SWORDS INTO PLOWSHARES: CIVILIAN APPLICATION OF WARTIME MILITARY TECHNOLOGY IN MODERN JAPAN, 1945-1964

DISSERTATION

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ABSTRACT

This dissertation examines civilian application of military technology in Japan after World War II. As a case study, I focus on the historical metamorphosis of wartime technology — such as military aircraft deployed for *kamikaze* suicide missions— into the highly successful *Shinkansen* high-speed bullet train. In retrospect, the shift in the socio-technological landscape in Japan after 1945 was drastic, spectacular, and unprecedentedly successful. Employing a bottom-up approach, I highlight the decentralized character of Japan's conversion process from wartime to postwar eras. Specifically, I examine the roles of former military engineers in the public research and development sector at the grass roots-level. The crucial variable in the conversion process, I argue, was the remarkable adaptability and flexibility of these engineers and their knowledge, especially in support of Japan's technological development. The course of the technological transformation was neither obvious nor preordained. It was largely idiosyncratic and contingent on numerous individual decisions and actions within the engineering community. At least the bullet train and other modern technological artifacts were a product of such

development; postwar technological artifacts were essentially amalgamations, reproductions, and reconfigurations of pre-1945 technologies with little orchestrated effort from the top. The postwar conversion went beyond a mere shuffling of human and financial resources. Many efforts came from grass-roots activities among engineers. The society as a whole beat swords into plowshares, renouncing war with peace-oriented technology.

Dedicated to my parents, Kiyoshi and Keiko Nishiyama

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CHAPTER 1

INTRODUCTION

Wars, defeat, survival, reconstruction, and rapid economic growth were the successive phases of Japan's transformation during the twentieth century. In many ways, the country's technological progress and its incessant armed conflicts outside its national boundaries were co-dependent factors. The Russo-Japanese War (1905), World War I (1914-1918), and World War II in Asia and the Pacific (1937-1945) provided the nation with a rationale and setting for increasing its industrial and technological muscle in Asia during the age of imperialism. Militarism and industrialism were also mutually dependent upon each other, supporting the country's pursuit of territorial expansion leading up to the 1940s. Leadership that concurrently had high optimism and a fatally unrealistic, fascism-tainted vision, led Japan into war in Asia and the Pacific. Japan's subsequent defeat, as expressed in its unconditional surrender to the Allied forces, was unmistakable. Large parts of the nation were reduced to rubble and ashes.

Understandably, the Japanese people in general were tired of war and looked forward to peace and tranquility after 1945. The years of survival during the Allied Occupation (1945-1952) were followed by years of phenomenal revival in several industries and in the national economy in general. In retrospect, the shift in the socio-technological landscape during the immediate postwar years seems remarkably drastic, spectacular, peculiar and successful on a never-before-seen scale. Owing to a series of reforms by the Allied Occupation, the shift was indeed both conspicuous and profound, particularly in the political, economic, and social spheres. But how fundamental was the shift among ordinary citizens in the socio-technical landscape in trans-World War II Japan? At the grassroots level, what technological legacies of the pre-1945 era, if any, were integrated into the post-1945 era, chiefly by whom, and to what ends?

In answering these questions, my dissertation will focus primarily on the actual architects of the modern technological development in society, namely engineers. More specifically, I will examine the roles of wartime military engineers in the technological transformation of modern Japan. My approach is thus inherently bottom-up; I will address how and why they actively participated in the country's pursuit of peace after the war's end in the fields of electrical engineering, mechanical engineering, material engineering, civil engineering, and aerodynamics in the railway industry. My focus will remain mostly, but not exclusively, on aeronautical engineers. I define them as professionals who specialized in the design, research and development (hereafter referred to as “R&D”), and mechanical performance of aircraft and its components. In the development of military and civilian technologies, the roles of aeronautical engineers were crucial at every point from 1945 through 1964 and beyond. After 1945, for instance, the former aeronautical engineers applied their wartime technology to the successful development of the high-speed bullet train, the *Shinkansen*. These agents of technological transformation developed devices for destructive ends before 1945 and constructive ends after that. Peace dividends of wartime technologies and engineers were latent, diverse, and crucial for the nation in reconstruction and thereafter.

1.1 Historical Issues

The focal points of my dissertation are R&D in the public sector, ordinary engineers, and the impact of peace on technological development in modern Japan. More specifically, I will highlight the roles of former military engineers who, individually and collectively, conducted R&D projects in railroad technologies from 1945 to 1964. This is a case study with a research scope that is admittedly limited. It nonetheless aims to fill three major lacunae that exist to date in historical scholarship about the technological development of Japan after the Meiji Restoration in 1868.

First, little scholarly attention has been paid to the R&D of engineering in the public sector. For our purposes, I define “public R&D” as the entirety of empirical engineering projects that are proposed, organized, managed, and conducted at research laboratories in the public sphere; furthermore, these facilities exist with financial support from the central government. Many studies have reduced much of modern industrial development in Japan to a business operation, as well as to the manufacture and distribution of products, in private firms; offices, production floors, and the commercial market are typical areas of historical interest. Many historians have examined private firms that are typically part of big business; indeed, light and heavy industries occupy central stage in the scholarly mainstream. The types of industries studied to date include agriculture,[1] silk weaving and textiles,[2] steel,[3] chemicals,[4] machinery,[5]

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[1] Penelope Francks, *Technology and Agricultural Development in Pre-War Japan* (New Haven: Yale University Press, 1984).

[2] Tessa Morris-Suzuki, "Sericulture and the Origins of Japanese Industrialization," *Technology and Culture* 33, no. 1 (1992), Akio Ōkōchi and Shin'ichi Yonekawa, *The Textile Industry and Its Business Climate: Proceedings of the Fuji Conference* (Tokyo: University of Tokyo Press, 1982).

[3] See, for example, Leonard H. Lynn, *How Japan Innovates: A Comparison with the U.S. In the Case of Oxygen Steelmaking* (Boulder: Westview Press, 1982), David G. Wittner, "Iron and Silk: Progress and Ideology in the Technological Transformation of Japan, 1850-1895" (Ph. D dissertation, Ohio State University, 2000), Seiichiro Yonekura, *The Japanese Iron and Steel Industry, 1850-1990: Continuity and Discontinuity*, *Studies in the Modern Japanese Economy.* (New York: St Martin's Press, 1994). For labor history in the steel industry, see Andrew Gordon, *The Evolution of Labor Relations in Japan: Heavy Industry, 1853-1955* (Cambridge: Harvard University Press, 1985), Andrew Gordon, *The Wages of Affluence: Labor and Management in Postwar Japan* (Cambridge: Harvard University Press, 1998). This “popularity” of the steel industry among scholars is reasonable, given the crucial importance of steel to shipbuilding, machinery, automobiles, and consumer electronics in particular.

[4] Barabara Molony, *Technology and Investment: The Prewar Japanese Chemical Industry* (Cambridge:

shipbuilding,[6] automobiles,[7] railroads,[8] and military defense.[9] Overall, the weight of government-sponsored R&D in the country's technological transformation after World War II has been significantly under-appreciated in scholarly circles.[10]

Secondly, engineers in general have been seen as docile, voiceless, and faceless agents of technological transformation. With some exceptions, engineers have been deemed largely incapable of initiating and leading a technological transformation.[11] One factor contributing to

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Harvard University Press, 1990).

5 Akira Gotō and Hiroyuki Odagiri, *Innovation in Japan* (Oxford: Oxford University Press, 1997).

6 Yukiko Fukasaku, *Technology and Industrial Development in Pre-War Japan: Mitsubishi Nagasaki Shipyard, 1884-1934*, *The Nissan Institute/Routledge Japanese Studies Series.* (London: Routledge, 1992).

7 See, for instance, Michael A. Cusumano, *The Japanese Automobile Industry: Technology and Management at Nissan and Toyota* (Cambridge: Harvard University Press, 1985).

8 For an examination of economic developments in the transportation industry, see Hirofumi Yamamoto, *Technological Innovation and the Development of Transportation in Japan* (Tokyo, Japan: United Nations University Press, 1993). For a detailed analysis of the politics of railway building during the Meiji era, see Steven J. Ericson, *The Sound of the Whistle: Railroads and the State in Meiji Japan* (Cambridge: Harvard University Press, 1996).

9 Yūko Maeda, *Senjiki Kōkū Sangyō to Seisan Gijutsu Keisei: Mitsubishi Kōkū Engine to Fukao Junji* (Tokyo: Tokyo University Press, 2001), Richard J. Samuels, *"Rich Nation, Strong Army": National Security and the Technological Transformation of Japan* (Ithaca: Cornell University Press, 1994).

10 One exception is a short survey history of several government R&D establishments after 1945, see Shūichi Tsukahara, "Kokuritsu Shiken Kenkyū Kikan No Taisei Seibi," in *Tsūshi: Nihon No Kagaku Gijutsu* (Tokyo: Gakuyō shobō, 1995).

11 For a well-written study of the vital role of industrial engineers from the 1930s to the 1950s, see Andrew Robertson, "Mobilizing for War, Engineering the Peace: The State, the Shop Floor and the Engineer, 1935-1960" (Ph. D dissertation, Harvard University, 2001). For a brief survey of the international and domestic politics that surrounded former military scientists and engineers during the Occupation years, see Masao Sasamoto, "Gun No Kaitai to Manpower No Heiwa Tenkan," in *Tsūshi: Nihon No Kagaku Gijutsu* (Tokyo: Gakuyō shobō, 1995). For a study of engineers in business operations and production, see also Earl H. Kinmonth, "Japanese Engineers and American Myth Makers," *Pacific Affairs* 64, no. 3 (1991). Training of the R&D workforce in corporate industry is examined in, for instance, Kevin McCormick, *Engineers in Japan and Britain: Education, Training, and Employment* (London: Routledge, 2000).; and Solomon Bernard Levine and Hisashi Kawada, *Human Resources in Japanese*

this notion is methodology, a view of how to think about historical change. Social scientists have typically sought to identify non-human factors, such as laws and some kind of structure, behind technological transformation before, during, and after 1945. Macro-economic variables in their studies conventionally include industrial policy,[12] strategic settings of corporate institutions,[13] and the integrated national system as a whole.[14] At the micro level, particular styles of business management purportedly epitomize the peculiar traits and characteristics of the nation in one way or another.[15] Irrespective of inherent diversity among the actual participants in the transformation, such studies tend generally to illuminate a "national style of innovation." At times, concrete human experience is seen to have perhaps an unwelcome randomizing effect on

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Industrial Development (Princeton: Princeton University Press, 1980).

[12] The classical literature in this field include: Chalmers A. Johnson, *MITI and the Japanese Miracle: The Growth of Industrial Policy, 1925-1975* (Stanford: Stanford University Press, 1982). For instances of MITI revisionist accounts, see Daniel I. Okimoto, *Between MITI and the Market: Japanese Industrial Policy for High Technology*, *Studies in International Policy.* (Stanford: Stanford University Press, 1989) as well as Hugh T. Patrick, Larry Meissner, and Committee on Japanese Economic Studies (U.S.), *Japan's High Technology Industries: Lessons and Limitations of Industrial Policy* (Seattle: University of Washington Press, 1986). For a direct contrast to Johnson's positive appraisal of the MITI, see for instance, Peter Drucker, "The End of Japan, Inc.? An Economic Monolith Fractures," *Foreign Affairs* 72, no. 2 (1993), Peter Drucker, "Trade Lessons from the World Economy," *Foreign Affairs* 73, no. 1 (1994).

[13] See, for example, Michael L. Gerlach, *Alliance Capitalism: The Social Organization of Japanese Business* (Berkeley: University of California Press, 1992), Kunio Yoshihara, *Sōgō Shōsha: The Vanguard of the Japanese Economy* (New York: Oxford University Press, 1982).

[14] See, for example, Christopher Freeman, *Technology, Policy, and Economic Performance: Lessons from Japan* (New York: Pinter Publishers, 1987), Fumio Kodama, *Emerging Patterns of Innovation: Sources of Japan's Technological Edge* (Boston: Harvard Business School Press, 1995).

[15] For a theoretical work in this vein, see for example, William G. Ouchi, *Theory Z: How American Business Can Meet the Japanese Challenge* (Reading, Mass.: Addison-Wesley, 1981). Empirical studies include Masanori Moritani, *Japanese Technology: Getting the Best for the Least* (Tokyo: Simul Press, 1982).

various events in time. Engineers in general have been considered as pawns of national or institutional policies, typically playing one marginal part in a larger technological system.

