Accessed December 07, 2012)

[4] Think again nuclear weapon, [http://www.foreignpolicy.com/articles/2010/01/04/think_again_nuclear_weapons], (Accessed December 09, 2012).

[5] Cold war history [http://www.atomicarchive.com/History/coldwar/page15.shtml], (Accessed June 12, 2012)

During World War II period, the US had nuclear superiority in comparison with the Soviets. However, by the late 1950s, the Soviet Union had built up a convincing nuclear arsenal to challenge this superiority. By the mid-1960s, unilateral deterrence gave way to "mutual deterrence," a situation of strategic stalemate.[6] Unfortunately, the subsequent years saw a huge increase in the stockpiles of the nuclear weapons. However, the concept of Mutual Assured Destruction (MAD) helped avoid any nuclear conflict amongst the superpowers in the Cold War era. These powers understood the importance of an effective deterrent that could survive a surprise nuclear attack. This demanded the requirement of designing and developing accurate delivery systems which could be dispersed easily in case of an imminent attack or the one which could remain deployed in the high seas.

Above discussion could be viewed as a backdrop for the foundation of a nuclear triad, essentially a structure to assure the massive second-strike capability and provide more 'teeth' to the deterrence.

The only nuclear munitions used in actual conflict (Hiroshima and Nagasaki) so far were dropped by the bomber aircrafts and B-29 bombers were used for this purpose and the bombs were dropped from approximate height of 30,000 feet above the target. Bombers/ aerial platforms offer great flexibility to the attacker who could abort the mission even at the last minute or change the target depending on the necessity. The aircraft can carry various types of missiles/bombs and this gives additional options to the invader to plan the mission. Because of the significant involvement of the human element in the entire mission, the technology dependence is restricted. For modern day combat an aerial platform is of use for the delivery of low yield weapons for precision air strikes.

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6 Ibid

7 P.K. Ghosh (2002): Economic dimension of the strategic nuclear triad, Strategic Analysis, 26:2, 277-293 (http://dx.doi.org/10.1080/09700160208450044), (Accessed September 24, 2012)

Ballistic missiles have their own significant advantages to undertake a nuclear attack. They can travel a longer distance and hence also offers flexibility in respect of deployment. The missile silos could be deep inside the assessor state and mostly such platforms are mobile in nature. They possess good accuracy, are available in various shapes and sizes and in specific cases offer an option of multiple targeting in single rocket launch. Also, a saturation raid by undertaking multiple launches on the same target helps to deceive the anti-missile defence systems. It is important to note that there is no "assured survivability" in case of using bombers or ballistic missiles as a weapon delivery platform.

Nuclear powered Ballistic Missile Submarines (SSBN) is grated as the finest delivery platforms. SSBNs are less vulnerable to enemy attack[7]. They can operate in vast ocean expanses with minimal exposure. Hence, SSBNs are extremely useful as retaliatory/second strike weapons. They do suffer from some vulnerability like the destruction at the harbour or at homeport or from Anti-Submarine Warfare (ASW). However, in relative terms they could be considered as safer option than bombers or ballistic missiles.

After independence, India started with its nuclear programme headed by Homi J. Bhabha under the Atomic Energy Act (AEA) of 1948 focusing on peaceful development[8]. India aspired to be a nuclear state after 1962 conflict with China, particularity after China conducted its first nuclear test in 1964. India carried out its first nuclear detonation a "peaceful nuclear explosion," on May 18, 1974. This test code named "Smiling Buddha" was conducted in the western parts of India over a dessert terrain at a small village called Pokhran. Since then this test has been mostly known as Pokhran-1 and it had demonstrated a yield of perhaps 12 Kilo Tons (kT).[9]. On May 11, 1998, India tested three devices at the Pokhran underground testing site, followed by two more tests on May 13,

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8 India's nuclear weapon programme, [http://nuclearweaponarchive.org/India/IndiaOrigin.html], (Accessed September 26, 2012)

9 "India's Nuclear Weapons Program - Smiling Buddha: 1974" Nuclear Weapon Archive.

1998. These tests include fission device with a yield of about 12 kT, a thermonuclear device with a yield of about 43 KT, and a sub-kiloton device.[10]

India as a nuclear weapon state desires to hold 'minimum credible deterrence'. India has adopted a 'No First Use' (NFU) policy after the 1998 (Pokhran II) nuclear tests. Even though there will be no first-use of nuclear weapons by India as per the 1999 draft nuclear doctrine (a) any threat of use of nuclear weapons against India shall invoke measures to counter the threat and (b) any nuclear attack on India and its forces shall result in punitive retaliation with nuclear weapons to inflict damage unacceptable to the aggressor[11]. This India's policy of 'retaliation only' implies that the survivability of India's nuclear arsenal will delineate its second-strike capability, thereby ensuring credible deterrence. India's nuclear doctrine calls for sufficient, survivable and operationally prepared nuclear forces; a robust command and control system; effective intelligence and early warning capabilities; comprehensive planning and training for operations in line with strategy; and the requisite primary and alternate chain of command to employ nuclear forces and weapons[12].

As per some conservative estimates, India has around 50 nuclear weapons. Probably, India could have weapon grade plutonium to produce more than the double weapons than what it already has[13]. India has nuclear neighbours namely China and Pakistan. In the past India has fought wars with both these states and still has many differences including unresolved border agreements. It is important to recognize the fact that due to conflict in interest this region has very high possibility of breaking conflict. China has adopted NFU policy well before India in 1964; with the affirmation not to be the first to use nuclear weapons "at any time or under any

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10 Nuclear weapon In India, [www.fas.org], (Accessed on September 26, 2012)

11 http://www.nuclearsecurityproject.org/uploads/publications/Indias_Nuclear_Doctrine.pdf, (Accessed December 10, 2012)

12 Monika Chansoria, "Needed, a nuclear triad", *The Sunday Guardian*, column (Accessed December 10, 2012)

circumstances." China has reaffirmed its NFU policy in 2009. However, it is perceived by many that China cannot be trusted. China suffers from credibility deficit. For instance, there were reports that China had considered nuclear strikes against the Soviet Union in the event of a conventional Soviet attack. It has capability to deliver nuclear weapons from aircraft, surface ships and submarines as well as missile[14].

Delivery System	India	Pakistan	China
Land Based	Prithvi (SS-250) Prithvi-2 Agni Agni-I Agni-II Agni III Agni-IV **ICBM** Agni-V **SLBM** Sagarika (K-15) **Cruise** Brahmos Supersonic	Ghaznavi (Hatf-3) Shaheen I (Hatf-4) Shaheen 1A Shaheen II (Hatf-6) Ghauri I (Hatf-5) Hatf-9 (Nasr) Hatf-II/Vengeance-II Abdalia[15] **Cruise** Babur (Hatf-7)	DF-3A (CSS-2) DF-4 (CSS-3) DF-5/5A (CSS-4) DF-11/11A(CSS-7) DF15/15A/ 15B(CSS-6) DF-21(CSS-5)Mod2 (21A/21B) DF-25 DF-31 (Mod 1) **ICBM** DF31 (CSS-9) DF-41 (CSS-X-10) **SLBM** JL-1 JL-2 **Cruise** DH-10 KH-55SM

[13] SIPRI Yearbook (2007), Armaments, Disarmament and International Security, Oxford University Press, Sweden, p. 539.

[14] South Asian studies by Col. R. Hariharan.[http://www.southasiaanalysis.org/%5Cpapers40%5Cpaper3920.html], (Accessed June 21, 2012)

[15] "Pakistan Continues Short-Range Ballistic Missile Tests" February 18, 2013 (http://missilethreat.com/), (Accessed February 22, 2013)

Delivery System	India	Pakistan	China
Sea Based	Arihant class submarine (Under Development)	None	Xia (type 092) Jin (Type 094)
Air Based	Jaguar (Shamsher) Mig-27 (Flogger) Mig-29K Su-30MKI-III Dassault Mirage 2000H/TH	F-16 Falcon Mirage III/V	Hong-6(B-6 or Tu-16 Badger) Qian-5 (A-5) Su-30 MKK J-11[Su-27 FLANKER]

Table 1: Delivery System *Source*: generated by the authors using Jane's, Centre for Defence Information, SIPRI Yr, and World Air force & Missile Threat Database

Above table shows India, China and Pakistan's nuclear triad centric capabilities.

India's most conflicting border issues are predominantly related to Pakistan. Pakistan has not declared its nuclear doctrine and it does not subscribe to NFU policy. However, this should not be necessarily understood as a first use doctrine[16]. At the same time the always volatile political situation in Pakistan, their tacit support to use of terrorism as a military option (both peacetime as well as wartime) against India and mostly military control over the nuclear button makes circumstances intricate. The veracity of the safety of their nuclear arsenal remains doubtful. Pakistan has capable air force

[16] Nuclear policy of Pakistan [www.nids.go.jp/english/publicatioN/Aiyo/pdf/bulletin_e2002_3.pdf], (Accessed June 24, 2012)

and missile forces to deliver the nuclear weapons on the correct target in case of necessity.

India has its unique place in the global nuclear settings. India has taken a principled view in regards to nuclear issues. It has played pioneering role in conceptualising the notion of NPT and has not signed the NPT because of its discriminatory nature. India argues that NPT permits only five countries in the world to hold nuclear weapons while not permitting the others and follows a biased policy. India envisions total disarmament of the nuclear weapons. It maintains a voluntary, unilateral moratorium on nuclear testing. On December 15, 1998, Prime Minister Vajpayee spelt out the principal elements of India's nuclear policy in a statement in Parliament: "India's resolve to preserve its nuclear independence, minimum nuclear deterrence, no first use, non-use of nuclear weapons against non-nuclear powers, and a firm commitment to the elimination of nuclear weapons".[17]

It has been also affirmed by the government that India's nuclear threat perceptions were not country specific. At the Millennium Summit of the United Nations in September 2000, Prime Minister Vajpayee defended India's nuclear test and reiterated India's willingness to sign the Comprehensive Test Ban Treaty (CTBT) and re-stated India's readiness to work towards the successful conclusion of the Fissile Materials Cut-off Treaty (FMCT).[18] India is a nuclear state because of the complicated security milieu in the sub continent. Understanding the dangers of nuclear weapons and the type of paranoia they could create both regionally and globally, India has by design adopted a policy to restraint which involves minimum deterrence and no NFU as the two vital pillars of its nuclear policy.

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[17] "PM's reply to Discussion in Rajya Sabha on Nuclear Tests (May 29, 1998)", Strategic Digest, October 1998, pp. 1583-1585.

[18] Address by Mr. Atal Behari Vajpayee, Prime Minister of India, at the Millennium Summit of the United Nations, Strategic Digest, XXX(10), October 2000, pp. 1431-1435.

Missiles

India began with its space programme in 1963 by launching of sounding rockets. India launched its first satellite named Aryabhatta during 1975 with USSR help. The rocket science was yet to involve indigenously. India became a space faring nation only by 1980 when it successfully launched a satellite using own rocket launching system. India's space programme is for the purpose of assisting in socioeconomic development. The mandate for India Space Research Organisation (ISRO) is strictly civilian in nature.

