Building Nonalignment:
Technological Interchange and India's Third Five-Year Plan (1961-1966)

by

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Abstract

The role of ideology in the modernization of India has been closely studied. Less well understood is the role that technological knowledge and artifacts played. This dissertation studies the role of technology in the Indian nation during the early-independence period. Four case studies examine technologies that originated outside of India and were currently in various stages of indigenization. The case studies are: 1) American aid to the Indian Air Force after the 1962 Sino-Indian War; 2) Saraighat Bridge, the first permanent bridge built across the Brahmaputra River; 3) the Umiam Hydroelectric Project; and 4) Tarapur Atomic Power Station, India's first nuclear powerplant.

These case studies are centered on the period of the Third Five-Year Plan, which ran from 1961 to 1966. The socialistic plans operated on the principle that India could develop more quickly and equitably in the context of a command economy, rather than through free-market capitalism. The Third Plan was the most ambitious of them all, because it declared that India's economy must become "self-reliant and self-generating." The plan thus intended to launch India toward attaining economic and technological autarky, thereby securing its status as a politically nonaligned nation.

This dissertation demonstrates how technological interchange took place during the Third Five-Year Plan. Because international technological interchange is the main

theme of this work, foreign countries play important roles in the narrative. Even with contributions from the United States and other nations, India was short on resources and had to make do with what it had on hand. Programs for technological autarky met with limited results not only because of the shortage of material and intellectual resources, but also because certain technologies were too difficult to produce indigenously, and Cold War politics limited Indian access to these items. The legacy of technological change in India during the early independence period was mixed: certain technologies became indigenized, but others remained foreign. The incomplete nature of technological development, influenced by Cold War politics as well as resource shortages, prevented a complete industrial transformation of Indian society.

Acknowledgments

Writing a dissertation is bound to be a long and difficult solo journey, and my experience was no exception. But along the way, many people have advised, encouraged, and otherwise supported me. Here I would like to recognize the people and institutions without whom I never could have been able to complete my dissertation.

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Writing a dissertation is an intellectual journey, and also a physical one. As I researched and wrote on two continents, I traveled thousands of miles by automobile, bicycle, aircraft, bus, train, ferry, and on foot. But just as Thoreau traveled widely in Concord, so too did my explorations begin at home. I remain ever thankful to the hardworking staff of the Ralph Brown Draughon Library at Auburn University, especially the interlibrary loan department. Without them, I never would have gotten my hands on microfilms of half-century-old newspapers or PDFs of obscure engineering journals.

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Part of what made my dissertation topic unusual is that it forced me to learn a new language from scratch, Hindi. The Department of State, the Department of Education, and the American Institute of Indian Studies (AIIS) funded my participation in three Hindi language programs. Each time, I studied at AIIS–Jaipur under the guidance of the remarkable Achyutanand Singh a.k.a. Swami-ji. I am especially thankful that I had the chance to participate in the last of the three programs. That time, AIIS gave me not only a chance to improve my Hindi, but also the time and space to write my dissertation.

I am not thankful to the monkeys of Moti Doongri. जब मैं मासूमी से हिन्दी पढ़ रहा था और अपना शोध-निबंध लिख रहा था, तुम सबों ने बात बिन बात मुझे सताया था। तुमने मुझे सीढ़ियों में फँसाया और मेरो गुस्ल-ख़ाना बरबाद किया (दो बार)। तुमने मेरा शीशा, तौलिया, और पोंछा चुराया। तुम में से एक ने मेरा कच्छा चुराकर अपने सिर पर रखा। इस दुर्व्यवहार की वजह से मैं तुम सबों को नफ़रत करता हूँ। काश कि मैं तुम्हारे थोबड़े कभी नहीं देखता। नगर निगम के ठेकेदार (बंदर पकड़नेवोले) द्‍वारा तुम सबको गिरफ़तार करके जयपुर से बहुत दूर किसी जंगल में निर्वासित किये जाये।

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Acronyms and abbreviations

AFHRA	Air Force Historical Research Administration (Maxwell AFB, AL, USA)
ALD	Assam Legislative Debates
APED	Atomic Power Equipment Department (General Electric)
ASEB	Assam State Electricity Board
AT	Assam Tribune
BBJ	Braithwaite Burns & Jessop Construction Co. Ltd.
BWR	Boiling Water Reactor
CongRec	Congressional Record
CWPC	Central Water and Power Commission
CWPR	Central Water and Power Research Station
DLF	Development Loan Fund
ECAFE	Economic Commission for Asia and the Far East
FRUS	Foreign Relations of the United States
GE	General Electric
GOI	Government of India
HCC	Hindustan Construction Co. Ltd.
HT	Hindustan Times
IAEA	International Atomic Energy Agency

IAF	Indian Air Force
IE	Indian Express
IJPRVD	Indian Journal of Power and River Valley Development
INTUC	Indian National Trade Union Congress
LSD	Lok Sabha Debates
MAPS	Madras Atomic Power Station
NAI	National Archives of India (New Delhi)
NARA	National Archives and Records Administration (College Park, MD, USA)
NFR	Northeast Frontier Railway
NLI	National Library of India (Kolkata)
NMML	Nehru Memorial Museum and Library (New Delhi)
NYT	New York Times
RAAF	Royal Australian Air Force
RAF	Royal Air Force (United Kingdom)
RAPS	Rajasthan Atomic Power Station
RIAF	Royal Indian Air Force
RSD	Rajya Sabha Debates
TAPP	Tarapur Atomic Power Project
TAPS	Tarapur Atomic Power Station
TISCO	Tata Iron and Steel Company
TOI	Times of India
USAEC	United States Atomic Energy Commission

USAF	United States Air Force
USAID	United States Agency for International Development
WP	Washington Post
WRCA	Water Resources Collection and Archives (University of California–Riverside)
WSJ	Wall Street Journal

Note on place names

In the past two decades, many places in India have received new names. With the exception of Delhi, nearly every major city in India has undergone a name change. Although some name changes have not been accepted by the residents of the cities themselves—most people from the capital of Karnataka still refer to their city as Bangalore rather than Bengaluru—the name changes are official and thus provide an additional layer of complexity to an already complex geopolitical landscape.

The mass renaming of cities occurred several decades after the period of the Third Five-Year Plan, but certain streets and monuments had already begun to be renamed during this period. For instance, Apollo Pier Road in Bombay became Chhatrapati Shivaji Maharaj Marg during the 1960s. Throughout this dissertation, I have used the place names used in the early-independence period. When a name changed in the middle of this period, I have preferred the older name.

For names that have alternate spellings, such as Tarapur and Tarapore, I have preferred the more phonetic spelling, e.g. Tarapur.

Note on units of measurement

Although India officially adopted the metric system during the early-independence period, the transition away from British Imperial units was slow. Currently, in the early twenty-first century, metric is the dominant form of measurement in India, but it does not enjoy a monopoly. In my travels and studies in India, I have found carpenters using feet and inches, schoolchildren carrying dual-unit rulers that happen to be twelve inches long, and nurses who measure their patients' temperatures in degrees Fahrenheit.

Since this dissertation is set at the very beginning of India's metric period, most of the sources I have consulted use British Imperial units rather than metric. For this reason—and because I am a scholar working in the United States, which still uses Imperial units rather than metric—I have preferred Imperial over metric units. In passages where I write in my own voice, I convert any metric units into Imperial units. Where metric units appear in quotations, I let them stand except where understanding the measurement is essential to my argument; in these cases, I have inserted an Imperial unit conversion in square brackets within the quotation.

Traditional Indian units of measurement, such as *kos* and *maund*, do not appear in the sources used in my research.

Introduction

The Shivalik Hills of the northern Indian state of Himachal Pradesh rise above the green wheatfields and paper-pulp forests of Punjab. At the town of Nangal, the Satluj River exits the hills, beginning its long journey through the flatlands toward its confluence with the Indus River in Pakistan. Just before leaving the hills, the river backs up behind an enormous concrete dam, forming the sixty-square-mile Gobind Sagar. The dam is 1700 feet wide at its crest, and it towers 550 feet above the riverbed. Its name is Bhakra Dam.

The dam at Bhakra is one component of a major combined hydroelectricity and irrigation project. Eight miles downstream from Bhakra, a much smaller dam in the town of Nangal redirects some of the water of the Satluj into two concrete-lined irrigation channels. This water, which initially retains the electric-blue tint of the glacial streams where it originates, ultimately flows to farms across the states of Punjab and Haryana, as well as the northwesternmost district of Rajasthan. Bhakra and Nangal dams are both managed by the Bhakra Beas Management Board (BBMB), which operates several other hydroelectric and irrigation projects on the Satluj and Beas rivers in Himachal Pradesh. Together, the BBMB projects make a major contribution to the economy of northern India by providing water for agriculture and power for industries.

Bhakra Dam was the largest of scores of major river engineering projects undertaken by the Indian government during the early-independence period. A large Indian labor force built the dam over the course of fifteen years. Construction began in 1948, and it was finally dedicated by Prime Minister Jawaharlal Nehru in October 1963. Although the dam was built departmentally and not by a foreign firm, foreign specialists made significant contributions to the project. The most prominent of these was Harvey Slocum, a self-trained American engineer who served on the Bhakra project from 1951 until his death in 1961. In addition to foreign citizens, foreign machinery also played an essential part in the construction. The generators in the original left-bank powerhouse came from the Soviet Union. Transformers, switchgear, cranes, and earth-movers were also all imported. Even the Buicks that the project engineers drove to the jobsite had to be bought abroad.[1]

During the dam's construction, American publications were particularly attracted to the project, likely because Slocum's involvement made it more relatable to American readers. *Life* magazine featured the project in a full-page spread in 1956. A correspondent for *National Geographic* described his visit to the construction site in an article published in 1963. The *New York Times* claimed that Bhakra was one of two construction sites in northern India that was a popular destination for foreign tourists; the other was the planned city of Chandigarh, sixty miles to the southeast of Bhakra.[2]

Since 1963, Bhakra's prominence has diminished somewhat, both within India and especially abroad. Bhakra has been overshadowed by China's Three Gorges Dam,

1. "Dedication of Bhakra Dam," *Indian Recorder and Digest*, November 1963, 6; "Harvey Slocum, dam builder, dies," *New York Times* (*NYT*), November 12, 1961.

2. "India builds a high dam in the Himalayas," *Life*, November 3, 1958, 45; John Scofield, "India in Crisis," *National Geographic*, May 1963, 604; T.V. Rajagopalan, "Exploring India: Holy cities, new dams and big game hunts await adventurous visitors," *NYT*, March 1, 1959.

which is by far the world's largest dam. Foreign tourists no longer visit Bhakra, because the Indian government has declared the dam a restricted area. *Lonely Planet*, the tourist guidebook most popular with western visitors to India, does not mention Bhakra Dam. Indian tourists can still get permits to see the dam at BBMB's Public Relations Office in Nangal township, although the dam no longer attracts the crowds that it once did.

When Bhakra Dam was new, it was a powerful symbol of India's modernity. The Bhakra-Nangal project represented the potential of technology to transform India from a former agrarian colony to a modern nation with an industrial economy. The most outspoken advocate of the dam was the Prime Minister himself, who frequently used it as an illustration in his speeches. Nehru's rhetoric about the project bordered on the religious. His most widely-quoted statement about the dam comes from his speech at the dedication ceremony, which he originally delivered in Hindi. Nehru declared Bhakra to be the "new temple of resurgent India." *Life* magazine quoted the Prime Minister comparing the dam with India's most famous monument: "The Taj Mahal is for the dead," he is supposed to have remarked; "Bhakra is for the living."[3]

Bhakra Dam is a symbol, but it is also more than that. Bhakra is technology. It is concrete, steel, pipes, cables, generators, transformers, electromagnetism, fluid dynamics. The role of ideology in the forming of the Indian nation has been closely studied. Less well understood is the role that technological knowledge and artifacts played. In this dissertation, I study the role of technology in the Indian nation during the early-independence period. I approach this topic through four case studies that examine

3. "India Builds a High Dam in the Himalayas," *Life*, November 3, 1958, 45. The "temple of resurgent India" quote is widely printed; I have drawn it from "Developmental History of Bhakra–Nangal Dam Project," *Bhakra Beas Management Board*, http://bbmb.gov.in/english/history_nangal_dam.asp (accessed February 17, 2014).

technologies that originated outside of India. During the early independence period, these technologies were at various stages of indigenization, which means that Indian industry had the material and human resources to produce some of these technologies domestically, but not others. Within a decade of independence, current bridge construction methods had become fully indigenized in India, but the country's first nuclear powerplant could be built only by importing complete reactors and supporting equipment from the United States.

The four case studies are centered on the period of the Third Five-Year Plan, which ran from 1961 to 1966. These socialistic plans operated on the principle that India could develop more quickly and equitably in the context of a command economy, rather than through free-market capitalism. The first two plans grew progressively more ambitious, and the Third Plan was the most ambitious of them all. Its introduction stated:

> The Third Plan represents the *first phase in a scheme of long-term development extending over the next fifteen years or so*, the preparation of which will now be taken in hand. In the course of this period, India's economy must not only expand rapidly but must, at the same time, *become self-reliant and self-generating*. This long-term approach is intended to provide a general design of development for the country's natural resources, agricultural and industrial advance, changes in the social structure and an integrated scheme of regional and national development.[4]

The Planning Commission hoped that the Third Plan would be the first step toward India's attaining economic and technological autarky. But by 1966, when the plan's five years expired, the commission had to concede that the plan had fallen far short of its objectives. There were several causes of the plan's failure. For one, geopolitical factors stunted the plan. India's defeat by China in the month-long 1962 Sino-Indian War

4. Planning Commission, *Third Five Year Plan* ([New Delhi]: Government of India, n.d. [1961]), xiv (emphasis added).

precipitated greatly expanded military spending by India. The military allocations drained resources away from civilian projects. Furthermore, as experience would demonstrate, the plan's goals were driven more by ideology than reality, and they turned out to be impossible to achieve. The Third Plan was such a failure that the Planning Commission declared a three-year plan holiday. A scaled-back Fourth Plan began in 1969.[5]

The four case studies in this dissertation show how technological interchange took place during the Third Five-Year Plan. This dissertation is at its core a technological history, but all of the case studies delve into domestic and international politics, economics, and culture. Because international technological interchange is the main theme, foreign countries assume prominent roles in the narrative. Three of the four case study topics received financial and technological input from the United States. The selection of so many American-assisted projects is not a coincidence, even though the United States was not the only industrialized nation to invest in India's modernization. The average Indian citizen was probably more aware of Soviet assistance than American activities in India.[6] Nevertheless, the United States, with its booming postwar economy, was able to devote more resources to India than the Soviet Union could.

In both India and the United States, American aid was controversial. Indian politicians and commentators feared that conditions placed on American aid could erode Indian sovereignty. They also felt insulted by the red-baiting and general name-calling that took place in the acrimonious debates that invariably broke out over aid appropriations bills in the American Congress. Americans, for their part, mistrusted India

5. Dharma Kumar, ed., *The Cambridge Economic History of India* (Cambridge: Cambridge University Press, 1983), 2:956.

6. Thomas F. Brady, "Soviet's India aid fifth that of U.S.," *NYT*, February 21, 1965.

because it was a nonaligned nation that maintained friendly relations with the Soviet Union. This dissertation is thus not only a story of technological change in a former colony; it is also a story of the Cold War.

Even with contributions from the United States, the Soviet Union, and other nations, India was short on resources and had to make do with what it had on hand. Programs for technological autarky met with limited results, not only because of a lack of material resources and a shortage of intellectual capital, but also because certain key technologies were too complex and too expensive to produce indigenously, and Cold War politics limited Indian access to these items. The legacy of technological change in India during the early independence period was mixed: certain technologies became indigenized, but others remained foreign. The incomplete nature of technological development, influenced by Cold War politics as well as resource shortages, prevented a complete industrial transformation of the Indian economy.

Background of this study

The origins of this study date back to my first visit to India. In 2009 and 2010, I spent nine months as a volunteer schoolteacher in the Garo Hills of the northeastern Indian state of Meghalaya. This first sojourn in India took place between my graduation from college with a Bachelor of Science in Engineering and my starting graduate school in a PhD program for History of Technology. Before first setting foot in India, I read book after book on the country, working my way through the DS 400s section of my college library. I was not really interested in learning about modern India, even though that was exactly where I was headed. In my last years of college, I had lost interest in engineering and industrialized society in general, and I wanted to go someplace that was less affected by industrialization and modernization. I thought that place would be India.

As I found out as soon as I landed at Chhatrapati Shivaji International Airport in Mumbai (formerly Bombay), India was not at all pre-modern or pre-industrial. There were flatscreen TVs in the terminal playing endless Indian cable news, and of course there were the airplanes themselves. As I flew from Mumbai to Kolkata (Calcutta), my seat-neighbor, a Bengali-American based in New Jersey, told me that India is one of the world's great industrial powers. Everything the country needs or wants, he said, is produced domestically: foodstuffs, clothing, consumer goods, vehicles. I had never heard such a claim before, but it certainly seemed to be supported by the goods I saw at the local market when I got to the Garo Hills. Everything seemed to be stamped "Made in India." This conversation on the plane showed me that there was much more to India than my preparatory reading had revealed, and I wanted to learn how India went from being a British colony to a major manufacturer. It was this question that would, much later, inspire the topic for my dissertation.

As it turned out, like the Third Five-Year Plan decades earlier, my co-passenger's statement about India's manufacturing prowess was excessively optimistic. Although the full range of industrial goods are manufactured in the country, from luggage locks to satellite launchers, many of the manufactured goods make heavy use of imported parts. India has successfully indigenized certain high technologies, such as nuclear reactors and rocket engines, but it has proven simpler and cheaper to import other technologies, including most types of aircraft. Nevertheless, with these limitations, the industrial expansion of India is remarkable, and worthy of study.

Although India was industrialized—some parts of the country more than others—it had not industrialized and modernized in the same way as the countries of Europe and North America. This was obvious to me from the moment I first set foot in India. I saw a particularly clear illustration of this difference a couple of months into my volunteer term. On a Saturday afternoon walk with some fellow-teachers from my school, I came across a village road under construction in the jungle. This was not a paved road, but it did require a substantial cut in the hillside to provide enough space for a jeep to use. Nobody was working on the road just then, but the workers had left their tools scattered about the construction site. All they had to use for this job were hoes with iron blades and bamboo handles. They had no earthmoving equipment or other mechanized tools. As I gaped at this evidence of human labor, one of my fellow teachers, the boys' dean, remarked that while the United States' economy is capital-intensive, India's is labor-intensive.

This too proved to be an oversimplification, as India has long relied heavily on capital for construction projects, in order to pay workers and purchase materials and tools. Even so, the capital-intensive/labor-intensive distinction is useful, because it highlights the differences between the modern economies of India and the industrialized West. Modern technology is not a universalizer; it is not used the same way from one side of the world to the other. Users must adapt any technology to suit their own cultural and geographical conditions.

When I returned stateside and started graduate school, I read a book for a historiography of technology seminar that first made me realize that my questions about Indian industry and technology might be the beginning of a dissertation topic. The book was Daniel Headrick's *Tentacles of Progress*, a remarkable study of how technology moved from Europe to India and other colonies during the colonial era. From railroads to sanitation systems to quinine, Headrick tracked how technology supported colonial domination even while these technologies mostly failed to become indigenous. I found the book fascinating and a worthy inspiration, but I was equally intrigued by what it left out. The book covered only the colonial period, and it left me wondering what happened afterward. Most of the infrastructure I had seen in nine months in India clearly dated after the British period. Other technologies, such as the jetliners I saw at Mumbai airport, necessarily arrived in India only after independence, because they were invented after 1947. I wanted to know how India's modern technological landscape came about, and to do that I decided to follow up on Headrick's work by studying the early-independence period.

India and the Five-Year Plans

When India became independent from the British Empire at midnight on August 15, 1947, the vast majority of the country's population lived in villages. The government of the newly-independent nation celebrated the auspicious occasion by giving speeches in the parliament building in New Delhi. Jawaharlal Nehru, who would lead India for the next seventeen years, declared that during the lengthy freedom struggle, his countrymen had made a "tryst with destiny," which was now partly fulfilled with the coming of independence. Nehru's speech, broadcast over All-India Radio, has become an icon of the moment when India broke free from colonial rule. But since only six cities in India had radio stations at the time, most of the citizens of Nehru's new nation would not hear his speech until later, if ever.[7]

Of the more than 315 million people in India, only 15 percent lived in urban centers in 1947. The remaining 85 percent lived in villages spread across the country from the southernmost tip in the Indian Ocean to Kashmir, and from the West Pakistan border to the hills of Assam. The rural population was immense and diverse, speaking innumerable languages and dialects, and belonging to a wide range of ethnic and religious communities.[8]

The urban population, though small in percentage, was large in absolute numbers. India's cities altogether had nearly fifty million inhabitants, a figure comparable to the total population of Britain at the time. Five urban areas had more than one million inhabitants. The biggest of these was Calcutta-Howrah, twin cities straddling the Hooghly River in West Bengal, with nearly three million people. The western Indian port city of Bombay, under a single municipal government, was almost as large, with a population of 2.8 million. The other three megalopoles were Delhi, Madras, and Hyderabad-Secunderabad.[9]

Modern industry and infrastructure existed in India in 1947, but with the exception of the railroads, it was almost completely restricted to the cities. Of the workers classified as industrial laborers in the censuses of the late colonial period, only 10 percent

7. Embassy of India, *One Year of Independence* (Washington, DC: Embassy of India, 1948), 33.

8. Frank Moraes, ed., *The Indian and Pakistan Year Book and Who's Who 1951* (Bombay: Times of India, 1951), 14, 18. The official population figures produced by the 1951 census omitted the tribal people of Assam and the inhabitants of the contested territory of Jammu-Kashmir.

9. Ibid., 14, 427, 476.

worked in large-scale, mechanized industry. The remainder worked in small-scale or cottage industries such as pottery or blacksmithing. The laborers employed in large-scale industrial operations (1.2 million in 1931) worked in industries that had been set up mostly by Indian industrialists with varying degrees of support from the colonial government. Mechanized industry first arrived in India in the 1850s, when Parsee capitalists, with government encouragement, set up textile mills in Bombay. Other pre-independence industrial centers were Ahmedabad in Gujarat, and Calcutta. The most prominent figure in the early industrialization of India was Jamsetji Tata, a Parsee businessman from Bombay. Among numerous other ventures, he established the Tata Iron and Steel Company. With American technical assistance, he built a steel mill and industrial township, Jamshedpur, in the eastern Indian state of Bihar. Although lukewarm about the project as a whole, the colonial government did provide official assistance in geological surveys, transport costs, and import arrangements.[10]

On the whole, British colonialists were disinclined to support Indian industrialization. India was a colony of Britain in an economic as well as political sense. This meant that India provided raw materials, which British factories transformed into finished goods. These finished goods were then sold back to India, with all of the value-added profits going to the British capitalists. This situation was a complete reversal of the earlier economic relationship between India and England. Prior to the colonial period, India produced many goods that European markets consumed, even ships for the Royal Navy. India's biggest export was cotton goods. Indian calicoes flooded European

10. *The Indian and Pakistan Year Book 1951*, 17; Gijsbert Oonk, "The Emergence of Indigenous Industrialists in Calcutta, Bombay, and Ahmedabad, 1850-1947," *Business History Review* 88 (Spring 2014): 43-71; Kumar, ed., *Cambridge Economic History of India*, 2:588-89.

markets, which could not compete with the foreign products. The situation reversed completely after British entrepreneurs developed a mechanized textile industry. Textiles produced in factories could out-sell Indian calicoes, even in Indian markets. The flood of low-cost English cloth into Indian markets ruined the Indian textile industry. It was thus symbolic, as well as practical, when Mohandas K. Gandhi, the leader of the Indian National Congress's independence movement, made hand-spinning of cotton a ritual for freedom-fighters. Gandhi wanted India to gain not only political independence, but also economic independence.[11]

The colonial government, as well as the leaders of some of the semi-independent princely states, undertook some projects to develop India along western industrial lines. They built the largest rail network in any colony, which left India with 24,565 miles of track after the Partition of Pakistan into a separate nation.[12] They constructed canals to irrigate fields and even a few hydroelectric projects to power cities and factories. The total power generative capacity in India was a little less than 2,000 MW at independence, or about 20 percent less than the capacity of the Tennessee Valley Authority in the United States at the time. Despite a self-proclaimed civilizing mission, the imperialists made no serious attempts to initiate an industrial revolution in India, as had occurred in western

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11. Kumar, ed., *The Cambridge Economic History of India*, 2:19; Andre Gunder Frank, *ReOrient: Global Economy in the Asian Age* (Berkeley: University of California Press, 1998), 198-99. Frank's book makes the useful historiographical contribution of showing how trade in the early-modern period was oriented toward Asia, although he ultimately over-argues his point by completely discounting Europeans' importance in world economic history.

12. When the British government agreed to the Partition of the Indian subcontinent into two independent nations, India and Pakistan, British judge Cyril Radcliffe had the duty of determining where the new international border would be located. In six weeks, the Radcliffe Commission planned the border based solely on population statistics. Muslim-majority districts were included in Pakistan; other districts fell on the Indian side of the border. The Commission did not conduct field surveys of any of the border areas, and as a result the border haphazardly divided infrastructure such as irrigation works and rail lines. Yasmin Khan, *The Great Partition: The Making of India and Pakistan* (2007; repr. New Delhi: Penguin, 2013), 126.

Europe, North America, and Japan. It was in the interests of the British imperialists to leave India without modern industry, so that the colony would continue to serve as a source of raw materials and a market for the finished products of British industry. The result of these policies was that Indian industry remained largely traditional, and crafts continued to absorb almost all of the industrial workforce. Even where the tools of mechanized industry arrived in India they remained, for the most part, foreign intrusions, having been designed and constructed in Europe. When objects moved from western nations to India, the knowledge of how to design, build, and use these objects usually did not. From contact with Europe, India acquired many of the economic, political, ideological, and technological trappings of modernity; but the country remained largely unindustrialized.[13]

Improving the economic condition of India was a top priority of the Indian National Congress, which became the ruling party of India after independence. Like Gandhi, India's first prime minister Nehru believed that true independence must be economic as well as political. Their approaches toward this end, though, were markedly different. The difference revolved around their understanding of the role technology should play in Indian society. From his time living in England and South Africa, Gandhi came to believe that modern industry corrupted everything it touched. "I cannot recall a

13. *One Year of Independence*, 31; *The Indian and Pakistan Year Book 1951*, 263; *Annual Report of the Tennessee Valley Authority 1948* (Washington, DC: Government Printing Office, 1948), 84. The argument about India becoming modern but largely unindustrialized is adapted from Daniel R. Headrick, *The Tentacles of Progress: Technology Transfer in the Age of Imperialism, 1850-1940* (New York: Oxford University Press, 1988), 384. Headrick argues that as a result of colonization, countries such as India became both modern and underdeveloped. If the countries had not been colonized, they would have been either modern and developed (such as Japan), or remained pre-modern and underdeveloped (such as Afghanistan). For reasons made clear later in this introduction, I avoid the terminology of development and underdevelopment throughout the rest of this dissertation.

single good point in connection with machinery," he wrote in 1908. Machinery allowed humans to travel at unnatural speeds and overstep the biological limits placed on them by God. Furthermore, through modern industry, a limited number of people were capable of gaining great wealth and power, while the common people lost what little wealth and power they had. Factory work was a new form of slavery—slavery to management and slavery to the machines. Rather than follow the western nations and recreate the horrors of Manchester in India, Gandhi hoped that independent India would develop small, localized, village-based economies, such as the hand-spinning of cotton that became the icon of the Congress movement. In this way, "We shall save our eyes and money and support Swadeshi [indigenous production] and so shall we attain Home Rule."[14]

Nehru completely rejected Gandhi's pre-industrial vision for independent India. He felt that this approach was backward-thinking, and hoped instead that India would become a modern, industrial nation. "If technology demands the big machine, as it does today in a large measure," he wrote, "then the big machine with all its implications and consequences must be accepted." Like Gandhi, Nehru also believed that modern technology was problematic because it offered the potential to concentrate great power in the hands of a few; unlike Gandhi, Nehru felt certain that the benefits outweighed the risks. He was convinced that careful economic planning in the context of a command economy provided the means to enjoy the material benefits of modern industry while avoiding its pitfalls.[15]

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14. The quotes are from "Machinery," in M.K. Gandhi, *Hind Swaraj, or Indian Home Rule* (1908; repr. Ahmedabad, India: Navajivan, 1938), 80-84. Gyan Prakash discusses the Nehru-Gandhi debate at length in *Another Reason: Science and the Imagination of Modern India* (Princeton, NJ: Princeton University Press, 1999), 201-25.

15. Jawaharlal Nehru, *The Discovery of India* (New York: John Day, 1946), 411, 414. On p. 411, Nehru explained his commitment to industrialization with planning: "I am all for tractors and big

From 1950 until his death in 1964, Nehru chaired the Planning Commission, a central government agency responsible for setting targets for national economic growth. The commission did this by compiling goals submitted by ministries of the central government, as well as state-level planning committees. Although centralized planning was limited by the checks and balances of the Indian Constitution, the Planning Commission did have the authority to sanction financial investment on projects. The commission's First Five-Year Plan took effect in April 1951. The objective of the plan was to improve the country's economy by reducing inequality. Wealth redistribution was not seen as practical or desirable, since people needed incentives to work. The plan focused primarily on finishing infrastructural projects that were already underway, some of which had been initiated prior to independence. The Second Five-Year Plan (1956-1961) had a broader scope, with an ambitious program of construction projects and social reform. The metals and machinery industries received focused attention during this plan. The Third Plan continued in the vein of the second, although it required even heavier foreign investment as a balance of payments crisis of the late 1950s had drained India's foreign exchange reserves. This plan also established economic self-reliance as an official national goal.[16]

The Planning Commission's Five-Year Plans reflected a distinctly modern,

machinery and I am convinced that the rapid industrialization of India is essential to relieve the pressure on land, to combat poverty and raise standards of living, for defense, and a variety of other purposes. But I am equally convinced that the most careful planning and adjustment are necessary if we are to reap the full benefit of industrialization and avoid many of its dangers. This planning is necessary today in all countries of arrested growth, like China and India, which have strong traditions of their own."

16. Kumar, ed., *The Cambridge Economic History of India*, 2:949-55; Paul Bareau, Roland Bird, and Andrew Shonfield, "India's Second Five-Year Plan," *International Affairs* 33 (July 1957): 301-9. The Planning Commission was the successor of the Congress's pre-independence National Planning Committee, established in 1938. The committee set goals for national production and consumption, with the aim of improving the living standards of the Indian population. The committee's work was interrupted by the outbreak of World War II and the arrest of chairman Nehru and the other Congress leaders.

twentieth-century belief that if experts are allowed to centrally direct an economy or society, then they will be able to engineer away the problems of the system. The first state to initiate centrally-directed industrialization on a large scale was the Soviet Union, although planning was already a popular idea among leaders of less-industrialized countries even before Stalin's First Five-Year Plan began in 1928. The rapid industrialization of the Soviet Union provided the gold-standard for planning in the mid-twentieth century. Nehru, like other leaders of recently independent nations, was dazzled by the apparent success of the Soviet project, and he wanted to replicate the results in his country. It was only later in the twentieth century that the inherent shortcomings of the Soviet model became obvious even to the most uncritical observers. Apart from the enormous human toll of dislocation, dispossession, and death, Soviet industrialization created an undiversified economy that favored big over practical, leading to environmental devastation and, in some places, population collapse. These same weaknesses were also unwittingly built into the Indian Five-Year Plans.[17]

Despite these flaws, the accomplishments of India's Five-Year Plans should not be easily dismissed. From 1951 to 1966, the first three plans oversaw large-scale industrialization and a great expansion of the Indian economy. Two statistics, railroads and electric power, represent the larger changes in the economy during this time. In 1969, the year the Fourth Five-Year Plan began, the Indian Railways had 36,585 miles of track,

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17. Morris Bian argues convincingly that Chinese planning under Mao was based on Sun Yat-sen's ideas formulated in the early twentieth century; the plans were not simply copies of Stalin's program. *The Making of the State Enterprise System in Modern China: The Dynamics of Institutional Change* (Cambridge, MA: Harvard University Press, 2005). For critiques of Soviet industrialization, see Loren R. Graham, *The Ghost of the Executed Engineer: Technology and the Fall of the Soviet Union* (Cambridge, MA: Harvard University Press, 1993); Boris Komarov, *The Destruction of Nature in the Soviet Union* (White Plains, NY: M.E. Sharpe, 1980).

a 49 percent increase since Partition. The increase of power generative capacity was even more dramatic. From 1947 to 1966, the total capacity in the country grew from just under 2000 MW to over 9000 MW, a 350 percent increase. Power distribution networks were also increasingly interlinked during this time. However incomplete the industrialization of the Nehruvian period may have been, economic growth then was much faster than it had been during the colonial period.[18]

Independence and autarky

Economic growth for the overall benefit of the Indian population was the main goal of the Five-Year Plans. The Third Plan added the long-term goal of making the Indian economy self-reliant—in other words, establishing autarky. In the vision of Nehru and the other planners, a self-reliant India would not be overly dependent on any other nation for anything, whether it be staple foods, consumer goods, or scientific knowledge. Fostering autarky therefore meant expanding India's agricultural capacity, building factories to manufacture goods that had previously been imported, and establishing institutions for research and education. By attaining autarky, India would free itself from the pattern of economic dependence that had been established during the colonial period. To varying degrees of success, programs for import-substitution attempted to manufacture indigenously products as simple as razors and as sophisticated as fighter jets.[19]

India's quest for autarky was part of an international movement in recently

18. Sham Lal, ed., *The Times of India Directory and Yearbook Including Who's Who 1969* (Bombay: Times of India Press, 1969).

19. David Edgerton discusses autarky in a global context in *The Shock of the Old: Technology and Global History Since 1900* (Oxford: Oxford University Press, 2007), 117-19.

decolonized nations or other countries whose leaders felt their economies were underdeveloped. The leaders of these countries were mostly nationalists who had fought to drive European imperialists out of their country but had, at the same time, internalized European critiques of their countries' economies and societies. While claiming to represent their countries' teeming masses, these leaders were elites who had European-style educations. Jawaharlal Nehru was an upper-caste Brahmin from a wealthy Allahabad family. He studied in England at Harrow and Cambridge and passed the Temple Bar. Despite his profession as a barrister, he was at least as interested in science and technology as he was in law. Sukarno of Indonesia not only had a technical inclination, he received a degree in engineering and followed this line of work for a few years before turning to politics. The modernizing elite represented by Nehru, Sukarno, and others such as Gamal Abdel Nasser of Egypt and Julius Nyerere of Tanzania, all wanted to liberate their countries of foreign economic influence and improve the lives of their citizens as a whole.[20]

The modernizing elites pursued several strategies for achieving autarky. India built dams and factories. Egypt poured almost all of its modernizing energy into a single

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20. Leslie H. Palmier, "Sukarno, the Nationalist," *Pacific Affairs* 30 (June 1957): 101–19; Justus M. van der Kroef, "Sukarno, the Ideologue," *Pacific Affairs* 41 (summer 1968): 245–61; Nathan J. Citino, "The 'crush' of ideologies: The United States, the Arab World, and Cold War Modernisation," *Cold War History* 12 (Feb. 2012): 89-110; C.L.S. Chacage, "The Arusha Declaration and Developmentalism," *African Review* 14 (Jan. 1987): 130-152. An early use of the term "modernizing elite" appears in Edward Shils, "Political Development in the New States: II," *Comparative Studies in Society and History* 2 (Jul. 1960): 379–411. Shils writes in broad terms about modernization without making many references to specific countries. Other scholars identify modernizing elites in countries such as South Korea, Jamaica, Turkey, and Iraq, as well as the major nonaligned nations Egypt, Indonesia, and India. See William A. Douglas "South Korea's Search for Leadership," *Pacific Affairs* 37 (spring 1964): 20–36; Charles C. Moskos, Jr. and Wendell Bell, "Attitudes towards Democracy among Leaders in Four Emergent Nations," *British Journal of Sociology* 15 (Dec. 1964): 317-37; Joseph S. Szyliowicz, "Political Participation and Modernization in Turkey," *Western Political Quarterly* 19 (June 1966): 266-84; James A. Bill, "The Military and Modernization in the Middle East," *Comparative Politics* 2 (Oct. 1969): 41-62.

colossus of a dam, the world's largest at the time. Indonesia made locomotives to run on the narrow-gauge railways of Java. And in many countries across Asia, Africa, and Latin America, foreign-owned assets were expropriated or seized outright.[21]

Many of the countries busily modernizing in the postwar period had something in common: they were unwilling to join sides in the Cold War. These were the nonaligned nations, which represented an alternative to the eastern and western blocs. Nehru was the architect of the foreign policy doctrine of nonalignment, and India accordingly became one of the founding members of the Non-Aligned Movement, an alternative to the Warsaw Pact and the North Atlantic Treaty Organization. Nehru believed that joining either the eastern or western bloc would compromise India's independence. In his eyes, both the United States and the USSR had serious flaws. The Soviet Union was an oppressive dictatorship, while the United States opposed communism so fiercely that it risked undermining liberal democracy within its borders and abroad. India had recently shaken off imperial domination for the first time in centuries, and Nehru wanted to avoid falling under the influence of another great power. If India sided with the United States or the Soviet Union, then the superpower would have undue influence over India. Nehru and his Congress Party believed the nonalignment was the key to securing India's independence.[22]

Domestically, Indian programs for autarky often encountered problems of resource shortages. India was rich in raw materials and had a large labor pool, but it was

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21. A good study of technology in modern Egypt is Timothy Mitchell, *Rule of Experts: Egypt, Techno-Politics, Modernity* (Berkeley: University of California Press, 2002). One of the indigenous Indonesian locomotives, Bima Kunting 3, is on permanent display in a park in front of Benteng Vredeburg, a historic Dutch fort in the central Javan city of Yogyakarta.

22. Robert J. McMahon, *The Cold War on the Periphery: The United States, India, and Pakistan* (New York: Columbia University Press, 1994), 37-41.

short on capital. Centuries of colonialism had drained wealth away from India to England. In order to attain autarky, India had to make judicious use of its resources, as far as possible using labor to save on capital. Improvisation with material goods and nonmaterial commodities such as labor is an established tradition in India, as in other countries and regions where a shortage of capital mitigates against patterns of repetitive mass consumption, as widely followed in the West.

The Indian tradition of improvisation and adaptive reuse is expressed in the Hindi language by the word *jugaad*.[23] In post-liberalization, early twenty-first-century India, *jugaad* has become something of a buzzword. To many Indians, the cleverness and ingenuity represented by *jugaad* are sources of national pride. The most ardent proponents of *jugaad* claim that it has been the key to India's economic growth. *Jugaad's* comparatively fewer but nevertheless vocal detractors identify it as an excuse for laziness and slipshod work, a mindset that has kept India mired in underdevelopment. The reality lies between these two extremes. *Jugaad* by other names is practiced not just in India but around the world. While *jugaad* cannot receive full credit for India's economic rise, it had long been an important aspect of the country's economy.[24]

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23. "जुगाड़ (*jugāṛ*). provision, means of providing." R.S. McGregor (ed.), *Oxford Hindi-English Dictionary* (New Delhi: Oxford University Press, 1993), 376. *Jugaad* is also less commonly transliterated *jugard*.

24. Some positive perspectives on *jugaad* are found in Anand Giridharadas, "A formula for winning in hard times," *International Herald Tribune*, July 24, 2010; Anuj Chopra, "From kerosene to rice husks: Powering India's rural revolution," *The Globe and Mail* (Canada), October 7, 2010. Articles written by *jugaad*'s detractors include: Manu Joseph, "For India, practicality is a weakness," *International Herald Tribune*, March 3, 2011; Sidin Vadukut, "Die, Jugaad, Die," *Livemint.com*, http://www.livemint.com/2011/12/09212109/Die-jugaad-die.html (accessed February 28, 2012). For examples of *jugaad* by other names, see Viviana Narotzky, "Our Cars in Havana," in *Autopia: Cars and Culture*, ed. Peter Wollen and Joe Kerr (London: Reaktion Books, 2002), 168-76; Hernando de Soto, *The Other Path: The Invisible Revolution in the Third World*, trans. June Abbott (New York: Harper & Row, 1989); Douglas Harper, *Working Knowledge: Skill and Community in a Small Shop* (Chicago: University of Chicago Press, 1987).

Contemporary discussions about *jugaad* generally focus on small-scale improvisation—a mechanic getting a car working again by plugging its radiator with chewing gum; dwellers of informal developments who use a bicycle rim as a television antenna; or a *lassiwala* (buttermilk-seller) who churns his product in a modified washing machine.[25] Examples of this sort of improvisation are everywhere in India. Less commonly discussed, but just as important, is improvisation in the context of large-scale mechanized industry. Two examples from the early-independence period illustrate how improvisation made up for resources that India lacked.

The first example comes from the public-sector import-substitution firm Heavy Electricals (India) Ltd. (HE(I)L, (discussed in more detail in Chapter 3). Windings (wires wrapped around rotors and stators in a generator) are normally made of copper. Since India lacked a reliable domestic source of copper, and the price of copper fluctuated wildly on the international market, British consultant J.H. Walker investigated on HE(I)L's behalf whether it would be economical to use indigenously available aluminum instead of imported copper. Walker's calculations concluded that aluminum windings did not represent a significant savings if used in place of copper. As he concluded in an article about his research published in *Proceedings of the Institution of Electrical Engineers*, "the use of aluminum in the stator winding would be justified only in a country where aluminum was indigenous and copper imported and the necessity of saving foreign exchange was important." In other words, it would be justified in a

25. These examples are all from Pavan K. Varma, *Being Indian: The Truth about Why the Twenty-first Century Will Be India's* (New Delhi: Penguin Books, 2004), 73-74. The climax of one blockbuster Hindi movie revolves around *jugaad*. In *Three Idiots* (dir. Rajkumar Hirani, 2009), students at an engineering college (implausibly) serve as midwives for the birth of the child of the principal's daughter. They improvise a suction system from a vacuum cleaner to reorient the fetus for safe passage through the birth canal.

country such as India.[26]

The second example is the construction of Nagarjuna Sagar Dam, ninety-five miles southeast of Hyderabad, in which cheap domestic labor substituted for capital-intensive imported machinery. Begun in 1955 and completed in 1967, the dam was a combined hydroelectric and irrigation project meant to irrigate the arid Deccan with the waters of the Krishna River. Although some cranes were used in the construction, workers did much of the heavy lifting. They carried stones and trays full of mortar up ramps that zigzagged up the face of the dam. According to one account, the workforce on the project was never smaller than 50,000 throughout the duration of construction. Compare this to the United States' Grand Coulee Dam, another combined irrigation and hydroelectric make-work project of comparable size. Even though Grand Coulee was completed more than twenty years before Nagarjuna Sagar, the American project relied far more heavily on machinery; the labor force never exceeded 11,000.[27]

India's programs for attaining autarky were subject to constraints internal and external; technological; political; and economic. The colonial legacy left India with an

26. J.H. Walker, "Aluminum windings for hydroelectric generators: A critical analysis," *Proceedings of the Institution of Electrical Engineers* 114 (Oct. 1967): 1464-70.

27. M. Malleswara Rao, "Taming the Krishna," *The Hindu Magazine*, http://www.hindu.com/mag/2005/12/18/stories/2005121800150200.htm (accessed April 6, 2012). By volume, Grand Coulee Dam is actually 15 percent larger than Nagarjuna Sagar Dam. Volume of Grand Coulee Dam: 11,975,521 cubic yards; volume of Nagarjuna Sagar Dam: 7,985,000 m^3 (10,440,000 cubic yards). In terms of electrical generation capacity, Grand Coulee is much larger. Installed capacity of Grand Coulee Dam: 6,809 MW; installed capacity of Nagarjuna Sagar Dam: 810 MW. U.S. Department of the Interior, Bureau of Reclamation, "Grand Coulee Dam Statistics and Facts," http://www.usbr.gov/pn/grandcoulee/pubs/factsheet.pdf (accessed April 1, 2014); Central Water Commission, "National Register of Large Dams – 2009," http://cwc.nic.in/main/downloads/National%20Register%20of%20Large%20Dams%202009.pdf (accessed October 25, 2012); *Large Dams in India*, vol. 1 (New Delhi: Central Board of Irrigation and Power, 1987), 5. Another example of high-tech *jugaad* appears in Ross Bassett's article "Aligning India in the Cold War Era: Indian Technical Elites, the Indian Institute of Technology at Kanpur, and Computing in India and the United States," *Technology and Culture* 50 (October 2009): 794. Bassett notes that second-hand IBM computers stayed in use in India long after they had passed into obsolescence in the United States. Students and faculty at IIT–Kanpur found creative ways to use these computers well past their intended service lives.

infrastructure and economy ill-suited for independence. Nehru once wrote that "India was, and is, a rich country, rich in agricultural resources, mineral wealth, human material; only her people are poor."[28] He hoped that these physical riches could transform India into an industrial nation that offered prosperity to all citizens. Despite this optimism, the transformation that occurred was only partial. As technology continued to change outside India, and foreign economies continued to grow, autarky remained an ever-receding dream.

Development and literature

The first industrial revolution began in England in the 1700s, and it reached India in the 1850s. The effects of industrialization were obvious from the beginning. Despite industrialization's initially negative social effects, England's neighboring countries scrambled to industrialize as soon as possible, in order to enjoy greater productivity and therefore increased profits. In the period of decolonization after World War II, industrialization became conflated with "development," a broad term that encompassed economic growth and modernization, usually along western lines. As Nick Cullather argues, proponents of development claimed that the economies of all nations travel on the same path, but some are more advanced than others. According to this worldview, all economies are working toward the same goal, and the less-developed economies will catch up with the more-developed economies eventually.[29]

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28. Jawaharlal Nehru, "The Unity of India," *Foreign Affairs* 16 (January 1938): 231.

29. Nick Cullather, "Damming Afghanistan: Modernization in a Buffer State," *Journal of American History* 89 (Sept. 2002): 513. An early proponent of the single-track modernization theory was Edward Shils, who argued in *The Intellectual between Tradition and Modernity: The Indian Situation* (The Hague: Mouton, 1961) that India's modernization was leading toward the goal of westernization. Lloyd and Suzanne Rudolph criticized Shils's argument in their book *The Modernity of Tradition: Political Development in India* (Chicago: University of Chicago Press, 1967), in which they emphasized the

The terminology of development allows the division of the world into developed and developing countries. In the twenty-first century, the latter term is frequently used as a substitute for the obviously pejorative term "third-world country." During the Cold War, the third world was the Non-Aligned Movement, as distinct from the first world (western bloc) and second world (eastern or Soviet bloc). "Third world" was initially only a political term, but it quickly acquired economic and social meanings. In the expanded meaning of the term, a third-world country had low incomes, poor infrastructure, and a corrupt administration. Although the term remains in widespread colloquial usage, it has gone out of fashion in literature in favor of other terms, such as "developing nation" or "global south."[30] While admitting the inadequacy of the "third world" terminology, these other terms are equally inadequate, because they are based on the dubious assumption that there is something inherently similar about all of the countries that are not highly industrialized. Mexico, Nigeria, India, and Fiji are grouped together into one category for no other reason than that they have less mechanized industry and lower per capita incomes than the United States, Germany, or Japan. This is not appropriate. The less-industrialized countries deserve to be studied individually and in comparison with each other, but attempts to develop a term grouping all of them together leads quickly to stereotyping and is ultimately meaningless.[31]

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continuity of traditional Indian thinking as represented by the worldview of Mohandas K. Gandhi.

30. B. R. Tomlinson, in "What Was the Third World?" *Journal of Contemporary History* 38 (Apr. 2003): 307, cites Peter Worsley who admitted in 1984 that "the nature of the Third World seemed so self-evident in the 1960s that in a book on *The Third World* I published in 1964, I saw no need to define it any more precisely than that it was the world made up of the ex-colonial, newly-independent, non-aligned countries."

31. The stereotyping inherent in the third world/developing nation/global south terminology is a form of Orientalism, the western construction of an eastern (i.e. oriental) Other. See Edward W. Said, *Orientalism* (1978; repr. New Delhi: Penguin Books, 2001). Another study of western views of the rest of the world is Michael Adas, *Machines as the Measure of Men: Science, Technology, and Ideologies of Western Dominance* (Ithaca, NY: Cornell University Press, 1989). This book is an intellectual history of

Proponents of industrialization have usually had their way, but there is also a long intellectual tradition of opposing industrialization. In 1840s Massachusetts, Henry D. Thoreau wrote of his distaste for the steam train that passed by Walden Pond, running tirelessly and blowing its whistle at every hour, even midnight. Gandhi's critique of industrialization was social and economic, unlike Thoreau's largely aesthetic critique. After World War II, the industrialization and modernization now grouped under "development" started to attract criticism. Like Gandhi in an earlier era, the critics of development hoped that the former colonies busily industrializing would change tack in order to avoid making the same mistakes that the western nations had made as they industrialized.

Among the most prominent critics of large-scale development were the Appropriate Technologists led by Swiss economist E.F. Schumacher. The definitive text of the movement was, and still is, Schumacher's *Small Is Beautiful: Economics as if People Mattered*, a collection of essays originally published in 1973. The essays collectively argue that the high-energy, capital-intensive course of development being pursued by the former colonies was leading to environmental degradation and social decay. Schumacher alleged that five-year plans in these countries (India and Turkey are mentioned by name) are counter-productive, as unemployment tended to increase during the plans, mainly as a result of mechanization of production. In Schumacher's view, the economies of these countries did not need capital-intensive industrial machinery.[32]

In one particularly influential passage of *Small Is Beautiful*, Schumacher

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how Europeans viewed non-European peoples as backward on the basis of their technology.

32. E.F. Schumacher, *Small Is Beautiful: Economics as if People Mattered* (New York: Harper, 1973), 175. Another influential appropriate technology book was Ivan Illich, *Tools for Conviviality* (London: Marion Boyars, 1985).

described three categories of technology. The first was the £1-technology (roughly $13 US today), which represented the low-capital tools used in pre-industrial economies. The second was the £1,000-technology, which represented the capital-intensive tools of industrial production. Schumacher argued that pre-industrial societies needed more effective tools than the £1-technology, but the £1,000-technology was totally unsuitable for low-capital economies. Instead, they needed a compromise, the £100-technology, which would take advantage of modern scientific knowledge but would not be so capital-intensive as to be out of the reach of pre-industrial economies. Schumacher called the £100-technology "intermediate technology." This term later became "appropriate technology." The terminology leaves unanswered the question of who decides which technologies are appropriate, and what criteria guide this decision. The Appropriate Technology movement peaked in popularity in the 1970s, although it lives on in a smaller scale in the ideology of rural development non-governmental organizations such as Engineers Without Borders.[33]

The literature of the Appropriate Technologists was prescriptive, as it offered plans, however unrealistic, for saving the world from the evils of industrialization. Since the 1970s, scholars have developed more refined critiques of industrialization and development; these critiques nevertheless owe an intellectual debt to the Appropriate Technologists. An exemplary critique is James C. Scott's *Seeing Like a State: How Certain Schemes to Improve the Human Condition Have Failed*. This wide-ranging survey analyzes the failures of such ambitious modern projects as scientific forestry, Soviet collectivization, and planned cities like Brasilia and Chandigarh. Scott argues that

33. Schumacher, *Small Is Beautiful*, 180.

in each case, modernizers simplified complex natural systems to make them understandable, but in the process they did not account for a wide enough range of variables. What is missing in the modern projects is *mētis*, informal knowledge that is learned through tradition or practical experience rather than formal education. Derived from a Greek word referring to cleverness and ingenuity, *mētis* emerges from natural cultural development and cannot be imposed by central authorities.[34]

This dissertation is neither a critique nor a celebration of development. Rather, it is an analysis of one aspect of development in the early-independence period, the indigenization of foreign industrial technologies. If the critics of development are represented by Gandhi, and its proponents by Nehru, then neither a Gandhian nor a Nehruvian approach serves in studying Indian technology. In other words, it is not appropriate to universally condemn or universally laud development projects. Instead, the projects should be studied objectively, as far as possible, on their own merits. From this perspective, this dissertation will show that indigenization programs had ambivalent outcomes.

The analysis of this dissertation is grounded in the historiography of technology. The theoretical background is provided by David Edgerton's *The Shock of the Old*. Edgerton argues that histories of technology need to be more geographically inclusive, and the way to achieve this is by adopting use-based rather than innovation-based narratives. Technological innovation is geographically and temporally limited; by focusing on the new, innovation-based narratives ignore older technologies that remain in

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34. James C. Scott, *Seeing Like a State: How Certain Schemes to Improve the Human Condition Have Failed* (New Haven, CT: Yale University Press, 1998).

use worldwide. A use-based narrative, on the other hand, allows us to view anyplace on earth that people live as a potential setting for a history of technology. This theory is relevant for the study of India during the early independence period. Nehruvian India was not a site of major technological innovation, but industrial technology was in widespread use.[35]

In terms of content, this dissertation is a direct response to Daniel Headrick's *Tentacles of Progress*. While Headrick studies European technologies in use across the imperialized world, this dissertation carries the narrative past independence in one national context. Despite a similarity of subject matter, the methodology of this dissertation differs from Headrick's work. Whereas Headrick writes about a widely-studied period and could rely completely on secondary sources, the post-independence period of Indian history has been less thoroughly studied. This is true for history of technology as well as Indian history as a whole.[36]

This dissertation, then, is a contribution to the historiography of post-independence Indian technology. The four case studies join the work of other historians of technology who have crossed the 1947 barrier in their studies of Indian technology. Ross Bassett examines the use of IBM computers at the Indian Institute of Technology–

35. David Edgerton, *The Shock of the Old: Technology and Global History Since 1900* (Oxford: Oxford University Press, 2007). Another history of technology theory that influences the analysis of this dissertation is the Social Construction of Technology (SCOT). The definitive work on SCOT is Wiebe E. Bijker, Thomas Parke Hughes, and T. J. Pinch, *The Social Construction of Technological Systems: New Directions in the Sociology and History of Technology* (Cambridge, MA: MIT Press, 1987).

36. The official government-issued history textbooks used at the school where I taught in Meghalaya stop with the adoption of the constitution in 1950. As Ramachandra Guha argues, popular historiography portrays independence as a climax and a culmination; after this, nothing important could happen because the nation had already arrived at its goal. While Indian social scientists continued to study the present, historians stayed in a historiographical never-neverland in which the historical past receded ever further from the present. *India After Gandhi: The History of the World's Largest Democracy* (New York: Ecco, 2007), 12-14. Another post-independence survey history is Bipan Chandra, Mridula Mukherjee, and Aditya Mukherjee, *India Since Independence* (New Delhi: Penguin Books, 2008).

Kanpur. David Arnold studies the adoption, use, and reinterpretation of small machines in India from the late 1800s to the 1960s.[37] Two areas of post-independence Indian science and technology have received considerable attention from historians: nuclear science and the Indian space program. The space program is outside the chronological scope of this dissertation, but nuclear science is not, and Chapter 4 contributes to the historiography of this topic. The existing literature focuses on nuclear weaponry, but the case study in this dissertation turns attention to the beginnings of Indian nuclear energy, which relied completely on imported technology.[38] This dissertation thus broadens the historiography of Indian technology with four case studies of topics that other scholars have studied little or not at all. Each of the case studies contributes to an understanding of how the Indian public sector used foreign industrial technologies and tried to make them Indian.

Outline of dissertation

This dissertation is divided into four chapters, one for each case study. Chapter 1 examines the American military aid program to India after the 1962 Sino-Indian War.

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37. Ross Bassett, "Aligning India in the Cold War Era: Indian Technical Elites, the Indian Institute of Technology at Kanpur, and Computing in India and the United States," *Technology and Culture* 50 (Oct. 2009): 783-810; David Arnold, *Everyday Technology: Machines and the Making of India's Modernity* (Chicago: University of Chicago Press, 2013). Arnold argues that the historiographical obsession with large-scale technology in the colonial era (such as Headrick studied) obscures the significance of "everyday technologies" such as typewriters and bicycles, which became widely available to the masses as well as the elites.

38. Works on nuclear science in India include: Itty Abraham, *The Making of the Indian Atomic Bomb: Science, Secrecy, and the Postcolonial State* (London: Zed Books, 1998); Robert S. Anderson, *Nucleus and Nation: Scientists, International Networks, and Power in India* (Chicago: University of Chicago Press, 2010). Works on Indian space research include: Gopal Raj, *Reach for the Stars: The Evolution of India's Rocket Programme* (New Delhi: Viking, 2000); P.V. Manoranjan Rao and P. Radhakrishnan, *A Brief History of Rocketry in ISRO* (Hyderabad: Universities Press, 2012); Asif A. Siddiqi, "Competing Technologies, National(ist) Narratives, and Universal Claims: Toward a Global History of Space Exploration," *Technology and Culture* 51 (Apr. 2010): 425-43. Siddiqi argues that the Indian space program is neither fully postcolonial nor fully western; it has elements of both. This assertion can be extended to the other post-independence Indian technologies discussed in this dissertation, as they were made up of both Indian and foreign elements.

This study shows how technological interchange between India and the western powers was inextricably tied with nonalignment and Cold War politics. The chapter also serves as an extended introduction to Indian foreign policy and nonalignment, as well as the history of the Indian aviation industry and air force.

