Stakeholders in the Indian Strategic Missile Program

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Among all the developing states with aspirations for weapons of mass destruction and long-range power projection capabilities, India has achieved a unique degree of success. Outside the group of the five legally accepted nuclear weapon states and Israel, India perhaps harbors the most sophisticated nuclear weapons and long-range ballistic missile program in the world. India's ballistic missile program has matured to the extent that New Delhi can now deploy short- and medium-range nuclear armed ballistic missiles in an operational mode against Pakistan and China. Four decades of investment in an extensive nuclear weapons and missile-related research, design, development, and manufacturing infrastructure have also made these sectors less vulnerable to long-term disruption by technology denial regimes. More significantly, India's sophisticated civilian satellite launch capability makes it one of the few developing states theoretically capable of building an intercontinental ballistic missile (ICBM) within this decade.

India's missile program is marked by considerable successes in the last three decades. Beginning with relatively simple projects aimed at developing missile subsystems, the program has progressed to the limited serial production of actual weapon systems. Similarly, reverse engineering projects with the objective of "competence building" have given way to research and development (R&D) efforts aimed at building relatively sophisticated ballistic, anti-tank, surface-to-air (SAM), and cruise missiles. From the late 1950s until the end of the 1970s, the nucleus of India's missile efforts consisted of a handful of organizations and institutional actors mainly centered on missile laboratories and the prime minister's office (PMO). Thereafter, the nucleus expanded by building powerful alliances with the armed services, government-owned public-sector entities, private companies, sections of India's nuclear and space agencies, and semi-autonomous universities and research organizations. More significantly, the missile program has emerged as an icon of modern India's technological achievements. Within the last two decades, the missile program has also partially transformed the image of the Defense Research and Development Organization (DRDO), the Indian government's primary military R&D agency, from an institution that had a history of program failures to one that, in the minds of many, epitomizes organizational and technical excellence.

South Asia specialists and proliferation analysts use three main models to explain nuclear and missile proliferation in India. The first approach can be dubbed the "domestic factors" model. This model attributes nuclear proliferation in India to domestic factors such as national prestige, great power aspirations, the post-colonial project of modernity, and the need to exorcise the ghosts of colonialism.[1] A variant of the "domestic factors" model is the "organizational model." This model links the proliferation of nuclear weapons and strategic missiles to the role of the powerful scientific and industrial lobbies within the Indian government such as the Department of Atomic Energy (DAE), DRDO, and the Indian Space and Research Organization (ISRO). Analysts have dubbed these organizations as India's "strategic enclave" and identified their bureaucratic-organizational interests as central to the proliferation drive in India.[2] A third model, "realism," discounts the domestic and organizational approaches and explains India's nuclear and missile programs in strategic terms, as rational responses to potential nuclear threats from China and Pakistan.[3]

An empirical analysis or programmatic history of India's missile program suggests that each of the above three models represents a partial truth. Each of these models can explain certain facets and historical periods of India's missile program, but none of the models explains the program in its entirety. In essence, India's nuclear and missile programs are the sum total of domestic, organizational, and strategic factors. Further, the nature and goals of the missile programs have changed considerably in the past four decades. In the late 1950s, for example, domestic ideological factors such as self-reliance and the scientific lobby's organizational interests were the primary drivers behind the missile programs. Similarly, in the 1970s, national prestige, technology demonstration, and the DRDO's organizational interests remained the key determining factors behind India's missile-related efforts. However, from the early 1980s onward, strategic factors—especially perceptions of potential nuclear threats from Pakistan and China—played an increasingly influential role in determining the direction and pace of India's strategic missile programs.

The existing approaches fail to account for the historical shifts in the nature, direction, and goals of India's missile programs. Proponents of the domestic and organizational approaches discount the role of national security factors in shaping India's strategic choices. Likewise, the realists reduce India's missile programs to a linear technological progression against a background of predetermined strategic goals. As a result, the above models assume an air of ahistoricity; neither do they account for the overlap nor do they explain the trade-offs and compromises among competing ideological, organizational, and national security goals in different historical periods. Equally significant, they fail to account for the shift in the power and influence among the actors and institutions that determine strategic policy in India. As a result, the existing approaches offer partial explanations of the dynamics of India's missile politics.

In contrast to the above models, which attempt to fit empirics within existing top-down theoretical frameworks, this paper adopts a bottom-up model for analyzing India's missile programs. It uses available information in open-source literature to construct an historical narrative of India's missile program from the 1960s to the present. The narrative is then used as an empirical backdrop to identify the key constituents in India's missile program. The constituents are described as "stakeholders," denoting the actors, institutions, and entities that have ideological, organizational, and financial stakes in the missile program. The historical narrative is also used to draw the contours of the coalition among the strategic missile programs' principal stakeholders as well as the dynamics of its expansion in the past four decades.

The stakeholders approach to understanding India's missile politics offers three principal advantages over the existing models. First, it does away with the problem of ahistoricity and establishes a clear correlation between stakeholders' ideological and institutional interests in a given historical period with specific technological outcomes. Second, this model offers a more persuasive explanation for the evolutionary shift in the nature of India's missile programs from their symbolic, technological-demonstration, and prestige-seeking orientation in the 1960s and 1970s toward more tangible national security objectives in the last two decades of the 20th century. Third, by identifying organizational and institutional interests of the principal stakeholders and fleshing out the medley of narratives and motivations that drive India's missile programs, this model creates a framework on which to plot the future direction of India's missile politics.

This paper is divided into three sections. The first section identifies the key institutional structures, procedures, and political culture-related specificities that inform strategic decisionmaking in India. Section two constructs a systematic historical narrative of India's missile program from the 1960s to the present. Section three identifies and deconstructs the worldviews, philosophies, and organi-

zational-institutional interests of the principal stakeholders in India's strategic missile program at both the individual and collective levels. The paper concludes by tying the analysis together to identify the prevailing and emerging trends likely to shape India's missile program in the short and medium terms.

STRATEGIC DECISIONMAKING IN INDIA

Post-independence India opted for a federal system of government. Power and responsibilities are distributed among the federating states and the central government; national defense and external affairs are the responsibility of the federal or, in Indian parlance, "central" or "union" government. At both the central and state levels, India has adopted a parliamentary system of governance. The parliament is elected by the people directly; the political party or coalition of parties that gain a parliamentary majority form a cabinet system of government headed by the prime minister. The Indian president, like the British constitutional monarch, plays a ceremonial role and is usually bound by constitutional rules to accept the advice of the union cabinet.

Although India has adopted a parliamentary system of democracy, its executive branch (cabinet and prime minister) is almost presidential in nature. The parliament, beyond the ritual passage of the annual defense budget and the cursory debate that accompanies this passage, plays a marginal role in the shaping of India's defense policy. Defense policy is decided in the defense ministry, which is usually headed by a minister of cabinet rank and one or two junior ministers of state. During the past five decades, Indian prime ministers have sometimes retained direct control of the defense portfolio. The defense ministry makes major policy and administrative decisions related to long-term defense planning, weapons procurement from abroad, indigenous R&D programs, defense production and supplies, and management of the armed services. The defense ministry also controls the DRDO, India's principal defense R&D agency.[4] The head of DRDO serves as the scientific advisor to India's defense minister.[5]

Historically, however, critical decisions related to nuclear weapons, nuclearization, and development of strategic weapon systems such as ballistic missiles have been made by the prime minister and a small circle of advisors based in the prime minister's secretariat, the PMO. Until the end of the 1990s, the decisionmaking structure concerning strategic weapons was personalized and ad hoc and could include high-ranking civilian bureaucrats, select members of the cabinet including the defense minister, and the heads of DRDO and the atomic energy establishment; occasional invitees could also include the service chiefs of India's armed forces.[6] However, since the advent of the BJP government to power in 1998, strategic decisionmaking has become more institutionalized through a three-layered national security council.[7]

Until the 1990s, India's strategic decisionmaking process was also highly fragmented and secretive. Important decisions were made on an ad hoc basis by the prime minister without informing the union cabinet or parliament. Information about such decisions was restricted to a handful of individuals within the central government and often communicated verbally by the principals to their subordinates.[8] Similarly, budgets for clandestine strategic programs were sanctioned through discretionary funds controlled by the prime minister or through creative accounting methods, which hid budgets for nuclear and missile programs under different departmental heads.[9] Until the end of the 1980s, when the Indian government decided to launch a crash weaponization program, the development of such strategic weapons continued independently of one another.[10] Coordination among the departments of atomic energy, defense, and space on these programs was minimal.

However, defense reforms initiated by the BJP government in the post-1998 period have led to important changes in India's opaque and ad hoc decisionmaking structure. There is now greater institutionalization in defense decisionmaking, and different actors and agencies have been directly or indirectly incorporated in the decisionmaking process. The centralized and ad hoc decisionmaking structure of the past, which was centered in the office of the prime minister, is gradually paving the way for a more broad-based structure with space for political and institutional bargaining. The restructuring of the national security planning process within the central government has also put an end to the fragmentation in India's strategic programs. The above measures have not only improved India's national security planning and decisionmaking processes; more significantly, they have also created a systematic channel for interaction among the actors and institutions, which make up India's nuclear and missile coalition, within and outside the federal government.[11]

IDENTIFYING THE PRINCIPAL STAKEHOLDERS

With the benefit of hindsight, we can identify four principal stakeholders in India's missile program. As explained earlier, the term stakeholder denotes actors, entities, and

institutions that have a combination of ideological, bureaucratic/organizational, and economic stakes in India's strategic missile programs. These criteria allow us to classify stakeholders into four broad categories: politicians, the strategic enclave, the three armed services, and the lobby of strategic analysts. To be sure, under the above criteria, other actors and institutions such as the Ministry of Defense, public and private sector companies, and quasi-governmental research institutions could also be described as stakeholders. However, governmental institutions such as the Ministry of Defense have been excluded because strategic policy in India is almost exclusively the purview of the PMO and top civilian nuclear and missile scientists, with limited input from the armed services and strategic analysts. Similarly, although public- and private-sector companies and quasi-governmental research institutions have been identified as part of the expanding coalition of stakeholders, they have not been classified as a separate category largely because the majority of the government-owned companies and quasi-governmental research institutions engaged in strategic defense programs are directly or indirectly controlled by the strategic enclave. On the other hand, the role of private-sector companies in Indian defense programs is still limited. Further, in the absence of transparency, the precise degree of their participation in the missile programs is still not very clear.

In this paper, India's strategic missile coalition is described as "composite" in that each of the coalition's constituents comprises a separate group; and yet like the composite class of materials in which fibers of a reinforcing fabric are set in the matrix of another material, each stakeholder in the missile program is bound by a common glue of shared values to form a self-reinforcing coalition.