Contributing equally to the myth is the prevalent top-down approach that tends to erase ordinary engineers from the historical landscape. Engineers in general, particularly in modern Japan, have been portrayed as more or less powerless to effect changes in the socio-technical landscape. Political, economic, and business leaders have typically received scholarly attention as harbingers of modern technology and subsequent changes it brought to the nation. Especially during the Meiji era, technology and modernity were interrelated social values that were imposed to great effect by technocratic leadership in the government. The top-down influence was more direct, tangible, and structured — especially from the time of the Meiji Restoration to the prewar decades of militarism — often in the name of national interest and security.[16] As some studies have shown, the roles of technocrats, the state government, and technology policy were often crucial in mobilizing the engineering workforce during wartime. In many historical studies, central directives figured prominently and played a central role in Japan's technological development particularly after 1945. What is commonly referred to as "administrative guidance" was subtle and indirect in nature; it skillfully employed an ideology of suasion and conformity in

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[16] Mark R. Peattie, *Sunburst: The Rise of the Japanese Naval Air Power, 1909-1941* (Annapolis: Naval Institute Press, 2001), Samuels, *"Rich Nation, Strong Army": National Security and the Technological Transformation of Japan*.

many cases especially after 1945. This tendency to emphasize the importance of centrally-orchestrated efforts at the national or industrial levels is seen clearly in studies about technology transfer and diffusion; the stages of technology transfer seem orderly, sequential, and rather simple from imitation to self-reliance.[17] The underlying assumption that remains to be tested is the homogeneity of the visions, goals, and aspirations of the actual agents who transferred and implemented engineering knowledge beyond the Meiji era.[18]

Thirdly, studies about the impact of peace on technological transformation, particularly in the context of modern Japan, remains infrequent and insubstantial to date. This is partly because before the year 1945, the country continued to engage in armed conflicts within and outside the national border without any long hiatus. Peace as defined as political stability and the long absence of armed conflicts at home provides a national context for technology to develop. Transformative power of peace in technological transformation becomes more observable over

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[17] "Japan," in *Technological Independence: The Asian Experience*, ed. Chamarik Saneh and Susantha Goonatilake (New York: United Nations University Press, 1994), Takeshi Hayashi, *The Japanese Experience in Technology: From Transfer to Self- Reliance* (Tokyo: United Nations University Press, 1990), Ryōshin Minami, *Acquiring, Adapting, and Developing Technologies: Lessons from the Japanese Experience* (New York: Macmillan, 1995).

[18] Jun'ichi Murata, "Creativity of Technology: An Origin of Modernity?" in *Modernity and Technology*, ed. Thomas J. Misa, Philip Brey, and Andrew Feenberg (Cambridge: MIT Press, 2003), Wittner, "Iron and Silk: Progress and Ideology in the Technological Transformation of Japan, 1850-1895". In Carol Gluck, *Japan's Modern Myths: Ideology in the Late Meiji Period* (Princeton: Princeton University Press, 1985), the author convincingly argues that the purported homogeneity of socio-political ideology during the Meiji era was a myth later constructed with a Marxist taint; rather, heterogeneous and somewhat confused responses were the norm in society.

years after war.[19] In the context of modern Japan, a few historians have empirically examined R&D in science and engineering during World War II,[20] but given their research interest and scope, such studies tend to cease at the year 1945. Although a few studies have looked into trans-war history of technology in modern Japan, the legacies of wartime R&D projects leading into the postwar era remain unexamined.[21]

1.2 Approach

The *Shinkansen* has been a potent symbol of technological modernity and successful economic development, ever since its business operation began in October 1964. It has served as Japan's main artery for overland transportation, and has thus functioned as a powerful engine of

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[19] See, for instance, Gabrielle Hecht, *The Radiance of France: Nuclear Power and National Identity after World War II* (Cambridge: MIT Press, 1998), Thomas P. Hughes, *Networks of Power: Electrification in Western Society, 1880-1930* (Baltimore: Johns Hopkins University Press, 1983). For the importance of political stability in the the industrial development across nations, see Mansel G. Blackford, *The Rise of Modern Business in Great Britain, the United States, and Japan* (Chapel Hill: University of North Carolina Press, 1988).

[20] Walter Grunden, "Science under the Rising Sun: Weapons Development and the Organization of Scientific Research in World War II Japan" (Ph. D dissertation, University of California, Santa Barbara, 1998), Morris Low, "The Useful War: Radar and Mobilization of Science and Industry in Japan," in *Science and the Pacific War: Science and Survival in the Pacific, 1939-1945*, ed. Roy M. MacLeod (Dordrecht: Kluwer, 2000).

[21] See, for instance, Tessa Morris-Suzuki, *The Technological Transformation of Japan: From the Seventeenth to the Twenty-First Century* (Cambridge: Cambridge University, 1994), Samuels, *"Rich Nation, Strong Army": National Security and the Technological Transformation of Japan*. For the transformation of ideology behind the technological transformation and technology management in trans-World War II Japan, see Kenkichirō Koizumi, "In Search of Wakon: The Cultural Dynamics of Manufacturing Technology in Postwar Japan," *Technology and Culture* 43, no. 1 (2002). and William M. Tsutsumi, *Manufacturing Ideology: Scientific Management in Twentieth-Century Japan* (Princeton: Princeton University Press, 1998).

national economic growth. Over the last forty years, for instance, roughly six billion passengers have benefited from its fast, reliable, and punctual rail service. In every year from 2000 to 2003, this technological phenomenon carried roughly 280 million passengers across the nation.[22] With the recent emergence of mini Shinkansen — which run on narrow-gauge lines used also by other regular trains — the high-speed rail service has been extended widely in the archipelago (Figure 1.1). As of March 2003, for instance, the *Shinkansen* covers a total of 2,153 km from Hokkaido to Kyushu; additionally, new lines are under construction in various parts of the country.[23]

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[22] Infrastructure and Transport Ministry of Land, *Kokudo Kōtsū Getsurei Hōkoku (Heisei 16-Nen, 7-Gatsu)* (2004 [cited August 7 2004]); available from Http://www.milt.go.jp/toukeijouhou/toukei04/geturei/07/geturei04_07_.html.

[23] Infrastructure and Transport Ministry of Land, *Tetsudō Iroiro Data Shū* (2001 [cited August 7 2004]); available from Http://www.milt.go.jp/tetudo/nandemo/13_03a.html. The breakdown of the total is as follows: Tohoku shikansen, 535.3km; Joetsu shinkansen, 303.6km; Hokuriku shinkansen, 117.4km; Tokaido shinkansen, 552.6km; and Sanyo shinkansen, 644.0km. Since 1987, different private organizations under the common name of Japan Railways (JR) have managed high-speed rail service in geographically-divided sections.

Figure 1.1: *Shinkansen* Lines in Japan[24]

The black-and-white lines indicate the existing trunk lines as of December 2002;

the red and blue lines are their extensions as planned at the time

Much of the requisite technology for this phenomenally successful rail service had its origins in the pre-1945 era. The central stage of the development was the Railway Technical Research Institute (hereafter referred to as "RTRI"), a research establishment within the Japan

[24] Infrastructure and Transport Ministry of Land, *Seibi Shinkansen Gaiyō Zu* (2002 [cited December 2 2004]); available from Http://www.mlit.go.jp/tetudo/. The visual illustration above is modified from the original Japanese map available on the web site.

National Railways (hereafter referred to as "JNR"). During the years 1957-1964, eight research groups at the RTRI were chiefly responsible for technological development. A crucial and conspicuous point to note is the deeper military heritage of the *Shinkansen* task force. The careers of six out of eight chief architects of the project, for instance, point to latent sources of Japan's successful conversion in technological landscape from wartime to postwar eras. These project leaders had all graduated from engineering departments at elite national universities before 1941, accumulated their engineering experiences in the military during the war, migrated to the railway industry right after the war, and drawn freely on their military engineering experiences in developing the bullet train. The engineers' engineering experiences in wartime and postwar were strikingly similar. Tadanao Miki, for instance, capitalized on his wartime knowledge of designing aerodynamically refined Navy aircraft to design stream-lined rail car structure after 1945 for high-speed run. Tadashi Matsudaira applied his wartime research knowledge in aerodynamics, as embodied in the legendary Mitsubishi Zero fighter, to develop highly sophisticated running gear of the bullet train for safe high-speed operation. Yasushi Shinohara, Hideto Ogata, Kumezawa Ikurō and Hajime Kawanabe — all wartime experts in electronics and electrical engineering — helped construct sophisticated mechanisms and devices for safe and reliable electrical operations of the high-speed bullet train. These engineers among many others were the carriers of wartime technologies into postwar Japan (Table 1.1).

Laboratory Leaders	Wartime Affiliations	RTRI Entry	Engineering Education	Research Projects
Miki Tadanao	Institute for Navy Aeronautics (1933-1945)	1945	Tokyo Univ. Navy Engineering	Rail Car Structure
Matsudaira Tadashi	Institute for Navy Aeronautics (1934-1945)	1945	Tokyo Univ. Navy Engineering	Running Gear
Shinohara Yasushi	Institute for Navy Aeronautics (1941-1945)	1945	Kyoto Univ. Physics	Automated Operation
Ogata Hideto	Navy Technical Research Center (1938-1945)	1945	Osaka Univ. Electrical Eng	Electricity
Kumezawa Ikurō	Army Technical Research Center (?- 1945)	1945	Tokyo Univ. Electrical Eng.	Contact Line Structure
Kawanabe Hajime	Army Technical Research Center (1941-1945)	1945	Kyoto Univ. Electrical Eng.	Signaling System
Kanō Masaru	Japan National Railways (1935-1945)	1935	Tokyo Univ. Mechanical Eng.	Vehicle Control
Hirakawa Tomoyuki	Japan National Railways (1939-1945)	1931	Tokyo Univ. Civil Eng.	Track Structure

Table 1.1: List of the Bullet Train Project Leaders at the RTRI as of 1962[25]

[25] Nihon kokuyū tetsudō tetsudō gijutsu kenkyūjo, *Tokaido Shinkansen ni kansuru kenkyū*, vol.3 (Tokyo: Nihon kokuyū tetsudō tetsudō gijutsu kenkyūjo, 1962), 9-69;*Kokutetsu shokuin meibo (gijutsu gakushi) shōwa 25-nen 8-gatsu 10-ka genzai* (1950)； Yukiko Kumezawa, letter to author, 22 March 2004; Yasuo Kanō, interview by author, Tokyo, 22 March 2004; Osamu Shinohara, letter to author, 11 March 2004; Matsubara Keiji, *Shūsenji teikoku rikugun zen geneki shōkō shokumu meikai* (Tokyo: Senshi kankō iinkai, 1985); and Kaigunshō, *Gen'eki kaigun shikan meibo* vol. 3 (Tokyo: Kaigunshō, 1944) In some cases, engineer were assigned to move from one research institute to another; thus, their wartime affiliations were not always fixed. For instance, Shinohara apparently belonged to the Navy Technical Research Center at one point in time. Hirakawa apparently inherited the laboratory from Hoshino Yōichi, a specialist in track structure and one of the four presenters in the RTRI public forum in May 1957. Hoshino entered the JNR

As I will show, at least three types of engineering knowledge transfer bore fruit in the development of the bullet train. The first is an international technology transfer from abroad via adaptation. For our purposes, I will highlight the international variables that surrounded and helped shape the course of the development in question. The transformation of engineering knowledge is rarely, if ever, possible in complete technological and geographical isolation. This was particularly so in such areas as the aircraft industry, where large amounts of financial and political support were required for growth. Technological development — and the role of engineers in its rollout in the domestic setting — need to be framed within an appropriate international context. Many studies to date have conventionally examined one side of technology transfer — the reception of the technology through adoption and adaptation. But the process invariably involves the overseas donor as well,[26] and I will examine both sides of the technology transfer.

The other two types of technology transfer — one from wartime to peacetime over the years, and another from aeronautics to railroad technology — were intertwined and contributed to each other. Observable patterns of behavior among former military engineers after the war can

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in 1931 and stayed with the organization until he retired.

[26] For an informative study that carefully examines the donor and recipient sides of technology transfer into Japan, see Steven Ericson, "Importing Locomotives in Meiji Japan: International Business and Technology Transfer in the Railroad Industry," *Osiris* 13 (1998).

help us understand the mechanisms of technology transfers. I will thus focus on one particular biological generation of engineers who lived through the prewar, wartime, and postwar years.[27] Age patterning of all the subjects under my study reveals that most were born before or around World War I. For them, time flowed continuously and fluidly in the twentieth century. The year 1945 was neither the beginning nor the end of their engineering lives; it was merely a period of transition in their lives and career styles. This biological generation of the engineers formed a sociological generation; that is, they played socio-culturally and institutionally prescribed roles that were particular to the time under study. Thus we are faced with two different, mutually reinforcing strands of histories: personal life-history of individual and collective, social history. As Erik Ericson pointed out, personal growth and communal change are inseparable, remain truly relative to each other, and help define each other.[28] Reflecting this frame of reference, a few scholars of Nazi Germany have successfully examined a crucial impact of a specific age group on the historical development of society.[29] Thus it seems possible to locate one generation,

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[27] This approach is derived from Kuroiwa Toshirō's work. It categorizes scientists and engineers under different age groups, and draws out similarities in each generation. Toshirō Kuroiwa, *Gendai Gijutsushi Ron* (Tokyo: Toyō keizai shinpō, 1987). For a more sophisticated analytical methodology, see in particular Chapter 8 of Philip Abrams, *Historical Sociology* (Ithaca: Cornell University Press, 1982).