The volatility of the security scenario in the region made India to invest in missile technology to safe guard its national security interests. On July 26, 1983 Integrated Missile Development Program (IGMDP) for the Research and Development (R&D) of a comprehensive range of missiles got started. The main agencies responsible for development of this programme were India's Defence research Development Organization (DRDO) and Ordinance Factories. The purpose of the project was to develop strategic missiles into various categories. IGMDP has developed five missiles and their variants: Prithvi, Agni, Akash, Trishul, and Nag.[19] On January 8, 2008 the DRDO has formally announced the successful completion of the IGMDP[20]. Agni missiles belong to the family of medium to intercontinental range ballistic missiles. DRDO has been developing a testing a range of such missiles since 1989 when the first technology demonstrator missile was test fired.

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[19] "Evolution of India's Missile development Programme", Complete development history can be read in this part of case study, by Wg. Cdr. Ajey Lele , A Vinod kumar and Gunjan singh (unpublished)

[20] http://brahmos.com/content.php?id=10&sid=25, (Accessed December 12, 2012)

Being a programme of strategic importance, Agni family of missiles was disconnected from the IGMDP and now functions as a singular programme. The DRDO has developed Agni series of ballistic missiles of different ranges. This programme includes Agni-1 (around 700 km); Agni-II (up to 2,000 km), Agni-III (up to 3,000 km), Agni-IV beyond 3,500 km and Agni-V which is beyond 5,000 km[21]. Though, for Agni-V to be entitled as ICBM is disputed due to its range, but according to purpose of this paper we will be quoting Agni-V as ICBM. Following table provides some useful details in this regard[22]:

Designation	**Class**	**Payload**	**Range**	**Status**
Agni-1	SRBM	Single warhead, 2,000 kg	700-1,200 km	Operational
Agni-2	IRBM	Single warhead, 1,000 kg	2,000-3,500 km	Operational
Agni-3	IRBM	Single warhead, 2,000 kg	3,500-5,000 km	Development
Agni-4	IRBM	Single warhead, 800 kg	3,500 km	Development
Agni-5	ICBM		5,000-8,000 km	Development
Agni (technical demonstrator)	MRBM	Single warhead, 1,000 kg	700-1,200 km	Terminated
Dhanush	SRBM	Single warhead, 500-1000 kg	250-350 km	Operational
Prahaar	SRBM	200 kg	150 km	Development
Prithvi 3	SRBM	Single warhead, 500-1,000 kg	300-350 km	Development

[21] "India successfully test-fires Agni-I ballistic missile" www.thehindubusinessline.com/news/india-successfully-testfires-agnii-ballisticmissile/article4190956.ece?homepage=true, (Accessed December 10, 2012)

[22] BALLISTIC MISSILES (http://missilethreat.com/missiles-of-the-world/), (Accessed December 10, 2012)

Designation	Class	Payload	Range	Status
Prithvi SS-150/ -250/-350	SRBM	Single warhead, 1,000 kg	150 km	Operational
Sagarika (K-15)	SLBM	Single warhead,	700 km	Developed
Shaurya	SRBM	Single warhead, 500-800 kg	700 km	Development
Surya-1/-2	ICBM	2,500 kg	8,000-12,000 km	

Table 2: ***Source:*** Missile Threat Indian Missiles[23]

Ballistic missile systems offer major advantages as a delivery platform but also suffer from few limitations. The basic characteristics of a system to deliver a nuclear weapon effectively include range, payload, accuracy, defence penetration and reliability. Missiles have advantage of better range variation from Short Range Ballistic Missile (SRBM) about 1000 km or less to InterContinental Ballistic Missiles (ICBM) more than 5000 km. In terms of accuracy, with advance navigation and modem computer-controlled guidance packages, that include missile's response-times and steering forces, missiles can hit target very precisely. The high speed and steep angle at which ballistic missiles strike a target make them considerably harder to defend hence there defence penetration is extremely superior.

At times, the payload capacity of nuclear capable ballistic missile is viewed as a limitation because any increase in the weight of nuclear warhead results into making compromise in the range of the missile. Besides this in ballistic missile reentry vehicles and its artillery shells, the designer needs to include ballasting material, which is an essentially useless weight, in order to balance the inertial forces and moments of the nuclear payload acting on it.[24] Hence, warhead has to be compromised further.

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[23] *Ibid.*

[24] Technologies underlying weapons of mass destruction, Author: United States. Congress Office of Technology Assessment.

Ballistic missile reliability to deliver and hold nuclear warhead is low as compare to combat aircraft delivery platform. Additionally, most recent ballistic missile consists of solid propellant based propulsion system which cannot be controlled once missile is fired. Often, the quality of the control system beyond a certain performance cannot considerably change the accuracy of a nuclear warhead, because a large fraction of the error arises after the powered phase of the flight as the vehicle reenters the atmosphere.[25]

Following table offers a snap view of India, Pakistan and China's ballistic missile inventory:

India	Pakistan	China
Prithvi (SS-250)	Ghaznavi (Hatf-3)	DF-3A (CSS-2)
Prithvi-2	Shaheen I(Hatf-4)	DF-4 (CSS-3)
Agni	Shaheen 1A	DF-5/5A (CSS-4)
Agni-I	Shaheen II (Hatf-6)	DF-11/11A
Agni-II	Ghauri I (Hatf-5)	(CSS-7)
Agni III	Hatf-9 (Nasr)	DF-15/15A/15B
Agni-IV	Hatf-II/Vengeance-II Abdali	(CSS-6)
ICBM		DF-21 (CSS-5) Mod 2 (21A/21B)
Agni-V		DF-25
SLBM		DF-31 (Mod 1)
Sagarika (K-15)		**ICBM**
Dhanush (Under Test)		DF31 (CSS-9)
		DF-41 (CSS-X-10)

[25] Standford, Assessing Ballistic Missile Proliferation, op. Cit., p. 43

India	Pakistan	China
Cruise Brahmos Supersonic	**Cruise** Babur (Hatf-7) Ra'ad (Haft-8) (Under Development)	**SLBM** JL-1 JL-2 **Cruise** DH-10 KH-55SM

Table3: India, China and Pakistan Ballistic missile inventory ***Source:*** Janes Strategic Weapon Systems, Sino defence and Global security org

Detailed technical parameters of above missiles are given in separately attached table, which is the basis for the analysis in this paper and table has been refereed as main table in the paper.

In order to compare and contrast this missile capability available with these three states some basic analysis in regards to overall missile system capabilities needs to be undertaken. The basic characteristics of a system to deliver a nuclear weapon effectively include a first-rate propulsion system, better range, higher payload, guidance and navigation for enhanced accuracy and reliability and capability to penetrate enemy defence. Some discussion on such salient features of the system is being carried out below. However, it needs to be emphasised that extremely scanty information is available in respect of various parameters such as thrust, specific impulse, exhaust velocity, mass ratio, factor of safety, etc. which decide the propulsion efficiency of a missile. Hence, any technical assessment suffers from such limitations.

Main Table

Missiles	Length (meter)	Diameter (meter)	Launch weight (Kg)	Range (Km)	Propulsion	Nuclear Warhead (kT)	CEP (meter)
China							
▪ DF-3A (CSS-2)	21.2	2.25	64,000	2,800	Liquid	1000-3000	1000
▪ DF-4 (CSS-3)	28.0	2.25	82,000	4,750	Liquid	3000	1,500
▪ DF-5/5A (CSS-4)	36.0	3.35	1,83,000	12,000/13000	Liquid	1000-3000	800/500
▪ DF-11/11A (CSS-7)	7.5	3.35	3,800/4,200	280/350	Solid	20	600/20-30
▪ DF-15/15A/15B (CSS-6)	9.1/10.0(15A/B)	1.0	6,200	600/800/900	Solid	90-150	300/30-45/5
▪ DF-21 (CSS-5)Mod 2 /(21A/21B)	10.07/12.3(21A/B)	1.4	15,200	2,150/2500	Solid	250-500/90-150	700/50/10
▪ DF-25	14	1.4	20,000	3,200-4,000	Solid	1000-3000	10
ICBM							
▪ DF31/31A (CSS-9)	13-16/18.7(18.7)	2.0	42,000/63,000	10,000-14000	Solid	1000	100-300
▪ DF-41 (CSS-X-10)	21.0	2.2	80,000	12,000-14,000	Solid	1000 at full range	100-500
SLBM							
▪ JL-1/JL-1A	10.7/12.3	1.4	14,700/15,200	2,150	Solid	250-500	700/50
▪ JL-2	13.0/13.6	1.8-2.0	38,000-42,000	8000	Solid	1000	150-300
Cruise							
▪ DH-10	7.2	0.75	1,800	1,500+	Solid	20-90	10 (Est.)
▪ KH-55SM	8.9	0.51	~1,700	3,000	Solid	200	6-9
India							
▪ Prithvi (SS-250)	9.0	1.1	4,000-4,600	250-300	Solid	10-20	50
▪ Agni-I	14.8	1.3	12,000	700-1,200	Solid	20-45	25
▪ Agni-II	20.0	1.3	16,000	2000-3,500	Solid	150-200	40
▪ Agni III	16.7	1.85	48,000	3,000-6,000	Solid	200-300	100
▪ Agni IV	20.0	-	17,000	3000-3500	Solid	35-40	Not Known
ICBM							
▪ Agni-V	17.0-19.0	2.0-2.2	54,000	5,000	Solid	Not Known	50+(Est)
SLBM							
▪ Sagarika K-15	8.56	1.0	5,600	700	Solid	Not known	Not known
Cruise							
▪ Brahmos Supersonic	8.4	0.6	3,000	290	Ramjet	Not Known	1-3

Missiles	Length (meter)	Diameter (meter)	Launch weight (Kg)	Range (Km)	Propulsion	Nuclear Warhead (kT)	CEP (meter)
Pakistan							
▪ Ghaznavi (Hatf-3)	8.5	0.8	4,650	290	Solid	12-20	250
▪ Shaheen I(Hatf-4)	12.0	1.0	9,500	750	Solid	35	200
▪ Shaheen 1A	12.0	-	n/k	Not confirmed	Solid	35	n/k
▪ Shaheen II (Hatf-6)	n/k	1.4	23,600	2,500	Solid	15-35	350
▪ Ghauri I (Hatf-5)	15.9	1.35	15,850	1,300-1,800	Liquid	15-35	2,500
▪ Hatf-9 (Nasr)				60 (estimated)			
▪ Hatf-II/Vengeance-II Abdali missile	-	-	-	180	Solid	-	-
Cruise							
▪ Babur (Hatf-7)	6.2	0.52	1,500	750	Turbojet	20-25	20-50

Main Table ***Source:*** generated by the authors using Jane's, Centre for Defence Information, SIPRI Yr, Globalsecurity.org, sinodefence.com and World Air force & Missile Threat Database

Propulsion system

Propellants, are the working matter of rocket engines, they comprise of the fluid that undergoes chemical and thermodynamic changes. Propulsion system is required to achieve vital conditions like range, speed and warhead carrying capability. Majority of the missile structure contributes toward its propulsion system.

There are mainly two types of propulsion systems

A. Liquid Propellant based

B. Solid propellant based

Depending upon its characteristics and requirement, different propellant could be used. Liquid propellant has some distinct advantages such as controlled fuel system just in-case target is deviated or mission has to be aborted, reduced body heat in comparison to solid fuel and have very high Specific Impulse (Isp). Major disadvantages of these fuels are its longer preparation time, additional weight due to extra storage, system complications and extra on-board computing. Mobility of the missile platform also gets compromised.