Politicians

The politicians, by virtue of having led India's anti-colonial movement against Britain and having established a constitutional civilian democracy, occupy the dominant position within India's composite coalition. The politicians' prestige has much to do with the leadership of post-independence Indian prime ministers. Until recently, a succession of prime ministers, especially the Nehru-Gandhis and their close circle of civilian advisors, set the ideological framework for India's foreign and defense policies and overall approach toward strategic weapon systems.

Despite India's being a parliamentary democracy, in practice, Indian prime ministers very nearly established a presidential system of government. From the mid-1960s on, the prime minister's office, which was originally created to coordinate policy among different government ministries, acquired greater powers and centralized power in the person and office of the prime minister. Centralized decisionmaking effectively reduced the power of the union cabinet and parliament.[12] As a result, critical decisions on India's strategic nuclear and missile programs were often made in the PMO, even though the actual implementation of decisions was delegated to individuals and specific ministerial departments.

The end of the Congress party's domination in Indian politics has resulted in the growth of coalition politics. The emergence of coalition governments at the national level has naturally resulted in a reduction in the powers of the prime minister. Institutional powers that were once appropriated by the PMO are gradually being restored to the cabinet and, to a lesser extent, parliament. But despite the re-growth of institutions in Indian politics, politicians (especially prime ministers and their top civilian bureaucratic advisors) dominate the strategic decisionmaking process in India.[13]

The Strategic Enclave

Although Indian political leaders have created an ideological framework for the development of an advanced technological and industrial manufacturing base, a small cross-section of key scientists from the country's nuclear, space, and defense sectors have played an influential role in steering those efforts toward the acquisition of strategic nuclear and missile capabilities. This group of scientists and the entities they represent are commonly termed India's *strategic enclave*.[14]

The enclave's principal organizational actors include the DRDO, DAE, and ISRO. Other actors include defense-related public-sector manufacturing units controlled by the departments of defense, space, and atomic energy. For political, ideological, and security reasons, the above organizations enjoy extensive patronage from India's political leadership. During the past five decades, each of these organizations has received generous budgetary support; according to one estimate, these organizations collectively consume nearly 60 percent of the Indian government's annual budget on R&D activities.[15] This high-tech sector is termed an *enclave* because it is kept insulated from the vagaries of day-to-day political activities. In relative terms, it enjoys a considerable degree of organizational autonomy and its activities are kept secret from the scrutiny of the parliament, media, and rival bureaucratic agencies.

Strategic Analysts

Strategic analysts constitute the third and perhaps the most vocal, public, and enthusiastic supporters of the DRDO's guided missile program. Although the strategic analysts do not have any direct organizational or financial stakes in the missile or nuclear weapons programs, they share the ideological worldview of India's political and scientific elites. The term *strategic analysts* applies to a broad category of analysts on foreign policy, defense, and strategic issues who occupy powerful positions in civil society institutions such as universities, think tanks, and nonprofit and media organizations. They mainly comprise journalists, academics, politicians, and legions of retired foreign service and defense personnel who have adopted strategic analysis as a post-retirement profession. The majority of individuals and institutions engaged in strategic analysis are based in New Delhi; in recent years institutions have also proliferated in regional centers such as Chennai and Bangalore.

The strategic analysts do not influence government policy directly; rather they influence policy indirectly through framing issues and molding public opinion. Although this influence may not seem as significant as direct participation in the government's decisionmaking process, its impact should not be underestimated. In India, policies on domestic, foreign, and defense issues are mainly shaped through debates in the national media. Influential individuals and institutions in civil society and government share a dialectical relationship: They reflect and influence each others positions. Furthermore, since 1998, the BJP has also attempted to incorporate sections of this lobby into the government through the institution of the National Security Advisory Board (NSAB).[16]

Armed Services

In the 1990s, India's armed services emerged as principal stakeholders in DRDO's missile programs. The armed services are anxious to take over the professional management of India's fledgling nuclear arsenal. Equally significant, their advocacy of nuclear weapons and related strike systems is fueled by interservice competition and rivalry with the civilian bureaucracy, which has historically controlled access to India's political leadership.[17]

Until recently, the armed services were rarely involved in strategic defense planning or policy decisions related to India's nuclear and missile programs. The exclusion of the military was largely the consequence of post-independence India's unique framework of managing civil-military relations. The politicians' fear of the proverbial "man on horseback" led to the separation of the armed services headquarters from the defense ministry. Gradually, the military was denied direct access to the political leadership and was forced to operate through civilian bureaucrats. Although the military regained autonomy over operations planning after the politicians' disastrous micromanaging of the border war against China in 1962, its role as an institution in planning grand strategy or long-term defense was curtailed. Politicians and their civilian bureaucratic advisors, including representatives of India's strategic enclave rarely advised or sought the armed services institutional advice on the direction of India's strategic programs.[18]

However, by the early 1980s, the consensus that had underwritten the above model of civil-military relations began to erode. An increasingly vocal coalition of civilian strategic thinkers, retired military, and foreign service officials argued that the existing model had outlived its utility. Critics pointed out that control of the military by the civilian leadership was essentially supposed to have meant the subordination of the military to the *civilian political leadership*. In the Indian case, this arrangement had metamorphosed into the subordination of the military to the *civilian bureaucracy.* The critics argued that the civilian bureaucracy was "generalist" in nature and lacked the specialized knowledge or institutional resources to manage national security and undertake long-term defense planning. Hence, there was an urgent necessity for redefining the relationship of the armed services within the federal executive branch.[19]

Further, as Indian democracy matured and democratic institutions began to take root, the fear of the man on horseback receded. While fears of a military coup were genuine during the 1950s and 1960s, the maturing of Indian democracy led to a renewed emphasis on the legitimate participation of the military in bargaining that took place within the executive branch of the federal government. In this new environment, the full-fledged participation by the military came to be viewed as a critical hallmark of a mature democracy.

The advocates of an overt nuclear posture also identified the exclusion of the military as one of the principal stumbling blocks in the path of seeking an operational nuclear capability. The proponents of overt nuclearization argued that so long as India's nuclear weapons capability remained symbolic, there was little necessity of directly involving the armed services in strategic decisionmaking. However, after India decided to weaponize its capability

and create an operational minimal deterrent, involving the armed services in the decisionmaking structure became imperative. The nuclear advocates berated the point that decisions related to weaponization, integration of weapons with delivery systems, storage, training, use, and secure command and control could not be made without the active and full-scale institutional participation of the military.[20]

In a belated acknowledgement of the above critique, India's ruling alliance has launched an ambitious effort to reform the framework of civil-military relations. The political leadership, in its eagerness to transform India into a nuclear weapon state, has also begun instituting measures that will directly involve the military in managing India's fledgling minimal deterrent. As a first step, armed services headquarters are being reintegrated into the defense ministry. The armed services chiefs now have direct access to the defense minister and the union cabinet through the revived Defense Minister's Committee and the Cabinet Committee on Security, respectively. The government is also planning on appointing a Chief of Defense Staff (CDS) who will formally command India's nuclear forces and render "single-point advice" to the union cabinet on nuclear issues. [21]

THE EMERGENCE AND EXPANSION OF INDIA'S MISSILE COALITION

Phase I (1955–1970): The First Steps

Phase I of India's missile program involved the design and development of first-generation anti-tank missiles. In the early 1960s, DRDO sold the idea of developing an anti-tank guided missile (ATGM) to India's Minister of Defense Krishna Menon and Prime Minister Jawahar Lal Nehru.[22] Subsequently, the DRDO and its principal missile laboratory, the Defense Research & Development Laboratory (DRDL), also secured political sanction to develop a three-ton thrust liquid-fuel rocket engine whose design was very likely based on the Soviet SA-2 sustainer motor.[23] The initiative for both projects appears to have emanated from DRDO. Indian scientists were convinced that missile systems would constitute principal weapon systems in future wars. They therefore made the case that India should invest in acquiring the scientific expertise and technological infrastructure to build modern missiles indigenously. As there were no plans for manufacturing missiles in India at this stage, the above missile-related R&D efforts were undertaken without solicitation of any formal advice or user requirement from the armed services.

However, both projects ended in failure. By 1969, DRDO was able to fabricate only a "500kg regenerative-cooling liquid propellant engine using kerosene and red fuming nitric acid as oxidizer," a far cry from the three-ton thrust engine originally envisaged.[24] Similarly, the project to develop a 1.6 kilometer- (km-) range, solid-motor, wire-guided, anti-tank missile faced significant technical obstacles and met considerable opposition from the armed services. The Indian Army was keener on importing state-of-the-art anti-tank missiles from abroad and had little confidence in the DRDO's ability to complete projects successfully. The Army also complicated the DRDO's task by changing the General Staff Qualitative Requirements (GSQR) for the anti-tank missile project midstream.[25] The ATGM project's other difficulties stemmed from the lack of adequate monitoring and tracking equipment. According to Indian scientists, the DRDO's inability to develop "foolproof non-destructive testing techniques" also resulted in "propellant defects" in the missile's "sustainer motor."[26]

Despite the overall failure of DRDL's efforts to develop an indigenous anti-tank missile, DRDO scientists claim that Indian laboratories imported and established facilities for "machining, tool making, injection, molding, assembly, inspecting, carpentry, and electroplating." These facilities gave India the technological capability to fabricate prototypes of gyroscopes, actuators, silver oxide-zinc batteries, booster and sustainer motors, air frame hardware such as fiberglass wings, ground launcher mechanisms, and wire spool winding and reeling mechanisms for first-generation anti-tank missiles.[27]

The anti-tank missile project was ultimately terminated in 1970, when India accepted a French offer to produce the first-generation SSIIBI anti-tank missiles under license from M/s Aerospatiale (Nord Aviation) for a period of 10 years. As part of the agreement, France also transferred the technology to produce SSIIBI missiles to a new Indian government-owned public-sector company, Bharat Dynamics Limited (BDL); BDL was expressly instituted in 1970 to produce missiles in India. [28]

During the late 1950s and 1960s, India's missile ambitions were mainly confined to first-generation ATGMs and the development of competency in designing liquid-fuel rocket engines. The push for both projects appears to have come from defense scientists in DRDO, who apparently convinced key political leaders and civilian bureaucrats of the value of investing in the development of a limited infrastructure for building modern missiles indigenously. It is unclear if the armed services were consulted prior to the inception of the projects. Although the issu-

ance of a GSQR for the anti-tank missile clearly suggests that the Army was involved in the project, the alliance between DRDO and the Army appears to be extremely weak. The Army was skeptical of DRDO's competence and indirectly sabotaged efforts by lobbying for imports and changing the GSQR once the project was launched. Despite some political and budgetary support within the PMO and defense ministry, alliances with the political leaders were not strong enough to permit sustained support for both projects. Ultimately, the DRDO's organizational and technological failures, India's limited manufacturing base, weak alliances with the politicians, bureaucrats, and the military, and the availability of technology from external suppliers led to the termination of both the liquid-engine and the ATGM projects.

