Indian Space Launch Vehicles and ICBM

February 29, 2008

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This piece explores why it is assumed within India and elsewhere that New Delhi will adapt its space launch vehicles to build an Intercontinental Ballistic Missile (ICBM). Some Indian commentators justify acquiring an ICBM by arguing it has special symbolism or that the country has the technical capability to do so. Elsewhere, analysts draw inferences about India's intentions from its space capabilities. Surveying the technical and the political factors will reveal that an Indian ICBM is a remote possibility. It shows that technical impediments can be potentially overcome, but argues that these are unlikely to override political preferences. The empirical evidence suggests that advances in India's missile capabilities do not and have not paralleled the pace and intensity in development of India's space launch rocketry.

Bharat Karnad, one of India's leading strategic analysts, says the Polar Satellite Launch Vehicle (PSLV), Augmented Satellite Launch Vehicle (ASLV) or the Geostationary Satellite Launch Vehicle (GSLV) can be easily turned into an ICBM with their satellite payloads replaced with a thermonuclear warhead.[1] Contrary to Karnad's assertion, India's space launch vehicles cannot be automatically converted into usable ICBMs, even if their technologies could help build one.

A brief survey of the technical evidence will demonstrate why this is difficult to achieve. Compared to the most sophisticated ICBMs in the Russian missile inventory, whose road-mobile SS-27 has a launch weight of 47.2 tons,[2] while its rail-mobile SS-24 variant weighs 104.5 tons,[3] India's SLVs are in a completely different launch weight category. The GSLV has a total weight that is over eight times (401 tons)[4] greater than the SS-27 and almost three times the weight of the SS-24. The PSLV, lighter than the GSLV, still weighs six times (294 tons) more than the SS-27 and approximately three times heavier than the SS-24.[5] Thus, the Indian space launch vehicles' excessive weight alone precludes easy conversion into an ICBM.

However, a 2005 U.S. Department of Defense report, making a generic observation about reconfiguring space launch vehicles into ICBMs, noted, "Demonstrating multistage booster technology sufficient to reach GEO [Geostationary Orbit] is an indication that a nation has capability to seriously pursue ICBM capabilities."[6] An indigenous GSLV capability is something India is yet to develop fully. The Indian Space Research Organization (ISRO) has launched five developmental flights of its GSLV, using Russian-supplied cryogenic engines. These engines are used in the upper stage of the GSLV, which bear similarity to their use in the American Saturn V and Saturn 1B rockets.[7] India is poised to launch in 2008 its GSLV-III with an indigenously developed cryogenic rocket engine, which can carry a 4-ton payload to geosynchronous orbit.[8] This launch platform is completely new: the vehicle is not a derivative of its previous Indian space launch vehicles.[9] The ground test was successfully carried out in November 2007 at the Liquid Propulsion Test Facility in Southern India. This engine will form the cryogenic upper stage of the GSLV-III.[10]

Even with this step forward, technical hurdles will remain in changing the GSLV into an ICBM. GLSVs use cryogenic engines which are liquid-fueled. The very low temperatures of cryogenic engines, if used for ICBM propulsion, render their storage over prolonged periods of time very difficult.[11] Indian SLVs use solid fuels for initial propulsion and liquid fuel during intermediate stages.[12] Unlike other fuels, the storage volume of liquid hydrogen is very high due to its extremely low density, which stands at 0.59 pounds per gallon.[13] In addition, as the 2005 DOD report mentioned earlier noted, "A propellant with a low storage temperature i.e., a cryogenic, will require thermal insulation, thus further increasing the mass of the launcher."[14] The United States in the 1960s decided to shift from its liquid-fueled ICBMs to solid-fueled rockets due to the problems associated with the storability of liquid-fueled engines and the enormous time it takes in preparing a liquid-fueled ICBM launch.[15]