[28] Eric Ericson's work of sociological psychoanalysis is useful to observe interplay of identy crisis in the life of an individual and social crisis in historical development. See, for instance, Eric Ericson, *Identity, Youth, and Crisis* (New York: W.W. Norton, 1968). My study, however, is clearly not about the formation of the engineers' identities or their sense of professionalism.

[29] Theodore F Abel, *The Nazi Movement: Why Hitler Came into Power* (New York: Atherton Press, 1966), Peter H Merkl, *Political Violence under the Swastika: 581 Early Nazis* (Princeton: Princeton University

as represented by some groups, to account for their ability or inability to effect historical change in the socio-technological landscape. My focus will remain on the process of technological reproduction in action by one age group of engineers; ideology that underlay the action is not part of my study.[30] My dissertation is thus far less concerned with the historical development of the bullet train than with the transfer of engineering knowledge in modern Japan.

My primary focus on engineering knowledge and engineers could easily leave, among some readers, an impression of "omnipotent engineers" or "engineering determinism." Ordinary individuals, as some claim, seem to loom larger than usual. To be sure, neither technology nor engineers solely drive history, nor should they offer a simple and singular panacea to our understanding of the complex interplay involved in technological change.[31] My study is to counterbalance previous studies of modern Japan that use structural history to examine the

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Press, 1974). They explained the Nazi movement as a cumulative effect of the life histories of individuals in a specific generation unit (such as experiences of living in economic collapse after World War I), class structure (i.e. children of working class or lower middle-class families), and German nationalism with cultural traits (namely dedication, patriotism, and obedience).

[30] To what extent their wartime thought structures or military ideology were reproduced after 1945 is a tricky and entirely different matter. Scholars have often failed to differentiate sensibly between the reproduction of a behavior and the reproduction of an ideology. As Emiko Ohnuki-Tierney convincingly demonstrates, a reproduction of overt action could occur in the absence of a reproduction in the thoughts and feelings purportedly related to the action; these two elements did not necessarily accompany each other. Her compelling case study about wartime *tokkotai* pilots serves as a warning for scholars who hastily read action as a symptom of ideology. Emiko Ohnuki-Tierney, *Kamikaze, Cherry Blossoms, and Nationalism: The Militarization of Aesthetics in Japanese History* (Chicago: University of Chicago Press, 2002).

[31] See, for instance, *Does Technology Drive History? The Dilemma of Technological Determinism*, ed. Merritt Roe Smith and Leo Marx (Cambridge: MIT Press, 1994).

process of technological transformation. The entire *Shinkansen* project involved much more than former military engineers, technology transfers and transformation. As with other high-speed rail projects around the world, it was a political, economic, and business-oriented undertaking as much as an engineering one. The course of development was inseparable from the areas of business and organizational management as well as from political and economic decision-making about railroad policy.[32] My study here offers neither a comprehensive history of the bullet train development, nor a general political, economic history of the nation; it aims to highlight the roles of ordinary engineers in the technological development, especially as an alternative to the typical top-down, system-engineering approach adopted by many scholars working in the history of technology in modern Japan.

Within these analytical frameworks, I highlight the decentralized character of Japan's conversion process from wartime to postwar eras. The crucial variable in the process, I argue, was the remarkable adaptability and flexibility of engineers and their knowledge on the grass-roots level for Japan's technological development. At least the bullet train and other modern technological artifacts were a product of such development; postwar technological

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[32] For a study about organizational management and technological evolution from steam locomotives to high-speed electric trains in the twentieth century, see Kenji Inayama, "Soshiki Katei to Shite No Gijutsu Tenkan: Chōkyori Kōsoku Densha No Hatten Katei" (Ph. D dissertation, Hitotsubashi University, 2003). For a similarly informative account of the technological evolution and the role of top-management in system engineering, see Dankichi Takahashi, *Shinkansen O Tsukutta Otoko: Shima Hideo Monogatari* (Tokyo: Shōgakukan, 2000).

artifacts were essentially an amalgamation, reproduction, and reconfiguration of pre-1945 technologies with little orchestrated effort from the top. The course of the transition was neither obvious nor preordained; it was largely idiosyncratic and contingent on numerous individual decisions and actions within the engineering community. With their wartime engineering knowledge, former military engineers actively made choices and molded socio-technical values — such as speed, safety, and reliability — within the postwar setting in which they found themselves. Instead of succumbing to the forces of conformity, they engineered an R&D environment for rail service to the extent that business and government leaders conformed to their ideas about technology and society. Engineering knowledge, after all, was a vital, indispensable tool for the purpose.

In supporting these main points, the following chapters will follow the years 1945 to 1964 chronologically. Chapter 2 examines how Japanese society integrated the wartime experience from 1945 to 1952. I argue that Japan's lack of a major "brain-drain" phenomenon provided postwar society with a requisite setting for the technological development that was to come. I will first discuss why the phenomenon was conspicuously absent in postwar Japan during the Occupation years (1945- 1952). A series of German-Japanese comparisons will illuminate several reasons for the phenomenon. I will then examine how postwar Japanese society initially treated former aeronautical engineers. In many ways, postwar society benefited tremendously from the skills and expertise that they had accumulated during the war. This development was probably most evident in the railway industry, particularly in the JNR. More specifically, the RTRI became a major site to which former military engineers migrated. The talent influx was seldom smooth and preordained; on the contrary, it created many smoldering tensions within the organization.

Chapter 3 argues for the importance of wartime engineering knowledge in postwar reconstruction from 1945 to 1955. Faced with the postwar climate of anti-militarism and the various organizational pressures to conform, the former military engineers cultivated their niches in the railway industry from 1945 to 1955. This was possible because during the period of postwar reconstruction, they functioned as the solvers of many problems in the technological landscape that threatened the safety of rail service. Their wealth of engineering knowledge and experience during the war proved crucial in these efforts. Cases in point were the Vibrations of Rolling Stock Laboratory and other laboratories at the RTRI. In many ways, the inheritance of military technology from wartime was conspicuous. Not all civilian applications of wartime technology were successful in the period as some attempts failed.

In Chapter 4, I argue that former individual engineers played a leading, indispensable role during technology transfers from 1950 to 1957. The chapter illuminates three types of technology transfer for high-speed rail service that eventually bore fruit in the *Shinkansen*. The first type was a planned, choreographed technology transfer from abroad; it was the industry's effort to develop lightweight, all-steel rail cars during the early 1950s. The second type of technology transfer was a delicate combination of technology transfer from abroad and an inter-disciplinary technology transfer at home. A case in point was the JNR's effort to employ a French model and make the public railways electric-powered. The last and least studied pattern of technology transfer in modern Japan is the interdisciplinary transfer of engineering knowledge at home. As a case study, I will look closely into how former military engineers in Miki Tadanao's laboratory capitalized on wartime studies on aerodynamics in a rail project and successfully established high-speed world records in 1957.

Chapter 5 highlights the role of ordinary engineers in actively molding the values — speed, safety, and reliability — involved in the modern technological transformation from 1955 to 1964. More specifically, it will analyze the independent decisions of engineers, the RTRI and JNR, and the political economy surrounding the development of the bullet train. With little long-term perspective on high-speed rail service before 1955, the JNR management and government bureaucrats were able to launch the *Shinkansen* project only after they appropriated former military engineers' efforts. In many respects, the technological product was an engineers' solution to the economic and legal issues of the industry of the time. It capitalized successfully on the interrelatedness between their wartime engineering knowledge and the social values with respect to technological modernity. The *Shinkansen* was a technological means whereby former military engineers indirectly and unknowingly molded postwar Japanese society.

1.3 Sources

This highly empirical study relies heavily on accounts of the career paths and experiences of roughly 150 former military engineers after 1945. The "engineers" to whom I refer are not craftsmen or technicians; they are highly-educated engineers who were graduates of the nation's top universities prior to 1945. Many have earned doctoral degrees in engineering during their lifetimes. My scope of engineers is thus admittedly narrow and therefore limited. I choose to focus primarily on such elite engineers to make full use of the available written primary sources. Tracking the career paths of the former military engineers was made possible mainly because before and after 1945, public institutions and private organizations kept directories of the engineers. Recorded information include engineers' names, dates of birth, addresses, phone numbers, ranks/positions in the institutions, educational backgrounds (i.e., fields of study and years of graduation), and the years in which they retired. Such records are detailed and reliable, especially when they refer to engineers who had earned baccalaureate degrees. Information about technicians and craftsmen without college degrees is seldom available, or it is not detailed enough to observe their career transitions in trans-war Japan. Curiously, historians of modern Japan have rarely used personnel directories of any sort, despite their extraordinary information-based value. Obviously, access to such personal information is normally highly restricted. Despite limited access to such information, it is entirely possible to collect many personnel directories from archives and via personal networks. My dissertation aims to call attention to the heretofore unappreciated importance of this type of primary source.

As Appendix A indicates, my dissertation relies also on personal interviews with former military engineers and/or their relatives — either in person, by telephone, via e-mail, or in written correspondence. At it turned out, oral interviews in particular were extremely challenging, far beyond my original expectation. This was because people often made their own history. Invariably, informants conveniently remember what they *want* to remember, thus knowingly or unknowingly recalling what they want me to remember and record. During my interviews, I remained deeply skeptical upon sensing any inkling of claims whereby informants credited themselves with the success of the bullet train development. To avoid accepting such claims at face values, I always sought records written prior to 1964, or sought the voices of different informants. In many ways, what the original informants told me proved less reliable and vital in my research than what they had not told me. To compensate for a lack of first-hand accounts, I often turned to highly informative narratives by journalists, namely Ikari Yoshirō and Maema Takanori. As aeronautical engineers themselves, they present a great many personal interviews they had conducted with former wartime engineers over a decade ago. The writers' products exemplify amateur empiricism and therefore lack systematic analysis, but they offer extraordinarily useful information when used carefully, selectively, and intelligently.

To accurately interpret both unpublished and published sources, I employ mainly two techniques. First, I assume that before the year 1963, neither aeronautical nor railway engineers had preordained visions of the eventual outcome of the high-speed bullet train. Many readily available sources, such as memoirs and institutional histories, were typically published after the success of the bullet train. Such highly personalized and/or official histories commonly look back at the technological development of the high-speed rail service from a presentist perspective, crediting the purported foresight and long-term vision of the top leadership. Regrettably, this type of Whig interpretation pervades some of Japanese scholarship and, consequently, the Western scholarship that uses such "tainted" Japanese sources. This tendency shows in the history of Japanese railways, the genesis of which lay in the compilation of company histories with the management's retrospection. Particularly after the success of the bullet train became obvious, many, especially in management circles, wrote memoirs and the like that credited themselves with the outcome. With a healthy dose of skepticism, I thus disregard most publications dated after 1964. I do so to understand the technological transformation as it unfolded *before* that year, and to avoid a "retrospective" or "after the fact" reconfiguration of complex realities. For this reason, my study does not rely heavily on official historical accounts prepared by the JNR after 1964. I use their information only when it collaborates with accounts written before that year. Secondly, I postulate that trial and error, rather than a series of successes, was the norm in the engineering communities under my study. My interviews with surviving military engineers confirmed this point. There were as many useless ideas as useful ones during the aircraft-to-bullet-train transition. I pay attention to how and why some ideas failed while others bore fruit. Only with this frame of reference am I able to grasp a fuller picture of the technology transfer and diffusion as experienced by the participants in the transformation of modern Japan.

To date, almost all available secondary writings about the transformation of advanced engineering in Japan are insubstantial in length; they also tend to lack serious, profound, systematic, and rigorous investigation. Some Japanese scholars and journalists have pointed to the contribution of wartime engineering knowledge to the postwar growth of consumer electronics,[33] automobiles,[34] and shipbuilding industries among others.[35] The actual participants in the technological transformation have often published their short accounts and memoirs in compilations.[36] The technological metamorphosis from wartime aircraft to the bullet train has

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[33] See, for instance, Miwao Matsumoto, "Gunji Kenkyū to Heiwa Tenkan: Radar Kaihatsu O Chūshin Ni," in *Tsūshi: Nihon No Kagaku Gijutsu*, ed. Shigeru Nakayama, Kunio Goto, and Hitoshi Yoshioka (Tokyo: Gakuyō shobō, 1995). Many former Navy engineers worked at SONY and other companies in the field of electronics soon after 1945, capitalizing on their wartime knowledge for subsequent technological development. See Yasuzō Nakagawa, *Kaigun Gijutsu Kenkyūjo: Electronics Ōkoku No Senkusha Tachi* (Tokyo: Nihon keizai shinbunsha, 1987), 13-15, 255-90. For a study about the wartime origin of postwar optical equipment as found at CANON and Olympus, see for instance,Kōgaku kōgyōshi henshū-kai, *Nihon No Kōgaku Kōgyōshi* (Tokyo: Kōgaku kōgyōshi henshū-kai, 1955).