Phase II (1971–1979): Symbolism and Technological Competence

Phase II of India's missile program roughly spans the decade of the 1970s. During this period, DRDO undertook two significant projects. The first, Project Devil, was an attempt to reverse-engineer the Soviet SA-2 surface-to-air missile.[29] The second, Project Valiant, was an ambitious attempt to develop a long-range ballistic missile.[30] Both projects apparently emanated from an alliance of scientists in DRDO, Prime Minister Indira Gandhi, and some of her influential bureaucratic advisors in the PMO and defense ministry.[31] Design competence and political symbolism were the primary objectives in both projects. For these reasons, and because of the peculiarities of India's civil-military relations, the armed services were apparently kept at the margins of the decisionmaking loop.

Project Devil was inaugurated in 1972 and opposed by the Indian Air Force. The Air Force had already acquired SA-2 batteries from the Soviet Union in the 1960s. The Air Force's waning interest in the SA-2 was partly the consequence of the missile's poor performance in the 1971 Indo-Pakistan war over Bangladesh (formerly East Pakistan). The Air Force's skepticism with the program also stemmed from DRDO's failure to develop a powerful gas turbine engine for the HF-24 Marut combat aircraft. For the above reasons, the Air Force regarded Project Devil mainly as a "technology gathering"[32] project and lobbied the Indian government to import the newer solid-fuel Pechora (NATO designation: SA-3 Goa) air defense missiles which were on offer from the Soviet Union.[33]

In undertaking Project Devil, DRDL adopted the philosophy of reverse engineering or "one-to-one substitution." The decision to reverse-engineer the Soviet SA-2 SAM was regarded as a means to acquire detailed knowledge of all the design parameters of a proven missile and to establish the infrastructure for the development of modern missiles in India in the future.[34] However, there were no plans to manufacture the reverse-engineered missile in India.

Toward the end of 1974, the Indian government appointed a technical audit committee to review progress of Project Devil. The committee consisted of scientists and engineers from ISRO and the Indian Institute of Sciences (IISc).[35] The committee met in early 1975 and concluded that DRDL had failed in its task. Committee member A.P.J. Abdul Kalam commented that, although DRDL accomplished the task of "hardware fabrication" and "systems analysis" in the design and development of the missile's "ground electronics," it needed to make more progress in the area of "liquid propulsion." The committee also noted that DRDL's philosophy of reverse engineering had taken precedence over the "generation of design data"; as a result, Indian missile engineers had been unable to make much progress in overall systems analysis. Despite the critical review, the committee recommended that DRDL be allowed to continue with the project.[36] India's defense ministry accepted the latter recommendation and continued to fund the project until it was shelved in 1980.[37] Despite the overall failure of Project Devil, DRDO sources insist that DRDL succeeded in developing two solid-fuel boosters and a three-ton liquid sustainer engine for the Devil missile.[38]

In 1971, Prime Minister Indira Gandhi directed the defense ministry and DRDO to explore the possibility of developing a long-range ballistic missile (8,000-km range with a 500-kg payload). Although the defense ministry was involved in the project, the Indian government apparently did not formally solicit the views of the armed services. As was the case with the 1974 "peaceful" nuclear explosion, the goal of the political leadership appears to have been to demonstrate India's competence in developing advanced technologies. Had pressing security considerations been paramount, the armed services and the atomic energy establishment would have been involved in the project.

Despite the enthusiasm of the PMO, several leading scientists and engineers in DRDL believed that India lacked the scientific, technical, and industrial base to build such a long-range missile. The scientists felt that they could perhaps build a 1,500-km-range ballistic missile within six to eight years if given access to unlimited financial and manpower resources. But even a missile of

this range was considered overambitious.[39] The design engineers and scientists at DRDL ultimately proposed a three-stage design for a long-range ballistic missile capable of delivering a 500-kg payload over a range of 8,000 km. Stage one would comprise a cluster of four 30-ton liquid-fuel engines, stage two would comprise two engines, and stage three likely would consist of one engine. Indian scientists reportedly hoped to use a scaled-up and modified version of the SA-2 liquid engine for the Valiant's propulsion.[40]

However, technological difficulties and inter- and intra-organizational differences hampered the Valiant project. For example, S.L. Bansal, Valiant's project director, believed that DRDL head V.S. Narayanan was far more focused on the Devil program.[41] Sometime in 1973 or 1974, due to faltering progress and insufficient interest in the Valiant program, the union cabinet requested the defense minister's scientific advisor Dr. Nagchaudhuri to explore whether the liquid-fuel engine under development for the Valiant program could be used by ISRO for the civilian satellite launch vehicle. During a meeting of DRDL and ISRO officials at IISc in Bangalore, ISRO rejected the liquid-fuel engine, citing its own efforts in developing solid motors. The IISc's aeronautical department also appraised the DRDL's efforts critically and cited "instability problems" in the Valiant's liquid-fuel engine. The Valiant program was subsequently terminated.[42]

Although DRDO failed to achieve any of its original objectives, the experience gained in developing the liquid-fuel engine may well have helped India in its ballistic missile development efforts in the 1980s. More significantly, from 1972 to 1982, DRDL imported the infrastructure for designing, developing, testing, and building guided missiles. This included "aerodynamic, structural, and environmental test facilities, liquid- and solid-propulsion test facilities, fabrication and engineering facilities, [and] control, guidance, rubber, and computer facilities."[43]

Despite the relatively increased financial and political support for the missile program and some involvement by government-owned public-sector entities in missile-related activities, DRDO was unable to build a broader coalition by enlisting the cooperation of either ISRO or the military leadership.[44] ISRO and DRDO competed with one another for increased funds and attention from the political leadership. Instead of pooling resources to capitalize on their respective organizational and technical strengths, both entities followed different technological trajectories. Similarly, the lack of participation of the armed forces in the research, design, and development phases also contributed to the overall failure of the missile efforts.

The program narratives of the Devil and Valiant projects suggest that both were guided by rationales having little to do with national security. When Project Devil was launched in the early 1970s, the Indian Air Force already had access to advanced SAMs; at the time, more sophisticated systems were also on offer from the Soviet Union at "friendship prices."[45] Reverse engineering might thus have had the effect of helping India develop a capability for indigenous research, design, and development of such missiles in the long term. However, the Indian government had no overwhelming security requirement to invest in such a capability.

Similarly, had national security requirements—particularly the much-touted Chinese nuclear threat—been paramount in the 1970s, it could be presumed that the Indian government would have pooled the organizational and technological resources of ISRO and DRDO to produce a long-range ballistic missile. However, both organizations followed different technological paths. ISRO focused on developing solid-fuel motors, while DRDO invested in the development of liquid-fuel engines. The pursuit of multiple paths was not a strategic technological choice, but rather a consequence of two competitive organizations acting independently of one another. Further, had national security concerns been significant, the armed services and especially the DAE, which at the time was working on a nuclear explosives project, would certainly have been consulted on the project to develop a long-range ballistic missile. However, throughout the 1970s, India's nuclear, civilian satellite launch vehicle, and ballistic missile programs continued independently of one another. The organizational and technological resources of India's strategic sector remained fragmented, and neither the political leadership in the PMO nor defense ministry made any attempt to achieve any form of integration. [46]

Furthermore, the PMO's original request to develop an 8,000-km-range ballistic missile capable of delivering a 500-kg payload was bizarre. If nuclear threats from China were the supreme concern, then India would have required only an intermediate-range ballistic missile with a range between 4,000 km and 5,000 km to hold targets hostage in China.[47] In this regard, India's first nuclear device was developed without any reference to the ballistic missile program. The nuclear device that was tested in May 1974 weighed several tons; it was large, unwieldy, and could be delivered only by a transport aircraft.[48] Therefore, the proposed Valiant missile could not have served as a po-

tential nuclear weapon carrier unless the Bhabha Atomic Research Center (BARC) succeeded in coordinating efforts with DRDL to build a more sophisticated and miniaturized nuclear device. The above factors indicate that the Valiant program was guided by reasons of organizational and political prestige, symbolism, and the development of technological competence in accordance with India's post-colonial philosophy of indigenization, self-reliance, and autonomy.

Phase III (1980–1994): Technology Demonstration and Creation of Operational Missile Systems

The Indian government revived the flailing missile program in 1980, and in 1983 it launched the Integrated Guided Missile Program (IGMDP) to develop a family of strategic and tactical guided missiles.[49] The years 1980–1994 marked a crucial turning point. During this period, India's forays into missile building were transformed from technology gathering, reverse engineering, and design competence, into a full-fledged program to build a series of operational missile systems. DRDO not only succeeded in developing a wide spectrum of technologies, but it also harnessed a broad coalition of institutional actors, which finally allowed the missile program to attain a degree of organizational and technological sophistication that earlier it had lacked.

In 1981, Dr. A.P.J. Abdul Kalam was appointed director of DRDL. Kalam was earlier director of ISRO's successful satellite launch vehicle project (SLV-3).[50] Kalam's shift to DRDO was indicative of an effort to revamp DRDL's management structure after the more dynamic and successful example of ISRO. But even more significantly, it marked the initiation of a process of breaking down the organizational and technological barriers that separated ISRO and DRDO. This was a significant development as, until the end of the 1970s, ISRO had jealously guarded its organizational autonomy and resisted participating in defense programs. ISRO's senior management was obviously aware that technologies developed for the civilian satellite launch vehicle program were essentially "dual-use" and could be deployed to develop ballistic missiles. However, ISRO avoided the atomic energy establishment's model of buttressing the civilian program through a weapons-related effort.[51] After the 1974 nuclear test resulted in sanctions on India's nuclear sector, ISRO feared that technology denials might jeopardize India's fledgling satellite launch vehicle program. However, Kalam's transfer to DRDO and the Indian government's decision in 1983 to launch the Agni technology demonstration program using the civilian SLV-3 first-stage motor indicate a partial commitment on the part of India's political and civilian bureaucratic leaders to harness technologies developed ostensibly for civilian purposes, for a military program.

