



CDI POLICY BRIEF

India's Space Ambitions: Headed Toward Space War?

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In March of last year, Indian President A.P.J. Kalam addressed the Indian Air Force (IAF) president's fleet review with bold goals for India's aerospace future. "I visualize the Indian Air Force of 2025 to be based on our scientific and technological competence in the development of communications satellites, high-precision resource mapping satellites, missile systems, unmanned supersonic aerial vehicles and electronics and communication systems," he said. By 2025, Kalam predicted the IAF will be a model force for the rest of the world, able to "succeed in the electronically controlled warfare in the midst of space encounters, deep-sea encounters, and ballistic missile encounters."¹

Meanwhile, New Delhi continues to emphasize the peaceful uses of space, civilian benefits, and an overall policy objective of preventing space militarization. Given these two contradictory messages, recent demonstrations of anti-satellite (ASAT) capabilities by the United States and China, and uncertainty over the future norms of space security, India's decisions and reactions may serve as a bell-weather for trends across the board.

Background

The Indian Space Research Organization (ISRO)², an organization under the Department of Space (DOS), has focused its efforts on two major activities:

- Satellites used for remote sensing, meteorology and communications;
- Rockets and launch capabilities for its satellites³

National economic development has been the primary goal of India's space program. Initial programming decisions focused on building stepping stones to national satellite production and national launching capability. Programs also sought to decrease

¹ "IAF will be Model for World by 20205: Kalam," *The Times of India*, March 7, 2007, <http://timesofindia.indiatimes.com/articleshow/1730115.cms> (accessed March 18, 2008).

² For a historical background on India's Space Research Organization see: ISRO Website http://www.ipcs.org/Military_articles2.jsp?action=showView&kValue=2220&keyArticle=1017&status=article&mod=a.

³ Dinshaw Mistry, "The Geo-Strategic Implications of India's Space Program," *Asia Survey* 41, no. 6, (November 2001) 1023-1043.

dependence on outside technology. Space assets that produced tangible development benefits at the national level were the organization's priority. From ISRO's inception, a driving objective has been delivering services such as remote education, telemedicine, weather forecasting, and disaster-monitoring⁴ – all efforts aiding primarily in national economic development. The commercial arm of ISRO, Antrix, is also successful, and brought in more than \$500 million in 2006 – which is over half the operating budget of the entire ISRO.⁵

The defense sector of Indian technology is handled primarily by the Defense Research and Development Organization (DRDO). This organization operates under the Indian Ministry of Defense, and India's missile technology was developed by DRDO. In the past, some cooperation between ISRO and DRDO has been evident. However ISRO's institutional preferences, and the limits of its civilian mandate, have acted as a significant check on DRDO attempts to involve the former in military endeavors. While ISRO defines itself as a civilian organization and consistently denies any interaction with DRDO, there are indications that ISRO does cooperate on military objectives. ISRO's launch of increasingly capable imaging satellites with implications for spying is one such indication, and some sources have even hinted the satellites were built by DRDO.⁶

The question of the level of military or dual-use projects worked on at ISRO is not new, though, as is evidenced by the U.S. State Department's May 1992 decision to impose trade sanctions against ISRO for proliferating missile, specifically rocket engine, technology.⁷ The Integrated Guided Missile Program (IGMP) benefited from the migration of around a dozen space scientists, including A.P.J. Abdul Kalam, who played a key role in designing India's Satellite Launch Vehicle (SLV-3). Kalam originally started in ISRO where he worked on the SLV-3 program, then moved from to DRDO to lead the IGMP.⁸ As project manager, he also helped design the 2,500-kilometer Agni-II IRBM which incorporates the first stage of the SLV-3. This was the most well-known transfer of expertise and technology from the civilian space program to the missile program.

⁴ Embassy of India, "India: Science and Technology," <http://www.indianembassy.org/dydemo/science.htm>; Frank Moring Jr., Michael A. Taverna and Bradley Perrett, "Not Just for Superpowers," *Aviation Week & Space Technology*, March 19, 2007, Vol. 166, Issue 12, 71.

⁵ Dr. Ashok Sharma, "India's Aerospace Command," Institute for Peace and Conflict Studies, February 14, 2007, http://www.ipcs.org/Military_articles2.jsp?action=showView&kValue=2220&keyArticle=1017&status=article&mod=a.

⁶ "India Building A Military Satellite Reconnaissance System," *Defense Industry Daily*, August 10, 2005 <http://www.defenseindustrydaily.com/india-building-a-military-satellite-reconnaissance-system-0996/> (accessed March 10, 2008).