[34] Takanori Maema, *Man Machine No Shōwa Densetsu: Kōkūki Kara Jidōsha E* (Tokyo: Kōdansha, 1996). Recently, this interdisciplinary technology transfer has caught media attention in the English-speaking world. See, for instance, "Zero Inspired Today's Innovations: Warplane's Engineers Later Excelled in Auto, Rocket Sectors," *The Japan Times*, January 14 2004.

[35] Sachio Yamashita, "Nihon Zōsengyō Ni Miru Gijutsu No Keishō: Senzen Kara Sengo E," in *Kigyō Keiei No Rekishiteki Kenkyū*, ed. Keiichirō Nakagawa (Tokyo: Iwanami shoten, 1990). Tomita Tetsuo briefly refers to several cases of the civilian use of military technology after 1945; one interesting example is a piece of rice-planting machinery, which helped boost rise production and has dominated the agricultural scenery since the war's end. According to the author, a former military engineer at Kobota tekkō corporation applied the automatic bullet-feeding mechanism of a machine gun to the agricultural machinery, so as to automatically sow rice seedling plants in a bed of soil. See Tetsuo Tomita, "Gijutsu No Juyō Ni Oyobosu Shijōkōzō Oobi Fūdo Kankyō Ni Kansuru Jisshōteki Bunseki " (Ph. D dissertation, Tokyo Institute of Technology, 1999). For a detailed study about the civilian conversion of private firms in industries after 1945, see Matthias Koch, *Rüstungskonversion in Japan Nach Dem Zweiten Weltkrieg: Von Der Kriegswirtschaft Zu Einer Weltwirtschaftsmacht* (Tokyo: Deutsches Institut für Japanstudien, 1998).

[36] See, for example, *Gunji Gijutsu Kara Minsei Gijutsu Heno Tenkan: Dainiji Sekai Taisen Kara Sengo Heno Waga Kuni No Keiken*, 2 vols. (Tokyo: Nihon gakujutsu shinkōkai, 1996), Junnosuke Kishida, "Sengo Gijutsu No Taishitsu O Kimeta Mono," in *Nihon No Gijutsuryoku: Sengoshi to Tenbō* (Tokyo: Asahi shinbunsha, 1986), Takeaki Teratani, "Kaigun Zōheikan No Kōsatsu," in *Kigyō Keiei No Rekishiteki Kenkyū* (Tokyo: Iwanami shoten, 1990).

attracted mostly popular attention and had occupied an important space in contemporary Japan.[37] At present, society often romanticizes and uncritically appraises the bullet train story, treating the technological artifact as an embodiment of the "good old days," when Japan experienced high-speed growth in the 1960s.[38] With a healthy dose of skepticism and sound judgment, one could integrate at least some of these perspectives into an appropriate, meaningful historical context of technological development in modern Japan.

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[37] See Tōru Koyama, "Shinkansen Kaitsū: Tetsudō to Sono Gijutsu No Saininshiki," in *Tsūshi: Nihon No Kagaku Gijutsu* (Tokyo: Gakuyō shobō, 1995).

[38] "Shūnen Ga Unda Shinkansen: Rōyū 90-Sai, Sentōki Ga Sugata O Kaeta," in *Project X* (Nihon hōsō kyōkai (NHK), 2002). This episode was originally aired nationwide on May 9, 2002 and since then, it has been broadcast at least three times, presumably due to its popular appeal to television viewers. This NHK-version of the bullet-train story has appeared on videotape and DVD as well as in writing (NHK Project X seisaku-han, in *Project X: Chōsensha Tachi* (Tokyo: Nihon hōsō shuppan kyōkai, 2000)) and even in cartoon (Noboru Rokuda and NHK project seisakuhan, *Shūnen Ga Unda Shinkansen*, vol. 2, *Project X Chōsensha Tachi* (Tokyo: Chū shuppan, 2001)). For a similar television program, see "Miki Tadanao: Shinkansen O Tsukutta Otoko," in *Lifeline* (Japan: Taiheiyō hōsō kyōkai, 2003), which was aired on August 9-10, 2003.

CHAPTER 2

INTEGRATING WARTIME EXPERIENCE IN POSTWAR JAPAN, 1945-1952

World War II acted as a catalyst for helping the field of aeronautics attract highly capable engineers across the nation. Its end meant the end of the demand for such engineers because the Occupation authorities completely dismantled the field and the aircraft industry. Almost overnight, the defeated country was left with an oversupply of wartime aeronautical engineers who initially seemed useless in the immediate postwar years. This occupation era, I argue, defined many social parameters for the development of rail service in the following decades. The radical change in the socio-technical landscape exerted a centrifugal force on the aeronautical engineers, releasing them into a volatile employment market. In retrospect, this development was a blessing in disguise. Only during the occupation years did various engineering groups freely mingle with one another, setting the stage for the successful marriage between aeronautical and railroad technology in the years that followed. Wartime engineers and some civilian leaders responded ad hoc to this unexpected social fluidity with remarkable adaptability and flexibility. There was little long-term thinking about the process in advance.

The first part of this chapter will examine both domestic and international migrations among wartime aeronautical engineers after the war's end. The individual experiences of jobless military engineers were diverse, but their career transitions formed observable patterns. A majority became self-employed or embarked on second careers in the civilian sector — and most importantly, virtually all stayed in Japan. The lack of any major "brain drain" phenomenon among wartime engineers from 1945 to 1952, I argue, was a major ingredient in the recipe for many technological developments in the 1960s and beyond.

The latter half of this chapter will analyze what happened to the military engineers and wartime research facilities that Japan retained after the summer of 1945. Many jobless wartime aeronautical engineers moved to the Japan National Railways (JNR) and, above all, to the Railway Technical Research Institute (RTRI). Many wartime research facilities followed the same patterns. Both the JNR and RTRI actively integrated these valuable human assets of the wartime era into the postwar railway industry. The integration, however, was somewhat premature and remained incomplete during the occupation years. The result was smoldering tension among engineers and technicians employed in the industry.

2.1 Experiences of Wartime Aeronautical Engineers, 1945-1952: Case Studies

News of Japan's unconditional surrender in August 1945 sounded an ominous alarm bell for wartime aeronautical engineers. This was because General MacArthur's Headquarters strictly prohibited all types of research and development in aeronautics, aircraft production, and other airborne activities by the Japanese on November 18, thereby ending the engineers' careers. Early postwar society also discounted wartime military technology because it had not brought victory, but rather defeat and misery. Almost overnight, the war's end rendered the wartime aeronautical engineers very much a dispensable part of society, creating an oversupply of unneeded talent in the new peace-loving era. The rate of unemployment was thus high, particularly among wartime scientists and engineers bearing this social stigma. According to one estimate, 100,000 specialists in general fields of engineering remained jobless in the spring of 1946 — and a great many of them were reportedly aeronautical engineers.[39]

The end of World War II was damaging particularly to university researchers in the field. According to one journal published in April 1946, university scholars were among the most poorly paid of educated workers. The salary for new elementary-school graduates was 200 yen, while that for new secondary-school graduates was 300 to 400 yen. The pay for national

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[39] Shigeru Nakayama, "Haisen Chokugo No Kagaku Gijutsukai No Jittai," in *Nihon No Kagaku Gijutsu* (Tokyo: Gakuyō shobō, 1995), 184.

university professors was no different, ranging from 200 to 400 yen — and this modest amount raised envy among assistant professors who earned 120 to 130 yen and research assistants who received only 80 yen.[40] Besides this severe underpayment, university researchers lacked the physical means to conduct any activities in their fields of study. A severe paper shortage reduced the volume of academic journal publications and greatly damaged the functions of various professional societies.[41] University scholars lacked physical facilities for empirical research and development; typically, they had only paper and pencils to pursue theoretical studies, and even then meagerly. Much of the overseas data necessary for such projects remained unavailable.[42]

A near mental breakdown was perhaps a logical consequence among particular university professors. Kimura Hidemasa, a senior researcher at Institute for Aeronautics at the University of Tokyo, is a case in point. The war ended his eighteen-year long career at the newly dissolved research institute in March 1946. For the next few years, he made his daily living by selling his camera, golf clubs, and furniture at pawn shops. His haggard, ghost-like appearance worried his mother who believed that he would commit suicide to end, in his words, the "tear-jerking misery." His anxiety manifested itself in an unstoppable, inexplicable urge to

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[40] Ibid.,185.

[41] Ibid.,186.

[42] Ibid.,84.

urinate every four to five minutes. Later his psychiatrist diagnosed the symptom as part of a severe stress disorder.[43]

In many cases, the accumulated knowledge of aeronautics during the war proved useless for university faculty at their new workplaces. Itokawa Hideo, an aircraft engineer who developed the Ki-43 Army type-1 fighter and the Ki-44 Army type-2 fighter at Nakajima Aircraft Company and a assistant professor at the University of Tokyo before 1945, is a good example. Suffering from severe neurosis, he visited a doctor's office and, with his credentials, found employment at Tokyo University's Faculty of Medicine. His new job was to suture the tissues of post-operative patients with a giant stapler, though he had no valid medical license. Upon request, he later built medical equipment that mechanically assessed the effect of anesthesia given to the patient on the surgical bed. This was a triumph, ending the existence of a peculiar yet once prevalent medical practice. Before Itokawa's successful invention, a surgical assistant had repeatedly called out a patient's name by the bedside until the anesthesia rendered the subject unconscious and unable to respond orally![44]

Many wartime aeronautical engineers became self-employed. Watanabe Saburō, a navy

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[43] Hidemasa Kimura, *Waga Hikōki Jinsei* (Tokyo: Nihon tosho center, 1997), 155-57, Takanori Maema, *Ys-11 Kokusan Ryokakki Wo Tsukutta Otokotachi* (Tokyo: Kōdansha, 1994), 82.

[44] Hideo Itokawa, *Kyōi No Jikan Katsuyōjutsu: Naze Koredake Saga Tsukunoka?* (Tokyo: PHP kenkyūjo, 1985), 162-63.

aircraft engineer, offers one such case. His employment was unstable from the summer of 1945 to the fall of 1951. At one point, he designed and built farming equipment to extract vegetable oil for cooking; later, he taught aerodynamics and structural mechanics at a technical school. Amid the unpredictable changes in the volatile job market, he stopped seeking employment altogether. Together with other aircraft technicians, he launched a second career by establishing an engineering consulting company, U.S. Consultant, Inc. in Tokyo. This cohort of experienced aeronautical engineers amply demonstrated their talents and skills, especially while inspecting and maintaining the quality of mass-produced parts during the Korean War.[45]

Self-employment did not necessarily involve wartime experience in aircraft engineering. Some able engineers, like Yamana Masao, left the field altogether despite their impeccable credentials. Yamana shared an academic appointment and lectured on aircraft fuselage structure at the Tokyo University Aeronautics Department. Concurrently, he had been the chief designer of the dive-bomber D4Y Judy, the twin-engine dive bomber P1Y Frances, and the rocket-propelled kamikaze glider MXY7 Ōka at the Institute for Navy Aeronautics. Soon after the end of the war, he left the University of Tokyo for his hometown of Atsugi. There he took up farming to feed his family, weathering the serious food shortage of the time.

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[45] Saburō Watanabe, Interview by author, 16 July 2003.

During the occupation years, turning to the commercial sector, such as the automobile industry, was also an attractive option for jobless aeronautical engineers.[46] Capitalizing on their wartime experiences in designing aircraft, some engineers introduced a new way of designing buses and trucks. One such engineer, Hasegawa Tatsuo, was a senior army aircraft designer at Tachikawa Aircraft Company during the war. What dismayed him the most upon his employment at Toyota in June 1946 was, in his view, the primitive design engineering techniques that pervaded the industry. Automobile engineers had seen no need for calculating the strength of the physical components in use. They lacked the means or standards to compute loads on various parts of cars during the design stage. After solving these critical issues successfully, Hasegawa introduced the construction technique — monocoque body structure — in his design of the Toyota BW bus.[47] This method effectively minimized the entire body weight without sacrificing the structural integrity. It eliminated the need for internal struts, vertical or horizontal, that had traditionally supported the body structure. Functioning like egg shell, the external skin was

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[46] A few studies have focused on the wartime aircraft industry and engineering as the basis for the postwar success in the civilian automobile industry. For a scholarly work that examines this issue with company history records, see, for example, Koch, *Rüstungskonversion in Japan Nach Dem Zweiten Weltkrieg: Von Der Kriegswirtschaft Zu Einer Weltwirtschaftsmacht*,152-75. For informative accounts about the transformation of wartime aircraft engines in the automobile industry after 1945, see for instance, Maema, *Man Machine No Shōwa Densetsu: Kōkūki Kara Jidōsha E*. For a case study about an aircraft engine used in the railway industry after 1945, see Shigeki Yamaoka, "Mitsubishi Zc707 Chijō Ni Orita Engine," *Tetsudōshigaku* 11 (1992).