The third phase of India's missile program was also characterized by more sustained political support, which was reflected in the scale of the IGMDP. For example, the IGMDP involved the development of five missile systems: a short-range ballistic missile (Prithvi); a medium-range technology demonstrator (Agni); a multi-role, short-range, surface-to-air missile (Trishul); a long-range surface-to-air missile (Akash); and a third-generation, anti-tank, guided missile (Nag). In initial presentations before the defense ministry, the DRDO made a case for developing the tactical surface-to-air missile and the 150-km-range ballistic missile in the first stage of the project, to be followed by other systems later. However, India's defense minister R. Venkataraman persuaded DRDO to undertake all five projects simultaneously.[52] Support from the political leadership was followed by generous budgetary provisions.[53] Both trends constituted a marked departure from the past and allowed DRDO to invest in a modern missile infrastructure which, over the span of two decades, gradually reduced its dependence on both ISRO and external suppliers.

As Kalam and his team revamped the management structure at DRDL, they made careful technology choices to capitalize on the lab's existing strengths and avoided mistakes that had contributed to the failure of the Devil and Valiant programs in the 1970s. In the early 1980s, Indian missile engineers and scientists debated the trade-offs between liquid-fuel engines and solid-fuel motors in missiles. The solid-fuel lobby argued that solid-fuel motors were simpler in design and easier to maintain; unlike liquid-fuel engines, they have no pumps and valves. Solid-fuel proponents also maintained that liquid fuels are toxic, require complex handling, add to the logistics chain, and prolong launch operations in the field by as many as 12 hours. However, the liquid-fuel lobby argued that the poor conditions of Indian roads made the solid-fuel in motors susceptible to cracks, which could lead to catastrophic failures. In addition, liquid-fuel engines would offer a greater elasticity in range, as the engine could be shut off by turning off the propellant supply as opposed to the complex thrust termination technology required in solid motors. At the time, India lacked both flex-nozzle and solid-fuel thrust termination technologies and would have

had to devote considerable financial and organizational resources to develop them. [54]

DRDO's senior management decided that, in the event that it chose to build the SSM 150 and SSM 250 (Prithvi-I and -II) using liquid-fuel engines, it could use the Prithvi engine in the second stage of the Agni technology demonstrator program. These choices were dictated by DRDO's organizational rivalry with ISRO and the fact that DRDL had considerable experience with the SA-2's liquid-fuel engines. For example, DRDL had developed liquid-fuel engines for both the Valiant and Devil programs in the 1970s. By drawing on some of the technologies developed in the past, DRDO was able to avoid program delays and cost overruns, factors that helped consolidate its alliance with the political leadership. In this regard, design choices for the Prithvi and Agni programs were driven by DRDO's organizational interests. In the early 1990s, when the Indian Army hesitated to purchase the liquid-fuel Prithvi, citing problems related to the missile's short range, fuel toxicity, and logistics train, DRDO used its clout with the political and bureaucratic leadership to force the Army to accept the missile.[55] In retrospect, the development of the all solid-fuel Agni-II and the short-range single-stage Agni-I toward the latter half of the 1990s suggests that the Prithvi was probably a stop-gap measure until such time that DRDO was able to design more sophisticated and longer-range solid-fuel missiles.

Apart from technical reasons, one of the key organizational reasons for the failure of India's missile programs in the past was the poor interaction between the DRDO and actual user services such as the Army and Air Force. The armed services were generally skeptical of DRDO's attempts to develop advanced technologies and weapon systems indigenously. The Army and Air Force were also unenthused about DRDO's efforts at reverse engineering existing weapon systems and technologies and preferred proven imports over indigenous designs. DRDO's projects were often characterized by shoddy design, poor workmanship, systems integration problems, program delays, and cost overruns, factors that prevented the development of a robust alliance between DRDO and the armed services.[56] In turn, DRDO accused the armed services of indirectly sabotaging domestic R&D efforts by lobbying for imports, making impossible technical demands, and often changing the GSQR midway through projects.

However, in developing the IGMDP, DRDO tried to secure the cooperation of the armed services by offering to develop missile systems that would be comparable to the best in their class. Representatives from the user services and relevant public-sector companies were invited to participate in the top, middle, and lower management rungs of all missile programs. This measure was taken to ensure adequate coordination between the R&D agencies, producers, and actual users in the field. Instead of developing all the technologies in-house, Kalam and his team decided to opt for the consortium approach and collaborate with private-sector companies and research institutes at universities outside the government. Experts from ISRO were invited to provide an informal pooling of knowledge for the missile program. [57] In another change in program management, DRDL adopted the "concurrent engineering" model of development and production. Under this model, once the commitment of the user and flexibility of the weapon system are established, the program of development, user interaction, industry interaction, and actual production are tightly coupled to minimize the time-gap between development and final serial production.[58] However, the development history of IGMDP suggests that the concurrent engineering model was overambitious and was never implemented in practice.

By the late 1980s, DRDL succeeded in conducting flight-tests of both the Prithvi and Agni.[59] The technical significance of these tests aside, they also caught the imagination of Indian political leaders, nuclear lobbyists, and the middle class. More importantly, the initial flight-tests proved that DRDO, which in the past had been unable to overcome technical and organizational hurdles to develop sophisticated weapon systems, was now capable of designing weapon systems of strategic significance. Unlike the 1970s, when the Devil and Valiant programs were kept under wraps, the IGMDP was surrounded by a blaze of publicity. Missile flight-tests, especially those of the Prithvi and Agni, became national media events. Kalam emerged as a national hero and sold the IGMDP to the political elite and the middle class as a symbol of India's technological and organizational excellence. Equally significant, the publicity and success of the Prithvi and Agni programs reinforced arguments from India's vocal nuclear lobby that India should opt for an overt nuclear posture and deploy operational nuclear forces.

By the end of the 1980s and early 1990s, the scale of the IGMDP expanded enormously. Besides the DRDL, 19 other defense laboratories, 21 public-sector organizations, and 6 private-sector companies participated in the program.[60] DRDO also developed competence in the areas of solid propellants, composites, and advanced metallurgy. It developed a state-of-the-art infrastructure for design-

ing and building modern missiles.[61] The facilities at DRDL were expanded and refurbished, and a new model research center with advanced technical facilities was built near the Imarat Kancha area near Hyderabad. The new facility, named Research Center Imarat, included an "inertial instrumentation laboratory, full-scale environmental and electronic warfare test facilities, a composites production center, a high enthalpy facility, and a state-of-the-art missile integration and checkout center."[62] In addition, DRDO established a dedicated test range on India's east coast in Orissa to track and test long-range missiles, air defense missiles, high-G maneuverable missiles, weapon systems delivered by aircraft, and multi-target weapon systems.[63]

By the late 1980s, India's missile coalition had expanded and consolidated its position significantly. Despite DRDO's discouraging track record and history of program failures, Indian leaders backed the IGMDP and sanctioned generous budgetary support for the project. Equally significant, the central government began to take steps to end the fragmentation within India's high-tech strategic sector. Thus the Agni program used technologies developed by ISRO for the SLV-3. DRDO was also able to use ISRO's Sriharikota range for testing missiles until the completion of its own test range in Orissa.

The armed services appear to have supported the IGMDP for reasons of their own. Support for the SAM and ATGM projects was probably premised on the assumption that development failures could be overcome through the time-honored practice of imports. But in the case of the Prithvi, support might have hinged on the Army's and Air Force's attempts to gain control over a weapon system that could be used for the delivery of nuclear weapons. This does not seem to be the case with Agni, which during the 1980s was largely viewed as a technology demonstration project; therefore neither the Army nor the Air force issued a GSQR for the Agni.

The narrative of the IGMDP also suggests that in comparison to support for the Devil and Valiant, national security factors played a greater role in determining political support for the Prithvi and Agni programs. Both programs coincided with the revival of the nuclear weapons project by Prime Minister Indira Gandhi after she returned to power in 1980; her government also came close to authorizing nuclear tests in the early 1980s.[64] However, the Prithvi and Agni could not possibly have been viewed as ideal nuclear delivery vehicles. The Prithvi had a 150–250-km range and was Pakistan-specific.[65] During a crisis, its short range necessitated deployments close to the border, which made it vulnerable to a preemptive strike. The missile's toxic fuel and large logistics train also created additional difficulties, besides making missile batteries vulnerable to early detection and destruction. Similarly, the Agni was a hybrid system that combined solid- and liquid-fuel propulsion systems; the Agni could not conceivably have been deployed in an operational mode, except in a grave national emergency. Further, the Agni's range of 1,400 km gave it limited utility against targets in Northern and Central China.[66] Therefore, in retrospect, it becomes apparent that the Agni served as a technology demonstration project that fit within the Indian government's broader "nuclear options" policy. In essence, the Agni program was used as a building block for more advanced missile systems in the future.

Phase IV (1995-2003): Limited Serial Production

The fourth phase of India's missile program stretches from the mid-1990s to the present. This phase has been characterized by partial success of the IGMDP, limited-series production of the Prithvi and Agni ballistic missiles, and overall consolidation of DRDO's alliances with the political elites, civilian bureaucracy, armed services, and public- and private-sector entities. In this period, the missile program progressed from a development and user trials phase to limited series production.[67] As a result of the armed services commitment to actually purchase indigenous missile systems, DRDO was finally able to shift its focus from demonstrating technology to modifying missile systems to meet the field requirements of the user in terms of deployment and operability. Capitalizing on its successes with the Prithvi and Agni, DRDO embarked on programs to develop a sea-launched ballistic missile (Sagarika), a cruise missile (BrahMos), and a naval variant of the Prithvi (Dhanush) and sought external collaborations with Israeli and Russian entities to provide India with its first anti-tactical ballistic missile system.[68]

By the mid-1990s, the Army version of the Prithvi had completed user trials and entered limited series production at Bharat Dynamics Ltd.[69] Similarly, user trials of the Air Force version of the Prithvi continued until 1999, and it is unclear if the latter has entered serial production.[70] The politicians and civilian bureaucrats in the PMO and the defense ministry persuaded a reluctant Army and Air Force to accept the Prithvi despite its design deficiencies. The ability of DRDO to persuade the armed services to accept the Prithvi marked an important first

in India's efforts to develop weapon systems indigenously. This was the first instance in post-independence India's history when the armed services had accepted a major weapon system of strategic significance designed and developed by DRDO.