⁷ "Missile Sanctions Laws," U.S. Dept. of State, <http://www.state.gov/t/isn/c15232.htm> (accessed March 10, 2008); "U.S. Sanctions Imposed on Russian, Indian Space Groups," *Global Security* <http://www.globalsecurity.org/wmd/library/news/india/1992/11478884-11482086.htm> (accessed March 10, 2008); These sanctions delayed, but did not disrupt, the development of rocket engines. Instead, the sanctions prompted an effort toward the indigenous technological capability to stem Indian reliance on foreign imports in key areas. See: Mistry, "India's Emerging Space Program," 158.

⁸ Dinshaw Mistry, "India's Emerging Space Program," *Pacific Affairs* 71, No. 2 (Summer 1998) 156.

Due to the implications of DRDO/ISRO cooperation, the two organizations have remained distant to avoid penalties and sanctions. After the Chinese ASAT test in January 2007 prompted questions about India's own capability, however, the senior adviser to the defense minister, and chief of DRDO, M. Natarajan, indicated the potential for more overt cooperation between the two organizations.⁹ The Chinese ASAT test, and the U.S. satellite shoot down in February 2008 came during a time of renewed push for military influence on space policy and budgeting in India, with the Indian Air Force (IAF) leading the effort. Cooperation between ISRO and military/defense elements that is already generally assumed to exist,¹⁰ for instance on the CartoSat series of satellites that have clear military applications,¹¹ may end up expanding so that New Delhi is assured its space capabilities are on par with major space powers.

At the least, systems that are civilian may serve as test beds for future military projects – an approach not uncommon in many countries (e.g., the French Spot system which led into Helios). If political leadership is persuaded that increased cooperation can be advantageous, then it is significant that ISRO remains under the budgeting and policy direction of the Indian Space Commission. The Space Commission, which reports directly to the prime minister and minister of state, is responsible for high level policy formulation and budget approval for ISRO and all programs that are constituent elements of the Department of Space.¹² Many analysts point out India's primary motivation is simply the development and advancement of technology and capability – whether it primarily ends up being used for civilian national development, commercial, or military purposes.¹³

Military Motivations and Potential Projects

There is no reason to believe India is focusing on space technology solely for military purposes. However, given the current uncertainty over the weaponization of space, programs that allow India to pursue dual-use technology that can easily be applied toward military projects are likely to gain more support. Military priorities that were tough sells to the political leadership in the past may start to gain traction as the arguments the military, particularly the IAF, make for space weapons gain more credibility.

Two major military priorities emerge out of India's current space capabilities. One is improvement of satellite reconnaissance capabilities, and the second is an integrated aerospace defense command. These efforts were further prioritized after China's ASAT

⁹ "India to Counter China's Anti-Satellite Test, Says DRDO," *Tribune News Service*, January 20, 2008, <http://www.tribuneindia.com/2007/20070121/nation.htm#15> (accessed March 10, 2008).

¹⁰ Mistry, "India's Emerging Space Program," 161-7.

¹¹ Cartosat-1 is reported to have "two cameras able to point at an object from two different angles," and Cartosat-2 operates at a one-meter resolution, and a 120GB storage for captured images. See technology list.

¹² Jerrold. F. Elkin and Brian Fredericks, "Military Implications of India's Space Program," *Air University Review*, May-June 1983, <http://www.airpower.maxwell.af.mil/airchronicles/aureview/1983/May-Jun/fredricks.htm> (accessed March 10, 2008).

¹³ Mistry, "India's Emerging Space Program," 162.

test;¹⁴ however both pursuits have been on the Indian agenda since the late 1990s.¹⁵ The primary motivations originate in the 1999 Kargil conflict and continued instability with Pakistan, coupled with India's rising regional role. The powerful impact of space assets on military power – particularly in the United States and China – and the ambitions of other nations in Asia also are noted by Indian defense officials.

Squadron Leader K.K. Nair, an IAF officer who specializes in the role of space in India's defense establishment, makes a case for India to recognize space-based assets as a modern necessity for ground, sea and air warfare, and plan accordingly. In research for The Center for Air Power Studies, an Indian defense research institution, he contrasts the 1999 U.S. intervention in Kosovo, which utilized space assets to a great extent, to the Kargil conflict, which did not utilize space assets despite the fact that India was a space-faring nation at the time. Attributing much of the success in Kosovo success to the U.S.-led coalition's use of space-based assets, he finds:

While Kargil was characterized by lack of information in all aspects ranging from intelligence on enemy locations to targeting information, weather inputs, etc., Kosovo was characterized by a surfeit of space-based military information for the coalition forces which paved the way for nuanced application of military power and consequently decisive success in battle.¹⁶

His assessment of the two conflicts concludes predictably: If India had “harnessed its extant space capabilities for national security”¹⁷ in 1999, enemy incursions could have been detected and assessed with more accuracy; air power could have been applied with greater precision; and the loss of life would have been decreased. Nair thus recommends that India – at the least – adapt and apply its existing space-assets and technology toward military endeavors.