[47] Takanori Maema, *Man Mashin No Shōwa Densetsu: Kōkūki Kara Jiddōsha E*, 2 vols., vol. 1 (Tokyo: Kōdansha, 1996), 604-13.

structurally integrated into the car body or aircraft fuselage, and supported the dispersed loads on the structure. Used mostly in aircraft design and construction before 1945, this method became widely used in automobiles, busses, and rail cars in the postwar period.

Hasegawa was not alone in the industry in pursuing the successful merging of aircraft and automobile design technology. A cohort of wartime aircraft engineers from the dissolved Nakajima Aircraft Company developed the bus, Fuji-gô, with the monocoque body structure at the newly established Fuji Heavy Industries in 1949. At the West Japan Car Company, designers of the Kyūshū J7W1 interceptor capitalized on their knowledge of the monocoque body structure and developed a new bus. The product earned the nickname Marumado for the four round shaped-corners of each window. This highly distinct window frame successfully dispersed the load of the car. The resulting frameless unit construction reduced the tare weight of the bus.[48] It permitted a more rigid and stronger car structure with improved performance than any previous style.[49]

In heavy industries, crippled business conglomerates like Mitsubishi, often provided wartime aeronautical engineers with safe havens. After the summer of 1945, Horikoshi Jirō headed the engineering department of Yoshimi Manufacturing, a Mitsubishi subsidiary that

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[48] *Yomiuri shinbun*, 15 August 2002.

[49] Mineo Yamamoto, *Jidōsha Kōgaku Kōza I: Sōsetsu Oyobi Kōzō* (Tokyo: Sankaidō, 1956), 55-68.

operated independently after the zaibatsu dissolution.[50] Similarly, unemployment proved to be rare among Horikoshi's colleagues in the Mitsubishi Nagoya plant. Sone Yoshitoshi — Horikoshi's right-hand man in the Zero project, and president of Mitsubishi Motors in 1979 — worked at Mihara Train Manufacturer after 1945, a Mitsubishi subsidiary where he played a vital part in developing the running gears for passenger trains. Tōjō Teruo — a son of the wartime prime minister on trial, an engineer in the Zero fighter development project, and president of Mitsubishi Motors in the 1980s — maintained an engineering position in Kawasaki. Likewise, some Mitsubishi wind-tunnel technicians were transferred to a shipbuilding laboratory in Nagasaki. This practice of transferring people internally continued within Mitsubishi until the end of the official ban on research and development in aeronautics. By 1956, all the engineers mentioned (except Sone in 1961) returned to their wartime homeland, the Mitsubishi Nagoya Plant, by invitation.[51]

But not all the business conglomerates in the wartime aircraft industry preserved the jobs of wartime engineers. Kawasaki Aircraft Company, the birthplace of a series of highly successful army aircraft during the war, is a case in point. In 1947, the media carried a report

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[50] Maema, *Ys-11 Kokusan Ryokakki Wo Tsukutta Otokotachi*,88.

[51] *Meikū Kōsakubu No Senzen Sengoshi: Moriya Sōdanyaku, Watashi to Kōkūki Seisan* (Nagoya: Mitsubishi jūkōgyō kabushiki kaisha Nagoya kōkūki seisakujo, 1998), 49-50, Tetsudō gijutsu kenkyūjō, *Kōsoku Daisha Shindō Kenkyūkai Kiroku, Dai Ikkai-Dairokkai* (Tokyo: n.p., n.d.).

about the younger brother of wartime prime minister Tojō, then on trial, being found among the crowd of vagrants in the impoverished Namba district of Osaka.[52] This homeless individual was a jobless aeronautical engineer, the head of the Kawasaki Gifu Plant during the war.[53] Doi Takeo —chief designer of sixteen army aircraft at the same establishment which included Ki-45 type-2 fighter "Nick," Ki-100 type-5 fighter, and Ki-66 type-3 fighter "Tony"— also roamed about jobless after the summer of 1945. This classmate of Horikoshi Jirō at Tokyo University Aeronautics Department spent his time at a job placement office in the distant city of Kobe every day, reading English newspapers in the lines of job-seekers. For some time, he earned his daily living by building wooden carts and wagons, but the deflationary economic initiative of 1948, the "Dodge Line," eliminated his job. For the next five months, he survived on his weekly unemployment allowance.[54]

2.2 Containment of Wartime Brains

In a larger framework, these individual cases point to Japan's lack of any significant

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[52] John W. Dower, *Embracing Defeat: Japan in the Wake of World War II* (New York: W.W. Norton & Co./New Press, 1999), 105.

[53] Maema, *Man Mashin No Shōwa Densetsu: Kōkūki Kara Jiddōsha E*,331.

[54] Takeo Doi, *Hikōki Sekkei 50-Nen No Kaisō* (Tokyo: Suitōsha, 1989), 250-53, Maema, *Ys-11 Kokusan Ryokakki Wo Tsukutta Otokotachi*,108.

"brain drain" in the field of aeronautics during the Occupation years.[55] Available records show a few isolated and rare cases — but virtually all such specialists remained within Japan. Perhaps the strongest evidence of this is to be found in student directories of the Department of Aeronautics at Tokyo University. Originally established in 1918, the department stood at the pinnacle of elite professional education in the field. It almost single-handedly trained Japan's highly able aeronautical engineers before the war. The university was the only institution to offer such a program until the mid-1930s. Student directories from the department list the names, career paths, and contact information for all the post-1923 graduates. According to this information, the department produced 435 graduates by the end of the war; among them only two — one in 1940 and another in 1942 — established their careers outside Japan, both in the United States.[56]

How does one explain the remarkable absence of a major brain drain pattern among Japanese aeronautical engineers in the immediate postwar years? Because Germany and Japan after World War II are comparable in many ways, German engineering communities offer useful

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[55] This is not to suggest that the phenomenon was absent among Japanese scientists in general before and after 1945. Readily available examples indicate otherwise and include, for example, bio-chemist Takamine Jōkichi (1854-1922). In the 1890s, he emigrated from Japan to the United States with his American wife. In New York City, he established his own research laboratory and conducted research on hormone adrenaline. Another illustrative example is Japanese female physicist, Yuasa Toshiko (1909-1980). By utilizing her professional training and personal connections, she returned to France after World War II and remained there until her death.

[56] *Kōkūkai Kaiin Meibo 1973* (n.p.: 1973), *Kōkūkai Kaiin Meibo 1976* (n.p.: 1976).

means of answering the question. The Allies stripped away both industrial capacity and technology with possible military applications from postwar Japan and Germany. The wartime aircraft industry was dismantled, and research and development establishments in aeronautics met the same fate.

Scholars have explored the story on the U.S. side in relation to immigration of German engineers. Cases of emigration among German engineers reflect larger patterns of brain drain to the Allies after the war's end. International politics played a crucial role in the emigration and technology transfer. Upon invitation, wartime German specialists in aeronautics moved to the United States during an early stage of the Cold War. American wartime intelligence had noted the excellent, highly developed nature of German science and technology, aiming to exploit these resources against the Japanese following the end of the war in Europe. Capturing scientific and engineering know-how from wartime or nearly postwar Germany was an urgent undertaking. Conducted in military secrecy under national security, this operation — better known as Operation Paperclip — was highly successful. Individual examples included Werner von Braun —chief aerospace engineer for the German V-2 rocket and, after the war, for ballistic missile development in the United States — among hundreds of rocket scientists and engineers. The Army Air Force exploited the German specialists in the fields of aerodynamics, electronics, aeronautical design, aircraft instruments and the like. The later hosts of such wartime German talent — Bendix Aviation Corporation and Grumman Aircraft Company — thrived in the engineering business.[57] Adolf Busemann, a leading figure in high-speed aerodynamics of wartime Germany, moved to the Langley laboratory at the National Advisory Committee for Aeronautics (NACA, later NASA) and contributed to the development of the swept-back wing in an early part of the Cold War. German aerodynamicists were indispensable for the development of advanced aerodynamics and high-speed flight in the United States from 1945 to 1958.[58] The visible hand of the U.S. government constituted the pivotal element of the "brain drain" and technology transfer.

The sharp contrast between the experiences of Germany and Japan poses an intriguing issue. At the end of World War II, Germany was clearly ahead of Japan in, for instance, the developments of jet engines, rockets, and high-speed aerodynamics, hence the reason for the almost unidirectional technology transfer from Germany to Japan during the war.[59] America's interest in Japanese aeronautical engineers may not be comparable in degree to that in German

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[57] John Gimbel, *Science, Technology, and Reparations: Exploitation and Plunder in Postwar Germany* (Stanford: Stanford University Press, 1990).

[58] Roger E. Bilstein, *Orders of Magnitude: A History of the Naca and Nasa, 1915-1990* (Washington, DC: National Aeronuatics and Space Administration, 1989).

[59] Hans-Joachim Braun, "Technolgy Transfer under Conditions of War: German Aero-Technology in Japan During the Second World War," *History of technology* 11 (1986).

engineers. But the first, reasonable question concerns the state of aeronautics in Japan when the war ended in August 1945. Were the Allies at all interested in the transfer of aeronautical technology and personnel from defeated Japan? Did postwar Japan have any sufficiently sophisticated technology, for example, in empirical and theoretical aerodynamics to offer to the Allies?

Numerous official investigations conducted by the Allies during the immediate postwar years seem to suggest that the answer to both accounts is negative.[60] At the most superficial level, this explains the Allies' purported lack of interest in hosting engineers from postwar Japan. The likelihood of emigration from postwar Germany or Japan depended largely on political support from such host nations as the United States. This factor was obviously crucial, because

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[60] Relevant official reports by the Allies during the Occupation years include, for instance, United States Army Forces General Headquarters, Pacific, Scientific and Technical Advisory Section, "Report on Scientific Intelligence Survey in Japan: September and October 1945," (United States National Archives, Maryland, 1 November 1945), United States Naval Technical Mission to Japan, "Reports of the U.S. Naval Technical Mission to Japan, 1945-1946," (Washington D.C.: Operational Archives, U.S. Naval history division, microform, 1975). As a few historians have pointed out, these official reports contain factual inaccuracies and misunderstandings of the time about the state of R&D in military engineering and science of wartime Japan. This is hardly surprising; time devoted to official investigations on Japanese soil was fairly limited, and the pool of able translators deployed for the purpose was severely limited. I am grateful to Walter Grunden for sharing his experience with and information about the Allies' investigation reports. Some former military engineers, for instance, have seriously questioned the validity, fairness, and accuracy of the Allies' postwar investigations. At the war's end, for instance, the Occupation authority called upon many military scientists and engineers to understand the nature of wartime R&D in Japan. But the informants were understandably far more fluent in German than English, and the intense questioning was conducted without an English translator. I am grateful to an anonymous wartime scientist in nuclear weapon development for sharing his experience openly at the symposium, Kaku kaihatsu no kokusaishi: Nichi-doku-soren no hikaku, at the Tokyo Institute of Technology on August 7, 2003. For a similar experience of a wartime aeronautical engineer, see for instance, Kaigun kōkū gijutsushō zairyōbu no kai, *Kaigun Kōkū Gijutsushō Zairyōbu Shūsen 50-Shūnen Kinenshi* (Tokyo: Kaigun kōkū gijutsushō zairyōbu no kai, 1996), 111.

political support by the emigrants' own governments was in shambles at the conclusion of World War II and remained non-existent for years following the war's end. Historically, Japan's political leadership often endorsed massive emigration of its citizens to neighboring nations in Asia and to Latin American countries,[61] but such official support disappeared in the summer of 1945. With a more careful look at the heart of the issue, this line of common, mono-causal explication is simplistic, premature, and misleading. The presumptive explanation for the Allies' limited interest in the R&D of wartime Japan requires a more sensible and thorough reevaluation.