One reason for this acceptability was that comparable strategic systems were not available from abroad.[71] But the other more critical reason had to do with the Indian government's decision to launch a crash nuclear weaponization program in the late 1980s. This decision gave a boost to the DRDO's missile program as at the time—with the exception of the Air Force's Mirage 2000, Jaguar, and MiG 27 aircraft, the Prithvi was India's sole alternative means for the delivery of nuclear munitions.[72]

The decision to modify the Prithvi as a nuclear weapon carrier contributed to the consolidation of the missile program in three ways. First, it strengthened political and budgetary support for the Prithvi and the longer-range Agni technology demonstration programs. Second, it produced a change in the attitude of the armed services. The Army had earlier opposed the Prithvi on grounds that it was not cost-effective as long-range artillery. The Air Force also feared that conventionally armed ballistic missiles were a long-term threat to the supremacy of its manned combat aircraft. However, both services now became supporters of the ballistic missile program due to inter-organizational rivalry over control of India's proposed nuclear deterrent.[73] Third, the necessity of weaponizing nuclear devices and configuring them for delivery on aircraft and ballistic missiles strengthened the historic links between DRDO and the influential nuclear establishment.[74]

In 1994, the Agni technology demonstration program reached an interim conclusion after two flight tests, which validated India's re-entry vehicle technology. Despite considerable political pressure from the United States on India to freeze the ballistic missile program, DRDO successfully secured political and budgetary sanction to proceed with the second phase.[75] The second phase of the program involved the development of all solid-fuel, longer-range, and rail- and road-mobile versions of the Agni.[76] The success of the DRDO's efforts to consolidate its alliances was evident not only from the political support that it received from the politicians and the armed services, but also from rival organizations such as ISRO. In the 1980s, ISRO had limited its participation in the Agni technology demonstrator program, citing time and organizational constraints. However, by the mid-1990s, ISRO agreed to design a solid-fuel second stage for the successor Agni II.[77]

DRDO's missile programs received an enormous boost with the advent of the BJP government to power in March 1998. While previous Indian governments had approached the question of nuclearization with trepidation and sought refuge behind the fog of opacity, the Hindu nationalists led by the BJP had long favored overt nuclearization. Soon after gaining power, in a rapid succession of events, the BJP authorized nuclear tests (May 1998), proclaimed India's status as a nuclear weapon state, and declared its commitment to a "credible minimum deterrent." These decisions were followed by substantial budgetary increases for the strategic nuclear and missile programs.[78]

The BJP also initiated other far-reaching defense reforms, which indirectly helped consolidate the nuclear and missile programs. As a first step it decided to initiate measures to end the artificial separation of the armed services headquarters from the defense ministry. The armed services, which earlier for political reasons had been kept at the fringes of national security planning, were now allowed limited participation in the nuclear decisionmaking process. The reintegration of the armed services was considered significant for professionalizing national security planning; it was also considered vital to facilitate the task of creating an operational nuclear force. However, it also opened the door for inter-service rivalry between the Army, navy, and Air Force for control of India's nuclear deterrent, which effectively gave each service an institutional stake in DRDO's strategic missile programs.[79] Similarly, the BJP's decision to accommodate the nuclearization project's supporters outside the government through the institution of the NSAB, provided DRDO's strategic programs added legitimacy.

The above factors have resulted in the emergence of a multi-faceted alliance with the DRDO and its missile laboratories at its core. India's strategic missile program enjoys support from a coalition of actors which include politicians, armed services, and the strategic elite. From the 1970s, DRDO has managed to expand this alliance to include government-owned public-sector entities, private-sector companies, semi-autonomous R&D centers, and universities. The missile programs have also caught the imagination of India's vast middle class, and DRDO has indirectly exploited popular support from the voting public to strengthen its bargaining position within the government.

However, despite this widespread support, not all parts of the missile program have met with an equal degree of success. Of the five projects that were launched under the IGMDP in 1983, the Prithvi and Agni ballistic missile

programs were the most successful. This success was largely due to the fact that they were able to draw on the liquid-fuel engine technologies developed during the 1970s and to ISRO's success with the SLV-3, which was reconfigured for the Agni technology demonstrator. The success of the Prithvi and Agni ballistic missile programs helped support less successful efforts to develop the short- and long-range surface-to-air missiles (Trishul & Akash) and the third-generation anti-tank missile (Nag).[80] More significantly, the successes of the Prithvi and Agni programs masked failures of DRDO's other big ticket items: Main Battle Tank, Light Combat Aircraft, and airborne early warning radar, which became increasingly bogged down in technological, organizational, and systems integration bottlenecks. As a consequence, the DRDO, like the DAE, has increasingly come to rely on islands of excellence to sustain itself organizationally.

WORLDVIEW AND IDEOLOGY OF INDIA'S MISSILE COALITION

India's missile coalition is a black box of ideological and institutional interests. Modern missile systems have different meanings for the conservative politicians, the strategic enclave, strategic analysts, and the armed services that collectively form this composite coalition.

Conservative politicians regard strategic weapon systems as a symbol of a resurgent and assertive India. They view modern missiles as an essential tool for national identity construction. Missile artifacts serve as a means to fortify the Indian state and restore its primacy as the guardian of modernity, security, and stability in an increasingly fractionated polity suffering from a crisis of governance. For the strategic enclave, the nuclear and missile programs constitute icons of technological and organizational excellence. The limited success of India's nuclear and missile programs cover up the enclave's other corporate failures and provide a means to build coalitions with the politicians and armed services. To the increasingly vocal body of strategic thinkers in locations of influence inside and outside the government (national security council, mass media, think tanks, and universities), the development of a "credible minimal deterrent" has become a means for jettisoning Nehruvian idealism in favor of a realist strategic culture. And finally, India's armed services have found a place in the nuclear coalition for the first time since India won independence in 1947. The armed services are concerned about potential nuclear threats from Pakistan and China and are anxious to take over the professional management of India's fledgling deterrent. More significantly, the armed services' interest in long-range delivery systems is fueled by intra-service competition and rivalry with the civilian bureaucracy, which in the post-independence era has controlled access to India's political leadership.

The Political Elite

India's political elite can broadly be classified into three groups: (1) Nehruvian secularists, (2) Hindu nationalists, and (3) leftists. In the first four decades after independence, Nehruvian secularists dominated Indian politics. They set the political, economic, foreign policy, and overall ideological agenda, which created a framework for India's defense policies and approach toward nuclear weapons and strategic strike systems. However, since the mid-1980s, the post-independence Nehruvian consensus has given way to a gradual shift toward the political right in Indian politics.[81] As a result, the moderates among Hindu nationalists have supplanted the hegemony of the Nehruvian secularists. In certain critical aspects of economic, defense, and foreign policies, the views of the Nehruvian secularists are often indistinguishable from the moderate Hindu nationalists. Hence, there is a consensus in Indian politics on issues of strategic concern.[82] Although the left-wing political parties and groups and their extreme right-wing counterparts hold views that run counter to this prevailing consensus, their current influence in the Indian polity is marginal.

Despite their degrees of political separation, the Nehruvian secularists and moderate Hindu nationalists stand united around the themes of modernity, sovereign equality of nation-states, and strategic autonomy. In India's post-colonial narrative, the project of modernity pertains to the replication (with local variations) of Western paradigms of political organization; economic, technological, social, and aesthetic development; and national security management. The majority among India's political elites regard modernity as the vehicle that will ultimately end India's "underdeveloped" status and propel it into the ranks of the great powers.[83]

Notwithstanding New Delhi's obvious economic and military deficiencies, Indian leaders tend to view India as a political co-equal among other great powers in the international system. Although their current claims to equality are founded on Westphalian legalism, India's historical antiquity, population size, successful experiment with democracy, and record of active participation in

multilateral institutions, Indian leaders hope that after the current transitional development period, India will be able to draw on the hard elements of power: economic size, technological infrastructure, strategic deterrent, and a regional power projection capability. The latter attributes would not only strengthen New Delhi's case for permanent membership to the UN Security Council, but also secure a place for India on the high table with other great powers.[84]

The Nehruvian secularists and Hindu nationalists also share a common belief in the concept of strategic autonomy. Leading Indian political leaders and foreign policy commentators have articulated the concept of strategic autonomy as the successor to India's Cold War foreign policy paradigm of nonalignment. Strategic autonomy entails the development of critical economic, technological, and military capabilities that will allow India relative autonomy of action in pursuit of its self-perceived strategic interests in the international system. Unlike nonalignment, which attempted to steer India clear of debilitating bipolar Cold War rivalries and power struggles, the notion of strategic autonomy is predicated on the self-fulfilling belief that India should invest in the requisite strategic capabilities to ensure global stability as one of the major power centers in an imagined multipolar world.[85]

However, beneath this consensus lie two competing world views. The first, which is the Nehruvian viewpoint, can be contextualized in India's colonial experience. It traces India's colonization to the technical superiority of British arms and the organizational failures on the part of domestic ruling elites. For the majority among Nehruvian-secularists, the most horrific impact of colonial rule was that it transformed pre-industrial India into a source of raw material for British industry and a captive market for finished industrial products. The profits that accumulated to British industry through such politically determined unequal trade perpetuated the "development of underdevelopment" in colonized societies such as India. The Nehruvian project of modernity is thus aimed at redeeming India's nationhood, which was abused by the colonial experience. Its central goal is to provide Indian society with a modicum of material prosperity and dignity. By the same token the Nehruvian-secularists regard the acquisition of nuclear arms and long-range missiles as necessary to safeguard the strategic frontiers and political ego of the Indian state, and by its extension, that of the Indian peoples.[86]

The Hindu nationalists view things differently and reference Indian history in civilizational terms. They regard nuclear weapons and related technological artifacts as a symbolic link to a mythical Hindu golden age that was interrupted by nearly ten centuries of benightedness imposed by Islamic rule. The Hindu nationalists also harbor self-perceptions of historical victimization. In their worldview, Hindus have repeatedly suffered mayhem, destruction, and conquest at the hands of Greek, Islamic, and Christian invaders successively. In their view, the post-colonial Indian state's decision to empower itself through the acquisition of a nuclear deterrent has both defensive and moral imperatives. It is defensive because it will ensure that the Hindu civilization, which has braved nearly five millennia of invasions and conquests, will survive into the next. Similarly, it also has a moral imperative because the Hindus alone among all other civilizations have never harbored aggressive tendencies toward others. [87]

Despite these differences, at a domestic level, the Nehruvian secularists and moderates among Hindu nationalists share two other themes in common. Both groups draw on the symbolism associated with nuclear weapons and long-range strike systems to buttress the authority, supremacy, and legitimacy of the Indian state. Again, this has something to do with historical legacies. Historically, from antiquity onward, the Indian polity alternated between strong centralized governance and political chaos resulting from disintegration and the weakening of the central political authority.[88] Hence the proprietorship of the supreme symbols of power (nuclear weapons and missiles) of the industrial era, reinforces the dominance of the central government against all other competing centers of authority and power within the Indian polity. It also allows the Indian state to appropriate resources and aggrandize power with the goal of producing national security goods for the common good, which is a critical function in the enterprise of state and nation building.