The remaining three chapters represent a spectrum of indigenization and approaches to technology transfer. Chapter 2 describes the planning and construction of the first bridge over the Brahmaputra River in Assam, executed by two private-sector prime contractors on behalf of the Northeast Frontier Railway (NFR) between 1959 and 1962. Hindustan Construction Company constructed the bridge's foundations and piers, and Braithwaite Burn & Jessop (BBJ) built the trusses that carried twin rail lines and a roadway. The Brahmaputra Bridge, dubbed Saraighat Bridge at its dedication in 1963, falls as close to the indigenous end of the spectrum as any project during the early-independence period. The Northeast Frontier Railway held an open tender for bids for the steel truss spans. Despite receiving slightly lower bids from foreign firms, NFR awarded the contract to BBJ. The main agenda of the tendering process had not been to secure the lowest-priced contract; rather, NFR wanted to determine whether any new bridge-building technology had developed outside India that was worth bringing into the country through this contract. NFR determined that Indian bridge-building was suitably up-to-date, and therefore awarded the contract to a domestic firm.

The Umiam (Barapani) Hydro-Electric Project, the subject of Chapter 3, falls somewhere in the middle of the indigenous/foreign spectrum. Umiam is a reservoir-storage hydropower plant built between 1960 and 1965 in the Khasi Hills of Assam (now

Figure 1. Map of India showing locations of the case studies and other significant places mentioned in the following chapters. (Source: http://commons.wikimedia.org/wiki/File:India_location_map2.svg, accessed April 7, 2011. Marks and labels added by the author.)

Meghalaya). Unlike the Brahmaputra Bridge, Umiam Dam was built departmentally by the public-sector agency that would use it, the Assam State Electricity Board (ASEB). After construction had already begun, the Indian government received a loan from the

United States government's Development Loan Fund to finance foreign-exchange costs for the project. An additional rupee loan under Public Law 480 covered the in-country costs of the project. With this American funding, ASEB purchased parts for the project from the United States and other countries around the world, although it was careful to avoid buying anything from Soviet-bloc nations against which the United States was then in ideological opposition. An Indian project from beginning to end, Umiam Dam could nevertheless not have been built without the financial, material, and technical contributions of foreign nations.

On the opposite end of the spectrum from the Brahmaputra Bridge is Tarapur Atomic Power Station, the subject of Chapter 4. India's first commercial nuclear powerplant, Tarapur was built between 1964 and 1969 at a coastal site sixty miles north of Bombay. Tarapur was constructed as a turn-key project by the Indian branch of the American firm General Electric, with Bechtel India serving as engineer-constructors. The Power Branch of the Indian Department of Atomic Energy oversaw the project and made significant contributions of expertise and labor. Here foreign involvement was the essential element of the project. Although India would ultimately develop indigenous power reactors, that technology was still decades in the future at the time of the construction of Tarapur.

Nehruvian development in context

The Third Five-Year Plan has been completed for a half-century now, and India is a markedly different place now than it was in 1966. Through the 1970s and 1980s, the Five-Year Plans continued to promote public-sector industrial development and the command economy. The command economy was weakened under Prime Minister Rajiv Gandhi in the mid-1980s, and finally in 1991, Finance Minister Manmohan Singh oversaw its dismantling. Economic liberalization, as it was called, opened the doors for greatly expanded private-sector investment, especially by foreign firms. Soon American fast food chains opened in major Indian cities, and German cars began to ply the Indian roads.

From the nonalignment period's quest for autarky through domestic production and public-sector investment, the pendulum had swung in the opposite direction. Indian culture, at least among the privileged classes, started to favor foreign brands and engagement with only the private sector as far as possible. An indigenous car brand such as Maruti or Tata was not as desirable as a Skoda or an Audi, even though most foreign-branded cars sold in India were nevertheless manufactured domestically. A prime destination for the upwardly-mobile classes of the early twenty-first century was Gurgaon, located in the state of Haryana, just outside of Delhi National Capital Territory. Through most of history, Gurgaon was, as its name suggested, just a village in the northern Indian wheat belt (*gaon* means village in Hindi). Then in the late 1990s, a revision in Haryana's state tax codes allowed Gurgaon to transform itself into a modern city. Fifteen years later, Gurgaon had a population of over two million. The city was built almost completely by private capital. Even the Rapid Metro system was built without public investment. Unlike Delhi just across the state line, which expands gradually and methodically under the guidance of the governmental Delhi Development Authority, Gurgaon has grown up virtually without a plan. The upwardly-mobile classes speak of

Gurgaon as a great triumph of public capital, achieving rapid urbanization in a way that the public sector's committees could only dream about.

The public sector in India should not be so easily dismissed, either in the present or in historical analysis. India's strongest advocates of free-market capitalism look back at the Nehru years as a wasted opportunity. These analysts reason that rather than allowing the private sector to generate wealth in a competitive market, the economy was hobbled by planning and an over-emphasis on the public sector. The flaw of this reasoning as that it overlooks the major contributions that the public sector has made to the Indian economy, in the past as well as the present. The Nehruvian period saw a major expansion of Indian industrial capacity, which the private sector later took advantage of. Even to this day, the public sector makes up a significant part of the Indian economy. Beyond the usual roles of policing, transit, highways, education, and so forth, undertakings of the central and state governments still include the national rail network, heavy manufacturing, steel, telecommunications, and even film production. Although the Nehruvian command economy has long been dead, the public-sector undertakings are still numerous and economically important. Rather than setting up the command economy as a straw man, as most commentators today do, the pre-liberalization era deserves to be studied on its own merit.

Chapter 1: Exercise Shiksha

On November 19, 1962, the government of India was in a desperate situation. For the past month, the Indian Army had suffered defeat after defeat at the hands of the Chinese People's Liberation Army (PLA) in the contested border regions of north and northeast India. In the Northeast Frontier Agency (NEFA),[1] the PLA appeared to be on the verge of breaking out of the mountains and into the flatlands of the Brahmaputra Valley.

For fifteen years, independent India had avoided allying itself with either of the great powers, the United States or the Soviet Union. During the Chinese attack, though, Prime Minister Jawaharlal Nehru concluded with regret that this policy of nonalignment was impractical during the present crisis. On November 19, Nehru dispatched two diplomatic cables to President John F. Kennedy. In the first, he provided an update of the military situation and stated that fighter aircraft were "absolutely necessary" for the defense of India. In the second letter, sent several hours later, Nehru announced that the situation had become "really desperate." He asked the United States to send radar stations and twelve squadrons of all-weather fighters to protect Indian cities from Chinese attacks. Since Indians did not yet have the training to operate this equipment, Nehru further requested that both the radar stations and the fighters be crewed by American personnel

1. The territory covered by NEFA consists of the eastern Himalaya, stretching from Bhutan to Burma. In 1962, NEFA was a subdivision of the Indian state of Assam. The territory of NEFA is now the Indian state of Arunachal Pradesh.

initially. In other words, Nehru was not only requesting military aid, but direct intervention. As historian Robert J. McMahon notes in *The Cold War on the Periphery*, "It must have been a moment of supreme humiliation for the proud Nehru, a man who had always insisted that India follow the path of independence and self-reliance."[2]

Kennedy never got a chance to reply to Nehru's request for fighter cover against the invading Chinese, because the war ended the next day. On November 20, with the PLA poised at the threshold of the plains of Assam, the Chinese government shocked India by offering a cease-fire. Chinese troops began to withdraw from their positions in Indian territory. The Chinese government never provided an official reason for the withdrawal; historians and analysts have since suggested various reasons, ranging from a fear of American involvement in the conflict, to an acknowledgment that the approaching winter snows would cut off supply lines from China. Whatever the underlying reasons for the Chinese withdrawal, the invasion of Indian territory had clearly demonstrated Chinese superiority in the region. Although India regained most of its lost territory, the war made a deep impression on the Indian government, military, and general public. As Sarvepalli Gopal wrote in his biography of Nehru, "No one who lived in India through the winter months of 1962 can forget the deep humiliation felt by all Indians, irrespective of party."[3]

Nehru's surprising and unprecedented request to Kennedy shaped US military policy toward India for the next three years. Both during and after the war, Nehru's

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2. Jawaharlal Nehru to John F. Kennedy, November 19, 1962 (two telegrams), Nehru correspondence, National Security Files, Presidential Papers, JFK Library; Robert J. McMahon, *The Cold War on the Periphery: The United States, India, and Pakistan* (New York: Columbia University Press, 1994), 292.

3. Sarvepalli Gopal, *Jawaharlal Nehru: A Biography* (Cambridge, MA: Harvard University Press, 1984), 3:232. For a discussion of the different explanations offered for the Chinese withdrawal, see Ramchandra Guha, *India After Gandhi: The History of the World's Largest Democracy* (New York: Ecco, 2007), 339. For a narrative of the end of the conflict, see McMahon, *Cold War on the Periphery*, 292-93.

government accepted military aid from the United States, thus drawing nominally nonaligned India toward the American orbit. In offering military aid to India, the United States did not abandon its South Asian ally Pakistan, because American military aid to Pakistan continued uninterrupted. Similarly, India's acceptance of American military aid did not signal an abandonment of nonalignment, because India signed no formal alliance with the United States and maintained cordial relations with the Soviet Union. Nevertheless, the military aid program represented a symbolic favoring of India by the United States and a westward shift in India's foreign policy.

In August 1963, the United States shipped secondhand radar sets to India, for use along the country's long mountainous border with China. Exercise Shiksha, named for a Sanskrit word meaning education, trained Indian crews in the use of this equipment. In November, a squadron of eighteen US Air Force (USAF) North American F-100 Super Sabre fighter-bombers deployed to Palam air base in Delhi to take part in the exercise. Both US and Indian Air Force (IAF) planes performed practice scrambles and interceptions against IAF and Australian target aircraft. Royal Air Force (RAF) Javelin fighters performed similar exercises alongside IAF aircraft at Kalaikunda air base near Calcutta. After the exercise concluded, the western aircraft redeployed to their home countries.

Exercise Shiksha illustrates how India's political nonalignment affected and ultimately complicated the country's modernization. Nonalignment did not prevent the United States from offering extensive civilian development aid to India; through the US Agency for International Development (USAID) and its predecessor organizations, the

United States provided billions of dollars worth of aid in the form of dollar and rupee loans. This development capital went to constructing some of the power stations, mills, and factories that Nehru and other Indian modernizers hoped would transform their country into an industrial nation. On the other hand, Nehru's foreign policy limited India's access to American military equipment. The United States distributed its military aid on ideological grounds; only formally US-aligned nations could access the best American equipment. After the Sino-Indian War, India received secondhand American radar sets, but no tanks or fighter jets. The United States was willing to offer civilian development aid to a nonaligned nation such as India, but it did not want to offer large-scale military aid to any nation that would not pledge its loyalty to the western bloc.[4]

It was not from a lack of effort on India's part. The leaders of the Indian Air Force stated that the experience of Exercise Shiksha had demonstrated their need for supersonic fighter jets, but the US government ultimately rejected Indian offers to purchase American planes. The Indian obsession with American supersonic fighters during Exercise Shiksha highlights differing conceptions of modernity, progress, and development in India during the early-independence period. As Itty Abraham notes, the concept of "development" was a post-World War II construct. Definitions of progress and modernity, and the relative importance of civilian and military technology, were similarly constructed and subject to change. In a 1956 speech before the Lok Sabha, the lower house of the Indian parliament, Nehru argued that a country's strength was based on its

4. The United States Information Service claimed that the United States was the largest provider of Indian foreign aid in *United States Economic Assistance to India*: *June 1951 – April 1971* (New Delhi, 1971), 40-41. For an overview of American development aid to India up to the mid-1960s, see Agency for International Development, *Program and Project Data Related to Proposed Programs – FY 1965: Near East and South Asia* (Washington, DC: n.p., 1964), 54-121.

industry, not its military. “The Five-Year Plan is the defence plan of the country,” he said. “What else is it? Because, defence does not consist in people going about marching up and down the road with guns and other weapons. Defence consists today in a country being industrially prepared for producing the goods and equipment of defence.” Make civilian industry strong, Nehru argued, and military industry will naturally follow.[5]

Not everyone in India accepted Nehru’s argument that military armament should be subordinate to industrial development. After Exercise Shiksha, the IAF leadership wanted American supersonic fighters because they based their service’s identity on technology. Just as the US Army Air Corps in the 1930s insisted that it needed the bigger and supposedly higher-tech B-17 Flying Fortress rather than the smaller but equally practical B-18 Bolo, the IAF leadership in 1963 wanted only what they perceived to be the best and highest-tech. In 1963, the IAF was not totally bereft of supersonic aircraft; the service was already operating MiG-21s from the Soviet Union. The MiG-21 was a simple, lightweight design that made up for its limited range and armament with speed and maneuverability. By comparison, the American fighters that the IAF leadership wanted were heavier, more expensive, and much more complicated. The IAF equated complexity with technological sophistication, and therefore it wished that it could have American rather than Soviet fighters. Since Cold War politics prevented India from obtaining these fighters, the IAF leadership could have claimed that, from their perspective, nonalignment had hindered their country’s modernization.[6]

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5. “The Plan is the country’s defence,” in *Jawaharlal Nehru’s Speeches* (Delhi: Ministry of Information and Broadcasting, 1958), 3:41; Abraham, *Making of the Indian Atomic Bomb: Science, Secrecy, and the Postcolonial State* (London: Zed Books, 1998), 11.

6. Bill Gunston, *Mikoyan MiG-21* (London: Osprey, 1986), 9, 68; Timothy Moy, “Transforming Technology in the Army Air Corps, 1920-1940: Technology, Politics, and Culture for Strategic Bombing,” in *The Airplane in American Culture*, ed. Dominick A. Pisano (Ann Arbor: University of Michigan Press,

In his 1989 *Technology & Culture* article, James Hansen calls on historians to study "aviation history in the wider view."[7] Hansen notes that most aviation history is internalist and decontextualized; the planes and the flying stories are justification enough for studying the subject matter. For this reason, aviation historiography had become almost completely separated from other historiography, and historians of other fields often looked down on aviation history as trivial. Hansen exhorts aviation historians to consider their topics in their broader context. He also hopes that historians from other fields will contribute outsider perspectives to aviation history.

One aspect of the field that Hansen identifies as particularly weak is the history of aviation outside the western world. There are countless books on the aviation pioneers of the United States, Britain, France, and Germany, but there is little literature on aviation outside North America and western Europe. This chapter is a response to Hansen's call to approach aviation history in the wider view. Exercise Shiksha receives its full contextualization in the following three chapters. Just as technology transfer was taking place in the field of aviation in India during the Third Five-Year Plan, it was occurring in other fields as well.

The American military aid program to India also offers insight into Indo-American relations during the Cold War, because Exercise Shiksha provides an opportunity to study the interactions between Indian and American military personnel who represented their own governments but were not diplomats. Despite press reports about healthy cooperation and camaraderie between Indian and American crews, cultural

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2003), 322-23.

7. James R. Hansen, "Aviation History in the Wider View," *Technology and Culture* 30 (July 1989): 643-56.

and political differences caused tensions throughout the planning and execution of the exercise. Because India had a socialist economy, and because Indian relations with the Soviet Union remained friendly in the period after the war with China, the American airmen suspected that nonaligned India had a secret inclination toward communism. Furthermore, in American eyes, India appeared underdeveloped and technologically backward, as illustrated by the comparatively unsophisticated fighters fielded by the IAF in Exercise Shiksha. Indian airmen, in their turn, resented such attitudes and suspected the Americans of imperialistic ambitions.

Exercise Shiksha illustrates the complex political interplays that attended technological change in nonaligned India. The concerned parties had their own contrasting understandings of the significance and role of technology in independent India. The Americans saw Exercise Shiksha as a diplomatic opportunity; they hoped that their contribution of materiel and expertise would represent the first step toward closer political cooperation between the world’s two largest democracies. For Nehru and his civilian government, Exercise Shiksha was a strictly military affair, and the importation of foreign military technology was merely a stop-gap until India could produce such equipment indigenously. The Indian Air Force leadership, on the other hand, saw importation of American technology as the best way to modernize their service, preferable to waiting for Indian industry to develop comparable capabilities. These differing understandings show how technology’s movement across international boundaries, contingent as it is upon culture and politics, was especially influenced by nonalignment in the Cold War world.

Background of the Sino-Indian border dispute

After gaining independence from the British Empire in 1947, India and Pakistan, estranged from each other by the trauma of Partition, took different approaches to foreign policy. Nehru believed that his policy of nonalignment was the key to securing world peace. By remaining nonaligned, India and other nations, mostly other former colonies, would provide a counterbalance to the diplomatic and possibly military excesses of the eastern and western blocs. Pakistan, by contrast, actively sought out foreign alliances. The smaller and weaker state to emerge from British India, Pakistan needed powerful friends in order to counter India. In 1954, Pakistan signed a mutual assistance agreement with the United States, which stipulated that Pakistan would receive American military aid in exchange for allowing American forces to use strategic air bases and port facilities. Pakistan would go on to join two different western-bloc treaty organizations, the South-East Asia Treaty Organization (SEATO) and the Central Treaty Organization (CENTO).[8]

South Asia was far from the centers of Cold War tensions, but India and Pakistan still found themselves swept up in the US-Soviet clash of superpowers. While Pakistan moved into the American orbit, India established friendly relations with the USSR. Even though Nehruvian India never signed any alliances or defense pacts with the Soviet Union, India's cultural and technological exchanges with the USSR made the United States increasingly suspicious of Nehru and his government. In the decades following Indian and Pakistani independence, the countries of South Asia served as proxies in the

8. McMahon, *Cold War on the Periphery*, 37-41, 142, 183; Frank Moraes, *Jawaharlal Nehru: A Biography* (New York: Macmillan, 1956), 472; John Keay, *Midnight's Descendants: South Asia from Partition to the Present Day* (London: William Collins, 2014), 125, 144. Another account of United States–Pakistan relations, aimed at political scientists and policy makers, is Dennis Kux, *The United States and Pakistan, 1947-2000: Disenchanted Allies* (Washington, DC: Woodrow Wilson Center Press, 2001).

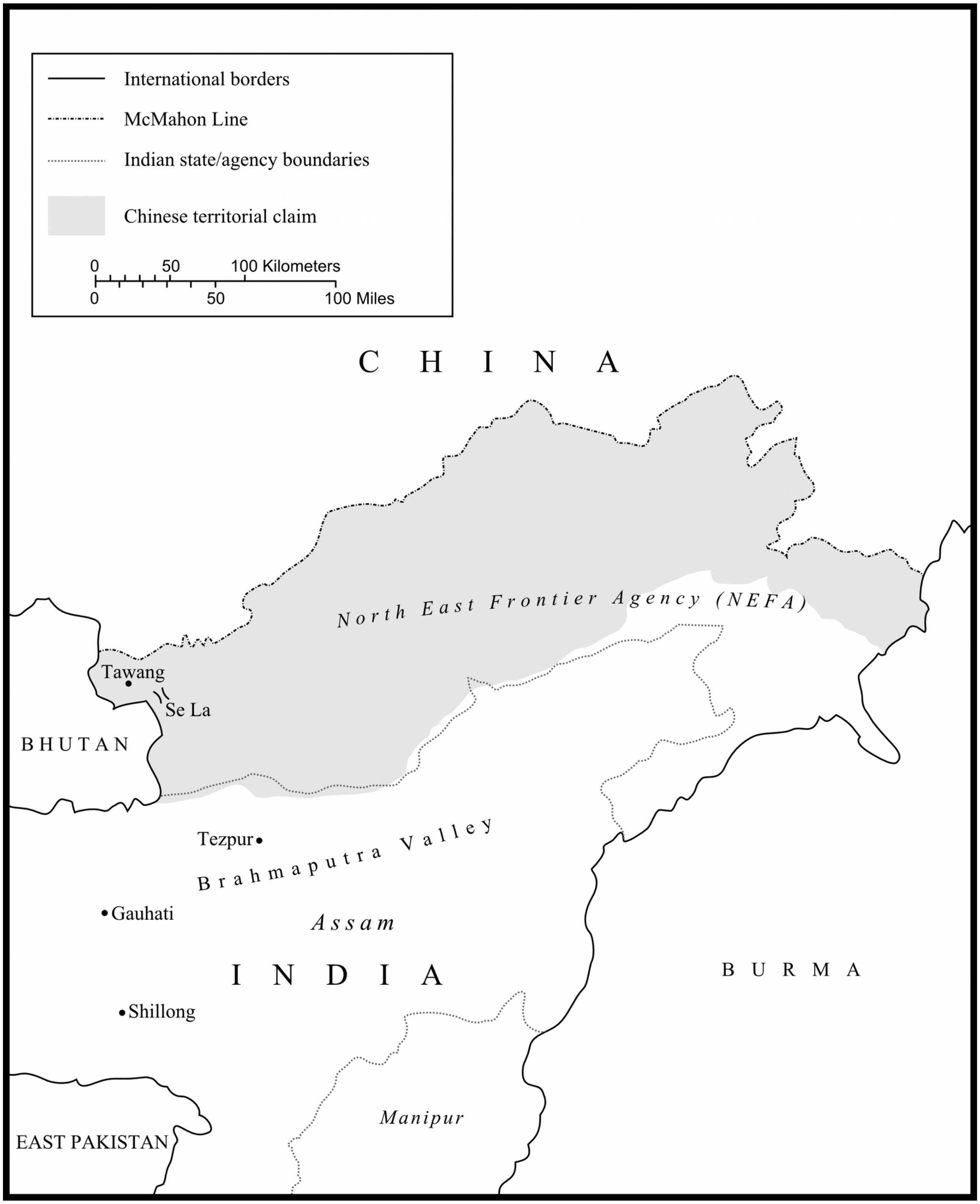

Figure 2. The eastern section of the China-India border, showing the contested area. (Map drawn by the author, based on map at http://www.lib.utexas.edu/maps/middle_east_and_asia/china_india_e_border_88.jpg, accessed March 2, 2012.)

larger struggle between the United States and the Soviet Union.[9]

When they came into existence in the years immediately following World War II, the modern states of India and the People's Republic of China had plenty of diplomatic common ground. The two largest countries in Asia, both had recently emerged from centuries of foreign domination, and both were attempting to rebuild and modernize their societies. Although Nehru and Chairman Mao had radically different political philosophies, both believed that their countries could best develop under socialistic command economies and centralized planning. Even though Nehru was dubious about the legality of China's annexation of Tibet in 1950, in 1954 he signed the Panchshila, a five-point agreement recognizing China's right to Tibet. Sino-Indian relations remained steady until March 1959, when the Dalai Lama, the temporal and political leader of Tibet, fled from his homeland and sought asylum in India. As a result, Sino-Indian relations rapidly deteriorated. Within months, Indian and Chinese border troops had begun skirmishing on the long frontiers between the two countries.[10]

Apart from India's support for the Dalai Lama, another contentious issue between China and India was the location of the international border (Figures 2 and 3). Chinese and Indian territorial claims overlapped in large areas of the Himalaya mountains. In the west, between Pakistan and Nepal, China and India claimed Aksai Chin, a barren and largely uninhabited plateau. On the other side of the frontier, between Bhutan and Burma, both China and India claimed the southern slopes of the Himalaya. These territorial

9. McMahon, *Cold War on the Periphery*, 223-24.

10. Ibid., 261. For the role of Tibet in Cold War relations between the United States and South Asia, see Robert J. McMahon, "U.S. Policy toward South Asia and Tibet during the Early Cold War," *Journal of Cold War Studies* 8 (summer 2006): 131-144. For a detailed account of American involvement in Tibet, see John Kenneth Knaus, *Orphans of the Cold War: America and the Tibetan Struggle for Survival* (New York: PublicAffairs, 1999).

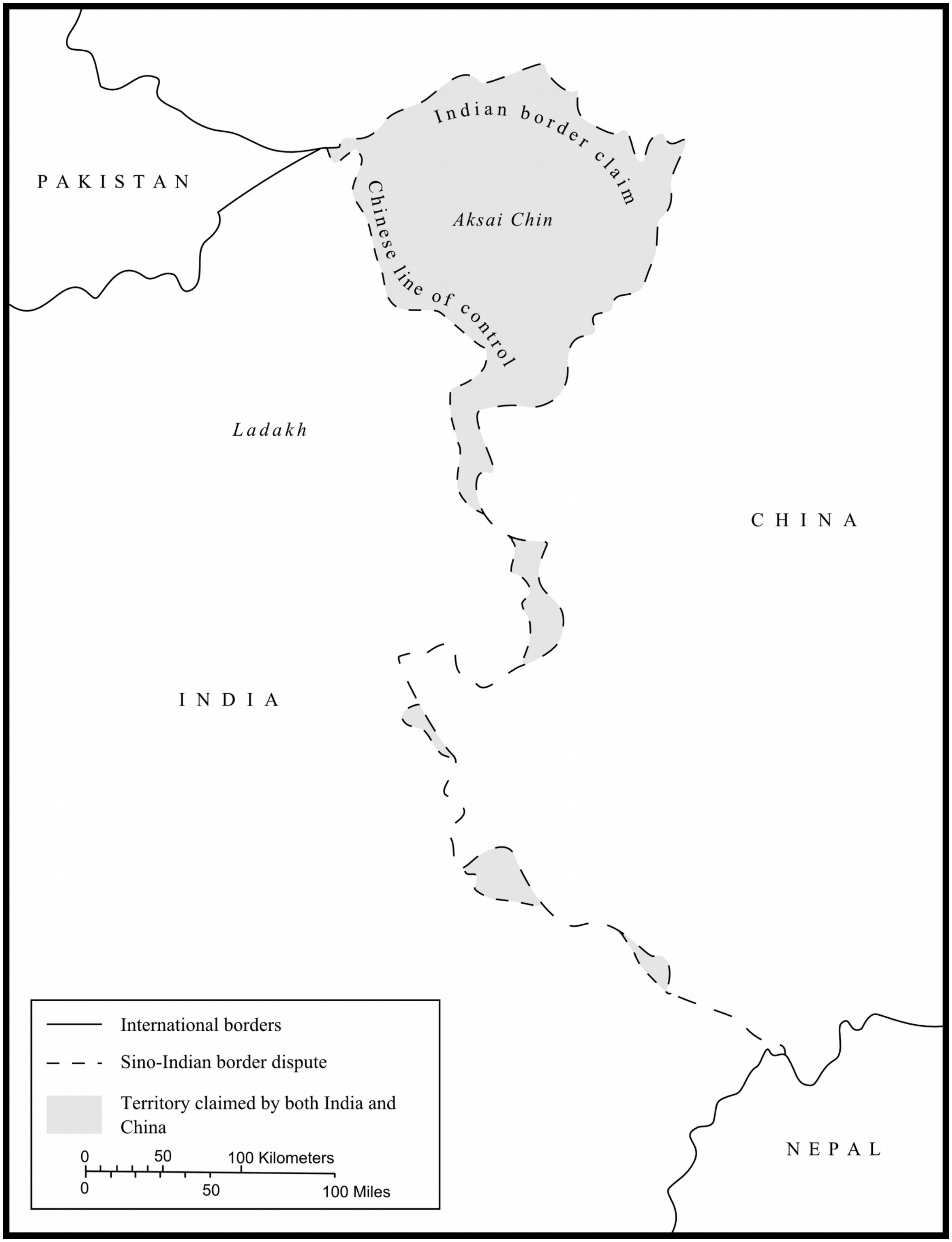

Figure 3. The western section of the China-India border, showing the contested area. (Map drawn by the author, based on map at http://www.lib.utexas.edu/maps/middle_east_and_asia/china_india_e_border_88.jpg, accessed March 2, 2012.)

disputes were rooted in colonial politics of the early twentieth century. The Indian territorial claim was based on the borders of the British Raj, established at a three-way conference in Simla among Britain, Tibet, and China in July 1914. In the east, the border running along the crest of the Himalaya was known as the McMahon Line. The Communist Chinese rejected the McMahon Line, arguing that the British had bullied the Chinese into making unfair territorial concessions. Instead, they argued that the disputed territories had historically been parts of Tibet, and therefore belonged to China. Furthermore, the maps drawn in the 1914 conference left room for debate over the exact location of the McMahon Line. The ambiguities in the line were grounds for numerous small Sino-Indian border clashes during the 1950s.[11]

On October 20, 1962, as the Cuban Missile Crisis distracted the attention of the major powers, the Chinese People's Liberation Army mounted a combined attack on the contested border areas controlled by India. Along the McMahon Line, Chinese troops crossed two 16,000-foot passes, routing the Indian border sentries. In Ladakh to the northwest, the Chinese army quickly overpowered the Indian *jawans* (soldiers) defending fifteen of twenty-one army posts. After initial successes in penetrating the high valleys along both fronts, the Chinese advance seemed to stall. An Indian counterattack of the Chinese positions in NEFA on November 14, though, failed to dislodge the invading force. Two days later, the Chinese suddenly renewed their offensive in the northeast, overtaking the town of Tawang and battling their way down toward Tezpur in the Brahmaputra Valley.[12]

11. For the Indian argument, see Shanti Prasad Varma, *Struggle for the Himalayas: A Study in Sino-Indian Relations* (Jullundur, India: University Publishers, 1965), 15. For a Chinese perspective, see Liu, *Sino-Indian Border Dispute*, 26.

12. Srinath Raghavan, "A Bad Knock: The War with China, 1962," in *A Military History of India*

In New Delhi, the Indian government began to panic. Shortly after the attack began, Nehru sent letters to the leaders of friendly nations, asking for "the sympathy and support of all countries." In domestic politics, support for Nehru's administration began to evaporate as the Chinese continued to advance against Indian defenses. Nehru reluctantly dismissed his abrasive defense minister V.K. Krishna Menon, whom the opposition blamed for India's failure to defend the borders with China.[13]

Half a world away in Washington, the Kennedy administration watched the events in India closely, even as United States–Soviet tensions mounted in the Cuban Missile Crisis. Although genuinely concerned about the threat to India, Kennedy and his cabinet saw India's crisis as an ideal diplomatic opportunity. If the United States played its cards correctly, military aid to India had the potential of increasing American influence in the region. The Kennedy administration dreamed of brokering a settlement between India and Pakistan over Kashmir, thereby bringing both countries into the anti-communist camp. The United States would have to act with care, though, since any move it made toward India would risk alienating their only South Asian ally, Pakistan.[14]

Nehru's request for "sympathy and support" had not explicitly mentioned military aid, but Kennedy inferred this meaning and offered to supply India with small arms, ammunition, and other equipment for mountain warfare. Nehru gladly accepted. In the

and South Asia, from the East India Company to the Nuclear Era, ed. Daniel Marston and Chandar S. Sundaram (Westport, CT: Praeger Security International, 2007), 157-74. Situated on the north bank of the Brahmaputra River, Tezpur was at this time headquarters of the Eastern Air Command of the Indian Air Force.

13. Guha, *India after Gandhi*, 337; Rajendra Kumar Jain, ed., *China South Asian Relations, 1947-1980* (New Delhi: Radiant, 1981), 1:214; Jawaharlal Nehru, "Nehru Writes to Heads of States" (New Delhi: Ministry of External Affairs, n.d. [1962]), 4, in "Foreign Relations of India, Part 1," *South Asia Ephemera Collection* (New Delhi: Library of Congress Office, 1997); "U.S. arms sped at Nehru plea as China gains," *New York Times* (*NYT)*, October 30, 1962.

14. McMahon, *Cold War on the Periphery*, 287; David R. Devereux, "The Sino-Indian War of 1962 in Anglo-American Relations," *Journal of Contemporary History* 44 (2009): 71-87.

first two weeks of November 1962, USAF Military Air Transport Service Boeing C-135 jets flew forty-eight missions to India, delivering the requested military aid. Later that month, Lockheed C-130 Hercules transports stationed in Europe took over the airlift. Between November 1962 and June 1963, the USAF flew more than 3,000 missions in India, shuttling supplies from the main airports in Delhi and Calcutta to isolated frontier areas. The USAF C-130s supplemented the airlift capacity of the IAF, which used Soviet-built Antonov An-12s and older and less capable American-built Fairchild C-119Gs.[15]

On November 20, 1962, the Chinese government made its surprise cease-fire offer and withdrew, leaving India relieved but badly shaken. In terms of unit deployments and casualties, the Sino-Indian War of 1962 was not a major conflict. The Indian Army committed only two and a half divisions and lost roughly 7,000 men as casualties or prisoners, while the PLA reported 2,000 casualties.[16] Despite Nehru's request for US fighter jets to defend Indian cities, this was ultimately a ground war only. The Chinese and Indian armies engaged each other in the rugged alpine terrain of the eastern and western Himalaya; the navies and air forces of both sides did not assume combatant roles in the conflict.

Nevertheless, the Sino-Indian War is an important episode in the history of the Cold War. The conflict was not a classic proxy war like the 1973 Yom Kippur War, in which US-backed Israelis fought Soviet-backed Arabs. Rather, India's border conflict

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15. History of the 2d Weather Wing, Jul-Dec 1963, Call # K360.2-2, IRIS # N3726, in the USAF Collection, Air Force Historical Research Administration, Maxwell AFB, AL.

16. P. B. Sinha, and A.A. Athale, *History of the Conflict with China, 1962* (New Delhi: Ministry of Defence , 1992), http://www.bharat-rakshak.com/LAND-FORCES/Army/History/1962War/PDF/index.html (accessed February 10, 2011), 412; Larry M. Wortzel, "Concentrating Forces and Audacious Actions: PLA Lessons from the Sino-Indian War," in *The Lessons of History: The Chinese People's Liberation Army at 75*, ed. Laurie Burkitt, Andrew Scobell, and Larry M. Burkitt (Carlisle, PA: Strategic Studies Institute, 2003), 327.

with China illustrates the complex, unpolarized nature of international politics in South Asia during the Cold War. China was communist but no longer aligned with the Soviet Union; the Chinese army invaded nonaligned India, which subsequently received aid from the United States and Britain. Meanwhile, American-allied Pakistan, resentful of American aid to India, began to tilt toward China.

Whether China or India should be held responsible for instigating the Sino-Indian War remains debatable. The Indian claim, that the Chinese attack was totally unprovoked, is dubious. Neville Maxwell argues that the Indians' aggressive border policy goaded the Chinese into attacking.[17] Whatever the Indians' initial intentions, though, the experience of defeat by the Chinese caused a drastic rethinking of Indian strategy and foreign policy. In the months following the war, India's humiliated political and military leaders attempted to rebuild their dignity and sense of self-respect. The Chinese had already proved their military superiority over India once; Indian leaders feared that a second attack would lead to permanent loss of territory and a decrease of India's regional influence in South Asia. To heighten the shame already felt by Nehru's administration, Chinese troops and fighter planes made regular sallies across the McMahon Line; the

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17. Neville Maxwell, *India's China War* (London: Cape, 1970), 428. Maxwell based his conclusions heavily on the Henderson Brooks–Bhagat Report, a classified Indian Army document produced in 1963. The report criticized the Indian Army's management of the border dispute. In March 2014, Maxwell leaked the report online. The release of the report has prompted a rethinking of Indian interpretations and collective memory of the Sino-Indian War. See Sandeep Unnithan, "Henderson Brooks report lists the guilty men of 1962," *India Today*, March 18, 2014, http://indiatoday.intoday.in/story/the-guilty-men-of-1962-india-china-war-jawahar-lal-nehru-krishna-menon/1/350080.html. Numerous other authors have studied the Sino-Indian War and the broader border dispute from a variety of angles. As Xuecheng Liu notes in *The Sino-Indian Border Dispute and Sino-Indian Relations* (Lanham, MD: University Press of America, 1994), 10, early historiography of the conflict showed sympathy to India by portraying China as an aggressor. This changed with Maxwell's *India's China War* and Karunakar Gupta's *Hidden Story of the Sino-Indian Frontier* (Calcutta: Minerva Associates, 1974). These books highlight the political and strategic missteps made by Nehru and his government.

Indian press interpreted these intrusions as portents of a second invasion.[18] With help from abroad, India's leaders hoped to strengthen their nation's defenses, especially air defenses, to prevent a repeat of the embarrassing 1962 war.

The modernization of the Indian Air Force

Like India's army and navy, the Indian Air Force traces its origins back to the era of British colonialism. From their respective establishments to Indian independence, all three branches of the Indian armed forces operated in parallel with the British armed forces in India. At its official establishment in 1932, the Indian Air Force supplemented the Royal Air Force, which had served in India since 1921. The first aircraft flight of the IAF, which came into existence in April 1933, consisted of six British-trained Indian flying officers and four Westland Wapiti IIA biplanes. On their first assignment, the IAF pilots policed the isolated tribal regions of Waziristan.[19]

After independence, India had difficulty supplying its air force with modern aircraft. India's fledgling aircraft industry, originally established in World War II to

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18. For instance: "China may attack again, warns Nehru," *Indian Express*, July 26, 1963. As Indian leaders complained about purported airspace incursions by Chinese aircraft, the Chinese government claimed that Indian planes had made repeated flights over Tibet. The Indian government denied these accusations. "India rejects Chinese complaints of air space violation," *Indian Express*, October 30, 1963. In a 1969 conference paper, IAF chief Arjan Singh explained the impracticality of shooting down enemy aircraft that made incursions into Indian airspace. A fighter flying at eight miles per minute could cover forty miles of Indian territory before an IAF fighter had the chance to scramble and intercept. If by some fluke an IAF interceptor shot down a Chinese or Pakistani fighter on a regular incursion mission, the international community would doubt that the intruding fighter was over Indian territory at the time of the shootdown. Arjan Singh, "The Air Force," in *Defence of India* (New Delhi: Press Institute of India, 1969), 29.

19. Pushpindar Singh, *History of Aviation in India: Spanning the Century of Flight* (New Delhi: Society for Aerospace Studies, 2003), 112. Gen. Hugh Trenchard, Chief of the Air Staff for the Royal Air Force, invented the tactic of "air control" as a means of cheaply policing uncooperative tribal areas across the British Empire. Air control provided a mission for the newly-independent Royal Air Force. Aircraft bombed village water supplies and other targets, forcing villagers to submit to British control. David E. Omissi, *Air Power and Colonial Control: The Royal Air Force, 1919-1939*, (Manchester: Manchester University Press, 1990), 8-9.

supplement British production, could not meet the IAF's demand. Cold War politics prevented nonaligned India from obtaining high-performance American fighters. India purchased its first jet fighters from Europe, starting with British de Havilland Vampires in 1948. In the meantime, Pakistan, thanks to its military alliance with the United States, obtained high-performance North American F-86 Sabres for its own air force. The United States sold some noncombat aircraft to India, such as the C-119G transport, but no fighters. India had to settle for second-tier fighters from France and Britain.[20]

The Indian Air Force, along with Indian industry, engaged in *jugaad* to keep foreign-sourced aircraft in operation long after the same types had passed into retirement in their countries of origin. On at least one occasion, they even performed adaptive reuse to induct new aircraft into their fleet. When the British and American armed forces left India after World War II, they abandoned nearly a hundred Consolidated B-24 Liberator bombers at the maintenance depot in Kanpur. In 1947, the IAF employed the state-owned industry Hindustan Aircraft Limited (HAL) to refurbish as many of these aircraft as possible. By November 1948, the first six Liberators were ready for service with the IAF. HAL ultimately put forty-two Liberators back into service. These planes served as coastal patrol aircraft and participated in Operation Vijay, the Indian annexation of Goa in 1961. The IAF gradually phased out the Liberator in favor of the more modern C-121 during the 1960s. In 1965, four Liberators were still patrolling the Indian coastline. The last of these retired from IAF service in 1968.[21]

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20. Vijay Seth, *The Flying Machines: Indian Air Force, 1933 to 1999* (New Delhi: Seth Communications, 2000), 39; Jasjit Singh, *Indian Aircraft Industry* (New Delhi: KW Publishers, 2011), 127, 161.

21. Singh, *Aircraft of the Indian Air Force, 1933-73* (New Delhi: English Book Store, 1974), 78-80; Kapil Bhargava, "India's Reclaimed B-24 Bombers," *Bharat Rakshak*, http://www.bharat-rakshak.com/IAF/History/Aircraft/Liberator.html (accessed March 27, 2011); Attachment to letter, R.J.

Local conditions and requirements shaped the aircraft that the IAF bought from abroad. The C-119G Flying Boxcar, a cargo plane powered by two piston engines, entered IAF service in 1953. Originally designed for American climates and conditions where the highest airfield was less than 10,000 feet above sea level, the C-119 suffered from severe performance shortcomings when operating out of the Himalaya mountains. Hindustan Aircraft, with the assistance of the American firm Steward-Davis, retrofitted twenty-seven IAF C-119s with single turbojet engines mounted on top of the planes' fuselages. This dorsal booster engine provided additional thrust on takeoff, allowing the C-119 to operate out of airfields at elevations as high as 16,800 feet.[22]

While the IAF was acquiring aircraft from abroad, the Indian government worked to build up a domestic aircraft industry. India's largest aircraft manufacturer was the aforementioned Hindustan Aircraft Limited, one of several companies founded by Indian industrialist Seth Walchand Hirachand. (Another Hirachand firm, Hindustan Construction Company, built the foundations for the Brahmaputra Bridge, the subject of Chapter 2.) Hirachand established HAL in Bangalore in 1940, which at that time was a part of the princely state of Mysore. The Maharaja of Mysore and the government of British India initially both owned 50 percent shares in the company. After independence, the Indian government nationalized HAL, on the grounds that strategic industries should be under direct control of the state. The company merged with several other public-sector aircraft manufacturers in 1964; at this point it became Hindustan Aeronautics Limited.[23]

Rebello to Charles E. Johnson, February 19, 1965, S. No. 18, Ambassador to USA subject files, papers of B.K. Nehru, NMML.

22. Singh, *Aircraft of the IAF*, 93-94.

23. Singh, *Indian Aircraft Industry*, 30, 44-48; Hindustan Aeronautics Ltd., *Second Annual Report 1964-65* (Bombay, 1965).

In 1950, the Indian government signed an agreement with the de Havilland Aircraft Company permitting the manufacture of nearly three hundred Vampire jet fighters under license by HAL. Later, HAL also manufactured Gnat fighters under a similar agreement with Folland Aircraft. HAL would go on to design and produce a highly modified version of the Gnat known as the Ajeet (Unconquered). The Gnat served as the IAF's main fighter during the 1960s and into the 1970s. The first twenty-three Gnats inducted by the IAF were manufactured in England and shipped to India complete. The IAF bought its next twenty Gnats as kits, which HAL assembled in Bangalore. All subsequent Gnats purchased by the IAF were built by HAL, from a mixture of domestic and foreign components. In addition to airframe manufacture, HAL built, under license, Orpheus 703 turbojets for the Gnat. Between 1962 and 1974, HAL built a total of 192 Gnats for the IAF.[24]

HAL also produced indigenous aircraft designs for the IAF. The first of these was the HT-2, a two-seat, piston-engined trainer resembling the de Havilland Chipmunk. Developed in the late 1940s and early 1950s, the HT-2 prototypes and production models were powered by four-cylinder British engine designs that predated World War II. The first prototype had a Gipsy Major 10, while the second prototype and all production models were fitted with Cirrus Major III engines. Including the two prototypes, HAL produced a total of 169 HT-2s. The major operators of the design were the Indian Air Force and Navy, although domestic flying clubs bought some, and in 1959 the Ghana Air Force purchased twelve.[25]

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24. Seth, *The Flying Machines*, 39; Singh, *Indian Aircraft Industry*, 146-50; Singh, *Aircraft of the IAF*, 121-22.

25. Singh, *Aircraft of the IAF*, 88-89.

In 1956, HAL embarked on a much more ambitious project: to design and producte an indigenous jet fighter. This aircraft, which came to be known as the HF-24 Marut, was designed by a joint German-Indian team led by Kurt Tank, former chief designer of Focke-Wulf. Tank and seventeen other Germans, along with three Indian senior and twenty-two Indian junior engineers, constituted the HF-24 design team. The eighteen Germans were a part of what Michael Neufeld calls the postwar "Nazi aerospace exodus," when German specialists transferred technical expertise to western-bloc, eastern-bloc, and nonaligned nations. The defeat of the Third Reich left the German aviation industry in limbo, and engineers who wished to find work in their field—and who had not already been impressed into service by one of the Allied powers—had to seek work abroad. Tank spent nearly twenty years overseas, working first for Perón's Argentina and then for India. His HF-24 design for India first began prototype flight trials in 1961. The type finally entered squadron service in 1967.[26]

The HF-24's major shortcoming was its powerplant. The original Indo-German team designed the fighter around the Orpheus 12 engine, under development in the late 1950s by Bristol Siddeley. HAL already had a relationship with Bristol Siddeley, because of the Indian firm's license to produce copies of the Orpheus 703 for the Gnat fighter. The Orpheus 12 was designed to produce 8,170 lbs of thrust, with afterburner. But Bristol Siddeley ran out of capital and could not complete development of the engine. It offered to continue development if India invested $10 million into the project. India's Ministry of Defence, still led by Krishna Menon, did not want to invest so much hard-earned foreign

26. Michael J. Neufeld, "The Nazi Aerospace Exodus: Toward a Global, Transnational History" *History and Technology* 28 (Mar. 2012): 49; Conradis, *Design for Flight*, 194-95; "India's Supersonic Fighter," *Aeroplane and Astronautics*, October 26, 1961, 548-48a.

exchange into an overseas company. The Ministry of Defence sent Bristol Siddeley its regrets, and began searching for another engine source. Ultimately, the HF-24 Mk. 1 simply used the lower-thrust Orpheus 703. With two of these engines mounted in its fuselage, the HF-24 could just reach supersonic speeds. A higher-powered HF-24 Mk. 2 never materialized, because India never found a suitable engine.[27]

The matter of engine procurement for the HF-24 would obsess the project leadership for more than a decade. Ironically, the search for an engine for this indigenous fighter indirectly led to India's purchase of more foreign fighters. One of the engines considered was the Klimov VK-7, which had a similar performance to the now-canceled Orpheus 12. Russia shipped two VK-7s to India for evaluation, but HAL quickly determined that the centrifugal-flow engine was too large to fit inside the HF-24 fuselage as designed. When the Indians turned their attention to the RD-9 engine, which powered the MiG-21, the Russians offered to sell them the complete planes instead. In 1962, shortly before the border war with China, Nehru's government signed an agreement with the Soviet Union calling for the purchase of some completed MiG-21s followed by the eventual license manufacture of the single-seat, Mach 2.1 fighters by Indian industry. HAL began manufacturing MiG-21s at a facility in Nasik, Maharashtra, in 1966. The Soviets allowed the Indian government to pay for the aircraft and licensing fees in rupees, which the Soviet government used to buy goods in India.[28]

Even after inking the MiG deal, the Indian government continued to hunt for a

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27. "India rules out P.1B Lightning, widens search for strike fighter," *Aviation Week and Space Technology*, July 23, 1962, 24; Pushpindar S. Chopra, "Harnessing the Storm Spirit," *Air Enthusiast*, May 1973, 218.

28. "India rules out P.1B Lightning, widens search for strike fighter," *Aviation Week and Space Technology*, July 23, 1962, 24; Singh, *Aircraft of the IAF*, 142-43; P.C. Lal, Ela Lal (ed.), *My Years with the IAF* (New Delhi: Lancer International, 1986),123.

suitable engine for the HF-24. This search took them to an unlikely place: the United Arab Republic (UAR), as Egypt was known at this time. Like India, UAR had an indigenous fighter program led by a German engineer. The project, which had begun in Franco's Spain but was purchased by the Egyptians, was known as the HA-300. The project was headed by another member of the Nazi aerospace exodus, Willy Messerschmitt, who had spent a brief period in India just after World War II advising HAL. Unlike the Indian project, the Egyptian program also involved the development of an indigenous jet engine, the E-300. UAR had a jet engine but India did not; for its part, India had a working aircraft prototype, experienced test pilots, and generally a deeper base of aeronautical expertise than UAR. The two countries entered into a technical collaboration agreement. HAL sent a modified HF-24 to UAR to serve as an engine testbed, and the IAF seconded a test pilot, Kapil Bhargava, to the Egyptian project. Bhargava flew the HF-24 engine testbed, as well as both prototypes of the HA-300. Despite promising performance of the Egyptian fighter, which Bhargava found "very pleasant to fly," the Indo-Egyptian technical collaboration ultimately fell apart. Neither the HA-300 fighter nor the E-300 engine ever entered production, and the Egyptian government canceled the project in May 1969.[29]

By this time, the Indian Air Force had become even more tightly bound to Soviet technology. Delays in the development of the HF-24 led the IAF to shop for foreign fighters or fighter-bombers to serve as intermediate ground-support aircraft until the HF-24 was ready. In the summer of 1966, the Indian government began to consider the

29. Kapil Bhargava, "Messerschmitt's HA-300 and Its Indian Connection," *Bharat Rakshak*, http://www.bharat-rakshak.com/IAF/History/1960s/Kapil-HA300.html (accessed December 31, 2012); A.C.N. Nambiar to S.A. Venkataraman, March 18, 1949, file no. 20(20)-EurII/49, Ministry of External Affairs, NAI.

Sukhoi Su-7, another Soviet design. The government placed an order for a hundred aircraft, the first of which arrived in crates at Bombay harbor in March 1968. These aircraft were manufactured in the Soviet Union; only the final stages of assembly took place in India, at Santa Cruz airfield, Bombay. With the purchase of such a large number of foreign aircraft, India's quest for an indigenously produced air force remained elusive.[30]

The West and India's air defenses

During the 1962 border war with China, IAF transport wings shuttled supplies to the mountain troops fighting in Ladakh and NEFA, but the IAF's combat wings spent the duration of the conflict sitting on the sidelines. This decision to exclude the IAF from combat perplexed foreign observers. At a November 19 presidential meeting, US Secretary of Defense Robert McNamara expressed disbelief that the Indians did not retaliate against the Chinese by air, as they could easily disrupt the Chinese supply lines by destroying the mountain roads. The Indian government gave its official reason for the disuse of the IAF as fear that an aerial attack of enemy troops might lead to retaliatory Chinese bombing of northern India's defenseless cities.[31]

Despite the IAF's noncombatant role in the conflict, air power assumed a central role in Indian defense planning following the Chinese invasion. For air defense

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30. Singh, *Aircraft of the IAF*, 164.

31. Memorandum for the Record, November 19, 1962, *Foreign Relations of the United States*, 1961-63, 19:394-96 (hereafter cited as *FRUS* with year and volume). Jasjit Singh notes in his biography of Air Marshal Arjan Singh that the Indian government wished to avoid escalating the war at all costs. Small-scale air raids on Calcutta, Madras, and other Indian cities by the Japanese in World War II caused little damage, but nevertheless left a deep mark in the minds of national leaders. The fear of escalation may have been influenced by the collective memory of the Japanese air raids two decades earlier. *The Icon: Marshal of the Indian Air Force Arjan Singh, DFC: An Authorised Biography* (New Delhi: KW Publishers, 2009), 121.

equipment, India turned to the West, particularly the United States and Britain. The western powers agreed to help supply equipment to this perceived new enemy of communists, although the United States, Britain, and India could not agree on exactly what equipment India needed for its own defense.

India's decision to purchase MiG-21s from the USSR had startled and dismayed the West. The US government feared that this represented a broader Indian shift toward the Soviet Union. The Kennedy administration wanted to draw India away from the Soviet Union by offering western-bloc arms, but as usual it felt uneasy about the possibility of angering Pakistan by closing an arms deal with India. The United States and Britain cautiously made an offer to supply India with one squadron of supersonic English Electric Lightning fighters and nine Lockheed C-130 Hercules transports, but only on the condition that India refrain from also buying MiGs from the Soviet Union. Since this offer was limited in scope and had no provisions for domestic manufacture, Nehru's government found it less appealing than the Soviet offer.[32]

Another American strategy for luring India away from the Soviet Union was offering assistance for the HF-24. The United States wanted India to focus on the HF-24 and drop the MiG-21 project. If the speed of the indigenous fighter could be increased beyond the modest transonic range, then India would not need MiGs. In February 1964, Robert Komer, of the National Security Council Staff, referred to the HF-24 as "our secret weapon" for distracting the Indians from further MiG deals. In July of the same year, an American team visited India to study the country's aeronautical establishments

32. SNIE 31/32-62, "Possible Reaction of Pakistan to the Provision of Supersonic Fighter Aircraft to India by the US or other Western Countries," June 6, 1962, *FRUS*, 1961-63, 19:263; Memorandum of Conversation, June 14, 1962, ibid., 269; telegram from the embassy in India to the Department of State, June 25, 1962, ibid., 292-94.

and assess their potential for expansion. This initiative would ultimately be stillborn, and at any rate it was now too late for India to back out of the MiG-21 deal.[33]

The United States made one more attempt to draw India away from the MiG-21, by beginning to drop hints about the possibility of another fighter deal. When the IAF went looking for foreign fighters to serve as stopgaps until the HF-24 was ready, the US government suggested that it might be able to supply Northrop F-5A Freedom Fighters or Douglas F-6A Skyrays. At the time of the initial offer, in mid-1964, the Indians decided to try holding out for the higher-performance Lockheed F-104G Starfighter. The Pakistan Air Force had already received F-104s, and there were differences of opinion within the American defense and diplomatic establishments whether or not India should also receive F-104s. Robert Komer suggested that they could offer F-104s to India, along with F-6As and assistance for the HF-24 program. In this matter, though, Defense Secretary McNamara's thinking prevailed; he argued that the F-104 was too expensive, too complex, and too politically fraught to sell to India.[34]

By the beginning of 1965, India's defense establishment realized that it was not likely to receive F-104s any time soon, and thus decided to change tack. In a meeting with US Ambassador Chester Bowles in late January, Defence Minister Y.B. Chavan reported that they were interested in the offer of F-5As after all. Negotiations for the F-5A purchase proceeded for several months, but they were derailed by the outbreak of

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33. Jacques Nevard, "U.S. may aid India on improving jets," *NYT*, July 16, 1964; Evert Clark, "U.S. offers India aid on air force," *NYT*, August 22, 1964; "HF-24," *Transport*, July 1964, 9-10; Robert W. Komer to Chester Bowles, February 27, 1964, *FRUS*, 1964-68, 25:46-47; Chester Bowles, telegram to State Department, January 29, 1965, ibid., 25:184-86.

34. Y.B. Chavan, telegram to Jawaharlal Nehru, May 22, 1964, S. No. 18, Ambassador to USA subject files, papers of B.K. Nehru, NMML; memo, Robert Komer to McGeorge Bundy, May 27, 1964, *FRUS*, 1964-68, 25:109-10.

fighting between India and Pakistan in the Rann of Kutch in April. On May 8, Secretary of State Dean Rusk advised Bowles that the US government had decided not to fulfill the Indian request for fighters.[35]

Although the United States never supplied fighters to India during the Cold War, American military aid would have a somewhat more lasting influence in the field of air defenses. The Sino-Indian War highlighted India's lack of air defenses, which left its cities vulnerable should the Chinese bring a hypothetical future conflict to the civilian population. On invitation from the Indian government, a joint team of military experts from the United States and Commonwealth nations visited India in January and February 1963 to determine how best to equip India to defend itself against "the possibility of any further Chinese attacks."[36]

The political opposition in the Indian government and press criticized the Nehru administration, arguing that the invitation of a foreign military mission violated nonalignment, the central tenet of India's foreign policy at the time. Britain, a fading imperial power, presented no danger to India, but the opposition to Nehru's government saw the United States as a real threat to Indian independence. An editorial in the *Times of India* claimed that the United States and Commonwealth militaries were planning to bring an "air umbrella" to India: foreign fighter planes, based on Indian soil, defending Indian cities. The United States' military and diplomatic influence would subsequently

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35. "Aide Memoire - Acquisition of F5A from USA," n.d. [January 28, 1965], S. No. 18, Ambassador to USA subject files, papers of B.K. Nehru, NMML; P.V.R. Rao to B.K. Nehru, March 6, 1965, ibid.; telegram, Chester Bowles to State Department, January 29, 1965, *FRUS*, 1964-68, 25:184-86; telegram, McGeorge Bundy to Chester Bowles, April 28, 1965, *FRUS*, 1964-68, 25:240-42.

36. *Keesing's Contemporary Archives: Weekly Record of Important World Events with Index Continually Kept Up-to-date* (London: Keesing's Publications, 1964), 14:19648.

engulf India, as it had already done to many other countries.[37]

Even though the "air umbrella" plan was nearly what Nehru had requested in his letters to President Kennedy, the Prime Minister flatly denied that the United States–Commonwealth military mission planned to bring such a defense system to India. In a February 21 speech to the Lok Sabha, Nehru stated that the reports of an "air umbrella" were "incorrect and greatly exaggerated." Further, he declared, "there is no question of the stationing of a foreign air force or the establishment of any foreign air bases in India. …India has to be defended by her own forces."[38]

Military aid to India also attracted criticism in the West. In the United States, opposition Republicans doubted the sincerity of Nehru's administration and feared that the Indians would pass information about American defense equipment on to the Soviets. In the House of Representatives, Republican Congressman Steven B. Derounian of New York placed in the record an alarmist article from the *Long Island Press*, which claimed that the White House was preparing to bring fifty "Indian scientists" to the United States in order to "familiarize them with the development and operation of top-secret rocket launching and radar systems." Commenting on this "most disturbing article," Derounian characterized Prime Minister Nehru as "a weakling in the face of communism" and a "great international phony."[39]

The *Long Island Press* article was likely referring to the planned visit of Indian scientists and engineers to research facilities of the civilian National Aeronautics and Space Administration (NASA). These specialists received basic technical training for

37. "Deceptive," *The Times of India* (*TOI*), July 24, 1963; "Readers' views," *Indian Express*, July 30, 1963.