Most of the Chinese missiles after being upgraded to newer solid versions are better in terms of quality and technology. It's believed that majority of them use Nitrate Ester Plasticised Polyether (NEPE) kind of propellant which integrates the advantages of double-base propellants and composite propellant, in other term collectively known as composite modified double based propellants[26]. India on the other side currently using Hydroxyl-Terminated Poly Butadiene (HTPB) which is a composite based

[26] PLA Ballistic missile, [http://www.ausairpower.net/APA-PLA-Ballistic-Missiles.html#mozTocId590353], (Accessed June 21, 2012)

propellant used in all versions of Agni missiles[27]. Pakistan series of ballistic missiles use similar HTPB propellant.

Chinese invested extensively in solid propellant programme and still are working for new and more advance solid propellants and enhancing the efficiency of existing propellants. It is essential that the solid propellant should have good mechanical properties to ensure that the rocket will perform as intended. The propellant must also retain its elastic properties down to the minimum service temperature and thus a low glass transition temperature is important. In fact, the major cause of failure of solid rocket motors is linked to the mechanical properties of the propellants. Mechanical properties such as elongation, tensile strength and transition temperature must be precise[28].

HTBP is developed in two variants one is Cartridge-Loaded Composite Propellants (CLCP), other is Case-Bonded Composite Propellants (CBCP). With various experiments in different laborites, following results were found on various parameters of mechanical properties in respect of transition temperatures[29].

It is important to note that for obvious reasons no country would make a detailed technological assessment above the performance of their missiles. Hence, to get a basic idea some results are presented below which are based on the experiment conducted earlier which incidentally offers an empirical view on the general properties of various propellants.

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[27] Agni series, [http://www.b14643.de/Spacerockets_1/Diverse/Agni/index.htm], (Accessed June 23, 2012)

[28] "Increasing the tensile strength of HTPB with different isocyanates and chain extenders", Wingborg N., Polymer Testing, 2002, 21, p. 283-287

[29] Effect of Temperature on Mechanical Properties of Solid Rocket Propellants by Himanshu Shekhar, *Defence Science Journal*, 61(6), November 2011, pp. 529-533.

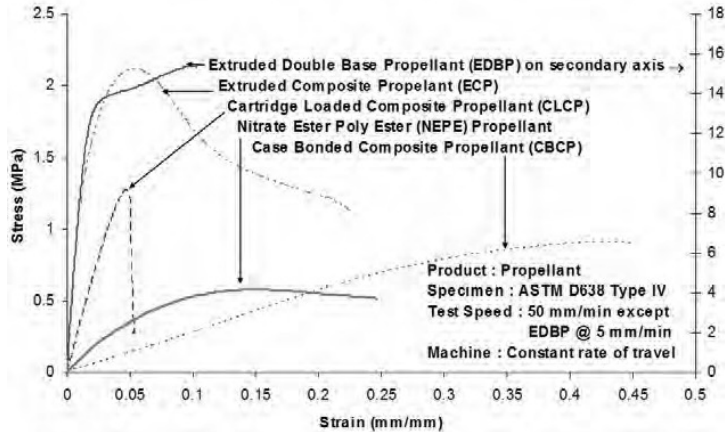

Figure 1: Tensile testing curve of all propellants at 27 °C[30]

Judgment in regards to the tensile strength of the propellant is essential because at higher initial thrust high tensile strength is needed, as more the tensile strength less will be elongation of propellant. Figures represent stress and strain curve representing tensile strength of various propellants at nominal temperature of 27°. As we increase stress, strain also increases and reach point after which elongation occurs i.e. material may not come back to its original composition.

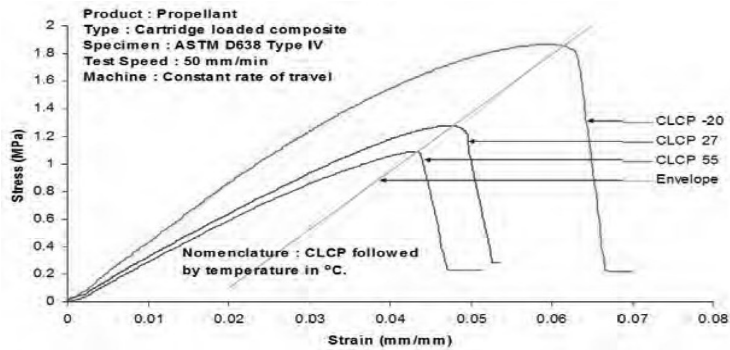

Figure 2: Stress strain curve of CLCP *Source*[31]

[30] *Ibid.*

[31] *Ibid.*

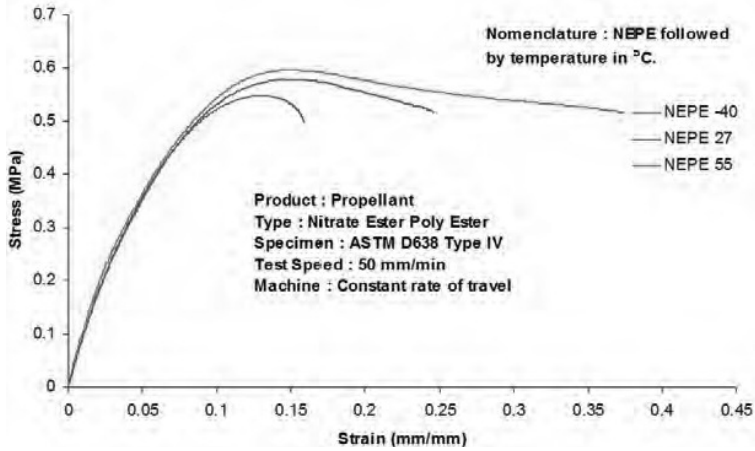

Figure 3: Tensile testing curves of NEPE propellant, *Source*[32]

In case of HTPB, it is observed that at elevated temperatures, composite propellant becomes soft; lowering of tensile strength and percentage elongation. Percentage elongation is the highest for medium temperature (27 °C). Same goes with CBCP where it is clear that as temperature reduces, tensile strength and modulus of the propellant increases, while percentage elongation reduces. This is the normal tendency exhibited by any polymeric material and CBCP in true sense represents polymeric nature of the propellants. High temperature induces softening of polymers resulting in more elongation and lowering of tensile strength[33].

For NEPE, it is observed that there is no change in nature of the curves at lower strains, making mechanical properties of propellant virtually independent of temperature. Cross-linking makes propellants almost invariant to temperature. Rise in temperature generally help strain induced crystallisation. At elevated temperature, more strain will induce crystallisation which reduces elongation and at low temperature, such crystallisations do not hold well and elongation is on the higher side. However, the initial

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[32] *Ibid.*

[33] "Increasing the tensile strength of HTPB with different isocyanates and chain extenders", Wingborg N., Polymer Testing, 2002, 21, p. 283-287

modulus is independent of temperature which is a significant feature of this class of propellant[34].

So fundamentally it is observed that NEPE propellants perform better at higher temperature and for longer period of time, also these propellant perform better in terms of mechanical properties than HTPB at transition temperature, as they become independent of temperature which is important factor for long range missiles especially ICBM. NEPE has various consistencies in its chemical composition, hence it offers wide window of opportunity to enhance efficiency of propellant.

In respect of specific impulse (it is the change in momentum per unit mass for rocket fuels, i.e. more the Isp better is initial thrust hence need of lesser fuel), due to composite modified double based fuel NEPE have better Isp than composite propellant HTPB. Better Isp also gives better initial thrust during stage separation hence longer range in lesser fuel[35].

Guidance, Navigation and Control

The three important flight functions performed that of guidance, control, and navigation requires separate technical considerations to undertake subsystem level assessment. *Guidance* refers to the process of determining a course to a target and maintaining that course by measuring position and altitude as the missile flies (while, at the same time, steering the missile along the course). *Control*, generally encompasses the hardware and software used during the missile's burn phase to change the missile's attitude and *course* in response to guidance inputs and to maintain the missile in a stable attitude[36]. Control also makes sure that warhead especially RV is

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[34] "Increasing the tensile strength of HTPB with different isocyanates and chain extenders", Wingborg N., Polymer Testing, 2002, 21, p. 283-287

[35] Encyclopedia Astronautica on engine, [http://www.astronautix.com/engines/index.htm], (Accessed July 03, 2012)

[36] Theater of Ballistic Missiles, (http://www.fas.org/nuke/intro/missile/tbm.htm), (Accessed July 03, 2012)

targeted precisely and accurately in terms of lower nuclear warhead yield aim harder targets.

Satellite Navigation normally offers geographical coordinators (latitude/longitude) and information on distances to objects and altitude/depth measurements. It assists in locating a target and launch point and the path that connects them in a three dimensional space. An effective design requires that all the three functions operate in concert before and during flight for the missile to reach its target. Some of the hardware and software in each feature overlaps functions[37].

The higher accuracy involve a much higher ratio between the lethality and the yield of a nuclear warhead, when they are employed against a small ("point") target, therefore a precise navigation and control deployment is important.

Following is the table on guidance, navigation and control of different missiles:

Missiles	**Guidance And Navigation**	**Control**
CHINA		
DF-3A (CSS-2)	INS/GPS	Efflux nozzles
DF-4 (CSS-3)	INS/GPS, Strap down	4 clipped delta wings during boost
DF-5/5A (CSS-4)	Gyro stabilised INS/GPS, Strap down	Gimballed engine
DF-11/11A (CSS-7)	INS/GPS, Terminal control, Optical Correlation	4 control fin rear with miniature propulsion system in warhead, 4 graphite vanes in exhaust
DF-15/15A/ 15B (CSS-6)	INS/GPS, Strap down, wind correlation, 15B has Active radar seeker & laser finder	2 sector segment on each of 4 wings, Efflux nozzles, & vernier motor during boost, miniature propulsion system in RV, 15B has control fin at rear

[37] Theater of Ballistic Missiles, (http://www.fas.org/nuke/intro/missile/tbm.htm), (Accessed July 03, 2012)

Missiles	Guidance And Navigation	Control
DF-21 (CSS-5) Mod 2 (21A 21B)	INS/GPS, Terminal control, radar correlation, Active radar seeker	Pop out fin at RV
DF-25	INS/GPS, Terminal guidance, active and passive radar or IIR, Network centric	N/A
ICBM DF31 (CSS-9)	INS/GPS, stellar,	Length motor stages,
DF-41 (CSS-X-10)	INS/GPS, stellar	N/A
SLBM JL-1	INS/GPS, terminal radar correlation	N/A
JL-2	INS/GPS, terminal radar correlation, stellar and radar seeker	N/A
Cruise DH-10	INS/GPS, TERCOM, active radar, GLONASS	Tandem mounted boost motor, wings, tailplane
KH-55SM	INS/GPS, Doppler radar/ terrain map updates; terminal guidance system, and an alternative active radar seeker	Extended fines and tailplane
INDIA		
Prithvi (SS-250)	INS/GPS, Strap down	4 clipped tip delta wing at mid and 4 small aerodynamic fins, gimbaled liquid propelled motor, thrust vector
Agni-I	INS/GPS, radar correlation, optical correlation	Twin microprocessor control system, 4 moving control fins at rear, secondary injection thrust vector, attitude control,
Agni-II	INS/GPS, terminal radar correlation	4 moving delta wings, liquid propelled thrust motor
Agni III	INS/GPS, radar correlation, IIR and active homing	-