Equally significantly, such symbolism masks the widening chasm between power and security in Indian society. In the five decades since independence, although the Indian state has acquired greater and more lethal legal and physical instruments of power, it has been unable to transmit their benefits at the societal level through means of enhanced security. On the one hand, India's internal crisis of governance, a consequence of corroding institutions and increased demands on the political system due to political mobilization, has eroded the ability of the central and state governments to enforce the "negative" security rights guaranteed to Indian citizens under the constitution. On the other, India's mixed record of develop-

ment has stymied the efforts of the state to help Indian people attain self-fulfillment through the achievement of "positive" security rights. In the face of this partial success, Indian politicians have resorted to using nuclear weapons and missiles as security metaphors with the objective of shoring up the eroded legitimacy of the state and renew the post-independence social contract with the Indian people.[89]

Ironically, India's extreme right-wing Hindu nationalist and left-wing political groups stand united in opposing this consensus from the opposite ends of the ideological spectrum. Whereas the extreme right-wing groups favor a maximalist nuclear posture, the left-wing groups vilify nuclearization as a project that symbolizes the colonization of India's political conscience. The latter also accuse mainstream political elites of blindly replicating the hegemonic development and national security models of the more advanced capitalistic societies and thereby forfeiting post-independence India's original philosophy of establishing a more humane, equitable, moral, and just international order.[90]

The Strategic Enclave

Members of the strategic enclave, especially the DRDO, have a principal stake in the missile program. The DAE is also a major stakeholder in the development of nuclear delivery systems as the latter are critical for the overall success of its nuclear weaponization process. Historically, the Indian government kept the DAE's nuclear weaponization efforts and DRDO's program to develop strategic missile systems on parallel tracks. Both organizations began cooperating only in the late 1980s, after the Rajiv Gandhi government decided to launch a crash weaponization program. The one agency that resisted participation in the missile program in the 1960s and 1970s—ISRO—is now a partial stakeholder in the missile program. However, ISRO remains primarily focused on the development of civilian space programs.

Four major themes inform the worldview of the scientists in India's strategic enclave: the notion of development leading to parity with other scientific elites, organizational and technological excellence, indigenization, and self-reliance.

Members of India's strategic enclave regard the development of nuclear weapons and related delivery systems as symbols of a developed society. The notion of development, of course, is not confined to strategic weapon systems alone. It also extends to advanced conventional weapons, satellite launch vehicles, satellites, parallel computing, information technology, biotechnology, advanced materials, and other state-of-the-art industrial and manufacturing technologies that constitute the project of modernity. However, the development of nuclear weapons and strategic missile systems assumes added significance in India, as they are perceived as the supreme symbols of power in the industrial era. The creation of complex technological and organizational systems to produce them also places Indian scientific leaders at par with their peers in the most advanced industrial societies of the world.[91]

India's strategic missile programs have also helped the DRDO reinvent itself and safeguard its organizational interests. This is significant because historically, until the launch of the IGMDP in 1983, the DRDO had very little success in completing major defense projects. Since the 1960s, all major defense programs have ended in failure. Some examples of these failures include the Marut HF-24 combat aircraft, Light Combat Aircraft, Arjun Main Battle Tank, airborne early warning radar system, and the Pinaka multi-barrel rocket launcher. The above programs have either been terminated or allowed to continue for purposes of technology gathering and competence building.[92] In this regard, the relative success of the strategic missile program in the 1980s and 1990s helped the DRDO's organizational interests in four ways. First, it helped DRDO build sustainable alliances with the armed services and the political leadership. The Prithvi and Agni missiles are the first major weapon systems that have gained the acceptance of the armed forces. Second, the creation of nuclear delivery systems helped cement the DRDO's alliance with India's powerful nuclear bureaucracy. Third, the success of the strategic missile programs—Prithvi and Agni—helped mask the development problems related to the IGMDP's other programs—Akash, Trishul, and Nag. And finally, the success of the Prithvi and Agni programs has boosted the DRDO's organizational morale and helped it launch a major public relations campaign that has transformed its image from an organization that until recently was synonymous with program failures, to one that epitomizes technological and organizational excellence.[93]

The strategic enclave's obsession with indigenous development and self-reliance is closely tied to India's legacy of colonization and related inferiority complex.[94] Although Indian politicians divide the blame for British colonial domination on medieval India's technological backwardness and the domestic failings of ruling elites,

the scientists are more prone to lay the blame only at the door of technological backwardness. The latter argue for instance, that India fell prey to British colonial rule because it was bypassed by the military revolution that overtook Europe in the 16th and 17th centuries. According to this worldview, India also missed out on the subsequent steam and industrial revolutions due to a deliberate British policy that treated India as a source for raw material and a captive market for dumping finished industrial goods. British colonial rule thus created a unique political economy that prevented technological and industrial development in India.[95]

This legacy endures in the post-independence era as India continues to rely on imports from "developed" countries for advanced industrial and technological goods. Such technological dependence prevents India from achieving political autonomy in the international system. Worse, it leaves India vulnerable to political and military pressure from other states. Therefore, in the scientists' worldview, the indigenous development of advanced technologies and strategic military systems is absolutely necessary to restore autonomy to the Indian state and ensure that Indian elites remain relatively immune to pressure from competitors in the international system.[96] Attainment of self-reliance also signals that, in contrast to the colonial and immediate post-colonial era, Indian society has once again emerged as a center for original thought, innovation, and development. Self-reliance thus theoretically restores parity between India and other developed societies.[97]

Strategic Analysts

From the mid-1960s on, the strategic analysts have to a large extent shaped India's strategic debate and have constituted perhaps the most vocal proponents of the nuclear weapons option. During the 1980s, they enthusiastically supported the IGMDP; in the 1990s, they led the debate in favor of rejecting the CTBT, conducting nuclear tests, and creating an operational nuclear capability. Political opinions among sections of this elite vary.

The hardliners favor a maximalist nuclear posture; the pacifists advocate a roll back or even a step backward to the posture of "non-weaponized" or "recessed" deterrence that prevailed through much of the 1990s. However, the majority can be described as moderate and are vaguely committed to a "credible minimal deterrent."[98]

India's strategic analysts are devotees of the realist school of thought in international relations. Despite globalization, the emergence of a global civil society, and the growth of transnational corporations, they view nation-states as the central units of the international system. Likewise, they also regard military power and physical force as the ultimate arbiter of outcomes in international politics. For these reasons they advocate that India invest in a system of nuclear deterrence; in their view, nuclear weapons and their delivery systems constitute the epitome of power, prestige, and political equality among nation-states in the post-World War II era. [99]

The consensus among them is that China and Pakistan constitute India's principal sources of nuclear insecurity. To deter such threats, India needs a credible deterrent. The key elements of a robust nuclear deterrent include a sufficient number of weaponized nuclear devices, diversified types of nuclear delivery systems, and a secure command-and-control architecture to ride out a first strike and launch a punishing second strike against an aggressor state. Ballistic and cruise missiles assume enormous significance because the Indian Air Force's current inventory of short-range combat aircraft can be successfully deployed only against Pakistan. But even for the task of deterring Pakistan, analysts favor the development of mobile, solid-motor, short- and intermediate-range ballistic and cruise missiles. Solid-motor ballistic and cruise missile are considered ideal for the delivery of nuclear munitions because such missiles offer greater mobility, enhanced survivability, reduced launch times, and overall operational flexibility. For purposes of deterring China, analysts favor the development of intermediate- and long-range ballistic missiles, including a sea-based capability. However, with some exceptions, few in India perceive any nuclear threat from the United States, Russia, Britain, or France. Hence, despite the occasional calls for a *touz azimuth* capability after the French model, the strategic analysts' lobby would in all probability accept a missile cap after the development of a small force of medium- and intermediate-range ballistic and cruise missiles, capable of targeting important industrial and urban centers in north and central China.[100]

The nuclear advocates have long favored the shift to an overt nuclear posture on grounds that India's earlier adherence to "non-weaponized deterrence" was nothing more than strategic bluff. This posture left India with a nuclear capability that was symbolic and existed only on paper. Successive Indian governments either did not think through the challenges of nuclear deterrence or else they assumed that the possession of a few disassembled nuclear devices would suffice to deter nuclear threats from China and Pakistan.[101] Central to the above conclusion is the advocates' presumption that the successful practice of

nuclear deterrence requires both the possession of operational nuclear forces and the will to use them. The emerging consensus in New Delhi is that India cannot anchor nuclear deterrence in a phantom nuclear capability. There is no special "third way" or oriental wisdom to practice nuclear deterrence. Nuclear weapons impose a logic of their own, and in order for India to practice deterrence successfully, it must reproduce, with regional variations, the strategic culture, technological systems, and some organizational approaches of the de jure nuclear weapon states.[102]

Beyond the above strategic reasoning, some analysts have also framed the development of a strategic missile capability as symbolic of India's internal transformation from a "soft" to a "hard" state. The term *soft state* is a distortion of the concept originally advanced by the Swedish political economist Gunnar Myrdal in the 1960s. Myrdal used the term to describe post-colonial societies such as India, which lacked the political and social discipline to execute tough policies geared toward modernization and reform.[103] However, the strategic analysts appropriated the term *soft state* to describe the apparent pusillanimity of successive Indian governments in adopting a posture of overt nuclear deterrence in deference to coercive pressure from the United States and the nonproliferation regime. Hence, these opinion makers now regard the nuclear and missile programs as symbols of a macho and post-adolescent Indian state, which is capable of reaching independent decisions in a tough global environment.[104]

Finally, India's strategic missile programs have become closely enmeshed with the bitter debate on India's strategic culture. Several Indian strategic thinkers believe that India has historically lacked a strategic culture. These critics attribute the inability of Indian rulers to stop Greek and Islamic invasions at the subcontinent's natural mountain and river frontiers during ancient and medieval times, and absence of investments in a robust naval capability to check the European invasions in the pre-modern era, as evidence of India's underdeveloped strategic culture. In a similar vein, they argue that successive post-independence Indian governments failed to draw a distinction between physical and strategic frontiers; while physical frontiers stop at land and sea borders, strategic frontiers are conditioned by strategic interests and extend far beyond borders. In a world transformed by the nuclear revolution and global strike capabilities, the Indian leadership failed to understand that the world had become an integrated strategic theater and that the defense of India's strategic frontiers lay in creating nuclear and long-range strike capabilities to deter existential nuclear threats from other nuclear weapon states. Several influential strategic analysts therefore view the Indian government's belated commitment to a "credible minimal deterrent" as a laudable development and a sign of a maturing Indian strategic culture. [105]