Nair also analyzes China's advancing militarized use of space. The manifold force-multiplying effects of military uses of space that Nair predicts for China are considered the predicate for a regional imbalance of power in Asia, a space-weaponization race, increased regional conflict, and a continuation of nuclear competition and tensions. The “inevitable spin-off to Pakistan”¹⁸ of China's military modernization is noted as well. Nair asserts Chinese space programs, both in military and dual-use terms, are “evolving at an extremely rapid pace... to the extent that it has decisively altered the balance of power overwhelmingly in its favor.”¹⁹ Anti-satellite weaponry is a particular concern of

¹⁴ “India in Aerospace Defence Plan,” *BBC News*, January 28, 2007
http://news.bbc.co.uk/2/hi/south_asia/6307875.stm.

¹⁵ For instance: In 1997, Indian Air Force's “Airpower Doctrine aspired to use space assets for surveillance and battle management”; in 2000, the Indian air force was “conceptualizing various doctrines and schemes for the establishment of an aerospace command and the military use of space, and a parliamentary committee also endorsed the idea.” Mistry, “The Geo-Strategic Implications,” 1039.

¹⁶ Nair, K.K., *Space the Frontiers of Modern Defense* (New Delhi: Knowledge World, 2006), 17.

¹⁷ Nair, 18.

¹⁸ *Ibid.*, 129.

¹⁹ *Ibid.*, 117.

Nair's.²⁰ Furthermore, he predicts China's actions will further trigger space-faring nations, particularly India and Japan, to adopt or expand upon militarized space programs. The use of satellites to expand and enable military capabilities has been occurring in India for some time, and it is likely that dual-use programs in terms of ASAT capabilities and space weapons will be pursued in order to keep pace with potential adversaries. As actors demonstrate their growing capabilities, it is likely that increased military uses of space and space weapons will become more tenable and seen as necessary.

There are two primary arguments gaining currency in Indian military and political circles. The first is the undeniable force multiplication power of space-based technology. Second is the threat of China's space program and military capabilities to the regional balance of power sparking a militarized "space-race." The Chinese and American satellite shoot downs only served to reinforce New Delhi's concern over ASAT capabilities. Indian officials made public statements concerning the need to be prepared for the use of ASAT and laser weapons by other nations even before China's test.²¹ After China acknowledged the destruction of its own satellite, India joined the United States, Britain and Japan in lodging a formal diplomatic protest to Beijing.²² China's secrecy and continued silence does little to mollify concerns in other nations.

Both arguments have broad implications in terms of India's conflict with Pakistan and New Delhi's status as a rising Asian power, thus re-enforcing Nair's broader call for India to pursue greater military capabilities in space. Nair's argument that it is "inevitable that space will become another medium of warfare besides an important economic center of gravity"²³ would have India expand its mainly commercial and civil space projects, some of which already have dual-use implications, to dedicated military uses.

Recent debates on India's need to refine and test a "satellite killing" capability have emerged since the U.S. decision to shoot down a faulty spy satellite on Feb. 20, 2008. Pointing to the history of the nuclear Non-Proliferation Treaty, in which India lost out on a "legitimate holder" status, Sreeram Chaulia opined that the time to test an ASAT capability is now, before any treaties or regimes present restraints.²⁴ This is significant considering the Feb. 22, 2008 statement by former president, and missile engineer, Abdul Kalam, that India already possesses the ability to "intercept and destroy any spatial object or debris in a radius of 200 km."²⁵ Another influential name in India's missile program, V.K. Saraswat, the chief controller of DRDO, also noted putting the necessary technology in place would be "just a matter of time."²⁶

²⁰ Ibid.,127-8;132-33.

²¹ Theresa Hitchens, *Future Security In Space: Charting a Cooperative Course* (Center for Defense Information: Washington D.C., 2004) 70.

²² Bill Gertz, "U.S. Satellites Dodge Chinese Missile Debris," *The Washington Times*, January 11, 2008.

²³ Nair, 43.

²⁴ Sreeram Chaulia, "Should India Also Develop Satellite-Killing Capability?" *Thaindian News*, March 2, 2008.

²⁵ "India too has Technology to Intercept, Destroy Rogue Satellites," *The Hindu Business Line*, February 22, 2008 <http://www.thehindubusinessline.com/2008/02/23/stories/2008022351582100.htm> (accessed March 10, 2008).

²⁶ Ibid.

The strategic decision of whether India will follow the lead of China and the United States in demonstrating ASAT capabilities is one that puts the political leadership's goal of ensuring the peaceful uses of outer space to the test. Even before the Chinese ASAT test, the chief of the Indian Air Force, S. Krishnaswamy, stated, "Any country on the fringe of space technology like India has to work towards such a command as advanced countries are already moving towards laser weapons platforms in space and killer satellites."²⁷ The psychological elements of prestige in missile and nuclear technology have long been noted in India. While the civilian nature of India's space program has traditionally been its pride, the ability to demonstrate technological advances and expertise may also be a consideration for Indian leadership calculating a path forward now that both the United States and China have demonstrated ASAT capabilities.