Agni IV	Ring Laser Gyro - INS (Inertial Navigation System), optionally augmented by GPS terminal guidance with possible radar scene correlation	-
ICBM Agni-V	INS/GPS, Ring laser gyroscope Terminal guidance with possible radar scene correlation	N/A
SLBM Sagarika K-15	INS/GPS, terrain contour matching	N/A
Cruise Brahmos Supersonic	INS/GPS, dual mode active/passive radar, terminal, IIR seeker,	Controlled fins, wings and tail fins, boost motor,
PAKISTAN		
Ghaznavi (Hatf-3)	INS/GPS, terminal, optical terrain correlation	4 small control fin at rear for RV
Shaheen I/A (Hatf-4)	INS/GPS, terminal	4 SM-03 small solid propellant motors at rear, small fins and trapezium tail plane.
Ghauri I (Hatf-5)	INS/GPS	Jet vane in motor exhaust during boost phase
Shaheen II (Hatf-6)	INS/GPS	4 SM-03 small solid propellant motors at rear
Hatf-9 (Nasr)	INS/GPS	N/A
Hatf-9 (Nasr)	INS/GPS, N/A	N/A
Hatf-II/ Vengeance-II Abdali	INS/GPS	N/A
Cruise Babur (Hatf-7)	INS/GPS, , GLONASS, radar altimeter, terminal, IIR	4 tail fin, tandem mounted solid propellant motor,

Table 4: Missile guidance and control, ***Source:*** Jane's Strategic Weapon Systems ISSUE 55-2011, Sinodefence, GPS- Global Positioning system, INS-Inertial Navigation System, N/A-Not Known

An evaluation based on above information indicates that Chinese missile have modest advantage over Indian missiles but are much advanced than the Pakistani missiles in terms of guidance and control. While India is yet to deploy network centric capability and laser finder for its RV, but at same time have considerably developed decent guidance navigation and control. India has all vital navigation and control system which confers an enhanced CEP which can be clearly articulated from the table with improved guidance, navigation and control system which reduces CEP and gives better accuracy and reliability.

Warhead

Nuclear weapon is feared for its maximum destruction capability (apart from radiation). Hence, nuclear weapons are essentially area weapons and a pinpoint delivery over the target and precise accuracy is never an issue with such type of weapons. However, in the 21st century with advancements in technology is has become possible to deign smaller weapons which engage relatively smaller targets. Such types of tactical nuclear weapons have become the part of modern day nuclear discourse. Also, it is believed that such weapons could restrict the collateral damage (in relative sense). On the other hand states are found making stronger defence in respect of the probable targets which could be attacked by the enemy using nuclear weapons. Targets like missile silos and command and control structures are made sufficiently hard so that no nuclear weapon of lower yield will have the energy to defeat them. Other targets, such as airfields and naval bases, are sufficiently dispersed that a massive amount of explosives would be required for their destruction[38]. All this demands the states to have various options ready in case of designing the 'yield' of the weapon.

[38] Nuclear Weapon in 21st century by Stephen M Younger, [http://www.fas.org/nuke/guide/usa/doctrine/doe/younger.htm]

The "yield" of a nuclear weapon is a measure of the amount of explosive energy it can produce. The yield is given in terms of the quantity of TNT that would generate the same amount of energy when it explodes. Thus, a 1 kiloton nuclear weapon is one which produces the same amount of energy in an explosion as does 1 kiloton (1,000 tons) of TNT.[39]

Damaging Cities and Airfields with Nuclear Warhead on a Delivered Missile										
	Hard Target (50 psi)					Soft Target 10 (psi)				
	5Mt	1Mt	250Kt	50Kt	10Kt	5Mt	1Mt	250Kt	50Kt	10Kt
Damage Area $(km)^2$	21.5	7.3	2.9	1.0	0.3	314.0	107.4	42.6	14.6	5.0
Causalities (1000s)	-	-	-	-	-	5500	1900	533	250	85

Table 5: Damage of soft and hard target in of context to the amount of warhead, ***Source:*** national university paper on nuclear capable ballistic missile

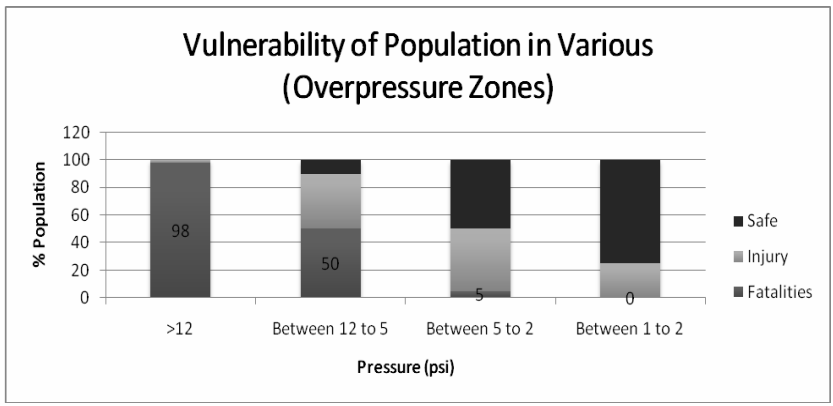

Figure 4: Population Damage (***Source:*** NRDC, The U.S. Nuclear War Plan: A Time for Change, 2001) (original source: OTA, The Effects of Nuclear War, 1979)

[39] National university paper on Nuclear capable ballistic missile, [asiapacific.anu.edu.au], Accessed August 07, 2012)

From above discussion and graphical representation we can come up with broad perspective how warhead can be lethal in terms of destroying area, population, soft and hard targets. China has substantial warhead capability in comparison to India as well as Pakistan. From the main table it is quite notable that the China's warhead yield varies from 1-3MT, which (from above table and figure) is considerable amount to destroy large area and more than 98 percent population. Addition of MIRVs further double folds the lethality by ranging overpressure zones at much higher level. Hence, it not only gives missile capability to penetrate hard target but also gives ability to have multiple targets from a single missile. It could also be inferred that the nature of warhead plays a vital role in devastation of area, population and infrastructure.

In context of India even though theoretical possibility exists of MIRV model of Agni-V but India is yet test such technology. Overall, India not really has much of advantage over China in terms of warhead but is fairly better than Pakistan.

Ability and Capability (Accuracy & Range)

Capability of a missile is broadly related to its range and ability is about how closely it can hit the target. Missile accuracy is usually given in terms of the Circular Error Probable (CEP), defined as imaginary circle taken with the ground target as centre. Using this concept, assessments of the efficiency of various missile systems are carried out. For example, a 1 Mt nuclear' warhead may be needed in order to destroy a particular hardened structure if the CEP of that nuclear weapon is 1 km. The same effect could result from a 125 kt warhead with 0.5 km CEP accuracy, or a 40 kT warhead with 0.33 km CEP. Thus, increased accuracy means that smaller yield warheads could replace high yield warheads[40].

[40] National university paper on Nuclear capable ballistic missile, [asiapacific.anu.edu.au], Accessed August 07, 2012) *Page 23*

The combination of both warhead yield and accuracy enhance reliability and lethality to a great extend. Following is the table representing the percentage damage CEP ability:

Accuracy	CEP (m)	Expected Percent of Airfield Area Damaged									
		Hard Target					**Soft Target**				
		5Mt	1Mt	250Kt	50Kt	10Kt	5Mt	1Mt	250Kt	50Kt	10Kt
Excellent	50	99%	83%	51%	21%	8%	100%	100%	100%	97%	70%
Better	100	99%	83%	50	21%	8%	100%	100%	100%	97%	69%
Good	250	99%	81%	48	20%	7%	100%	100%	100%	96%	67%
Fair	500	98%	75%	43	17%	6%	100%	100%	100%	94%	61%
Poor	1000	92%	57%	29	11%	4%	100%	100%	99%	81%	44%
Very Poor	2000	62%	28%	12	4%	2%	100%	99%	85%	48%	20%

Source of nuclear effects: Samuel Gladstone and Philip J. Dolan, ed, The Effects of Nuclear Weapons, US Department of Defence and Department of Energy, 1997, pp 113-115, assuming a 400 feet scaled height of burst in each case and a 2km target radius.

Table 6: Percentage Area Damage due to CEP ***Source:*** Samual Gladstone and Flip J. Dolan ed. The effect of nuclear weapon, department of defence and department of energy 1997.

The detailed main table indicates that the CEP of Indian missiles are fair to good in comparison with China in same range, but much superior to Pakistan. Despite the high payload and longer range, CEP of Chinese missiles is highly precise. Majority of Indian missiles have CEP close to 50m which make them highly precise vis-à-vis to Pakistan whose CEP range varies between 200-300m. Above table also gives a very close relationship between CEP and warhead yield signifying amount of percentage damage. Chinese missiles are effectiveness in both the area is imperative.

Following is the map showing glimpse of few Chinese missile and their capability to reach Indian Territory from one base called Xinang near Tibet.

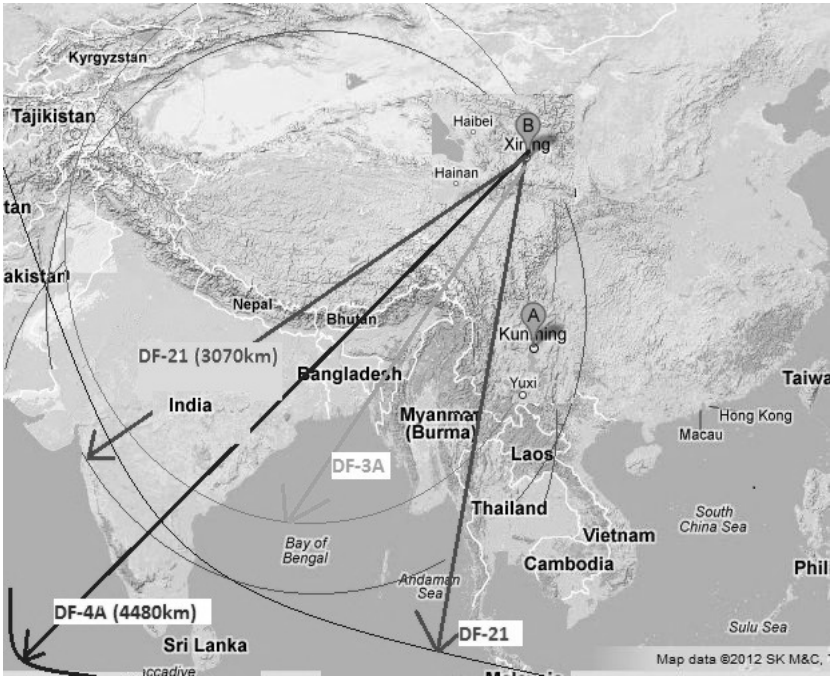

Figure 5: Chinese Ballistic Missile Range ***Source:*** Generated by authors using NAIS study report 2007 on 'China's ballistic missile assessment"

From the detailed main table we can articulate that Indian missiles limits in its range category. We are yet to deploy better range missiles which are able to target major areas of China. While India claim to reach China by Agni-V but its reliability is yet to be given a profound foundation as there is only one or few successful test so far. While Chinese missile's Multiple Independently targetable Reentry Vehicle (MIRV) are well tested and reliable, India is yet to integrate and test this technology.