Armed Services

The armed services are the latest entrants in the nuclear and missile coalition. In India, nuclear warheads are still maintained separately from missile and aircraft delivery systems. The civilian AEC and DRDO retain control over nuclear warheads, while custody of the nuclear delivery vehicles is divided between the Army and Air Force. The Air Force has custody of combat aircraft (probably Mirage 2000s) configured for nuclear delivery; the status of the Air Force's version of the Prithvi (250-km range) remains unclear. On the other hand, the Army retains control over the 150-km-range version of the Prithvi and will receive custody of the medium-range and future intermediate-range rail- and road-mobile Agni ballistic missiles.[106]

The government's decision to build a "credible minimal deterrent" has created bitter rivalry between the Army and Air Force for control of India's nuclear delivery systems. The Air Force views itself as the natural custodian of all long-range strike assets and has staked its claim over the medium-range and future intermediate-range versions of the Agni.[107] It has also expressed an interest in acquiring long-range combat aircraft, which could conceivably be reconfigured for purposes of nuclear delivery. In view of its rivalry with the Army, the Air Force has also opposed the creation of a CDS and has suggested that all nuclear strike assets be placed under an Air Force strategic command.[108] However, the Indian government has overruled the Air Force and appears determined to proceed with the creation of the position of CDS. There are reports that it may divide control of the rail- and road-mobile Agni missiles between the Army and Air Force, or alternatively, place the missiles under the joint custody of the both services.[109]

Despite losing the organizational battle to consolidate all nuclear assets under its control, the Indian Air Force has recast itself as a joint space and Air Force. The Air Force's organizational ambitions make it a likely partner in DRDO's venture to develop an anti-anti-tactical ballistic missile (ATBM) system. Since the mid-1990s,

DRDO has sought to procure Russian S-300 SAMs and now the Israeli Arrow, and integrate them with the indigenous Rajendra phased-array radar to provide India with a rudimentary anti-ballistic missile capability.[110] Similarly, the Air Force could also be expected to team up with DRDO and ISRO in developing the proposed reusable aerospace vehicle using ramrocket technology.

Thus far, the Indian Navy has remained a junior partner in the inter-services organizational rivalry over the nuclear deterrent. However, the navy has signaled its interest by backing DRDO's efforts to develop a 350-km to 500-km naval variant of the Prithvi ballistic missile (Dhanush) as well as a sea-launched ballistic missile, Sagarika.[111] Although the value of deploying liquid-engine ballistic missiles on surface ships remains in doubt, it is highly possible that the navy will emerge as a dark horse and gain the largest stake in India's nuclear deterrent in the medium term.[112] The Indian government has long sought a sea-based nuclear delivery platform for reasons of survivability and operational flexibility. In this regard, the navy is likely to benefit from two recent developments. First, the DRDO has succeeded in securing Russian collaboration to co-develop the BrahMos antiship cruise missile. The BrahMos is capable of delivering a 200-kg warhead over a range of 300 km.[113] DRDO and Russian entities are currently modifying the missile so that it can be configured for launch from submarines, surface vessels, ground-based silos, and aircraft.[114] The BrahMos is also being modified for attack against land-based targets. Second, India is reportedly negotiating an agreement to finance the completion and lease two unfinished Akula II-class nuclear submarines at the Amurskiy Shipyard in Russia.[115] Russian entities are also actively involved in India's indigenous nuclear submarine, or Advanced Technology Vessel (ATV), program.[116] The acquisition of Russian nuclear submarines and cruise missile technology could ultimately pave the way for an Indian sea-based nuclear strike capability.

The recasting of civil-military relations is thus poised to transform the historically fragile relationship between India's R&D agencies and its armed forces. In the past, the artificial segregation of the armed services from the defense ministry and their exclusion from direct participation in the strategic programs was a major factor in the failure of India's missile programs. However, the Indian government's defense reforms and decision to create an operational nuclear capability have created a context where the armed services have emerged as a principal stakeholder in DRDO's missile programs.

CONCLUSIONS

An analysis of stakeholders demonstrates that India's missile program is supported by a diverse coalition of actors and institutions. This composite group is united by a common string of shared values, but members of the coalition also represent different, though often interrelated and overlapping, individual and institutional interests. Since the stakeholders' interests sometimes conflict with one another, missile-related organizational and technical outcomes are determined by bargaining among them. The programmatic narrative of India's missile development activities also reveals that the diversification and growth of the missile coalition has partially transformed the underlying mandate of the missile program. During the 1960s and 1970s, for example, the missile programs were characterized by political symbolism and technological determinism. Both characteristics were the outcome of the domination of the DRDO and its political patrons in the coalition. However, political symbolism and the DRDO's organizational interests are now giving way to politically determined strategic objectives and the operational requirements of the armed services. These latter characteristics are clearly the consequence of the inclusion of other stakeholders in the missile program.

In the 1960s and 1970s, the DRDO and a handful of politicians in the PMO, defense ministry, and their civilian bureaucratic aides, constituted the primary stakeholders in the missile program. Due to the peculiarity of India's civil-military relations, the armed services were largely excluded from defense planning related to strategic weapon systems. Furthermore, the armed forces doubted the DRDO's competence in producing major high-technology weapon systems. Due to the specificities of these institutional relationships, India's missile programs were not based on actual user requirements. The goal was technology gathering and reverse engineering. Since there were no plans for the serial production and manufacture of actual weapon systems, DRDO did not build sustainable alliances with government-owned public-sector entities. Similarly, the secrecy surrounding the programs effectively excluded private-sector companies, quasi-government research institutes, and the growing body of civilian strategic analysts who occupy influential positions in India's civil society.

Since then, however, DRDO has succeeded in building a relatively robust alliance with the military. Limited serial production of the Prithvi and Agni ballistic missile systems has also given government-owned public-sector

companies a stake in the missile program. DRDO's adoption of a consortium approach by subcontracting research, development, and manufacturing to semi-autonomous institutions and private-sector companies has also added to the list of the stakeholders in the missile program. Furthermore, the program has gained legitimacy due to support from vocal elements among India's lobby of civilian strategic analysts.

Strategic missile systems such as the Prithvi and Agni series have emerged as the center of DRDO's efforts to develop major weapon systems. These weapon systems are not only important politically and strategically; they represent DRDO's first success in developing a major weapon system that has gained acceptability from India's armed services. Even though the Prithvi and Agni represent vintage technologies from the 1950s and 1960s, in the Indian context they are considered relatively state of the art because of international curbs on the sale of long-range missiles, and because India happens to be among the select few countries that have managed to develop them, despite technology denials from the United States and other developed countries. In India's case, the ballistic missile programs have helped DRDO partially transform its image from an institution that was synonymous with program failures, to an organization that symbolizes organizational and technological excellence. The Prithvi and Agni programs have also, to an extent, helped mask the DRDO's failure to produce other big ticket items such as the Arjun main battle tank, ATV, and the airborne early-warning radar. Equally significant, the success of these programs has provided political cover for the DRDO's inability to overcome developmental problems related to the Nag ATGM and the Akash and Trishul SAMs, which were originally conceived as parts of the IGMDP in the 1980s.

DRDO has capitalized on the success of the Prithvi and Agni programs to push for political support for new missile programs. Proposed programs include both defensive and offensive missile systems. The list of defensive systems includes ATBMs designed to provide point defense for India's nuclear command-and-control centers and high-density population targets. Offensive weapon systems include an intermediate-range version of the Agni ballistic missile, longer-range versions of the BrahMos cruise missile, a submarine-launched ballistic missile, and a Hyperplane that would theoretically be capable of launching nuclear strikes from outer space.

The Vajpayee government's political conclusion that a U.S. ballistic missile defense is inevitable and DRDO's case for a limited ATBM capability have produced an historic shift in India's position on ballistic missile defense from opposition to outright support for the U.S. program. The flip side, of course, is that India's missile coalition expects technological assistance from the United States and its allies to build a limited ATBM system capable of intercepting short-range ballistic missiles. In the interim, however, DRDO hopes to integrate the Russian S-300 SAM or the Israeli Arrow with the indigenous Rajendra phased-array radar system. In this context, India has also acquired the Green Pine radar system from Israel for purposes of detecting long-range ballistic missile launches.

In its push for an ATBM capability, the DRDO has received support from the Indian Air Force. The Air Force, which has lost the battle against the Army for overall control of India's missile-based nuclear delivery systems, now appears to be backing the ATBM project to safeguard its redefined organizational doctrine as an air and space force. The Air Force is also actively pushing the BrahMos cruise missile project. DRDO hopes that the BrahMos cruise missile could ultimately be configured for launch from air, land-, and sea-based platforms. Thus in the future, the Air Force could be expected to make the case for an air leg of the proposed minimal deterrent using long-range strike aircraft with a standoff cruise missile capability.[117] In this regard, the Air Force is also likely to support DRDO's futuristic reusable space launch vehicle, Hyperplane. The proposed Hyperplane will be built around an integrated power plant of ramjet, scramjet, and rocket motors.[118] The Hyperplane could theoretically be used as a nuclear delivery system with a global strike capability; it could also serve as an asset to strike enemy space-based surveillance and communication targets, or for ferrying civilian and military payloads into space. Should the Hyperplane project take concrete shape, there could be a consolidation of interests between the DRDO, ISRO, and the Indian Air Force with active support from India's political leadership.

DRDO is also actively consolidating its alliance with the Indian Navy by developing sea-launched versions of the Prithvi ballistic missile, a submarine-launched ballistic missile, and by planning to configure the BrahMos cruise missile for launch from submarines and ships. The current version of the BrahMos has an anti-ship capability, but future systems will incorporate a land-attack capability.[119] The current sea-based version of the Prithvi (Dhanush) is limited by short range (350 km) and uses a liquid-fuel engine. The missile's short range and the dangers associated with liquid fuel on board submarines and

surface ships make it unlikely that the navy will accept the Dhanush for active deployment. However, the development of the Dhanush will most likely enable the navy to stake a claim in India's emerging nuclear deterrent. It is also probable that current liquid-engine versions of the Prithvi will be replaced by solid-motor and longer-range systems in the future. India's draft nuclear doctrine, which should be read as a statement of ambitions and future intent, does envisage a sea-based nuclear capability for reasons of operational flexibility and survivability. If New Delhi does indeed succeed in developing a nuclear submarine indigenously, or in acquiring nuclear submarines and long-range cruise missile technology from Russia in the near term, an Indian sea-based nuclear capability could emerge by the end of this decade.