India's overall policy remains one emphasizing the peaceful uses of outer space. Historically, New Delhi has sought to promote establishing cooperative uses of outer space, and strengthen the international norms and legal regimes regarding the use of space. In an April 2007 address to an IAF seminar focusing on aerospace power in tomorrow's world, Minister of External Affairs Shri Pranab Mukherjee noted that "recent developments show that we are treading a thin line between current defense related uses of space and its actual weaponization," and pointed out India's interest in ensuring outer space remains free from weapons. In his address, he noted the important role of satellites in military efforts, as well as the important potential of "soft power" partnerships utilizing space for cooperative disaster-management, and common threats such as nonstate actors or natural disasters.²⁸ This emphasis on India's longstanding interest in peaceful uses of outer space stands in direct conflict with IAF's push for space weapons.

The competition for resources and political support for military projects in space isn't new to the IAF. In the past this conflict between the civilian and military sectors has made the push for military uses of space an uphill battle. Given the changing dynamics of space weaponization, an emphasis on military uses is beginning to emerge. For instance, in October 2003, the IAF chief stated that India had begun work toward a command station to have a weapons platform in space. Later, he retracted the statement under pressure from civilian leadership.²⁹ However, by 2004 the creation of an Indian aerospace command received support from the Parliamentary Standing Committee on Defence. The committee's report stressed the importance of preparing to counter a threat from space, and recommended beginning concrete work on a space command to exploit military uses of space.³⁰ Skeptics have noted that the actual progress toward the command is minimal, and it exists primarily within IAF papers and plans. IAF officials

²⁷ Jeffrey Lewis, "What if Space were Weaponized? Possible Consequences for Crisis Scenarios" (Center for Defense Information, Washington, D.C., July 2004) 29.

²⁸ External Affairs Minister Shri Pranab Mukherjee Address at the Inaugural session of the International Seminar on "Aerospace Power in Tomorrow's World," April 2, 2007, <http://meaindia.nic.in/speech/2007/02/04ss01.htm> (accessed Jan. 16, 2008).

²⁹ Sean Kay, *The Quest for Power and the Search for Peace* (New York: Rowman and Littlefield, 2006) 188; "India Working on Space Weapons: IAF Chief," *Press Trust of India*, October 3, 2003. <http://www.rediff.com/news/2003/oct/06iaf1.htm> (accessed January 16, 2008).

³⁰ "India should go ahead with plans to tap potential space tech," *Press Trust of India*, April 19, 2004.

have pushed a transformation from 'Air Force' to an 'Aerospace Power' and for India to apply space-based technology to the modernization of the military for years with little to show.

Yet, as India increasingly depends on satellites for economic development and military reconnaissance, the argument to protect these interests seems to be growing more relevant. The 2004 Defense Committee report is one indication of that, and momentum only increased since the Chinese ASAT test, two weeks after which the Indian Air Chief Marshal Shashi Tyagi indicated that training a core group of people for the aerospace had begun.³¹ Tyagi also added that while the planned aerospace command would be under the military, civilian expertise would be used to build it, stating, "We will take the help of ISRO for the aerospace command, but it will have distinct features as it is a military command."³² The aerospace command is generally assumed to take a form similar to North American Aerospace Defense Command (NORAD).

Missile Defense and International Cooperation

In December 2007, Saraswat also indicated India will have a ballistic missile defense system in place by 2010 – although experts examining the issue are skeptical of the timeline.³³ According to Saraswat, "The shield has been designed with a range of 2,000 km that should be able to counter any ballistic missile threat with a reaction time of less than four minutes." The shield also is designed with two layers so that two missiles can be fired simultaneously at a target both outside the atmosphere at a 45-50 km range, and also inside the atmosphere at a 15-25 km range.³⁴ Saraswat added:

The system is being configured with radars for long-range surveillance and tracking, command, control, and communication systems for effective control and optimization of exo- and endo-atmospheric interceptors at altitudes above 40 km and below 25 km respectively.³⁵

While indigenous technology is being used, Indian officials indicated they are considering purchasing systems from the United States, Israel and Russia. India also announced the end of its IGMDP program, a signal that future missile projects will incorporate the private sector and international cooperation.³⁶

Israel

³¹ "India Aerospace Defence Plan," *BBC News*, January 28, 2007, http://news.bbc.co.uk/2/hi/south_asia/6307875.stm (accessed March 10, 2008).

³² "India to set up Aerospace Command," *The Tribune*, January 28, 2007, <http://www.tribuneindia.com/2007/20070129/main4.htm>.