Following map indicates probable ranges of different versions of Agni missiles:

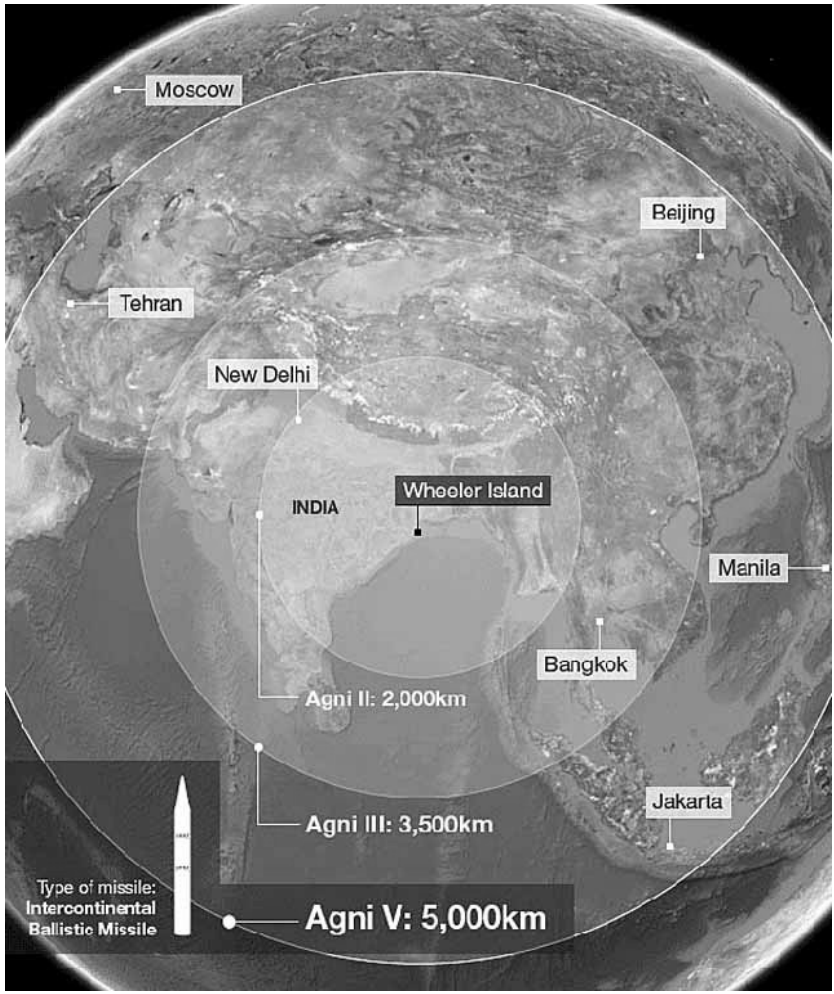

Figure 6: Agni missile range on map, ***Source:*** Defence Research Development Organisation (DRDO) via external website

In terms of Pakistan, India does have concern of their competence to reach all majors cities, but in terms of ability they lack some stand against India

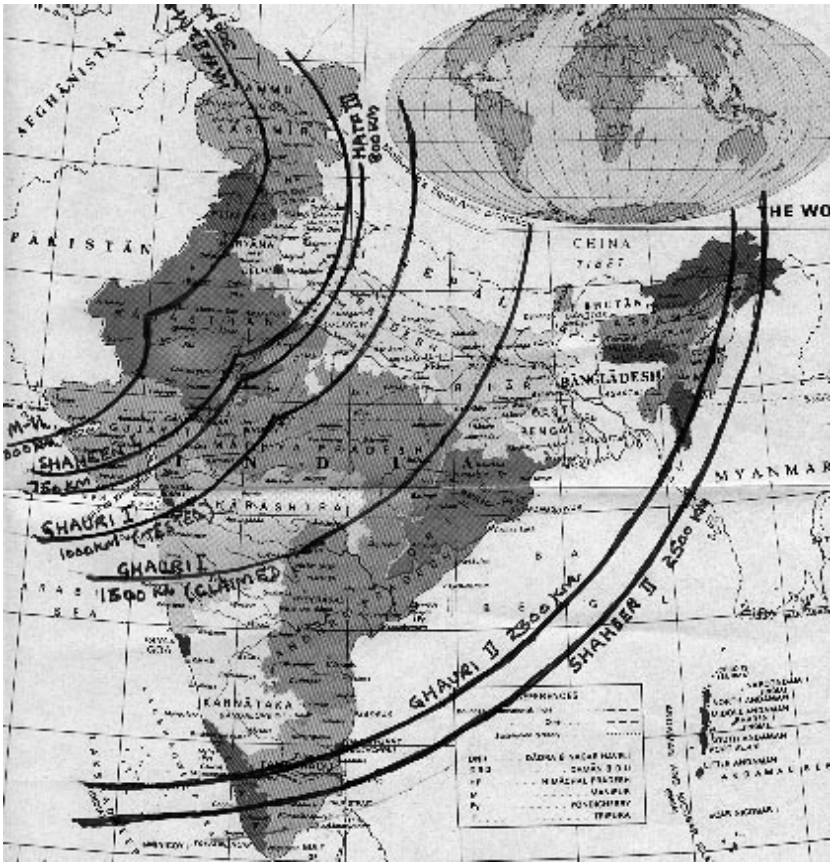

Figure 7: Pakistan missile range in context to India, ***Source:*** South Asian analysis group

Assessment

In current scenario we can conclude that Chinese missiles possess advantage over both the countries. They have better range, are precise and have extremely high payload capability. India over the decades has profoundly enhanced the quality of its missile

technology. It is also significant that most of these technologies are indigenous which give it more confidence. The synergy among these nations has not improved over the period hence possibility of conflict rise is eminent. Pakistan on the other hand trying to cope up with India's pace. With recent successful test of Agni-IV, Pakistan subsequently tested its Hatf-VII in September 2012[41] but so far have unsuccessful test of Hatf-V/ Ghauri in December 2012 tests.

[41] Pakistan successful missile test fired, (http://tribune.com.pk/story/437933/pakistan-test-fires-hatf-vii-babur-cruise-missile/) (Accessed December 12, 2012)

Aircraft

The only nuclear weapon ever used during any war was dropped by using a bomber aircraft by the US Air Force against Japan. The Combat Fixed-Wing Aircraft are the second leg of 'Nuclear Triad' which is used for delivering nuclear weapon. In any theater of war, Aircraft offers immense flexibility to deliver conventional as well as nuclear weapons on the target. Ability of Aerial platforms to be reused for longer period of time and modern day avionics offers a variety of advantages for weapon delivery.

Aviation technology has evolved over the years and same is the case with munitions technologies. Most of the modern bombers can carry variety of nuclear payloads effectively and reliably. Also, aerial platforms are economical platforms.

The chief attributes for any aircraft to successfully deliver nuclear weapon on the target could be

1. Most reliable delivery of the weapon with nil margin for any form of error
2. Ability to penetrate defences and capability to engage alternative targets, if required
3. All-weather, day and night capability

For the purposes of deploying a nuclear weapon it's enviable that the normal fighter bomber be able to cater for technological huddlers in terms of initial power and power-conditioning, method of weapon integration, and operational control and security. Essentially nuclear weapons are required to have specific attributes for aerial delivery on the target. Weapon control systems desired to have inbuilt interlocks to formulate a system which could be made fail-safe. Weapon release system should be designed in such a way that only after the code entry and corresponding to specific parameter the weapon is released on the target. Additionally, modern aircraft

which are capable of delivering nuclear weapon are equipped with fire arm systems which shield the avionics of aircraft from Electromagnetic pulse (EMP) generated by nuclear detonation. For detonation of a nuclear weapon considerable amount of electronic power is required which could be made obtainable with the munitions itself or by the aerial platform...[42]

Aircraft that qualifies to be nuclear capable and are in the inventory of India, Pakistan and China are as follows:

	India	Pakistan	China
Type of Aircrafts	Fighter Bombers Jaguar (Shamsher) Mig-27 (Flogger) Mig-29K Su-30MKI-III Mirage 2000H/TH	F-16 Falcon Mirage-III/V	Strategic Bombers Hong-5(H-5) Hong-6(H-6 or Tu-16 Badger) Fighter Bombers Qian-5 (A-5) Su-30 MKK J-11[Su-27 FLANKER]

Table 7: Inventory of India, Pakistan and China's Aircraft Inventory
***Source*:** Compile by authors from Janes all the World Aircraft, Sinodefence and Golbal Security Org

Any nuclear weapon state would try to induct aircrafts offering following traits:

1. Air craft with the capability to increase its range
2. Accuracy of weapon delivery (modern day PGMs/JDAMs have inbuilt systems for this purpose and are guided by satellites)

[42] MIT Paper "US Nuclear weapon safety and control" [www.web.mit.edu/gelliott/Public/sts.072/paper.pdf], (Accessed August 12, 2012)

3. Methods to mask or otherwise disguise flight signatures to detection networks (additional aircrafts would be part of nuclear attack mission employed in various roles like EW, ECM, ECCM etc)

4. Stealth capability and ability to undertake day and night tasks in all-weather condition situations.

Techniques Adopted for Increasing the Range

Targets for nuclear attacks are most likely to be area targets and only in rare cases point targets. The impact of nuclear weapons is expected to cover a wider geographical area. Hence, it could also be argued that 100 per cent accuracy for delivering such weapon may be desirable but not necessarily be a vital requirement. Nuclear weapons are expected to engage strategic targets which could be located deep inside the enemy country. In situations where geographical extent of enemy territory is vast and targets are located deep inside greater penetration would be essential for effective weapon delivery. Most of the aircraft specially the fighters and medium range bombers have limited fuel capacity and that restricts their range. To overcome such difficulty few range enhancement techniques as explained below could be used.[43]

- **Aerial Refueling System**: Commonly known as 'Mid-air Refueling'. This involves In-Flight Refueling system (IFR) or Air-to-air (AAA) refueling system. It is the process of transferring fuel from one aircraft (the tanker) to another (the receiver) during flight. The aerial refueling system enable added advantages such as the receiving aircraft to remain airborne longer, thereby, extending its range or loiter time on station and it can fly with higher payload.

[43] Federation of American Scientist "Means of Delivery Technology" [www.fas.org/irp/threat/mctl982/p2sec01.pdf], Accessed August 20, 2012)

- **Refueling Tankers:** Aircraft capable of mid-air refueling and refueled tankers are complimentary to each other. In some cases a state can even increase the range of its bombers without having a tanker aircraft. In some cases such as Chinese H-6 and Q-5 aircrafts can be modified to Arial refueling tankers while other use heavy lift transporters such as IL-78[44]. India and its nuclear neighbours own Russian Ilyushin Il-78M Midas Aerial Refueling Tankers. In addition, China has additional H-6U/DU Badger Aerial Refueling Tanker.