The Augmented Satellite Launch Vehicle (ASLV), weighing 41,000 kilograms, has a launch weight that is closer to that of Russian ICBMs.[16] But even in the case of the ASLV, there are liabilities. The ASLV is likely to be cumbersome as a road-mobile ballistic missile. The ASLV is a five-stage rocket, and removing its two strap-on boosters would bring its weight down to approximately 19,000 kg – a figure that fits well with the launch weight of a road-mobile ICBM.[17] The ASLV is, however, designed to carry a 150-kg[18] payload, but modifying the ASLV by stripping its strap-on boosters will trigger a loss in payload delivery capabilities, rendering it incapable of carrying a 1000-kg payload to intercontinental ranges.[19] More critically, in a road mobile configuration, the enormous diameter of ASLVs' strap-on boosters makes them unwieldy as an ICBM.[20] The only option available then is to place the ASLV/PSLV in a fixed silo, which increases its vulnerability to attack and makes the missile more easily detectable. Similar technical challenges apply in the case of the PSLV's transformation to an ICBM. The PSLV is a four-stage rocket whose first stage has amongst the world's largest solid-propellant engines.[21] With a diameter of 2.8 meters, it compares unfavorably to the Russian SS-27 road-mobile ICBM, which has a diameter twice as small as the PSLV.[22]

Also, the re-entry speed of an ICBM is greater than a launch vehicle, and requires greater capacity to resist high atmospheric temperatures and hydraulic drag.[23] One commentator recently suggested that India may have been constrained from pursuing the development of an ICBM due to the non-export of polyacrylonitrile (PAN) fiber to India by several countries.[24] This material, a Missile Technology Control Regime (MTCR) regulated item, is indispensable for carbon fiber ablatives that enable heat resistance of re-entry vehicles of ICBMs.[25] There is some evidentiary justification to this point. The Defense Research and Development Organization (DRDO) that runs the Indian missile program recently issued a contract for carbon fabric such as warp fiber and weft fiber which are based on a PAN precursor.[26] Warp fiber and weft fiber have aerospace applications. The tender also stipulates that the fibers be compatible with epoxy systems.[27] Epoxy systems have excellent insulating properties that enable chemical heat and electrical resistance.[28] Nevertheless, one cannot clearly deduce that the DRDO's quest to acquire PAN fiber will inevitably find its way into the missile program, because the material has other defense applications.

Despite these technical hurdles that India will experience in converting its space launch vehicles into ICBMs, they are not necessarily insurmountable. Thus some Indian commentators have urged India's leadership to demonstrate the political fortitude to acquire ICBMs using SLV technology, regardless of need and international consequences. This would be a case of technology driving strategy, rather than the way around.[29]

The last point is critical to understanding whether India's political leadership will allow technological determinism and bureaucratic momentum to drive its missile program. Bureaucratic interests epitomized by India's strategic enclaves will push for the involvement of the space program to enable the growth of India's missile capabilities, but their influence will be circumscribed by the preferences of India's political leadership. To that degree, policy outcomes regarding India's missile program cannot be determined by bureaucratic momentum and technological determinism alone, they are ultimately a function of political choice. As Stephen Krasner points out, "The values which bureau chiefs assign to policy outcomes are not independent."[30]

At the other end of the spectrum lies technological determinism, as advanced by analysts like Raju G.C. Thomas, who argued in the 1980s that India's nuclear and missile intentions are a product of technological capacity "whether it is for development or defense purposes."[31] This is inaccurate, at least in the latter case. Instead, the Indian leadership has successfully prevented technological imperatives from driving the missile program "by carefully directing the pace of research and development through stringent control of funding and by basing all testing and deployment decisions on political necessity rather than merely on technical capability – and this dynamic is unlikely to change in the future."[32] India for over three decades had the opportunity to militarize the Rohini series of sounding rockets, but has not.[33] The political leadership has shown no inclination in divesting civilian control of the sounding rocket program from the ISRO to the DRDO, which would be a significant boon to the latter's missile plans.

Another case in point is the Agni, a medium-range ballistic missile (MRBM), which was first flight-tested in 1989. Initially it was declared a "technology demonstrator" in a bid to validate capability. Two additional tests were carried out and in 1996 the Indian government briefly suspended the Agni's development.[34] The Agni program in effect went through a phase of stops and starts for nearly a decade since the launch of the Integrated Guided Missile Development Program, despite the DRDO's attempt to mobilize support for the project.[35] To that extent, the Indian missile program has not acquired an untrammeled momentum.