³³ Steve Herman, "India Plans Missile Shield by 2010," *Voice of America News*, December 13, 2007.

³⁴ "India to build anti-ballistic missile shield by 2011," *Kalinga Times*, January 25, 2008 (accessed March 18, 2008).

³⁵ *Ibid.*

³⁶ "India Expands Foreign Collaboration in Missile and Space Program," March 2008 http://www.wmdinsights.com/I23/I23_SA1_IndiaExpands.htm.

Israel and India have cooperated on a number of ventures, as India's launch capabilities complement Israel's developments in remote sensing satellite technology. Israel's synthetic aperture radar allows a satellite to "see through" clouds, rain and other adverse conditions and high resolution pictures using radar technology. The decision to launch Israel's TecSar from India was reportedly hailed by defense officials as an important milestone symbolizing the growing military ties between the two countries.³⁷ The launch of TecSar, designed to monitor Iran, was delayed in September, but was successfully launched from India's Satish Dhawan space center in January 2008.³⁸ Bilateral space civil cooperation for education and exploration purposes has also increased.

India has become the largest client of Israel's defense industry, and Israel India's second largest supplier (after Russia). Brig. Gen. (ret.) Shmuel Brom, the director of Institute for National Security Studies, an academic institute in Tel Aviv focusing on Israeli national security, finds that the growing military relationship between Israel and India is only becoming more significant. He predicts as it grows the Israeli Aerospace Industry will seek more formal partnerships with Indian defense industries. There is some speculation that these growing ties will result in explicit technology sharing deals, and a focus has been placed on joint research and development projects. Agreements on joint development of surface-to-air missiles (SAM) and interceptors, ship-launched rotary unmanned aerial vehicles, and advanced radars³⁹ are indications that Indo-Israeli defense cooperation is moving from more traditional arms deals to long-term cooperation.⁴⁰ Particularly noteworthy is joint development on an advanced Barak medium-range SAM, led by the Israel Aerospace Industries, IAF and DRDO, with the DRDO as the prime contractor of the missile defense system.⁴¹ The missile will surpass the 70 km range of Israel's Barak 8, reaching up to 150 km.⁴²

This high level of cooperation is important, as it shows increasing long-term interest in joint development between Israel and India on advanced weapons technology that have potential uses as space weapons. Already India has imported and modified Israeli technology in missile defense. One example is the long-range tracking radar (LRTR) which was used in the "exo-atmospheric" BMD system that intercepted an incoming Prithvi missile in November 2006. This technology originated in the Israeli Green Pine radar, two of which India imported, and the DRDO claims it modified the technology to

³⁷ Yaakov Katz, "Israel to Launch New Spy Satellite Aboard Indian Rocket. IAI-developed TecSar will keep an eye on Iran in all weather conditions," *The Jerusalem Post*, July 20, 2007.

³⁸ "India Launches Israeli Satellite" *BBC News*, January 21, 2008, http://news.bbc.co.uk/2/hi/south_asia/7199736.stm (accessed March 11, 2008).

³⁹ "Israel flaunts wares and Defence Expo," *The Times of India*, February 17, 2008 (accessed March 18, 2008).

⁴⁰ P.R. Kumaraswamy, "Indo-Israeli military ties enter next stage," *ISN*, March 8, 2007, <http://www.isn.ethz.ch/news/sw/details.cfm?ID=17937> (accessed March 12, 2008).

⁴¹ "India, Israel to Jointly Develop \$2.5 billion Missile Defense System," *World Tribune*, July 20, 2007, http://www.worldtribune.com/worldtribune/WTARC/2007/me_military_07_19.asp (accessed March 12, 2008).

⁴² M Shamsur Rabb Khan, "Indo-Israel Defence Cooperation: A Step in the Right Direction," December 23, 2007, Institute of Peace and Conflict Studies, <http://www.ipcs.org/whatsNewArticle11.jsp?action=showView&kValue=2463&status=article&mod=b> (accessed March 18, 2008).

make it capable of tracking intermediate-range ballistic missiles. However, aside from the basic radar, the rest of the elements were developed in India.⁴³ Thus, cooperation also demonstrates India is able to take advantage of niche technologies developed outside, incorporating them into indigenous systems. Israeli companies have also become very active in modernizing Soviet/Russian military equipment, which is beneficial to India.

Russia

Russia and India gradually moved from a supplier-client relationship to one where joint-development and marketing of weapons systems is emphasized, while protecting intellectual property rights of Russian technology through an IPR agreement.⁴⁴ The BrahMos supersonic cruise missile is one example of a joint project. The Soviet-era Global Navigation System GLONASS will be used to track the missiles' movements, and as such is planned to be made fully functional by joint efforts. This development reduces Indian dependence on the U.S. Global Positioning System (GPS). The IPR agreement between Russia and India, which was signed in December 2005, paves the way for future cooperation on advanced technology. Like India's cooperation with Israel, these agreements enable India to develop advanced technology and weaponry without necessarily having indigenous capability, as well as reduce reliance on any one outside actor.