38. *Keesing's Contemporary Archives*, 14:19648.

39. *Cong. Rec.*, 88th Cong., 1st sess., 1963, vol. 109: A4635.

assembling imported rockets, launching, tracking, and data acquisition. They did not visit any military installations. On November 21, 1963, a NASA-supplied two-stage Nike-Apache rocket took off from coastal Thumba in the southern Indian state of Kerala. This event marked the beginning of space and rocketry research in India.[40]

Three weeks after Congressman Derounian placed the *Long Island Press* article on the record, Republican Congressman Ed Foreman of Texas reported to the House that he had received “reliable information” that the Kennedy administration was planning to pass some decommissioned radar equipment on to India. “This is a deplorable and almost unbelievable situation,” Foreman declared; the United States should not shut down its own military installations and send them to “a Socialist country such as India that has continually played footsie with the Communists.”[41]

The military aid program received cautious support from New Frontier Democrats. Congressman Thomas Gill of Hawaii argued that “foreign aid is not only a humanitarian effort, but also an essential tool of our foreign policy.” The United States could choose whatever justification it wanted for helping India—either the humanitarian reason of improving the lives of 450 million people, or the “selfish national reason” of keeping these same people from succumbing to communism. Whatever the reason, Gill argued, “we must participate in the development of India.”[42]

Career diplomat Chester Bowles, who returned to India for a second term as

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40. Gopal Raj, *Reach for the Stars: The Evolution of India’s Rocket Programme* (New Delhi: Viking, 2000), 16-17, 32; “India fires first rocket for space research,” *Hindustan Times*, November 22, 1963. One of the members of the Indian delegation to NASA was A.P.J. Abdul Kalam, who would go on to lead the teams that launched India’s first satellite in 1980 and developed India’s ballistic missiles later that decade. Kalam also served as President of India from 2002 to 2007. A.P.J. Abdul Kalam, with Arun Tiwari, *Wings of Fire: An Autobiography* (Hyderabad: Universities Press, 1999), 37-39.

41. *Cong. Rec.*, 88th Cong., 1st sess., 1963, vol. 109: 15006.

42. Ibid.: 15071.

American ambassador in July 1963, had mixed feelings about the military aid, as he confided in his memoir, *Promises to Keep*. Bowles pessimistically saw most US military aid to non-European countries as a bribe for them to support American foreign policy. Military aid begat more military aid in a vicious escalating cycle. Foreign governments kept military assistance coming in increasing quantities by threatening to expel American troops based in their countries. Despite these concerns, Bowles supported the aid program to India, because he saw that country as a special case. India had no interest in entering into a military alliance with the West and flatly refused to allow foreign troops to be stationed on its soil. If the West did not offer support, though, India might swing toward the Soviet Union.[43]

As debates over military aid raged both in India and the West, negotiations among Indian, Commonwealth, and American military leaders continued through the first half of 1963. On July 9, John Kenneth Galbraith, outgoing US Ambassador to India, culminated these discussions by signing an official agreement outlining the United States' and India's commitments to each other in the project of strengthening India's air defenses. To the United States, this was a long-term commitment and the beginning of a closer military relationship with India. The six-point agreement Galbraith signed stated that the United States would provide India with permanent radar stations to cover almost the entire northern border. In the year or more that it would take to complete these stations, the United States would lend India two portable radar sets for the defense of Delhi and Calcutta. The USAF would train Indian crews to operate both the temporary and

43. Chester Bowles, *Promises to Keep: My Years in Public Life, 1941-1969* (New York: Harper & Row, 1971), 476-77.

permanent radar stations, as well as send supersonic fighter squadrons to India intermittently for training exercises with the IAF. In the event of another attack, the United States would ask India if it needed help; if the government of India deemed this to be the case, it would take responsibility for accommodating any American personnel deployed to India.[44]

The Indian government announced the air agreement on the evening of July 22. The government stated that, in addition to providing training to IAF personnel on modern radar equipment, the air exercise "will also provide an opportunity to I.A.F. squadrons to practise alongside fighter aircraft from the U.S.A. and the U.K., from which they will gain valuable experience regarding the latest techniques of air defence." The carefully-worded announcement neatly sidestepped the issue of nonalignment by stating that the American and British governments had made no promise to come to India's defense in the event of another attack by China. Reiterating Nehru's statement to the Lok Sabha, the agreement declared that "the defence of India, including its air defence, is wholly and solely the responsibility of the Government of India."[45]

The agreement came under immediate criticism both in India and abroad. Chinese propaganda declared that the agreement signified India's capitulation to American imperialism; India was now on the road to becoming a "major U.S. aggressive military stronghold." Nehru's daughter Indira Gandhi, on a state visit to the Soviet Union at the time of the announcement, reassured a concerned Soviet Premier Nikita Khrushchev that the joint air exercises would in no way affect Indian sovereignty.[46]

44. Telegram from the Embassy in India to the Department of State, July 10, 1963, *FRUS*, 1961-63, 19:615-17.

45. *Keesing's Contemporary Archives*, 14:19649.

46. "Joint air exercises; assurance to Khrushchev," *TOI*, July 31, 1963. A cartoonist for the

In the West, the *London Times* claimed that, despite the Indian government's protests to the contrary, the radar and joint training agreement was simply a repackaging of the old "air umbrella" idea: "No matter how thick the wrapping, in other words, the tell-tale outline of the umbrella persists."[47] An editorial in the *Times of India* accused the government of obscuring the truth about the air agreement by disguising it with a misleading title. In the editorialist's eyes, the so-called training exercise was actually intended to create a "slot" into which western air power could fit if needed in the event of another attack by China. The Indian government was acting deceptively toward its own citizens, and the first course of action should be "to call a spade a spade and nothing more."[48]

Whether or not the United States sincerely believed in the strategic value of training the IAF, the primary objective of the air exercises, as the critics suspected, was to "slot" western forces into Indian defenses. The military mission that visited India in January 1963 concluded that peacetime training exercises of western forces in India would be essential for the proper cooperation of western and Indian forces in the event of another attack. The Indian leadership conceded this point but nevertheless felt uneasy about potential negative public reactions to western forces in India. In a May 17 conversation with US Secretary of State Dean Rusk, T.T. Krishnamachari of the Indian Ministry of External Affairs stated that, at the time of Nehru's plea to Kennedy at the end of the Sino-Indian War, the government had thought of disguising the visits of western

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Hindustan Times parodied the Soviet concern over the air exercises. In the cartoon, which ran in the July 26 edition, a visibly upset Khrushchev points angrily at a newspaper announcing the air exercises. A calm Nehru offers Khrushchev an Indian-made cigarette—a product that India would soon begin exporting to the Soviet Union—telling the Soviet premier to "Relax! Relax!"

47. "British and U.S. fighters to visit India," *London Times*, July 23, 1963.

48. "Deceptive," *TOI*, July 24, 1963.

fighters as simple joint training exercises.[49] The Indian government followed this policy in its announcement of the exercise, but the ruse failed to deceive the press.

At the beginning of August, another western military mission arrived in New Delhi to discuss the details of the first joint training exercise. The negotiations established that the IAF-led exercise, held in the coming November, would be commanded by Air Vice Marshal (AVM) Arjan Singh, Deputy Chief of the Air Staff. The name of the joint exercise would be "Shiksha," after the Sanskrit word for "education."[50] In the exercise, the IAF planned to field Hunter and Gnat fighters as interceptors, and English Electric Canberra bombers as target aircraft. The RAF would send one squadron of Gloster Javelins, while the USAF would dispatch a squadron of North American F-100 Super Sabres. The Royal Australian Air Force also planned to make a token contribution to the exercise, sending thirteen airmen and two of its own Canberra bombers to supplement the IAF fleet.[51]

Air operations in Exercise Shiksha

On the morning of November 6, 1963, six USAF Tactical Air Command F-100s from the 354th Tactical Fighter Wing arrived over IAF Palam[52] in southwest Delhi after a

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49. Memorandum from Secretary of State Rusk to President Kennedy, May 8, 1963, *FRUS*, 1961-63, 19:579-83; Telegram from the Department of State to the Embassy in India, May 18, 1963, ibid., 599-600.

50. शिक्षा (śikṣā): Learning, study, teaching, training, instruction, etc. Vaman Shivaram Apte, *The Student's Sanskrit-English Dictionary* (Delhi: Motilal Banarsidass, 1970), 554. *Shiksha* is a Sanskrit word that is used for formal vocabulary in modern Indian languages; in Hindi, the word means "education." R.S. McGregor (ed.), *Oxford Hindi-English Dictionary* (New Delhi: Oxford University Press, 1993), 950.

51. "RAF team will arrive today," *HT*, August 2, 1963; "Joint air exercise: Talks open for technical plan," *HT*, August 3, 1963; "It's Shiksha for IAF," *HT*, August 6, 1963; "U.S. jets take part in Shiksha," *American Reporter*, November 15, 1963.

52. Built during World War II as a military airfield ten miles southwest of New Delhi, Palam served both military and commercial traffic by 1963. In 1986, Palam Airport was renamed Indira Gandhi International Airport.

nonstop flight from Dhahran Air Base in Saudi Arabia. They were the first of three waves of US fighters headed to India for Exercise Shiksha. With the help of tanker aircraft supplied by the Strategic Air Command, the planes had spent three days flying to India from their home base at Myrtle Beach, South Carolina. Upon arrival at Palam, the planes flew over the airfield in tight formation, then circled around to land. After the pilots had disembarked from their planes, US Embassy officials and IAF brass welcomed them to India in a ceremony held at the airfield. The IAF gave the visiting pilots a snack of tea and sandwiches to show that they were their guests. US Ambassador Bowles addressed the pilots with a stirring speech that placed their work in the context of India's struggle with China. Since the "ruthless attack" by the Chinese, he said, India "has been strengthening her defenses both on the ground and in the air.…You are a part of this major training and organization effort." After Bowles's speech, Air Marshal Aspy Merwan Engineer, the head of the IAF, declined an opportunity to speak.[53]

Before departing for India, the American fighter pilots had spent a month preparing for Exercise Shiksha; their training included aerial refuelings and practice intercepts of Martin B-57 bombers, the American-built version of the Canberras used by the IAF and RAAF in the exercise. Other USAF personnel had been preparing for the exercise since shortly after the conclusion of the air agreement in July 1963. In August and September, American transports airlifted two complete radar stations to India. Each temporary station included two radar sets: an AN/MPS-11 search radar and an AN/MPS-

53. History of the 354th Tactical Fighter Wing (TAC), Jul-Dec 1963, Call # K-Wg-354-HI, IRIS # N0728, in the USAF Collection, AFHRA; History of the 499th Air Refueling Wing (SAC), Nov-Dec 1963, Call # K-Wg-499-HI, IRIS # 00463290, ibid.; "U.S. planes arrive; stage set for 'Siksha'," *HT*, November 7, 1963; "U.S. planes arrive for India exercises," *NYT*, November 7, 1963; "U.S. jets take part in Shiksha," *American Reporter*, November 15, 1963; "Operation 'Shiksha'," *Indian Aviation*, November 1963, 319-20, 337.

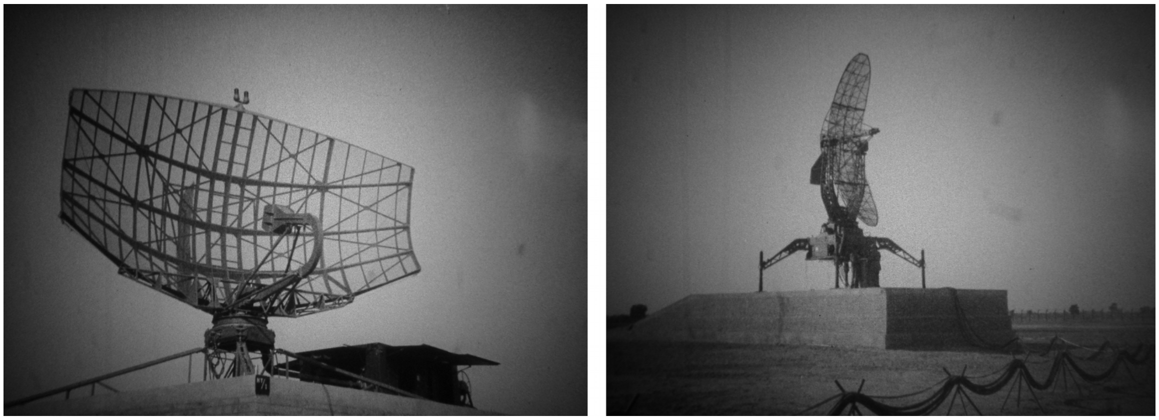

Figure 4. American mobile radar sets in use during Exercise Shiksha: AN/MPS-11 search (left) radar and AN/MPS-16 height-finder (right). (Source: "Operation Shiksha," Moving Images Relating to Military Aviation Activities 1909-1984, RG 342, NARA.)

16 height-finder (Figure 4). Both radars were portable models that could be deployed and dismantled easily. Together, they allowed the exercise participants to triangulate the positions of the target aircraft.[54]

The squadron of RAF Javelin fighters arrived at IAF Kalaikunda, near Calcutta, more than a week ahead of the USAF fighters. On October 31, RAF and IAF fighters demonstrated air interception techniques for a British dignitary and members of the press. Two IAF Hunters and two RAF Javelins performed a mock scramble—a hurried takeoff to intercept an imaginary bomber. According to a *Hindustan Times* reporter who observed the mock scramble, the Indian and British personnel based at IAF Kalaikunda seemed excited about the forthcoming training events.[55]

When Exercise Shiksha began on November 9, though, it got off to a rocky start. The first phase was a day-long interception drill in the eastern sector, during which IAF

54. "U.S. radar equipment arrives," *HT*, August 17, 1963; "More radar equipment arrives," *HT*, September 16, 1963; "RAF group arrives for exercises," *HT*, October 18, 1963; History of the 354th Tactical Fighter Wing (TAC), Jul-Dec 1963; General Electric, "Technical Manual Operation: AN/FPS-8 and AN/MPS-11," http://www.mobileradar.org/Documents/MPS-11_TO.pdf (accessed August 14, 2014).

55. "RAF planes arrive," *HT*, October 29, 1963; "7 more Javelins arrive in Calcutta," *HT*, October 30, 1963; "Radar demonstration by IAF, RAF planes," *HT*, November 1, 1963.

and RAF pilots attempted to intercept IAF and RAAF bombers flying out of Agra. The target aircraft maneuvered within a roughly 1,000-square-mile area, between 20,000 and 50,000 feet elevation. The defending aircraft intercepted relatively few of the attacking planes.[56]

November 14 was the busiest day of Exercise Shiksha, with air operations running concurrently in both eastern and western sectors. The Indian press reported that nearly 140 fighter aircraft participated in the exercise on that day, flying practice interceptions against fifty Canberra bombers. The exercise zone reportedly stretched across north India, from West Bengal in the east to Punjab in the west. From time to time during the day, residents of Delhi caught sight of fighters and bombers above the city.[57]

In the western sector, IAF and USAF pilots stationed at Palam participated in two phases of the exercise, on November 14-15 and 17-19. After the first phase, the pilots reviewed the results of their test interceptions and received suggestions for improvement. Wing Commander Donald Michael, the commanding officer of IAF No. 3 Wing, recalled the results of the one-day critique in an article written for the Indian website *Bharat Rakshak*. During the exercise, the pilots recorded their interceptions of target aircraft by exposing a frame of gun camera film. As Michael recalled, the IAF pilots had taken several good pictures of the target bombers, but the films from the American planes were blank. The Indian planes were armed with cannons, but the American planes would, in real combat, carry Sidewinder missiles. As soon as their plane locked on to the target aircraft by radar, the American pilots exposed their gun camera film, because they trusted

56. "'Attacking' planes give good account in Shiksha," *HT*, November 10, 1963; "India's air defense fails in first drill," *NYT*, November 10, 1963.

57. "140 jet fighters take part in 'air battle'," *HT*, November 15, 1963.

their missiles to find and destroy targets beyond visual range.[58]

Exercise Shiksha ended with the last air operations flown in the western sector on November 19, followed by another day of critique and debriefing. General Walter J. Sweeney, head of the US Tactical Air Command, visited India on the last day of the exercise. He told the press that "cooperation between the IAF, USAF, RAF and Australian Air Force appears to have been superb." On the following day, the Indian Ministry of Defence released a communique expressing its satisfaction with the training value of Exercise Shiksha, which gave the IAF "valuable experience" in operating radar equipment under realistic conditions.[59]

Although the original July 1963 air agreement had stated that these exercises would take place periodically for the strengthening of India's air defenses, Exercise Shiksha was the first and only joint air exercise conducted between the Indian and US air forces during the Cold War. After the exercise ended in the eastern sector, an Indian Defence Ministry spokesman told the press that there were no talks underway for a sequel.[60]

There was never a second Exercise Shiksha because the Indian government viewed the first one as a political expedient rather than the first step toward a deeper relationship with the West. This reflected deeper misunderstandings between India and the western powers throughout the planning and execution of the Exercise. The United

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58. History of the 354th Tactical Fighter Wing (TAC), Jul-Dec 1963; Donald Michael, "Exercise Shiksha," *Bharat Rakshak*, http://www.bharat-rakshak.com/IAF/History/1960s/Shiksha01.html (accessed February 13, 2011).

59. History of the 354th Tactical Fighter Wing (TAC), Jul-Dec 1963; "Air exercise ends: RAF unit leaves," *HT*, November 20, 1963; "I.A.F. gains good experience," *TOI*, November 21, 1963; "Air tests in India said to open way for fast U.S. aid," *NYT*, November 22, 1963.

60. *Keesing's Contemporary Archives*, 14:19648; "Use of radar: I.A.F. gain good experience," *The Hindu*, November 17, 1963.

States and Britain hoped that their military aid programs to India would discourage further Chinese ambitions in South Asia, and at the same time strengthen ties between India and the West. Repeated joint air exercises could have helped accomplish the second objective. India had more straightforward objectives for Exercise Shiksha: it wanted modern radar equipment and the technical training to use it effectively. Having received what it wanted from Shiksha, India felt no need to call for another joint air exercise.

Cultural misunderstandings in Exercise Shiksha

The interactions of the Indian and American crews during Exercise Shiksha highlight cultural and political differences between the two countries. Press reports referred to amicable cooperation between the IAF and the USAF. To be sure, the militaries of the two countries worked well together in their first major joint operation since World War II and Indian independence. Furthermore, some Indian and American airmen developed real friendships during the exercise. In his memoir, Brig. Gen. Gordon M. Graham, who commanded the American forces in the exercise, writes admiringly of his IAF counterpart, AVM Pinto, commanding officer of the exercise in the western sector.[61] Nevertheless, both Indian and American documents show evidence of cultural tensions between the airmen of both countries, tensions that reflect broader misunderstandings between India and the United States during the Cold War.

The Indian government considered Exercise Shiksha a strictly military affair, while the United States saw it as a diplomatic opportunity as much as a military mission. To that end, the USAF pilots learned about social and political conditions in South Asia

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61. Gordon M. Graham, *Down for Double: Anecdotes of a Fighter Pilot* (White Stone, VA: Brandylane Publishers, 1996), 169.

by watching US Army "Area Study" films and attending briefings by intelligence officers. After arriving in India, the pilots received an additional briefing from Brigadier General Graham, who warned them of sensitive topics to avoid in discussions with Indian airmen. According to the unit history of the 354th Tactical Fighter Wing, "Every effort was made to impress upon all participants in the exercise the importance of making a good impression for Tactical Air Command, the United States Air Force and the United States of America."[62]

The Indians also took care not to offend the Americans. One way they did this was by keeping Soviet technology out of sight. The IAF's supersonic MiG-21s did not participate in the exercise with the western aircraft. When a member of the Indian press asked a Defence Ministry spokesman why the MiGs had been excluded from the exercise, the spokesman replied obliquely, "MiGs are not being used because we do not want to mix up the two." As Chapter 3 will discuss in more detail, US policy explicitly forbade the use of eastern-bloc hardware in American-financed development projects. The July 1963 air agreement was not subject to these same restrictions, but the Indian defense establishment understood that the Americans would not appreciate a reminder of India's connections with the Soviet Union by the deployment of MiG-21s in Exercise Shiksha.[63]

The exclusion of the MiG-21 also reflected Indian sensitivity to Soviet desires for secrecy. The Americans had a natural curiosity about the MiG-21, the most sophisticated Soviet fighter in operation at the time of Exercise Shiksha. In his memoir, Graham

62. History of the 354th Tactical Fighter Wing (TAC), Jul-Dec 1963.
63. "Shiksha improves IAF interception techniques," *HT*, November 17, 1963;

describes that he was able to see inside the cockpit of a MiG-21, with the help of AVM Pinto. Posing as an "exchange officer," Graham went to an airbase in an IAF uniform. There, a pilot officer checked him out in the MiG-21. When Graham was preflighting the aircraft, within minutes of taking off, the pilot officer ran back out to the flightline and told Graham that he had to leave immediately. Despite Pinto's precautions, word of Graham's attempt to fly the MiG-21 had leaked to the IAF high command, who put a stop to the flight before it got off the ground.[64]

The Indians, for their part, were impressed by the high-performance fighters brought in by the western air forces. In the press, the RAF Javelins elicited some admiration for their all-weather capabilities, but the supersonic USAF F-100 Super Sabres received the most attention. An article in the conservative and generally pro-western newspaper *The Hindu* reported that the F-100 could attain supersonic speeds in level flight while carrying a fearsome array of weapons. The article concluded: "The F-100's are really fantastic fighters." The IAF leadership also preferred western-bloc fighters, a preference that may have arisen out of jealousy of Pakistan, which had operated the F-104 Starfighter since 1961. As events in the 1971 Indo-Pakistani War would show, India's MiG-21s were more capable fighters than Pakistan's F-104s.[65] At the time of Exercise Shiksha, though, bigger and more complex American fighters held an appeal to the Indians that the Soviet fighters lacked.

The USAF fighters were considerably larger than the fighters fielded by the IAF in the exercise. The Folland Gnat was so small that its pilots could enter the single-seat

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64. Graham, *Down for Double*, 173-74.

65. "Better show by Indian & U.S. pilots," *The Hindu*, November 14, 1963; Pushpindar Chopra, "India and the MiG-21," *Air Enthusiast*, July 1973, 10.

cockpit without the aid of a ladder. Footage shot during Exercise Shiksha by the USAF 1365th Photographic Squadron shows a Gnat pilot boarding his plane by first approaching the cockpit with a running start. When he reaches his craft, he places both hands on the cockpit rim at chest-level, hops once, then leaps up to the cockpit. He brings his left foot up to the cockpit rim, then swings his right leg into the cockpit, followed by his left leg and the rest of his body. The pilots of the larger Hawker Hunters did not need to perform such gymnastics to board their planes, since they could use seven-rung ladders that were cantilevered off of the port side of the fuselage. Footage of a staged practice scramble with a Hunter shows the pilot running toward his plane and leaping from the ground to the third rung of the ladder.[66]

Larger still than the Hunters were the F-100 Super Sabres that *The Hindu* so admired. Although the F-100 was only five feet longer than the Hunter, it weighed 65 percent more when empty, and it could carry three and one-half times as much armament, in terms of weight. The large size of the F-100s is apparent in the USAF footage of the exercise. Maintenance crew members only need to stoop a little to walk under the cockpit. At the welcome ceremonies at Palam Field, the line of Super Sabres looms over the guests present.

The USAF footage seems to have originally been shot for an informational or propaganda film that was never completed. Scenes of military operations in the exercise feature prominently. In addition to practice scrambles, there are scenes of the command tent, the control tower at Palam, and the communications and radar systems. Apart from

66. USAF 1365th Photographic Squadron, unedited footage of Exercise Shiksha (35 mm film, 11 reels), 1963, US moving images compiled 1947-1984, RG 342, NARA.

these, there are non-military scenes that cast the United States and Indo-American relations in a positive light. In footage shot in the racially-integrated barracks of the American camp, an African-American airman plays cards with his white compatriots. During a period when escalating racial strife in the United States was making headlines around the world, the US government's public affairs officers and propagandists used scenes like this to present a more positive image of the United States.

Similarly, scenes of friendly interactions between Indians and Americans represented the US government's hope that the two countries would have amicable relations. At some point during their visit to India, two American airmen (one of whom was of African descent) took a break from their military duties to go on a tour of Delhi with an IAF officer and the USAF camera crew. The footage shows the three airmen, all in uniform, walking around the twelfth-century Qutb Minar complex and the twentieth-century secretariat buildings of New Delhi. In a later scene, two different US airmen, out of uniform (and both white), travel to the old Mughal capital of Agra to visit the iconic Taj Mahal. After seeing the monument, they visit a craftsman who makes miniature reproductions of the mausoleum in marble, complete with wobbly minarets. Toward the end of the unedited footage, the USAF airmen attend a party and cultural program in a garden in New Delhi, along with some of the city's well-dressed elites. The party guests eat, drink, chat, and watch groups of girls and boys perform traditional dances.

All is well for Indo-American relations in the scenes captured in the USAF footage. Other sources without a propaganda agenda paint a more complex picture of the interactions between Indian and American personnel in the exercise. According to Brig.

Gen. Graham's memoir, discord between Indians and Americans began as soon as the command plane touched down in India. As Graham recalled, when his C-130 landed at IAF Palam, the Indian airfield personnel acted surprised and claimed to know nothing of the air agreement and Graham's mission. Graham and his fellow airmen argued with the airfield personnel, who refused to allow the Americans to use a telephone to call the embassy. After several hours of waiting, an embassy representative arrived to lead them through customs. A further altercation erupted when the Indian customs officials attempted to confiscate electronic equipment, including a handheld tape player that Graham had brought. Graham had received clearance for these items before departure, but the customs officials had not been notified. "We were there from morning to dark, arguing," Graham recalled. "It was hot and miserable."[67]

General Graham's memoir, written more than thirty years after the fact, is clearly exaggerated. It also does not agree with contemporary sources. Graham's arrival was covered by a Press Trust of India report, which was printed in Indian papers such as the *Hindustan Times*. The arrival also appears in the USAF footage. Graham and the commanding officer of the naval component of the exercise, Marine Maj. Gen. Perry B. Griffith, arrive in a C-135, not a C-130. When they disembark from the plane, they are greeted by Air Marshal Aspy Merwan Engineer, chief of the IAF.[68]

Even if Graham misremembered the circumstances of his arrival in India, his account is representative of cultural tensions that cropped up from time to time during the exercise. Although the IAF pilots all spoke English fluently, some nonflying personnel

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67. Graham, *Down for Double*, 167.
68. "U.S. Shiksha units chief arrives," *HT*, October 30, 1963.

had trouble communicating with the Americans. The history of the 354th Tactical Fighter Wing describes one "far from desirable" situation apparently caused by poor communication. At Palam, the IAF supplied an ambulance to wait alongside the flightline as a safety precaution during air operations. The driver did not understand that he was expected to be on call all day. On two afternoons, he drove away at 1:30 and did not return until the next morning.[69]

In *Comrades at Odds*, Andrew J. Rotter argues that Americans viewed India as disorderly, unpredictable, and above all, filthy. In American eyes, Indians were children in their understanding of technology. Westerners' beliefs in their own technological superiority dated back to the industrial revolution. In the postcolonial era, Americans perpetuated this tradition of judging nonwestern technology as inherently inferior to their own. This attitude comes across in General Graham's memoir. He clearly viewed the IAF as inferior to his own air force. Ignoring the MiG-21's faster speed and higher ceiling than the USAF's F-100s, Graham criticized the IAF for having "a stable full of real trash for airplanes," which lacked missiles and could not fly as fast as the American jets.[70]

A similarly negative characterization of Indians appears in Joseph A. Dabney's account of the Ladakh airlift in his history of the C-130, *Herk: Hero of the Skies*. After the C-130 performs many miraculous feats, an anonymous "air vice marshal" is overcome in childlike amazement at the capabilities of the American planes. Dabney also quotes a USAF transport pilot who described Indian Army officers instructing 120

69. History of the 354th Tactical Fighter Wing (TAC), Jul-Dec 1963.

70. Andrew J. Rotter, *Comrades at Odds: The United States and India, 1947-1964* (Ithaca, NY: Cornell University Press, 2000), 18, 85; Michael Adas, *Machines as the Measure of Men: Science, Technology, and Ideologies of Western Dominance* (Ithaca, NY: Cornell University Press, 1989), 4, 402; Graham, *Down for Double*, 169.

jawans to sit on the floor of a C-130's cargo bay for the duration of a flight to Assam. The *jawans* sat obediently still during the flight, "but when we landed and they filed out, you could see where many of them had wet their pants."[71]

Rotter also argues that Indians also viewed Americans as Others. To Indians, American men were arrogant and violent cowboys or gangsters. At this time, in the early 1960s, Indians were well aware of racial inequality in the United States, since civil rights activism and racial violence received full coverage in the Indian press. Indians believed that Americans had absorbed racist colonial attitudes, and thus Indians viewed them with the same suspicion as they had viewed their colonial overlords.[72]

Indian perceptions of arrogant Americans are evident in a response to Dabney's account of the USAF airlifts in India after the Sino-Indian War, written by IAF pilot A.G. Bewoor and published on *Bharat Rakshak*. Bewoor flew IAF An-12s into Ladakh at the same time as the USAF airlift. The Soviet-built An-12 was a cargo plane powered by four turboprop engines, similar in configuration to the C-130. Both planes had similar ranges and payload capacities. The An-12 had a faster maximum speed than the C-130, but it lacked pressurization in the cargo compartment.[73] While Bewoor concedes that the C-130 was a superior aircraft, he criticizes Dabney for exaggerating the merits of the C-130 while magnifying the flaws of the An-12.[74]

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71. Joseph A. Dabney, *Herk: Hero of the Skies* (Fairview, NC: Bright Mountain Books, 2003), 152-55.

72. Rotter, *Comrades at Odds*, 24, 169. For international coverage of the American civil rights movement, see Mary L. Dudziak, *Cold War Civil Rights: Race and the Image of American Democracy* (Princeton, NJ: Princeton University Press, 2000).

73. Range: 2,113 mi (An-12), 2,090 mi (C-130); payload capacity: 44,000 lb (An-12), 45,000 lb (C-130); maximum speed: 444 mph (An-12), 383 mph (C-130). René J. Francillon, *Lockheed Aircraft since 1913* (Annapolis: Naval Institute Press, 1987), 376; Singh, *Aircraft of the Indian Air Force*, 134.

74. A.G. Bewoor, "A Veteran Recollects: Flying the An-12 into Ladakh," *Bharat Rakshak*, http://www.bharat-rakshak.com/IAF/History/1960s/Ladakh.html (accessed March 30, 2011).

From an Indian perspective, the USAF appeared to colonize a part of IAF Palam temporarily. The American personnel who participated in Exercise Shiksha were housed in a secure area of Palam known as Camp Shiksha. Like a military cantonment in British India, Camp Shiksha reproduced, as closely as possible, the conditions and culture of the home country. Before the exercise began, transports brought in almost all supplies that would be needed for the duratio, including fresh food from Incirlik Air Base in Turkey. Six Air Force cooks prepared meals for the three hundred US personnel stationed at Camp Shiksha. The all-American menus included such dishes as ham, roast beef, and southern fried chicken. Pre-departure attempts to teach US airmen about Indian culture did not extend to actually sampling it firsthand in the dining hall once they arrived.[75]

The Indo-American cultural misunderstandings did not hinder the successful completion of the exercise, but they are indicative of the wider Cold War tensions between the two countries. Although Indians appreciated the military aid offered by the United States, they disliked cavalier American attitudes about Indian culture and technology. There is ample evidence of respect between Indian and American individuals during the exercise, but American policy approached India as a younger and weaker nation. Helping India to defend itself against communists was part of the "white man's burden" that Americans inherited from European colonialism and now carried as the leading western power.

75. "Six cooks feed 300 in Shiksha," *Air Force Times*, November 27, 1963.

Conclusion

The American fighters left India on November 22, 1963, two days after the close of Exercise Shiksha. The end of the successful exercise was soon clouded by dual tragedies. On the same day as the departure of the American fighters, a helicopter crash in the mountains of Jammu and Kashmir, near the cease-fire line with Pakistan, claimed the lives of five high-ranking officers of the Indian military. One of the victims was AVM Pinto, who had commanded the air exercise in the western sector and had befriended Brig. Gen. Graham. Later that day, President Kennedy was shot dead in Dallas. When the USAF pilots returned to their home base at Myrtle Beach on November 25, they joined the rest of the Air Force in a month-long period of formal mourning.[76]

Policy makers in both India and the United States continued to view communist China as a threat looming just to the north of India. The perceived Chinese threat escalated when, on October 16, 1964, the Chinese nuclear establishment detonated its first atomic bomb at the Lop Nur Nuclear Weapons Test Base in Sinkiang (Xingjiang). The Chinese had begun developing their bomb with substantial Soviet assistance, although this aid was cut off in April 1960 with the collapse of Sino-Soviet relations. The USSR had also aided China's missile program by shipping two R-2 (SS-2) missiles to China in January 1958. By 1960, Chinese engineers had already constructed a copy of the R-2, and then begun to modify the design. As a result, in 1964, not only did China have nuclear weapons, the country was also actively developing the ability to deliver these weapons to neighboring countries such as India.[77]

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76. History of the 3974th Combat Support Group (SAC), Nov 1963, Call # K-Gp-Sup-3974-HI, IRIS # M0157, in the USAF Collection, AFHRA; History of the 354th Tactical Fighter Wing (TAC), Jul-Dec 1963; "5 top military men dead in air crash," *The Hindu*, November 23, 1963.

77. John Wilson Lewis and Xue Litai, "Strategic Weapons and Chinese Power: The Formative

The United States saw the Chinese bomb test as another opportunity to expand Indo-American cooperation. In the words of Under Secretary of State George Ball, the US government hoped to counter the Chinese threat by "building prestige of Indian science and technology." Providing direct assistance to an Indian nuclear weapons program was out of the question, and in any event India did not yet have such a program. But the US government saw plenty of opportunity to expand nonmilitary Indian science, and by early 1965, talks with Indian scientists such as Homi J. Bhabha had already begun.[78]

In April 1965, conflict broke out again in the Indian subcontinent. This time, India's adversary was not China but the American ally in South Asia, Pakistan. The Indian and Pakistani armies began by skirmishing around Kanjarkot Fort in the Kutch wasteland between Gujarat and Sind. At the beginning of September, the conflict erupted into a full-blown, albeit brief, war. India used a Pakistani infiltration of Kashmir as a pretext for counterattacks in Pakistan-controlled Kashmir, Punjab, and Sind. The two countries fought to a stalemate over the next three weeks. A UN-brokered cease-fire took effect on September 22, 1965. India and Pakistan negotiated the formal end of the conflict in January 1966 at Tashkent in the USSR, with Alexei Kosygin mediating.[79]

Years," *China Quarterly* 112 (Dec. 1987): 541-45, 549.

78. Telegram, George W. Ball to Embassy in India, December 12, 1964, *FRUS*, 1964-68, 25:169-71; "Indian nuclear energy program," memo, February 22, 1965, ibid., 187-90.

79. McMahon, *Cold War on the Periphery*, 327-31. As Stephen P. Cohen notes in "India's China War and After: A Review Article," *Journal of Asian Studies* 30 (Aug. 1971): 848, the 1962 Sino-Indian War inspired more literary output than the 1965 Indo-Pakistani War: "The former was a traumatic shock, the latter simply the violent irruption of a long and bitter conflict whose causes are well understood." Publishers in both India and Pakistan produced books and pamphlets blaming the other country for initiating or perpetuating the conflict. These included Hari Ram Gupta's *India-Pakistan War 1965*, 2 vols. (Delhi: Hariyana Prakashan, 1967) and Russell Brines's *Indo-Pakistani Conflict* (London: Pall Mall, 1968). Only one feature film about the 1962 Sino-Indian War ever emerged from mainstream Indian cinema: *Haqeeqat* (*Reality*), directed by Chetan Anand and released in 1964. The film follows several fictionalized army units stationed near the Chinese border in Ladakh. The border posts are overrun by racially-

In the 1965 war Pakistan, and to a lesser extent India, used military equipment that had been supplied by the United States. Rather than equipping and training India and Pakistan to fight against communists, American military aid had armed the two countries to go to war against each other. In response to the Indo-Pakistani conflict, the United States cut off all military aid to both India and Pakistan. As a result, the US State Department deferred indefinitely its previous offer of F-5A Freedom Fighters to India. Throughout the negotiations for the sale of fighters and other military equipment to India, American diplomats had repeatedly exhorted the Indians not to rely on the Soviets for aid, because the Soviets could easily reach rapprochement with China and then cut off aid to India as a result. The irony is that it was not the Soviets but the Americans who proved to be the fickle providers of aid.[80]

In several ways, the middle years of the 1960s represent a turning point in the history of modern India. The 1962 conflict with China discredited Nehru's belief that India could lead Asia by moral force rather than military might. The conflict also complicated India's efforts to attain economic and technological self-reliance. Nehru's trickle-down argument, that increase in military production capacity could only naturally follow the growth of civilian industry, now seemed inadequate. Industrial autarky could only come slowly, but India needed more military equipment immediately. To get these arms, India would have to import them. Following the border war with China, India ramped up military expenditure. Between 1962-63 and 1963-64, India's total reported military expenditures jumped from 4.74 to 8.16 billion rupees ($1 to $1.7 billion).

stereotyped Chinese soldiers who speak Hindi with thick accents. In the ensuing battles and retreats, the majority of the film's major characters die.

80. McMahon, *Cold War on the Periphery*, 332; P.V.R. Rao, memo about meeting with Chester Bowles, September 18, 1964, S. No. 18, Ambassador to USA subject files, papers of B.K. Nehru, NMML.

Defense spending continued to escalate during the subsequent tensions and conflicts with Pakistan.[81]

Exercise Shiksha sheds light on several aspects of this important period in modern India's history. First, it is a microcosm of nonaligned India's foreign relations at the time, in particular the country's complex, contentious relations with the United States. As a nonaligned nation, India sought military aid from the western and eastern blocs at the same time. The Indian defense establishment met with representatives of both the United States and the USSR. When Defence Minister Y.B. Chavan met Soviet Ambassador Ivan Benediktov in June 1964, he informed the ambassador about his government's aid agreements with the United States. Three months later, in turn, Chavan explained the MiG-21 deal to Ambassador Bowles. Regarding American aid to India, domestic opposition in both countries had the effect of limiting aid. Political opposition in the United States government opposed sending military aid to nonaligned India; at the same time, opposition within the Indian government opposed accepting military aid from the United States. In his meeting with Chavan, Benediktov accused the United States of waffling in its aid decisions, while in contrast the Soviet Union had always been decisive. What Benediktov did not acknowledge was that the USSR could afford to be decisive because its single-party political system suppressed opposition. The power-sharing American system permitted Congress to reduce or block a President's aid package.[82]

Exercise Shiksha does not just illustrate high-level diplomatic relations between

81. John W. Garver, "India, China, the United States, Tibet, and the Origins of the 1962 War," *India Review* 3 (April 2004): 171; *The Times of India Directory & Yearbook 1967* (Bombay: Times of India Press, 1967), 7; *The Times of India Directory & Yearbook 1969* (Bombay: Times of India Press, 1969), 12.

82. P.V.R. Rao, memo about discussion with Soviet Ambassador, June 11, 1964, S. No. 18, Ambassador to USA subject files, papers of B.K. Nehru, NMML; P.V.R. Rao, memo about meeting with Chester Bowles, September 18, 1964, Ibid.

India and the United States; it also offers examples of interactions between representatives of the Indian and American governments, mainly military personnel, who were not diplomats. These interactions, in turn, can highlight the similarities and differences between Indian and American culture in the 1960s. Andrew J. Rotter notes in *Comrades at Odds* that "decision makers are creatures of culture, not just policy wonks who shed their images of others like raincoats at the office door."[83] The same could be said of the Indian and American airmen who participated in Exercise Shiksha. During the exercise, Americans such as Brigadier General Graham viewed Indians as unsophisticated and dangerously inclined toward communism. In Graham's eyes, the IAF's second-tier fighters and the (likely misremembered) behavior of some IAF personnel reinforced these stereotypes. For their part, Indians were impressed by American technology, but they also felt that Americans frequently acted brashly and arrogantly. IAF veteran A.G. Bewoor detected these negative American tendencies in Joseph Dabney's account of the American and Indian airlifts into Ladakh.

Finally, Exercise Shiksha was a site of technological interchange, both in terms of artifacts and expertise. The interchange was mainly unidirectional, although it is possible that the USAF's experience in India informed the service's operations in southeast Asia later in the 1960s.[84] In connection with the exercise and military aid program, India received modern air defense radar, and training for how to use it. The radar sets, above

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83. Rotter, *Comrades at Odds*, xx.

84. An article in the *New York Times* at the close of the exercise mentioned another possible example of knowledge gained by the United States in India. The article states that Americans learned "certain operational techniques" from the IAF, which the USAF might adopt. One of these was broadcasting mission instructions to pilots by loudspeaker while they are running to their planes during a scramble, rather than delivering the instructions by radio after the pilots have boarded their aircraft. "Air tests in India said to open way for fast U.S. aid," *NYT*, November 22, 1963.

everything else, demonstrate how nonalignment complicated India's defense modernization. The portable radar sets deployed in the exercise were for temporary use only, until permanent secondhand radar stations could be installed and brought online. When the United States cut off military aid in 1965, the permanent stations remained incomplete. To bring the stations online, the IAF had to improvise, making do with components that were available at the time in India. In other words, the IAF had to perform *jugaad* to complete its sophisticated imported air-defense radar system.[85] Throughout the history of India in the early-independence period, examples like this of international politics affecting India's access to technology appear again and again. The Cold War, along with economics and domestic politics, influenced and often frustrated Indian programs of technological modernization and indigenization.

85. Singh, *The Icon*, 124.

Chapter 2: Brahmaputra Bridge

On October 31, 1962, Northeast Frontier Railway Chief Engineer (Survey and Construction) Bankim Chandra Ganguli presided over a small, informal ceremony declaring the Brahmaputra Bridge at Gauhati, in the northeastern state of Assam, officially open to goods traffic. Ganguli cut a ribbon strung across the opening of the left-bank landing of the bridge. Then trains began to roll across one of the dual meter-gauge rail lines on the lower deck of the bridge. Seven months later, on a rainy June day, Prime Minister Nehru visited Assam to formally dedicate the bridge. At the ceremony held at Maligaon Railway Stadium, Nehru announced to the crowd of 10,000 that the name of the bridge would be Saraighat, after a seventeenth-century battle in which the Ahoms (Assamese) fought back the Mughal army's last attempted invasion of Assam. According to the *Assam Tribune*, "The Prime Minister's announcement was greeted with loud cheers and hand-clapping by the crowd who collected in their thousands at the Maligaon Railway Stadium despite continuous rain."[1]

Constructed over a period of less than four years, from January 1959 to October 1962, Saraighat Bridge was the first permanent crossing of India's last major unbridged river, the Brahmaputra. During the colonial era, British authorities had overseen the construction of bridges across the Ganga, Yamuna, Narmada, Krishna, Indus, and many

1. "Brahmaputra Bridge declared open to goods traffic," *Assam Tribune* (*AT*), November 1, 1962; "Brahmaputra bridge named Saraighat," *AT*, June 8, 1963.

of the Subcontinent's smaller waterways, but at Partition, the Brahmaputra remained unbridged along its entire length running through Assam.[2]

Double-decked Saraighat Bridge consisted of ten main spans and two shore spans, all constructed of steel double Warren trusses[3] and spanning a total distance of 4,258 feet across the river. The spans rested on two shore piers and eleven main piers, the deepest of which reached 199 feet below high flood level. The bridge carried two meter-gauge rail lines on the lower deck and a paved motorway and pedestrian pathways on the upper deck. The project also included the construction of road and rail approaches to the bridge, the remodeling of the Gauhati train station, and the construction of a new railway marshaling yard at Narangi in eastern Gauhati. The total project cost just over 100 million rupees, of which roughly half was spent on the bridge itself.[4]

The Brahmaputra Bridge represents the Indian government's use of infrastructure to bind the Indian nation together, and at the same time set the limits of the nation. The bridge linked isolated, sometimes trouble-prone Assam to the rest of India, establishing for the first time a permanent connection between the Indian mainland and the areas south of the Brahmaputra. Surrounded by foreign countries, including India's foes East Pakistan and China, Assam was in a strategic position. It was a coincidence, but nevertheless symbolic, that Saraighat Bridge carried its first goods traffic during the Sino-Indian War.

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2. Memo, "Brahmaputra Bridge Contract," NFR to Rail Secretary, March 9, 1965, file no. 62/W5/BR1/17/1-135, Ministry of Railways, NAI.

3. In American English, a *truss* is a structure made of multiple individual beams, known as *girders*; trusses are capable of spanning openings and may be used in bridges or roofs. In Indian English, *girder* refers to a complete truss as well as its individual members. Except in quotations, this chapter uses the words *truss* and *girder* in their American senses.

4. "Brahmaputra conquered after fifty years' planning," *Assam Tribune Magazine*, June 17, 1962; B.C. Ganguli, "The Northeast Frontier Railway in service of nation," *AT*, April 10, 1962.

The Brahmaputra Bridge project was implemented by the Northeast Frontier Railway (NFR), the easternmost subdivision of India's national rail network. B.C. Ganguli, who had the honor of cutting the ribbon across the bridge in October 1962, served as Chief Engineer on the project. Throughout planning and construction, Ganguli and NFR were closely supervised by the Railway Board in New Delhi, represented by Karnail Singh, Member (Engineering). All major decisions regarding the bridge had to be cleared by Singh and the board prior to implementation. Two private firms contracted to construct the bridge. Hindustan Construction Co. (HCC) of Bombay dug the foundations in the riverbed and constructed the concrete piers. Braithwaite, Burn and Jessop (BBJ) of Calcutta constructed the twelve steel spans that stretched from pier to pier across the Brahmaputra.

When work on the Brahmaputra Bridge began in 1958, HCC and BBJ had recently finished work on Rajendra Pul, a crossing of the Ganga River at Mokameh, Bihar. On the Ganga Bridge project, as Rajendra Pul was called prior to its dedication, the two companies worked together under the umbrella organization Ganga Bridge Construction Company.[5] On the Brahmaputra Bridge project, however, the two companies worked separately. The Railway Board awarded the contract for the foundations and piers directly to HCC, without calling for open bidding. The board's reasoning was that HCC was the only company in India qualified to undertake the work.

For the trusses, the Railway Board called for international tenders, but nevertheless selected BBJ over eight other firms. The Railway Board did not select BBJ

5. Ganga Bridge Construction Co. Ltd, "Tender for the construction of main bridge over River Ganga near Mokameh (excluding training and approachworks)," May 28, 1954, file no. 62/W5/BR1/17/1-135, Ministry of Railways, NAI; H.K.L. Sethi, "Bridge across the Ganga near Mokameh," March 13, 1959, file no. 59/W5/BRI/6/1-48, Ministry of Railways, NAI.

simply because the Indian firm's bid used the least foreign exchange. The open tender for the trusses was not just a search for the lowest bidder; it was also a survey of contemporary bridge construction technology outside India. The Railway Board determined that Indian bridge-building practices were sufficiently up-to-date, and therefore it was not necessary to transfer new technology into India. Therefore it concluded that an Indian firm could do as good a job as any foreign firm.

The Brahmaputra Bridge was thus a nearly wholly indigenous project. BBJ employed a British firm to design and analyze the trusses, but the rest of the construction techniques were already well established in India by the late 1950s. Furthermore, all of the capital and labor, and almost all of the materials, were indigenous to India. The bridge therefore represents one end of the spectrum of technologies studied in this dissertation. In contrast to the aircraft studied in Chapter 1, and the power stations described in Chapters 3 and 4, the bridge technology in this chapter was never part of a concerted governmental indigenization program. Instead, the technology had already been indigenized as far as possible during the late colonial and very early independence periods.

The Brahmaputra River in northeast India

After the Partition of the Indian subcontinent in 1947, the Brahmaputra River Valley of Assam belonged to northeast India, a region separated from the Indian mainland by the eastern wing of Pakistan. East Pakistan, which would become Bangladesh in 1971, was carved out of the Muslim-majority districts of the Indian state of Bengal, as well as one district of Assam, Sylhet. A narrow strip of land was all that connected northeast

India with the rest of the country. Pinched off between East Pakistan and Nepal, this strip of land, known as the Siliguri Corridor or the Chicken's Neck, was less than fifteen miles wide at its narrowest point.

At 1,800 miles in length, the Brahmaputra River is one of the Indian subcontinent's longest rivers. The source of the river is well outside India, in southwestern Tibet. The river flows eastward through Tibet for its first 800 miles, then turns to the south and cuts through the Himalaya mountains. After cascading down the mountains for 200 miles, the river turns to the west and for 350 miles passes through the valley of Assam. Here the river flows through a broad, silty channel, frequently changing course during the floods of the monsoon season. In two places, Guwahati (formerly Gauhati) and Jogighopa, the river is constrained by hills, and there the course has remained stable for centuries. Once the river reaches the western flanks of the Garo Hills of the Meghalaya Plateau, it turns south and crosses into Bangladesh, where it merges with the Ganga and flows into the Bay of Bengal.[6]

The Brahmaputra River Valley of Assam (Figure 5) is bordered to the north by the Duars (Himalayan foothills), to the east by the hills of Manipur and Nagaland, and to the south by the Karbi Hills and the Meghalaya Plateau. The hills surrounding the Brahmaputra mostly have cooler climates, but the valley itself has a hot monsoon climate. The months of November through March, including the short winter of December to January, are the dry season, and no rain at all may fall in parts of Assam during these months. The seven-month rainy season begins with the pre-monsoon *chhota*

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6. Northeast Frontier Railway, "Brahmaputra Bridge Project (Amingaon): Project Report and Construction Estimate," 1959, file no. 59/W5/BR1/19/1-22, Ministry of Railways, NAI (hereafter cited as NFR, Brahmaputra Bridge Project Report (1959)).

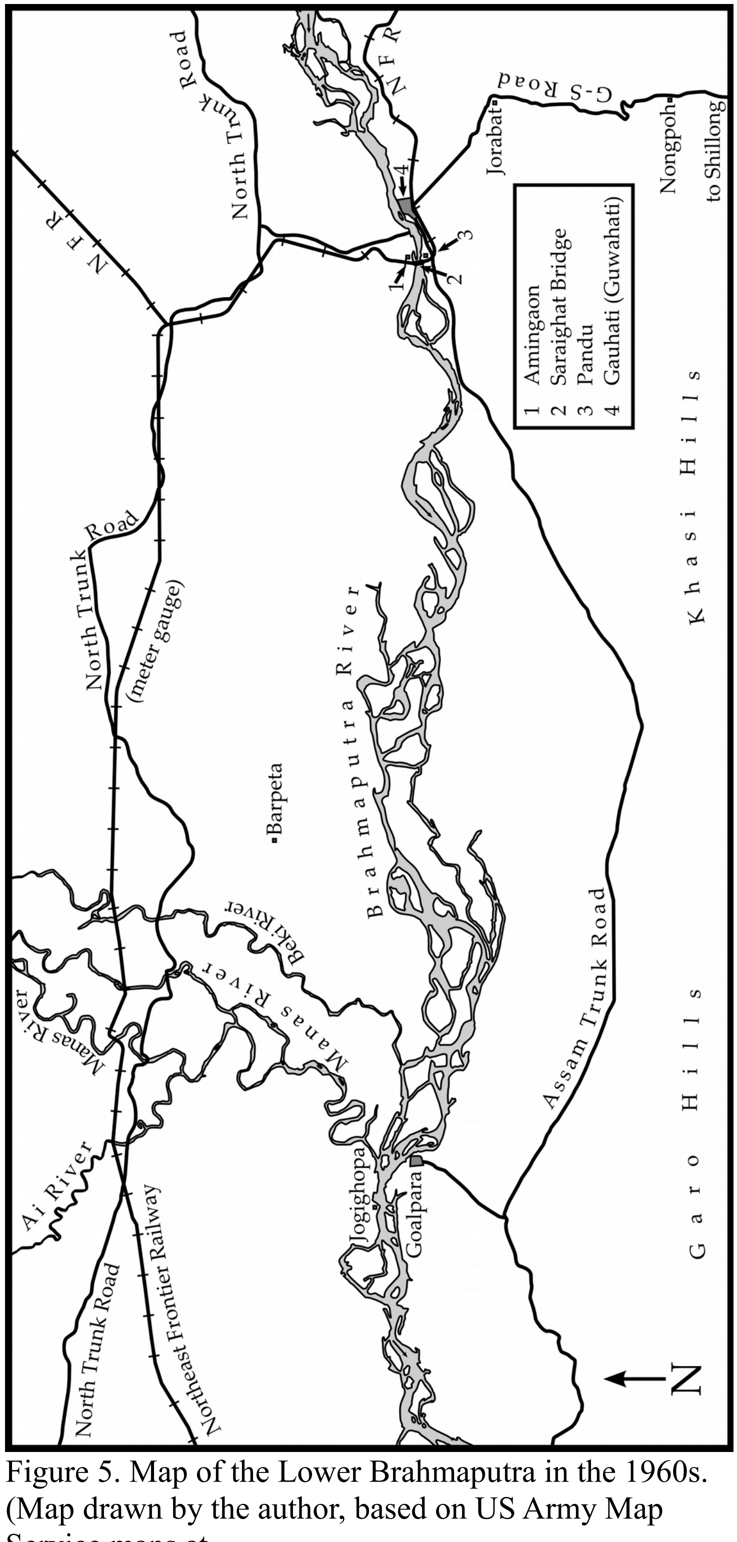

Figure 5. Map of the Lower Brahmaputra in the 1960s. (Map drawn by the author, based on US Army Map Service maps at http://www.lib.utexas.edu/maps/ams/india/, accessed April 21, 2016.)

barsaat (little rain) storms in April and May. The *chhota barsaat* merges with the Indian Ocean monsoon, which usually strikes Assam around the first of June. Monsoon storms almost invariably lead to flooding in some parts of Assam, and occasionally the floods reach catastrophic levels.[7]

Apart from seasonal flooding of the Brahmaputra and its tributaries, the most serious natural hazard in the Brahmaputra Valley is earthquakes. The valley lies at a major geological fault between the Australian-Indian and Eurasian plates, and earthquakes occur frequently along this fault. The Global Seismic Hazard Assessment Program ranks everywhere in Assam as either "high hazard" or "very high hazard" (its highest rating) areas for major earthquakes. Other regions of comparable seismicity to northeast India include Nepal, southern China, Iran, western Turkey, and the Pacific coast of South and Central America.[8]

The most devastating recorded earthquake in the region struck Assam on the afternoon of June 12, 1897. Epicentered in the Khasi Hills, the quake leveled all stone structures in the hill station Shillong, heavily damaged the cities of Gauhati and Sylhet, destroyed roads and rail lines, rerouted rivers, and killed more than 1,500 people. In 1950, another major earthquake, registered at 8.4 on the Richter scale, struck the Himalayan foothills of northeast India. The 1950 quake caused landslides that dumped sediment into the Brahmaputra and its tributaries, thus raising the level of the river beds

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7. M. Taher and P. Ahmed, *Geography of North-East India*, 4th ed. (Guwahati: Mani Manik Prakash, 2007), 48-57.

8. "Global Seismic Hazard Map," Global Seismic Hazard Assessment Program, http://www.seismo.ethz.ch/static/gshap/ (accessed September 21, 2012). Earthquake hazard rankings are based on a 10 percent probability that peak ground acceleration caused by an earthquake will exceed a given amount within a period of fifty years. For high hazard regions, the peak ground acceleration is above 2.4 m/s^2; for very high hazard, greater than 4.0 m/s^2.

and causing them to flood with greater frequency than before. The Brahmaputra also shifted its course in upper (eastern) Assam. In 1954, the river flooded and partially destroyed the city of Dibrugarh. A government program to protect the city with wooden and stone revetments succeeded in saving the rest of the city from being washed away by the river.[9]

Despite the natural hazards, civilization has long thrived in the Brahmaputra River Valley. Cultivators learned early on to take advantage of the the Brahmaputra's frequent floods and shifting to new channels, which left behind fertile, silt-laden land. The dominant civilization in Assam immediately before British colonization was the Ahom kingdom. According to the Ahom chronicles, known as *buranjis*, the Ahoms first migrated into Assam from Upper Burma under the leadership of their swargdeo (literally, "spirit of heaven") Sukapha in the thirteenth century. Although Yasmin Saikia argues convincingly that the *buranjis* are eighteenth-century texts of Ahom identity construction rather than reliable historical narratives, the chronicles nevertheless remain the major source for understanding the period of Ahom rule in Assam. In 1906, colonial administrator Edward Gait published *A History of Assam*, which relies heavily on the *buranjis*. Despite its shortcomings in terms of source base and colonial agenda, the book remains the most widely accessible history of pre-modern Assam. Therefore, it continues to influence how Assamese and outsiders understand the history of the region.[10]

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9. R.D. Oldham, "Report on the Great Earthquake of 12th June 1897," in *Memoirs of the Geological Survey of India* (Calcutta: Government of India Central Printing Office, 1899), 29:4-7; Edward Gait, *A History of Assam* (1906; repr. Delhi: Surjeet Publications, 2006), 402-3; Taher and Ahmed, *Geography of North-East India*, 91; F. Kingdon-Ward, "Aftermath of the Great Assam Earthquake," *The Geographical Journal* 121, no. 3 (Sept. 1955): 299-300; Kanuru Lakshman Rao, "Engineering Problems in Recent River Valley Projects in India," *Proceedings – Institution of Civil Engineers* 11 (Jan. 1958): 31-32.