The Allies' purported lack of interest in brining in Japanese engineers after 1945 may have been a myth altogether. A personal account of Masayoshi Tsuruno, a senior aircraft designer at the Institute for Navy Aeronautics, suggests this point. From the late summer of 1945, the Allied occupation forces conducted numerous oral interviews with wartime aeronautical engineers. Simultaneously, they confiscated many functionally operational Japanese airplanes and studied them intensively in Japan and later in the United States. One navy experimental interceptor, Kyūshū J7W1, attracted the attention of the investigators. Its highly unusual canard configuration displayed a design based on advanced theoretical aerodynamics. This heavily

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[61] See, for instance, Louise Young, *Japan's Total Empire: Manchuria and the Culture of Wartime Imperialism* (Berkeley: University of California Press, 1998).

armed fighter had its engine and a six-blade propeller at the rear of the aerodynamically refined slim fuselage. The resulting high-speed flight capability was designed as a countermeasure to the high-altitude B-29 bombers flying unchallenged over Japan. The U.S. military proposed that Tsuruno continue his R&D in the field of aerodynamics in the United States, but he declined the offer.[62] Presumably disgusted by the war, he ended his career as a military aeronautical engineer altogether in October 1945 and moved on to the cement business at Sumitomo.

Tsuruno's case points to a severe technical impediment against the international migration of Japanese engineers in the immediate postwar years. They were unlikely to receive recognition and invitations from outside the country unless the Allies physically captured and studied the wartime aircraft. The world knew little or nothing about aeronautical research and development within Japan. Geographically and technologically, the engineering community of wartime Japan was quite isolated from the rest of the world. Aeronautical engineers and scholars in government-funded research institutes, such as the Institute for Navy Aeronautics and Institute for Aeronautics at the University of Tokyo, produced publications, but the volume was limited because by war secrecy. Even if published, these were usually disorganized lab reports written in Japanese.[63] Translation of all the technical papers in experimental and theoretical aerodynamics

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[62] "Maboroshi No Tsubasa," *Yomiuri shinbun: Seibu-ban*, 14-15 August 2002.

[63] Masatada Tada, "Kōsoku Fūdō Ni Yoru Tubasakata No Jikkenteki Kennkyū," *Nihon kōkū gakkaishi* 4,

into Western languages was neither possible nor necessary during or even after the war.[64] The wartime urgency imposed a series of design tasks for new aircraft on a severely limited pool of aircraft engineers. This left them practically no time for other activities. For example, Tsuruno produced no written reports, let alone any publications, about his navy aircraft development. Under an avalanche of work orders, he sent only one telegram to navy headquarters, in this case requesting a supply of fuel for a test flight of the Navy aircraft J7W1.[65] Typically, wartime aeronautical engineers, particularly in commercial industry, did not display their engineering knowledge in publications, but only in technological artifacts.

From 1945 to date, Japan's lack of international migration among military engineers has remained largely unexplored. The issue has remained entirely open to informed speculation. One avenue through which one could delve into the intriguing German-Japan contrast may lie in one of the provocative diversions of writing history, which involves asking about hypothetical possibilities. Granted, this leads to a neither verifiable nor conclusive end, but it is a heuristically useful and constructive way of sharpening the focus on the issue and viewing it from a different

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no. 29 (1956): 135.

[64] This phenomenon shows not only in aeronautics per se but also in wartime science in general. For view of the U.S. Occupation authorities, see, for instance, Bowen C. Dees, *The Allied Occupation and Japan's Economic Miracle: Building the Foundations of Japanese Science and Technology 1945-52* (Surrey: Japan Library, 1997), 207-09.

[65] Masayoshi Tsuruno, "Ente-Gata Kyokuchi Sentōki," in *Umiwashi No Kōseki* (Tokyo: Hara shobō, 1982), 289.

perspective. Japanese aeronautical engineers apparently had less of a chance to leave their motherland than did the Germans for various reasons. One could raise economic, socio-cultural, and geographical factors operating within Japan itself in mediating international migration.

First, Japanese aeronautical engineers had neither lawful access to hard currency nor any other financial support had they attempted to leave the country with their families. The conversion of the Japanese yen to the U.S. dollar was possible only on the black market. The rumor that lawbreakers, if caught, would be sent to the remote island of Okinawa for hard labor apparently deterred initiative here.[66] Some sociologists studying the mechanisms and patterns of international migration suggest the following point. Typically, the higher the cost of movement in money, time, or energy, the less likely a migration is to occur. The availability of money and other types of necessary assistance usually declines as the distance to the target increases.[67]

Second, unlike the Germans, socio-cultural forces constrained Japanese aeronautical engineers from pursuing careers outside their homeland. Usually, the ages of senior, experienced aeronautical engineers of wartime Japan ranged from the late 20s to late 30s by 1945. In many cases, this age group supported rather extended families with young children and often aging

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[66] Shigeru Nakayama, "Kagakusha No Kaigai Haken," in *Nihon No Kagaku Gijutsu* (Tokyo: Gakuyō shobō, 1995), 170-71.

[67] Gary Coombs, "Opportunities, Information Networks and the Migration-Distance Relationship," *Social Networks* 1 (1979): 258-59.

parents. Almost invariably they lived together even after a temporary separation. An illustrative case is that of Horikoshi Jirō. In 1946 he moved to Tokyo for work, leaving his entire family, including his mother, wife, and six children in his hometown. He earned his daily living by repairing pots and pans, farming equipment, refrigerators, and the like. Only after the Mitsubishi conglomerate was reestablished in 1952 did he bring his entire family to Tokyo to live.[68] The burden of socio-cultural obligation for the male family head to care for his entire family and tombs of his patrimonial ancestors was heavier on first-born males when compared to their younger siblings. In addition, language posed a major issue. Wartime aeronautical engineers did not pursue the idea of relocating abroad with family, which demanded daily communication in a foreign language.

Thirdly, nor did geography help emigration of wartime Japanese engineers. Sociologists have empirically noted a strong inverse relationship between the volume of migration and the distance traveled. The greater the distance, the lesser the volume of migration,[69] and the physical constitution of Japan complicates this picture. Emigrating from Japan as an archipelago posed far greater physical and mental challenges than simply walking overland out of Germany. The relative ease of the emigration portrayed in the film The Sound of

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[68] Maema, *Ys-11 Kokusan Ryokakki Wo Tsukutta Otokotachi*,88.

[69] Coombs, "Opportunities, Information Networks and the Migration-Distance Relationship," 257-76.

Music — in which a large Austrian family and their tutor flee together from Nazi Germany overland across a national border to Switzerland — did not exist in Japan. Of course, Japan was not geographically situated like Germany, which was surrounded by Allied and politically neutral nations. Britain and France actively evacuated German specialists for postwar development from under the noses of the Americans, but no such countries were near Japan.

In retrospect, the organized relocation of Japanese military engineers in foreign lands would have largely failed even with requisite support from their host nations. This was because together with the three factors involving Japan itself, at least three socio-political factors in the host nation — the United States — deterred the outflow of Japanese aeronautical engineers. First, Japanese wishing to emigrate were severely disadvantaged because post-1945 emigration was highly contingent on historical precedents. By contrast, the influx of German aeronautical engineers to the United States was not new. After the end of World War I in 1918, a number of prominent German scholars in aeronautics-related fields relocated to the United States by invitation. Subsequently they contributed markedly to the further development in the fields. A good example is Michael Max Munk, a highly acclaimed German aeronautical engineer. In 1920 he moved to the United States; at NACA headquarters, he developed a method useful for theoretically predicting airfoil lift and moments. After his resignation, he worked for

Westinghouse, Brown Boveri, and the Alexander Airplane Company and taught at the Catholic University of America in Washington D.C.[70] No such Japanese case existed before 1945 in the United States. Notable precedents like this reduced cultural and political resistance to the post-1945 immigration of German engineers.

Second, the presence of earlier German immigrants in the host country could help the flow of information about various opportunities abroad, encouraging a "brain drain" from postwar Germany, whereas the absence of such individuals impeded successful emigration from postwar Japan. Commonly, the size and attraction of potential target communities depend heavily on the availability of relevant incoming information. Network contacts in the target nation could play a vital role in the outflow of immigrants. A background in research, as well as a common place of origin, could attract migrants with such characteristics. Several sociologists have shown that the mass media and other channels of information flow could influence the volume and direction of a migration considerably.[71] Within this framework, German engineers and scientists in aeronautics during World War I could supply information to the engineering communities of their origin via formal and informal networks, reducing the risks and uncertainties associated

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70 John David Anderson, *A History of Aerodynamics and Its Impact on Flying Machines* (Cambridge: Cambridge University Press, 1998), 295-96.

71 Coombs, "Opportunities, Information Networks and the Migration-Distance Relationship," 259-61, Davor Jedlicka, "Opportunities, Information Networks and International Migration Streams," *Social Networks* 1 (1979): 277-84.

with the post-1945 migration. But this option was not available to Japanese technicians and scientists. During the Occupation, with only a few exceptions, the Occupation authorities closed the window of opportunity for ordinary Japanese seeking to go abroad. American authorities did not grant visas to Japanese applicants unless their relatives abroad guaranteed the necessary financial support in writing. A select few did join study abroad programs after successfully passing rigorous examinations, but they financed their tuition and other expenses through individual contacts with their hosts abroad.[72] Only after January 1950 did the Occupation authority loosen these tight reins. Thereafter, the Ministry of Foreign Affairs became more responsible for supervising the foreign travel process for ordinary Japanese citizens.[73]

Third, international migration depended heavily on the time of its occurrence. In 1945, racial discrimination remained a tenacious factor in the United States. John Dower's compelling account shows that wartime racism against the Japanese was more intense in degree and malicious in nature than that against the Germans.[74] The cultural backlash against the Japanese as a whole did not provide them with a healthy and conducive environment for a free flow of

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[72] Nakayama, "Haisen Chokugo No Kagaku Gijutsukai No Jittai,"171-72.

[73] Kagaku gijutsu seisakushi kenkyūkai hen, *Nihon No Kagaku Gijutsu Saisakushi* (Tokyo: Mitō kagaku gijutsu kyōkai, 1990), 56-57.

[74] John W. Dower, *War without Mercy: Race and Power in the Pacific War* (New York: Pantheon Books, 1986).

information across the Pacific. The complete prohibition on Japanese immigration to the United States from 1924 through 1947 precluded the chance for such an information flow into Japan. Above all, the engineering communities of the host country continuously espoused the perception of the Japanese as imitators and copycats in aircraft technology. Partly for this reason, captured German and Japanese aircraft met different fates after a series of tests. Most, if not all, the German aircraft survived, but the vast majority of the Japanese aircraft were destroyed.[75]

Emigration of aeronautical engineers from Germany was thus far more visible and common that that from postwar Japan. All the contingent variables that I have examined helped shape the probability and significance of the larger contingency, namely Japan's lack of brain-drain pattern among engineers in the immediate postwar years. An "invisible hand" discouraged Japanese engineers from pursuing their careers abroad in the United States or anywhere else. The absence of post-1945 emigration among Japanese aeronautical engineers thus passed on their accumulated wealth of wartime military experience and knowledge almost exclusively within Japan. Contextual variables helped deter the emigration — and consequently encouraged domestic migration — of engineers after the end of the war.

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75 I thank John F. Guilmartin for sharing with me his insightful observation.

2.3 Whereabouts of Military Engineers at Home: Japan National Railways (JNR), 1945-1952

Within the country, many wartime aeronautical engineers embarked on second careers in the railroad industry during the occupation years. This transfer of human capital was possible primarily because the Japan National Railways (JNR) actively absorbed hundreds of wartime engineers, at least half from the military sector. The JNR was, in fact, among the limited number of public organizations that accommodated wartime engineers on a large scale during the Occupation years. The employee directory of August 1950, for instance, lists 267 new registered employees with baccalaureate degrees who joined the JNR during between 1945 and 1950. Their wartime institutional affiliations can be seen in Table 2.1:

Wartime Backgrounds	Number of Employees
Army	48
Navy	95
Central Aeronautical Research Institute	24
Others (aircraft related)	14
Conscripts	24
South Manchurian Railroad	35
Korean Railroad	14
Others (railroad related)	13
Total	267

Table 2.1: Wartime Background of 267 New Engineers at the Japan National Railways[76]

This infusion of wartime military engineers was a product of JNR's institutional legacy. The organization acted, at least in part, from a sense of obligatory duty to absorb the wartime engineers. Upper management had planed ahead for the end of the war which seemed imminent by early 1945. Managers thus held meetings, both official and unofficial, before the war's end. One major, impending issue for the JNR and the Ministry of Transportation was the millions of soldiers returning from abroad. Within this context, Horiki Kenzō (1898–1974) — the director of the Railway Board within the Ministry of Transportation during the war, and the Minister of

[76] *Kokutetsu Shokuin Meibo (Gijutsu Gakushi) Shōwa 25-Nen 8-Gatsu 10-Ka Genzai* (Tokyo: n.p., 1950).

Health, Labor and Welfare in the 1950s — was in charge of government railway operations. In a morning meeting taking place on August 15, 1945, Horiki emphasized the duty of the railroad industry to absorb not only railroad engineers returning from Asia, including Manchuria and Taiwan, but also wartime military engineers. A few hours after that, Emperor Hirohito's reedy voice on the radio broadcast publicly proclaimed the end of the war[77]— and Horiki's view apparently constituted the backbone of the JNR recruitment strategy thereafter.