Despite rumors and occasional calls from Indian missile scientists for the development of a global strike capability, it is doubtful that an ICBM program will have support from India's political elite or its military leadership. Unlike the 1970s and 1980s when the political accent was on developing technological artifacts for demonstration and symbolic purposes, current Indian programs have a greater national security component. Since Indian strategic and military elites perceive potential nuclear threats only from China and Pakistan, it is feasible that India might restrict its ballistic and cruise missile programs to intermediate- and medium-range systems as a conscious political choice to avoid ruffling sensibilities of the other nuclear weapon states. Such a decision could also partly be a function of the growing strategic partnership with the United States and the need to cooperate with the United States and Israel in developing a limited ballistic missile defense.

Finally, the centrality of strategic missiles in DRDO's organizational priority of interests, potential nuclear threats from Pakistan and China, and the growth and expansion of India's missile coalition, have ended the technological fragmentation within India's strategic enclave. At their inception in the late 1960s, India's missile programs were hampered by the fragmentation in India's high-technology sector. The central government made no attempt to harmonize, complement, or integrate the technological and organizational strengths of the civilian space sector and DRDO's missile laboratories; neither did the government impose any specific national security objectives on the strategic enclave. For example, the subterranean nuclear explosive project was conceived and executed in 1974 without any reference to DRDO's missile programs.

However, that situation has now changed. Since the early 1980s, the Indian government has attempted to end the fragmentation within India's strategic enclave and give it a strategic direction. In this regard, the IGMDP and the Agni program marked the beginning of limited cooperation between ISRO and DRDO. By the late 1980s, DRDO and DAE launched joint programs to weaponize nuclear devices and modify a limited number of combat aircraft and ballistic missiles for the delivery of nuclear munitions. Cooperation between the three sectors of India's strategic enclave continued in the 1990s. During this period, DRDO and ISRO worked jointly on the second phase of the Agni program; likewise, DRDO and DAE cooperated in the design, development, and weaponization of more sophisticated nuclear warheads. The Vajpayee government's authorization of nuclear tests in May 1998 and subsequent decision to build a credible minimum deterrent have now created an overarching strategic framework for cooperation among these organizations.

As a result, at the end of three decades, India's guided missile program has assumed a self-sustaining character. Unlike the 1970s, the missile program is now guided by a clear strategic vision and buttressed by a diverse coalition with strong organizational stakes in politically and strategically determined technological outcomes. In retrospect, the guided missile program has not only become central to India's proposed minimal deterrent, but more significantly, it has emerged as the symbol of an independent, self-reliant, and strategically autonomous Indian state.

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[1] George Perkovich's history of India's nuclear program perhaps best exemplifies the "domestic factors" approach. See George Perkovich, *India's Nuclear Bomb: The Impact on Global Proliferation* (Los Angeles: University of California Press, 1999); also see Itty Abraham, *The Making of the Indian Atomic Bomb: Science, Secrecy, and the Postcolonial State* (London: Zed Books, 1998).

[2] Itty Abraham, "India's Strategic Enclave: Civilian Scientists and Military Technologies," *Armed Forces and Society* 18 (Winter 1992), pp. 231-252.

[3] Sumit Ganguly, "India's Pathway to Pokhran II: The Prospects and Sources of New Delhi's Nuclear Weapons Program," *International Security* 23 (1999), pp. 148-177.

[4] For an overview of India's defense management see, A.L. Venkateswaran, *Defense Organization in India,* (New Delhi: Ministry of Information and Broadcasting, Government of India, 1967); also see the Indian Ministry of Defense website, <http://mod.nic.in/>.

[5] Defense Research and Development Organization website, <http://www.drdo.org/>.

[6] For a critique of India's national security decisionmaking institutions and culture see, Jaswant Singh, *Defending India* (London: Macmillan Press Limited, 1999), pp. 22-58.

[7] "Six-member National Security Council formed," *Times of India* (Mumbai), November 20, 1998, <http://timesofindia.indiatimes.com>.

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Strategy (Delhi: Macmillan India Limited, 2002), p. 649.
[9] Raj Chengappa, *Weapons of Peace: The Secret Story of India's Quest to be a Nuclear Power,* (New Delhi: Harper Collins Publishers India Pvt. Ltd., 2000), pp. 333-334.
[10] Chengappa, *Weapons of Peace,* pp. 321-336 and 382-384; also see Karnad, *Nuclear Weapons & Indian Security,* pp. 344-397.
[11] See Indian Ministry of Defence, "Reforming the National Security System: Recommendations of the Group of Ministers," February 2001, pp. 97-117, <http://mod.nic.in/newadditions/rcontents.htm>.
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[13] Stephen P. Cohen, *India: Emerging Power* (Washington, D.C.: Brookings Institution, 2001) pp. 93-126.
[14] Abraham, "India's Strategic Enclave," pp. 231-252.
[15] Dhirendra Sharma, "India's Lopsided Science," *Bulletin of Atomic Scientists* (May 1991), p. 35.
[16] "Six-member National Security Council formed," *Times of India*, November 20, 1998; B. Muralidhar Reddy, "NSC Advisory Board to be set up soon," *Hindu* (Chennai), November 25, 2001, <http://www.hinduonnet.com>.
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[18] Stephen P. Cohen, "The Military and Indian Democracy," in Atul Kohli, ed., *India's Democracy: An Analysis of Changing State-Society Relations* (Princeton: Princeton University Press, 1988), pp. 123-132.
[19] "Retired military officers appeal for restraint," *Times of India* (Mumbai), January 30, 1999, <http://timesofindia.indiatimes.com>; Kuldip Nayar, "Blunders of babudom," *Indian Express* (Mumbai), January 19, 1999, <http://www.expressindia.com>; and V.R. Raghavan, "Restoring civil-military relations," *Hindu* (Chennai), January 5, 1999, <http://www.hinduonnet.com>.
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[21] Indian Department of Defence, "Reforming the National Security System," pp. 97-117.
[22] Chengappa, *Weapons of Peace*, pp. 136-137.
[23] Ibid., pp. 144-145.
[24] Dr. N.C. Birla and B.S. Murthy, eds., *Indian Defence Technology: Missile Systems* (DRDO, Ministry of Defence, December 1998), p. 92.
[25] Chengappa, *Weapons of Peace,* p. 142.
[26] A. Subhananda Rao, "Development of Solid Propulsion Systems for Guided Missiles," in H.S. Mukunda and A.V. Krishnamurty eds., *Recent Advances in Aerospace Sciences and Engineering,* (Bangalore: Interline Publishing, 1992), p. 183.
[27] Birla and Murthy eds., *Indian Defence Technology: Missile Systems*, p. 77.
[28] Chengappa, *Weapons of Peace*, p. 142.
[29] Ibid., p. 152.
[30] Ibid., p. 159.
[31] Ibid., pp. 129-131.
[32] The term "technology gathering" refers to the acquisition of design parameters and the creation of an R&D and manufacturing infrastructure for the manufacture of a weapon system or subsystem/s.
[33] Chengappa, *Weapons of Peace,* pp. 167-168.
[34] A.P.J. Abdul Kalam with Arun Tiwari, *Wings of Fire: An Autobiography* (Hyderabad: Universities Press (India) Limited, 1999), p. 73.
[35] Ibid., p. 74.
[36] Ibid., pp. 74-75.
[37] Chengappa, *Weapons of Peace,* pp. 233-234.
[38] Rao, "Development of Solid Propulsion Systems for Guided Missiles," in *Recent Advances in Aerospace Sciences and Engineering,* p. 183.
[39] Chengappa, *Weapons of Peace,* p. 131.
[40] Ibid., pp. 169-171. Although Chengappa claims that the Valiant missile involved the design of a 30-ton-thrust liquid-fuel engine, other and more credible sources suggest that by 1980, DRDL succeeded in building a 12-ton-thrust liquid-fuel engine. See Birla and Murthy eds., *Indian Defence Technology: Missile Systems,* p. 78.
[41] Chengappa, *Weapons of Peace*, pp. 169-172.
[42] Ibid., pp. 172-174.
[43] "Historical Background," Defence Research & Development Laboratory website, <http://www.drdo.org/labs/missiles/drdl/index.shtml>.
[44] DRDL's budget increased nearly forty-fold, from 4 million rupees in 1972 to 160 million rupees in 1974. See Chengappa, *Weapons of Peace*, p. 166.
[45] The Soviet Union often sold weapon systems at politically determined reduced prices to allies and client states during the Cold War. From the late 1960s until the collapse of the Soviet Union in the early 1990s, the Indian military benefited enormously from these arrangements. See, for example, Admiral (retd.) J.G. Nadkarni, "Trial by media," *Rediff on the Net,* April 10, 2002, <http://www.rediff.com>.
[46] Perkovich, *India's Nuclear Bomb*, pp. 161-189.
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[52] Kalam with Tiwari, *Wings of Fire*, pp. 113-114; Chengappa, *Weapons of Peace*, pp. 276-279.
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[54] Chengappa, Weapons of Peace, pp. 309-312; Steven M. Flank, Reconstructing Rockets: The Politics of Developing Military Technology in Brazil, India, and Israel, Ph.D. Dissertation (MIT, 1993), pp. 131-194.
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[56] Eric Arnett, "Military technology: the case of India," *SIPRI Yearbook 1994* (New York: Oxford University Press, 1994), pp. 343-344.
[57] Chengappa, *Weapons of Peace*, pp. 279-284; Raj Chengappa, "The Missile Man," *India Today* (New Delhi), April 15, 1994, p. 44; Kalam with Tiwari, *Wings of Fire,* pp. 111-127.
[58] Birla & Murthy eds., *Indian Defence Technology: Missile Systems,* pp. 2-6.
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[60] "Head's Remarks," *Times of India* (Mumbai), August 10, 1991, in JPRS-TND-91-015 (September 27, 1991), p. 18.
[61] Rao, "Development of Solid Propulsion Systems for Guided Missiles," in *Recent Advances in Aerospace Sciences and Engineering,* pp. 184-186.
[62] Kalam with Tiwari, *Wings of Fire,* pp. 125, 133-134.
[63] Federation of American Scientists, "Nuclear Forces Guide," <http://www.fas.org>; "Interim Test Range to be upgraded," *Indian Express* (Mumbai), August 17, 1998, <http://www.expressindia.com>.
[64] Perkovich, *India's Nuclear Bomb,* pp. 242-244.
[65] There are two existing versions of the Prithvi. The Prithvi I is in service with the

Indian Army and has a maximum range of 150 km; the Air Force version is known as Prithvi II and has a maximum range of 250 km. DRDO is currently developing a 350-km-range version, named Dhanush, for the navy.

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[71]Chengappa, "The Missile Man," p. 40.

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