With a range of 3,000 kilometers, the Agni-3 is the longest range missile in India's ballistic missile inventory, even if it is still in its testing phase. This missile was originally conceptualized in the 1980s for targeting China, but active development only began in the late 1990s and it was successfully flight-tested for the first time only in April

2007. As one report noted, “Agni-III was by far the most difficult version of India’s primary nuclear-weapon carrier. Five years in the making, Agni-3 was designed to be a stubbier and shorter version of Agni II but with the power to traverse an additional 1,000 km. To give it the extra thrust, scientists had to fabricate all new, solid-fuel rocket engines with diameters twice the size of Agni II.”[36] Pending further tests, its deployment is still uncertain. One of the principal factors behind this “haphazard” development process is funding constraints, despite the imperatives of India’s leadership to create an array of delivery systems. In the absence of committed resources, the DRDO is unable to intensify its production capabilities, improve the quality of its engineering performance, or establish economies of scale.[37] These limitations have induced successive Indian governments to temper the growth of its missile capabilities.

Finally, there are no strategic motivations for India to develop an ICBM to target the United States or any other country located at intercontinental ranges, because there are none that threaten India. Ultimately, the development of an Indian ICBM will be conditioned by the quality of its political relations with the United States, Europe or even Russia. It is therefore hard to agree with one American commentator that India intends to build an ICBM by adapting its space launch vehicles to target the United States.[38] As George Perkovich notes, “Indians aren’t going to go crazy and build up…It’s not in their interest, it’s not in the priorities, it’s not in the culture.”[39] More likely, India and the United States may have struck a tacit bargain that allows New Delhi to expand its strategic capabilities only to the degree that it does not directly threaten the United States.[40] This implies that India will be expected not to develop missiles beyond a range of 5,000 kilometers, or in other words, missiles that can only reach as far as China.[41] To that extent, bureaucratic and technological factors will not be the key drivers behind India’s missile capabilities.

1 Bharat Karnad, “India’s Force Planning Initiative: The Thermonuclear Imperative,” *Nuclear India in the Twenty-First Century,* ed. Sardesai and Raju G.C. Thomas (NY: Palgrave-Macmillan, 2002), p. 200.
2 “RT-2UTTH – Topol-M,” *Federation of American Scientists,* http://www.fas.org/nuke/guide/russia/icbm/rt-2pmu.htm (accessed on February 26, 2008).
3 Ibid; See also “RT-23/SS-24 Scalpel,” *Federation of American Scientists* http://www.fas.org/nuke/guide/russia/icbm/rt-23.htm (accessed on February 26, 2008).
4 “Geosynchronous Satellite Launch Vehicle (GSLV)”, *Department of Space: Indian Space Research Organisation,* http://www.isro.org/gslv.htm (accessed on February 16, 2008).
5 “Polar Satellite Launch Vehicle,” *Department of Space: Indian Space Research Organisation,* http://www.isro.org/pslv.htm (accessed on February 16, 2008).
6 “List of MCTL Technology Data Sheets: 19.6 Launch Propulsion for Space Systems,” *Militarily Critical Technologies List: Section 19: Space Systems Technology,* Department of Defense, October 2005, http://www.dtic.mil/mctl/MCTL/Sec19MCTLg.pdf, p. 96.
7 Ibid
8 “Indigenous Cryogenic Stage Successfully Qualified,” *ISRO,* Nov. 15 2007, http://www.isro.org/pressrelease/Nov15_2007.htm.
9 “Space Launch Vehicles,” *Bharat Rakshak,* http://www.bharat-rakshak.com/SPACE/space-launchersgslv.html#gslvmk3 (accessed February 10 2008).
10 Space Launch Vehicles”, *Bharat Rakshak,* http://www.bharat-rakshak.com/SPACE/space-launchersgslv.html#gslvmk3 (accessed February 10, 2008).
11 “List of MCTL Technology Data Sheets: 19.6 Launch Propulsion for Space Systems,” *Militarily Critical Technologies List: Section 19: Space Systems Technology,* Department of Defense, October 2005, http://www.dtic.mil/mctl/MCTL/Sec19MCTLg.pdf, p. 96.