10. Arupjyoti Saikia, "Ecology, Floods and the Political Economy of Hydropower: The River Brahmaputra in the 20th Century," in *Perspectives in Indian Development: New Series* (New Delhi: Nehru

Assam has a distinctive regional identity, thanks to the Ahoms' introduction of southeast Asian culture to the Brahmaputra Valley. Assam has also had long links with cultures farther west in South Asia. These links would legitimize Assam's incorporation into the Indian nation. The majority population of modern Assam identify themselves as non-tribal Assamese. They speak Assamese or Asomiya, a Sanskritic language closely related to Bengali. Vaishnava Hinduism became widespread in Assam during the sixteenth century. Hinduism is now the majority religion in the state, but like elsewhere in South Asia, Islam also has a strong presence.[11]

Although Assam had religious and linguistic links with other parts of South Asia, the territory was politically separate until the nineteenth century. In the seventeenth century, the Ahom kingdom collided with the expansive military ambitions of the Mughal Empire. In a series of campaigns, the Mughal army invaded Assam and attempted to incorporate the Ahom kingdom into the Mughal empire. In 1671, during the long reign of Aurangzeb, Raja Ram Singh of Amber led the Mughal military into Assam, in an attempt to win back territory that had previously been recaptured by the Ahoms. At the Battle of Saraighat, the Ahom river navy and infantry met and defeated the Mughal fleet. Following this campaign, the Mughal military retreated from Assam and made no further attempts to conquer the territory. The commander of the Ahom forces, Lachit Barphukan, was ill during the battle and apparently died shortly afterward. He has since become an

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Memorial Museum and Library, 2013), 22:6-7; Yasmin Saikia, "Religion, Nostalgia, and Memory: Making an Ancient and Recent Tai-Ahom Identity in Assam and Thailand," *Journal of Asian Studies* 65 (Feb. 2006): 34-37; Edward Gait, *A History of Assam* (1906; repr. Delhi: Surjeet Publications, 2006). Saikia's full treatment of Ahom identity is *Fragmented Memories: Struggling to Be Tai-Ahom in India* (Durham, NC: Duke University Press, 2004).

11. Taher and Ahmed, *Geography of North-East India*, 266-67; Maheswar Neog, "A Militant Vaisnava Sect: The Mayamaria," *Journal of Indian History* 56 (Aug. 1978): 420.

Assamese folk hero. His birthday, November 24, is celebrated as Lachit Divas (Lachit Day) in Assam each year. The public-sector Assam Tourism Development Corporation has contracted Gammon India to build a pier in the Brahmaputra adjacent to Guwahati, to hold a colossal thirty-foot statue of Lachit Barphukan, along with eight members of his army and two cannons.[12]

In pre-modern times, constructing a permanent bridge across the Brahmaputra was technologically unfeasible, although there are historical accounts of an Ahom general, Kalia Bhomara, collecting timbers in preparation for bridging the river at Tezpur. A temporary bridge was constructed on at least one occasion. During an earlier, more successful invasion of Assam, the Mughal army under Mir Jumla crossed the river, Xerxes-like, on a temporary bridge of boats. This was during the winter low water; during the monsoon, crossing the river by boat can be dangerous, and in flood conditions, it can become impossible.[13]

Although not suited for a river as large as the Brahmaputra, the Ahoms had masonry bridge technology, originally imported from Bengal. Some pre-modern bridges are still in use in Assam. A particularly fine example is the Namdang Stone Bridge, near the old Ahom capital of Sibsagar. This 200-foot bridge spanning the Namdang River has six arches, although one of them has been filled in. The design is attributed to Ghansyam, a Bengali architect who came to Assam about the turn of the eighteenth century at the invitation of king Rudra Singh, who was unable to find anyone in his kingdom capable of

12. Gait, *History of Assam*, 160-61; Maheswar Neog, *Lachit Barphukan: The Victor of the Battle of Saraighat* (New Delhi: Publications Division, 1983), 78-80; "Lachit Divas," *AT*, November 22, 2009; "Officials inspect site of Lachit statue project," *AT*, July 29, 2015.

13. S. Ponnuswamy and V.C. Sharma (eds.), *Bridging River Brahmaputra: Past Present and Future* (Guwahati: Northeast Frontier Railway, 1988), 17; Gait, *History of Assam*, 139.

building the brick structures that he wanted. The main construction materials of Ghansyam's bridge are stone and brick, with some iron used for reinforcement. The stones are joined with cement made of ingredients including lime, *surkhi* (pounded brick), and eggs. The bridge is decorated with scalloped arches and carvings of deities on the piers. It was located on an important road when it was constructed, and it still is today; National Highway 37, the Assam Trunk Road, runs over the bridge.[14]

The Ahom monarchy was able to construct large public works projects, such as roads, bridges, and flood-control dikes, because of the state's system that substituted forced labor in place of direct taxation in cash or kind. The *paik* system, as it was known, originated in the early seventeenth century, during the reign of Pratap Singha. Every male between the ages of fifteen and fifty was required to register as a *paik*. Groups of three or four *paiks* were known as a *got*. From each *got*, one *paik* at a time was called up to service. During peacetime, the *paik* would serve the state on public works projects; in wartime, he would join the infantry. In his absence, the other members of his *got* would tend his fields for him. This arrangement allowed the Ahom state simultaneously to employ labor in public works or warfare and maintain agricultural productivity.[15]

Decades of political instability in the late eighteenth and early nineteenth centuries led to the collapse of the Ahom kingdom and the annexation of Assam by the British. During this period of instability, the kingdom of Burma meddled in Ahom political affairs, culminating in the de facto annexation of Assam in 1822. The British

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14. Subhra Das and S.H. Pargiri, "Namdang Stone Bridge," Indira Gandhi National Centre for the Arts, http://www.ignca.nic.in/asi_reports/ASSSIV_015.pdf (accessed October 30, 2015); Gait, *History of Assam*, 176.

15. S.L. Baruah, "Military System in Medieval Assam under the Ahom Rule," *Journal of Indian History* 64, (Jan. 1986): 96.

East India Company, alarmed by these developments, declared war on the Burmese and forced them to renounce any further claim on Assam in the Treaty of Yandabo, signed February 24, 1826. The company attempted to restore the Ahom monarchy, but the administration of Purandar Singha, the restoration monarch, was ineffective, and the British decided to annex Assam fully in 1838.[16]

Assam proved to be a profitable territory for British colonists, as the broad, hot, and rainy Brahmaputra Valley was well suited to plantation agriculture. Beginning in the mid-nineteenth century, plantations began to grow tea plants in Assam, using the labor of tribal Adivasi people brought in from central India. The variety of tea plant grown in Assam, *Camelia sinensis* var. *assamica*, was a cross of Chinese tea and a shrub native to Assam. Over the course of the latter half of the nineteenth century, Assam replaced China as the chief source of tea imported by Britain.[17]

British colonizers and the largely non-Assamese Indian merchant classes developed the economy of Assam on colonial lines, with emphasis on extraction of agricultural products, especially tea, and mineral resources such as the oil of upper Assam. Transportation routes favored extraction of resources over communication within the province. The Brahmaputra itself served as a major transportation corridor, as it had for centuries. Starting in the 1860s, steamboats began running on the river. They ferried laborers into Assam to work the tea gardens, and brought tea back out for the English market. In addition, two rail lines reached into the province. Assam's capitalists had little interest in developing local processing facilities to add value to extracted resources and

16. Priyam Goswami, *The History of Assam from Yandabo to Partition, 1826-1947* (Hyderabad: Orient Blackswan, 2012), 15-17, 59-60, 72.

17. Ibid., 166-67; Gait, *History of Assam*, 404-7.

make them marketable directly from Assam. Instead, Assam served as the hinterland of eastern India's biggest industrial center, Calcutta. This colonial economic pattern, once formed, persisted for decades after independence. As late as 1984, *Indian Express* journalist Shekhar Gupta commented in his book *Assam: A Valley Divided:* "Most people in the north-east still buy Lipton, Brooke Bond or Tata-Finlays tea, produced in their state but packed and taxed in Calcutta. Besides, they pay the marketing firm's profit, transport, and overheads."[18]

Although colonial economics would persist for decades, independence and Partition did bring immediate changes to the Brahmaputra Valley, and Assam would continue to change rapidly in the years following 1947. An influx of displaced persons at and after Partition contributed to a dramatic rise in the population of Gauhati, Assam's major urban center. Although the town had largely been bypassed by the industrial revolution prior to independence, Gauhati had long been the commercial and transportation hub of Assam. The city's name, which derives from Assamese words meaning "areca nut market," reflects the city's historic status as an economic center. (The current spelling of the name is "Guwahati," which more closely represents the pronunciation of the city's name in Assamese.) In 1901, the city registered a population of 11,661 in the census. Over the next half century, Gauhati grew to the modest size of 43,615. Then by the next census, in 1961, the city's population had exploded to 100,707.[19]

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18. Shekhar Gupta, *Assam: A Valley Divided* (New Delhi: Vikas Publishing House, 1984), 69; Basil Greenhill, "The Steamers of the Brahmaputra and the Ganges," *Mariner's Mirror* 52 (Feb. 1966): 53-60; Goswami, *History of Assam*, 177.

19. "An introduction to tentative master plan for Greater Gauhati," *Assam Tribune* Greater Gauhati supplement, November 25, 1958; E.H. Pakyntein, *Kamrup District Census Handbook, Census of India 1961* (Government of Assam, 1964), Assam State Archives.

Government planning brought changes to Assam as well, even if the plans never fully achieved their ambitions. Development was organized under both state-level and central government-level Five-Year Plans. Under the First Five-Year Plan of the Union (central) government (1951-56), hundreds of miles of dikes and embankments went up alongside the Brahmaputra, to protect the land from flooding. During the second and third plans, electric power projects made power available for industrial development, so that Assam could begin to produce its own products rather than simply serving as Calcutta's hinterland. (The biggest of these projects, Umiam Hydroelectric in the Khasi Hills, is the subject of Chapter 3.) The government also established public-sector industrial operations to process Assamese resources in Assam. One of these was Noonamati Refinery in Guwahati, completed in 1962 with Romanian technical collaboration. A sixteen-inch pipeline connected the refinery with Nahorkatiya and Moran oilfields in upper Assam.[20]

Development of transportation infrastructure also received attention in the Five-Year Plans of the Union and state governments. The Assam Public Works Department, under the state plans, expanded roads, repaired damage, and replaced mile or furlong posts along the highways with kilometer posts. Two national highways ran along opposite sides of the Brahmaputra: the Assam Trunk Road, which passed through Gauhati, and the North Trunk Road. Prior to independence, both were largely unpaved, and the North

20. E.H. Pakyntein, Kamrup District Census Handbook, Census of India 1961 (Government of Assam, 1964), Assam State Archives; "Nehru inaugurates Gauhati refinery this morning," *AT*, January 1, 1962; "River Crossing Every Nine Miles for Oil India Pipeline," *International Oilman*, December 1959, 407-8. Arupjyoti Saikia argues that the construction of embankments was politically motivated, as plantations of tea, jute, and other cash crops received more attention than plots of subsistence agriculture. "Jute in the Brahmaputra Valley: The Making of Flood Control in Twentieth-Century Assam," *Modern Asian Studies* 49 (Sept. 2015): 1433-34.

Trunk Road was passable only in the dry season. By the mid-1960s, the Assam Trunk Road had been partially paved. In the thinking of Indian planners, more important than roads were railroads, which received particular attention in Assam and elsewhere during the early independence period.[21]

Background of the Indian Railways

The modern Republic of India has one of the world's largest rail networks, and the public-sector undertaking Indian Railways is the world's single largest employer. Trains remain the main means of long-range travel in the country. India's large, mobile population rides trains in huge numbers every day of the year. Reserved seats on important mainline trains can be waitlisted months in advance. In addition to the mainline trains, commuter trains in major cities are also operated by Indian Railways. The suburban trains of Mumbai (Bombay), operated by Western Railway, carry six million people a day, more passengers than any other mass-transit system in the world.[22]

The Indian rail network originated during the colonial period, but it is inappropriate to attribute the railways in any period completely to British agency. The initial colonial development of the railways was planned by British engineers and overseen by British foremen, but a variety of groups had interest in the railways. Rulers of princely states and Indian capitalists patronized railways alongside the colonial

21. Shyam Bhadra Medhi, *Transport System and Economic Development in Assam* (Gauhati: Assam Publication Board, 1978), 41; Goswami, *History of Assam*, 187-88; Government of Assam Public Works Department (PWD), "Report on the Administration of Public Works Department (Roads & Buildings Wing), Assam for the Year 1961-62," Assam State Archives; Government of Assam PWD, "Report on the Administration of Public Works Department (Roads & Buildings Wing), Assam for the Year 1963-64," Assam State Archives.

22. Indian Railways, "About Indian Railways," http://www.indianrailways.gov.in/railwayboard/view_section.jsp?lang=0&id=0,1 (accessed November 5, 2015); Western Railway, "About us," http://www.wr.indianrailways.gov.in/view_section.jsp?lang=0&id=0,1 (accessed November 5, 2015).

Government of India and British capitalists. Almost all the labor for construction, of course, was Indian. After independence, the Indian railways continued to develop, with nationalization, reorganization, construction of new lines and stations, conversion from steam to diesel or electric locomotives, introduction of domestically-produced locomotives and rolling stock, and conversion of lines to broad gauge. It is thus as meaningless to attribute the modern Indian rail network to the British, as it would be to identify long-dead British colonists as the main actors in the modern Indian economy.

The colonial development of the Indian railways established the starting conditions for the post-independence development of the railways, and for that reason it is important to understand the pre-independence context. Railway technology first reached India in the 1850s, brought by private British capital with the grudging approval of the East India Company. The first rail line in India, running twenty-one miles between Bombay and Thane, opened in 1853. This was the beginning of the Great Indian Peninsula Railway. The next year, India's second rail line, belonging to the East India Railway, opened on the other side of the subcontinent.[23]

Railways in India subsequently grew piecemeal through private and government investments. During the 1860s, broad-gauge (5 ft 6 in) private railways connected the major cities of India. Commercial competition and the political unification of the Indian subcontinent under a single colonial administration meant that rail lines could, and did, develop into dense networks rather than single resource-extraction lines from mines or plantations to ports. The colonial government displayed little interest in railways until the

23. Daniel R. Headrick, *The Tentacles of Progress: Technology Transfer in the Age of Imperialism, 1850-1940* (New York: Oxford University Press, 1988), 60; Arup Kumar Dutta, *Indian Railways: The Final Frontier – Genesis and Growth of the North-East Frontier Railway* (Guwahati: Northeast Frontier Railway, 2002); 9-11.

Mutiny of 1857, when railways proved to be a strategic asset as well as a commercial venture. The colonial government started investing in railways in the 1870s, building meter-gauge (3 ft 3⅜ in) railways that were blocked from connecting with each other by the broad-gauge lines already in place. These railways, despite being built more cheaply in the smaller, lighter-weight meter gauge, proved unprofitable for the government.[24]

Railway development did not just take place in British India; it also occurred in the princely states. Under the terms of treaties, the princes had surrendered to the British their rights of conducting foreign relations and defending their territory, but they retained sovereignty within their own territories. British-built rail lines had to obtain consent from a prince when crossing through a princely state. The first railway built by princely agency was constructed on behalf of the Nizam of Hyderabad, beginning in 1875. The Nizam himself was disenchanted by industrial technology, but his chief minister, Salar Jang, was a proponent of modernization; eventually the chief minister prevailed and managed to get the railway built with financing from London. Princes of other states were themselves interested in modernization, and actively promoted development of their own rail lines. One of these was Sawai Madho Singh II of Jaipur, distant successor of the Ram Singh defeated by the Ahom army at Saraighat. In addition to establishing hospitals, improving roads, and building irrigation works in his realm, Madho Singh II established the Jaipur State Railways. The first line, running from Jaipur to the hunting reserve at Sawai Madhopur, opened in 1907. At Sawai Madhopur, the Jaipur State Railway connected with the British-owned Bombay, Baroda and Central Indian Railway (BB&CI). Initially, BB&CI operated the Jaipur State Railway, but the princely state government took over

24. Headrick, *Tentacles of Progress*, 65, 71-72.

operation of the railway in 1936.[25]

By the beginning of the twentieth century, India already had one of the world's largest rail networks. In 1920, India had a total of 38,500 miles of track, more than Germany and less than only the United States, Canada, and the Soviet Union. Among these countries, India was the only one that was still a colony. Although rail lines had originally been built in India for the commercial interests of the colonizers, the Indian public soon started riding trains in large numbers. It was thus from transportation of India's huge population, rather than freight, that the private railways became profitable.[26]

The two major physical obstacles to railway construction in India were the Western Ghat mountains, which have a steep grade from the western coast to the Deccan Plateau, and the rivers, which like the Brahmaputra have highly variable flow, unstable channels, and deep scour of the riverbeds during monsoon floods. Building railways, and particularly rail bridges, became infused with symbolism representing the colonial project. In the eyes of the colonists, railways represented modern technology and rationalism triumphing over the apparent ignorance and disorder of India.[27]

The colonial symbolism of rail bridges is apparent in Rudyard Kipling's short story "The Bridge-Builders," about the construction of a fictionalized bridge over the Ganga. In the words of Gyan Prakash, the story portrays the bridge as a "triumph of reason over India's unruly nature and mythic culture." Like Saraighat Bridge, the "Kashi Bridge" of the story has two decks, with a road on the top and rails on the bottom. During

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25. Headrick, *Tentacles of Progress*, 73; Ram Pande, *History of Railways in Rajasthan* (Jaipur: Shodhak, 2003), 33-34.

26. Headrick, *Tentacles of Progress*, 53-56, 63.

27. Ibid., 69-70; Gyan Prakash, *Another Reason: Science and the Imagination of Modern India* (Princeton, NJ: Princeton University Press, 1999), 166.

a massive flood that strikes just before the completion of the bridge, the chief engineer Findlayson and an Indian assistant named Peroo get washed downriver to an island. Both men have taken opium on account of the cold, and as they lay dazed on the island, they see the major Hindu gods gathering to discuss the new bridge over the river. Despite her best efforts Ganga, represented by a crocodile, admits that she cannot destroy the bridge. Morning comes, the gods vanish, and when Findlayson and Peroo get rescued by the steam launch of a local raja, they learn that their bridge still stands, with "not a stone shifted anywhere."[28]

Daniel Headrick argues in *The Tentacles of Progress* that the colonial development of railways represented technology transfer in one sense but not others. Locomotives, rolling stock, rails, signaling systems, and so forth moved from Europe or North America to India, but the only technology transfer was physical. Knowledge was not transferred at the same time. The engineers who laid out the railways in British India and the princely states were British, as were the engineers who operated the locomotives. Early on, the railways did establish workshops for maintenance of locomotives, which also doubled as locomotive manufacturing centers. Seven hundred locomotives were built in India prior to independence, 444 of which came from Baroda and Central India's workshop in Ajmer and 217 from East India Railway's facility in Jamalpur. But these seven hundred locomotives represented only 4 percent of the locomotives used in India before independence. By comparison, 14,420 locomotives (80 percent) came from Britain, and the balance from Germany or the United States. The Indian railways

28. Prakash, *Another Reason*, 167-68. "The Bridge-Builders" first appeared in the Christmas 1893 number of the *Illustrated London News*.

imported so many high-quality and high-price British locomotives, in lieu of building more of their own, because the British government wanted to protect industry in Britain from competition in the colonies.[29]

By the beginning of the 1930s, railroads had spread across almost the entirety of the British Empire in India, from the southern tip of the subcontinent to Peshawar near the Khyber Pass to Afghanistan. In the northeast, two separate lines ran into Assam. From Calcutta, a broad-gauge line of the government-operated Eastern Bengal Railway ran to Parbatipur in eastern Bengal, where it connected with a meter-gauge line that ran along the western and northern side of the Brahmaputra to Amingaon. The second route, belonging to the private Assam Bengal Railway and built entirely in meter gauge, began in Chittagong in eastern Bengal and ran through the Surma and Barak valleys to Upper Assam. In 1942, the colonial government nationalized the Assam Bengal Railway and merged it with the Eastern Bengal Railway.[30]

The world wars and the intervening global economic depression of the 1930s had negative effects on the Indian railways. In World War I, strategic priorities compelled the railways to send locomotives, rolling stock, rails, and sleepers to Iraq. In the depression, revenue of the railways decreased, and the railways were unable to keep up with maintenance. Already deteriorating railways were further affected when World War II forced the railways to surrender more equipment for military use. In the process of turning over trains and 4,000 miles of track, the railways had to close twenty-six branch lines. In addition, railway workshops were converted to armaments production. The result

29. Headrick, *Tentacles of Progress*, 81-82.
30. Ibid., 67; NFR, Brahmaputra Bridge Project Report (1959).

Figure 6. The Sankosh River Bridge on the Assam Rail Link in 2015. The spans are single Warren trusses. (Photo by the author.)

was that the railways had badly deteriorated by 1947.[31]

Two years after the war, the poorly-maintained railways were further affected by Partition, as new international borders cut railways in two. The western railways of India lost most of their workshops to Pakistan. In the Northeast, the two major pre-Partition rail lines into Assam had run through the gentler terrain of eastern Bengal, which was now East Pakistan. Assam's existing transportation infrastructure was therefore cut off from the rest of India. In response, the Railway Board launched a crash program in 1948 to build meter-gauge rail lines to connect Assam's orphaned rail network with the tracks of the rest of the country. In just under two years of work, engineers and laborers under the command of engineer-in-chief Karnail Singh completed the Assam Rail Link, which passed only through Indian territory. Freight trains first ran on the completed link in

31. Planning Commission, *First Five Year Plan*, http://planningcommission.nic.in/plans/planrel/fiveyr/1st/welcome.html (accessed January 13, 2014); Headrick, *Tentacles of Progress*, 78-81.

December 1949; passenger trains began service the following month. Construction of the link included the laying of 142.5 miles of track in four sections and installation of twenty-two bridges with deep-well foundations, the longest of which was 1,425 feet in length.[32]

As constructed just after independence, the Assam Rail Link provided permanent connections only to the right (north) bank of the Brahmaputra. At Amingaon, trains transferred to a ferry, which crossed the river to Pandu, five miles downstream of Gauhati. The ferry was inefficient and slow, with as much as a six-hour delay as carriages had to be uncoupled and individually shunted onto the ferry. The maximum capacity of the ferry was only 250 carriages a day. The ferry could be dangerous, and service often had to be canceled during the seasonal monsoon floods. In addition to the railway ferry, smaller ferries operated by the state Public Works Department crossed the river at various points. One of the ferry services sailed regularly from Gauhati proper to the city's suburb across the river. This service was also risky, as demonstrated by occasional ferry sinkings in inclement weather. In February 1958, a ferry was caught in a sudden hailstorm, and the resulting accident killed eight of the twenty people on board.[33]

On January 15, 1958, the Ministry of Railways formalized the establishment of the Northeast Frontier Railway (NFR), by splitting all of Assam and parts of West Bengal and Bihar off the North East Railway. At a ceremony held at Pandu, the headquarters of the new railway zone, Railway Minister Jagjivan Ram flipped a switch to cause a map lit

32. "Assam Rail Link Project" (n.d. [1950?]), in "Railroads in India, Part 1," *South Asia Ephemera Collection* (New Delhi: Library of Congress Office, 1994); Ratan Lall, "N.F. Railway does it," *Assam Tribune Magazine*, April 16, 1961; D.C. Baijal, "The North-East Frontier Railway," *Overseas Railways*, 1958, 51-52.

33. NFR, Brahmaputra Bridge Project Report (1959); Dutta, *Indian Railways: The Final Frontier*, 278; Northeast Frontier Railway, "50 Glorious Years of Saraighat Bridge" (Guwahati, 2012); "Boat disaster in the Brahmaputra between Gauhati and North Gauhati," *Proceedings of the Assam Legislative Assembly*, May 2, 1958, in *The Assam Gazette* Part VI, January 20, 1960, 3477-80.

in a single color to change to two different colors, one for the North East Railway and one for the new Northeast Frontier Railway. The new railway zone would undertake the major project of constructing the Brahmaputra Bridge.[34]

Preparations for the Brahmaputra Bridge

The first modern plan to construct a permanent bridge over the Brahmaputra was a 1910 proposal by the Eastern Bengal Railway. This plan was never implemented, but the railway picked up the project again in the 1930s. In 1933, the railway made detailed estimates of the project, and in 1937-38, the Central Irrigation and Hydrodynamic Research Station in Poona (later the Central Water and Power Research Station or CWPRS) performed model experiments on a proposed Brahmaputra bridge.[35]

The strategic situation of World War II brought the question of a Brahmaputra bridge to the forefront, and the colonial government began to consider the project seriously. With the Japanese conquest of Burma, northeast India became a theater of war. The Japanese army crossed the Indian border and captured parts of the princely state of Manipur. The rivers of eastern India hindered the movement of materiel to the front. In response, the colonial government built strategic bridges across certain waterways. The iconic Howrah Bridge, which crosses the Hooghly in Calcutta, was completed during this time. Building a bridge over the Brahmaputra proved to be a more formidable undertaking, and the colonial government did not pursue the project further than preliminary planning before war's end. Instead, the Amingaon-Pandu ferry was expanded

34. "New railway zone inaugurated," *AT*, January 16, 1958.
35. NFR, Brahmaputra Bridge Project Report (1959); B.C. Ganguli, note on Brahmaputra Bridge for the Railway Board, September 7, 1957, file no. 57/W5/BRI/17 (Contract)/1-135, Ministry of Railways, NAI.

with the addition of more ferry slips.[36]

After the end of the war, the population and economic growth of Assam ensured that proposals for a Brahmaputra bridge remained relevant. During the latter half of the 1940s and into the 1950s, the siting of the bridge remained an open question. Not all parts of the river were equally bridgeable from geographical, technical, and economic standpoints. Only two sites received serious consideration, Jogighopa and Gauhati, as these are the only two places where the river's channel is constrained by rock outcroppings. In June 1946, the Chief Engineer of the Bengal and Assam Railway dispatched G.C. Chatterji to survey the site at Jogighopa. At the survey location, the river was 9,600 feet wide. Water borings down to a depth of 210 feet found no bedrock, just pebble beds. Chatterji concluded that a bridge at the site would have to be anchored in the river sediment, not on bedrock.[37]

In January and February 1948, another survey team traveled to Jogighopa to study the site. At this time, the river was at its seasonally lowest level, so only 3,600 feet of the river's 9,600-foot-wide channel lay underwater. Even in this season, the water was as deep as seventy feet, and the survey team restricted their studies to the parts of the riverbed that were currently exposed. The team studied the sub-surface geology by a resistivity method, in which they ran electric current between electrodes spaced as far as 1,300 feet apart in the riverbed. This method worked on the assumption that bedrock had a higher resistivity than the surrounding sediment. The tests indicated that the depth of bedrock varied widely across the proposed span of the bridge, ranging from more than

36. Ibid.; S. Ponnuswamy, "Challenges in Bridging River Brahmaputra," *Indian Concrete Journal*, August 1997, 399.

37. "Bridge Site: Jogighopa, Goalpara District, Assam," *Records of the Geological Survey of India* 79 (1954):820.

350 feet near the north bank to only 100 feet near the south bank. Engineers for the railway deemed it unwise to build some piers on bedrock and other piers on sediment, because they wanted the piers to respond to earthquake stresses uniformly. For this reason, they recommended against siting the bridge at Jogighopa.[38]

Economic and geographical considerations also favored Gauhati over Jogighopa. At Gauhati, the river is not as wide as it is at Jogighopa. The narrowest part of the river, 2,600 feet at Kamakhya Hill, was unsuitable because the water was swift and turbulent at that point. Further downstream, the channel widened and the river slowed. Between Pandu and Amingaon, the river was 4,000 feet wide, which was still less than half of the 9,600-foot channel at Jogighopa. A narrower river channel meant fewer piers and fewer spans, and therefore a cheaper bridge. At the Gauhati site, neither bank of the river channel needed stabilizing, while the south bank at Jogighopa would need an embankment. While the railway already crossed the river by means of the ferry at Gauhati, a bridge at Jogighopa would need an additional twenty miles of track from Bongaigaon on the north bank and sixty miles of track to Goalpara on the south bank.[39]

There was one shortcoming with Gauhati, which threatened to negate the benefits of the site. The rail line to Amingaon crossed the basin of the Manas River, which joins the Brahmaputra just upstream from Jogighopa. The Manas is one of several rivers that flows down from the Bhutanese Himalaya between Jogighopa and Amingaon. The geology of the north-bank tributaries of the Brahmaputra, which have steep slopes, sandy beds, and high silt loads, makes them susceptible to flooding or shifting into new

38. L.N. Kailasam, “Some Results of the Application of Resistivity Methods to Problems of Civil Engineering, Mining and Ground Water in India,” *Bulletins of the Geological Survey of India*, Series B: Engineering Geology and Ground-Water, no. 3 (Calcutta: Government of India Press, 1952).

39. NFR, Brahmaputra Bridge Project Report (1959).

channels. By contrast, the south-bank tributaries, flowing out of the Garo and Khasi Hills of the Meghalaya Plateau, have flatter grades, and they meander almost from the foot of the hills through the floodplain to the Brahmaputra. Therefore, they are much less prone to flooding.[40]

In 1942, serious flooding in the Manas basin caused damage to the rail line and made the railway authorities consider circumventing the Manas by bridging the river at Jogighopa. The railway formed a study committee in 1944 to consider the problem. The committee finally delivered its report in 1948, stating that geological concerns clearly favored avoiding the Manas basin. By this point, though, Partition had added an additional political dimension to the question of siting a bridge. Although the 1948 report initially favored the Jogighopa site, it made an about-face in its conclusion. Citing the "closeness of the boundary of Pakistan," and the likelihood that a bridge at Jogighopa would carry less traffic than one near Gauhati, the report recommended that "the proposed bridge at Jogigopa [*sic*] may be deferred and one with far less cost may be built at Amingaon." Later, when the Assam Link Stabilisation Committee determined that the line through the Manas basin could be stabilized, the most serious objection to the Gauhati site was removed. Thus, for geological, geographical, economic, and political reasons, Gauhati emerged as the clearly favored site for a permanent bridge across the Brahmaputra. In subsequent communications later in the 1950s, members of the Railway Board and NFR repeatedly cited these arguments in favor of a bridge near Gauhati rather than Jogighopa.[41]

40. Ibid.

41. Ibid.; "Summary record of the meeting held in the room of the Member, Engineering, Railway Board on 2nd September, 1957," file no. 57/W5/BRI/17 (Contract)/1-135, Ministry of Railways, NAI; B.C. Ganguli, note on Brahmaputra Bridge for the Railway Board, September 7, 1957, ibid.; [Jagjivan Ram] to

The Second Five-Year Plan, issued by the Planning Commission in 1956, made reference to the railways' intention to begin construction of "three important bridges" during the plan period, "one each across the Brahmaputra, the Jumna and the Gandak." Accordingly, on September 2, 1957, Karnail Singh, Member (Engineering) of the Railway Board, called a meeting in his office in the North Block secretariat, New Delhi, to initiate preparations to construct the bridge. Representatives of the North Eastern Railway and the Assam Rail Link project attended the meeting. Singh identified two matters that needed immediate attention: finalizing the location of the bridge and selecting the contractor to construct the piers. It was imperative to begin preparations for constructing the bridge's foundations as soon as possible, because the five-month working season in Assam would come to an end when the *chhota barsaat* (pre-monsoon storms) began in March. "The matter is most urgent," Singh wrote in a memo about the meeting, "and any delay, of a few days or weeks now, would mean a year's delay in execution of works in the field." [42]

By this point, B.C. Ganguli had already been selected as Chief Engineer of the Brahmaputra Bridge project for the North Eastern Railway. He would continue to hold this position for the Northeast Frontier Railway after the reorganization of the railway zones in January 1958. On September 7, 1957, Ganguli wrote a note to the members of the Railway Board requesting that they approve the site of the bridge as Amingaon–

Jawaharlal Nehru, November 1957, ibid.

42. Planning Commission, *Second Five Year Plan*, http://planningcommission.nic.in/plans/planrel/fiveyr/2nd/welcome.html (accessed January 13, 2014); "Summary record of the meeting held in the room of the Member, Engineering, Railway Board on 2nd September, 1957," file no. 57/W5/BRI/17 (Contract)/1-135, Ministry of Railways, NAI; Karnail Singh, "Improvements in rail communications between Assam and the rest of India," memo, September 5, 1957, Ibid.

Pandu, near Gauhati, rather than Jogighopa. The Railway Board accordingly approved the location. In November, Minister of Railways Jagjivan Ram wrote to Jawaharlal Nehru, informing him of the plans to construct the bridge. In reply, the Prime Minister indicated his approval of the plans, and asked that Ram announce the decision in Cabinet, which he did on November 20.[43]

Regarding the matter of which contractor should build the foundations of the bridge, the Railway Board and NFR never seriously considered any firm other than Hindustan Construction Company (HCC). Seth Walchand Hirachand (1882-1953) had founded HCC in 1926. Hirachand was an Indian capitalist and industrialist with diverse interests; he also founded Scindia Steamship Navigation Company, Hindustan Shipyard, and Hindustan Aircraft (discussed in Chapter 1). Hindustan Construction Company's first contract was for a railway tunnel in the Bhor Ghat above Bombay. In the following decades, the company built up a diverse portfolio of projects executed for the railways, state public works departments, municipalities, and private industry. Just after independence, HCC received a contract to build bridges for the Assam Rail Link. The company's subsequent experience on the Ganga Bridge convinced the railways that the company was qualified to build the Brahmaputra Bridge.[44]

Before the railways had opened negotiations with HCC, an offer to build the piers

43. B.C. Ganguli, note on Brahmaputra Bridge for the Railway Board, September 7, 1957, file no. 57/W5/BRI/17 (Contract)/1-135, Ministry of Railways, NAI; H.D. Awasty, memo, September 14, 1957, ibid.; [Jagjivan Ram] to Jawaharlal Nehru, November 1957, ibid.; Jawaharlal Nehru to Jagjivan Ram, November 18, 1957, ibid.

44. "Our Founder – Biography," *Hindustan Construction Company*, http://www.hccindia.com/mission.php?page=about_us&id=3 (accessed October 22, 2015); HCC, "Statement of works executed and in hand for year ending 31-12-48," S. No. 341, HCC subject files, papers of Walchand Hirachand, NMML; HCC, "Directors' Report and Statement of Accounts for the Year Ended 31st August 1954," S. No. 342, Ibid.

of the Brahmaputra Bridge came seemingly out of nowhere from another company. M.R. Venkataram wrote to the Railway Board on behalf of Hind Constructions Ltd., which was headquartered either in Madras or Calcutta (the letter left this point unclear). "I wish to lay before you," Venkataram wrote, "that the Hind Constructions Ltd., can certainly undertake Bridges of that magnitude with confidence. We have about 3 air-locks two of which are in commission at present on the Highway Bridge at Mandvi, Surat." Venkataram went on to explain that the company also had a contract on a bridge near Karagpur (West Bengal), and had also "taken two crores [20 million rupees] of work at the Roorkela Steel Plant." Venkataram guaranteed the Railway Board that his company was fully qualified to work on a project as big as the Brahmaputra Bridge.[45]

After receiving this surprising request, Railway Secretary R.E. de Sa wrote some letters to check the background of Hind Constructions, and in the process found that this firm was something less than it had claimed to be. S.K. Mukerjei, Deputy Secretary in the Ministry of Defence, reported on Hind Constructions' poor performance on the Naval Dockyard Expansion Scheme. The firm had been contracted to dredge, reclaim land, and construct wharves, but its progress was "extremely slow" and it ultimately abandoned the work and forfeited the contract. In another response to de Sa's background-checking, D.N. Chopra reported that Hind Construction was not employed as contractor or subcontractor at Rourkela Steel Plant. A third response, anonymous and undated, gave a further indictment of Hind Constructions' already poor credentials. The firm had submitted a tender to build a combination road and rail bridge over the Godavari River

45. M.R. Venkataram to N.K. Roy, October 2, 1957, file no. 57/W5/BRI/17 (Contract)/1-135, Ministry of Railways, NAI.

near Rajahmundry. "When the tenders were opened," the report states, "the Company withdrew their tend as their tenders were so ridiculously low."[46]

With Hind Constructions definitively removed from consideration, the Railway Board opened negotiations with HCC. On January 2, 1958, S.S. Godbole, Deputy General Manager of HCC, wrote a letter to the Railway Board laying out his firm's offer for the Brahmaputra Bridge. Although HCC already had the necessary machinery for constructing foundations in rivers, Godbole argued that other considerations would make a bridge over the Brahmaputra more expensive than the recently completed Ganga Bridge. In recent years, the prices of cement, steel, and coal had all risen. In Bihar, the Ganga Bridge project had used electricity from the state grid; in Assam, where the electric power grid was less developed, the Brahmaputra Bridge project would have to generate its own electricity. Transportation costs would be higher, because Amingaon, the railhead for the construction project, was not centrally located like Bihar. Labor and staff would have to be recruited from out of state, and company officials would have to spend more time and money traveling farther to recruit. For all of these reasons, Godbole offered his company to build the bridge at a 7.5 percent higher rate than the Ganga Bridge.[47]

Two weeks later, Godbole sent a second letter to the Railway Board. In a shift from his request for higher rates in the first letter, he now offered 2.64 percent below the Ganga Bridge rates. In response, he expected the Railway Board to provide his firm

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46. R.E. de Sa to R.E. Aserappa, October 25, 1957, file no. 57/W5/BRI/17 (Contract)/1-135, Ministry of Railways, NAI; S.K. Mukerjei to R.E. de Sa, November 8, 1957, ibid.; D.N. Chopra to Karnail Singh, November 11, 1957, ibid.; Memo, n.a., n.d., ibid.

47. S.S. Godbole to Rail Secretary, January 2, 1958, file no. 62/W5/BR1/17/1-135, Ministry of Railways, NAI.

certain concessions, including use of a barge from the rail ferry for a floating crane, a half mile each of broad-gauge and meter-gauge tracks, and land near the project site for camps, offices, workshops, a power house, and so forth. The Railway Board found these terms acceptable, and on January 18, the Rail Secretary sent a letter to HCC authorizing the firm to start preparations for the bridge construction immediately.[48]

The selection of the second contractor

The second party in the Ganga Bridge Construction Company had been the Calcutta-based firm Braithwaite, Burn, and Jessop (BBJ). Since BBJ already had experience working with HCC on the Ganga Bridge, the company seemed a natural choice to serve as contractor for the Brahmaputra Bridge trusses as well. In March 1958, two months after HCC received the green light to begin foundation preparation, William Miller, General Manager of BBJ, wrote to the Rail Secretary, asking whether the railways had begun to consider selecting the contractor for the bridge superstructure, and if so, offering his company's services. B.C. Ganguli of NFR favored negotiating directly with BBJ. By the end of May, though, BBJ management had changed their minds. In another letter to the Railway Board, Miller wrote that the management had determined that "there are snags in the way of negotiating a contract," and requesting instead that his company be allowed to submit an open tender against other companies. The ensuing tender process, perhaps unsurprisingly, resulted in BBJ's receiving the contract. What the tender process reveals is how, in the case of this development project, early-independent India's modernizers balanced considerations of capital, foreign exchange, and technology

48. Rail Secretary to HCC, January 18, 1959, file no. 62/W5/BR1/17/1-135, Ministry of Railways, NAI.

transfer.[49]

Formed in 1935, Braithwaite, Burn and Jessop was a consortium of three Calcutta-based engineering companies. The consortium built the Howrah Bridge, a single-deck road bridge spanning the Hooghly River at Calcutta. Although engineers working in India preferred simply-supported truss spans for bridges, BBJ built the Howrah Bridge as a cantilever truss, crossing the river with a single span. Unlike HCC, the constituent companies of BBJ were founded by British, not Indian, capitalists, and the combine remained under British management into the 1950s and 1960s. Since BBJ was based in Calcutta, and it accepted payment in rupees, it qualified as an Indian company. In concert with HCC, BBJ built the Ganga Bridge at Mokameh Ghat, Bihar, and railway authorities cited this experience as evidence that the combine was qualified to build the Brahmaputra Bridge.[50]

NFR wrote up a tender notice and detailed tender documents for the design, fabrication, erection, and maintenance for one year (from date of completion) of ten spans of 397 feet each, plus two shore spans of 104 feet, 9 inches. The dimensions of the proposed trusses matched the piers that HCC had already begun to prepare to build. NFR sent the draft tender documents to the Railway Board for approval. The Railway Board returned the draft with orders to make two changes. First, the railway deck of the trusses, proposed to be built with two meter-gauge rail lines, should be readily convertible to

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49. William Miller to Rail Secretary, March 13, 1958, file no. 57/W5/BRI/17 (Contract)/1-135, Ministry of Railways, NAI; William Miller to M.N. Berry, May 28, 1958, ibid.; B.C. Ganguli to N.K. Roy, April 22, 1958, file no. 58/W-5/BRI/7/1-132, Ministry of Railways, NAI.

50. Proceedings of the tender committee for Brahmaputra Bridge girders, August 20, 1959, file no. 58/W-5/BRI/7/1-132, Ministry of Railways, NAI; "Company Profile / About Us," *Bharat Bhari Udyog Nigam Ltd.*, http://bbunl.com/profile.html (accessed November 9, 2015). The Indian government nationalized BBJ in 1987, and in July 2015 the company was amalgamated into Bharat Bhari Udyog Nigam Ltd. (India Heavy Industry Corporation Ltd.) or BBUNL.

carry a single broad-gauge line. Second, an engineer of the railways should be seconded to the contractor and “placed in charge of the erection of girders [trusses].” The intention of this clause was for the railways to have control over construction and also learn from the contractor’s experience.[51]

On August 9, B.K. Mitra of NFR delivered 120 copies of the tender notice to the Railway Board, half of which were earmarked for delivery to the diplomatic missions of foreign countries in New Delhi. The Soviet Embassy initially expressed interest in the “Braxmanympa Bridge” tender, but later Technoexport wrote from Moscow with regrets that it was already overcommitted, and thus did not intend to tender for the bridge. By March 31, 1959, the date of the opening of the tenders, the NFR had received tenders from nine firms. The tenders had come from Indian companies as well as firms based in West Germany, France, Yugoslavia, and Japan. With three firms submitting multiple options, NFR received a total of eighteen tenders.[52]

The Railway Board and NFR collaborated in inspecting the tenders. NFR constituted the tender committee on June 10, 1959. The three-member committee consisted of two engineers (one of whom was B.C. Ganguli) and an accounts officer, G.F. Penn Anthony. Members of the Railway Board also cross-examined the representatives of the tendering companies. The tender committee determined that the majority of the tenders had inherent flaws that allowed them to be removed from consideration immediately. Two of the tenders were incomplete; one left off the required road deck, and

51. M.N. Bery to B.C. Ganguli, March 7, 1958, file no. 58/W-5/BRI/7/1-132, Ministry of Railways, NAI; M.N. Bery to NFR General Manager, July 26, 1958, ibid.; NFR, “Tender documents for the Brahmaputra Bridge at Amingaon,” ibid.

52. V. Sergeev to Rail Secretary, September 30, 1958, file no. 58/W-5/BRI/7/1-132, Ministry of Railways, NAI.; N. Trufanov to Rail Secretary, January 10, 1959, ibid.; G.P. Warrier, memo, September 22, 1959, ibid.

the other tendered for erection only, not design. Eight others omitted full design details and calculations. And two welded designs were eliminated because Indian railway codes required rivets to be used in structures subject to impact (such as a boat or debris striking the bridge during a flood). The six remaining tenders represented just three companies: three tenders from Ingra Zagreb (Yugoslavia), two from Gollnow-Werke (Germany), and one from BBJ.[53]

The tender committee studied the six remaining tenders in detail, working through the calculations and determining where the structures would need to be strengthened. Because of design modifications and other considerations such as customs duty and supply of facilities by the railway, the committee adjusted the tender estimates. Before adjustment, the lowest bid was 21.2 million rupees (Rs.) for rhomboidal trusses from Ingra Zagreb. Gollnow-Werke's lowest estimate was Rs. 21.8 million, and BBJ's single estimate was Rs. 22.7 million. Since both Ingra Zagreb's and Gollnow-Werke's designs needed strengthening, the tender committee increased the estimates. At the same time, the committee found BBJ's tender suitably strong, and even subtracted Rs. 179,000 from the estimate. With these adjustments, BBJ's tender became the lowest by a narrow margin of Rs. 12,000.[54]

Total cost of the tender was not the only financial consideration; the foreign exchange component was also a central factor in the tender committee's deliberations. In this regard, BBJ enjoyed an advantage from the beginning, because the Indian firm's tender called for Rs. 7.4 million to be spent abroad, mainly for importing British steel. By

53. G.P. Warrier, memo, September 22, 1959, file no. 58/W-5/BRI/7/1-132, Ministry of Railways, NAI; Proceedings of the tender committee for Brahmaputra Bridge girders, August 20, 1959, ibid.

54. Ibid.

comparison, Gollnow-Werke's two tenders each called for Rs. 8 million of foreign exchange, and all of Ingra Zagreb's alternatives required Rs. 9.3 million.[55]

The tender committee also expressed a preference for BBJ because the firm was Indian and had already worked with the country's railways. The report of the committee's August 20 meeting stated that of the companies that tendered bids, only Ingra Zagreb, Gollnow-Werke, and BBJ were really qualified to build the bridge. Ingra Zagreb had recently carried out some contracts for the Indian Railways, and had also built major bridges in Yugoslavia. On the basis of this prior experience, the committee concluded that Ingra Zagreb's ability to build the Brahmaputra Bridge's superstructure "is, therefore, not denied." The committee cast some aspersions on Gollnow-Werke's qualifications, though. "M/s. Gollnow Werke are understood to have carried out works of fabrication and erection of big girders [trusses]," the committee stated, "and they should be able to successfully carry out this contract." In the copy of the report in the Railway Ministry's file, the word "should" is struck out, and "may" written above it.[56]

Braithwaite, Burn, and Jessop, by comparison, had impeccable qualifications. The committee cited the company's experience with the Howrah Bridge, Chakki Bridge, and Malviya Bridge, as well as the recent Rajendra Bridge (Ganga Bridge). Because of these qualifications, "they are fully capable of undertaking this work." Since BBJ had the lowest estimate (after adjustments) and the lowest foreign exchange cost, the tender committee recommended BBJ to serve as the contractor for the superstructure. Furthermore, since this was a high-profile project, it would "definitely add to the prestige

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55. Proceedings of the tender committee for Brahmaputra Bridge girders, August 20, 1959, file no. 58/W-5/BRI/7/1-132, Ministry of Railways, NAI.

56. Ibid.

and experience of the firm undertaking the work," and it was preferable that an Indian firm gain this prestige. Additionally, the committee mentioned the potential that foreign aid on a project could be cut off if international politics changed. It was thus safer to entrust the work to an Indian company. Therefore, the decision to select BBJ was influenced by considerations of national pride and autarky as well as considerations of overall costs and foreign exchange.[57]

The Railway Board deferred a final decision until the tenderers could provide further information about their proposals. On October 20, representatives of the three eligible companies met with Karnail Singh and other members of the Railway Board and NFR to discuss the tenders. The committee told Gollnow-Werke's representative, Serge de Pahlen, that the firm did not supply stress sheets and influence line diagrams, and without those, the design was difficult to evaluate. Ingra Zagreb's proposal also had shortcomings, as it omitted a complete erection plan, with calculations of stresses that would develop in the girder members at each step. BBJ's representatives learned that their design was satisfactory. They suggested that they could offer a discount of 1.5 percent, because of their prior experience on the Ganga Bridge contract. The committee requested that BBJ propose a discount based on actual savings, rather than an arbitrary percentage.[58]

Ingra Zagreb and Gollnow-Werke offered further clarifications to their designs, and they proposed incentives to make their offers more appealing. BBJ also proposed an alternative to its earlier tender. Rather than importing British steel, as the company had

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57. Ibid.

58. Memo regarding Brahmaputra Bridge project meeting held on October 20, 1959 in North Block, file no. 58/W-5/BRI/7/1-132, Ministry of Railways, NAI.

done on the Ganga Bridge project, BBJ offered to use Indian-made steel as far as possible. Indian steel was at this time more expensive than imported steel, because India still had a limited steel production capacity. The use of Indian steel would raise the price of the tender by Rs. 550,000, but it would also cause the foreign exchange component to drop from Rs. 7.4 million down to only Rs. 600,000. The remaining foreign exchange would mostly pay for specialized steel components that could not be produced economically in India. The Railway Board found BBJ's offer to use domestic steel persuasive, and therefore it decided to accept the firm's offer, even though the added price of Indian steel would raise the cost of the bridge above some of the tenders for foreign firms. In this case, saving foreign exchange and promoting Indian industry proved to be more important considerations than spending the least money on the bridge overall.[59]

Not everyone was convinced. Serge de Pahlen, the representative of Gollnow-Werke, continued to argue in favor of his company long after the railways had decided in favor of BBJ. Count de Pahlen, as he styled himself himself in his letters, arrived in India in August 1959 and settled into the Ashoka Hotel in New Delhi, whence he addressed voluminous correspondence with government officials on hotel stationery. In response to the requests of the committee that met in Karnail Singh's office on October 20, de Pahlen forwarded further technical details for his design. He also offered to substitute the foreign exchange requirements for the bridge with a barter deal, in which the export of Indian iron ore to Germany would take the place of hard currency. Even after the Railway Board

59. G.P. Warrier, memo, September 22, 1959, file no. 58/W-5/BRI/7/1-132, Ministry of Railways, NAI; B.C. Ganguli, Note on tenders received for Brahmaputra Bridge project, attachment to letter to D.R. Kohli, July 3, 1959, ibid.; Citation: G.P. Warrier to NFR General Manager, November 19, 1959, ibid.

accepted BBJ's offer on November 19, de Pahlen wrote to the board, offering to collaborate with Indian industry. When de Pahlen heard that BBJ's accepted offer had apparently been higher than Gollnow-Werke's, he wrote accusing letters to the Railway Board, and even brought his case to the Finance Minister, Morarji Desai.[60]

By this point, the Railway Board had started filing de Pahlen's letters unanswered. When the Finance Ministry looked into the case, the Railway Board had to explain its decisions. J. Dayal, financial adviser of the Railway Board, prepared a memo explaining that BBJ's offer had been lower than Gollnow-Werke's. "From the papers which I have examined and which are placed below," Dayal wrote, "it seems to me that the award of the contract to Messrs. B.B.J was done in a regular manner, and in the best interests, financial and otherwise, of the Government." The "otherwise" interests, left implicit in the letter, were promoting Indian industry and letting an Indian company gain the prestige of completing a large project like the Brahmaputra Bridge.[61]

The railways had originally planned to offer the contract for the superstructure to BBJ, and then after a lengthy tender process, BBJ ended up receiving the contract. Why, then, did the railways go to the trouble of calling an open tender in the first place? B.C. Ganguli explained the rationale in a letter to D.R. Kohli of the Railway Board: "Global Tenders were called for this work with a view to collect up-to-date knowledge of the technological advancement in this type of work if any, and a financial advantage therefrom, if possible, commensurate with the expenditure of foreign currency." In calling for tenders, the railways were investigating the possibility of technology transfer.

60. Anang Pal to Home Secretary, February 6, 1960, file no. 58/W-5/BRI/7/1-132, Ministry of Railways, NAI.; S. de Pahlen to J. Dayal, October 22, 1959, ibid.; S. de Pahlen to J. Dayal, November 29, 1959, ibid.; S. de Pahlen to G.T. Venugopal, December 30, 1959, ibid.

61. J. Dayal, memo, December 18, 1959, file no. 58/W-5/BRI/7/1-132, Ministry of Railways, NAI.

Modern bridge building techniques were well established in India by this point, but the railways wanted to know if the technology had changed outside India, and if so, whether their own country would benefit from importing this technology. One way to study the state of foreign technology would have been for the railway to send a team of engineers on a study tour of current bridge projects in industrialized nations. There was precedence for this; for example, Jagman Singh, a junior engineer on the Bhakra Dam, visited the United States in 1952 to tour current American projects such as Folsom Dam near Sacramento and Detroit Dam in Oregon. Another strategy, adopted by NFR for the Brahmaputra Bridge project, was to have the foreign countries come to them, and with their detailed tenders display the current state of their technology. From analysis of the tenders from foreign firms, NFR determined that Indian bridge-building techniques were suitably up-to-date, and there would be no benefit in employing a foreign firm.[62]

This did not mean that BBJ's design for the bridge spans was entirely indigenous. BBJ contracted Freeman Fox and Partners of London to design and analyze the bridge structure. Freeman Fox had also subcontracted the similar truss design for the Ganga Bridge. As per the conditions laid out in the tender documents, NFR engineer N.J. Vacha was seconded to BBJ in February 1960. In this capacity, he oversaw the design and analysis of the bridge spans in London. By doing so, Vacha gained experience that he brought back to the Indian railways after completing his duties with BBJ. In this respect, technology transfer did take place in the Brahmaputra Bridge project, even though an Indian firm served as the prime contractor for the spans.[63]

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62. Jagman Singh, *My Tryst with the Projects Bhakra and Beas* (New Delhi: Uppal Publishing House, 1998),139-41; B.C. Ganguli, Note on tenders received for Brahmaputra Bridge project, attachment to letter to D.R. Kohli, July 3, 1959, file no. 58/W-5/BRI/7/1-132, Ministry of Railways, NAI.

63. "Minutes of the meeting held in the office of the Engineer-in-Chief, Brahmaputra Bridge

Building the Brahmaputra Bridge

Hindustan Construction Company began building the Brahmaputra Bridge's piers in the dry season of 1958-59, when the maximum depth of the river was forty-five feet. Plans called for eleven main piers founded in the riverbed and one shore pier each at Amingaon and Pandu. The foundation wells reached deep into the riverbed, and they rose one foot above the highest flood level. On top of the foundation wells stood twin concrete cylinders of sixteen-foot diameter that raised the level of the bridge up to forty feet above the high flood level. The Ganga Bridge had been built with a clearance of thirty-five feet, but the Assam government requested greater clearance to allow for passage of taller boats without the need for a movable span.[64]

To place the piers accurately, HCC carefully surveyed the bridge alignment and riverbank. The surveyors established two baselines along the riverbank, one on each side of the river. Because of the site geography, the baseline on the Amingaon side had several setbacks to stay on dry land. The baseline on the Pandu side was straight, but it was not perpendicular to the bridge alignment. To locate each pier, the surveyors used triangulation, taking readings from reference points along the baselines on both sides of the river. The intersection of the reference points represented the location of the pier. In

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Project, Pandu on 22nd December, 1959," file no. 58/W-5/BRI/7/1-132, Ministry of Railways, NAI; "Minutes of the meeting held in the Office of The Braithwaite Burn & Jessop Construction Co. Ltd. … on Friday, the 29th January, 1960, at 11.00 A.M.," Ibid.; Contract, "Manufacture, supply, erection and maintenance for one year of ten spans of 397′ feet and two spans of 104′ -9″ girders for the Brahmaputra Bridge at Amingaon," January 25, 1965, file no. 65/W5/BR1/2/1-9, Ministry of Railways, NAI; S. Ponnuswamy, "Challenges in Bridging River Brahmaputra," *Indian Concrete Journal*, August 1997, 400; S. Ponnuswamy and V.C. Sharma (eds.), *Bridging River Brahmaputra: Past Present and Future* (Guwahati: Northeast Frontier Railway, 1988), 21.

64. "Discussion note on technical data for the Brahmaputra Bridge at Amingaon," November 1957, file no. 57/W5/BRI/17 (Contract)/1-135, Ministry of Railways, NAI; "Brief technical note on the foundations of the Brahmaputra Bridge in comparison with those of the Ganga Bridge at Mokameh," n.d. [February 1958], ibid.; "Brahmaputra conquered after fifty years' planning," *Assam Tribune Magazine*, June 17, 1962.

reality, the reference points never intersected exactly; instead, they formed a small triangle. By HCC's standards, a triangle smaller than one inch was satisfactory.[65]

Up to this point, the surveying was theoretical, since location markers could not be placed temporarily in the river's current. The piers were the first structures placed permanently in the river. These piers were put in place by means of steel caissons, which HCC contracted Braithwaite, Burn and Jessop to supply. BBJ constructed the foundation wells on the riverbank during low water; when the water level rose slightly, the caissons began to float. Eight winches on the banks moved a pier into position, and the position was carefully checked by surveying. Surveyors checked multiple points on the piers, because the pier had to be properly positioned so that its major axis was perpendicular to the alignment of the bridge. When the pier had been properly positioned, it was sunk into the riverbed, and excavation of the foundation could begin.[66]

Construction of the piers started at Amingaon on the north bank of the Brahmaputra and proceeded sequentially, one by one, southward across the river. The north bank of the river had the rail link to the Indian mainland, the source of the cement and steel used in the bridge. The rock quarry was also located near the project site in Amingaon. During the 1958-59 working season, HCC completed the foundation wells of Piers 1 and 2 and the Amingaon side shore pier. It was critical that the wells be firmly founded in the riverbed before the pre-monsoon floods began, as a partially completed

65. S. Ponnuswamy and V.C. Sharma (eds.), *Bridging River Brahmaputra: Past Present and Future* (Guwahati: Northeast Frontier Railway, 1988), 41-44. This is the only book-length treatment of bridge construction over the Brahmaputra. The authors, both engineers, focus on the technical aspects of the construction of the bridges at Guwahati, Tezpur, and Jogighopa (then under construction). The chapters about Saraighat Bridge are based on the papers of B.C. Ganguli, in many cases including direct quotations from Ganguli's own writings.