Yet the JNR apparently treated military engineers as "outsiders," not as part of the central command at headquarters. With some exceptions, the wartime engineers ordinarily lacked chances for promotion in the central management structure. Aeronautical engineers, however "elite" they might have been in the military during the war, were not treated as such in the postwar railroad industry. In fact, 92 percent of wartime military engineers worked at JNR's subsidiary institutes, or railway factories and bureaus located in geographically remote areas. The patterns of personnel distribution within the JNR are shown in Table 2.2:

[77] Manabu Kanematsu, *Shūsen Zengo No Ichi Shōgen: Aru Tetsudōjin No Kaisō* (Tokyo: Kōtsū kyōkai, 1986), 46-47.

Wartime Backgrounds	Central Headquarters	Peripheries (Factories/Bureaus)	Peripheries (Research Centers)
Army	5	16	14
Navy	3	17	40
Central Aero Research Institute	0	2	10
Others (aircraft related)	0	7	4
Conscripts	1	18	0
South Manchurian Railroad	5	30	1
Korean Railroad	1	13	1
Others (railroad related)	2	10	0
University Faculty	0	6	4
	17	119	74
Total	17	193 (=92%)	

Table 2.2: Military Engineers' Wartime Backgrounds and Postwar Employments in the Japan National Railways[78]

This diffusion of military engineers across Japan was beneficial to the employed and employers within the railroad industry. Local factories gained the engineering expertise of military engineers for repairs and maintenance. Many engineers, on the other hand, settled down in remote areas where living conditions and food shortages were better off than in urban areas. As a

[78] *Kokutetsu Shokuin Meibo (Gijutsu Gakushi) Shōwa 25-Nen 8-Gatsu 10-Ka Genzai*.

result, the Niigata, Sendai, and Moji Bureaus in the peripheral regions retained an ample numbers of engineers; but the Tokyo and Osaka Bureaus suffered from a manpower shortage.[79] The JNR calmed the highly volatile national landscape to a degree by satisfying the daily needs of the military engineers, and by placing them in remote areas away from Tokyo.

What encouraged the massive expansion of the engineering work force at the JNR were the sociopolitical circumstances of the time. Postwar suffering was evident in the fact that the railroad transport system had come under heavy wartime bombardment. The damaged lines that survived needed maintenance. Demobilized soldiers and evacuated schoolchildren in the countryside returned home. The urgent need for repairing the badly damaged infrastructure and for providing transportation service far exceeded what the available JNR manpower could accomplish even with overtime work. In this context, labor unions with political clout altered the size and composition of the JNR work force. The labor agreement of February 1947 stipulated an 8-hour work day, 20 days of paid vacation per year, and five holidays per year. These new standards prohibited the JNR from working underage and older workers who had substituted for those mobilized for military service, and in 1947, led the JNR to increase its total workforce by 20 percent.[80] Consequently, the total number of JNR employees doubled from 300,000 in 1939

[79] Un'yushō, *Kokuyū Tetsudō No Genjō: Kokuyū Tetsudō Jissō Hōkokusho* (Tokyo: 1947), 47-48.

[80] Ibid.,42-45.

to 600,000 in 1948.[81]

2.4 Railway Technical Research Institute (RTRI), 1945-1952

2.4.1 Expansion of Manpower and Property

Among the many JNR establishments, the Railway Technical Research Institute (RTRI) can best elucidate how the postwar society integrated demobilized troops via a civil conversion of wartime manpower and research facilities. Bureaucratically and financially, the RTRI was a subsidiary research institute; it supported the central headquarters for further development of railway engineering. Originally established in 1907 with 38 members, the research and development institution acquired its official name, the Railway Technical Research Institute, in March 1942. Roughly 400 workers engaged in a wide array of research and development projects as part of the Ministry of Transportation throughout World War II. The areas of research and development they covered were fairly comprehensive. For instance, one laboratory focused its research entirely on the car body structure of steam locomotives, electric trains, passenger cars, freight cars, special utilities cars, and automobiles.[82]

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[81] Eiichi Aoki et al., eds., *A History of Japanese Railways, 1872-1999* (Tokyo: East Japan Railway Culture Foundation, 2000), 122.

[82] Nihon kokuyū tetsudō tetsudō gijutsu kenkyūjo 50-nenshi kankō iinkai, *Nihon Kokuyū Tetsudō Tetsudō Gijutsu Kenkyūjo 50-Nenshi* (Tokyo: Ken'yūsha, 1957), 26-27.

In the immediate postwar years, the RTRI integrated a temporary oversupply of wartime engineers on market into the research system. From 1944 to 1947, the number of employees increased consistently from 380 to 1557, or by roughly 400 percent! But such a massive expansion was short-lived. The subsequent purge around 1949 removed from the public service sector (including the RTRI) those deemed "socially undesirable" for having contributed actively to the war effort. For instance, a chief designer of the legendary giant battleship Yamato perforce left the RTRI and sought employment elsewhere.[83] The number of employees at the RTRI continued to dwindle, presumably under monetary pressure within the JNR, then operating at a deficit. The Science Council of Japan discussed the possibility of privatizing the RTRI. In June 1949, Prime Minister Yoshida suggested an option of reducing its research and development activities and the size of its work force by as much as 30 percent.[84] In April 1950, the newly established Transportation Technology Research Center absorbed two laboratories and researchers in seven laboratories from the RTRI.[85] During 1950 and 1951, the total number of RTRI employees returned to the wartime level, and stabilized thereafter (see Table 2.3).

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[83] Ibid.,51-52.

[84] Nihon kagakushi gakkai-hen, *Nihon Kagaku Gijutsushi Taikei*, vol. 5 (Tokyo: Daiichi hōii shuppan, 1969), 204-05.

[85] Nihon kokuyū tetsudō tetsudō gijutsu kenkyūjo 50-nenshi kankō iinkai, *Nihon Kokuyū Tetsudō Tetsudō Gijutsu Kenkyūjo 50-Nenshi*,3

Year	Number of Workers	Event
1942	519	
1943	468	
1944	385	
1945	1,160	
1946	1,464	
1947	1,557	
1948	1,497	
1949	676	Purge
1950	549	Creation of TTRC
1951	512	

Table 2.3: Increase and Decrease of RTRI Workers[86]

The temporary nature of the postwar personnel transfer coexisted with a long-term integration of some of the wartime military engineers. Wartime aeronautical engineers constituted a substantial part of the new engineering work force at the RTRI in 1950. A majority came from the military and aircraft-related background, and a minority from the field of railroad engineering (see Table 2.4).

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[86] Ibid.,40-43.

Wartime Background	Number of Workers
Navy	37
Army	13
Central Aeronautical Research Institute	11
Others (aircraft related)	3
South Manchurian Railway	1
Korean Railway	1
Others (railroad related)	26
University faculty	4
New university graduates	29
Total	125

Table 2.4: Wartime Backgrounds of 125 New Engineers at the RTRI[87]

This curious breakdown resulted primarily from individual initiatives with political ramifications. For instance the RTRI director, Nakahara Juichirō, played a central role in actively recruiting many jobless aeronautical engineers in 1945. A case in point was the transfer of wartime engineers from the Central Aeronautical Research Institute to the RTRI in December 1945. The two research institutes were familiar to each other because they had shared some administrative personnel during the war. Nakahara's postwar position in both establishments further linked them together for the eventual transfer of engineering personnel. In September, he

[87] *Kokutetsu Shokuin Meibo (Gijutsu Gakushi) Shōwa 25-Nen 8-Gatsu 10-Ka Genzai*.

officially headed the Central Aeronautical Research Institute that ceased to operate and awaited its fate under the Allied Occupation.[88] During 1945 and 1946, 73 percent of a total of 1,526 workers at the dissolved Central Aeronautical Research Institute migrated to the RTRI.[89] The transfer was smooth and complete, at least on paper. The associates continued to work at the former establishment until December 30, 1945; and they worked at the RTRI from the next day.[90] Their experience differed markedly from that of many jobless aircraft technicians searching for employment at war's end.

During the occupation years, the RTRI inherited not only the wartime manpower, but also research and development facilities from the Central Aeronautical Research Institute. This wartime establishment resulted from a close collaboration between the Navy and the Ministry of Communication, contributing markedly to the development of civil aeronautical technology after April 1939.[91] After the war's end, the tangible assets of the research institute were literally sold in pieces, a chance for the opportunistic RTRI management. From 1946 to 1948, the airfield and

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[88] Nihon kokuyū tetsudō tetsudō gijutsu kenkyūjo 50-nenshi kankō iinkai, *Nihon Kokuyū Tetsudō Tetsudō Gijutsu Kenkyūjo 50-Nenshi*,784-85.

[89] Nihon kōkū gakujutsushi henshū iinkai, *Nihon Kōkū Gakujutsushi (1910-1945)* (Tokyo: Maruzen, 1990), 292, Nihon kokuyū tetsudō tetsudō gijutsu kenkyūjo 50-nenshi kankō iinkai, *Nihon Kokuyū Tetsudō Tetsudō Gijutsu Kenkyūjo 50-Nenshi*,42.

[90] Morihisa Takabayashi, Letter to author, December 14 2002.

[91] Hikari Mizusawa, "Rikugun Ni Okeru 'Kōkūkenkyūjo' Setsuritsu Kōsō to Gijutsuin No Kōkū Jūtenka," *Kagakushi kenkyū* 42, no. 225 (2003).

facilities in Ibaragi prefecture — which included a one-story building on 45 acres of land (1,361 tsubo) as part of 3,072 acres of land — became the testing site for the Disaster Prevention Laboratory and Soil Research Laboratory of the RTRI.[92] In October 1947, the management gained permission from the General Headquarters to use buildings on 443 acres (13,400 tsubo) and a land tract of 793 acres (24,000 tsubo), both wartime assets of the dissolved Central Aeronautical Research Institute.[93] These buildings included dormitories in which each family in residence occupied one room during the war; after major renovation, each RTRI family lived inexpensively in two rooms.[94] Moreover, the RTRI inherited the wartime knowledge base — 1,000 books and 2,000 back-numbered journals — from the Central Aeronautical Research Institute. The RTRI management gained a total of 2,200 books from the defunct Navy.[95] The accumulated experience and knowledge of the wartime years found their niche in the postwar environment.

From the Navy, the RTRI successfully obtained research facilities that had escaped the fate of wartime reparations. Shortly after the war, for instance, its management petitioned

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[92] Nihon kokuyū tetsudō tetsudō gijutsu kenkyūjo 50-nenshi kankō iinkai, *Nihon Kokuyū Tetsudō Tetsudō Gijutsu Kenkyūjo 50-Nenshi*,150-51.

[93] Ibid.,149.

[94] Ibid.,66.

[95] Ibid.,84-85.

General Headquarters for the right to use the Navy Technology Institute, a research site for highly advanced radar technology development among other projects during the war. In 1954, the RTRI personnel physically transported a giant fatigue tester — applied primarily to hulls, locomotives, and aircraft during the war — from its original site to the RTRI.[96] The ambitious effort to obtain wartime research facilities extended to the Kure Navy Arsenal. In 1946, the RTRI successfully gained from the Ministry of Finance temporary permission to use equipment for testing hulls at the site. Subsequently, the railroad engineers experimented on rail cars, bridges, and other structures. Unshackled from various restrictions in 1955, the engineers freely used other testing facilities, including one-story buildings on 9.5 acres (286 tsubo) of land, and additional space of 14 acres (426 tsubo).[97]

Similarly, the RTRI obtained research facilities from the former Imperial Army. In January 1946, its management obtained temporary access to vacant buildings of the Army Armaments School from the Ministry of Finance. Soon they established their Automobile Laboratory on the site, using 6 one-story buildings and 982 acres (29,700 tsubo) of land for research purposes. Four months later, the RTRI gained storage facilities from the 2nd Army Rail Regiment and buildings from the Army Arsenal. After major renovation, the wartime facilities

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96 Ibid.,167-69.

97 Ibid.,151.

became part of a railway testing laboratory that made effective use of spacious one-story buildings and 1,429 acres (43,220 tsubo) of land.

2.4.2 Smoldering Tensions Within and Outside the RTRI

The integration of wartime research facilities and engineers into the RTRI caused deep divisions within the railroad industry. Rarely did the outcome of the integration seem salutary to all concerned, and it divided industry between the camp of wartime military engineers and that of wartime railroad engineers. This unexpected development resulted mainly from JNR and RTRI managements' mistakes that revealed an ad hoc, confused response to changing circumstances in the postwar environment. The management cohort failed to demonstrate a coherent, carefully thought-out policy about the civil conversion of military technology in the aftermath of the war.