  Some reports indicate that China had twenty H-6U (also known as Xian HY-6U) version aircrafts but their present number and other details on the number of H-6 Badgers changed to tankers and technical details on the configurations remain vague. There are variants of H-6 acting as refueler such as H-6U, H-6D and HY-6, though their other details and nomenclature are unclear. According to Global Security website 10 HY-6 refueling planes are in service with the PLAAF. As of 2010 the People's Liberation Army Air Force (PLAAF) had a regiment of about 10 new-build HY-6 tankers[45]. Chinese H-6 can refuel two J-10's or two Su-30MKK's at a time while Il-78M Midas can refuel maximum of three aircrafts at a time.

- **Jettisonable/Drop Tanks**: A drop tank (external tank, wing tank, or belly tank) is an auxiliary fuel tank externally carried by aircraft. A drop tank is expendable and always jettisonable. This usually integrated on pylons (suspension device externally installed under the wing or fuselage) which can carry drop tanks in order to increase range and have option of dropping them

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[44] IL-78 Midas Air-to-Air Refuelling [www.airforce echnology.com/projects/ilyushin-il-78/], (Accessed August 22, 2012)

[45] IISS Military report 2006 [www.iiss.org/military-balance/the-military-balance-archive/the military-balance-2006], (Accessed August 25, 2012)

in case of emergency or air-to-air combat. Depending on aircraft they can carry one oversize integrated on fuselage or two small size tanks integrated on pylon.

- **Propulsion System:** A propulsion system is that which produces forward force to push an object**.** It also help in sustaining overall system in aircraft such as avionics, weapon system, oxygen generation, system integration and every possible system on aircraft. Aircraft propulsion system is broadly categorised of two types- Turbofan and Turbojet. Turbofans as an entire configuration offer enhanced efficiency than turbojets at high subsonic and transonic speeds. Generally, Aerial bombing/ Air drop bomb or also commonly known as drop bombing, is used to deliver nuclear weapon but there are other ways such as toss bombing by which bomb can be delivered[46]. In order to do such sudden maneuver there is external gravity force (Known as G force) acting on the aircraft; hence to overcome this force medium to high specific thrust is required. Hence, turbofan can create high specific thrust much effectively. That's why most of the modern aircraft use turbofan, only few aircraft such as Chinese Qiang-5, Hong-6 and India's Mig-27 (Bhadur) still use turbojet engines.

Increasing the Targeting Reliability

As with aircraft human factor is also involved, reliability of system is anticipated to be high. In any unfortunate event on enrooting target flight crew must be able to take decision accordingly. Most pilots usually rely on their visual to confirm target. Guidance and navigation subsystems are vital support in navigation to the target. Less efficient system can create considerable errors in targeting

[46] Ibid

due to irregular winds, inaccurate fusing information, or inefficient aerodynamic design.

It is important to note that the 'special' status of the nuclear weapons does not demand any major additions or modifications in the avionics onboard on an aircraft or any structural changes in the design of the aircraft. Modern day munitions have their own guidance systems and other essential mechanisms. However, it is advisable to have aerial platforms to have following capabilities (which all modern aircraft usually do have). Fundamental factors aircraft can have is to increase targeting reliability in order to deliver nuclear weapon which includes:

- Guidance and Navigation subsystems
- Weapon integration
- Their ability to follow contour in terrain
- All weather and with day and night capability
- Addition of Stealth
- Response time

Though, aircraft can be navigated visually if metrological conditions are viable but technologically enhanced system allows an aircraft to operate day and night and all weather condition can significantly upraise efficacy of the system. In addition, technology also allows an airplane to fly outside of its normal operating environment such as near the contour of ground or very low altitude to defy radar or any other air defence system.[47]

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[47] Means of Delivery Technology/II-1-48 [www.fas.org/irp/threat/mctl982/p2sec01.pdf], (Accessed August 12, 2012)

Following table gives a glimpse of guidance, control and navigation system commonly used onboard of aircraft and their military applications during missions:

GUIDANCE, CONTROL, AND NAVIGATION			
Technology	Technical Issues	Military Applications	Alertnative Technologies
Digital radar maps	Reducing radar images to digital representations that can be stored and retrieved efficiently	Delivery of a munitions within a lethal radius	GPS topographical maps
Global Navigation System	Time required to calculate position and corrections to position to obtain desired flight path	Delivery of a munitions within a lethal radius	IMUs; radio controlled or preprogrammed flight profiles
Map Guidance Technology	Resolution of the surface of the Earth particularly in height in order to ensure all obstacles are cleared by the flight vehicle	Increased operations envelop to include night and all weather flight	More restrictive operational conditions
GPS receivers	Correcting civil code to protected code	Navigation	GLONASS receivers
Full authority flight control system	Maintenance of adequate gain andphase margins; adequate response time over flight envelop; redundancy vs. safety	Increased reliability and accuracy	Pilot integration of parameters

Table 8: Guidance, control and Navigation ***Source:*** FAS Mean of Delivery Technology

Most modern fighters and bombers at present have highly sophisticated avionics systems with all advance multifunctional radar systems, communication systems with added Electronic Warfare (EW) or Electronic Counter Measure (ECM) systems. While India and China both have versions of Sukhoi-30 as their most advance 4th generation fighter fleet, China also have J-11 Chinese version of Su-27. India is in process of upgrading its fleet of Mirage -2000H/TH, Mig-29K and Jaguar to new generation avionics suite, Pakistan has F-16 version as their modern fighter fleet. To manifold its fleet capability, India in collaboration with Russia is on the verge of coming up with 5th generation stealth fighter to be called as T-50 PAK-FA. From all open sources from India and Russia, it has been indicated that India to shares 25 percent contribution in development of design. Being a 5th generation fighter, it is anticipated that aircraft will be able to deliver tactical nuclear weapon[48]. Russia intends to operate at least 200 PAK-FAs, India 250 of the Indian 5th Generation Fighter Aircraft (FGFA) variant.

China has Su30MKK version while India has Su-30MKI version of Russian Sukhois which comes with basic N001VE Multi Functional Radar (MFR) system. India in recent years is on the verge of upgrading its entire fleet of Sukhois under three phases that is Su-30MKI-I, Su-30MKI-II and Su-30MKI-III which will suit up these fighters with new generation avionics and advance radar system. As a result, new avionics will enhance existing radar, navigation, landing aids, data link, and Electronic Counter Measures (ECM) functions. Addition of ECM and jammers technology is intended to enable aircraft to fly undetected by existing radar systems in carrying out their mission. This will also enhance detecting Surface to Air Missiles (SAM) and enemy aircraft much earlier which will give pilot enough time to respond.

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[48] Accessing Sukhoi PAK-FA, (http://www.ausairpower.net/APA-2010-01.html#7), (Accessed August 12, 2012)

In order to deliver nuclear weapon precisely, accurately and more effectively, aircraft need to have a good maneuvering ability, able to follow close contour terrain to avoid defence batteries and should have quick response time. Su-30MKI had been added with single-axis thrust vectoring nozzle inclined 32° outward, 3-D thrust vectoring control nozzle and advance hydraulic system which is not present in Chinese version of Su-30MKK.

In general, Chinese versions are comparatively inferior to India's advance fleet of Sukhoi. China is proposing to upgrade its fleet while India is planning to upgrade the existing Su-30s to Super Sukhoi (5th generation category). It would have a reduced radar cross section of the airframe which will enhance its stealth capability reducing radar cross section. Several structural changes to the airframe would help reduce its radar signature, while airframe will also get special radar absorbing paint coat to further reduce its Radar Cross Section (RCS).[49]

Chinese also have J-11, the Chinese version of Russian Su-27 Flanker, which is one of the recent versions of aircraft in its fleet. The Su-27 is equipped with a Phazotron N001 Zhuk coherent Pulse-Doppler (PD) radar with track-while-scan and look-down / shoot-down capability. The fighter also has an OLS-27 Infrared Search and Track (IRST) system in the nose just forward of the cockpit with a 80–100 km range. This system also incorporates a laser rangefinder[50]. The system can be slaved to the radar, or used independently for "stealthy" attacks with infrared missiles but the airframe design lacks stealth features, so the RCS is large. Although, the avionics system provide all weather operating capability and day and night ability but system requires further up gradation [51]

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[49] Sukhoi Flankers – *"The Shifting Balance of Regional Air Power"*[www.ausairpower.net/APA-Flanker.html], (Accessed September 02, 2012)

[50] J-11/Su-27 [www.globalsecurity.org/wmd/world/china/j-11.htm], (Accessed September 04, 2012)

[51] *"China copies Su-27 fighter may compete with Russia"* - paper. RIA Novosti.

Apart from Su30s, the other Indian aircrafts which could deliver nuclear weapons include Mirage-2000H/TH (Vajra), Mig29K and Mig-27 (Bhadur). While Mig-27 is a vintage aircraft, others are under up gradation plans to next generation increasing its effectiveness and reliability. In December 2006, according to a report Indian Air Force (IAF) was "close to finalising" a EUR 1.5 billion (about $2 billion) to upgrade its mirage-2000 fleet. Word is that the upgrade will bring India's Mirages to the full Mirage 2000v5 Mk 2 standard, including a new RDY-3 radar with greater air-air and air-ground capability, a new night vision compatible all-digital cockpit, and improved EW systems.[52] Mig 29K is also being upgraded, MiG-29K/KUB are fitted with the advanced multifunctional multimode PD onboard radar "Zhuk-ME", the modern multi-channel optic-location station and target-designation system for the passive anti-radar. The fighters' avionics suite opens architecture allowing integration of the new Russian and foreign-made equipment and armament onboard the aircraft.[53] All these up gradations will assist aircraft to intrude deep inside the enemy territory to deliver the weapon precisely and effectively.

Indian Jaguar can deliver nuclear weapons in form of freefall and laser guided bombs and they can be carried on the pylons of wing or one fuselage attachment stations. To mark targets for laser-guided weapons, the aircraft carries the Thermal Imaging and Laser Designation (TIALD) pod[54]. Perhaps the Jaguar's most imposing feature is its navigation and attack system. All the vital information fed to the system is displayed on pilot's head up display, which makes it much convenient for pilot to make instantaneous decision. From the display, the pilot can identify exactly where the target is

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[52] *India's fighter upgrade of Mirage-2000* [www.defenseindustrydaily.com], (Accessed September 04, 2012)

[53] *Mirage 2000H Vajra*, Global Security Org. [http://www.globalsecurity.org], (Accessed September 05, 2012)

[54] Jaguar Specat, (http://tjgladman.tripod.com/Jaguar.html) , (Accessed September, 2012)

located and exactly when to release his weapons for maximum effect.

The fleet is currently undergoing an upgradation programme, and this will see aircraft fitted with new cockpit displays, helmet-mounted sights, the ability to carry the new Advanced Short Range Air-to-Air Missile (ASRAAM) and other system improvements to further extend the life of the aircraft well into the next century.[55] Mig-27 Flogger is under up gradation; earlier version has dielectric head above the pylon on the MiG-23 was used on the MiG-27 to house electro-optical and radio-frequency. The new avionics and radar up gradation is yet to be revealed but it is estimated that this up gradation will increase 10 years of service life.[56]

Pakistan has a fleet of F-16 Falcon. In an air combat role, the F-16's maneuverability and combat radius (distance it can fly to enter air combat, stay, fight and return) exceed. The first F-16 was delivered to Pakistan in October 1982, and eight aircraft were delivered in the same phase. Since then, almost 141 aircraft has been delivered so far under different phases with modification in each phase[57].