66. Ibid., 49-53.

well could be knocked out of alignment, thus ruining the entire bridge. (This was not the case with Piers 1 and 11 which, like the shore piers, had their foundations on the riverbank.) In the next season, 1959-60, HCC sank the wells of Piers 3 through 7, as well as the shore pier on the Pandu side. In the last season, 1960-61, HCC completed the wells of the four remaining main piers, Piers 8 through 11.[67]

While sinking Piers 1 and 2 in the first season, HCC discovered to its dismay that the Brahmaputra riverbed had a much higher clay content than originally expected. The original 1958 railway-contractor agreement had been based on the experience of the Ganga Bridge at Mokameh Ghat, Bihar. In his January 2 letter to the Railway Board, S.S. Godbole of HCC stated that the company understood that "wells will be sunk through strata consisting mostly of sand and very little of clay." The Ganga riverbed in Bihar had consisted of 2 percent clay. By contrast, the Brahmaputra riverbed was fully 29 percent clay. The higher clay content slowed HCC's progress. It also forced the company to incur higher expenses, as it had to use heavy kentledge blocks[68] to weigh down the wells, and even resort to blasting in the case of some piers. HCC claimed that NFR owed them Rs. 180,000 on account of this additional work. NFR refused at first, but at length it agreed to pay Rs. 170,000 after arbitration by the Railway Board.[69]

The wells and piers of the Brahmaputra Bridge were similar to those of the Ganga

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67. Memo, "Brahmaputra Bridge Contract," NFR to Rail Secretary, March 9, 1965, file no. 62/W5/BR1/17/1-135, Ministry of Railways, NAI; Karnail Singh, "Improvements in rail communications between Assam and the rest of India," memo, September 5, 1957, file no. 57/W5/BRI/17 (Contract)/1-135, Ministry of Railways, NAI.

68. Kentledge blocks are large rectangular blocks of a heavy material (usually concrete), used on construction projects for ballast or footings for temporary structures.

69. S.S. Godbole to Rail Secretary, January 2, 1958, file no. 62/W5/BR1/17/1-135, Ministry of Railways, NAI; N.J. Vacha to NFR Works, December 1, 1960, ibid.; "Note on the discussion held on 16.7.1965 with M/s Hindustan Construction Co. regarding their outstanding claims in respect of Brahmaputra Bridge Works," memo, n.d. [1965], ibid.

Bridge. One significant difference was that NFR considered the Brahmaputra Valley to be more seismically active than Mokameh Ghat, Bihar, and therefore the piers of the Brahmaputra Bridge had to be stronger. The Ganga Bridge was designed to withstand lateral acceleration of g/20, or 5 percent of acceleration due to the force of gravity near the Earth's surface. By comparison, NFR's requirements for both the piers and the trusses called for them to withstand a seismic factor of g/10, twice the design standard of the Ganga Bridge. HCC brought the design of the piers up to code by making the foundation walls thicker and using a richer mix of concrete. The mix of concrete had to be adjusted daily, depending on the moisture content of the aggregate, as tested in an on-site laboratory.[70]

Even before all of the piers were completed, erection of the trusses had begun. Like the piers, the trusses were also similar in design to those of the Ganga Bridge, although they too had to be strengthened to withstand higher seismic loads. Additionally, they were redesigned to carry two rail lines on the lower deck. The trusses were double Warren type. A Warren truss is one of the simplest of truss designs, as it is made of equilateral triangles placed side-by-side. Warren trusses are easy to construct because all of the girder members are the same length, and thus can be ordered to identical specifications in bulk. A double Warren truss, as used in the Ganga and Brahmaputra bridges, consists of one Warren truss stacked on top of another. The upper truss carried the roadway, while the lower truss carried the dual meter-gauge rail lines.[71]

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70. NFR, Brahmaputra Bridge Project Report (1959); "Brief technical note on the foundations of the Brahmaputra Bridge in comparison with those of the Ganga Bridge at Mokameh," n.d. [February 1958], file no. 57/W5/BRI/17 (Contract)/1-135, Ministry of Railways, NAI; Ponnuswamy and Sharma, *Bridging River Brahmaputra*, 51.

71. S. Ponnuswamy, "Challenges in Bridging River Brahmaputra," *Indian Concrete Journal* 71 (Aug. 1997), 400-01.

As with the piers, erection of the trusses began on the north bank and proceeded southward. With the help of derrick cranes that traveled along the uppermost girders of the bridge, work crews built the trusses in place, piece-by-piece, cantilevering each new truss out over the water. As the incomplete trusses extended from one pier to the next, stresses developed in the girders that would not occur once the trusses were complete. Parts of the trusses had to be temporarily strengthened with extra material, which was removed when the trusses were complete.[72]

As construction progressed, ceremonies marked key stages of the project. On November 28, 1960, Karnail Singh of the Railway Board presided over the grounding of the caisson for the bridge's eighth pier. The chairman of the Thai Railway Board, who was touring the project with other engineers from southeast Asia, also participated in the inauguration. Each man broke open a coconut as part of the inauguration. A coconut also featured prominently in the inauguration of the bridge's final truss on July 14, 1960. After B.C. Ganguli broke a coconut, a crane lifted the last girder section into place. In the words of the *Assam Tribune* report of the event, on Ganguli's signal "the aluminum erection crane hoisted it gracefully to the jubilation of all those present." These milestone ceremonies drew on the Hindu tradition of breaking coconuts at the beginning and end of construction projects, thereby linking this modern project, built along foreign lines, with India's cultural and religious heritage.[73]

After the completion of the trusses, considerable work remained to be done on the bridge. When B.C. Ganguli opened the bridge to traffic in October 1962, only one of the

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72. Ponnuswamy and Sharma, *Bridging River Brahmaputra*, 53.

73. "ECAFE Engineers at Pandu: Visit to Brahmaputra Bridge Sites," *AT*, November 29, 1960; "Brahmaputra bridge: erection of girders completed," *AT*, July 15, 1962.

twin meter-gauge rail lines on the lower deck was completed; the roadway on the upper deck was likewise incomplete. Passenger trains started crossing the bridge in December, and motor vehicles began to use the bridge in March of the following year.[74]

The Brahmaputra Bridge in use

The Brahmaputra Bridge was nearly finished when the Sino-Indian War broke out, and the first train rolled across it just days after the outbreak of the conflict. The actual contribution made by the bridge to the defense of Assam remains to be evaluated, although official publications claimed afterward that the bridge had been a key strategic asset. According to a 1963 article in *Assam Information*, "The bridge has already played a notable part in helping the Railways to step up supplies to Assam in the first few months of the Emergency following the Chinese invasion." Come the 1965 conflict with Pakistan, the bridge again assumed strategic importance. All India Radio claimed in a September broadcast that Pakistani planes had made three attempts to destroy the Brahmaputra Bridge, but each time antiaircraft guns kept the planes at bay.[75]

Saraighat Bridge was designed from the start to be a multipurpose project, as it supported both road and rail traffic. The rail traffic fell under one administrative system, in what historian Wolfgang Schivelbusch refers to as the conjoining of route and means into the "machine ensemble." By contrast, the road traffic was distinctly multimodal. Ivan Illich wrote in *Tools for Conviviality* that automobiles in western countries, particularly the United States, are examples of a "radical monopoly," in which one technology comes

74. "Saraighat Bridge: A Boon to Assam Stands to Serve the Nation," *Assam Information* 1963, 19-20.

75. "Saraighat Bridge: A Boon to Assam Stands to Serve the Nation," *Assam Information* 1963, 19-20; "Attack on the Brahmaputra," *New York Times*, September 11, 1965.

to dominate over all others, even going so far as to transform the landscape to exclude technological alternatives. While Illich's deterministic implications about automobile technology are questionable, his argument stands that infrastructure as well as American culture have marginalized non-automobile forms of transport such as cycling and walking. This is not the case in India. Automobiles have not established a radical monopoly—not now in early twenty-first century India, and especially not during the early independence period. Thus when the road deck of the Brahmaputra Bridge opened in March 1963, the traffic that began to roll across it was not just motor vehicles, but also bicycles, ox-carts, and horse-tongas.[76]

Combination road-rail bridges are uncommon in the West but not in India. There are several reasons why bridges are often built in India with both road and rail decks. One reason is resources: it is cheaper to build a single bridge than two smaller bridges side-by-side, one for a roadway and the other for rail lines. Other explanations for the popularity of road and rail bridges involve timing and jurisdiction. In the United States, development of road networks lagged behind the railroads, and therefore rail bridges tended to be built at strategic locations before road bridges. In India during the early independence period, road and rail networks were developed concurrently. Furthermore, both the road and rail networks in India were nationalized, whereas only roads are public in the United States; railroads are private. The rare examples of road-rail bridges in the

76. Wolfgang Schivelbusch, *The Railway Journey: The Industrialization of Time and Space in the 19th Century* (Berkeley: University of California Press, 1977), 16-18; Ivan Illich, *Tools for Conviviality* (London: Marion Boyars, 1985), 52. Bicycles now cross the bridge on the footpath; signs instruct cyclists to dismount and push their cycles across with the pedestrians. In May 2015, only the footpath on the downstream side of the bridge was open. In a strange oversight, there are no arrangements for pedestrians on the approaches to the bridge. Social trails lead through the weeds on the road embankment to the footpath.

United States tend to carry public roads and public rails belonging to municipal public transit systems. An example of this is the Manhattan Bridge, which carries seven road lanes and five lines of the New York City Subway across the East River.

Besides carrying multimodal traffic, the Brahmaputra Bridge had an additional function: carrying an oil pipeline that ran from the oil fields in upper Assam, through Gauhati, and into mainland India. The installation of the pipeline was the outcome of a lengthy dispute between the Railway Board and the Department of Fuel. To save on costs, the Department of Fuel had requested to run its pipeline across the Brahmaputra Bridge, but the Railway Board refused, citing safety and security concerns. Oil India, a joint public-private undertaking, explored other options for the pipeline, including building a separate suspension bridge downstream from the road-rail bridge. Oil India made it as far as awarding a contract for foundations to HCC, but this bridge was never completed. Eventually, in June 1963, the Khosla Committee, a mediation board from the central government, agreed in favor of the Department of Fuel. The pipeline would run across the bridge, provided that it was reinforced to protect against earthquakes and guarded by armed personnel at all times.[77]

Earlier in June 1963, Nehru returned to Assam to dedicate the Brahmaputra Bridge. Before the June 7 dedication ceremony, the bridge had been known in all official literature as simply "Brahmaputra Bridge," because it was the only one of its kind. At the dedication ceremony, Nehru gave the bridge a new name: Saraighat Bridge, after the

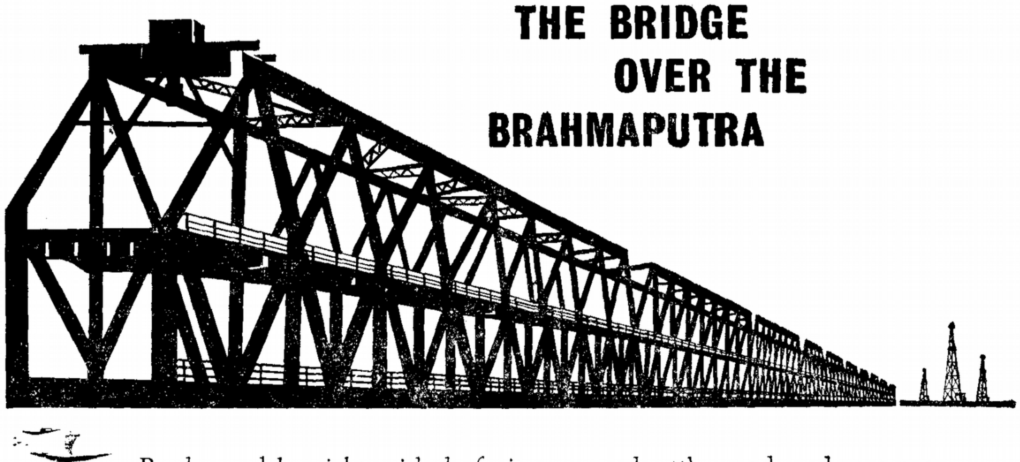
77. J.N. Roy to B.D. Gaur, November 4, 1960, file no. 57/W5/BRI/17 (Contract)/1-135, Ministry of Railways, NAI.; M.M. Kohli to D.R. Kohli, November 2, 1960, ibid.; "Crossing the Brahmaputra River: World's Longest Pipeline Suspension Bridge," *Petroleum Times* 64 (Dec. 16, 1960): 855-57; "Rail Bridges to Carry Pipelines," *Hindustan Times*, June 29, 1963. Also crossing the bridge are various cables and battered old telegraph lines.

decisive victory of the Ahom army over the Mughals in 1671. Promotional materials issued afterward claimed that the bridge was built on the site of the battle. This was not strictly true, as the precise location of the battle remains unknown. There was, however, a general consensus among scholars of the Ahom period that the battle took place somewhere in the vicinity of Gauhati, so in this respect the name was not inappropriate. It is significant that the name was not chosen by an Assamese, but by an outsider. (Nehru was raised in Allahabad in northern India, but he identified closely with his Kashmiri ancestry.) The Battle of Saraighat was an event that ensured, for a time, Assam's independence from the pan-Indian Mughal Empire. In the modern period, independence for Assam was out of the question, but Nehru's selection of the battle as the name of the bridge reflected his belief in plurality and regional distinctiveness within the Indian nation.[78]

The significance of the bridge to Assamese regional identity is outside the scope of this study.[79] The national significance, though, is relevant. Despite the name, Saraighat Bridge was ultimately more Indian than it was Assamese. The project was financed by the central government, directed by a Bengali engineer, overseen by the Railway Board represented by a Punjabi engineer, and constructed by firms based in Calcutta and

78. "Brahmaputra bridge inaugurated," *India News*, June 14, 1963; "Brahmaputra bridge named Saraighat," *AT*, June 8, 1963.

79. Bridges over the Brahmaputra, or the lack thereof, are a component of the Assamese perception of their own (under)development. Shekhar Gupta noted that "the entire length of the mighty [Brahmaputra] river has just one bridge, near Gauhati, for which too, the state had to agitate and ultimately thank the Chinese for, before our government woke up. The Ganga on the other hand, now has 15 bridges." Shekhar Gupta, *Assam: A Valley Divided* (New Delhi: Vikas, 1984), 64. Gupta was a mainland Indian journalist who wrote sympathetically about Assam after being posted there by his employer, *Indian Express*. Assamese novelist Rita Chowdhury's *Makam* (2010, English translation 2015) contains a scene of Chinese-Assamese being forced to ride the first train across the unproven Brahmaputra Bridge during the Sino-Indian conflict. The Chinese-Assamese were subsequently expelled from Assam. More positively, Assamese singer, songwriter, and poet laureate Bhupen Hazarika is supposed to have written a verse commemorating the construction of Saraighat Bridge. Dutta, *Indian Railways: The Final Frontier*, 276.



By day and by night, with deafening roar and rattle, goods and passenger trains hurtle across the new Brahmaputra Bridge, connecting Amingaon and Pandu. When on 7th June 1963, Prime Minister Nehru formally opened the Saraighat Bridge, wholly Indian in design and execution, it marked the culmination of a plan first thought of in 1910.

Work commenced in November 1958, and it took Rs. 10.6 crores and nearly four years of round-the-clock effort to throw the bridge across the mighty and turbulent Brahmaputra.

When the first goods train travelled over the bridge on 31st October 1962, it heralded a new era in the fast-developing economy of north-eastern India. For the first time, an all-rail-cum-road link was established between the tea gardens and the oilfields of Assam and the rest of the country.

No less than 4.2 million cubic feet of concrete, 40,000 tons of cement and 14,000 tons of steel were used to build the 10-span, two-tier bridge with a roadway on top and rail tracks below. Of about 11,000 tons of vital mild and high tensile steel required to build the girders of the bridge, about 60 per cent came from the steel works at Jamshedpur. This is yet another example of Tata Steel in the service of the nation.

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JWTTN 18A

Figure 7. Tata Steel advertisement featuring Brahmaputra Bridge, as it appeared in Eastern Economist.

Bombay using steel from Bihar and the labor of non-Assamese Indian workers.[80] When Prime Minister Nehru inaugurated the project in January 1960, the long speech that he gave was in Hindi, as he could not speak Assamese. The foundation stone he laid also had a monolingual inscription in Hindi.[81]

An advertisement for Tata Steel, which appeared widely in Indian periodicals after the opening of the Brahmaputra Bridge, illustrates the national significance of the project (Figure 7). Under an all-caps title identifying "The Bridge over the Brahmaputra," a silhouette of the bridge's trusses (sans piers) floats across the page. At the far end of the bridge, derrick towers represent the oil fields of upper Assam. Beneath the illustration are two hundred words of text, beginning with a characterization of the bridge as a center of human activity: "By day and by night," the ad copy reads, "with deafening roar and rattle, goods and passenger trains hurtle across the new Brahmaputra Bridge, connecting Amingaon and Pandu." The copy goes on to describe the bridge's dedication by Nehru, its importance for the economic development of Assam, and some statistics about the large quantities of materials used in the project's construction. Sixty percent of the steel used in the construction came from the Tata mill at Jamshedpur; "This is yet another

80. In the Assam Legislative Assembly on April 7, 1959, Gaurisanka Bhattacharyya, representing the Gauhati constituency, criticized the central government for allowing the contractors to employ exclusively non-Assamese labor on the bridge project. He claimed that the contractors preferred non-local laborers because they had "no root on the soil," and therefore were easier to exploit for lower wages. "Consideration of the report of the Commissioner for Scheduled Castes and Scheduled Tribes," *Assam Legislative Assembly Debates* 1 (1959): 3433-34. The District Census Handbook of Kamrup for the 1961 census lamented that while the Ahoms had an effective, albeit cruel, labor system, modern Assam "has been compelled to import from other parts of India almost all the labour required for the development of the Province and its industries." E.H. Pakyntein, *Kamrup District Census Handbook, Census of India 1961* (Government of Assam, 1964), Assam State Archives.

81. Jawaharlal Nehru, speech at public meeting in Gauhati, January 10, 1960, in Madhavan K. Palat, ed., *Selected Works of Jawaharlal Nehru: Second Series* (New Delhi: Jawaharlal Nehru Memorial Fund, 2014), 56:239-63; "Jawaharlal Nehru," *Indian Railways*, June 1964, 359. Although Nehru was an eloquent writer and speaker in English, his first language, he was less confident in his Hindi. The speech that he gave at the inauguration of the bridge was peppered with awkward grammatical constructions.


Figure 8. Saraighat Bridge in 2015. (Photo by the author.)

example of Tata Steel in the service of the nation."[82]

Conclusion

For more than fifty years, traffic has continued to roll across the Saraighat Bridge. For twenty-two years, meter-gauge trains ran on twin lines on the bottom deck of the bridge; since 1984, when the Northeast Frontier Railway converted the gauge of the route to Gauhati, broad-gauge trains have run on a single line on the bridge. In 2012, the Northeast Frontier Railway celebrated the bridge's fiftieth birthday by hosting a function attended by the chief minister and governor of Assam. The railway also installed decorative lighting on the superstructure and staged a fireworks display.[83]

Since Saraighat Bridge's construction, two other bridges have been completed at other strategic locations across the Brahmaputra. Finished in 1987, the Kalia Bhomara bridge at Tezpur, upstream from Gauhati, departed considerably from the precedent established by Saraighat Bridge, as the newer bridge has a road deck only, with

82. "The Bridge over the Brahmaputra," *India Quarterly*, 1963, 310.

83. Dutta, *Indian Railways: The Final Frontier*, 280; "Call to rename Saraighat Bridge after Lachit Barphukan," *AT*, November 6, 2012. In addition to the gauge conversion of the lower deck, NFR has had to maintain the bridge, a task that includes regular repainting of all steel girders with silver-colored paint. In 2000, the railway installed new expansion joints at the ends of all of the trusses.

reinforced concrete spans cast in place. In 1979, the Assam state government reopened the case of a bridge at Jogighopa, which had originally been abandoned in favor of the site near Gauhati. The Jogighopa bridge, dubbed Narayanan Setu, was completed in 1998; it looks like a scaled-up and stretched copy of Saraighat Bridge, as it too has successive spans of double Warren trusses.[84]

Saraighat Bridge, once completed, created a permanent link across the Brahmaputra River for both road and rail traffic. This link facilitated economic expansion of Assam and allowed for greater traffic in and out of the region. The Amingaon-Pandu train ferry shut down after the completion of the bridge, and some of the infrastructure from the ferry landings, such as the locomotive sheds on both sides of the river, were shifted to the new rail yard at Narangi.[85]

The bridge facilitated automobile and bus traffic across the river. As Gauhati and the surrounding areas grew, traffic increased across the bridge. Traffic begat more traffic, as it has the tendency to do, and today the bridge hosts frequent traffic jams during rush hours. While the bridge eliminated the need for rail ferries, it did not put all ferries in the Guwahati area out of business. Saraighat Bridge is awkwardly sited to serve the city of Guwahati, as it is five miles downstream. The quickest route from Guwahati to North Guwahati across the river, home of a campus of the Indian Institute of Technology, is still by ferry. Small wooden ferries, operated by the state government's Inland Water Transport Department, still make regular crossings of the river. These ferries have an upper deck made of corrugated steel, which is big enough to carry scooters or

84. S. Ponnuswamy, "Challenges in Bridging River Brahmaputra," *Indian Concrete Journal*, August 1997, 401-05.

85. N. Krishnaswamy to Y.P. Kulkarni, January 28, 1960, file no. 59/W5/BR1/19/1-22, Ministry of Railways, NAI.

motorbikes, but not automobiles. The ferry ports on either side of the river are themselves decommissioned ferries, made of metal and much larger than the craft currently operating. They are relics of a time when all traffic crossed the river by boat.

At the time of writing, two other bridges are under construction across the Brahmaputra River in Assam. One is a second Saraighat Bridge, located just downstream of the original structure. The new bridge is being built under the auspices of the National Highways Authority of India, with Gammon India serving as prime contractor. Like the Kalia Bhomara Bridge, the new Amingaon-Pandu bridge has a single road deck atop reinforced-concrete arch spans. The government plans to run two lanes of northbound traffic on the new bridge; the road deck of the old bridge will carry two lanes of southbound traffic. This arrangement is intended to alleviate the traffic snarls that frequently occur on the original bridge.[86]

The second new Brahmaputra bridge is under construction at a site near Dibrugarh in upper Assam. Bogibeel, as the bridge is called, is another Northeast Frontier Railway project, with both road and rail decks. On April 25, 2014, the first of thirty-nine welded truss spans was launched for the bridge's construction. In a scene reminiscent of construction milestone ceremonies held fifty years earlier at the site of the first Brahmaputra Bridge, officials of the Northeast Frontier Railway attended the launching ceremony. Press releases about the bridge echo earlier promotional materials about Saraighat Bridge; they state that the new bridge will increase connectivity of Assam and provide a strategic link with the border areas of Arunachal Pradesh. It remains to be seen

86. "East-West Corridor project hit by problems galore," *AT*, October 13, 2015; "List of Current Projects Having Contract Value More Than 100cr.," "Only second bridge can ease traffic on Saraighat," *AT*, July 14, 2015; *Gammon India*, http://www.gammonindia.com/projects/current-project-for-gammon-india.htm (accessed November 9, 2015).

what effect these new bridges will have when completed. Both have lagged drastically behind their original construction schedules. Whereas it took only four years to construct the first Brahmaputra Bridge, the fourth and fifth have each been under construction for a decade or more.[87]

The most significant difference between Bogibeel and Saraighat bridges lies in the design of the trusses. Although the railways had to eliminate tenders based on welded trusses for the first Brahmaputra Bridge in 1959, welded trusses are now permitted by Indian Railways codes. A consortium of three companies is building the trusses: Hindustan Construction Co., VNR Infrastructures of Hyderabad, and a German firm, DSD Brückenbau GmbH. The German firm is responsible for the design of the trusses.[88]

What the trusses of the Bogibeel Bridge demonstrate is that technology transfer into a country does not happen just once. In 1959, bridge construction practices in India were up-to-date with those abroad, but this was no longer the case when HCC–VNR–DSD received the Bogibeel Bridge contract in 2011. Ever since Indian independence, a tension has existed between importation of foreign technology on the one hand, and technological autarky on the other. One-time technology transfer can lead to a certain technology being seemingly frozen in time in one country, as the technology continues to change outside the country's borders. In the context of India, it would be hard to find an example more representative of this approach than the Ambassador car, manufactured in Calcutta by Hindustan Motors Corporation. The Ambassador was based on the 1950s British design Morris Oxford. The production line was set up in the 1950s, and it

87. "First girder span of Bogibeel Bridge launched," *AT*, April 28, 2014; "Work on Bogibeel Bridge progressing well, claims NFR," *AT*, July 6, 2014.

88. "HCC, associates bag Rs 987-cr railway order," *The Hindu BussinessLine*, November 24, 2011.

produced cars nearly unchanged for more than twenty years. In the intervening time, automotive technology abroad changed considerably, while Indian automobiles appeared to be trapped in the 1950s.[89]

This was one approach to technology transfer and indigenization. The second approach was piecemeal importation of technologies, as in the case of the bridge projects. A third approach would be for India to become a major source of technological innovation. The third approach has yet to materialize; the first could hardly be satisfying to a nation with great industrial ambitions. For this reason, technology transfer has been a continual process. Technology transfer was hardly necessary for the first Brahmaputra Bridge, but by the beginning of the twenty-first century, technology outside India had changed enough to make importation of foreign technology desirable.

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89. See Ziauddin Sardar, "The Ambassador from India," in *Autopia: Cars and Culture*, ed. Peter Wollen and Joe Kerr (London: Reaktion Books, 2002), 208-18.

Chapter 3: Umiam Hydroelectric Project

On January 8, 1960, at the town of Aswan in southern Egypt, President Gamal Abdel Nasser of the United Arab Republic formally initiated construction of the Aswan High Dam. To celebrate the culmination of six years of preparation, the Egyptian government flew a crowd of foreign dignitaries up from Cairo. Although the official chief guest at the festivities was King Mohammed V of Morocco, the most significant personage was Ignati T. Novakov, the Soviet Minister of Electric Power Station Construction, whose government had agreed to finance the construction of the dam with a starting loan of $93 million. In front of the assembled dignitaries, Nasser pushed a button to trigger charges of dynamite along the river half a mile away. The resulting explosions began to open the first canal to divert the waters of the Nile. Clearly visible even from this distance were white lines painted on the cliff faces on both sides of the river, outlining the planned dimensions of the 12,500-foot dam.[1]

The next day, 3,600 miles away, a similar scene played out in the Khasi Hills of northeast India. Prime Minister Jawaharlal Nehru, on a three-day tour of Assam, inaugurated the construction of the Umiam (Barapani) Hydroelectric Project on the Umiam River. Like Nasser, Nehru pushed a button to set off the first explosive charge of the project. The explosion blasted the first hole for the river diversion tunnel and sent

1. "Nasser starts construction of Aswan Dam on the Nile," *New York Times*, January 9, 1960; Tom Little, *High Dam at Aswan: The Subjugation of the Nile* (New York: John Day, 1965), 44.

rocks flying several hundred feet. Nehru then delivered a forty-minute speech in English in which he exhorted the people of Assam to work hard to create "a free society, a cooperative society, a prosperous and fearless society." In Nehru's view, one way to create this society was through industrial development, of which the Barapani project would be an important part. Scheduled for completion in 1963, the project included a 640-foot long concrete dam and two earthen dams designed to create a reservoir in the Umiam River Valley. A conduit diverted water from the reservoir to a 36-MW hydropower station. Transmission lines took the project's power up to Shillong and down to the Brahmaputra River Valley.[2]

The Aswan High Dam justifiably attracted international attention from its inception in the 1950s. Nasser promoted the dam as a symbol of postcolonial Egypt's entry into the modern age. The project was and still is famous as a major engineering work; modern technology had finally gained the ability to tame the ancient caprices of the Nile. The project also gained notoriety for flooding the entirety of Nubia, thereby displacing the local population and inundating ancient cultural sites. UNESCO launched a publicized, and ultimately successful, attempt to cut apart and relocate the monument of Abu Simbel, but other unexplored cultural sites disappeared beneath the Nile.[3]

By comparison, the Indian hydroelectric project known interchangeably as Barapani or Umiam received mostly regional attention, as it was just one of dozens of

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2. "Nehru envisages Assam's great future; Umiam Hydel Project inaugurated," *Assam Tribune* (*AT*), January 10, 1960; "Umiam Hydel Project," *AT*, January 9, 1960; Jawaharlal Nehru, speech at public meeting in Shillong, January 9, 1960, in Madhavan K. Palat, ed., *Selected Works of Jawaharlal Nehru: Second Series* (New Delhi: Jawaharlal Nehru Memorial Fund, 2014), 56:232-39. The next day, Nehru laid the foundation stone of the Brahmaputra Bridge at Pandu.

3. See "The Nubians" and "Abu Simbel" in Little, *High Dam at Aswan*, 129-46, 185-96.

hydroelectric projects initiated during Nehru's tenure as prime minister.[4] The river Umiam was little-known outside northeast India, and the project was small compared to the few high-profile river valley projects undertaken in other parts of India. From the early independence period, Bhakra, Hirakud, and Nagarjuna Sagar dams have received the most attention. Bhakra was the highest concrete dam in India, Hirakud had the longest earthen dam, and Nagarjuna Sagar employed a 50,000-strong manual workforce, which was a favorite subject of magazine photographers. These dams have had their share of articles and book chapters written about them. More recently, the still incomplete Sardar Sarovar Dam on the Narmada River in central India has drawn attention because of fervent protests against its construction. Medha Patkar, the leader of the movement against the dam, employed Gandhian tactics and threatened to allow the rising reservoir to drown her. Man Booker Prize-winning novelist Arundhati Roy has helped popularize Patkar and make her famous among environmentalists and social activists around the world.[5]

Apart from the polemical writings of Roy, scholars have produced more balanced analyses and critiques of large dams in India. Sanjeev Khagram, in his book *Dams and Development*, shows how activists such as Patkar have played a role in slowing the rate

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4. The name *Umiam* comes from Wah Umiam, the river dammed to create Umiam Lake. In the Khasi language, the name means "weeping river" or "the river of weeping water." *Barapani* is a Hindi name (बड़ापानी, *baḍāpānī*), meaning "big water." U Nissor Singh, P.R.T. Gurdon (ed.), *Khasi English Dictionary* (1904, repr. New Delhi: Mittal Publications, 2001), 86, 242, 244; R.S. McGregor (ed.), *Oxford Hindi-English Dictionary* (New Delhi: Oxford University Press, 1993), 622, 700.

5. Arundhati Roy's definitive anti-dam essay is "The Greater Common Good," originally printed in the Indian magazines *Frontline* and *Outlook* in 1999, and subsequently included in the essay collection *The Algebra of Infinite Justice* (New Delhi: Penguin India, 2001), 43-137. Jacques Leslie provides a sympathetic portrait of Medha Patkar in the first of three chapters of *Deep Water: The Epic Struggle over Dams, Displaced People, and the Environment* (New York: Farrar, Straus and Giroux, 2005), although he has no sympathy for Arundhati Roy. In an editorial about Arundhati Roy's literary activism in *The Hindu* (November 26, 2000), Ramachandra Guha concluded, "We would all be better off were she to revert to fiction."

of large dam construction in India. Books and articles written by scholars working in the field of subaltern studies have revealed the human toll of displacement and dispossession caused by dams and other industrial development projects in independent India.[6]

The environmental and social legacies of the large dams are well-understood by students of modern India. Less attention has been paid to the dams as technological artifacts. Memoirs by the builders of large dams like Bhakra include technical details, as the authors were mostly engineers, but there is little secondary source literature on Indian dams that treats them as technological artifacts.[7] This chapter will serve as a case study of an Indian dam from the early-independence period, focusing on the dam as a technology and paying particular attention to questions of technological interchange and international collaboration on the project.

The Umiam Hydroelectric Project in particular is significant for three reasons. First, only a few hydroelectric projects in India approached the size and prestige of Bhakra Dam. Instead, most projects implemented in the early-independence period were mid-size projects in the 10-50 MW range, comparable to the Umiam Project, which makes it a more representative case study.

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6. Sanjeev Khagram, *Dams and Development: Transnational Struggles for Water and Power* (New Delhi: Oxford University Press, 2005). Works about industrialization and displacement include: L. T. Sharma and Ravi Sharma, *Major Dams: A Second Look – Development Without Destruction* (New Delhi: Environment Cell, Gandhi Peace Foundation, 1981); Walter Fernandes and Enakshi Ganguly Thukral, *Development, Displacement, and Rehabilitation: Issues for a National Debate* (New Delhi: Indian Social Institute, 1989).

7. Jagman Singh served as a junior engineer on Bhakra, and he devoted more than a hundred pages of his memoir to his experiences during the construction. *My Tryst with the Projects Bhakra and Beas* (New Delhi: Uppal Publishing House, 1998), 80-212. The construction of a hydroelectric project also serves as the setting for at least one Indian novel, Kamala Markandaya's *The Coffer Dams* (1969; repr. New Delhi: Penguin Books India, 2008). The novel centers on a fictional dam in southern India, constructed by a British contractor after independence. Markandaya used this imaginary setting (no major hydroelectric project was constructed by a foreign contractor in the early-independence period) to comment on the persistence of colonial attitudes among the builders of development projects after independence.

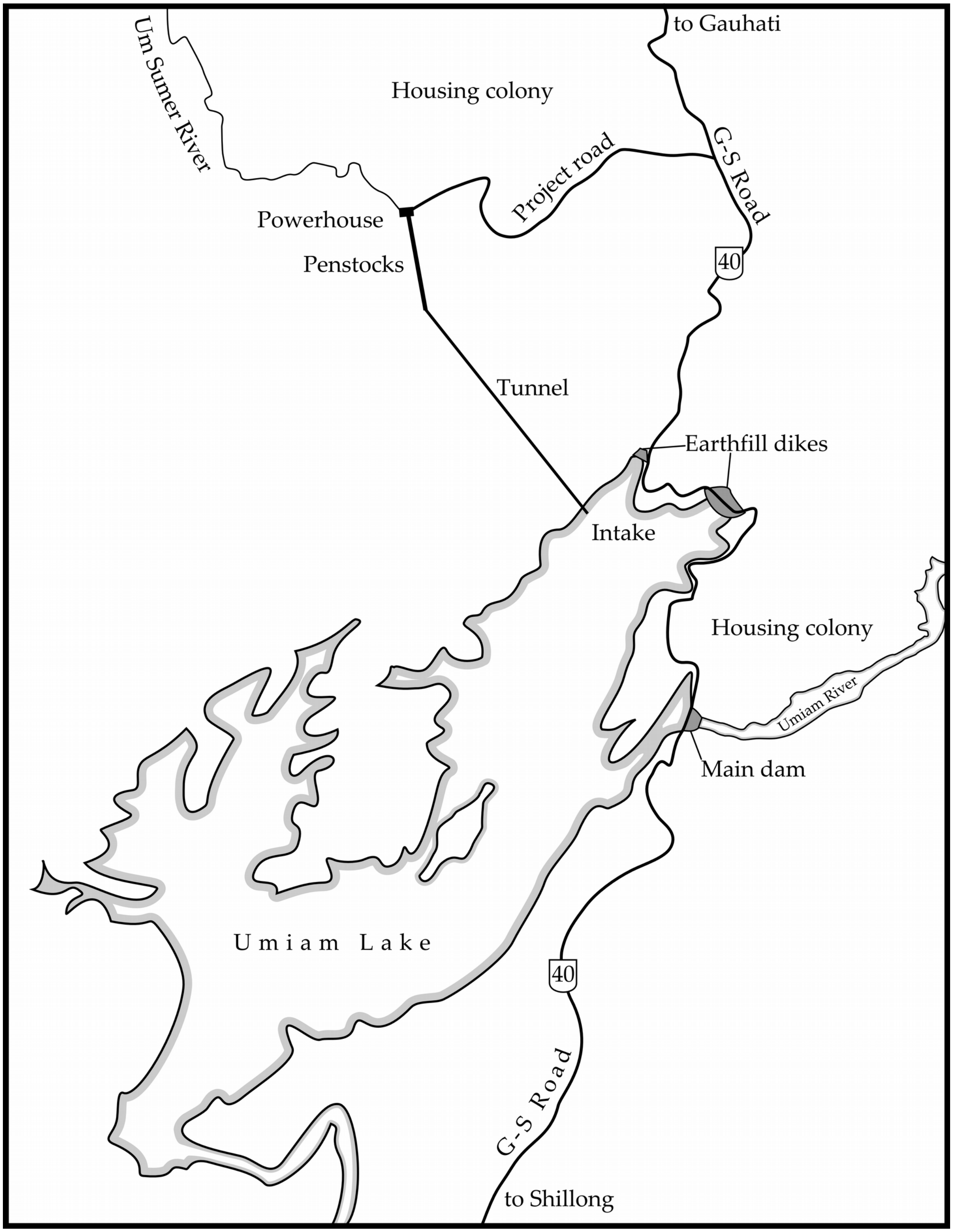

Figure 9. Map of Umiam Lake and surroundings. (Map drawn by the author, based on map in Assam State Electricity Board, "Umiam Hydro-Electric Project," commemorative pamphlet, n.d. [1966], Office of Director (Generation), Meghalaya Energy Corporation Ltd., Shillong.)

Second, the Umiam Project brought a large (for its time) amount of power to a region that had little. This sudden availability of power provides an opportunity to test the modernizers' claims about the effects electric power can have on economic development. In the early years after the project's completion, the resulting glut of power found few customers. Later, with the expansion of the regional electric grid, industrialization, and rising living standards, the Umiam Project, now greatly expanded, could not keep up with demand. The Khasi Hills, which originally had a surfeit of electricity, now had to buy electricity from neighboring grids.

Third, Umiam was the first Indian hydroelectric project offered full financing by the United States government. Previous projects had already been underway when they received financing, but the Umiam Project was just starting when the US government offered to finance it. The US government intended that two loans would cover the complete costs of the project. The first was a dollar loan of $2.5 million, meant to cover foreign exchange costs incurred while importing goods or paying foreign experts. The Development Loan Fund agreed to this loan in July 1960. The second loan, falling under Public Law 480 and worth Rs. 64 million ($13.1 million at the time), covered domestic costs.[8]

Even though the Umiam Hydroelectric Project was built on modern design principles that originated outside India, the project was Indian in design, conception, ownership, and implementation, and stakeholders from across India and around the globe participated. The Assam State Electricity Board (ASEB) implemented the project

8. DLF, press release on loan for Barapani project, July 8, 1960, box 2, USAID Mission to India Subject Files 1955-62, RG 286, NARA; Allen J. Ellender, *Review of United States Government Operations in South Asia* (Washington, DC: Government Printing Office, 1968).

departmentally. Khasi landowners sold the land occupied by the dams, powerhouse, and reservoir. The Planning Commission placed the project in the Second and Third Five-Year Plans. The Central Water and Power Commission (CWPC) prepared the plans at its headquarters in Delhi and tested designs of the dam in its laboratory in Poona. Domestic contractors provided construction materials and a few of the specialized electrical components. From outside India, the United States offered financing for the project and provided earthmoving machinery and instrumentation. Japan provided the four turbine-generators, as well as financing for the fourth unit, a later addition that was not covered by the American loan. Other components came from Austria, France, West Germany, Italy, Sweden, and the United Kingdom.[9]

In terms of indigeneity, the Umiam Hydroelectric Project falls between the Brahmaputra Bridge (Chapter 2) and the Tarapur Atomic Power Station (Chapter 4). The engineers of the Central Water and Power Commission and the Assam State Electricity Board, thanks in part to their degrees from foreign universities, already knew how to design and build dams. Only specialized knowledge, like the use of instrumentation, to monitor the dams and dikes, had to be imported for this project. While most expertise existed in the country, the tools and specialized components did not. Equipment, along with financing, had to be imported.

9. T.V. Thadani to C.L. Garg, August 28, 1962, file no. 15(11)60, Ministry of Finance, NAI.

Modernization in the Khasi Hills

Assam State Electricity Board built the Umiam Hydroelectric Project in the Khasi Hills, the central section of the Meghalaya Plateau, a mountainous region south of the Brahmaputra River Valley. The dam was located less than sixty miles away from Gauhati and the Saraighat Bridge, but the two projects were built in markedly different geographical settings. The Brahmaputra River Valley has a hot-monsoon climate, but the high Khasi Hills have a much cooler climate than the lowlands of Assam.[10]

The Khasi Hills are named after their main inhabitants, the Khasi people, who are considered a Scheduled Tribe under the Sixth Schedule of the Indian Constitution. Scheduled Tribe or ST status is accorded to ethnic groups who fall outside the Indo-Aryan or Dravidian mainstream of Indian society. The Khasis, for their part, speak a language unrelated to either Sanskrit or the Dravidian languages of South India. Although no historical records survive of their arrival in India, their Mon-Khmer language suggests that they originated in Southeast Asia. The Khasis were a preliterate society until the nineteenth century, but they have a wide range of oral traditions that describe their past.[11]

In addition to language, traditional Khasi society has several distinctive features that distinguish it from Assamese culture predominant on the plains below. Most subdivisions of the Khasi tribe are both matrinomial and matrilineal. This means that

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10. M. Taher and P. Ahmed, *Geography of North-East India*, 4th ed. (Guwahati: Mani Manik Prakash, 2007), 57-58.

11. The Sixth Schedule of the Indian Constitution accords special rights to people living in designated tribal areas in the states of Assam, Meghalaya, Mizoram, and Tripura, all of which are located in northeast India. Assam originally encompassed the entire region, but after the other states spun off in the 1970s and 1980s, the Sixth Schedule was amended to include the new states. The Fifth Schedule accords rights to tribal people living in parts of India aside from the four northeastern states. *Constitution of India*, "Sixth Schedule [Articles 244(2) and 275(1)]: Provisions as to the Administration of Tribal Areas in the States of Assam, Meghalaya, Tripura and Mizoram," *Government of India, Ministry of Law and Justice*, http://lawmin.nic.in/olwing/coi/coi-english/Const.Pock%202Pg.Rom8Fsss(34).pdf (accessed December 2, 2015).

children join the clan of the mother (matrinomial) rather than the father, and inheritance passes from the mother to the daughter (matrilineal) rather than from the father to the son (patrilineal). The name Khasi means "born of the mother," and mothers traditionally control the household and manage family business.[12]

Despite the prominence of women, Khasi society is not matriarchal. As Hamlet Bareh has emphasized, Khasi culture is patriarchal, because men dominate administration. The leaders of Khasi society are the (mostly male) chiefs known as Syiems and Sardars. They preside over darbars (village councils), which are composed of all male residents of an area. The Syiems and Sardars control the disposition of public lands, although traditionally they have no authority to make final decisions on land transfer without approval of the darbar. The Khasis originally recognized three types of land-ownership: *Ri-Raid* (public land), *Ri-Kynti* (land belonging to a single clan), and sacred groves, which were set aside for ceremonial purposes only.[13]

All members of the community had rights to cultivate the public land, but not to sell it. The darbars apportioned the public land to members of the community for use in *jhum* (shifting or slash-and-burn) cultivation. Individuals who improved the land by building permanent structures or establishing permanent crops such as wet-rice or fruit trees would gain an inheritable right to the land. If they left this land fallow for three years, though, the land would revert back to the community.[14]

The arrival of British colonists in the first half of the nineteenth century further

12. Hamlet Bareh, *The History and Culture of the Khasi People* (published by the author; printed by Naba Mudran, Calcutta, 1967), 250.

13. Ibid., 287, 337.

14. J.N. Das, *A Study of the Land System of Meghalaya* (Guwahati: Law Research Institute of Gauhati High Court, 1990), 54-56.

complicated Khasi land tenure. In other parts of northeast India, such as the Brahmaputra Valley and the Jaintia Hills (located to the east of the Khasi Hills in the Meghalaya Plateau), the British government appropriated the entire territory and then permitted the inhabitants to use the land for certain activities such as cultivation. In the Khasi Hills, by contrast, the British recognized the traditional territorial rights exercised by the Sardars and Syiems, and accordingly treated the Khasi Syiemships as semi-independent princely states. By treaty, the Syiems ceded away their rights to manage defense and foreign relations, but they continued to maintain sovereignty within their own territories. Traditional Khasi land tenure also persisted inside the Syiemships. Toward the end of the nineteenth century, the British Raj recognized twenty-five different states in the Khasi Hills.[15]

In some cases, the British acquired land inside the Khasi Syiemships for their own use. This came to be known as government land, and it fell under British land revenue laws. In 1829, Dewan Singh, the chief of Cherrapunjee, granted land in his territory to David Scott, in exchange for British-controlled land in the Sylhet district. This land became the site of the first headquarters of the British in northeast India. In 1863, the Syiem of Mylliem agreed to transfer to the British some of his territory near Shillong Peak, the highest point in the Khasi Hills. From this land grant, the British built a cantonment and sanitariums for what would become Shillong town, their new headquarters in northeast India.[16]

Over the following decades, Shillong grew up around the original government

15. Ibid., 53, 102.
16. Ibid., 104-6.

land granted by the Syiem of Mylliem. Further land transfers brought other parts of the surrounding area under government control, but much of the territory remained subject to the Khasi land system. Shillong town was thus a patchwork of British government lands and Khasi lands, the latter of which were mostly *Ri-Kynti* or private land. Adjoining the British Cantonment, a large Khasi market grew up known as Iewduh or Bara Bazar (Big Market). Even though it was in the midst of a Khasi state, Shillong became a cosmopolitan town, as its population was a mixture of Europeans, transplants from other parts of India, and Khasis.[17]

Shillong served as the capital of British Assam. The cool climate of the Khasi Hills attracted British colonists, who preferred the hills to the sweltering heat of the plains in the summertime. Shillong and other towns built at altitude were known as hill stations. The most famous hill station in India was Simla (Shimla), which served as the summer capital of British India when the heat in Delhi became unbearable. Rather than moving from plain to hill and back each year, the colonial government of Assam stayed in Shillong year-round. Colonists in the hill station built wooden bungalows, churches, commercial and government buildings, parks, and a golf course. The earthquake of 1897 destroyed much of the town, but the survivors rebuilt it on similar lines as before.[18]

With Indian independence, the Khasi states surrounding Shillong merged into Indian territory. Shillong became capital of the state of Assam in the Indian union. The Sixth Schedule of the Indian Constitution, which came into effect in 1950, granted the Khasis special rights because of their tribal status. They were expected to set up

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17. Ibid., 110, 113.
18. Edward Gait, *A History of Assam* (1906; repr. Delhi: Surjeet Publications, 2006), 335.

Autonomous District Councils, which would manage the usage of tribal lands. These councils had authority to sell land for development.[19]

At independence, Assam had no electric power grid. Instead, major towns had their own diesel generating stations, and there were also a few small hydroelectric stations. In March 1955, the state government formed the Assam Electricity Department, which oversaw the construction of the first major hydroelectric project in the Khasi Hills, named after the Umtru River in the northern Khasi Hills, where it was located. Umtru Hydroelectric Project consisted of a weir that diverted water from the river into a 4,600-foot conduit running to the powerhouse. The powerhouse had three turbine-generators of 2.8 MW each. The project received financial aid and technical assistance from the Dominion of Canada under the Colombo Plan.[20] The Central Water and Power Commission of the Indian government prepared the plans for the Umtru project, and Montreal Engineering Company served as consultant. The project was completed and dedicated in 1957.[21]

By 1960, when work on the much larger Umiam Hydroelectric Project began, Shillong was still isolated and difficult to reach, despite its political importance as the capital of Assam. The main road to Shillong, known as National Highway 40 (NH-40) or

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19. Das, *Land System of Meghalaya*, 53.

20. The Colombo Plan was established in 1951 with the mission of promoting development in South Asia, both through aid projects and providing training to technical specialists. Originally consisting of only Commonwealth nations, the Colombo Plan has since expanded to include non-Commonwealth nations, such as the United States. Canada was a founding member of the plan, but it withdrew in the 1990s. "History," *Colombo Plan Secretariat*, http://www.colombo-plan.org/index.php/about-cps/history/ (accessed November 27, 2012). For a full-length monograph about the Plan, see Daniel Oakman, *Facing Asia: A History of the Colombo Plan* (Canberra: Pandanus Books, 2004).

21. "Barapani Hydro-Electric Project (Assam): Installation of IV Generating Unit," n.d. [August 1961], file no. 6(16)/61 vol. 3, Ministry of Finance, NAI; "India-Canada Co-operation in River Valley Development," *Indian Journal of Power and River Valley Development* (*IJPRVD*) 12 (Oct. 1962): 19-20, 26.

the Gauhati-Shillong Road (G-S Road), was a one-lane road—not one lane in each direction, but a single lane that ran in only one direction at a time. Gates on the highway opened and closed based on a published schedule, allowing traffic to run in only one direction on the road at a time. Traffic coming up from Gauhati would pass through Jorabat Gate and begin to climb the Khasi Hills. At about the same time, downward traffic passed through Mawlai Gate near Shillong and began its descent toward the Brahmaputra River Valley. At Nongpoh, the halfway point between Gauhati and Shillong, there was another set of gates, allowing the upward and downward traffic to pass each other and continue onward.[22]

Also in 1960, the Assam Legislative Assembly passed a bill that inadvertently led to the political reorganization of the Meghalaya Plateau. The Assam Language Act established Assamese as the official state language. English shared official language status with Assamese; at an unspecified point in the future, English would be replaced with Hindi. The Khasis felt that the government had imposed Assamese upon them without respecting their own linguistic heritage. They joined their neighboring tribal people in the Meghalaya Plateau, the Garos and the Jaintias, in agitating for a separate state of their own in the Indian union. In 1970, Meghalaya became an autonomous state within Assam, and in 1972 it received full statehood. The government of Assam was forced to vacate Shillong and move down the hills to Gauhati.[23]

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22. C.S. Booth, timings on the Gauhati-Shillong Road, January 3, 1961, in *The Assam Gazette Part IIA*, January 11, 1961, 173; "Bus accidents in Shillong-Gauhati Road," *Proceedings of the Assam Legislative Assembly*, May 2, 1958, in *The Assam Gazette Part VI*, January 20, 1960, 3649.

23. "Assam Official Language Bill, 1960," *Assam Gazette*, October 10, 1960, 623-25; B. Datta Ray and S.P. Agrawal, ed., *Reorganization of North-East India since 1947* (New Delhi: Concept Publishing Company, 1996), 65, 160-61.

Dams in independent India

Building engineering works to harness nature and make it serve the needs and wishes of humanity, as the Umiam Hydroelectric Project was intended to do, was not new to India in the twentieth century. Particularly in arid western and central India, where unreliable rainfall meant that water shortages were a recurring problem for human settlements, local rulers began building dams and irrigation works in ancient times. Pietro della Valle, an Italian who traveled around western India in the seventeenth century, encountered many artificial pools, reservoirs, cisterns, and tanks built for the storage of water in the arid climate. "Indeed, these Indian Lakes are goodly things," della Valle wrote, "and may be reckon'd amongst the most remarkable structures in the world."[24]

The largest extant pre-modern artificial lake in India is Jaisamand, thirty miles south of Udaipur in southern Rajasthan. Built in 1685 on behalf of Maharana Jai Singh of Mewar, the twenty-square-mile lake is impounded by a 1,500-ft marble dam. During refurbishment in the early independence period, the front face of the dam was covered with a concrete structure. The crest and back side of the dam, though, kept their historical appearance. A series of white marble steps still lead down to the water. There are also six stone chhatris (domed pavilions), six carved marble elephants, and a temple. The Rajasthan state government has developed the dam as a tourist site, with boat rides out into the lake.[25]

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24. Pietro Della Valle, *The Travels of Pietro Della Valle in India*, trans. G. Havers, ed. Edward Grey, 2 vols. (London: Hakluyt Society, 1892), 102.

25. James Tod, *Annals and Antiquities of Rajasthan of the Central and Western States of India* (London: Oxford University Press, 1920), 1:458; *Large Dams in India* (New Delhi: Central Board of Irrigation and Power, 1987), 1:206-7; Central Water Commission, "National Register of Large Dams – 2009," http://www.cwc.nic.in/main/downloads/National%20Register%20of%20Large%20Dams%202009.pdf (accessed October 25, 2012).; "Vast marble dams, hidden for centuries in hills of India, are unsung triumphs of engineering," *Popular Science Monthly*, April 1922, 37-38. A concrete post in the park

Throughout history, the vast majority of dams built in India have been for the purpose of irrigation. Hydroelectricity, a modern use of dams, first arrived in India at the beginning of the twentieth century. Like the construction of rail lines, the early electrification of India was a colonial project undertaken in British India and some of the princely states. The first powerplant in India was established in 1897 at Darjeeling. Before World War I, electrification occurred only on a small scale in India, restricted to urban areas. The only major state effort for electrification during this time was made by the princely state of Mysore. In 1902, the state built the first hydroelectric project in India, Sheshadri Iyer Power Station at Sivasamudram Falls. In the interwar period, electrification took place in conjunction with industrialization. Power stations were established all across India, including a small hydroelectric plant at Bishop's Falls near Shillong. Then during World War II electrification slowed considerably, as industry retooled for military production.[26]

Colonial authorities and the princely states built several large dams before independence, but the pace of dam construction increased after independence as the five-year plans set high goals for industrialization. In a technological break from the past, all of these large dams were built according to modern concrete design principles that were imported from the West. The fast pace of dam construction continued after Nehru's death, ultimately peaking in the 1970s and 1980s, before tapering off in the decades after

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on top of Jaisamand Dam has the inscription "*Sinchaai Vibhaag San 1960*" [Irrigation Department, 1960].

26. V. Venkatarama, *Power Development in India: The Financial Aspects* (New Delhi: Wiley Eastern, 1972), 29; United States Department of Commerce, *The Electrical Equipment Market in India* (Washington, DC: Government Printing Office, 1927), 8; Hamlet Bareh Ngap Kynta, *The Economy of Meghalaya: Tradition to Transition* (Guwahati: Spectrum Publications, 2001). The original Swiss-made Pelton turbine runner from the powerhouse of the Sheshadri Iyer Power Station is on display in the Visveswaraya Industrial and Technological Museum in Bangalore.

economic liberalization.[27] The period between independence and the beginning of the Fourth Five-Year Plan in 1969 saw the completion of 684 dams higher than ten meters (33 feet) in India. As before, the majority of these dams (91 percent) were primarily for irrigation. Only 52 of the dams (8 percent) were connected to electric generating stations; one impounded the cooling water reservoir for Satpura Thermal Power Station, while the remaining 51 had hydroelectric powerhouses. Twelve of the dams with powerhouses were multipurpose and also served as headworks of irrigation systems.[28]

In independent India, as in Egypt and elsewhere in the postcolonial world, the building of dams became infused with modernist ideology. Prime Minister Nehru was the most outspoken and eloquent proponent of dam-building in the early independence period, but his was only one of the many public and private voices calling for the development of rivers. To the planners of modern India, the United States' Tennessee Valley Authority (TVA) represented the great progress that a nation could achieve by building dams. TVA, a government-owned electric utility, has its origins during World War I. At that time, the US Army Corps of Engineers started building Wilson Dam over the Muscle Shoals of the Tennessee River in northwestern Alabama. The Corps intended to use the dam to power a plant producing nitrates, which were essential for the

27. Sanjeev Khagram, *Dams and Development: Transnational Struggles for Water and Power* (New Delhi: Oxford University Press, 2005), 35, 27. Khagram argues that the decrease in the annual number of large dams built in India and other nations after the 1980s was due, in part, to the negative pressure placed on elites by grassroots resistance groups.