United States

The United States and India continue to explore cooperation on missile defense, and even a joint missile defense shield. Secretary of Defense Robert Gates indicated in late February 2008 that the United States is seeking a steady expansion of the defense relationship with India. Since 2002, there has been talk of expanding cooperation on missile defense and other advanced technologies.⁴⁵ In June 2005, the United States and India signed a 10-year defense pact guiding strategic cooperation on defense collaboration in the areas of two-way defense trade, technology transfers and co-production, expanded missile defense collaboration, and a bilateral defense procurement and production group.⁴⁶ India has also sought to purchase the Arrow anti-missile system from Israel, a move which the United States has blocked as the system was a co-development. In cooperation on missile defense, specific collaboration focused on integrating outside technology that improves guidance, fire control, and other issues is likely to be the goal.

⁴³ "Israeli Imprint in Prithvi Missile Test," *The Times of India*, December 3, 2006, <http://timesofindia.indiatimes.com/articleshow/msid-690102> (accessed March 12, 2008).

⁴⁴ Vladimir Radyuhin, "India, Russia to Sign Defense Secretary Agreement," *The Hindu*, April 27, 2005 <http://www.hindu.com/2005/04/27/stories/2005042703521400.htm> (accessed April 23, 2008).

⁴⁵ "Joint Statement of India-US Defense Policy Group," May 23, 2002, Washington DC http://www.indianembassy.org/press_release/2002/may/23.htm (accessed April 24, 2008).

⁴⁶ K. Alan Kronstadt, "India-US Relations," Congressional Research Service, April 6, 2006 <http://www.au.af.mil/au/awc/awcgate/crs/ib93097.pdf> (accessed April 24, 2008).

Appendix 1

Indian Satellite Technology

INSAT 3B – Indian National Satellite 3B

Launched: March 21, 2000

Orbit: Geostationary

Lifespan: 10 years

Purpose: Communications, particularly voice, data, fax transmissions

According to ISRO, 3B is expanding Very Small Aperture Terminal (VSAT) services. Today, there are about 7,500 VSATs, serving about 300 corporations in about 400 locations. The major VSAT users include banking and financial institutions, stock markets, consumer goods, and medium to heavy engineering companies. At present seven transponders from INSAT-2B and INSAT-2C are being used for these applications and INSAT-3B will almost double the transponder capacity for these services. Also used for interactive training and developmental communication and will be a further extension of the present Training and Developmental Communication Channel of INSAT that is being used by several government agencies for interactive training and education.

INSAT 3C – Indian National Satellite 3C

Launched: Jan. 23, 2002

Orbit: Geostationary

Lifespan: 12 years

Purpose: Communications, particularly voice, video, digital data service to India and neighboring countries. It carries Fixed Satellite Services (FSS) transponders, Broadcast Satellite Services (BSS) transponders and Mobile Satellite Services (MSS) transponders.

INSAT 3A – Indian National Satellite 3A

Launched: April 9, 2003

Orbit: Geostationary

Lifespan: 12 years

Purpose: Communications, Meteorology,

Carries 12 C-band, six extended C-band, six Ku-band for voice, video and data transmission to West Asia, East Asia, India. INSAT 3A carries a three-channel Very High Resolution Radiometer (VHRR) with 2 km resolution in the visible band and 8 km resolution in thermal infrared and water vapor bands for meteorological observation. It also carries a Charge Coupled Device (CCD) camera operating in visible and short wave infrared bands with a spatial resolution of 1 km. A Data Relay Transponder (DRT) operating in UHF band is incorporated for real-time hydro-meteorological data collection from unattended platforms located on land and river basins. The data is then relayed in extended C-band to a central location. A Satellite Aided Search and Rescue (SAS&R) payload has global receive coverage with 406 MHz uplink and 4500 MHz downlink with India coverage, for relay of signals from distress beacons in sea, air or land.

INSAT 4A – Indian National Satellite 4A

Launched: Dec. 21, 2007

Orbit: Geostationary

Lifespan: 12 years

Purpose: Communications INSAT-4A carries payloads of: 12 ku-band 36 MHz bandwidth transponders employing 140 W TWTAs to provide an EIRP of 52 dBW over the footprint covering Indian main land; 12 C-band 36 MHz bandwidth transponders employing 63 W YWTA to provide an EIRP 39 dBW with expanded radiation patterns encompassing Indian geographical boundary, an area beyond India in southeast and northwest regions, and some parts of Asia Pacific and Gulf countries. Of 32 direct to home (DTH)-specific transponders, the ISRO allotted all 12 Ku-band transponders on INSAT-4A to DTH provider Tata Sky and nine to Dish TV.