12 David Baker, ed., "Indian Space Launch Vehicles," *Jane's Space Directory* (Coulsdon, UK: Jane's Information Group Ltd., 2006-7), p. 365.
13 "List of MCTL Technology Data Sheets," Department of Defense, October 2005, p. 96.
14 Ibid.
15 Ibid, p. 103.
16 Ibid.
17 Ibid.
18 "ASLV", *Department of Space: Indian Space Research Organization* http://www.isro.org/aslv.htm (accessed on February 26, 2008).
19 "List of MCTL Technology Data Sheets," Department of Defense, p. 96.
20 Ibid.
21 "Space Launch Vehicles," *PSLV: Polar Satellite Launch Vehicle, Bharat Rakshak*, http://www.bharatrakshak.
com/SPACE/space-launchers-pslv.html (accessed on February 26, 2008); See also, "RT-2UTTH – Topol-M," *Federation of American Scientists,* http://www.fas.org/nuke/guide/russia/icbm/rt-2pmu.htm (accessed on February 26, 2008).
22 Ibid.
23 Anupam Srivastava, "India's Growing Missile Ambitions: Assessing the Technical and Strategic Dimensions," *Asian Survey*, Vol. XL, No.2, 40:2, 2002: p. 322-323.
24 Sharad Joshi, "India and Pakistan Missile Race Surges On," James Martin Center for Nonproliferation, October 2007, http://cns.miis.edu/pubs/other/wmdi071008d.htm.
25 Ibid.
26 See the first and second part of the tender: "Short Term Agreement Part 1: Invitation to Tender," Defense Research and Development Organization (DRDO), Dec. 17 2007, http://www.drdo.org/tender/r&de/rde191207sp2_1.pdf; "Short Term Agreement Part II: Invitation to Tender", Defense Research and Development Organization (DRDO), Nov. 29, 2007, http://www.drdo.org/tender/r&de/rde191007sp1.pdf.
27 See Fibermax Composites for overview of epoxy systems, "Types of Resin Families," *Fibermax Composites*, http://www.fibermaxcomposites.com/index.files/resinsystems.htm (accessed February 12 2008).
28 Ibid.
29Harsh V. Pant and G. Bharath, "Launch into the Ivy League," *Indian Express*, April 30, 2007.
30 Stephen Krasner, "Are Bureaucracies Important?: (Or Allison Wonderland)," *Foreign Policy*, no. 7, (summer 1972): p. 166.
31Raju G.C. Thomas, "India's Nuclear and Space Programs," *World Politics*, vol. 38, no.2 (January 1986): p. 340
32 Ashley J. Tellis, *India's Emerging Nuclear Posture: Between Recessed Deterrence and Ready Arsenal* (Santa Monica: RAND, 2001), p. 100.
33 Aaron Karp, *Ballistic Missile Proliferation: The Politics and Technics* (Stockholm: Oxford University Press, 1996), p. 61.
34 George Perkovich, *India's Nuclear Bomb: The Impact on Proliferation* (Berkeley: University of California Press, 1999), p. 338-439.
35 Ibid.
36 Raj Chengappa, "Building India's Missile Muscle," *India Today International*, April 30, 2007, p. 36-39.
37 Srivatsava, Ibid.
38 See Richard Speier, "U.S. Aid to India: On a "Glide Path" to ICBM Trouble?" *Arms Control Today*, March 2006, http://www.armscontrol.org/act/2006_03/MARCH-IndiaFeature.asp. Speier argues that India intends to build an ICBM known as "Surya" based on the statements made by some DRDO officials. However, at no point have India's leaders shown the remotest enthusiasm to support an ICBM program.
39 See Perkovich's comments in "U.S.-India Relations: The Global Partnership," Panel III Speakers, George Perkovich and Ashley J. Tellis, Carnegie Endowment for International Peace, Transcript, May 16, 2006, p. 10.
40 Siddharth Varadarajan, "India-U.S. Nuclear Deal and U.S.-India Relations," Seminar, Center for Nonproliferation Studies, Monterey Institute, Nov. 11 2007.
41 Ibid.