28. Data from Central Water Commission, "National Register of Large Dams – 2009," http://www.cwc.nic.in/main/downloads/National%20Register%20of%20Large%20Dams%202009.pdf (accessed October 25, 2012). The International Commission on Large Dams catalogs two categories of dams. *Large dams* are taller than 15 meters; dams 10-15 meters in height may also be classified as large dams if they satisfy other requirements. *Major dams* must satisfy at least one of three requirements: height above 150 meters, volume in excess of 15 million cubic meters, reservoir storage greater than 25 cubic kilometers, or power generation greater than 1000 MW. Khagram uses the term *big dam* to refer to both *large dams* and *major dams*. See *Dams and Development*, 217 n. 9.

production of explosives. The dam was such a large and complicated project, though, that the Corps was unable to finish it until six years after the war ended. By this time, the original market for the dam's power had long since disappeared. Henry Ford tried to buy the dam at a deep discount in order to use its power to transform the town of Muscle Shoals into a second Detroit. Nebraska senator George W. Norris opposed this plan, arguing that the Tennessee River belonged to the nation and therefore deserved to be controlled and further developed by the national government. With President Roosevelt's backing, a bill sponsored by Senator Norris passed in Congress, thus creating the Tennessee Valley Authority. Wilson Dam became TVA's first power station. Over the following decades, TVA intensively developed the Tennessee River and its tributaries. Wilson Dam and its successors produced huge amounts of cheap electricity, which attracted private investment to the area, and Tennessee and northern Alabama industrialized quickly thanks to power from TVA's dams.[29]

The example of TVA appealed to modernizing elites in recently decolonized nations in Asia and Africa. These modernizers believed that the success of Alabama and Tennessee could be replicated in their own countries, and TVA clones started to appear in the former colonies. The first of these was Damodar Valley Corporation, founded in 1948 to develop a network of rivers in the eastern Indian states of Bihar and West Bengal. Multipurpose river valley development schemes appealed to Nehruvian ideology that promoted economic planning and centralized state control of natural resources.[30]

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29. Rohan D'Souza, "Damming the Mahanadi River: The Emergence of Multi-Purpose River Valley Development in India (1943-46)," *Indian Economic and Social History Review* 40, no. 1 (2003): 81-83; Patricia Bernard Ezzell, "Tennessee Valley Authority," *Encyclopedia of Alabama*, http://www.encyclopediaofalabama.org/article/h-2380 (accessed December 3, 2015).

30. D'Souza, "Damming the Mahanadi River," 81-83.

Agencies of the Indian central and state governments initiated the majority of dam projects in the early-independence period. Damodar Valley Corporation was the joint responsibility of the central government and the state governments of West Bengal and Bihar (later Jharkand). Municipal governments of some of India's larger cities also initiated the construction of dams. An example is Vaitarna Dam, completed in 1954, which supplied water to Bombay. Dams could be constructed departmentally, as in the case of Umiam Dam, or by a contractor. Again, Vaitarna Dam provides the example; Hindustan Construction Co. served as the main contractor.[31]

In addition to serving as contractors and supplying materials, Indian private industry also advocated continued development of rivers in India. A mouthpiece of the private-sector hydroelectricity lobby was the *Indian Journal of Power and River Valley Development*, which commenced publication in Calcutta in 1951, the same year the First Five-Year Plan began. The journal carried technical articles reporting the research of Indian engineers and scientists. It also printed more generally accessible articles about power and irrigation development in India and abroad; these articles were often reprints of press releases or publicity materials. The journal also brought out frequent special issues to celebrate the completion of major dams or cover broader topics such as electrical development in particular states.

Development of hydroelectric power projects between 1947 and 1969 was concentrated in southern India. Of the fifty-two dams built for power generation in this period, more than half of them were located in the two southernmost states of the country,

31. Hindustan Construction Co., "Directors' Report and Statement of Accounts for the Year Ended 31st August 1950," S. No. 340, Hindustan Construction Company subject files, papers of Walchand Hirachand, NMML; *Large Dams in India*, 1:205-13; "Overview," *Damodar Valley Corporation*, http://www.dvc.gov.in/dvcwebsite_new1/overview/ (accessed November 24, 2015).

Kerala and Madras (Tamil Nadu). The remaining hydroelectric projects were scattered around India. The only two hydroelectric projects completed in Assam during this period were Umtru and Umiam.[32]

The fifty-one dams with hydroelectric powerhouses built between 1947 and 1969 represent thirty-three different hydroelectric projects, as numerous projects used more than one dam. In some projects, such as Umiam, three dams were required to impound a single reservoir. In other projects, water from several reservoirs fed a single generating station. In terms of generating potential, the largest project was Bhakra-Nangal. Two powerhouses at the foot of the main dam and an additional two in the irrigation canals had a total capacity of 1,024 MW by the end of 1969. Other large projects were Sharavathi in Karnataka (938 MW) and Koyna in Maharashtra (600 MW). The remaining hydroelectric projects were smaller. Out of the thirty-three projects, thirteen had potentials in the 10-50 MW range. At 36 MW, the Umiam Project fell in this range. Table 1 shows the capacity distribution of projects completed in this period.

32. "National Register of Large Dams – 2009."

Capacity (MW)	Projects completed
0-10	5
11-50	13
51-100	4
101-250	5
251-500	3
501-750	1
751-1000	1
1000+	1
Total:	33

Table 1. Generational capacity of hydroelectric projects completed in India, 1947-1969.

The turbines, generators, transformers, switchgear, and other heavy electrical equipment used in these projects were almost all imported. Just after independence, the Indian government began to contemplate setting up public-sector industries to manufacture heavy electrical equipment. In other words, these plants would do import substitution. In 1955, the government established Heavy Electricals (India) Ltd., or HE(I)L, in Bhopal. Plants in Tiruchirapalli, Hyderabad, and Hardwar were spun off in 1964 as a separate company, Bharat Heavy Electricals Ltd. (BHEL). In 1971, the two companies were brought back under unified management with the name BHEL.[33]

The establishment and expansion of the Indian heavy electricals industry used equipment and technical expertise from both eastern- and western-bloc countries. HE(I)L, Bhopal was the first and only one of the heavy electricals plants to be established with British technological collaboration. The establishment of the first three BHEL plants

33. V. Krishnamurthy, "Management of organizational change: The BHEL experience," *Vikalpa* 2, (Apr. 1977): 113-19; D.C. Baijal, "March towards self-sufficiency: Power development in India," *Indian and Foreign Review*, February 15, 1966, 10-11.

called on Czechoslovakian and Soviet technical assistance. The donor countries provided machinery as well as training abroad for hundreds of Indian specialists. Upon returning to India, the trainees served as factory supervisors and managers. To create a skilled labor force, management established training schools at the plants. Some students entered the training school with no prior manufacturing experience. At the end of the two-year course, they were ready to enter the regular workforce of the factory.[34]

Expertise is essential for the indigenization of technology, but expertise alone is not sufficient. By the time the technical collaboration agreements expired and the foreign specialists returned home, HE(I)L and BHEL still relied heavily on imported raw materials and parts. In fiscal year 1969-70, the Tiruchy plant was BHEL's most indigenized facility, but it still imported half of its raw materials. More than 70 percent of the parts used in the Hyderabad and Hardwar facilities were imported. An article in *Economic and Political Weekly* entitled "BHEL's Wonderland Accounting" criticized the company, which had been established for the purpose of import substitution, for relying so heavily on imports for raw materials and machinery. "Though New Delhi tries to give the impression of being highly selective in permitting import of components by private sector units," the article complained, "BHEL was allowed import of components ranging from 65 per cent to 90 per cent in different plants."[35]

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34. S. Swayambu, "A decade of progress in power equipment manufacture," *Indian Journal of Power and River Valley Development* (*IJPRVD*) 21 (Apr. 1971): 113-14, 147; S. Sarangapani, "Heavy Electrical Project," *Assam Tribune Magazine*, November 6, 1960; BHEL, *First Annual Report 1964-65* (New Delhi, 1965); "Starting production of heavy power equipment in India," *Czechoslovak Heavy Industry*, May 1966, 20; BHEL, *Second Annual Report 1965-66* (New Delhi, 1966); "Bharat Heavy Electricals' maiden profit," *IJPRVD* 21, no. 9 (September 1971): 354-55; "BHEL boiler know-how pact with US firm," *IJPRVD* 21, no. 3 (March 1971): 109; A. Chakravarti, "The Social Profitability of Training Unskilled Workers in the Public Sector in India," *Oxford Economic Papers* 24, no. 1 (March 1972): 114-15.

35. BHEL, *Sixth Annual Report 1969-70* (New Delhi, 1970); "BHEL's Wonderland Accounting," *Economic and Political Weekly*, May 16, 1970, 792-93.

Using largely imported parts at first, the HE(I)L and BHEL plants began to manufacture Indian-made electrical machines and install them in plants around the country. They also produced boilers and other equipment for industrial use. The first powerplant to use largely indigenous machinery was Ennore Thermal Power Station in Madras State; both HE(I)L and BHEL contributed components to the project. BHEL's first hydroelectric plant was the Giri Project in Himachal Pradesh. In 1971, BHEL received orders for two 30 MW turbines for a later stage of the Umiam Hydroelectric Project.[36]

From its beginning, the heavy electricals industry had a captive market: the state electricity boards. In response to the Five-Year Plans, the state electricity boards were actively expanding their capacities, and thus had high demand for transformers, breakers, boilers, turbines, and generators. HE(I)L and BHEL grew to supply this demand. The failings of the Third Five-Year Plan, though, led to the delay and scaling-back of the Fourth Plan. The orders placed during the Fourth Plan period disappointed the expectations of the heavy electricals plants, and ultimately, BHEL turned to the export market in order to survive. With revenues buoyed in part by sales of electrical equipment abroad, BHEL reported its first profitable year in 1971.[37] In this way, an industry that had originally been established for the purpose of import substitution ultimately became a major exporter and earner of foreign exchange.

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36. BHEL, *Fourth Annual Report 1967-68* (New Delhi, 1968); Y.K. Murthy, "The Giri Hydro-Electric Project," *IJPVRD* 18 (July 1968): 259-64; "HEL's power projects," *Hindustan Times*, December 27, 1965; Swayambu, "A decade of progress in power equipment manufacture," 146; "Bharat Heavy Electricals' maiden profit," *IJPRVD* 21 (Sept. 1971): 354-55.

37. BHEL, *Fourth Annual Report 1967-68*; "Bharat Heavy Electricals' maiden profit," *IJPRVD* 21 (Sept. 1971): 354-55.

United States capital and Indian development projects

Hydroelectric dams, like other industrial development projects, are capital-intensive. For a country short on capital like India after independence, finding financing for these projects could prove to be a challenge. Some projects could be financed directly from the public coffers, such as the first Brahmaputra Bridge. But India's tax base could only carry so much development expenditure at a time. The domestic banking industry also had limited capacity. A balance of credits crisis in the late 1950s further weakened the Indian financial position and foreign exchange reserves. The Indian government felt compelled to look abroad to finance many of its development projects. Although only around 20 percent of all investments in development during the first two decades of Indian independence were financed by foreign aid, the most capital-intensive sectors, such as power, relied more heavily on foreign aid.[38]

Expenditures on almost every project fell into two categories: domestic costs and foreign exchange. Domestic costs were payable in rupees, as they were not spent outside of the country. Unless an exporting nation made a special exception, however, foreign exchange had to be used for importing anything from abroad, whether machinery or the services of a foreign specialist. This proved to be more difficult to obtain, as the Indian rupee was not considered hard currency on the international market. The Indian government built up stocks of hard currency or foreign exchange from the sale of Indian goods abroad. This foreign exchange could be meted out as needed for importing goods. The government's stocks of foreign exchange were never sufficient, especially after the

38. Dharma Kumar, ed., *The Cambridge Economic History of India* (Cambridge: Cambridge University Press, 1983), 2:955, 971.

balance-of-payments crisis of the late 1950s. It was not unusual, then, for a large development project to receive financing from a foreign government for its import costs, particularly after the late 1950s.

The United States was a major supplier of aid to India. Like the military aid discussed in Chapter 1, civilian aid was a part of American Cold War policy, but it was not as politically fraught. In most cases, the US Congress approved civilian aid to India, although there were a few exceptions. The highest-profile example of failed American aid was the Bokaro Steel Plant. The Indian government requested American financing for a large new steel plant to be built in Bihar (now Jharkand), the fourth public-sector plant. Stage 1 of the project required $512 million of foreign exchange, the largest aid package that India had yet requested from the United States. President Kennedy was in favor of American financing of the plant, and Ambassador Galbraith all but promised Nehru's government that it would receive the requested financing. The Republican-controlled House of Representatives, though, blocked the aid appropriation bill on grounds that the American government should not support a project that might compete with US private industry. Nehru's government withdrew its request for aid, and announced that it would build the plant without foreign aid. Within a year, though, the Soviet government offered to aid the plant, and India accepted. The Bokaro plant was finally completed years behind schedule.[39]

The example of Bokaro Steel Plant should not be taken as representative of the

39. U.S. House, Committee on Appropriations, Foreign Operations Appropriations for 1964, Hearing, July 22, 1963 (Washington: Government Printing Office, 1963), 1396; ibid., Hearing, July 24, 1963, 1481; Jawaharlal Nehru to John F. Kennedy, August 28, 1963, India: Security, President's Office Files, Presidential Papers, Papers of John F. Kennedy, JFK Library; Padma Desai, *The Bokaro Steel Plant: A Study of Soviet Economic Assistance* (New York: American Elsevier Publishing Company, 1972), 39-41.

American aid experience in India. During the Cold War, the United States government financed scores of projects in India. Compared to military aid, United States nonmilitary aid was more proportional to India's size and population. After the 1965 Indo-Pakistani War, the United States temporarily suspended all aid to both India and Pakistan. Nevertheless, in a 1971 fact sheet commemorating the twentieth anniversary of the first American wheat loan to India, the United States Information Service could claim that total American aid to India to date was nearly $9.9 billion. The fact sheet concluded: "Eighty percent of the resources employed in India's economic development comes from India herself. Foreign aid accounts for the remainder. The United States, which provides 56.5 percent of all foreign aid utilized by India, is pleased to be associated with India's progress." By comparison, the USSR had contributed only 5.6 percent of the aid, less than the World Bank, West Germany, and the United Kingdom.[40]

With both its military and civilian aid to India, the United States was fighting the Cold War in South Asia, but the long-term objectives of the two types of aid were different. Military aid, which proved to be limited in scope, was meant to help defend India against communism and forge direct ties between the two nations' militaries. The Americans hoped that nonmilitary aid, on the other hand, would generally encourage economic conditions that would make India less susceptible to communism. Projects supported by American funds would presumably improve economic and social conditions in India; they would also increase American prestige internationally. Any project fully financed by the United States was one that the Soviet Union could not support.

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40. Agency for International Development, *Program and Project Data Related to Proposed Programs – FY 1967: Near East and South Asia* (Washington, DC: n.p., 1966), 41; *United States Economic Assistance to India, June 1951 – April 1971* (New Delhi: United States Information Service, 1971), 40-41.

Nevertheless, even though American investment in India was much greater than the USSR's, Soviet aid had a higher profile. The Soviets economized their investments and carefully chose to assist large and highly publicized projects. American investment in smaller projects spread across the country doubtless had a greater influence on the Indian economy, but Soviet aid had a better image among the Indian population. "Soviet economic aid to India is less than one-fifth the magnitude of United States aid," American columnist Thomas F. Brady complained in the *New York Times* in 1965, "but dollar for dollar or ruble for ruble the Soviet Union gets about five times as much credit."[41]

During the Eisenhower presidency, American aid to India fell under two separate jurisdictions, Development Loan Fund (DLF) and Public Law 480 (PL-480). The Development Loan Fund was established in 1957, to provide foreign exchange financing to recently decolonized countries. Initially, DLF allowed a certain portion of the foreign exchange from its loans to be spent outside the United States, as long as the receiving country was not in the eastern bloc, which was explicitly prohibited by DLF policy. The recipient of the loan also had to issue a notification to American businesses, to make sure that they got the first opportunity to bid for a contract. In October 1959, DLF changed its policy to require that all of the loan amounts be spent in the United States. The money lent out would thus circle back into the American economy. Some loans were repayable in rupees, and others had to be repaid in dollars. In the case of the latter loans, the money would return to the American economy a second time when repaid with interest.[42]

41. Desai, *Bokaro Steel Plant*, 1; Thomas F. Brady, "Soviet's India aid fifth that of U.S.," *New York Times*, February 21, 1965.

42. House Committee on Appropriations, Foreign Appropriations for 1963: Hearing before a Subcommittee of the Committee on Appropriations, 87th Cong., 2nd sess., August 1, 1962, 403.

PL-480, also known as Food for Peace, created by the Agricultural Trade Development and Assistance Act of 1954, was another initiative of the Eisenhower presidency. Under the program, the United States disposed of its agricultural surpluses by selling wheat and other staples to countries experiencing food insecurity. The US government signed the first PL-480 agreement with India in August 1956. Under the terms of the agreement, the United States sold $362 million worth of American-grown wheat, rice, cotton, tobacco, and dairy products to India. The Indian government paid for the purchase in rupees, which the American government subsequently offered back as financing for domestic costs of development projects. In 1961, the Kennedy administration amalgamated DLF, PL-480, and other government programs into a rebranded assistance organization, the United States Agency for International Development (USAID), which has overseen American government-directed international assistance ever since.[43]

The US Agency for International Development's regional report for fiscal-year 1965 provides a snapshot of American nonmilitary aid activities in India. At this time, USAID extended two forms of aid to India: projects and loans. Projects were grouped under a variety of categories, including agriculture, industry, health and sanitation, and education. Specific projects included introducing the land-grant educational concept to India, developing trade unions, introducing hybrid seeds, founding a new Indian Institute

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43. James C. Hagerty, White House press release, May 4, 1960, S. No. 7, Dwight D. Eisenhower Library papers, NMML; Fact sheet, "India's Participation in Public Law 480," May 4, 1960, ibid.; [Dwight D. Eisenhower], undated draft speech, ibid.; Dwight D. Eisenhower, "Special message to the Congress on agriculture," January 29, 1959, Gerhard Peters and John T. Woolley, *The American Presidency Project*, http://www.presidency.ucsb.edu/ws/?pid=11523 (accessed December 8, 2015). Other recipients of PL-480 aid included Brazil, Colombia, Peru, Indonesia, and Pakistan.

of Technology at Kanpur,[44] eradicating malaria, and introducing modern American-style management to India. USAID provided funding both for “US Technicians” and for “Participants,” who were Indian nationals. The funding allowed Indian participants to travel to the United States to receive training as part of a project. For instance, three participants in the malaria eradication program each received four months of training in malaria eradication techniques in the United States. The total financial outlay for all of these projects was valued at $6.8 million.[45]

The loans listed in USAID’s FY 1965 report represent a broad range of projects undertaken both by the Indian government and by private industry. The report lists forty-four development loans that had been approved to date. In sum, these dollar loans provided India with nearly $1.4 billion of foreign exchange funds. Most of the loans were intended to cover the full foreign exchange costs of specific projects. Although USAID provided some loans to private Indian firms, such as Premier Automobiles, Ltd. and Tata Engineering and Locomotive Company, the majority of the loans went to the public sector. Aside from several large blanket loans for the use of Indian public and private industry, the largest loan for a specific project had a value of $80 million and went to the Tarapur Atomic Power Project, described in Chapter 4. Fully twenty of the forty-four loans financed foreign exchange costs for power projects, one of which was the Umiam Hydroelectric Project.[46]

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44. See Ross Bassett, “Aligning India in the Cold War Era: Indian Technical Elites, the Indian Institute of Technology at Kanpur, and Computing in India and the United States,” *Technology and Culture* 50 (October 2009): 783-810.

45. Agency for International Development, *Program and Project Data Related to Proposed Programs – FY 1965: Near East and South Asia* (Washington, DC: n.p., 1964), 54-77.

46. Ibid., 78-121.

Financing Umiam Dam

The Development Loan Fund first provided financing for Indian electrification in 1958 with a general development loan of $10 million. In June 1959, DLF expanded its involvement in Indian power development by considering a list of six projects for which the Indian government was requesting financing. Later, with the addition of two other projects, DLF extended foreign-exchange financing to a total of eight Indian power projects in 1959-60, with a combined value of $78.6 million. Of the eight projects assisted, six were thermal (fossil-fuel) plants and two were hydroelectric. One of these, Sharavathi project, was already under construction when it received DLF financing. The other, the Umiam Project, had just begun.[47]

DLF loan no. 141 (later redesignated USAID loan 386-A-030) provided $2.5 million toward the foreign exchange costs of the Umiam Project, with a twenty-year repayment period at 3.5 percent interest. Repayment would be made in rupees. The loan was formalized and announced in July 1960, although it was not formally signed until December 5, when DLF administrator Vance Brand was visiting India. The loan had already been under consideration when DLF formalized its American-purchases-only policy. Therefore, DLF grandfathered into these loan agreements the allowance for a certain amount of the funds to be spent outside of the United States. The allowance was

47. United States Department of Commerce, *Status of Active Foreign Credits of the United States Government and of International Organizations as of June 30, 1966* (Washington, DC: Government Printing Office, 1966), 55; Barapani Hydel Project summary sheet, attachment to letter, Harold W. Feldt to Ralph Trisko, February 11, 1960, box 2, USAID Mission to India Subject Files 1955-62, RG 286, NARA; "Six proposed DLF power projects (GOI submission of June 2, 1959)," memo, ibid.; House Committee on Appropriations, Foreign Appropriations for 1963: Hearing before a Subcommittee of the Committee on Appropriations, 87th Cong., 2nd sess., August 1, 1962, 403. The six thermal plants were located in the cities of Ahmedabad (extension of an existing plant), Barauni, Birsinghpur, Chandrapura, Durgapur (extension), and Kanpur (extension).

generous; of the $78.6 million between the twelve loans, $50 million could be spent elsewhere besides the United States. The prohibition against spending money in eastern-bloc countries still stood, as did the "small business notification" requirement, which stipulated that American businesses should get the first chance to fill contracts.[48]

The Ministry of Finance and Central Water and Power Commission served as intermediaries between Development Loan Fund and Assam State Electricity Board. The Finance Ministry negotiated the terms of the loan agreement, based on information furnished by ASEB via CWPC. While these negotiations were still in progress, ASEB nearly committed a diplomatic *faux pas*. Since Assam did not have an extensive electrical grid, electricity for the construction of the Umiam Project would have to be generated on-site by diesel units. ASEB placed an order, payable in rupees, for four 560-KW diesel sets from the Czechoslovakian firm STC. As an eastern-bloc country, Czechoslovakia was designated as a foreign policy-restricted country under Code 899 of the ICA Geographic Code Book. As described in Implementation Letter No. 2, which DLF delivered to the Finance Ministry after the formal signing of the loan agreement, countries not on the American-approved list were the "Union of Soviet Socialist Republics, Albania, Bulgaria, Czechoslovakia, Soviet-occupied Germany, Hungary, Poland, Rumania and China (Mainland)."[49]

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48. Development Loan Fund, Loan No. 141, Loan Agreement, December 5, 1960, file no. 15(11)60, Ministry of Finance, NAI; Telegram, C.S. Krishna Moorthi to N.C. Sengupta, November 5, 1960, ibid.; House Committee on Appropriations, Foreign Appropriations for 1963: Hearing before a Subcommittee of the Committee on Appropriations, 87th Cong., 2nd sess., August 1, 1962, 403; Agency for International Development, *Program and Project Data Related to Proposed Programs – FY 1965: Near East and South Asia* (Washington, DC: n.p., 1964), 84. In addition to the dollar loan, a PL-480 loan of Rs 64 million ($13.1 million in US currency at the time) was meant to cover domestic costs of the project.

49. C.S. Swaminathan, handwritten note on memo by T.V. Thadani about DLF assistance to Barapani project, June 15, 1960, file no. 15(11)60, Ministry of Finance, NAI; E. Kolet, Extract of CWPC note recorded in file no. F.2/4/50-DW.III, May 3, 1960, ibid.

C.S. Swaminathan of the Finance Ministry recognized the implications of ASEB's order, and inquired of the Central Water and Power Commission whether the diesel sets were integral to the project. K.L. Vij of CWPC replied that in his opinion, the diesel sets were not integral, as they would be removed immediately after completion of construction. Swaminathan nevertheless insisted that ASEB not use any eastern-bloc equipment on this project. As he explained in a memo, "It appears that we should not take a risk of allowing equipment from countries not acceptable to DLF to be used even in the construction stage. By doing so (even if the action may be deemed technically defensible), we will not be strengthening the confidence of DLF in us." ASEB agreed to put the Czechoslovakian sets to use elsewhere, and instead placed new orders in Yugoslavia, which was a nonaligned nation and therefore on the American-approved list.[50]

The financing agreement signed on December 5, 1960, defined the project as the construction of "a 27,000 KW hydro-electric plant on the Umiam River in the State of Assam," along with "related transmission lines and two substations." During the financing negotiations, ASEB remained undecided about whether it wanted to build a station with three or four 9-MW turbine-generators. The final loan agreement called for a station with three units, although ASEB kept the option of the fourth unit open. The tender notice for the turbine-generators requested bids for three 9-MW units, with the possible addition of a fourth to the order. In response, ASEB received fifteen bids from manufacturers in seven different countries. None of the companies were based in the

50. C.S. Swaminathan, memo, July 2, 1960, file no. 15(11)60, Ministry of Finance, NAI; K.L. Vij to C.S. Swaminathan, June 24, 1960, ibid.; C.S. Swaminathan to K.L. Vij, July 8, 1960, ibid.

United States. ASEB decided that the offer of Japanese firm Toshiba best met its needs. After receiving clearance from DLF for offshore procurement, the electricity board placed an order for three turbine-generators from Japan.[51]

In addition to the $50 million cap on offshore purchases between the eight loans, the Umiam loan agreement stipulated that 50 percent of tonnage imported for the project had to be carried on American flag vessels. Transportation costs could only be financed by the loan if an American vessel was used, unless DLF agreed to special dispensation. No American flag vessels made regular sailings between Japan and India. In the case of insulators ordered from a Japanese company for the project, the Finance Ministry informed ASEB that it did not need to receive authorization from DLF. ASEB should ship the insulators on an Indian flag carrier, or the vessel from any other nation provided it was not eastern European. The same conditions applied to the turbine-generators from Japan.[52]

After signing the agreement with Toshiba, ASEB decided to include the fourth turbine-generator unit in the project after all. The Japanese firm had been forewarned that it might be asked to provide a fourth unit. The Planning Commission also agreed to place the fourth unit in the Third Five-Year Plan. The difficulty with this decision lay in the financing. The loan agreement had specified a powerhouse with three units, not four. When the Finance Ministry began to consider the matter, N.C. Sen Gupta pointed out that while it would make the most sense from a technical standpoint to purchase the fourth

51. Development Loan Fund, Loan No. 141, Loan Agreement, December 5, 1960, file no. 15(11)60, Ministry of Finance, NAI.; B.C. Kapur to G.R. Iyer, June 23, 1960, ibid.; telegram, N.C. Sengupta to C.S. Krishnamoorthi, August 22, 1960, ibid.; M.R. Sita Ram to Finance Ministry attn. K.R. Chari, July 7, 1961, ibid.

52. T.V. Thadani to ASEB Chief Engineer (Hydro-Electric), January 7, 1961, file no. 15(11)60, Ministry of Finance, NAI.

unit from the same source as the first three, the $50 million cap restricted the amount of purchases that could be made outside the United States. As far as DLF was concerned, a better approach would be to order the fourth unit from an American company, but since no bids had been received from American companies the first time, Sen Gupta doubted that a second round of tenders would be any more fruitful than the first.[53]

C.S. Krishnamoorthi and P. Govindan Nair, at the Indian embassy in Washington, made inquiries of DLF in early 1961 about the prospects of using the loan to finance the fourth turbine-generator as well. Initially, John Ulinski, the regional director for South Asia, was positive about the potential of DLF covering the expansion of the project. The question would have to be cleared by the board first, and before he could present the question, he would need some more information, including project details and the justification for the additional unit. The Assam State Electricity Board wrote up a draft report with the required information. The draft made it as far as the Indian embassy in Washington before A.K. Ghosh returned it to the Finance Ministry. As Ghosh explained in a letter to C.S. Swaminathan, "I started to modify the language of the note in order to correct the typing mistakes, but while doing so, I found I could not understand the justification given for the fourth generating set." The staff of the Power Wing of the Central Water and Power Commission produced a revised project description, and the Indian embassy relayed this to DLF in Washington. The American agency again asked for further information, this time about offshore purchases already made for the Umiam Project.[54]

53. P.P. Agarwal to K.S. Sundara Rajan, December 15, 1960, file no. 6(16)/61 vol. 3, Ministry of Finance, NAI; N.C. Sen Gupta to C.S. Krishna Moorthi, December 23, 1960, ibid.

54. P. Govindan Nair to N.C. Sen Gupta, January 4, 1961, file no. 6(16)/61 vol. 3, Ministry of Finance, NAI; ASEB, "Information furnished to foreign exchange cell (CW & PC)," n.d. [July 1961], ibid.;

By the end of 1961, though, DLF was opposed to financing the fourth unit from Japan. Krishnamoorthi of the embassy in Washington reported in a letter to the Finance Ministry that the subject should not be taken up before February of the next year. In February, a telegram from the Finance Ministry to the embassy reported that the decision had been made in New Delhi to drop the matter of financing the fourth unit from the American loan. The Government of India, realizing the direction the negotiations were heading, decided to withdraw of its own volition, rather than waiting for the American government to give them the inevitable rejection. This was what would happen on a much larger scale with the aid request for Bokaro Steel Plant the next year. These carefully planned diplomatic maneuvers were meant to keep the providers of aid happy and to save face on both sides. Ultimately, ASEB placed an order for the fourth unit from Toshiba, the Japanese firm that had already contracted to supply the first three units, with the Japanese government providing ad hoc financing for the fourth unit.[55]

The amounts of the $2.5 million DLF and Rs 64 million PL-480 loans were based on initial construction estimates prepared at the beginning of the project by ASEB and CWPC. The signing of the loan agreements guaranteed only that the US government would provide a maximum of the specified amounts for this project. ASEB received the loan funds only after providing detailed documentation of project expenditures. To pay foreign suppliers directly, the Indian government initially had to release its own foreign

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A.K. Ghosh to C.S. Swaminathan, August 14, 1961, ibid.; T.V. Thadani to C.L. Garg, August 28, 1961, ibid.; "Barapani Hydro-Electric Project (Assam): Installation of IV Generating Unit," n.d. [August 1961], ibid.; C.S. Swaminathan to T.V. Thadani, October 31, 1961, ibid.

55. Telegram, C.S. Krishnamoorthi to K.S. Sundara Rajan, December 23, 1961, file no. 6(16)/61 vol. 3, Ministry of Finance, NAI; telegram, C.S. Swaminathan to A.K. Ghosh, February 19, 1962, ibid.; Assam State Electricity Board, "Umiam Hydro-Electric Project," commemorative pamphlet, n.d. [1966], Office of Director (Generation), Meghalaya Energy Corporation Ltd., Shillong.

exchange by a bureaucratic process that required applications to the Ministry of Finance. Then when the US government disbursed loan funds, the money went back into the Indian government's foreign exchange reserves, and could then be used for other purposes. Only certain expenditures were eligible to receive disbursement from the loan, though; DLF and later USAID were the arbiters of eligibility, based on the contents of the loan agreement and agency policy. This was the reason that the Indian authorities paid so much attention to the question of whether or not DLF would finance the fourth unit. The authorities did not want to commit to such a large expenditure and file a disbursement request, only to have it rejected by DLF.[56]

As stated in the original agreement for the DLF loan, the terminal date for requests for disbursement was December 31, 1964. This meant that the US government would disburse loan funds only for documentation received before the final day of 1964, unless the aid agency agreed to extend the deadline. By request of the Indian authorities, the disbursement deadline was extended twice. The authorities requested the first deadline extension, to the end of 1965, because they were still making incremental payments for machinery that had already been installed at the project site. They were also still paying wages to foreign specialists overseeing the installation of their companies' equipment.[57]

In fact, the project was running behind schedule and would not be ready for commissioning until September 1965. In that month, when the turbine-generators started

56. Development Loan Fund, Loan No. 141, Loan Agreement, December 5, 1960, file no. 15(11)60, Ministry of Finance, NAI.

57. Ibid.; "Format to accompany borrower's request for extension of terminal date for disbursement," DLF Loan 141, June 27, 1964, file no. 15(11)60, Ministry of Finance, NAI; Barapani project summary, attachment to letter, M.R. Sita Ram to C.L. Garg, December 9, 1964, ibid.; John A. Ulinski to GOI Ministry of Finance, December 15, 1964, ibid.

feeding electricity into the Assam grid, conflict between India and Pakistan erupted into war. A shipment of 33 kV circuit-breaker kiosks from West Germany was intercepted while passing through East Pakistan on the Brahmaputra River. By the end of 1965, ASEB was still waiting for full information from some suppliers. USAID extended the deadline by a year again. When the second extension passed, ASEB applied for yet another extension. It hoped to reorder the kiosks impounded by Pakistan, and it still had not received full documentation from suppliers and shipping companies for some of their orders. USAID rejected this third extension request. Since at this point, the project was producing electricity commercially, USAID determined that the extension was not necessary. It also felt that the project authorities had already had ample time to provide the requested documentation.[58]

The project had spent $90,000 in foreign exchange that USAID refused to disburse under the loan. The actual foreign exchange cost of the project had nevertheless fallen far short of the original estimate. By the time the last disbursement deadline passed, USAID had only disbursed $1.9 million of the maximum authorized $2.5 million. USAID deobligated $641,000 of the loan. Based on a new amortization schedule, the Indian government would end up paying a total of $2.3 million, $400,000 of which was interest, by the last payment date of May 7, 1977. While the US government had initially offered full financing for the project, additional financing for the project also came from the Japanese government and the Indian government's own resources due to project alterations and other exigencies.[59]

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58. N. Vishwanathan, memo, April 10, 1967, file no. 15(11)60, Ministry of Finance, NAI.

59. Implementation Letter No. 11, Thomas L. Cranmer to R.K. Jerath, June 19, 1967, file no. 15(11)60, Ministry of Finance, NAI.

Building Umiam Dam

The land where the Umiam Project was built was Khasi tribal land administered by an autonomous district council, under the provisions of the Sixth Schedule of the Indian Constitution. Under the traditional system of Khasi land ownership, this was *Ri-Kynti* (public) and *Ri-Raid* (clan) land. Except for a few parts previously acquired for the Gauhati-Shillong Road right-of-way, the land remained in tribal ownership and was not government land. Plans for the hydroelectric project called for inundating part of the Umiam River Valley, where Khwan (Barapani) and Umsaw villages were located. In total, about two hundred families would be forced to vacate their lands to make way for the reservoir, dam, and powerhouse.[60]

Initial surveys for the project began in the mid-1950s, but they were put on hold in October 1956. When Assam State Electricity Board picked up the investigations after its inception in June 1958, the residents of Khwan and Umsaw opposed the plan to flood their villages. In response, ASEB issued a public notice, printed in the *Assam Tribune*, justifying the project. ASEB listed the numerous benefits of the project—not just electricity but also irrigation, tourism, and pisciculture (fish farming), as well as creating jobs during construction. Even though the notice had an imploring prose style, ASEB claimed that it did not want to impose the project on the people. “In case the people do not want the Project, then the Project would not be taken up.”[61]

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60. M. Deka, notice of land acquisition in Shillong subdivision, November 16, 1959, in *The Assam Gazette*, November 18, 1959, 4089.

61. “Controversy over Barapani project: State Electricity Board clarifies position,” *AT*, October 27, 1958. Residents of other parts of Assam were unhappy that the power project was not built in their district. In the Assam Legislative Assembly on September 15, 1959, Radha Krishan Khemka of Tinsukia (upper Assam) suggested that a hydroelectric project be built on the Dihing River. “The Dihing River also has the capacity to produce a very big measure of electricity, and if electricity were produced from that river, then Tinsukia, Makum, and other places nearby would have convenient access to electric power. At this time,

Ultimately, the State Electricity Board had its way. On November 16, 1959, before the district council had given consent to the land acquisition, the Assam State Revenue Department issued a notice declaring that 2,400 acres of land in the Umsaw, Khwan, Mawlyndep, and Umniuh villages were "likely to be needed for a public purpose, viz., for the construction of Umniam [*sic*] Hydel Project by Assam State Electricity Board." Employees of the electricity board were authorized to enter the land and begin their surveys. A month later, on December 12, the tribal leaders, following the recommendation of an ad hoc committee, decided to acquiesce to the government and sell their land for the project.[62]

The people displaced by the project were set to receive compensation for the loss of their land. Policy for rehabilitation of displaced persons was developed in cooperation between the central and state governments. In 1957-58, the Commissioner for Scheduled Castes and Scheduled Tribes circulated recommendations among the state governments. One of the recommendations was that displaced persons should not be compensated in cash; instead, they should be "rehabilitated in well-planned colonies to be set up for this purpose." In its response to the recommendation, the Assam state government noted, "Government do not consider it desirable to segregate the Scheduled Caste and the Tribal people from the general communities lest it may defeat the aim of a classless society."

Tinsukia and Makum need about 6,000 KW of power. Hopefully the government will make the arrangements to fulfill this requirement." "Discussion on the budget of the State Electricity Board," *Assam Legislative Assembly Debates*, September 15, 1959, 237 (translated from Hindi by author).

62. M. Deka, notice of land acquisition in Shillong subdivision, November 16, 1959, in *The Assam Gazette*, November 18, 1959, 4089; "Barapani Hydel Project: Khasis now give consent," *AT*, December 17, 1958. In reporting on the decision of the tribal leadership to sell the land, the *Assam Tribune* mentions the key role played by Stanley Nichols-Roy, who mediated in the negotiations. Of mixed Khasi and American parentage, Nichols-Roy embodied a bridge between the traditional tribal and the modern industrialized worlds. Robert Gilkey, "Assam's 'weeping river' power project," *AT*, June 18, 1961.

This policy, while intended to improve the quality of life of the displaced people, nevertheless resembles coercive integration and assimilation programs undertaken by other governments against their tribal populations.[63]

The Umiam Project reservoir inundated four square miles of land at 3,000 feet elevation in the Khasi Hills north of Shillong. Before the construction of the project, the Umiam River flowed northward through a wide valley, then turned to the east and passed through a narrow ravine. The valley was inundated by the reservoir, and the ravine served as the site of the main concrete dam. Once completed, the dam had a maximum height of 254 feet above its lowest foundations. The maximum width at foundation level was 262 feet, and its length at the crest was 640 feet. In addition to the main dam, two lower earthen dams plugged other potential escape routes for reservoir water. These dikes were located at the northern end of the reservoir, separated by a naturally-occurring ridge. The longer of the dikes was 1,520 feet long and 122 feet high; the shorter was 550 feet long and 57 feet high.[64]

The main dam was built with two spillways, which occasionally released excess reservoir water into the main channel of the Umiam River. In normal usage, though,

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63. "Statement showing action taken or proposed to be taken on the recommendations made by Commissioner regarding the rehabilitation of Scheduled Caste and Scheduled Tribe persons displaced on account of construction of industrial and agricultural projects in various states," in L.M. Shrikant, *Report of the Commissioner for Scheduled Castes and Scheduled Tribes for the Year 1959-60*, Part II, 166. Contrary to the central government's recommendation, the Assam state government did pay out cash compensations to the people displaced by the Umiam Project. In March 1961, Kamakhya Prasad Tripathi, Minister of Power of the state government, claimed that ASEB had already paid out almost Rs 4 million in compensation. "Power projects in Assam; electricity board praised," *AT*, March 31, 1961.

64. Assam State Electricity Board, "Umiam Hydro-Electric Project," commemorative pamphlet, n.d. [1966], Office of Director (Generation), Meghalaya Energy Corporation Ltd., Shillong; "Barapani Hydro-Electric Project (Assam): Installation of IV Generating Unit," n.d. [August 1961], file no. 6(16)/61 vol. 3, Ministry of Finance, NAI; "Plans and Projects: Assam's Second Power Project," *Iron & Steel Review* 9 (1965), 25; "Umiam Hydel Project," *AT*, January 9, 1960; Robert Gilkey, "Assam's 'weeping river' power project," *AT*, June 18, 1961.

water was not released back into the Umiam River. Instead, water entered an intake at the northwestern end of the reservoir, then flowed through a 7,000-foot tunnel that passed under a ridge. At the end of the tunnel, the water entered two 1,800-foot steel-lined penstocks, which sloped down a hillside to the powerhouse. Traveling down the penstocks, the water lost 560 feet of elevation but gained a comparable amount of head (pressure). This arrangement of routing water through a tunnel allowed water to reach the turbines with higher head than if the powerhouse had been located at the foot of the dam.[65]

Although frost is not uncommon in the upper Khasi Hills during the winter, the climate is never quite cold and wet enough for snow. Therefore, the rivers of the Khasi Hills relied entirely on rainfall, which meant that their flows varied widely throughout the year. During the rainy season months, from April to October, the rivers ran high while draining some of the heaviest rainfall in the country. But during the dry season, with no rain to feed them, river levels sank considerably as aquifers drained. The Umiam Project offered a solution for the unreliability of the Khasi Hills' rivers. The reservoir, which would fill during the rainy season, could theoretically hold enough water to supply the project's turbines during the dry months. Furthermore, the reservoir could supply water to the Khasi Hills' first hydroelectric project, Umtru. A run-of-river project, Umtru Dam raised the level of the river just enough to produce sufficient head (or pressure) to turn the turbines, but it did not back the river up very much or impound a storage reservoir. Therefore, the Umtru power station relied on the seasonally variable flow of the Umtru

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65. Assam State Electricity Board, "Umiam Hydro-Electric Project," commemorative pamphlet, n.d. [1966], Office of Director (Generation), Meghalaya Energy Corporation Ltd., Shillong; "Umiam Hydel Project," *AT*, January 9, 1960.

River to turn its turbines. Downstream from the Umiam Project's powerhouse, water flowed into the Sumer Stream, a tributary of the Umtru River. The Umiam reservoir thus provided a consistent water supply for both the Umiam and Umtru hydroelectric projects.[66]

The Central Water and Power Commission created the plans for the Umiam Hydroelectric Project at its headquarters in New Delhi and analyzed the design at its laboratory in Poona. CWPC came into being in 1948, with the amalgamation of two institutions founded in the late colonial period, the Electric Commissioner's Office and Central Power Board. CWPC had the mandate to initiate and support, in cooperation with state governments, engineering projects for the use of national water resources for irrigation, navigation, electric power generation, and flood control. The commission was organized into three wings: Water, Power, and Flood. The Hydro-Electric Directorate of the Power Wing prepared the designs for Umiam and other hydroelectric projects built across India during the early-independence period.[67]

The Water Wing of CWPC, although primarily concerned with the irrigation projects that vastly outnumbered hydroelectric projects, also contributed to hydroelectric development. The Member (Design & Research) of the Water Wing oversaw the Central Water and Power Research Station (CWPRS) in Poona. The laboratory had originally been established in 1916 by the government of Bombay Presidency; later it was transferred to the central colonial government, then came under the purview of the

66. "Canada and the Colombo Plan: The Umtru Project," *External Affairs* 9 (Aug. 1957), 241-43; "Umiam Hydel Project," *AT*, January 9, 1960; "Umiam Hydel Project," *Indian Railway Gazette* 62 (Sept. 1964), 239.

67. K.C. Khatri, "Organisational Set-up of the Central Water and Power Commission," *IJPRVD* 9 (Sept. 1959): 45-49.

CWPC after independence. Over the decades before and after independence the laboratory grew to support full hydrodynamic model studies of dams as well as canals, ports, and bridges.[68]

The laboratory also supported other experimental methods for analysis of structures. For the Umiam Project, site geology required that part of the foundation would have to be built on sloped rock. This created particular problems in the analysis of the structure. To analyze the stresses that would develop in the dam, CWPRS employed isochromatics, in which a scaled cross-section of the dam was cut out of plastic and placed in a rig that put pressure on the test article to simulate the loading of the dam. In the test article, the loads produced tiny deformations in the plastic cross-section; when viewed through cross-polarized light, the deformations appeared as rainbow patterns. The patterns allowed the engineers of CWPRS to visualize the stresses developed inside the dam without employing long and costly numerical calculation methods.[69]

By 1960, when construction of the Umiam Project began, India already had an institution capable of designing hydroelectric projects without the need for hiring foreign consulting firms—namely, the Central Water and Power Commission. Assam State Electricity Board was also capable of implementing the project. DLF initially requested that ASEB employee foreign consultants to oversee the project in its entirety, but the Indian authorities, wary of the costs and confident in their own abilities, resisted; eventually DLF relented. ASEB did consider employing Japanese consultants for the

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68. "Introduction with Vision and Mission," *Central Water and Power Research Station*, http://cwprs.gov.in/Page/Introduction.aspx (accessed November 8, 2015).

69. C.L. Handa and B. Pant, "Role of Experimental Methods in the Solution of Foundation Problems," *Journal of the Indian National Society of Mechanics and Foundation Engineering* 4 (Jan. 1965): 18-21.

construction, because they would have experience with building in seismic zones. Japanese expertise also came into the project when T.K. Bandopadhyay and two other ASEB engineers traveled to Tokyo to receive training in the operation of the turbine-generators from the manufacturer.[70]

Apart from engineering degrees held by Indian participants in the project (Additional Chief Engineer (Civil) D.N. Dutta's was from the University of Colorado–Boulder), the main American technical contribution to the project was supplying instrumentation to monitor the dams and dikes. Professor Roy W. Carlson of the University of California–Berkeley contracted to supply the instrumentation. Since 1925, the MIT-educated professor had worked on dams in the United States and abroad. ASEB ordered $16,000 worth of instrumentation from the professor's catalog, including thermometers, strain gauges, and stress meters. Carlson traveled to Assam and oversaw this equipment's installation in the dam.[71]

Apart from instrumentation, the major American material contribution to the project was heavy construction equipment. By the late 1950s, Caterpillar, the American manufacturer of heavy machinery, had entered the eastern Indian market through its authorized dealer, Tractors (India) Ltd. The dealer staged programs in which its machines demonstrated earthmoving capabilities in front of potential buyers and their employees.

70. Sundarajan to C.S. Krishna Moorthi, November 9, 1960, file no. 15(11)60, Ministry of Finance, NAI; Agency for International Development, *Program and Project Data Related to Proposed Programs – FY 1967: Near East and South Asia* (Washington, DC: n.p., 1966), 71; T.K. Bandopadhyay, "Umiam Hydro-Electric Project: Efficiency Tests for Turbines," *IJPRVD* 17 (May 1967): 13-16, 25; "Barapani Hydel Project: Jap firm to supply turbines," *AT*, May 16, 1961.

71. Robert Gilkey, "Assam's 'weeping river' power project," *AT*, June 18, 1961; Acceptance of tender, India Supply Mission to Roy W. Carlson, August 8, 1961, file no. 15(11)60, Ministry of Finance, NAI; Assam State Electricity Board, "Umiam Hydro-Electric Project," commemorative pamphlet, n.d. [1966], Office of Director (Generation), Meghalaya Energy Corporation Ltd., Shillong. A seismograph was also installed at the dam site. A.N. Tandon and H.M. Chaudhury, "A Report on the Seismicity Studies by the Indian Meteorological Department," *Symposium on Earthquake Engineering* (1966): 34-43.

When the Umiam Project construction began, Bahri & Co., a private concern, received a contract to construct the earthen dikes at the northern end of the reservoir. The company had already purchased some Caterpillar D 8 tractors and DW 21 scrapers, which now needed to be overhauled with spare parts. ASEB requested to use the DLF loan for the parts, and DLF agreed. Furthermore, since the parts to be imported were proprietary, the Indian authorities requested an exemption of the small business notification clause, which DLF granted.[72]

ASEB also ordered new construction equipment from the United States for the dams. A ten-ton movable crane was sold to the project by Rocky Mountain Export Co. of Colorado. Caterpillar supplied several more machines to the project, including two D 8 tractors, three 619 scrapers, and three D 4 tractors. Other American-sourced equipment included drilling sets and an ammonia printing and developing machine for making blueprints.[73]

Most of the imported machinery and equipment actually installed in the project came from third countries, as the purchases fell under the $50 million limit allowed between the eight loans. The four turbine-generators came from Japan, as well as 132 kV insulators. Companies in Britain supplied testing equipment and cables for the transmission lines. A testing generator and transformer came from Austria. Germany supplied DC ammeters, France transmission line erection tools, and Sweden switchgear.[74]

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72. "Technical Notes and News: New Caterpillar Equipment," *IJPRVD* 11 (Feb. 1961): 31-32; K.P.S. Nair, memo, December 5, 1960, file no. 15(11)60, Ministry of Finance, NAI; M. Gopalakrishnan, memo, January 10, 1961, ibid.; K.V. Rajagopalan to DLF Loan Services Staff, February 21, 1961, ibid.

73. T.V. Thadani to C.L. Garg, August 28, 1962, file no. 15(11)60, Ministry of Finance, NAI; Daya Shankar to ASEB Chief Engineer (Hydro-Electric), May 4, 1961, ibid.

74. T.V. Thadani to C.L. Garg, August 28, 1962, file no. 15(11)60, Ministry of Finance, NAI; Daya Shankar to ASEB Chief Engineer (Hydro Electric), August 7, 1961, ibid.

Apart from specialized machinery, the material used in the dams was sourced from India. The cement came from Bihar, and the aggregate came from a quarry near the project site. The laborers were also Indian, and unlike the Brahmaputra Bridge project, the Umiam Project employed local labor as well as skilled laborers brought in from other parts of the country. ASEB housed the laborers in two purpose-built colonies—a large one at the concrete dam site and a smaller one near the powerhouse. After the completion of construction, the colonies were converted into housing for the operators of the dam and powerhouse. Despite the heavy machinery imported from the United States, thousands of laborers performed tasks by hand that, in a comparable project in the West, would have been mechanized. This included stripping the foundation to bedrock and prying out loose rocks with hammers and chisels. In addition to common hazards of heights and blasting faced by workers at any construction site, the laborers at the Umiam Project faced further dangers in the Khasi forests. In December 1960, a tiger mauled three project workers, one seriously. The local authorities employed a *shikari* (big-game hunter) and some soldiers to track down and kill the tiger.[75]

Before the construction of the Umiam Project, generation and use of electricity in Assam was localized, with diesel generating stations providing power directly to the cities and towns they served. The only major power station was Umtru Hydroelectric Project, which served Gauhati through a short transmission line. As part of the Umiam Project, ASEB built transmission lines that stretched across lower Assam. The lines used

75. Robert Gilkey, "Assam's 'weeping river' power project," *AT*, June 18, 1961; "Progress of Umiam Hydel Project: Commission expected next year," *AT*, May 16, 1962; "Tiger mauls three Umiam employees," *AT*, December 12, 1960; Assam State Electricity Board, "Umiam Hydro-Electric Project," commemorative pamphlet, n.d. [1966], Office of Director (Generation), Meghalaya Energy Corporation Ltd., Shillong.

imported British wires as well as domestic wires produced by Aluminum Industries Ltd., a private-sector firm headquartered in Hyderabad. Major lines with a voltage of 132 kV ran from the powerhouse at Sumer up to Shillong and down to Gauhati via Umtru powerhouse. Lesser lines of 33 kV extended the network from Shillong to Cherrapunjee on the southern side of the Meghalaya Plateau overlooking East Pakistan. This was a dual circuit line, with telephone cables strung alongside the first circuit. These lines were the first to be built for the project. In later expansions of the transmission network, lines reached to Namrup in upper Assam, where a 69-MW gas-turbine generating station was built concurrently with the Umiam Project. Wires strung from towers built on ridges upstream of Saraighat Bridge stretched 6,295 feet across the Brahmaputra, carrying power to the towns on the north bank of the river.[76]

Although originally scheduled for completion in early 1963, expansion of the project and delays in receiving certain key components pushed the commissioning of the Umiam Hydroelectric Project back to 1965. By the time the fourth turbine, which had been bought with Japanese financing, came online on September 11, 1965, the project had a potential capacity of 36 MW. Over the next twenty-seven years, the construction of three additional stages downstream from the original powerhouse extracted more power from the water of the Umiam River as it flowed down toward Umtru powerhouse. Stage II again used Japanese turbines, but the third and fourth stages used turbines built

76. Citation: M.R. Sitaram, "Report on the transmission line Umiam (Barapani) Project," n.d. [April 1961], file no. 15(11)60, Ministry of Finance, NAI; K.P.S. Nair to C.L. Garg, July 31, 1961, ibid.; "Break down cost of equipment & labour per mile of … double circuit line…" n.d., ibid.; "Now…to Umiam Project," *Andhra Pradesh*, August 1965, 33; Assam State Electricity Board, "Umiam Hydro-Electric Project," commemorative pamphlet, n.d. [1966], Office of Director (Generation), Meghalaya Energy Corporation Ltd., Shillong; A.K. Ganguly, "Major Power Stations in Assam," *IJPRVD* 19 (Aug. 1969): 342-344.

domestically by Bharat Heavy Electricals, Ltd. When Stage IV came online in 1992, the combined Umiam-Umtru project had a potential capacity of 185.2 MW, four times their original combined capacity.[77]

The Umiam environment

More than any of the other technologies studied in this dissertation, dams and the reservoirs they create have the potential to alter the environment drastically. Umiam Lake was created during a period that Ramachandra Guha has called an "age of ecological innocence." In the first two decades after Indian independence, the environmental consequences of the large development projects were secondary in planners' minds to the great benefits that these projects would produce. This was the case for Umiam Dam. Before construction began, ASEB's notice advocating the project listed its benefits as power, irrigation, tourism, and pisciculture. The notice did not even hint at potential negative consequences of the project.[78]

The only consequence that received any mention in the documents of the 1950s and 1960s was the loss of agricultural land under the reservoir. The construction of the lake also flooded 3.5 miles of the Gauhati-Shillong Road, which originally ran through the Umiam Valley beside the river. The Assam Public Works Department constructed a diversion of the highway that ran higher on the hillside and crossed the concrete dam and

77. Meghalaya Energy Corporation Limited, "Existing power stations," http://meseb.nic.in/network.htm (accessed April 18, 2012); Agency for International Development, *Program and Project Data Related to Proposed Programs – FY 1967: Near East and South Asia* (Washington, DC: n.p., 1966), 71; Uttama Choudhury, "River Umiam and Its Role in Hydro-Electricity Generation, Tourism, and Industrial Growth," in *Rivers and Riverine Landscape in North East India*, ed. S. Sengupta, et al. (New Delhi: Concept Publishing, 2006), 138; Meghalaya Energy Corporation Limited, "Stage IV power station," http://meseb.nic.in/psstage-iv.htm (accessed April 18, 2012).

78. "Controversy over Barapani project: State Electricity Board clarifies position," *AT*, October 27, 1958; Ramachandra Guha, *How Much Should a Person Consume? Thinking Through the Environment* (Gurgaon: Hachette India, 2010), 45.

the larger of the earth dikes. This new section of road had two lanes, one for each direction. Concurrently with the diversion of the highway, the PWD began rebuilding the rest of the highway to two-lane width. Funds for road construction were tight, though, and it was not until the Fourth Five-Year Plan that the PWD was able to finish the two-laning work and abolish the system of gate timings on the highways.[79]

In the 1980s, the government first started to pay attention to Umiam Lake as an ecosystem. R.N. Bhattacharya of the Central Board for the Prevention and Control of Water Pollution, in cooperation with the Assam State Pollution Control Board, studied the water quality of the lake. Bhattacharya collected samples from the lake and its tributaries, then took the samples for analysis to the Public Analyst laboratory of the Assam state government. The report stated clearly that the lake was produced solely for the purpose of hydroelectric generation, and therefore protection of the lake's environment would be secondary to the lake's primary purpose. Only later did biologists and environmental scientists study the plant and animal life of the lake.[80]

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79. "Progress of Umiam Hydel Project: Commission expected next year," *AT*, May 16, 1962; Government of Assam Public Works Department, "Report on the Administration of Public Works Department (Roads & Buildings Wing), Assam for the Year 1963-64," Assam State Archives; Raghuraj Singh, "Additional allocation for the Third Five Year Plan to Assam Government," memo, August 2, 1962, file no. WI-33(6)/62, Ministry of Transport, NAI.

80. Central Board for the Prevention and Control of Water Pollution, *Environmental Status: Barapani Lake, Meghalaya* (New Delhi, n.d. [1982-83]); Bashida Massar, Sudip Dey, and K. Dutta, "An Electron Microscopic Analysis on the Ultra Structural Abnormalities in Sperm of the Common Carp *Cyprinus carpio L.* Inhabiting a Polluted Lake, Umiam (Meghalaya, India)," *Microscopy Research and Technique* 74 (Apr. 2011): 998-1005.

Figure 10. The polluted Umkhrah River on the north side of Shillong in 2015. (Photo by the author.)

Umiam Lake receives drainage from a catchment area of 85.5 square miles in the Khasi highlands. The city of Shillong is located at an elevation of 4,900 feet within this catchment area. Two rivers flow through Shillong, both joined on their way by innumerable smaller tributaries and drains. The Umkhrah River (Figure 10), on the northern side of the city, is separated from the Umshirpi River to the south by a ridge where the main bazaars and government buildings are located. West of Shillong, the Umkhrah and Umshirpi join to form the Roro River, which subsequently flows into the Umiam River.[81]

The Shillong town plan creates particular problems in terms of water pollution.

81. H.B. Gupta, "Power Development in Assam," *IJPRVD* 12, no. 9 (Sept. 1962): 2; Central Board for the Prevention and Control of Water Pollution, *Environmental Status: Barapani Lake, Meghalaya*.