INSAT 3E – Indian National Satellite 3E

Launched: Sept. 27, 2003

Orbit: Geostationary

Lifespan: 14 years

Purpose: Communications/Earth Science

INSAT 3E carries 24 Normal C-band transponders providing an edge of coverage EIRP of 37 dBW over India; 12 Extended C-band transponders providing an edge of coverage EIRP of 38 dBW over India.

INSAT 4B – Indian National Satellite 4B

Launched: March 11, 2007

Orbit: Geostationary

Lifespan: 12 years

Purpose: Communications

INSAT 4B provides “direct to home” (DTH) television and telecommunications services primarily to India. It carries 24 transponders, 12 in the high-power Ku band. Nearly seven of them are used by DTH provider Sun Direct, and the other give to Doordashan’s DD Direct. Twelve transponders in the C band are for TV, radio and telecommunications.

INSAT 4CR – Indian National Satellite 4CR

Launched: Sept. 2, 2007

Orbit: Geostationary

Lifespan: 10 years

Purpose: Communications

INSAT 4CR carries 12 Ku band transponders and a Ku band beacon that aids satellite-based tracking. It is designed to provide DTH television, VSAT, and high bit-rate data transmissions. It is a replacement for INSAT-4C that was lost in a launch failure in June 2006.

Edusat (GSAT-3)

Launched: Sept. 20, 2004

Orbit: Geostationary

Lifespan: Seven years

Purpose: Communications

Edusat is built to serve the educational sector and allow for educational institutions to provide interactive distance education throughout the country. It enables internet, radio, and televised broadcasting and allows for audio-video interaction, audio-voice interaction, voice chat through the Internet and video conferencing. It carries five Ku-band transponders providing six spot beams; one Ku-band transponder providing a national beam; and six Extended C-band transponders with national coverage beam.

HAMSat (VUSat Oscar 52)

Launched: May 5, 2005

Orbit: Near Circular Polar Low Earth Orbit

Lifespan: Two years

Purpose: Communications

Hamsat is a microsatellite contributing to amateur radio (AHF and VHF) for Southeast Asia. ISRO points out the satellite can also play a vital role as a low cost, readily accessible means of communication during emergencies such as floods or earthquakes.

IRS-1D – Indian Remote Sensing Satellite 1D (inactive)

Launched: Sept. 29, 1997

Orbit: Sun-synchronous

Lifespan: Designated three to four years

Purpose: Earth observation

IRS-1D carried a combination of three cameras: i) a Panchromatic camera (PAN) with a spatial resolution of 5.8m, ii) Linear Imaging Self Scanner (LISS-III) operating in four spectral bands with spatial resolution of 23.5m in visible and near-infrared bands and 70.5m in short-wave infrared band and iii) a Wide Field Sensor (WIFS) with a ground resolution of 188-m. In addition to the Indian National Remote Sensing Agency in Hyderabad, data from the constellation of IRS satellites are reportedly sent to ground stations in the United States (Norman, Okla., and Fairbanks, Alaska), Germany, Dubai, Ecuador, Saudi Arabia, Japan, South Korea, Australia, Taiwan and Thailand under commercial agreements.

Oceansat-1 – IRS p4 (inactive)

Launched: May 26, 1999

Orbit: Polar sun-synchronous circle

Lifespan: Five years

Purpose: Remote Sensing

IRS-P4 carried an Ocean Color Monitor (OCM) and a Multi-frequency Scanning Microwave Radiometer (MSMR). OCM is a solid state camera operating in eight narrow spectral bands. The camera collected data on chlorophyll concentration, phytoplankton blooms, and atmospheric aerosols/suspended sediments in the water. MSMR operates in four microwave frequencies both in vertical and horizontal polarization, and collected

data on sea surface temperature, wind speed, cloud water content and water vapor content in the atmosphere above the ocean.

TES – Technology Experiment Satellite

Launched: Oct. 22, 2001

Orbit: Sun-synchronous

Lifespan: Three years

Purpose: Remote Sensing/Photo Reconnaissance

India's TES takes high resolution photos of anything more than three-feet in size at a one-meter resolution. TES can be used for mapping, geographical information, and "civilian use consistent with security concerns," according to an ISRO official. It has a panchromatic camera for remote sensing, and its successful launch made India the second country after the US to offer images with one-meter or less resolution. TES is considered dual use for mapping and Indian military purposes.