These aircrafts are capable of locating targets in all weather conditions and detecting low flying aircraft in radar ground clutter. In an air-to-surface role, the F-16 can cover a distance of 500 miles (860 kilometers), to deliver its weapons with greater accuracy, secure itself against enemy aircraft, and revert to its starting point.[58] An all-weather capability allows to precisely deliver weapons during

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55 *India Jaugra*, Global Security org [www.globalsecurity.org], (Accessed September 09, 2012)

56 India Upgrading Mig-27 boost capability [www.defence.pk/], (Accessed September 10, 2012)

57 Pakistan Airforce, (http://www.f-16.net/f-16_users_article14.html), (Accessed September 07, 2012)

58 Turkish Air Force *"Our History"* www.hvkk.tsk.tr, Retrieved: 3 February 2012.,Accessed September 05, 2012)

non-visual bombing environment. Avionics systems include a highly accurate inertial navigation system in which a computer provides steering information to the pilot. The plane has Ultra-High Frequency (UHF) and Very-High-Frequency (VHF) radios plus an instrument landing system. It also has a warning system and modular countermeasure pods to be used against airborne or surface electronic threats[59]. The fuselage has space for additional avionics systems. For easy and accurate control of the aircraft during high G-force combat manoeuvres, a side stick controller is used instead of the conventional centre-mounted stick. Hand pressure on the side stick controller sends electrical signals to actuators of flight control surfaces such as ailerons and rudder.[60] This reduces the stick force applied by pilot and increases maneuverability and reduces pilot fatigue.

Methods to Increase Penetration

In order to deliver nuclear weapon deep inside the enemy territory, aircraft need to overcome defence batteries. Some fundamental techniques used are:

- ECM
- Many aircrafts launching a simultaneous attack (saturate raid)
- Glide bomb
- Formation flying

In WW-II to invade and penetrate the defence batteries too many aircraft were used, which makes it extremely difficult for enemies to intercept them. This is a high cost and human intensive option.

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[59] F-16 Fighting Falcon, (http://tech.military.com/equipment/view/89689/f-16-fighting-falcon.html) Accessed September 07, 2012)

[60] *F-16,Pakistan*,Golbal Security org. [http://www.globalsecurity.org], (Accessed September 07, 2012)

However, the major advantage is that the enemy gets confused to indentify between the actual Weapons of Mass Destruction (WMD) aircraft and the other dummy aircrafts. In order to deliver nuclear bomb, aircraft need to evade enemy radar as far as possible to avoid getting intercepted. Formation' flying is assumed to increase penetration and usually consist of the main strike bomber aircraft equipped with nuclear weapon and assisted by two or more fighter capable of proving EW support and if necessary could engage the enemy in air combat. It also could be given an AWACAS cover to provide radar countermeasure from ground based defence batteries. It is important to note that actual area of operation of AWACAS would decide whether this platform would have its own escort aircraft or not. China has eight Il-76/KJ2000 (AEW), India has three Il-76 (AWACS) while Pakistan has four Saab 2000 (AEW) for such purposes and could be put in use in case of a nuclear conflict.[61]

ECM is the most common technique used by modern aircraft. Incase aircraft is detected or within range of defence radars, it can use ECM in numerous ways to manipulate defence assets. These sophisticated countermeasures thus modify the signal returned to the defence radar to craft the aircraft which might appear big or in manipulated area. ECM is an integrated circuit consisting of various electronic equipments such as jammers.[62].

Most of the fighters and bombers carry ECM integrated with radar in pod and centerline on pylons while other can carry within the fuselage or on various parts of airframe. Some of the ECM part are also carried in missile form such as anti-radiation missiles, active and passive radar etc.

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[61] World air force 2010-2011 [www.flightglobal.com/airspace/media/reports_pdf], (Accessed September 10, 2012)

[62] Mean of delivery technology.pdf/ II-1-47, Accessed August 12, 2012)

Assessment

Aircraft is an important platform for nuclear triad. Indian aircraft fleet have gone and currently undergoing up gradation with its platforms and avionics. For example Indian fleet of Sukhoi-30 MKI has undergone almost three phases of up gradation and currently working on next level. In comparison, it appears that China is a bit slow in regards to upgrading their aerial platforms. No significant up-gradation in respect of Chinese Sukhoi-30 MKKK is found undertaken. Same is the case with fighter bombers and other aircrafts. China needs an extensive upgradation programme to remedy this deficiency. Chinese aircraft such as Q-5A and H-6 BADGER are vulnerable to modern air defence weapons systems and would be hard-pressed to survive in the modern air defence environment[63]. But it is also noteworthy that Chinese are striving for indigenisation of its entire aircraft fleet which will certainly enhance their flexibility for any technological integration in future. Pakistan has comparatively better machines in its fleet like the F-16 and Mirage-III/5.

Human skills would play an important role to make its aircraft deliverable weapons part of nuclear triad successful. Effective use of aircraft for any country in a combat role requires ongoing training, maintenance, and functioning of a substantial infrastructure. Indian pilots are better trained and have long flying experience. They participate in number of exercises worldwide and have gained significant amount of experience and have also demonstrated their skills. Not much information is available in regards to the skills of the aviators from China and Pakistan but is expected to have reasonable basic skills. There were some reports indicating that in many exercises China's pilots were found struggling for mid air-refueling especially overwater refueling. May be the pilots from these two states require more exposure.

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[63] *PLA Nuclear weapon delivery and strategy*, FAS report, [http://www.fas.org/irp/dia/product/prc_72/app_a.htm], (Accessed September 12, 2012)

Submarine

Submarines carrying nuclear-armed ballistic missiles present a credible deterrent. Because of its stealth character, most of the world's military forces have a great difficulty in locating or destroying a quiet submarine. Ballistic missile submarines equipped with nuclear warheads, which are also called Submarine Launch Ballistic Missiles (SLBM), serve as the third and most important leg of the nuclear triad. The invisibility, mobility and flexibility of submarines offer both a reliable means of survival against an attack, and a first-strike capability - particularly given the type of the weapons they carry. The era of SSBN started during Cold War, when survival against nuclear attack for second strike was found crucial. Today, with most of the states following NFU status the need for the second strike capability is obvious hence SSBN form an important part of modern day nuclear dynamics.

Indian peninsula has a long coastline. In addition its neighbour especially China and Pakistan are also states with maritime boundaries[64], hence SSBNs are crucial to all these three states. This is one area where China has clear advantage in regards to India. Pakistan is yet to make any fore in this arena

however, there are few news reports giving some indications about their intentions. In one of the article it was stated that Pakistan is planning to acquire about six SSN/SSBNs from China though, there is no clarity in regards to the class of submarines[65].

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[64] "Strengthening India's Naval capability" from institute of peace and conflict studies [www.ipcs.org], (Accessed September 13, 2012)

[65] Pak plans to acquire 6 submarines from China, March 9, 2011. Chinese *The Express Tribune* and latter stated by *The Hindu*

China's overall plans regarding its submarines have some ambiguities as all information is not in a public domain. It has single Xia-class SSBN and is building at least three Jin-class SSBNs—possibly more.

Details of Chinese and Indian investments in this regard are as followings:

China						
Class	**Displacement in tones (Submerged)**	**Dimension (m)**	**Sonar**	**Weapon**	**Power O/P**	**Personnel**
Xia (Type 092)	6,500	L:120 Beam:10 Draft:8	Trout cheek bow-mounted; active/passive search and attack; medium frequency	Torpedo tubes: 6X533 mm bow tubes. Missile SLBMs: 12XJl-1 (CSS-N-3)	Nuclear plant: 1 PWR Power O/P: 90 MW	140
JIN (Type 094)	8,000	L:137 Beam:11 Draft:7.5	Hull mounted passive/active medium frequency ; H/ SQC-207 flank-array and towed arrays	Torpedo tubes: 6X533 mm bow tubes.Missile SLBM : 12XJl-2 (CSS-NX-5)	Nuclear plant: 2 PWR Power O/P: 150 MW	140
India						
Arihant (Formerly ATV)	6,000 (Est.)	L:95/105 (Est.) Beam: 11 Draft:7/9 (Est.)	Ushus and Panchendriya combined sonar suites	Torpedo tubes: 6X533mm (Est.)Missile SLBM: 12XSagarika K-15 to be replaced by K-X (Est.)	Nuclear plant: 1 PWR Power O/P: 80 MW (Est.)	100 (Est.)

Table 9: Est. (Estimated,) O/P (Output) & PWR (pressure water reactor)
Source: Jane's underwater warfare systems 2011 12, Sino Defence and Global Security Org.

India is yet to deploy its first ever SSBN Arihant class (Advance Technology Vessel (ATV)) which is currently on sea trail and estimated to be operational by 2013[66]. India is also projecting Arihant as technology demonstrator but it is believed that navy is ready to deploy Arihant completing India's third leg of triad.[67]

China's Jin-class SSBN programme is progressing slowly. Six years after it was launched in 2004, one unit is inducted fully operational along single Xia class SSBN, while five submarines are yet to get fully operational. None of its submarines have ever sailed on a deterrent patrol, and their successful missiles trials are suspicious.[68]

Evasiveness is the important character of any Submarine and it needs to evade from detection, therefore low noise level is important. Some US based reports[69] indicate that China's new Jin-class ballistic missile submarine is noisier than even the Russian Delta III-class submarines built more than 30 years ago. But its comparative analysis with Arihant could only be possible after it will be operational.[70]

There are reports indicating that Chinese naval exercises have increased in sophistication in recent years and currently encompass such categories as command and control, navigation, ECM, and weapon testing. But it is unconfirmed that which class of submarine took part in exercise and number of patrolling done by SSBN class.[71]

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66 "Why INS Arihant, submarine in final stages of testing, is so important", [ndtv.com], (Accessed September 15, 2012)

67 Chinese nuclear forces by 2010 [http://bos.sagepub.com/content/66/6/134.full], (Accessed September 17, 2012)

68 Defense Department (2010) Military and Security Developments Involving the People's Republic of China 2010 Office of the Secretary of Defence, August 16

69 FAS Secrecy News Blog cited , pla-na, vy.pdf, [www.navy.mil], (Accessed September 18, 2012).

70 China's noisy nuclear submarine [http://www.fas.org/blog/ssp/2009/11/subnoise.php], (Accessed September 19, 2012)

71 Chinese submarine petrol [http://www.fas.org/blog/ssp/2009/02/patrols.php], (Accessed September 19, 2012)

Submarine's vital component to be effective is its communication channel with surface based network centric warfare system and its nuclear command and control from highest nuclear command authority. As per the case reported in 2009 US reports and various Jane's intelligence reports in 2010 underscore the command and control challenges[72] faced by Chinese leadership for the highest nuclear command authority. The report also states that "the PLA has only a limited capacity to communicate with submarines at sea, and the PLA Navy has no experience in managing a SSBN fleet that performs strategic patrols with live nuclear warheads mated to missiles."[73] Recently, it has been reported that Chinese scientists are working on technologies for secure communication with submarine but command and control issue is of vital concern especially in case of conflict scenarios[74]. While in case of India there is no clarity, at least in open domain, on the ultimate command and control authority. It appears both the Indian Navy and the Chinese Navy suffer from same limitations.