The town's hilly geography and patchwork of tribal lands have mitigated against the construction of a municipal sanitary sewer. Septic tanks collect sewage from homes and businesses, and municipal workers or contractors carry the waste away in trucks for treatment. When tanks leak or are not emptied properly or on time, the sewage finds its way into the Umshirpi or Umkhrah Rivers, and thence into Umiam Lake. Garbage and pollutants from motor vehicles also wash into the rivers. Apart from Shillong, another significant source of pollution in the lake is the practice of *jhum* (slash-and-burn) cultivation, which removes vegetation cover on hillsides, thus leading to erosion. The central government's study of the lake in the early 1980s concluded that the water was of class C quality, which meant that it would need to be both conventionally treated and disinfected before being used as a potable water source. A later study, published in 2011, studied the effects of the pollution on the lake's most numerous fish, the common carp (*Cyprinus carpio*). The study found that pollution had caused the fishes' sperm to have folded tails, thereby adversely affecting their reproductive capabilities.[82]

Even before construction of the Umiam Project began, one of the secondary uses of Umiam Lake foreseen by Assam State Electricity Board was recreation. It was not until decades after the reservoir's completion, though, that the state government and private industry began to develop any recreational facilities at the lake. Motorists driving up from Gauhati appreciated the scenery as the national highway passed by the lake, but there was no other way to use the lake recreationally. This began to change in the 1980s. The first recreational facility constructed was the Lake View Cottage, managed by Hotel

82. Amitangshu Acharya, "Umiam, Shillong's 'wasted' pride," *Calcutta Telegraph*, September 30, 2009; Central Board for the Prevention and Control of Water Pollution, *Environmental Status: Barapani Lake, Meghalaya*; Massar et al., "An Electron Microscopic Analysis," 998, 1001.

Figure 11. View of the picnic area and boat ramp of the Water Sports Complex at Umiam Lake in 2015. (Photo by the author.)

Pinewood Ashok, one of the premier hotels of Shillong. Later came two more extensive and widely accessible recreational facilities operated by different departments of the Meghalaya state government, Lum Nehru Park and the Orchid Lake Resort and Water Sports Complex.[83]

Lum Nehru Park (Nehru Hill Park), which opened in 1990, is operated by the Wildlife Wing of the State Forest Department. The park is located on a plateau north of the Umiam gorge. The plateau falls off toward what used to be the floor of the valley, and is now flooded by the lake. At the bottom of the park, near a viewpoint overlooking the lake, a stern-faced statue of Jawaharlal Nehru stands on a black pedestal. The statue commemorates Nehru's inaugurating the Umiam Project at this place in 1960, although visitors are left to draw their own conclusions as the pedestal has no inscription. Higher

83. *A Guide to Shillong and the Neighbourhood* (Gauhati: Spectrum Publications, 1983), 13.

up, closer to the entrance of the park, the dedication plaque of the Umiam Hydroelectric Project, originally laid by Nehru, is set in a red stone monument. The plaque's inscription is in English, and it states the name of the project, the identity of the inaugurator (Nehru), and the date (January 9, 1960). Along the south side of the park, above the Umiam gorge, trees screen the view of the back side of the dam. The state government, concerned about security, has a no-photography policy for the dam. Visitors who come to the park can appreciate views of the lake and the pine-forested hills beyond, but they cannot get a good view of the dam that created the lake.

To the north of Lum Nehru Park is the Orchid Lake Resort and Water Sports Complex, both operated by Meghalaya Tourism Development Corporation Ltd. (Figure 11). The facility was designed by modern Indian architect Charles Correa, whose other works included the Life Insurance Corporation Building in New Delhi and the cultural center Jawahar Kala Kendra in Jaipur. Correa drew inspiration for many of his designs from *vastu vidya*, traditional Indian architectural practices. *Vastu vidya* designs are based on square grids of nine or more parts, known as *mandalas*. Correa's designs often made heavy use of squares, and Orchid Lake Resort was one such design. The cabins and picnic shelters of the facility all have square floorplans and roofs shaped like truncated pyramids with a cube on top. At the Water Sports Complex, visitors eat at the snack bar, picnic with their own food, and take boat rides in the lake. Swimming in the lake's polluted water is out of the question, but there is a boat ramp where visitors can wade out into the water.[84]

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84. Madeline Tham, "Charles Correa and the Shillong connection," *Shillong Times*, June 21, 2015; Vibhuti Sachdev, and Giles Tillotson, *Building Jaipur: The Making of an Indian City* (London: Reaktion, 2002), 169.

The Umiam Hydroelectric Project was not built to be multipurpose. Assam State Electricity Board built the project for the sole purpose of generating hydroelectricity. The secondary uses that ASEB proposed for the project—recreation, irrigation, and pisciculture—were low priorities compared to hydroelectricity. Over time, interested parties apart from the state electricity board found additional uses for the lake. Although Umiam Lake has never been used for irrigation, tourists visit it, and fishermen (ignoring the pollution) harvest the fish that live in the lake.[85]

Conclusion

When Stage I of the Umiam Project came online in 1965, Assam State Electricity Board hoped that the 36 MW offered by the project would attract industrial development to the state. At first, though, the project offered too much power. Along with Namrup gas plant, the Umtru project, and diesel generating sets, ASEB produced 160 MW of power. An article in *Indian Engineer* in March 1965 reported that the electricity board had found buyers for only 60 MW, thus leaving more than half of the grid's capacity unsold. The anticipated industrial investment was slow to materialize. The article attributed sluggish investment to fears of further Chinese incursions into northeast India. B.C. Kapur, chair of the electricity board, told the press that he expected industrial investment and demand for power to pick up soon.[86]

Kapur was more than proven correct over the following decades, when rising demands for power shot past the state electricity board's ability to generate power. The

85. Amitangshu Acharya, "Umiam, Shillong's 'wasted' pride," *Calcutta Telegraph*, September 30, 2009.

86. "Barapani Hydro-Electric Project's Progress," *Indian Engineer*, March 1965, 34-37.

construction of three additional stages of the Umiam Project led to a fivefold increase in generative capacity, but this was not enough to keep up with rising demand. When it split off from Assam State Electricity Board in 1975, Meghalaya State Electricity Board generated surplus power that it could sell to neighboring utilities. Since then, industrial development, population growth, and the escalating wants of the privileged classes have created demands for power that the state grid cannot meet. Meghalaya Energy Corporation Ltd., the public-sector electric utility that now operates the Umiam Project, has to pay heavily to buy electricity from the North Eastern and national power grids. Even this is insufficient; at times of peak power demand, particularly in the summer months, the utility must cut power to selected areas. These scheduled blackouts, known as load shedding, have become a fact of life in areas served by power from the Umiam Project.[87]

Hydropower generation in the Meghalaya Plateau is a microcosm of hydroelectric ambitions and realities around the world. Indian planners saw the gold standard of hydroelectric development, the Tennessee Valley Authority, as proof that large-scale, government-directed hydro projects could bring clean, cheap power to an area that had little, thereby stimulating industrial expansion and economic growth. For TVA, though, the surplus of cheap hydroelectricity only lasted so long. Once the Tennessee River and its major tributaries had been dammed from one end to the other, TVA had to start building fossil-fuel plants, and later nuclear plants. Similarly, India's first TVA clone, Damodar Valley Corporation, after constructing three hydroelectric projects in the 1950s,

87. "Demand of Power in Meghalaya," *Meghalaya Energy Corporation Limited*, http://meecl.nic.in/demand.htm (accessed November 6, 2012); Uttama Choudhury, "River Umiam," 136; "No immediate load shedding in state: MeECL," *Shillong Times*, October 8, 2012.

switched to building thermal plants in the 1960s. Hydroelectricity has therefore proved to be less effective than the planners anticipated. Hydroelectric projects carried early stages of industrial expansion, but eventually the industry outgrew limited hydroelectric resources. Some utilities began to focus on different forms of generation. Others, such as the state utility of Meghalaya, have bought power from elsewhere, or simply made do with generative capacity that falls short of demand.[88]

Umiam Lake remains a part of the life of Shillong. The city's main English-language newspaper, *Shillong Times*, prints reservoir levels on its front page each day. The newspaper has carried several alarmist articles and letters to the editor portending the imminent demise of the lake and the power project, unless the authorities take immediate action. Siltation of the lake is one problem identified. When the water level sinks in the dry season, shoals appear in the lake. In November 2011, *Shillong Times* reported another problem: the penstocks for the Stage I powerhouse had developed a leak, and the turbines were missing out on "gallons of water." The state government reported that it would investigate the leak, as well as other mechanical problems with the project. The state utility has since launched a major refurbishment program for Umiam Stage I, in collaboration with Japanese consultants. Japanese industry provided the original turbine-generators in the 1960s, and now a half-century later, Japanese expertise is again being called on to extend the life of the project.[89]

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88. Patricia Bernard Ezzell, "Tennessee Valley Authority," *Encyclopedia of Alabama*, http://www.encyclopediaofalabama.org/article/h-2380 (accessed December 3, 2015); "Generating units," *Damodar Valley Corporation*, http://www.dvc.gov.in/dvcwebsite_new1/generating-units/ (accessed December 3, 2015).

89. Paramita Sarma, letter to the editor, *Shillong Times*, March 17, 2014; "Leakage in Umiam power house," *Shillong Times*, November 1, 2011; "Govt looking into water leak at Umiam, says Mondal," *Shillong Times*, November 9, 2011. In a letter to the editor, Eladbor Laloo argued that the silting of the lake was actually keeping the dam from leaking. After forty-five years, the cementing material behind the dam

The Umiam Hydroelectric Project represents a transitional stage in the industrialization of India. When Assam State Electricity Board built the first stage of the project in the 1960s, the institutions for designing hydroelectric plants were already established in India. ASEB only needed limited foreign technical assistance for the peculiar problems of building and monitoring a dam in such a seismically active area. But even though expertise was present in India, equipment (with a few exceptions) and capital were not. With foreign financing, the project imported construction machinery, turbine-generators, transformers, and other specialized equipment. But from beginning to end, Umiam Stage I was designed and implemented by Indians.

Since 1965, Indian industry has developed the capability to produce most of the machinery and specialized equipment that had to be imported for Umiam Stage I. Public-sector Bharat Heavy Electricals Ltd. manufactures turbine-generators, transformers, switchgear, and other equipment needed for hydroelectric plants. Another public-sector firm, Bharat Earth Movers Ltd. makes heavy machinery for construction projects. In addition, private-sector foreign companies such as JCB, Caterpillar, and Hyundai produce construction equipment at factories in India. Because of this industrial growth, Meghalaya State Electricity Board, the successor of ASEB, did not have to import turbines during the construction of the third and fourth stages of the Umiam Hydroelectric Project; the board could buy Indian.

Between the Third Five-Year Plan period and now, India has become less dependent on imported machinery. But the goal of technological independence remains

had begun to degrade, but silt was plugging the gaps. "What ails the Umiam Reservoir?" *Shillong Times*, November 27, 2012.

elusive. Despite the expansion of industrial capacity, foreign expertise remains important in India. Not only do foreign specialists still assist in the transfer of new technologies to India, they also continue to advise the people who operate and maintain projects like Umiam Stage I, built with foreign assistance a half-century ago.

Figure 12. The main gate of the Tarapur Atomic Power Project site, ca. 1969. The ventilation stack and reactor building are visible in the background. (Source: Photographs of Assistance Programs in Foreign Countries, RG 286-CP, NARA.)

Chapter 4: Tarapur Atomic Power Project

By the beginning of September 1965, the west coast monsoon had receded, giving the personnel building Tarapur Atomic Power Station a chance to increase the pace of the work. The daily torrential downpours of June, July, and early August had let up, and the Arabian Sea had stopped lashing the coastline. The effects of the monsoon had been planned into the construction schedule by General Electric, the primary contractor, and Bechtel, the main construction subcontractor. The construction of Tarapur, the first commercial nuclear powerplant built in India, was on schedule.

The station, which was being built on the Indian west coast sixty-five miles north of Bombay, was starting to take shape. One year after the first work had begun on the site, the main plant buildings were starting to rise above the ground. On the eastern side, farthest from the water, the concrete walls of the reactor building had risen as high as forty feet above the ground in some places; reinforcing bars sprouting from the tops of the wall indicated that they were far from complete. Standing in the middle of the reactor building were two large steel spheres. These were the drywells, containment vessels that would house the station's twin reactors, to be installed at a future date. The drywells had been fabricated in pieces by Chicago Bridge & Iron Co. in Greenville, Pennsylvania, then shipped to Bombay, transshipped to Tarapur, and assembled on-site with the help of a towering derrick crane standing on the west wall of the reactor building.

West of the reactor building, the turbine-generator building was also taking shape, although its walls had risen only fifteen feet above grade. Farther west still, workers had begun excavating a canal that would bring cooling water from the sea to condensers located in the turbine-generator building. Also on the site, a crew had begun preparing a landing slip that small ships could use for delivering the reactor cores and other heavy and unwieldy equipment directly to the project site, bypassing the port at Bombay entirely. Other parts of the site had yet to have any work done on them. The foundation for the administration building had not yet been excavated, and little work had been done on the transmission lines and switching yard that would tie the electrical grids of Gujarat and Maharashtra together. According to the schedule, the project would not be completed for another three years.[1]

1. GE, TAPS monthly report 15, August 1965, box 21, USAID Closed Project Loan Files 1960-1971, RG 286, NARA.

In the first days of September 1965, planes from the Indian and Pakistani air forces began clashing along the border between the two countries. On September 6, the conflict turned into open war. As Indian and Pakistani planes attacked cities and airfields in each other's territory, local governments on both sides of the border responded by enacting blackout regulations. In Maharashtra, the cities of Bombay and Poona closed cinema halls at 6:00 every evening. Also in Maharashtra, Tarapur Atomic Power Project (TAPP) observed a blackout as well. Situated as it was on the Indian west coast, the site was vulnerable to attack by the Pakistan Air Force (PAF). The closest PAF base to Tarapur was Mauripur, five hundred miles away in Karachi—well within the range of Pakistan's American-made B-57 Canberra bombers. Starting on September 7, the TAPP authorities shortened the second shift, eliminating all work during night hours. From September 16 until the ceasefire on September 22, they canceled the second shift entirely.[2]

Although PAF planes never attacked Tarapur, the conflict nevertheless affected the project directly. At the outbreak of fighting, two American cargo ships carrying parts for the Tarapur project happened to be docked at Karachi harbor: SS *Express* and SS *Steel Vendor*. When the fighting began, Pakistani authorities boarded the ships and ordered that their cargoes be unloaded in Karachi. *Steel Vendor* carried only a few easily replaceable parts for the project, such as steel plate for lining the suppression pool. On the other hand, the cargo hold of *Express* contained twenty-five tons of materials for the drywells, including a specialized hatch known as the personnel lock. Despite the

2. GE, TAPS monthly report 16, September 1965, box 21, USAID Closed Project Loan Files 1960-1971, RG 286, NARA; TAPP quarterly report 4, July-September 1965, box 20, ibid.

protestations of the ships' crews, the Pakistani authorities confiscated the parts destined for Tarapur before sending the ships on their way.[3]

Diplomatic channels failed to get the parts returned, and the project authorities were forced to reorder the parts from the United States. The drywell components were critical-path parts, which meant that the construction schedule depended on their timely delivery and installation. GE estimated that the seizure of the parts would delay the project three to five months. This estimate was unnecessarily dire. Ultimately, reinstitution of the second shift after the ceasefire and expansion of the workforce put the project back on schedule. Although the 1965 Indo-Pakistani War did not leave a lasting mark on Tarapur, the war's temporary effects on the project illustrate the complex interplay between technology and international relations in South Asia during the Cold War.

The construction of Tarapur Atomic Power Station (TAPS) is an important episode in the industrialization and modernization of India during the late-Nehruvian period. As a foreign-financed project built with foreign expertise and with a large portion of foreign parts, Tarapur represents an extreme end of the indigenization of technology spectrum. Whereas Saraighat Bridge was an essentially Indian project that used small amounts of imported materials and relied on limited foreign expertise, Tarapur Atomic Power Station was a foreign technological system adapted—largely by foreign experts—to the Indian environment. Promotional literature describes Tarapur as a "turn-key project," as if the only Indian contribution to the project was to receive the completed station and turn a key to start it running. While this is not entirely true—India's

3. GE, TAPS monthly report 16; TAPP quarterly report 4.

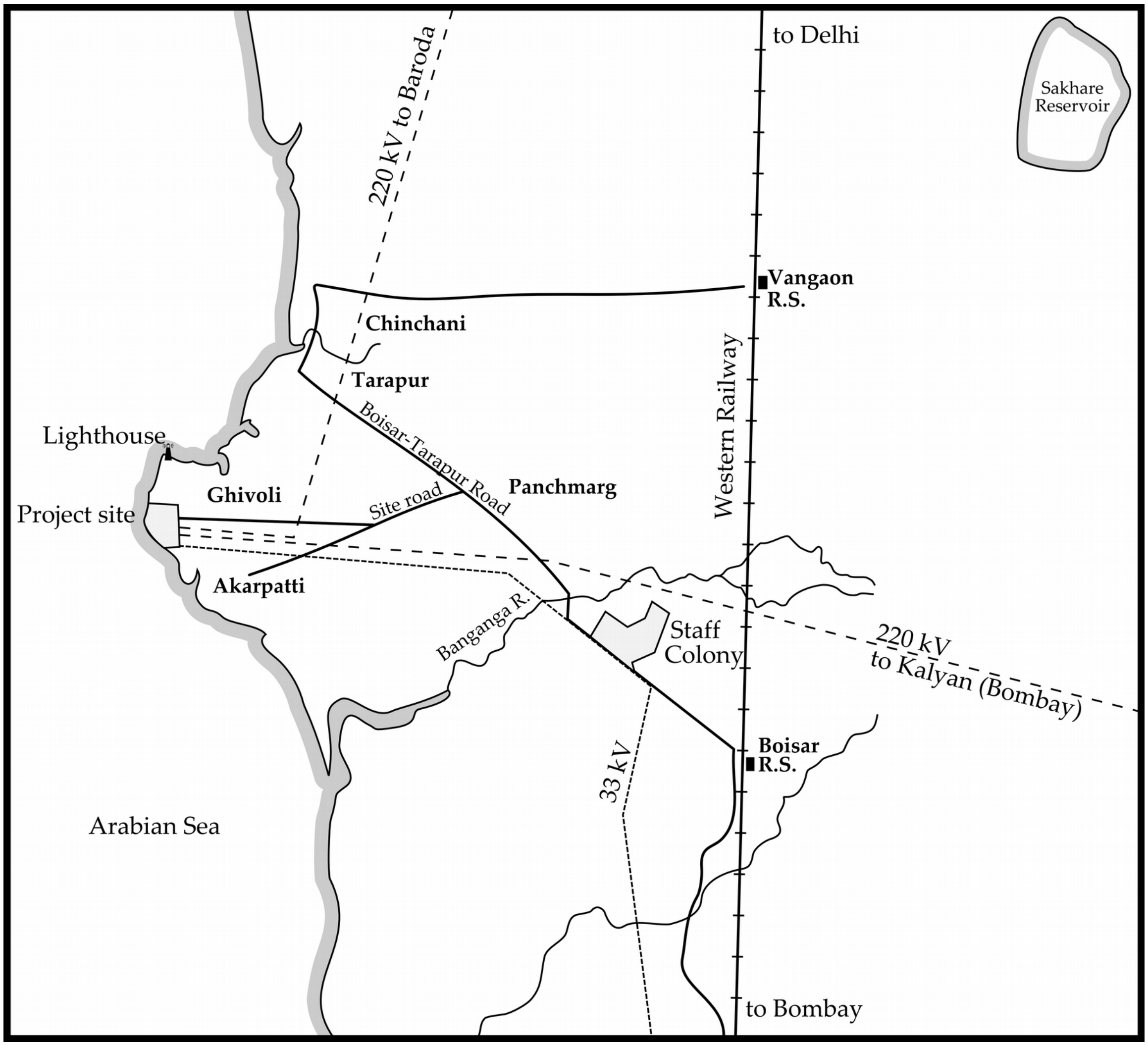

Figure 13. Map of the North Konkan Coast around Tarapur. (Map drawn by the author, based on map in M.N. Chakravarti and M.R. Srinivasan, "Selection of Site for the Tarapur Atomic-Power Station," in International Atomic Energy Agency, Siting of Reactors and Nuclear Research Centres (Vienna: International Atomic Energy Agency, 1963), 457-65.)

contribution of land, materials, labor, and expertise was considerable—the "turn-key" idiom vividly expresses the un-indigenous nature of the project.

Tarapur Atomic Power Station was not simply a foreign imposition. The Government of India initiated the project in hopes that it would meet immediate Indian needs for expanded electric generation capacity. The Tarapur project also had broader significance: India's modernizing elites hoped that the installation of a foreign power reactor on Indian soil would be a step toward indigenizing nuclear power technology. In order to escape their past status of colonial dependence, the builders of modern India wanted to attain technological autarky. Thus, indigenization of nuclear power technology was yet another episode of this decades-long, and still unfinished, project.[4]

The Tarapur project highlights several key themes from this period. The first is the role of foreign aid. Although Tarapur was just one of several Indian power projects financed by the United States in the early 1960s (Umiam Hydroelectric Project, described in Chapter 3, was another), it received especially focused attention in national and international news. The governments of both India and the United States gave priority to parts and personnel needed for this project. The US government considered Tarapur a prestige project, the flagship of benevolent American plans to help India and other former colonies transform themselves into modern nations with industrial economies. The Indian government also considered Tarapur to be a prestige project; by adopting nuclear power, one of the highest-of-high western technologies, India was demonstrating that the nation had become modern at last.[5]

Ultimately, the technology contained in Tarapur Atomic Power Station came to be of only limited use in modern India. In 1973, four years after Tarapur was completed, the first reactor of a second foreign-designed nuclear powerplant came online: Rajasthan Atomic Power Station (RAPS) on the shore of Rana Pratap Sagar near Kota. RAPS was

4. David Edgerton discusses autarky in a global context in *The Shock of the Old: Technology and Global History Since 1900* (Oxford: Oxford University Press, 2007), 117-19.

5. An earlier Indian prestige project was Bhakra Dam. Ellsworth Bunker referred to Bhakra as such in a letter to Adolph Ackerman, December 15, 1959, box 3, USAID Mission to India Subject Files 1955-1962, RG 286, NARA.

supported by the Dominion of Canada and used Canadian-style CANDU (pressurized heavy-water) reactors. India's third nuclear powerplant, Madras Atomic Power Station (MAPS), used the country's first indigenous commercial power reactors; the first unit came online in 1984. MAPS and all subsequent Indian nuclear plants have followed the lead of RAPS by using pressurized heavy-water reactors (PHWR), rather than the American-style boiling-water reactors (BWR) used at Tarapur. In 2005 and 2006, when the third and fourth reactors at Tarapur came online in a new, greatly enlarged plant facility, the new reactors were PHWRs. American-style reactors thus were a technological dead-end in India.

On a larger scale, nuclear power itself in India has been of only limited use. Even in the twenty-first century, the percentage of India's electricity generated by nuclear stations remains in the single-digits—below hydropower and far below fossil fuels. In France, nuclear energy came to supply the majority of the country's electricity and also become an integral part of national identity. In India, by contrast, nuclear power failed to have much influence on either front.[6]

The nuclear age and independent India

Nuclear technology is one of the few aspects of post-independence Indian technology that has attracted considerable scholarly attention, although this interest mainly focuses on the Indian atomic bomb project. The first Indian atomic bomb exploded under the Rajasthan desert on May 18, 1974. The Indian government claimed that the explosion should not be considered a bomb test; it was part of a program to use

6. Gabrielle Hecht, *The Radiance of France: Nuclear Power and National Identity after World War II* (Cambridge, MA: MIT Press, 1998).

nuclear explosions for non-military purposes such as earth-moving and mining. The government accordingly dubbed the test "Peaceful Nuclear Explosion" (PNE). Domestic and international observers, though, quickly perceived that the test was part of a weapons program.[7]

Ever since 1974, scholars in India and the West have been fascinated by the question of how India was able to develop one of the twentieth century's highest of high technologies less than thirty years after independence. As Itty Abraham notes, no nation's nuclear program was completely domestic; every program relied on technical input from other countries. During the Cold War, the Soviets contributed to the Chinese program, and scientists from all over the world received training in nuclear physics at American universities. India was no exception.[8] Nevertheless, India's making a bomb was a distinctive accomplishment. Like India's first satellite launch eight years later, the PNE was an expression of Indian modernity and a sign that India had joined the ranks of the world's most technologically sophisticated nations.

India became independent at the beginning of the atomic age, just two years after the two bombs dropped on Hiroshima and Nagasaki provided a devastating demonstration of the power of nuclear technology. Not wanting to be left behind in the race to exploit this new technology, the Government of India founded the Atomic Energy

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7. Although deliberately misleading, the Indian government claim was not as preposterous as it might now seem in the twenty-first century. From the late 1950s to the early 1970s, the US Atomic Energy Commission proposed employing nuclear explosions in large civil engineering projects such as forming an artificial harbor in Alaska or excavating a section of the Tennessee-Tombigbee Canal in Mississippi. Although these schemes were never executed, the AEC did perform a series of nuclear tests under the code-name Project Plowshare (a reference to Isaiah 2:4: "They shall beat their swords into plowshares, and their spears into pruning hooks"). See Scott Kirsch, *Proving Grounds: Project Plowshare and the Unrealized Dream of Nuclear Earthmoving* (New Brunswick, NJ: Rutgers University Press, 2005).

8. Itty Abraham, *The Making of the Indian Atomic Bomb: Science, Secrecy, and the Postcolonial State* (London: Zed Books, 1998), 9.

Commission in 1948. In 1954, the Department of Atomic Energy (DAE) was founded as a branch of the Atomic Energy Commission. The same year, DAE established its first dedicated atomic research laboratory, Atomic Energy Establishment, Trombay (AEET) in Bombay, under the leadership of Dr. Homi Jehangir Bhabha.[9] The first nuclear reactor built in India, Apsara, was a small 1-MW swimming pool-type reactor that first went critical at Trombay in 1956. In this reactor type, the entire reactor assembly is submerged in a tank of water. This arrangement shields the surroundings from radiation but also allows for easy access and servicing. Swimming pool-type reactors are too small to use for commercial power generation; Apsara served as a research reactor for fifty-four years, until its final shutdown in 2010.

In 1955, Canada signed an agreement to provide India a 40-MW reactor under the Colombo Plan. The reactor, dubbed Canada–India Reactor or CIRUS, used natural uranium as fuel and heavy water as a moderator. The first loading of fuel also came from Canada, and the United States supplied the heavy water. Both uranium and heavy water production were later indigenized, so by the mid-1960s, the reactor was running without any foreign input. CIRUS was a degree of magnitude larger than Apsara, but still suitable only for research. It also produced plutonium, and under the Indo-Canadian agreement, the Indian government did not have to account for how this plutonium was used. To the distress of Canada's leaders, the Canadian reactor evidently supplied fissile material for the PNE.[10]

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9. A Cambridge-educated physicist, Bhabha found that he could not break the colonial glass ceiling and so decided to return to India where he would receive more support. After his death in a plane crash in 1966, AEET was renamed Bhabha Atomic Research Centre (BARC). Itty Abraham deconstructs Bhabha's legacy in *Making of the Indian Atomic Bomb*, 36-43.

10. Robert Gillette, "India: Into the Nuclear Club on Canada's Shoulders," *Science*, June 7, 1974, 1053-55.

By the end of the 1950s, nuclear power technology had begun to spread across the industrialized world. At the turn of the decade, the Soviet Union, Britain, the United States, and France were already operating nuclear plants; Belgium, Canada, West Germany, Italy, and Sweden had plants under construction. In 1960, nuclear power technology first arrived in Asia, when construction of the Japan Power Demonstration Reactor began. At about the same time, India became the first nation outside the highly-industrialized world to begin a nuclear power program, with the formation of the DAE's Power Unit in August 1959. M.N. Chakravarti, General Manager of the Western Railway, led the unit. M.R. Srinivasan served as Principal Project Engineer, and Maheshwar Dayal also joined the team, serving as Project Engineer (Electrical). In 1961, construction of a nuclear powerplant became an official goal of the Third Five-Year Plan. The Plan called for the construction of a plant at Tarapur with two reactors, each producing 150 MW of power. Rs. 510 million were allocated to the project.[11]

Planners in the DAE had several rationales for initiating an atomic power project. Official publications explained the decision as the outcome of a simple cost-benefit analysis. The Indian west coast was already one of the most heavily-industrialized areas in India by the time the project began in 1959; industrial growth was creating an ever-increasing demand for power. India's coal resources were mainly on the eastern side of the country; transporting coal across the country would be prohibitively expensive. In addition, the region's hydropower potential was already mostly tapped out. With the elimination of these options, the planners saw a nuclear plant as the best option for the

11. Planning Commission, "Third Five Year Plan," http://planningcommission.nic.in/plans/planrel/fiveyr/3rd/welcome.html (accessed January 13, 2014); M.R. Srinivasan, "An Intermezzo," in *Selected Lectures of Dr. M.R. Srinivasan* (Bombay: Department of Atomic Energy for the Nuclear Power Corporation of India, n.d. [1990]), 6.

region.[12]

The same official publications implied, but never formally acknowledged, an additional motive: the planners wanted their country to have its own nuclear powerplants because they saw nuclear power as higher-tech and more modern, and therefore more desirable, than any other option. An anonymous writer, reflecting on the dedication of Tarapur in 1970 for *The Indian and Eastern Engineer*, expressed unbridled technological enthusiasm by writing: “As we looked around the quiet surroundings, the serene buildings, the sea to the west and lush green lawns below the 112m ventilation stack, as we looked at the august gathering and mingled with them freely, we could sense the feeling of partnership, a feeling of triumph at the success of another venture in the path of human progress.”[13]

Tarapur and the Cold-War world

The DAE’s nuclear power project became Tarapur Atomic Power Project with the selection of a plot of land near Tarapur village as the site for the plant. To moderate the temperature of the reactors, the station needed large quantities of water. Rivers in western India were unreliable, so the plant needed to be sited on the coast for access to seawater. The Power Unit decided against using large hyperboloid cooling towers, since they are inefficient in hot climates, and also expensive. After studying maps of 200 miles of coastline between Bombay and the Gulf of Cambay in Gujarat, the Power Unit decided to investigate four sites. Shortly after the formation of the Power Unit in 1959, M.N.

12. M.N. Chakravarti and M.R. Srinivasan, “Selection of Site for the Tarapur Atomic-Power Station.” In International Atomic Energy Agency, *Siting of Reactors and Nuclear Research Centres* (Vienna: International Atomic Energy Agency, 1963), 458.

13. “Dedication of Tarapur Nuclear Power Plant,” *The Indian and Eastern Engineer*, February 1970, 113.

Chakravarti and M.R. Srinivasan scouted the sites. Survey teams followed behind them and performed hydrographic surveys and exploratory drilling at each location. Tarapur Point, where the North Konkan Coast juts out into the Arabian Sea north of Bombay, emerged as the most favorable site. Since it was located on the Deccan Trap landform, the location was not susceptible to earthquakes. Bedrock was close to the surface, sound basalt appearing in the drillings as close as fifteen feet below ground level. Crucially, Tarapur was close to the Western Railway railhead at Boisar.[14]

Three decades later, when M.R. Srinivasan recalled his first visit to the site, he portrayed it as an isolated, desolate, monsoon-swept stretch of coast, accessible only by bullock-cart.[15] In fact, the area was well-connected by rail, and it already had a long history of human habitation. This part of the Indian coast, known as the North Konkan, changed hands multiple times during the medieval and early-modern period. In 1534, the Portuguese gained control of the coastal area when the Sultan of Gujarat ceded it to them. To control the coast and defend against rival powers that they considered pirates, the Portuguese built defensive garrisons at various strategic positions on the coast, including Tarapur. In 1593, under the viceroyalty of Matias de Albuquerque, the defensive post at Tarapur was upgraded into a proper fort, with stone walls thirty feet high and ten feet thick. The Portuguese clashed with the Mughals in the North Konkan, but they were able to hold their own. In 1739, after holding the territory for two hundred years, the Portuguese lost the North Konkan to the army of the Maratha Empire under the command of Chimnaji Appa. The Marathas repaired Tarapur Fort, adding some Indian architectural

14. Chakravarti and Srinivasan, "Selection of Site for the Tarapur Atomic-Power Station," 457-65.

15. Srinivasan, "An Intermezzo," 6. Itty Abraham criticizes Srinivasan's account for representing the "rational, scientific modern emerging from the *tabula rasa* (or rather, the slate *made* blank) of the traditional Indian landscape." Abraham, *Making of the Indian Atomic Bomb*, 161.

flourishes to an otherwise European structure.[16]

After nearly eighty years under Maratha rule, the North Konkan again changed hands, this time transferring to the British East India Company under the terms of the Treaty of Poona, signed in June 1817. From this date until Indian independence, the Tarapur area was directly administered by the British as part of the Bombay Presidency. In 1947, the presidency became Bombay State. In 1960, after riots in Bombay, Ahmedabad, and other cities, Bombay State split on linguistic lines. The northwestern portion, which had a majority Gujarati-speaking population, became Gujarat; the southeastern part, where the Marathi language was dominant, became Maharashtra. After the reorganization, Tarapur village fell within the new state of Maharashtra, but it was only twenty-five miles south of the Gujarat border.[17]

By the time Chakravarti and Srinivasan scouted the Tarapur site, the area was home to thousands of people living in several different villages. The chosen location for the powerplant was on the south side of Tarapur Point, directly facing the Arabian Sea. On the north side of the point, northwest of Tarapur lighthouse, the twin villages of Tarapur and Chinchani straddled a creek. According to the 1961 census, the combined population of these two villages was over 12,600. The main occupations of the residents of Tarapur, Chinchani, and other nearby villages were fishing, agriculture, and poultry-

16. Alexander Kyd Nairne, "History of the Konkan," in *Gazetteer of the Bombay Presidency: History of the Konkan Dakhan and Southern Maratha Country* (Bombay: Government Central Press, 1896), 460, 46, 54, 84, 97, 115, 119. An inscription on the northern wall of Tarapur Fort declares, "This fort was ordered to be built by the illustrious Sir Matias de Albuquerque, viceroy of India, in the year 1593." (Translation from the Portuguese by Lucas Machado.) Simon Layton, writing about a slightly later period in the history of the Konkan Coast, argues that the British designated rival powers "piratical" in order to legitimize their own authority in India. From other perspectives, these "piratical states" would be considered legitimate powers. "The 'Moghul's Admiral': Angrian 'Piracy' and the Rise of British Bombay," *Journal of Early Modern History* 17 (2013): 75-93.

17. Nairne, "History of the Konkan," 115; Bipan Chandra, Mridula Mukherjee, and Aditya Mukherjee, *India Since Independence* (New Delhi: Penguin Books, 2008), 128-29.

rearing. Tarapur also had a sea-salt works, and the residents of Uchali and Kelwa farmed oysters. Although the Tarapur area was not modern or industrialized before the construction of the nuclear power station, it was an economically vibrant area, connected by trade with the rest of India.[18]

Having settled on the Tarapur site, the DAE issued a request for international firms to submit bids for the construction of a 300-MW nuclear plant running on natural uranium. A tender notice issued by M.N. Chakravarti on October 10, 1960, formally announced the bidding competition. According to the notice, representatives of interested firms could visit Chakravarti's office on Apollo Pier Road in Bombay to obtain a copy of the four-part enquiry specifications, for a nonrefundable fee of Rs. 1,000 (US$210 at the 1960 exchange rate). Although the specifications called for natural-uranium reactors, the tender notice stated that firms manufacturing enriched-uranium reactors could, at their own risk, bid for the contract, provided that they clearly identified their bid as enriched uranium.[19]

Chakravarti's office received seven bids from companies representing four different western countries; the Soviet Union did not participate. English Electric, General Electric Company of the United Kingdom, and an ad-hoc French consortium submitted bids for natural uranium gas-graphite reactors. Canadian General Electric Company and Atomics International (an American firm) also proposed natural-uranium reactors, although the DAE rejected these tenders because they did not offer firm cost

18. P.R. Kamath, I.S. Bhat, A.A. Khan, and A.K. Ganguly, "Preoperational search for baseline radioactivity, critical food and population group at the Tarapur Atomic Power Station Site," paper presented at the First International Congress of IRPA (Rome, September 5-10, 1966), Government Publications, NLI.

19. TAPP, Tender Notice, box 9, US Mission to IAEA Classified Records 1957-1963, RG 84, NARA.

estimates. Two American firms took the risk of submitting bids for enriched-uranium reactors: Westinghouse and General Electric.[20]

In the 1960s, General Electric was actively marketing its brand of boiling water reactors internationally. The bid for Tarapur was just a part of the expansion of the brand; GE ultimately sold BWRs to ten countries, including Japan, Germany, and Mexico. The company placed advertisements in Indian periodicals such as the *Indian Journal of Power and River Valley Development*, highlighting its international experience. One such ad, titled "Excellent progress being made around the world on General Electric boiling water reactor projects," appeared in the October 1961 issue of the journal. The two-page spread features a photograph of the 160-foot containment sphere of the Garigliano Nuclear Power Station in Italy, which was purportedly "twice the size of St. Peter's dome." The ad copy also mentions the Tokai Mura plant in Japan and Big Rock Point and Humboldt Bay projects in the United States. "Long identified as a leader in atomic development," the copy boasts, "G.E. is engaged in a widely diversified program of nuclear application. BWR plants are now being offered up to 500 megawatts, incorporating such advanced concepts as high-power density cores, pressure suppression containment and internal steam separation."

On the international market, two different types of American reactors, GE's

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20. M.N. Chakravarti and M.R. Srinivasan, "Tarapur Atomic Power Station," in *Proceedings of the Third International Conference on the Peaceful Uses of Atomic Energy*, vol. 5: *Nuclear Reactors -I. Gas-cooled and water-cooled reactors* (New York: United Nations, 1965), 192-198; "Tarapur/Oyster Creek Comparison," n.d., Tarapur project summary file, box 24, USAID Closed Project Loan Files 1960-1971, RG 286, NARA. English Electric submitted its bid in collaboration with another British firm, Taylor Woodrow Construction, and the Indian firm Hindustan Construction Company. Although English Electric did not receive the contract, HCC later built the foundations for Rajasthan Atomic Power Station. Hindustan Construction Co., "Thirty-sixth Directors' Report and Statement of Accounts for the Year Ended 31st August 1961," S. No. 240, Hindustan Construction Company subject files, papers of Walchand Hirachand, NMML.

BWRs and Westinghouse's pressurized water reactors (PWR) were in direct competition with the gas-graphite reactors from France and Britain, and the CANDU pressurized heavy-water reactors from Canada. All of the different types of reactors represented slightly different approaches to nuclear power generation, based on whether they used light or heavy water for the reactor moderator, and enriched or natural uranium as reactor fuel. Both BWRs and PWRs used enriched uranium, which was produced in hugely expensive gaseous diffusion plants. At the time, the only western-bloc facility capable of enriching uranium on a large scale was located at Oak Ridge, Tennessee. The Soviet Union also produced enriched uranium for its reactors, but the quarantining of eastern- and western-bloc technology in early-independent India ensured that Soviet uranium would not be an option for the Tarapur project.[21]

During the bidding process, GE's representatives felt at turns pessimistic and cautiously optimistic about their prospects of getting the contract. Robert King of GE's New York office and William Lalor, Jr. of the Atomic Power Equipment Department in San Jose traveled to India in January 1961 to gather information on the project. They spent several days talking with Chakravarti, and also visited the Tarapur site. The American Consul General in Bombay, Sidney Sober, reported in a foreign service dispatch that King and Lalor would not make a decision on whether their company should bid until Homi Bhabha guaranteed that their submission would be given a "fair chance." When the men met with Bhabha in New Delhi and asked whether natural-uranium reactors would be preferred over enriched-uranium reactors, Bhabha replied, "I

21. M.N. Chakravarti and M.R. Srinivasan, "Selection of Site for the Tarapur Atomic-Power Station," in International Atomic Energy Agency, *Siting of Reactors and Nuclear Research Centres* (Vienna: International Atomic Energy Agency, 1963), 458; M.N. Chakravarti, "Tarapur Atomic Power Project," *IJPRVD* 18 (Feb. 1968), 41.

think both types will receive equal consideration." Feeling reasonably assured, they tentatively decided to recommend to company headquarters that GE should prepare a bid. Within days, though, Bhabha had appeared before the Indian press and hinted strongly that he hoped India's first nuclear powerplant would use natural uranium. To assuage the fears of the American companies, Chakravarti wrote a letter dated March 29, 1961 to both GE and Westinghouse. The letter made no mention of Bhabha's assurance of "equal consideration," but it was enough to convince GE and Westinghouse to submit bids.[22]

But as the bidding deadline of August 31, 1961 approached, prospects for the American companies, especially GE, again began to look negative. Consul General Sober declared in a foreign service dispatch that "the Indian DAE clearly hopes to have the Tarapur station built by a British firm supplying natural uranium reactors." In a further negative turn, the US government announced that it would not finance the project. By this time, though, the two American companies had spent considerable time and resources preparing bids, and they felt that it was too late to quit. Representatives of the Indian subsidiaries of GE and Westinghouse delivered their companies' bids to the Bombay project office by the August 31 deadline.[23]

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22. "General Electric interest in proposed atomic power plant; related notes on India's nuclear development program," foreign service dispatch 248, Amcongen Bombay to Department of State, January 30, 1961, box 1, USAID Classified Central Subject Files 1953-1962, RG 469, NARA; "Proposed atomic power plant at Tarapur," foreign service dispatch 489, American Consul General Bombay to Department of State, February 24, 1961, box 9, US Mission to IAEA Classified Records 1957-1963, RG 84, NARA; "Recent developments concerning proposed atomic power plant at Tarapur," foreign service dispatch 581, American Consul General Bombay to Department of State, April 7, 1961, ibid.

23. Foreign service dispatch 581; "American bids on Tarapur Nuclear Power Plant," air pouch, American Consul General Bombay, October 3, 1961, box 9, US Mission to IAEA Classified Records 1957-1963, RG 84, NARA. G.B. Sujan was the Westinghouse Regional Representative in Bombay who delivered his company's bid. According to Consul General Sober, Sujan reported to the consulate that "he had presented to the Indian authorities a plastic model of a single-reactor plant about 30″ square and 10″ high, scaled at 1/16″ to the foot [1/192]. This model, which is not necessarily a true model of a plant that Westinghouse might build at Tarapur, is said to have made a hit with the Indian officials."

It came as a surprise, then, when the DAE issued a letter of intent to General Electric, announcing that the American firm had emerged as the most favored of the seven bidders. GE had underbid the other tenderers, and its bid still managed to offer 380 MW of net power, 80 MW more than required by the enquiry specifications. The DAE's letter of intent was still subject to intergovernmental agreements regarding financing and the transfer of nuclear equipment and materials. The US government changed its policy and agreed to finance the foreign-exchange costs of the project; an $80 million USAID loan was authorized on June 28, 1963. The loan agreement had many of the same provisions as the agreement for Umiam Hydroelectric Project, including the small business notification clause. The formal intergovernmental agreement for the project as a whole was signed on August 8, 1963. On May 8, 1964, the Government of India signed a formal contract with General Electric and its Indian subsidiary, calling for the completion and handover of Tarapur Atomic Power Station within fifty-two months of the contract date.[24]

Throughout the project preparation, construction, commissioning, and operation of Tarapur Atomic Power Station, the Americans and Indians held conflicting views of the meaning and significance of the technology in the plant. The Americans saw Tarapur as an opportunity to create ties between the United States and India; India's purchase of an American reactor from GE would draw India into the American economic orbit.

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24. "Loan Agreement (India: Tarapur Nuclear Power) between the President of India and the United States of America," December 7, 1963, file no. 2(21) AID/69, Ministry of Finance, NAI; Tarapur Atomic Power Project contract between the President of India and General Electric for the construction of an atomic power station to be located near Tarapur, final draft, April 10, box 12, USAID Closed Project Loan Files 1960-1971, RG 286, NARA. In 1967, USAID deobligated $5 million of the loan amount. Implementation Letter No. 6, Daniel G. Pfoutz to Finance Secretary, January 13, 1969, file no. 2(21) AID/69, Ministry of Finance, NAI.

Ambassador John Kenneth Galbraith stated as much in a foreign service dispatch dated May 3, 1961. After concluding that the Indian government's plans for a nuclear plant near Bombay were economically unfeasible, he turned around and stated that he believed the United States should finance the project anyway. "It [Tarapur] would be known as the 'American-aided' plant … It would appeal to the educated groups, to the scientists, to the most progressive Indians, and to those to whom India's prestige in Asia is of primary importance. U.S. financing of this project would link the name of the United States with scientific achievement and advanced techniques."[25]

The sale of a nuclear reactor to India, then, would improve America's international reputation. What was good for American business was good for America as a whole. The sale of the Tarapur reactors was one step toward American manufacturers' dominating the market over the French and British, as well as the Soviets. *The Wall Street Journal* understood this when it wrote in response to the contract's announcement, "The plant is considered a prime indicator of U.S. nuclear power plant manufacturers' ability to compete in the international power market."[26]

The Indians viewed this technology differently. They saw it as a stop-gap, an intermediate step between colonial dependence and full indigenization of nuclear power technology. This was the ideal. The reality was that the establishment of a nuclear power

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25. "Should the U.S. finance the nuclear power plant at Tarapur?" foreign service dispatch 1144, American Embassy New Delhi to Department of State, May 3, 1961, box 9, US Mission to IAEA Classified Records 1957-1963, RG 84, NARA. Galbraith used similar arguments to support the ultimately stillborn aid package for Bokaro Steel Plant, as discussed in Chapter 3. In a telegram to Secretary of State Dean Rusk in May 1963, the ambassador declared, "The cement that holds the free community together is not r[e]p[ea]t not the alliances. These under serious strain would disappear like a gastric manifestation in a gale. Nor does it depend on the skill, perspicacity or speed of the oral policy of our state department. Our position depends overwhelmingly on our aid program." J.K. Galbraith to Secretary of State, May 14, 1963, India: Security, President's Office Files, Presidential Papers, Papers of John F. Kennedy, JFK Library.

26. "GE signs India contract," *Wall Street Journal*, May 11, 1964.

station in India would establish a long-term dependency relationship on the donor country. In addition to the plant and its supporting infrastructure, the Tarapur station would also need to import a regular supply of nuclear fuel.

The question of which kind of nuclear fuel would be used in the plant had been a significant issue during the bidding process. The DAE initially planned to request bids for natural uranium reactors only. Since the two major American manufacturers, Westinghouse and General Electric, both used enriched uranium in their designs, the natural uranium clause effectively excluded American bidding. Shortly before the tender notice was released, representatives for Westinghouse convinced the DAE to include a clause permitting bids for enriched uranium reactors.[27]

Even after the concession to Westinghouse, members of the DAE held conflicting views about whether they should seriously consider enriched uranium bids. In a discussion with US Consul General Sidney Sober in February 1961, H.N. Sethna, head of the Chemical Group at Atomic Energy Establishment Trombay, gave three reasons for favoring natural uranium as a fuel source over enriched uranium. First, a reactor using natural uranium could produce plutonium, which would ultimately allow India to use domestically-sourced thorium for power generation. Second, using natural uranium would avoid recurring foreign-exchange payments for imported fuel. Third, using imported fuel ran the risk of the fuel supply's interruption during an emergency. In Sethna's view, these three reasons shifted the balance in favor of natural uranium. It is significant that all three reasons relate to autarky and self-reliance; they call on common themes of using indigenous materials, conserving foreign exchange, and protecting the

27. "American bids on Tarapur Nuclear Power Plant," October 3, 1961.

security of strategic assets.[28]

M.N. Chakravarti expressed a more pragmatic perspective, and it was his approach that prevailed during the bidding process. Chakravarti refused to let an ideological commitment to autarky become an obstacle to building India's first nuclear powerplant. For him, the more important factors were cost and foreign exchange components of the tenders; he was not concerned about whether the fuel supply was indigenous or imported.[29]

Even though the fuel supply would tie Tarapur to the United States long after the project's completion, the selection of an American station would promote autarky in one respect, by diversifying India's dependencies on nuclear nations. With the Canada–India Reactor, India already relied on Canada. India's second nuclear power station, then in early planning stages, would also be constructed with Canadian assistance. By selecting an American bid for the first plant, India was diversifying risk. A downturn in Indo-Canadian relations could lead to the freezing of Canadian assistance, just as the 1965 Indo-Pakistani War cut short American military aid to the two belligerents in the conflict. The United States might not cut off aid for the same reasons as Canada, so the risk of losing all support was lower if the aid came from multiple nations. As an editorial in the *Indian Journal of Power and River Valley Development* argued, "If the huge capital investment required for such stations are not immediately borne by India, it may be better if we make a start with two stations with the aid of two countries instead of with only one."[30] As events would demonstrate, this strategy was wise. After India's first nuclear

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28. Foreign service dispatch 489.
29. Ibid.
30. "Policy for Atomic Power," editorial, *IJPRVD* 10 (Mar. 1960), 31.

bomb test in 1974, Canada cut off all nuclear aid to India, leaving the second reactor at Rajasthan Atomic Power Station unfinished. The United States, on the other hand, did not immediately cut off the fuel supply to Tarapur as a result of the test.[31]

Although uranium is much more energy-dense than fossil fuels, a station of Tarapur's size still required large amounts of fuel. When Tarapur received its first load of fuel in 1969, each reactor swallowed up forty metric tons (88,000 lbs) of enriched uranium. This fuel stayed in the reactors for two and one-half years before requiring replacement. Each year afterward, the reactors took an additional twenty-two metric tons of fuel. In order to overcome the Indian government's objections to importing this fuel, the US government guaranteed a long-term fuel supply over the course of twenty-five years, the planned lifespan of the plant. These terms proved convincing, and the Indian government agreed to buy American reactors that ran on American fuel.[32]

Closely related to the problem of fuel supply was the issue of safeguards. The United States feared nuclear proliferation, which by the American definition meant a non-nuclear state's gaining access to nuclear weapons, either by indigenous development or purchase.[33] America's Cold War leaders did not want to be complicit in proliferation to any nation, especially a nonaligned one, and they pursued several strategies to prevent

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31. In his comments on an earlier version of this chapter, presented at the Society for the History of Technology's annual meeting in 2014, Arne Kaijser suggested yet another reason for India to buy an American plant rather than a Canadian one. By working in plants designed by engineers from two different countries, the specialists of the Department of Atomic Energy would gain experience with a broader range of technologies.

32. M. Dayal, "Experience from Operating and Fuelling a Nuclear Power Plant in an Industrially Developing Country," in *Experience from Operating and Fuelling Nuclear Power Plants: Proceedings of a Symposium on Experience from Operating and Fuelling Nuclear Power Plants, Organized by the International Atomic Energy Agency and Held in Vienna, 8-12 October 1973* (Vienna: International Atomic Energy Agency, 1974), 85-87; M.N. Chakravarti, "Tarapur Atomic Power Project," *IJPRVD* 18 (Feb. 1968): 41-47.

33. The Indians were also concerned about nuclear proliferation, but they defined it as nuclear states such as the United States and Soviet Union expanding their nuclear weapons arsenals.

this from happening. By the early 1950s, when it became clear that the United States had lost its monopoly on nuclear weaponry, the Americans began pushing for an international system of safeguards for atomic weapons and power facilities. In a 1954 speech before the General Assembly of the United Nations, President Eisenhower called upon the nuclear-capable countries to develop nuclear technology for the benefit of all people. "It is not enough to take this weapon [nuclear weaponry] out of the hands of the soldiers," he declared. "It must be put into the hands of those who will know how to strip its military casing and adapt it to the arts of peace." This speech, known as "Atoms for Peace," led to the creation of the United Nations International Atomic Energy Agency (IAEA), which had a mandate to inspect nuclear facilities internationally.[34]

In the negotiations before the construction of Tarapur, the United States and India clashed over the question of safeguards for the station. The United States wanted India to submit Tarapur to IAEA safeguards, in order to prevent the diversion of any fissile materials from the plant to a hypothetical nuclear weapons program. India did not want to allow IAEA inspections, because it felt that the organization discriminated against nations that did not already have fully-developed nuclear programs. Instead, India wanted to enter into a bilateral inspection agreement with the United States. The agreement, which the two countries signed on August 8, 1963, was a compromise. It stipulated that the United States would inspect the plant at first, with a vague provision that inspections would shift to the IAEA someday. Under continued American pressure, India agreed in 1971 to submit to IAEA inspections.[35]

34. Dwight D. Eisenhower, "Atoms for Peace," *Eisenhower Presidential Library*, http://www.eisenhower.archives.gov/all_about_ike/speeches/atoms_for_peace.pdf (accessed January 11, 2016).

35. Cong. Rec., 88th Cong., 1st sess., 1963, vol. 109, 15221-25; Ajit Bhattacharjea, "Agreement

Constructing Tarapur

On September 13, 1964, excavation began at the Tarapur site, marking the beginning of construction work. On October 28, 1969, General Electric officially handed control of the plant over to the Indian government, marking the end of the project. In the intervening five years, thousands of men and women worked to transform a stretch of coastal jungle into the home of India's most sophisticated power station.

Before the construction phase proper could begin, the project site had to be rationalized and transformed into a legible site where the plant could be created.[36] At the Boisar railhead, two warehouses were built to store materials until they could be transported to the site. To access the site, workers built a 2,000-foot approach road, branching off from the Boisar-Tarapur Road. They also dug tube-wells to provide fresh water. The Maharashtra State Electricity Board strung a branch line to provide power from its grid. The entire site was leveled to stand at a regular elevation of 103 feet, relative to the project's datum. The datum did not represent height above mean sea level; instead, it was based on a preexisting structure, the plinth of Tarapur lighthouse, which was considered to stand at 100 feet. Low tide could be as low as 74.5 feet, or 25.5 feet below the lighthouse plinth. Zero on the datum was always deep underwater. For the duration of the construction, progress reports gave building heights based on the datum, where grade stood at 103 feet. Thus the roof of the reactor building, given in the reports as being at elevation 248′ 6″, actually stood at 145′ 6″ above grade, or about 165 feet

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on U.S. aid for Tarapur reactor," *Hindustan Times*, June 27, 1963; "India Agrees to Inspection of Atomic Plant," *New York Times*, June 26, 1963.

36. The concepts of rationalization and legibility come from James C. Scott, *Seeing Like a State: How Certain Schemes to Improve the Human Condition Have Failed* (New Haven, CT: Yale University Press, 1998), 2-3.

Figure 14. View of the cooling water intake structure on the west side of the plant. (Source: Photographs of Assistance Programs in Foreign Countries, RG 286-CP, NARA.)

above mean sea level.[37]

General Electric received the prime contract from the Government of India, but the majority of the construction work was done by employees of the main subcontractor, Bechtel. In addition, Bechtel was responsible for designing the non-nuclear parts of the facility. By the mid-1960s, Bechtel boasted an impressive dossier of projects that it had built across the United States and around the world, including oil industry infrastructure

37. TAPP quarterly report 1; "Tarapur Reporter," August 5, 1966, box 24, USAID Closed Project Loan Files 1960-1971, RG 286, NARA (hereafter cited "TR" and the date); "Meeting with consultant to discuss status of circulating water system design, San Francisco, February 17, 1964," "Tarapur Nuclear Project, 1963-1964," J.W. Johnson papers, box 1, folder 93, WRCA.

in the Arabian Peninsula, mines in Venezuela and South Africa, and pipelines in Canada, Austria, France, and Indonesia. Bechtel had also built the world's first functioning nuclear power reactor, Experimental Breeder Reactor 1 (EBR-1), in Arco, Idaho. EBR-1 first went critical in 1951, although like the Canada–India Reactor a decade later, it was too small for commercial power generation. Later, Bechtel also served as engineer-constructor for the Dresden Nuclear Power Plant outside Chicago, the first large-scale use of General Electric BWRs for commercial power production.[38]

An assortment of other subcontractors provided services at the site, including Chicago Bridge & Iron (drywell assembly), Hochtief Modern (construction of intake and discharge canals), and Blue Star Project (reactor control system). An additional presence at Tarapur was the Kuljian Corporation and its local subsidiary, Kuljian–India. According to the terms of the USAID loan agreement, the Indian government was required to hire its own consultants for the project. Under USAID policy, thermal power projects were required to have consultants, and the agency extended this requirement to Tarapur as well. Engineers from Kuljian joined the project after receiving the Indian government contract in May 1965.[39]

The Kuljian Corporation was originally founded in 1930 by Harry Kuljian of Philadelphia. The company worked on engineering projects worldwide, mostly in the electric power sector. Kuljian expanded his company's operations to India shortly after independence, when he met Sadhan Chandra Dutt, an Indian mechanical engineer who was temporarily in the United States to learn about electrical engineering from General

38. Richard Finnie, *Bechtel in Arab Lands: A Fifteenth-Year Review of Engineering and Construction Projects* (San Francisco: [Bechtel], 1958); Robert L. Ingram, *The Bechtel Story: Seventy Years of Accomplishment in Engineering and Construction* (San Francisco: [Bechtel], 1968).

39. Chakravarti, "Tarapur Atomic Power Project," 43.

Electric. Kuljian trained Dutt for a year in Philadelphia, then made him his permanent representative in India. In August 1961, Kuljian's Indian operation was spun off as its own company, 51 percent Indian-owned, with the remaining 49 percent of shares retained by the parent corporation in Philadelphia. Kuljian's stated intention was to spread the benefits of industrial technology by nativizing engineering expertise.[40]

The project authorities, contractors, and subcontractors also hired individual consultants from American universities on an ad-hoc basis. Alongside American industry and USAID, academics were the third essential party of Americans involved in international development. One such academic-consultant was J.W. Johnson, a professor at the University of California–Berkeley. Johnson consulted for engineer-constructors Bechtel, whose main offices were located across the bay in San Francisco. Based on a Bechtel field trip report, and model studies performed in Berkeley and Poona, Johnson recommended changes to the design of the cooling water intake system. Johnson and Roy W. Carlson, who installed the instrumentation in Umiam Dam, are two examples of American academics who contributed to international development projects. Without their expertise, large-scale international development projects would not have been possible.[41]

Manufacturers across the contiguous United States contributed parts for Tarapur.