Kalpana-1 (Metsat-1)

Launched: Sept. 12, 2002

Orbit: Geostationary

Lifespan: Seven years

Purpose: Earth Science

Metsat-1 carries a Very High Resolution Radiometer (VHRR) that produces images of the Earth in visible, thermal infrared, and vapor bands at a 2 km resolution. It also has a Data Relay Transponder (DRT) that collects meteorological data from unattended platforms throughout India, and relays them back to the Meteorological Data Utilization Center in New Delhi. Metsat-1 can take pictures of cyclones, clouds and water vapor content in the atmosphere.

GSAT-2

Launched: May 8, 2003

Orbit: Geostationary

Lifespan: Seven years or more

Purpose: Communications/Technology Development

GSAT-2 is an experimental satellite that carries four C-band transponders, two Ku-band transponders, one MSS payload consisting of S-band forward link and C-band return link. It also carries a Total Radiation Dose Monitor (TRDM) that studies radiation around the satellite; a Surface Charge Monitor (SCM) examining the charging environment near the satellite; a Solar X-ray Spectrometer (SOXS) to study solar flare emissions; and a Coherent Radio Beacon Experiment investigating variations in the ionosphere.

IRS-P6 (Resourcesat-1)

Launched: Oct. 17, 2003

Orbit: Sun-synchronous

Lifespan: Five years

Purpose: Remote Sensing

Resourcesat-1 carries three cameras. The first is a high resolution Linear Imaging Self Scanner (LISS-4) with 5.8 m spatial resolution, a swath of 23 km that operates in the

Visible and Near Infrared Region (VNIR). It can also be operated in monochromatic mode providing a resolution of 5.8 m and a 70 km swath. It can also be steered across a track to take stereoscopic imagery. The second, a medium resolution camera (LISS-3), operates with a 23.5 m resolution and a swath of 141 km in VNIR, and in short-wave infrared. The third camera operates in three spectral bands in VNIR, and one band in short-wave infrared, with 56 m resolution and 740 km swath. The satellite also carries a Solid State Recorder that can hold 120 gigabits to store the images, and that can be read out later to ground stations.

CartoSat1 (IRS P5)

Launched: May 5, 2005

Orbit: Polar

Lifespan: minimum 5 years

Purpose: Remote Sensing

Cartosat-1 provides global remote sensing catering to terrain modeling and mapping, and can photograph objects smaller than a passenger car with a three-dimensional view. It carries two Panchromatic (PAN) cameras that take black and white stereoscopic pictures of the earth in the visible region of the electromagnetic spectrum. The swath covered by these high resolution PAN cameras is 30 km and their spatial resolution is 2.5 m. Near simultaneous imaging of the same area from two different angles is possible. This facilitates the generation of accurate three-dimensional maps. The cameras are steerable across the direction of the satellite's movement to facilitate the imaging of an area more frequently. The images taken by Cartosat-1 cameras are compressed, encrypted, formatted and transmitted to the ground stations. The solid state recorder it carries holds up to 120 gigabytes to store images.

CartoSat-2 (IRS P7)

Launched: Jan. 10, 2007

Orbit: Sun-synchronous Polar Orbit

Lifespan: Five years

Purpose: Remote Sensing

CartoSat-2 enables remote sensing and mapping and produces panchromatic images at one-meter resolution and a swath of 9.6 km. CartoSat-2 can produce images of down to 80cm in resolution, compared to 100cm offered by the U.S.-made Ikonos. The satellite can be steered up to 45 degrees along and across the track, and has a revisit period of up to four days. It also has a 64 gigabytes capacity for image and data storage.

Cartosat-2A

Launched: April 28, 2008

Orbit: Polar Sun Synchronous Orbit

Lifespan: Five years

Purpose: Remote sensing, mapping, terrain modeling

Cartosat-2A carries a Panchromatic camera providing images of a resolution better than one meter, and a swath of 9.6 km. The satellite can be steered up to 45 degrees along and across the track, and the data obtained can be used for mapping both urban and rural areas, as well as applications in Land Information System and Geographical Information

System. It can store 64 gigabytes. Some reports indicate Cartosat-2A is a dedicated military satellite, however ISRO does not indicate its mission is military in nature.

IMS-1

Launched: April 28, 2008

Orbit: Polar Sun Synchronous Orbit

Lifespan: Two years

Purpose: Remote sensing, experimentation

IMS-1, Indian Mini Satellite 1, carries a multi-spectral camera with a 37m resolution and a hyper-spectral camera with a 506m resolution. The satellite is being used as a platform for experimenting with new technologies, particularly those that miniaturize remote sensing technologies.

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Appendix 2

Organizations Influencing Indian Space Policy

Source: Dinshaw Misty, "India's Emerging Space Program," *Pacific Affairs* 71, no. 2, (Summer 1998) 151-174

The Department of Space (DOS) and its constituent organizations are all civilian, however it is noteworthy that the Space Commission, which is under the direction of the Minister of State and Prime Minister, is the ultimate budgeting and programmatic authority for DOS endeavors.