Marrying missile with any delivery platform is of immense importance. Hence, designing of missile system is equally important for any weapon system. China continues to produce a new class of nuclear-powered ballistic missile JL-2 for its JIN-class (Type 094) SSBNs with JL-1 for its previous Xia class (Type 092) SSBN. But the success of both missiles is questionable. Pentagon's delayed annual report 2009 on China's military power, now renamed *Military and Security Developments Involving the People's Republic of China*, reported that JL-2 missile have technical difficulties in the final stages and continues to fail. The system did not reach an Initial

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72 Annual report to congress , Military and Security Developments Involving the People's Republic of China, 2009 www.defense.gov/pubs/pdfs/2009_cmpr_final.pdf], (Accessed September 19, 2012)

73 "Chinese Bulava?" Fedration for American Scientist [http://www.fas.org/blog/ssp/2010/08/china2010.php], (Accessed September 22, 2012)

74 FAS Secrecy News Blog cited, pla-navy.pdf, [navy.mil], (Accessed September 23, 2012).

Operational Capability (IOC) by 2010 as Department of Defence (DoD) had anticipated. Once China overcomes the remaining technical hurdles, the PLA Navy will be charged for protecting its sea shore with nuclear arsenal.[75]

India's Sagarika (Oceanic) began development in 1994 as a Submarine-Launched Cruise Missile (SLCM) and was projected for deployment around 2005. The programme though had met with considerable delays but has successfully completed all tests early this year, and is ready for deployment[76]. It will arm India's nuclear submarine, INS Arihant to complete India's strategic nuclear Triad. Similarly, the Dhanush (P-3) is reported to have been made three flight tests since March 2007 and further launch was reported in March 2009.[77]

China						
Missile	**Propulsion**	**Dimension (m)**	**Guidance**	**Warhead**	**Range (km)**	**CEP (m)**
JL-1A (CSS-N-3)	2 stage solid	L:12.3 Dia:1.4	Inertial with GPS and radar correlation	90-150 kT	2,500	50
JL-2 (CSS-NX-4)	3 stage solid	L:13.3 Dia:1.8-2.0	Inertial with GPS and Stellar updates	1 MT or MIRV with selectable 20,90 or 150 MT	8,000	150-300
India						
Sagarika (K-15)	2 stage solid	L:10.8 Dia:0.8	Inertial with GPS and Terrain contour matching	N/A	700 (Est.)	N/A

Table 10: CEP (Circular Probable error), MIRV (Multiple Independent Re-entry Vehicles) ***Source:*** Jane's Strategic Weapon System-1011 and Global security org

[75] National Air and Space Intelligence Center (2009), Ballistic and cruise missile threat. NASIC-1031-0985-09, June 23.

[76] "India's K-15 Sagarika Submarine Launched Ballistic Missile Completes Developmental Tests", defence update 27th January 2013 available at (http://defense-update.com/20130127_k5_slbm_complete_tests.html), (Accessed February 03, 2013)

[77] Jane's Strategic weapon issue ISSUE 55-2011

Assessment

There are numerous challenges Chinese are facing with their SSBN programme such as China's ability to conduct continuous or near-continuous submarine patrols, JL-2 SLBM final stages problem, JL-1 which remains under development and coping with the command and control challenges which are major issues associated with the deployment of a sea-based deterrent force. Recognising the importance of sea deterrence, Chinese are working robustly on the challenges faced. There are numerous research institutes continuously working on technological challenges and trying to fill that gap. While India waits for its first underwater journey, it is yet to face and recognise the hidden challenges. Sagarika is successful while Dhanush is under development but their full operational deployment would be a greater challenge. Once China overcomes remaining technical hurdles, the PLA Navy will be charged with protection of a nuclear asset. China's continuous patrols and participation in numerous naval exercises will increase their experience and confidence till India will be completing its triad by deploying first SSBN and China will still remain a greater challenge to face in near future. Even though, Pakistan has recently shown its aspiration for having SSN soon but it will take them long time to consolidate their resources.

Warheads and Yield Coalesce

The actual (and factual) information in regards to number of warheads and nuclear yields of the weapons are not likely to be disclosed by any nuclear weapon state. The information presented below is based on limited sources and that too mostly of Western origin. It has been observed that by and large the assessments made by various agencies do not drastically differ from each. The purpose behind presenting these figures is to get a broad idea about the numbers and yield of the weapons in a relative sense.

Missiles	**Number of warhead**	**Nuclear Yield (kT)**
China[78]		
DF-3A (CSS-2)	~16	1000-3000
DF-4 (CSS-3)	~12	3000
DF-5/5A (CSS-4)	~20	1000-3000
DF-11/11A (CSS-7)	-	20
DF-15/15A/15B (CSS-6)	-	90-150
DF-21 (CSS-5)Mod 2/(21A/21B)	~10-20	250-500/90-150
DF-25	-	1000-3000
ICBM		
DF31/31A (CSS-9)	~60/10-20	1000
DF-41 (CSS-X-10)		1000 at full range

[78] Bulletin of the Atomic Scientists, Hans M. Kristensen and Robert S. Norris Chinese nuclear forces, 2011 (http://www.fas.org/programs/ssp/nukes/publications1/Article2012_France.pdf),

Missiles	Number of warhead	Nuclear Yield (kT)
SLBM		
JL-1/JL-1A	N/k	250-500
JL-2		1000
Cruise		
DH-10	N/k	20-90
KH-55SM		
Total		
Aircraft	**~138**	
H-6	~20	Bomb
Others	~20	Bomb
Total	**~178**	
Others*	**~60**	
TOTAL Inventory	**~240**	
India[79]		
Prithvi (SS-250)	20	10-20
Agni-I	~10	20-45
Agni-II	~15	150-200
Agni III		200-300
Agni IV	~10	35-40
ICBM		
Agni-V		Not Known
SLBM		
Sagarika K-15		Not known
Dhanush(Under Test)		10-20

* Others- These are the inventories which is undefined and according to a report are additional warheads which are thought to be in storage to arm in future weapons

[79] Bulletin of the Atomic Scientists, Hans M. Kristensen and Robert S. Norris Chinese nuclear forces, 2012

Missiles	Number of warhead	Nuclear Yield (kT)
Aircraft[80]		15
Jaguar IS/IB-NGB* (1980)	~10-30	~30
Mirage 2000H/Vajra-NGB*	~20-50	~125
(1990)	0-10	~12
Total Inventory	**~80-100**	~1
Pakistan[81]		
Ghaznavi (Hatf-3)		12-20
Shaheen I(Hatf-4)	~10	35
Shaheen 1A	~0-5	35
Shaheen II (Hatf-6)	~0-5	15-35
Ghauri I (Hatf-5)	~10	15-35
Hatf-9 (Nasr)		
Hatf-II/Vengeance-II Abdali missile		-
Cruise		
Babur (Hatf-7)		20-25
Aircraft		15
F-16 Falcon-NGB* (1984)	~10	
NGB (1998)	~10	~25
Total[82] **Inventory**	**~90-110**	~25-30

Table 11: Warheads and Yield coalesce ***Source:*** FAS, Bulletin of Atomic Sciences[83]

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[80] Strategic Nuclear Forces of the World, March 2008 Part 5: Israel, India, Pakistan, North Korea, and Iran compiled by Wm. Robert Johnston Available at(http://www.johnstonsarchive.net/nuclear/stratnuk-5.html), (Accessed February 21, 2013)

* NGB is Nuclear Gravity Bomb

[81] Nuclear warheads and applications compiled by Wm. Robert Johnston available at (http://www.johnstonsarchive.net/nuclear/wrjp159z.html), (Accessed February 21, 2013)

[82] Status of world nuclear forces, available at (http://www.fas.org/programs/ssp/nukes/nuclearweapons/nukestatus.html) (Accessed February 21, 2013)

[83] *Ibid.*78-82

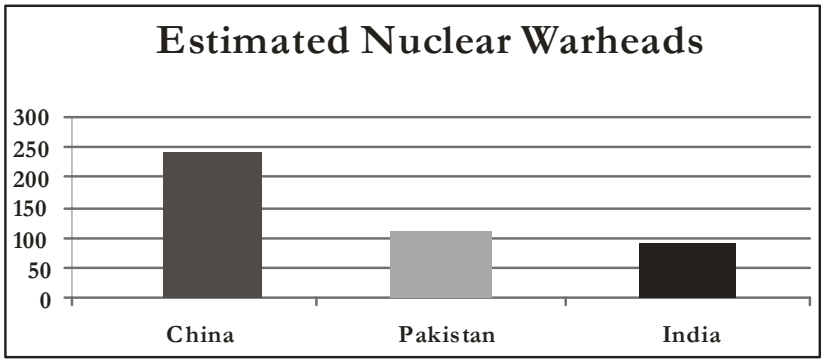

Figure 8: Nuclear Warhead, ***Source:*** SIPRI database-2012, Bulletin of the Atomic Scientists-2013 and The Guardian[84]

The above inputs are not sufficient (and probably its reliability could also be questioned) to draw any definitive conclusions above the capabilities of China, Pakistan and India, but may facilitate in understanding the trend. It is clear that China has more number of warhead vis-à-vis to India and Pakistan. Broadly, India and Pakistan have roughly same numbers of warheads in their possession with Pakistan showing marginal edge. China has about 60 DF-31 and about 20 DF-31A ICBM which is highest number in any other range of missiles. This indicates China's investment in its nuclear deterrence is not only aimed at its regional adversaries but also have larger strategic implications. The nature of the nuclear yield carrying capability of China is indicative that in accordance with their NFU policies that they are fully geared-up to provide massive retaliatory second strike. India needs to do some catching-up in respect of both number of warheads and yield capabilities. Chinese also have MIRV capability which offers them both tactical and strategic advantages and enhance deterrence ability of their nuclear arsenal.

Summing Up

Modern day warfare is multidimensional warfare essentially fought by using weapon systems on land, sea and air. For a peninsular state like India which shares its boundaries with neighbours with nuclear-weapons complex, it is essential to remain prepared to fight a multidimensional war. India's nuclear deterrence mechanism should have strategic delivery platforms capable of mounting an attack using land, sea, and air systems. India is yet to possess a fully operational nuclear triad capability. However, above analysis indicates that India is making significant amount of efforts towards that direction and shortly should have its nuclear triad operational. The weapon delivery platforms available with India's neighbours in some cases are bit superior while in some cases Indian platforms are better. It is important to note that for a nuclear weapon state more than the quantity and types of platform having a correct mix of platforms is very essential. It is important to have platforms which can match your adversary but, at the same time particularly in the context of nuclear weapons it is important to develop a system which matches with your doctrine. Nature of strategic targets envisaged and the nature and type of weapons the country is capable of producing would also dictate the states investments in the triad. It is also important to note that nuclear strategy can never be static and triad should not be viewed as an end itself. Space is finding increasing acceptance as an additional dimension of warfare. It could be premature to talk of orbital weapons now but it is difficult to predict the future. There are laws to restrict any use of space for using WMDs; however that does not fully guarantee that strategic nuclear strike missions in future would not have a space based platform.

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[84] http://www.armscontrol.org/factsheets/Nuclearweaponswhohaswhat and http://www.guardian.co.uk/news/datablog/2012/dec/13/north-korea-nuclear-weapons, (Accessed February 25, 2013)

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