40. A.K. Ganguly, "U.S. Engineer Helps Develop India's Power Resources," *Indian Railway Gazette*, July 1963, 287-88. In addition to Kuljian Corporation, McLain Associates and Nuclear Utility Services, both of the United States, provided further specialized consulting services.

41. J.W. Johnson to Burr H. Randolph, December 9, 1963, "Tarapur Nuclear Project, 1963-1964," J.W. Johnson papers, box 1, folder 93, WRCA; R.L. Wiegel, et al., "Model Study of Proposed Cooling Water Systems for Nuclear Power Plant to be Located at Tarapur, India" (Berkeley: University of California Hydraulic Engineering Laboratory, December 1964), WRCA; R.L. Wiegel, Yuan Jen, and Ismail Mobarek, "Model Study of Wave Resonance in the Cooling Water Intake Structure, Tarapur Nuclear Power Plant" (Berkeley: University of California Hydraulic Engineering Laboratory, April 1965), WRCA.

Although most of the major suppliers were located in the eastern industrial belt, manufacturers in Tennessee, California, Oregon, and Washington also supplied components. Several different General Electric facilities contributed to the project: the turbine-generators came from Schenectady, New York; the reactor control rods were built at the Atomic Power Division in San Jose; the switchgear came from Philadelphia; and the transformers came from Pittsfield, Massachusetts.

As far as possible, the project authorities sourced materials from Indian suppliers, in keeping with the policy of promoting indigenous production. Aggregate for the concrete walls was quarried from a riverfront site and screened and washed at an on-site plant, then transported to the job site and mixed with Indian cement to form the concrete that made the majority of the structure. Reinforcing steel came from India's growing steel industry. For the most part, Indian manufacturers supplied less capital-intensive materials, in keeping with what Indian industry was able to produce at that time. The most sophisticated components supplied by Indian industry were the control and instrument panels of the main control room, built by Atomic Energy Establishment, Trombay.[42]

In April 1966, the first reactor core arrived at the project site on board a specialized landing craft transport, *Inagua Gull*. The reactor vessel, which was over fifty feet long and weighed 268 tons, was too bulky to transport by rail from Bombay. Instead, the *Inagua Gull* beached itself on a purpose-built landing spit at the project site. The front of the ship opened up and lowered a ramp onto the beach. Then the reactor was

42. TAPP quarterly report 4, July-September 1965, box 20, USAID Closed Project Loan Files 1960-1971, RG 286, NARA.

transferred to a wooden sled and hauled across the site to the reactor building. On May 29, a giant stiff-leg derrick crane mounted atop the wall of the reactor building lifted the reactor vessel off the ground and lowered it into its home inside the drywell. Later that year, the second reactor arrived from the United States and was installed in a similar manner.[43]

The Tarapur project included more than just the main plant building with the reactors, turbine-generators, and control room. Dominating the site, a 366-foot ventilation stack stood adjacent to the southeast corner of the reactor building. The stack vented air out of the reactor building. Despite multiple layers of shielding, it was possible that the vented air could contain small levels of radiation. The height of the stack was intended to give the radioactive material a chance to diffuse to harmless levels before it reached the ground. Venting only took place at certain times, when a weather station mounted on a nearby 650-foot tower indicated that atmospheric conditions were favorable for dispersal.[44]

Next to the stack stood a 600,000-gallon raw water storage tank. The reactors used fresh water in their boiling water cycle; this water came from Sakhare Reservoir, impounded by a purpose-built dam fifteen miles northeast of the plant. Buried pipes carried the reservoir water to the plant site. The Indian project officials recommended adding the storage tank to the plan in the event that the water mains were disrupted.[45]

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43. GE, TAPS monthly report 23, April 1966, box 19, ibid.; GE, TAPS monthly report 24, May 1966, ibid.; USIS, "Nuclear Power from Tarapur," 1969, US Moving Images compiled 1982-1999, RG 306, NARA.

44. P. Abraham, "Safety Features at Tarapur," *The Indian and Eastern Engineer*, February 1970, 117-120; V. Ramachandran, et al., "Design and construction of the 120 metre high meteorological tower facility at the Tarapur Atomic Power Station," *The Journal of the Institution of Engineers (India)* 48 (Sept. 1968), 268-69.

45. M.N. Chakravarti, "Tarapur Atomic Power Project," *IJPRVD* 18 (Feb. 1968): 46-7; TAPP

Also on the site were a radwaste building, for storage of spent nuclear fuel; an administration building with a conference room and a cafeteria; a workshop and warehouse building; a switching yard that linked the Gujarat and Maharashtra grids (built by the Maharashtra State Electricity Board); and a system of intake and discharge canals, which included two 3,000-foot jetties stretching out into the sea.

The construction relied heavily on imported machinery. The largest of these was the stiff-leg derrick, used for handling the reactor cores and other particularly cumbersome pieces of equipment. This crane weighed 300 tons; M.N. Chakravarti, in an article he wrote for the *Indian Journal of Power and River Valley Development*, speculated that this piece of equipment was "presumably one of the largest cranes of its kind." On a similarly large scale, the intake canal, built by subcontractor Hochtief Modern, was excavated with the help of two gantries that moved along rails laid on the sea floor. Riding on the back of the gantry, a backhoe scooped up the seafloor between the rails. On a smaller scale, but no less important for the project, were American trucks, jeeps, and other smaller construction machines for digging, lifting, and moving. According to the first TAPP quarterly progress report, thirty-seven shipments left the United States in the latter half of 1964, consisting mostly of construction equipment "including dump trucks, rear dumpers, traxcavators, tractor dozers, mobile cranes, crawler cranes, dragline buckets, fork lifts, [a] sand washing plant, [a] concrete batching plant, stone crushers, trucks, and welding sets."[46]

Just as essential as the mechanized equipment was human labor. Although the

quarterly report 1.

46. TAPP quarterly report 1, June-December, 1964, box 19, USAID Closed Project Loan Files 1960-1971, RG 286, NARA; TAPP quarterly report 12, July-September 1967, box 20, ibid.; TR, July 1, 1966. "Tarapur Reporter" excitedly announced the arrival of "BACKHOE" by writing the name in all-caps.

project reports spend less time discussing the non-mechanized aspects of the construction, photographs and films of the project highlight the essential role played by human labor. A portion of the intake canal was enclosed by a cofferdam and the area pumped dry. Part of this excavation was done by hand. Project photographs also prominently feature individual men and women trudging across the work site while balancing trays full of cement or aggregate on their heads.

The Tarapur workforce expanded and contracted based on project needs and the status of labor disputes that simmered through 1965 and 1966. Data for workforce strengths are supplied in the TAPP quarterly project reports, and supplemented by data from GE monthly progress reports. At the beginning of the reports in the latter half of 1964, the workforce numbered just over 2,000. As construction progressed from sinking foundations to erecting the buildings, the workforce steadily expanded, reaching its peak in first quarter 1966 at just over 6,800. From there, the workforce shrank, although in fourth quarter 1966 it jumped again because of increased demand for welders. By the last report, issued in second quarter 1969, the workforce had shrunk to just under 1,000.[47]

According to the project newsletter, the workforce came from all over India. Statistics printed in the July 16, 1965 issue of "Tarapur Reporter" stated that 3,364 Indian nationals were employed on the project as of the last day of June. These workers came from thirteen different states. Maharashtra was dominant, with 1,526 workers. Punjab came in a distant second, with 504 workers. Others came from as far away as Kerala, Andhra Pradesh, and West Bengal. Nepal, although a sovereign nation, was included

47. TAPP quarterly report 1, for June-December 1964, box 19, USAID Closed Project Loan Files 1960-1971, RG 286, NARA; TAPP quarterly report 6, January-March 1966, box 20, ibid.; TAPP quarterly report 9, October-December 1966, ibid.; TAPP quarterly report 19, April-June 1969, ibid.

among the thirteen states as sixty-three Nepalese were employed on the project. These statistics show the diversity of the Tarapur workforce, although they are apparently incomplete. In the next issue of "Tarapur Reporter," the newsletter staff reported that they had received complaints for not including the territory of Goa on the list of workers' home states.[48]

Throughout the project, Indians vastly outnumbered expatriates from the United States or other countries. The highest number of American workers on the project, reported in first and second quarters 1967, was seventy-three. During the early phases of construction, the American personnel were predominantly Bechtel employees; the ranks of GE supervisors remained in single-digits or the low teens. Later, as concrete construction was mostly complete, the Bechtel force shrank and GE employees increased to oversee the installation and testing of the plant's electrical equipment.

There is little evidence of major conflicts or misunderstandings between Indians and Americans on the project, although there were likely some, just as there were in Exercise Shiksha. There are ample records of long and acrimonious disputes between labor and management. Early in the project, the Bechtel management officially recognized a workers' union affiliated with the conservative and nonconfrontational Indian National Trade Union Congress (INTUC), a wing of the Congress Party. In 1965, Bechtel's employees began to agitate for the recognition of an alternative union affiliated with the Bombay Labour Union. The leaders of this union notified the Bechtel management that they would strike if their union was not recognized. Since the management already recognized the INTUC union, they did not respond to the demand,

48. TR, July 16, 1965; TR, July 23, 1965.

and thus on December 9 all Bechtel employees walked off the job. (Work on the cooling water canal, under contract to Hochtief Modern, continued during the Bechtel strike.) The Bombay Labour Union was at this time under the leadership of the socialist trade unionist George Fernandes.[49]

The strike's most dramatic, and tragic, moment came on December 29. In response to rising tensions in the labor camp, the management turned over control of the area to the police. In a showdown between the police and the strikers at the labor camp canteen, the police opened fire and killed eight workers. The actual cause of the shootings is difficult to determine, since all sources on the event are heavily slanted in one direction or another. The management perspective, as recorded in the project reports and repeated by most news outlets, was that the workers had turned belligerent, threatening to wreck company property; the police had fired back in defense. George Fernandes's own account was that the riot had begun when somebody had accidentally dropped a glass; the glass's shattering on the canteen floor was enough to make the police think that the strikers were attempting to wreck the canteen, and therefore they fired back in retaliation.[50]

Whatever the facts, the various accounts of the police shooting were used to support the claims of both sides. An article in *Eastern Economist* condemned the strikers for interrupting "work on a power project of great national importance." By contrast, an

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49. As a professional labor organizer in Bombay in the 1950s through the 1970s, Fernandes clashed frequently with the law and served several prison sentences. During the Emergency under Indira Gandhi in 1975, he was arrested while planning an insurgency against the government. After the Emergency, he was rehabilitated and served in the central government, even becoming Minister of Defence from 2001 to 2004. Ramachandra Guha, *India After Gandhi: The History of the World's Largest Democracy* (New York: Ecco, 2007), 503-4, 534, 664.

50. TAPP quarterly report 5, October-December 1965, box 20, USAID Closed Project Loan Files 1960-1971, RG 286, NARA; "Eight killed in strike riots at atomic plant," *The Times* (London), December 31, 1965; "Americans accused of firing," *The Times* (London), January 1, 1966.

article in *Himmat*, although claiming to be advancing no political agenda, offered support to the workers' cause by profiling the plight of Surendra Kaur, the widow of one of the slain strikers, a Punjabi truck driver named Kundan Singh. Although the Bombay Labour Union had offered to pay her expenses for the next six months, she did not know how she would manage afterward. The editors of *Himmat* asked readers to contribute to a fund to help her recover. Prolabor narratives did their part, and ultimately the workers' cause prevailed. On January 31, 1966, the union and the Bechtel management reached an agreement recognizing Bombay Labour Union as the workers' union, on the condition that the union not call any more strikes. Work resumed on the project the following day.[51]

The strike of December 1965 and January 1966 was the longest and most dramatic work stoppage on the project, but it was not the only one. From July to September 1966, the welders on the project, ignoring the no-strike agreement, called a wildcat strike. The Bechtel management promptly fired the strikers, but a shortage of qualified welders in India ultimately forced management to agree to rehire the welders.[52] The welders' strike was one of several disruptions to the project schedule that pushed the final commissioning date of the station back a year, from 1968 to 1969. Other delays included the discovery of widespread cracking in some reactor parts, and delays in finishing the switchyard that interconnected the Gujarat and Maharashtra power grids.[53]

General Electric finally turned the plant over to the Government of India on

51. "Tarapore: Tragic Interlude," *Eastern Economist*, January 14, 1966, 45-46; Hari Mohan Sharma, "Why Did He Have to Die? Asks Tarapore Widow," *Himmat*, January 21, 1966, 18; TAPP quarterly report 8, July-September 1966, box 20, USAID Closed Project Loan Files 1960-1971, RG 286, NARA.

52. TAPP quarterly report 8, July-September 1966, ibid.; TR, September 9, 1966.

53. TAPP quarterly report 17, October-December 1968, box 20, USAID Closed Project Loan Files 1960-1971, RG 286, NARA.

October 28, 1969. On January 19, 1970, Prime Minister Indira Gandhi formally dedicated the plant to the Indian nation. In her speech at the dedication, she stated that the plant's construction represented the partial fulfillment of the dreams of two great men, her father and Homi Bhabha. She expressed her hope that the plant would "increasingly contribute to our national wealth," and that India could in turn pass on some expertise in nuclear technology to other countries.[54]

Life at Tarapur

Tarapur was not just a site of labor; it was also a community, which at any given time consisted of thousands of Indians and upwards of a hundred Americans employed on the project, as well as the families of both. More precisely, the Tarapur workforce consisted of several different communities, divided by class, ethnicity, race, language, and occupation. Sometimes these communities interacted peacefully and occasionally, in the case of the 1965-66 strike, they clashed violently. The most complete source in the official records about community life at Tarapur Atomic Power Project is the official weekly newsletter, "Tarapur Reporter." Content of the newsletter included project progress reports, world news digests, community news and classifieds, riddles and puzzles, and safety cartoons. The newsletter was originally issued exclusively in English from the project's Bombay engineering office, overseen by Leela Sajnani. Later, Hindi and Marathi editions also began publication.[55]

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54. Indira Gandhi, "Tarapore: A Dream Come True," in *Selected Speeches of Indira Gandhi*, vol. 2: *The Years of Endeavour, August 1969-August 1972* (New Delhi: Publications Division, Ministry of Information and Broadcasting, Govt. of India, 1973), 421-24.

55. Partial runs of the English edition of Tarapur Reporter from 1965 and 1966 are found in box 24, USAID Closed Project Loan Files 1960-1971, RG 286, NARA. In 1966, "Tarapur Reporter" entered into an affiliation with the public relations firm Consilium International. The format changed slightly, and it was at this time that the Hindi edition began publication. At the expansion of the newsletter in 1966,

The newsletter is an essential source for understanding the project, because it provides details that are not found in the official reports. It also has its pitfalls. "Tarapur Reporter" was written from the perspective of management; the workers' perspective is not represented. The newsletter portrays the project workforce as a harmonious community united by a common objective. The labor-management conflicts clearly demonstrate that the workforce was far from harmonious. With a close reading of "Tarapur Reporter," the fault lines between workforce communities become evident.[56]

The most distinct dividing line separated the National Camp and the IGE Colony. The National Camp, adjacent to the jobsite, had the capacity to house about 2,150 men, or roughly half of the Indian laborers working on the project. (The remainder, like the ill-fated truck driver Kundan Singh, found accommodations in one of the nearby villages.) These men lived in sixty temporary barracks, which were some of the first structures built for the project. Although certainly spartan, the camp barracks had features that many of these working-class Indian men did not have in their own homes. Each barrack was outfitted with electricity, running water, and kerosene. In addition, the common areas of the camp had such recreational facilities as a football field, a volleyball court, and a recreation hall with a library and a reading room. A permanent market was located just outside the grounds of the camp. In August 1966, eighty-six people worked at the National Camp, keeping the residents healthy and well-fed, and making sure that the grounds were safe and clean. The diversity of the inhabitants of the National Camp led to

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volume numbering reset, and for that reason volume or issue numbers are not included in citations in this chapter.

56. The author is grateful to Arne Kaijser for recommending a critical interpretation of "Tarapur Reporter."

Figure 15. Don T. Spangenberg and G.J. Larsen of General Electric in the Tarapur control room. (Source: Photographs of Assistance Programs in Foreign Countries, RG 286-CP, NARA.)

its receiving the nickname of “Chota India” or “Little India.”[57]

Seven miles away, on the Boisar-Tarapur Road, the Indian and American administrators and engineers who were overseeing the project lived with their families in the IGE Colony. Expatriates who were working on the project only for a short term stayed in single-occupancy accommodations and ate at the colony’s mess hall. The inhabitants of the IGE Colony were ethnically mixed. In January 1965, when the colony’s buildings were three-quarters complete, eight expatriate and seventeen Indian families had already taken up residence. By August 1966, the total number of families had

57. “The men behind the job: National Camp and IGE Colony,” TR, August 5, 1966; TR, August 12, 1966.

increased to 104, and they had been joined by 40 expats living without their families.[58]

Both the National Camp and the IGE Colony hosted special events on a regular basis. In both places, films in Hindi, Marathi, and English were screened once or twice a week. Titles screened included *Abbott and Costello Lost in Alaska* (1952), *The Millionairess* (1960), and the Raj Kapoor romantic comedy *Dulha Dulhan* (1964). At the National Camp, football matches and table-tennis tournaments attracted participants from both residential areas.[59]

The workers participated in festivals and celebrations to mark important days in both the Indian and American calendars. During the monsoon season, Indians and Americans celebrated their respective national holidays. According to "Tarapur Reporter," the residents of the IGE Colony celebrated American Independence Day with a potluck dinner at the colony clubhouse on July 3, 1966, and a fireworks display launched from the baseball field the following evening. The next month, Tarapur Atomic Power Project marked Indian Independence Day, August 15, with a major celebration. On the evening of August 14, a variety show featuring entertainers brought in from Bombay played to a packed auditorium in the National Camp. On the morning of August 15, Burns Woodward, the acting GE manager of the project, performed the traditional Indian flag-raising on the football ground; this was followed by a march-past of the project's security force. Then the project hosted an enormous open house, reportedly visited by 40,000 people who had traveled there from the local area as well as from as far away as Bombay.[60]

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58. GE, TAPS monthly report 8, January 1965, box 21, USAID Closed Project Loan Files 1960-1971, RG 286, NARA; TR, August 5, 1966.

59. TR, June 24, 1966; TR, July 8, 1966.

60. "Fourth of July celebrated," TR, July 8, 1966; "Thousands visit Tarapur Atomic Power

The Tarapur communities also participated in religious festivals and services. In the IGE Colony, the Tarapur Union Church met every other Sunday. A dedicated church building had not been included in the colony plan, so the congregation met in the clubhouse or the school room. Christian members of the Tarapur workforce attended the church, took communion there, and even christened their children.[61]

Far outnumbering the Christians, the Hindus in the workforce also performed their religious rituals at the site. The workers marked the Ganapati (Ganesh Chaturthi) festival, which falls in August or September and is especially popular in Maharashtra, by setting up a four-foot clay idol of the god Ganesh on a platform in the National Camp recreation hall. For ten days, the idol stood on the platform, and thousands of workers and their families, as well as residents of nearby villages, came to perform *puja* (worship), sing *bhajans* (devotional songs), and receive *prasad* (sweets). At the end of the ten days, they carried the idol down to the beach and immersed it in the ocean waves adjacent to the project site. At about the same time as Ganapati, the workers also celebrated Vishwakarma Puja. This was a particularly important festival for the workers, because it is a time when craftsmen revere the tools that they use for their work. In preparation for the festival, the workers decorated all of the project offices with banana plants, palm leaves, and flowers. The workers, along with their families, sang *bhajans* and performed traditional dances. The Indian staff also invited the American supervisors

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Project," TR, August 19, 1966. Until the end of the 1960s, security forces for Indian public-sector industrial undertakings were constituted ad-hoc or drawn from state police forces. In 1969, the government formed the Central Industrial Security Force (CISF), which had a mission to protect industrial sites such as Tarapur Atomic Power Station. The scope of CISF has expanded since its founding; CISF officers now provide security for airports, government buildings (including the National Archives), and the Delhi Metro. Surender Singh, "Director General's Message," *CISF*, http://www.cisf.gov.in/dgmsg/ (accessed January 11, 2016).

61. TR, June 17, 1966; TR, July 22, 1966; TR, August 12, 1966.

and their families; according to the characteristically upbeat account of the 1966 celebrations in "Tarapur Reporter," the Americans "took an equally keen interest in the celebrations."[62]

The residential segregation of National Camp and IGE Colony reflected a hierarchical division of the workforce based on class. Another demonstration of class-based hierarchy was the Tarapur Swim and Racquet Club. Established in September 1965, the club was meant to replicate the functions of the elite social clubs of Bombay and other Indian cities by providing its members with recreational facilities and regular social activities. The club's facilities included a swimming pool, two tennis courts, an air-conditioned badminton court, a library, and a lounge with a piano and a radiogram (a combined radio and record player). The club hosted monthly parties and dances for its members, usually corresponding to western holidays such as Valentine's Day and St. Patrick's Day. By the first anniversary of its founding, the club had become such an integral part of IGE Colony life that "Tarapur Reporter" declared it to be the "centre of the social activities in the colony."[63]

Social clubs in India, like so many other institutions, originated in the colonial period to serve the needs and wants of British colonists; later, they were Indianized. At their establishment, clubs almost invariably had racially-exclusive membership policies. At first all non-Europeans were excluded; later, wealthy Anglo-Indians and full-blooded Indians were allowed to join. Eventually, upper-class Indians replaced Europeans in the social clubs, just as they slotted into the hierarchy of modern India as a whole after the

62. TR, September 9, 1966; "Ganapati festival begins" and "Vishwakarma Puja festival celebrated by Bechtel employees," TR, September 23, 1966.

63. TR, December 10, 1965; TR, September 9, 1966, TR, September 23, 1966.

departure of the British.[64] Thus, even though Tarapur Swim and Racquet Club was racially inclusive, it was still exclusive in terms of class.

The children of the American expatriate families living in the IGE Colony had their own distinctive experience, different from life back home but also different from their predecessors, the British children who lived in India during the Raj. Although the IGE Colony had many modern comforts that were inaccessible to the majority of the Indian population—including imported appliances and consumables covered under an omnibus import license that also included materials for the construction project—living there was not the same as living in an American suburb.[65] One important difference was that the Colony was much more integrated than the average American neighborhood. In North and South alike, American housing developments tended to divide on racial lines. In the American racial hierarchy of the 1960s, Indians occupied an ambiguous position. Although obviously not of African descent, many Indians visiting or residing in the United States during this time suffered discrimination and marginalization on account of their "black" skin color. Some had trouble renting or buying property. De-facto white suburbs often excluded Indian immigrants as well as African-Americans. The IGE Colony, by contrast, was not segregated; both Indian and American families lived there, with Indians constituting the majority.[66]

The experience of American children at Tarapur also did not match the experience of British colonial children. Although the term of a family's stay could be several years in

64. The integration of social clubs in Bombay was still incomplete during the 1960s when Tarapur Atomic Power Station was under construction. The last whites-only holdout was Breach Candy Club in South Bombay.

65. TAPP quarterly report 1.

66. Andrew J. Rotter, *Comrades at Odds: The United States and India, 1947-1964* (Ithaca, NY: Cornell University Press, 2000), 166-67.

length, the Americans had not moved to India with the intention of establishing a generational presence. British colonialists had structured their lives based on the duties of their class and race. Children lived in India from birth to about the age of five, when their parents sent them to England for their schooling; they stayed there until they were grown and ready to return and take up the work of the Empire.[67] For American children at Tarapur, there was no set structure for their lives. Unlike both British and Indian cultures, Americans do not have a strong boarding school tradition. The American children stayed with their families and attended ad hoc schools set up in the Colony to educate the children of project employees. The teachers of the school were Indian-born women who were educated in both India and the United States, and had experience teaching in both countries. One of them, Mrs. Banudwala, had previous teaching experience at another industrial site, a chemical plant in Uttar Pradesh. For older children, a corner of the Bombay engineering office was set aside for high school classes. In December 1965, according to "Tarapur Reporter," an Indian teacher, M.K. Chitanvis, was teaching four expat students, using correspondence course material produced by the University of California.[68]

Living in India gave American children the chance to have experiences that would be unimaginable back home. Some of these were frightening or confusing, such as the ferocity of the monsoon or the variety of tropical insects and snakes they encountered. Other experiences were more pleasant. Toward the end of the 1966 monsoon, children from first through third grades in the colony school went on a picnic and field trip to

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67. Charles Allen and Michael Mason, *Plain Tales from the Raj: Images of British India in the Twentieth Century* (New York: St. Martin's Press, 1976), 31-33.

68. "Tarapur Teachers," TR, July 23, 1965; "High School," TR, December 10, 1965.

nearby attractions. With Labh Singh acting as their driver and guide, these six children explored the ruins of Tarapur Fort, visited a Shiva temple, and toured a fishing village, before eating their lunch on Chinchani Beach and heading back to the IGE Colony.[69]

The residents of IGE Colony receive the most attention in the pages of "Tarapur Reporter," while the laborers living in National Camp or the neighboring villages get much less coverage. Although National Camp had its recreation hall, the laborers lacked anything resembling the Tarapur Swim and Racquet Club. If the children of the laborers went on any organized excursions, this was not reported in the newsletter. The residents of IGE Colony, Indians and expats combined, were a minority of the workforce. The lifestyles of the project management and engineers, as portrayed in the newsletter, were unattainable for the majority of the workforce.

The meaning of Tarapur

Official documentation of the Tarapur project tended to be straightforward and often dry. The TAPP quarterly reports and the GE monthly reports almost never attempted to provide any interpretation of the wider significance of the project. The authors of the reports took it as a given that anybody reading the report would appreciate Tarapur's importance. In comparison, "Tarapur Reporter" was produced for a wider audience, and its pages occasionally carried reminders that the project was India's first commercial nuclear powerplant, and therefore it was important to keep on schedule.[70] These notices usually corresponded with management's injunctions against labor unrest. But the clearest statements of the significance of Tarapur appear outside the official

69. "School picnic," TR, August 5, 1966.
70. For instance: TR, July 22, 1966.

documentation or "Tarapur Reporter." Contemporary magazine and journal articles, films, and speeches, created by people not directly associated with the project, offer interpretations of Tarapur's significance in national and international contexts.

Almost unanimously, the magazine articles published around the time of the plant's commissioning portray Tarapur as modern, with only the most advanced safety equipment and the most up-to-date control room. Not only is the technology modern, its aesthetic is modern too; several articles, all apparently based on the same promotional material or press release, describe the plain reactor and generator buildings as "cubist." What Tarapur is not is an ugly, polluting, earth-destroying relic of outdated nineteenth-century industrialism. Numerous articles describe the plant's setting as "serene," "placid," and even "romantic." The plant is located on a landscaped campus with green, closely-cropped lawns and palm trees. While the ventilation stack may resemble a factory smokestack, "practically no wisp of smoke ever emergs [*sic*] from it. The contrast with a coal burning thermal power station with its continuous outpouring of dense columns of smoke night and day is startling." The portrayal of Tarapur as clean and quiet echoes Lewis Mumford's theory that the "neotechnic" era (his own age, the twentieth century) brought the material benefits of modern industrial technology without the pollution and environmental degradation brought by the machines of the "paleotechnic" nineteenth century.[71]

"Nuclear Power from Tarapur," a thirteen-minute film produced by the US Information Service for screening in India, takes this theme even further. The film takes

71. "Tarapur: Gateway to the Nuclear Age," *The Economic Studies* 10 (1968), 421; "Tarapur: India's Gateway to Atomic Power," *Yojana*, June 29, 1969, 7-8; "Dedication of Tarapur Nuclear Power Plant," *The Indian and Eastern Engineer*, February 1970, 112; Lewis Mumford, *Technics and Civilization* (New York: Harcourt, Brace and Co, 1934), 424.

the viewer on a tour of the facilities at Tarapur, including the "government laboratory" that tests the "air, water, soil, food grown, and sea fish" of the area for radiation contamination. The narrator explains: "These are standard precautions in Tarapur, as in twenty-five other nuclear plants around the world, all operating safely and without health hazards." Not only is Tarapur clean and safe, it even represents peace. The narrator describes the turbines as "today's *charkha*, another powerful wheel of peace." The *charkha* was the manual spinning wheel promoted by Mohandas Gandhi and adopted as the symbol of the Indian National Congress. For Gandhi, the *charkha* was a humanistic technology that represented economic self-reliance and independence from the tyranny of modern industry. Tarapur's turbine-*charkhas*, on the other hand, represented economic self-reliance through the use of industrial technology.[72]

Even though the civil works of the plant are much smaller than even some of the mid-size dams built in Nehruvian India, the size of Tarapur Atomic Station is a recurring theme in these articles. Many publications billed it as not just the largest nuclear powerplant in Asia, but also as the second-largest in the world, after Hinkley Point in England. Tarapur also invited comparison with premodern Indian monuments, particularly Qutb Minar. This 238-foot twelfth-century tower in southern Delhi served as a standard measuring stick for Indian structures, and comparisons with Qutb Minar were common in publications about development in India during the early-independence period. For example, according to an article in *Assam Information*, the distance between the bottom of the foundations and the top of the piers of the Saraighat Bridge is almost as

72. USIS, "Nuclear Power from Tarapur," 1969, US moving images compiled 1982-1999, RG 306, NARA.

much as the height of Qutb Minar. Another article boasts that Bhakra Dam is three times as tall as Qutb Minar; this figure also includes the dam's foundation. The feature of Tarapur that invited comparison with Qutb Minar was the 366-foot ventilation stack, which is "much taller than the Qutb Minar."[73] Comparing modern Indian development projects with premodern monuments was a way to legitimize the current projects by linking them with the past. At the same time, it was also a way to transcend the past, to prove that the present was better than both the precolonial and colonial pasts.

Some of the most vivid rhetoric about Tarapur's significance to the Indian nation appears in Prime Minister Indira Gandhi's speech at the dedication of the plant. The text of the speech carries a strong strain of modernism and even techno-utopianism. According to Mrs. Gandhi, India had begun to leapfrog developmental stages; the construction of sophisticated projects such as Tarapur would have a technological trickle-down effect that would benefit many other fields of society. Modern technology allowed India to escape the Malthusian checks that had hindered its growth in the past. In her most techno-utopian statement in the speech, Mrs. Gandhi declared that "man's expanding knowledge and power render largely obsolete the scarcity logic on which much of the world's planning and programming are based." In this view, Tarapur was one step toward engineering away problems that had plagued India since time immemorial.[74]

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73. "Tarapur: Gateway to the Nuclear Age," *Economic Studies* 10 (1968), 421; "Saraighat Bridge: A Boon to Assam," *Assam Information*, November 1963, 20; "Dedication of Bhakra Dam," *Indian Recorder and Digest*, November 1963, 6; "Tarapur Atomic Power Station," *The Indian Railway Gazette*, September 1965, 254-56.

74. Indira Gandhi, "Tarapore: A Dream Come True," in *Selected Speeches of Indira Gandhi*, vol. 2: *The Years of Endeavour, August 1969-August 1972* (New Delhi: Publications Division, Ministry of Information and Broadcasting, Govt. of India, 1973), 421-24.

Conclusion

Even after the official handover of the plant to the Government of India, Tarapur remained tied with the United States. The agreement signed in 1966 guaranteed that the United States would provide fuel to Tarapur for twenty-five years. The project initially imported completed zircaloy-clad fuel pellets from the United States, although the Indian AEC started building a fuel-fabrication facility in Hyderabad to convert American-enriched UF_6 (uranium hexafluoride) into fuel pellets. This facility was not ready when it came time to reload the reactors for the first time in 1971, so the project had to import completed fuel pellets again.[75]

Under the fuel supply agreement, spent fuel was to be carefully monitored and inspected to make sure that it was not diverted to weapons production. In May 1974, India set off the Peaceful Nuclear Explosion. The PNE did not make use of any materials from Tarapur; nevertheless, the United States worried that the reactors at Tarapur could be used for further nuclear proliferation. Although Canada immediately canceled the technical collaboration agreement for Rajasthan Atomic Power Station, the United States did not cut off the uranium supply to Tarapur in 1974; instead, it clamped down on safeguards. In 1978, the US Congress passed the Nuclear Non-Proliferation Act, which mandated that the United States cut off nuclear assistance to any country that did not submit to IAEA inspections at all of its nuclear facilities. India was one such country.

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75. M. Dayal, "Experience from Operating and Fuelling a Nuclear Power Plant in an Industrially Developing Country," in *Experience from Operating and Fuelling Nuclear Power Plants: Proceedings of a Symposium on Experience from Operating and Fuelling Nuclear Power Plants, Organized by the International Atomic Energy Agency and Held in Vienna, 8-12 October 1973* (Vienna: International Atomic Energy Agency, 1974), 85-87; M.N. Chakravarti, "Tarapur Atomic Power Project," *IJPRVD* 18 (Feb. 1968): 41-47; R. Bhaktavatsalu, "Purchase of first reload fuel requirement and of fuel design for the Tarapur Atomic Power Station," memo, August 25, 1969, file no. 2(29)-AID 1969 (Part I), Ministry of Finance, NAI; Arjunan Gnanaolivu, memo, August 26, 1969, ibid.

Tarapur was already subject to safeguards, but the Canada–India Reactor remained unsafeguarded. The United States wanted to keep safeguards in place at Tarapur, but also wanted to pass the plant off because it was politically problematic. In 1981, France agreed to take over fuel supply duties and maintain safeguards.[76]

While India succeeded in indigenizing nuclear technology, nuclear power did not prove to be the technological boon that India's planners had anticipated. India built more reactors, including two more at Tarapur, but these reactors did not bring about an industrial or economic transformation of the country. By 2011, only 1.8 percent of Indian electrical generation capacity was nuclear power. Even wind turbines, at 6.8 percent, generated a far larger share of India's electricity than nuclear reactors. The dominant power source in India, as for most countries, remains fossil fuels such as coal and natural gas; more than 70 percent of Indian electricity comes from these sources. Although India was able to build indigenous power reactors, nuclear energy was too capital-intensive to become the signature power source of country, unlike France. Instead, the power source that actually did transform the Indian nation was hydroelectricity. Even though hydroelectric projects produce only 17.8 percent of India's power, dams have become the signature source of power for modern India. As discussed in Chapter 3, the seasonal monsoon rains made generation of hydroelectricity from reservoir storage practical in many parts of India. Dams could be built mostly from domestic materials, and India's huge labor force could be used in place of many machines, thereby saving foreign exchange. By comparison, atomic power was higher-tech, more capital-intensive, and

76. Gursharan S. Dhanjal, *Tarapur: The Politics of Nuclear Age* (Delhi: Rajdhani Book Service, 1992), 18, 84-85, 88.

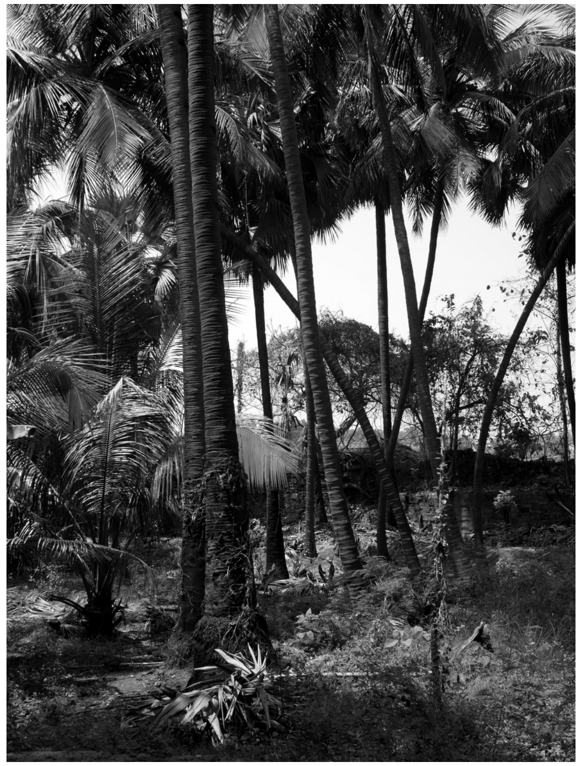

Figure 16. The coconut plantation inside Tarapur Fort in 2015. (Photo by the author.)

harder to indigenize.[77]

Although the original planned lifespan of Tarapur Atomic Power Station was twenty-five years, the plant will complete fifty years of operation at the end of this decade. The plant is now operated by Nuclear Power Corporation of India Limited (NPCIL), a branch of the Department of Atomic Energy established in 1987. NPCIL operates all nuclear powerplants in India. The central government sells the power produced by its plants to the state utilities. In 2011, the aging reactors at Tarapur became a source of controversy after another GE plant of a similar design, Fukushima Daiichi,

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77. These statistics come from U.S. Energy Information Administration, “International Energy Statistics,” http://www.eia.gov/cfapps/ipdbproject/IEDIndex3.cfm?tid=44&pid=44&aid=1 (accessed February 24, 2014). The IAEA’s online Power Reactor Information System (http://www.iaea.org/PRIS/CountryStatistics/CountryDetails.aspx?current=IN) gives a larger number for the share of Indian power produced by nuclear reactors: 3.53 percent. Both figures indicate that the share of nuclear power contributing to India’s grid is relatively small.

melted down when the Japanese coast was struck by a major tsunami. Articles appeared in the Indian press denouncing the NPCIL leadership as incompetent, and alleging that Tarapur was on the verge of becoming the next Fukushima Daiichi. In a rejoinder to one such article, NPCIL claimed that Tarapur had an excellent safety record: "A large number of Parliamentary delegates and nuclear experts of Nuclear states have visited our nuclear power station at Tarapur on various occasions and are impressed with the safety and overall performance of our reactors."[78]

The area around Tarapur has grown up in the years since the nuclear powerplant's construction, although the development has been concentrated around Boisar and the plant itself. The original IGE Colony, now renamed NPCIL Colony, still houses the employees who operate the plant. Two other housing developments flank the NPCIL Colony, one for Bhabha Atomic Research Centre (formerly Atomic Energy Establishment–Trombay) and the other for Maharashtra State Electricity Board.

Northeast of the power station, the town that gave the plant its name, Tarapur, is still just a town. From the 1961 to 2011 censuses, Tarapur's population grew by 66 percent, compared to 175 percent for the population of the country as a whole.[79] Tarapur village, with its narrow streets and metal-roofed houses, seems far from the nearby nuclear powerplant in every respect. Four-hundred-year-old Tarapur Fort, which once defended the North Konkan for the Portuguese and Marathas, now stands in ruins. A sign placed by the Maharashtra Tourism Development Corporation points from the Boisar-

78. "Our comments on your story 'India's Nuclear Neros,'" *NPCIL*, http://npcil.nic.in/pdf/news_25mar2011_02.pdf (accessed January 11, 2016). The article in question was written by Praful Bidwai and published in *Outlook* magazine on March 28, 2011.

79. Population figures from "Population Finder 2011," *Census of India*, http://www.censusindia.gov.in/pca/Searchdata.aspx (accessed January 11, 2016).

Tarapur Road to the fort, but the authorities have not stabilized the structure or posted any interpretive signs. The spacious parade ground inside now serves as a coconut plantation (Figure 16).

An advertisement that appeared in Indian magazines shortly after General Electric's selection as prime contractor for the project declared, "A dreaming old-world village wakes upto [*sic*] atomic age!" This was hyperbole in two respects. First, Tarapur was economically active, not "dreaming," before the power station's construction. Second, signs of any nuclear awakening are imperceptible in present-day Tarapur. In the case of this village, as in India as a whole, the actual effects of nuclear power have been far more subtle than the planners and proponents had hoped.[80]

80. The advertisement was produced by International General Electric and appeared in the October 1963 issue of *IJPRVD*.

Conclusion

In the first half of the twentieth century, anyone entering or leaving India was likely to pass through the Port of Bombay. Over 160,000 passengers began or ended overseas voyages in Bombay in 1949-50. Most of these embarked or disembarked at deep-anchorage Ballard Pier. A few of the most important ships anchored in the deep water off of Apollo Pier, adjacent to the Taj Mahal Hotel, and their passengers traveled the intervening distance by small craft. In 1911, the Emperor and Empress of India, King George V and Queen Mary landed at Apollo Pier at the beginning of their visit to their colony. The Gateway of India was subsequently built at the end of Apollo Pier to commemorate the royal visit. After independence, the last British troops in India marched through the gateway before boarding their ship and sailing for England.[1]

By the second decade of the twenty-first century, the city, now renamed Mumbai, was still a busy freight port, but international passenger traffic no longer arrived there. The biggest vessels that dock at Apollo Pier now are the ferries that take tourists to see the ancient caves on Elephanta Island. In the winter months, the ferries are followed by flocks of squawking seagulls attracted to food thrown by passengers. In place of Apollo Pier, the main entrance point to western India is now Chhatrapati Shivaji International Airport. The new Terminal 2, which opened in 2014, is an enormous, aggressively

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1. Frank Moraes, ed., *The Indian and Pakistan Year Book and Who's Who 1951* (Bombay: Times of India, 1951), 337-38.

modern building, with glass walls on all four sides, gleaming white columns, and a soaring roof.

From Apollo and Ballard Piers—outdoors with the squawking seagulls—to enclosed, air-conditioned Chhatrapati Shivaji International Airport, the aesthetic change of the entry point to India reflects deeper economic and technological changes in the years since independence. Fifty years after the Third Five-Year Plan, India now has a large and diverse industrial capacity. Between public and private industrial concerns, India is capable of manufacturing rocket engines, space probes, nuclear reactors, nuclear warheads, and more prosaic products such as automobiles, buses, and mobile phones. In terms of value-added industrial output, India is the world's sixth-largest manufacturing nation, after China, the United States, Japan, Germany, and South Korea. Although India still lags well behind China and the United States, the biggest industrial powers, its current status represents significant progress in the seventy years since independence. The United Kingdom, the nation that once exploited India's resources for its own industrialization, now produces less than its former colony and stands at ninth place in the international industrial rankings.[2]

Indian industry relies on a mix of indigenized technology and the continued importation of technology from abroad. As the history of bridges built over the Brahmaputra demonstrates, technological indigenization is at once a measurable fact and

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2. Data are from "National Accounts Main Aggregates Database," *United Nations Statistics Division*, http://unstats.un.org/unsd/snaama/selbasicFast.asp (accessed February 3, 2016). Data represent total production in 2014, expressed in US dollars. The world's ten largest manufacturing nations, with their percentage of total world output in parentheses, are: China (24.00%), the United States (17.19%), Japan (6.97%), Germany (6.45%), South Korea (3.19%), India (2.66%), Italy (2.43%), France (2.32%), United Kingdom (2.32%), and Russia (1.97%). Although India's production now exceeds Russia's, the total production of the fifteen former members of the Soviet Union, at 2.87% of world total, is still greater than India's.

a social construct. A technology becomes indigenized when it can be produced domestically without any further foreign technical input. A technology ceases to be indigenized when its users decide that it no longer serves their needs, and an imported technology would serve them better. India's industries, once established, have continued to receive foreign technical inputs from time to time. As these four case studies have shown, the Indian public sector has been successful in establishing Indian-owned industries such as Bharat Heavy Electricals Ltd. that produce goods that would have to be imported otherwise. Even if technology can never be fully indigenized, domestic production still contributes to some measure of autarky.

The construction of metro railways in India's biggest cities illustrates how technical interchange has taken place in the post-liberalization period. India's largest metro is the Delhi Metro which, as of February 2016, has 160 stations and 132 miles of track. In 1997, during the metro's early planning stages, the Japanese government's Overseas Economic Cooperation Fund agreed to finance more than half of the cost of the first phase of the project. The following year, a consortium of five international consultancy firms led by PCI of Japan signed an agreement with Delhi Metro Rail Corporation (DMRC) to advise on the project. The broad-gauge rolling stock for the first phase was designed by an international consortium and manufactured in South Korea by ROTEM. The tender notice for rolling stock stipulated that the company that received the contract should build make provision for "technology absorption" in India. Accordingly, ROTEM provided plans and training to employees of public-sector firm Bharat Earth Movers Ltd. Now BEML manufactures ROTEM-type coaches at its facility in

Bangalore.[3]

With the completion of the first stages of the sleek and (usually) efficient Delhi Metro, metro railways have become talismans of metropolitan modernity, and now every city of any size in the country wants to have one to prove that it has finally arrived.[4] This metro-mania has led to a spate of systems that, at least in their earliest phases, are impractical, as they link low-traffic sections of cities. Even Gurgaon has a little three-coach metro, built entirely with private capital, running in a one-way loop among the high-rises and stopping at stations named for companies that bought the naming rights by auction. In the construction of metros outside Delhi, including Bangalore, Kolkata, and Jaipur, DMRC has served as consultant. In this way, Delhi's metro has passed along to other cities metro-building expertise that it obtained from collaboration agreements with foreign companies.[5]

India's least successful indigenization program to date has been fighter jets. The first indigenous fighter program, HF-24 Marut (discussed in Chapter 1), was not a total failure, as it did produce an aircraft that entered service in the Indian Air Force, and even served in combat. Nor was it a resounding success. HF-24 could not be produced in large enough quantities to satisfy the IAF's need for fighters, thus forcing India to fall back on Russian-made Sukhoi fighters. Furthermore, the HF-24 that was actually built and

3. "About Us," *Delhi Metro Rail Corporation Ltd.* (*DMRC*), http://www.delhimetrorail.com/about_us.aspx#Introduction (accessed February 1, 2016); Annual reports, 1995-96 to 2001-02, *DMRC*, http://www.delhimetrorail.com/annual-reportsfolders.aspx (accessed February 1, 2016); P. Manoj, "BEML to rake in big money from proposed metro projects," *The Hindu*, August 25, 2005.

4. Itty Abraham, in *The Making of the Indian Atomic Bomb: Science, Secrecy, and the Postcolonial State* (London: Zed Books, 1998), 20-21, calls the dams, steel mills, and nuclear reactors of India in the early-independence period fetishes, which were used for "marking out a postcolonial national space." On a subnational scale, metro railways serve a similar purpose in contemporary Indian cities.

5. Kolkata's Soviet-assisted one-line metro predates the Delhi Metro, so DMRC has consulted on the expansion and modernization of the system.

entered service was disappointingly underpowered. The HF-24 played a supporting role in Indian airpower in the 1970s, but it could never upstage foreign fighters in the central roles.

It is too early to say whether India's second indigenous fighter program, Light Combat Aircraft (LCA) or "Tejas" (Radiant), will overcome the disappointing legacy of its predecessor. The LCA program began in 1983 with the objective of producing a domestic replacement for the MiG-21s that the IAF had already been using for twenty years. The LCA project was under development for eighteen years before the first prototype flew in 2001. The IAF finally received its first production-series LCA in January 2015, although full squadron deployment was still several years in the future. Although the airframe is a domestic design, only about 60 percent of the parts used in the plane are indigenously-sourced. Just like the HF-24, LCA uses a foreign-designed engine. The Tejas Mk I fighters use the General Electric F-404, while the subsequent Mk II aircraft will use the more powerful GE F-414. In a near-repeat of the IAF's turning to Sukhoi fighters in the late 1960s, delays in the LCA program have compelled the IAF to order thirty-six French-made Dassault Rafale fighters in the interim.[6]

Why have the Indian government's technological indigenization programs met with such mixed success? The four case studies in this dissertation have provided several explanations, and this conclusion will advance one more. Chapter 1 showed that nonalignment restricted India's access to certain technologies. The polarization of the Cold War world made military equipment from the West difficult or impossible to obtain.

6. "India, US finalise Rs. 3000 cr jet engine deal," *Hindustan Times* (*HT*), January 20, 2013; Chethan Kumar, "32 years on, HAL finally hands over Tejas to IAF; induction still far away," *Times of India* (*TOI*), January 18, 2015; "Agreement on Rafale price will take another month's bargaining," *TOI*, January 26, 2016; "*Mig 21 ki jagah lenge ghaatak Tejas vimaan*," *Rajasthan Patrika*, February 2, 2016.

India received defense radar and supplies for mountain warfare from the United States, but no fighter jets. Attempts to produce indigenous fighters were only partially successful, as it ultimately proved cheaper to import a proven foreign design. Creating a fighter jet is a highly resource-intensive endeavor that only a few nations can undertake competitively. Even Canada could not afford to complete development of its CF-105 Arrow fighter, and instead ended up importing American designs.[7]

The bridges over the Brahmaputra, discussed in Chapter 2, demonstrate that technological indigenization does not necessarily last forever. A technology stays indigenized only as long as its users are content with it as it is, and do not feel that they need to update it to reflect changes abroad. The Northeast Frontier Railway decided that Indian bridge-building techniques were up-to-date when it awarded the contract for the Saraighat Bridge's trusses to the domestic firm Braithwaite, Burn and Jessop in 1959. But by 2011, new techniques had been developed abroad, and NFR accordingly selected a German firm, DSD Brückenbau, to design the trusses for the Bogibeel Bridge.

The power projects in Chapters 3 and 4 show how technologies in varying stages of indigenization often still relied on foreign inputs. To construct Umiam Dam, the Assam State Electricity Board was able to use mainly Indian expertise, but it had to import machinery and development capital. Bharat Heavy Electricals Ltd., the Indian government's import-substitution industry for equipment used in power stations, was unable to find a sufficiently large domestic market, and it only really succeeded after it turned to the export market. Nuclear power technology, discussed in Chapter 4, was

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7. The comparison between the Indian and Canadian fighter programs is made by Michael J. Neufeld in "The Nazi Aerospace Exodus: Toward a Global, Transnational History" *History and Technology* 28 (Mar. 2012): 51.

indigenized after the period of this study, but even so has found limited application in India. Nuclear plants require higher initial capital outlay and more restrictive siting requirements than thermal plants, so it has usually proven cheaper to build a thermal plant, even factoring in the recurring fuel costs.

Apart from the explanations shown in the case studies, one additional factor has hampered India's establishment of technological and industrial competency: the out-migration of qualified technical specialists, or the "brain drain." India has produced a large, competent workforce of technical specialists who are highly sought-after in the West. Indians who receive a bachelor's or graduate degree in the West often have the chance to stay on after graduation, because western countries, especially the United States and Britain, have no shortage of firms eager to recruit well-trained Indian engineers, at higher salaries than a comparable company in India would offer. There have been some examples of Indians who initially settled abroad choosing to buck the trend and return to India, usually to work in the information-technology industry. The general trend, though, has been out-migration of technical talent.[8]

The Indian command economy period has been finished for a quarter-century

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8. For an example of the reverse brain drain, see Saritha Rai, "Indians find they can go home again," *New York Times*, December 26, 2005, http://www.nytimes.com/2005/12/26/business/worldbusiness/indians-find-they-can-go-home-again.html (accessed February 4, 2016). Frédéric Docquier and Hillel Rapoport, in "Globalization, Brain Drain, and Development," *Journal of Economic Literature* 50 (Sept. 2012): 681-730, show that since the late 1990s, scholars have argued that brain drain can sometimes be beneficial to the source country. The dominant popular opinion, though, is that brain drain has an overall negative effect on the source country. An example of this critique is the Indian film *Swades: We the People* (2004, dir. Ashutosh Gowariker), in which an Indian-born NASA scientist returns to his home village for a visit and, after being impressed by the economic problems of rural India, decides that India needs him more than the United States. From the West, the American spoof newspaper *The Onion* satirized an apparent lack of social responsibility on the part of the emigrants with an article headlined, "India's top physicists develop plan to get the hell out of India," *The Onion*, November 6, 2002, http://www.theonion.com/article/indias-top-physicists-develop-plan-to-get-the-hell-29 (accessed February 4, 2016).

now, and it would be hard to imagine a situation in which it might return. Instead, the contemporary mood is very much in favor of the free market. The command economy had its opponents from the beginning. Gandhians wanted a localized, village-centered economy rather than big industry, while the captains of private industry wanted to direct their own undertakings without government interference or competition. In the early-independence period, though, command-economy socialists dominated politics and were thus able to implement their economic plans. Since 1991, the situation has reversed, and now a large portion of the upwardly-mobile Indian middle class, at least, remembers the command economy as an era of lost opportunity during which the Indian government wasted decades fumbling around with impractical Five-Year Plans when it should have been fostering private industry and foreign investment.[9]

It is true that the Indian economy has grown at a much faster rate since liberalization. It is also true that the post-liberalization growth has been unequal. The middle class, big in numbers but small in overall percentage, have gained most of the benefits as the poorer classes have been left behind. Furthermore, as these case studies have shown, the command economy period was a time of great industrial and economic expansion. The Indian public sector gradually established an industrial and infrastructural base that the private sector was able to build upon after 1991. Without the large public

9. The proponents of Nehru's legacy call "lost years" opponents such as Tirthankar Roy and Meghnand Desai "neo-colonial scholars." Among the proponents is Jawaharlal Nehru University history professor Aditya Mukherjee, who stated at a seminar at Aligarh Muslim University, "The neo-colonial scholars look back from the vantage point of the high growth rates since the 1991 economic reforms. This is ahistorical. Nehru saved India from becoming a banana republic by not imposing the post-'91 strategy in the '50s." Eram Agha, "Demonizing Nehru has become quite the fad: Historians," *TOI*, November 12, 2015, http://timesofindia.indiatimes.com/india/Demonizing-Nehru-has-become-quite-the-fad-Historians/articleshow/49759429.cms (accessed February 3, 2016). The early opponents of the command economy are discussed in Dharma Kumar, ed., *The Cambridge Economic History of India* (Cambridge: Cambridge University Press, 1983), 2:949-51.

sector, the private sector could never have become as successful as it is today.[10]

The final nail in the coffin of the Indian command economy era, if it needed one, came with the election of Narendra Modi as Prime Minister in the general election of 2014. In his first Independence Day address as Prime Minister, Modi announced that the Planning Commission would be disbanded. Since 1991, the Planning Commission had continued to produce plans, but with little real authority. Following Modi's announcement, the Twelfth Five-Year Plan would be allowed to run its course, but after its completion no further plans would be produced. Yojna Bhawan, the headquarters of the Planning Commission on Sansad Marg in New Delhi, was rebranded with the name of the commission's successor NITI Aayog, which had a vague mandate to promote economic growth and eradication of poverty by serving as a think tank.[11]

Instead of state control of industries, Modi believes strongly in attracting foreign private investment into India. He hopes to do this through a program called "Make in India." The Make in India logo, a striding lion made of gears, has become ubiquitous in newspapers, magazines, and posters. A giant animatronic version of the logo even appeared as a float in the 2015 Republic Day parade in New Delhi. By attracting foreign investment to India, Modi hopes to give the Indian economy a shot in the arm. Made-in-India products will not only be exported to earn foreign exchange; they can also be sold on the domestic market to save the necessity of importing manufactured goods.[12]

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10. A scathing critique of the upwardly-mobile Indian middle class is found in Pavan K. Varma, *The Great Indian Middle Class* (New Delhi: Penguin Books, 1998).

11. "Modi makes a clean break, ends Plan era, wants to build Team India ," *TOI*, August 16, 2014. "NITI" stands for "National Institution for the Transformation of India."

12. "FDI means First Develop India, PM tells bizmen," *TOI*, September 26, 2014; "'Make in India' tableau steals the show in Republic Day parade," *TOI*, January 26, 2015, http://timesofindia.indiatimes.com/india/Make-in-India-tableau-steals-the-show-in-Republic-Day-parade/articleshow/46018355.cms (accessed February 3, 2016).

An early technological achievement of India under Modi's administration was the Mangalyaan-1 probe's entry into the orbit of Mars on the morning of September 24, 2014. Mangalyaan-1 was designed and built in India, financed by Indian taxpayers, and launched on an Indian PSLV rocket from Shriharikota in Andhra Pradesh. Over the course of a month, the probe orbited the Earth, progressively climbing to higher orbits before using Earth's gravity to slingshot it toward Mars. When Mangalyaan finally reached Mars almost eleven months later, it became the first probe built in Asia to reach the Red Planet. This was also the first time that any nation successfully sent a probe to Mars on its first attempt.[13]

The Indian media was abuzz over this distinctive national accomplishment. Commentators praised the engineers and scientists at the Indian Space Research Organisation (ISRO) for reaching Mars cheaply and efficiently, but still flawlessly. Narendra Modi observed the goings-on at mission control in Bangalore, and then delivered a televised speech to a crowd of ISRO engineers. In his speech, Modi emphasized that the probe was built "indigenously and upon Indian effort, spreading from Bangalore to Bhubaneshwar, and Faridabad to Rajkot," for less than the cost of a Hollywood movie.[14]

Whether Modi realized it or not, the rhetoric of indigeneity and technological self-reliance that he expressed in his speech was already more than fifty years old. These ideas were first clearly articulated in the Third Five-Year Plan. Even with the demise of

13. Arun Ram, Chetan Kumar, and Srinivas Laxman, "India enters super exclusive Mars club," *TOI*, September 25, 2014.

14. "PM Narendra Modi's speech from ISRO on successful insertion of 'Mangalyaan' into the Martian orbit," *Rajya Sabha TV*, https://www.youtube.com/watch?v=jwHBMR8C6B0 (accessed September 25, 2014).

the command economy and the death of the Planning Commission, the Nehruvian dream of technological independence lives on in post-liberalization India.

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