In the immediate postwar era, a controversial, thorny issue involved the sometimes crude integration of wartime military engineers at the RTRI. The resentment of them in the RTRI gradually flared up after the war's end. At a RTRI job interview, for instance, one engineer from the Institute for Navy Aeronautics was called "kokuzoku," a traitor to the country. Later he declined the offer with resentment.[98] Many railway engineers scornfully called wartime military

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[98] Yoshirō Ikari, *Kaigun Gijutsushatachi No Taiheiyō Sensō* (Tokyo: Kōjinsha, 1989), 262.

engineers at the RTRI "shinchūgun," an occupation force, behind their back.[99] In this setting, newly employed wartime aeronautical engineers embraced their prerogative of free rides on the national rail service, using their abundant free time at the establishment. Simply lacking necessary research equipment and tasks to do, they cut grass and often planted potatoes in the backyard to weather the food shortage of the time. Those who spent 2 to 3 hours traveling each way to the RTRI every day essentially became commuting farmers.[100] This curious "research and development system" in railway engineering naturally invited criticism from the Ministry of Transport. "The 1,500 research associates and the massive research system at the RTRI," one opined in a Ministry journal, "…contribute very little to JNR's business operation."[101] Other disgruntled engineers fanned the fire from within the RTRI. One engineer, for instance, harshly criticized the new research and development system based on wartime military engineers:

> "With no experience in the field of railway engineering, some new boys came [to the RTRI] by invitation simply because they had the title of engineer. Some sections went

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[99] Hiroshi Nakamura, Telephone conversation with author, 24 March 2004.

[100] Masami Hayashi, "Watashi No Sengo," in *Kaigun Kōkū Gijutsushō Denkibu* (Tokyo: Kūgishō denkibu no kai, 1987), 97, Tadanao Miki, "Monorail 45-Nen No Tsuioku," *Monorail* 82 (1994): 1, Nakamura, Tetsudō gijutsu kenkyūjo-hen, *Tetsudō Gijutsu Kenkyūjo Sōritsu 70-Shūnen: 10-Nen No Ayumi* (Tokyo: Nihon kokuyū tetsudō tetsudō gijutsu kenkyūjo, 1977), 290-91.

[101] Un'yushō, *Kokuyū Tetsudō No Fukkō: Tetsudō 75-Nen Kinen Shuppan Daiisshū* (Tokyo: 1948), 203.

> too far; these engineers formed the center of research and tailored it to Army or Navy styles, a development detrimental to the traditional spirit and history of railroad engineering. The inconsistent policy of expansion and a lack of order in each enlarged section disgracefully created similar laboratories… The expansion seemingly resulted in the formation of a strong system for research and development, but in reality, the system became shallow and weak… This is because the opportunistic leadership held certain preconceptions [about military engineers], pursuing expansion hastily and capriciously. The policy resulted in nothing but the opening of new laboratories, enormous expenses for research facilities, and bad feelings against the new researchers.[102]

This highly critical article appeared in a technical journal and was read fairly widely within the railroad industry, a development which suggests similar frustration among wartime railway engineers within and outside the RTRI.

The smoldering tension resulted in part from management's alleged favoritism for wartime military engineers vis-à-vis wartime railway engineers. This view was somewhat

[102] Masaki Kubo, "Tetsudō Gijutsu Kenkyūjo No Genzai to Shōrai Heno Michi," *Kōtsūgijutsu* 30 (1949): 10-15.

justifiable in retrospect. The RTRI indeed highly valued the military engineers and appointed several of them to laboratory leadership positions “by necessity,” in part for socio-political reasons. As of 1950, the research establishment consisted of 30 laboratories; but curiously, only 14 or so of the 30 laboratory leaders possessed prior experience in railroad engineering, while the other half were clearly new to the field (see Table 2.5).

Lab leaders: Wartime background	Number of Lab Leaders
Japan National Railways	15
Navy	10
Army	2
Central Aeronautical Research Institute	1
Southern Manchurian Railway	1
University Faculty	1

Table 2.5 Wartime Backgrounds of RTRI Laboratory Leaders as of 1950[103]

Their appointments, never justified publicly, were apparently a response to prevalent, highly demoralizing labor unrest of the time. Alarmed by the leftist threat to a fragile social stability,

[103] *Kokutetsu Shokuin Meibo (Gijutsu Gakushi) Shōwa 25-Nen 8-Gatsu 10-Ka Genzai*, *Shōwa 25-Nen 12-Gatsu 15-Nichi Genzai (Honchō) Nihon Kokuyū Tetsudō Shokuinroku* (Tokyo: n.p., n.d.).

General MacArthur instructed Prime Minister Ashida in July 1948 to prohibit strikes by public servants, government railway workers among them. As it turned out, employees retained the right to collective bargaining;[104] and in this way, the voices of wartime military engineers could be heard through the system of laboratory leaders who shared a similar background.

Appointments of military engineers, in effect, created a potential threat to the RTRI management as well as the JNR civilian leadership. The new laboratory leaders were typically fairly young engineers with no experience in railway engineering. According to various personnel directories as of 1950, the ages of the thirty laboratory leaders ranged from 34 to 46. Half of them were in their thirties, and the average age of all of them was approximately 39 years old. Among the 30 leaders, a half of them — ten leaders in 1945, four leaders in 1946, and one leader in 1947 — became employed at the RTRI from outside the field of railroad engineering (see Table 2.6). Within this context, such young "outsiders" at the RTRI gradually formed a group ready for a revolt against tradition-bound, seniority-based cohorts of railroad engineers.

[104] Aoki et al., eds., *A History of Japanese Railways, 1872-1999*,121.

Ages as of 1950	Number of Laboratory Leaders
34	2
35	3
36	2
37	3
39	3
40	4
41	3
42	4
43	1
46	1
Average Age	38.9

Table 2.6: Ages of RTRI Laboratory Leaders as of 1950[105]

As the previous chapter has shown, the successful transfer of engineering knowledge in trans-WWII Japan owed much to the Occupation years from 1945 to 1952. Japanese postwar society successfully integrated wartime experience with life after the war, but its products were hardly planned ones. Japan's conspicuous lack of a major brain-drain pattern among engineers was largely the byproduct of a socio-political and geo-cultural setting; it nonetheless provided the defeated nation with the requisite engineers needed for the technological transformation that would occur in the years that followed. I have compared and contrasted the observable patterns

[105] *Shōwa 25-Nen 12-Gatsu 15-Nichi Genzai (Honchō) Nihon Kokuyū Tetsudō Shokuinroku*, *Tetsudō Gijutsu Kenkyūjo Senpai・Genshokusha Meibo: Shōwa 52-Nen 1-Gatsu 1-Nichi Genzai* (Tokyo: n.p., n.d.).

of the brain-drain phenomenon in postwar Germany and Japan. In retrospect, postwar Japan was unknowingly "blessed" with several factors that discouraged emigration in any form. The peace-oriented postwar society did not welcome former military engineers in the immediate postwar years, but society successfully capitalized on their wartime expertise in the long run. The railway industry, particularly in JPR, showed this pattern. The resulting migration of the former military engineers, however, left difficult issues for railway engineers employed from the pre-1945 era.

Against this backdrop, wartime military engineers developed their engineering culture within the railway industry, leading to the requisite research and development in the field for the bullet train development. In the process, the engineers actively made decisions and actions, using their engineering knowledge as a tool to shape the research environment and industry as a whole. The result was that turf battles developed between wartime aeronautical engineers and wartime railway engineers, and between the engineering science of aeronautics and the tradition-bound empiricism of railroad engineering. The next chapter will examine the rise of military engineers as problem solvers in the postwar railway industry during the period of national reconstruction from 1945 to 1955.

CHAPTER 3

RISE OF WARTIME MILITALY ENGINEERS IN THE POSTWAR RAILWAY INDUSTRY, 1945- 1955

This chapter will examine individual decisions by wartime military engineers at the Railway Technical Research Institute from 1945 to 1955. This is because a more complete understanding of the civilian application of military technology needs to incorporate both the independent judgment of engineers—who developed infrastructure for high-speed rail service—and nature of the postwar industry within which the engineers made their choices. Faced with the new climate of anti-militarism and various pressures to conform, the wartime military engineers did not settle easily into the structure that had existed before 1945. After the war's end, they mounted both individual and collective efforts on their own behalf, acting as agents of technological transformation. They did not function as agents for some kind of long-term thinking, nor did they present any visions of modernity imposed from the top; such elements were rarely, if ever, present in society from 1945 to 1955. The military engineers cultivated their niches in the postwar railway industry fairly free of external constraints. During the period of postwar reconstruction, they successfully solved many technical problems that had caused numerous train accidents and threatened the safety of rail service. The wealth, adaptability, and flexibility of their wartime engineering knowledge proved crucial in these efforts. The resulting process of technology transfer was not pushed ahead by some internal logic of technology, but was rather shaped largely by engineers' individual decisions within the postwar context of their worth.

To illustrate these points, this chapter begins by examining the state of the Japanese industry under the Allied Occupation. Severe physical damage to infrastructure and rail service during the war naturally posed major technical challenges after the war. Many train accidents, as it turned out, provided the ground on which the military engineers successfully solved many technical problems, gained autonomy, and established themselves firmly in the industry during the years that followed. For our purposes, we will look into decisions and actions by wartime engineers who contributed markedly to research and development in rail car vibrations, bridges, rail lines, crossties, construction metals, and wireless communication after 1945. Many civil applications of military technology, as I will show, had been smoothly and successfully introduced by 1955.

3.1 Postwar Sufferings in the Japan National Railways, 1945-1952

All the railway facilities were in a dire condition during the immediate postwar era, but the urgent need to repair them remained for a time unfulfilled. The severe damage to infrastructure included 682 breaks in main rail tracks and 361 breaks in side rail tracks. As many as 465 stations and other buildings were heavily damaged.[106] Roughly 100 bridges in 50 different locations across the country had come under devastating aerial bombardment and gunfire especially in July and August 1945.[107] As many as 15 percent and 13percent of steam and electric locomotives, respectively, had been heavily damaged. Likewise, passenger carriages and freight wagons were in poor condition due to overuse and low wartime manufacturing standards.[108] Material resources needed for repairing the physical damage were in short supply. For instance, the availability of wood within the industry decreased after the war in part because the country was unable to import the material. To fix damaged crossties, the JNR needed roughly

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[106] Aoki et al., eds., *A History of Japanese Railways, 1872-1999*,118.

[107] Nihon kokuyū tetsudō tetsudō gijutsu kenkyūjo 50-nenshi kankō iinkai, *Nihon Kokuyū Tetsudō Tetsudō Gijutsu Kenkyūjo 50-Nenshi*,274.

[108] Aoki et al., eds., *A History of Japanese Railways, 1872-1999*,118.

34.7 million cubic feet of wood (5,450,000 koku) in 1946 but obtained just half of that amount.[109] A severe shortage of coal, the chief energy source of motive power in the industry, greatly hampered logistics. A major campaign to save coal began in September 1946; nonetheless, passenger operations nationwide were reduced in December by 16 percent.[110] A serious shortage of steel available for repairing physical infrastructure and locomotives greatly impeded reconstruction (Table 3.1):

[109] Nihon kokuyū tetsudō tetsudō gijutsu kenkyūjo 50-nenshi kankō iinkai, *Nihon Kokuyū Tetsudō Tetsudō Gijutsu Kenkyūjo 50-Nenshi*,666.

[110] Nihon kokuyū tetsudō-hen, *Tetsudō Gijutsu Hattatsushi Dai 6-Hen (Senpaku), Dai 7-Hen (Kenkyū) Dai 8-Hen (Nenpyō)* (Tokyo: Nihon kokuyū tetsudō, 1958), 362.

Year	Shaped Steel Products (ton)	JNR Consumption (ton)	Percentage
1941	4,264,000	237,000	6
1942	4,871,000	230,000	5
1943	4,522,000	196,000	4
1944	2,622,000	136,000	5
1945	400,000	46,000	9
1946	326,000	87,000	21
1947	578,000	91,000	16
1948	1,230,000	139,000	11
1949	2,261,000	143,000	6
1950	3,580,000	158,000	4

Table 3.1**:** Shaped Steel Products and JNR Consumption in Japan from 1941 to 1950[111]

In this situation, postwar society experienced an alarming rise of devastating fatalities in rail service. Almost on a daily basis, the press reported on the threat to safety in rail service, and this development was in some degree the product of the unprecedented freedom permitted after the war's end. The heavy, organized censorship of the media that had existed during the war vanished. The press was no longer an instrument of national goals for war; it no longer expounded nationalistic, evocative themes — such as "Sacrifice for the Emperor" — that tended to fan the wartime fires. Now the press expressed the views of the consumers and civilians,

[111] Nihon kokuyū tetsudō, *Tetsudō 80-Nen No Ayumi, 1872-1952* (Tokyo: Nihon kokuyū tetsudō, 1952), 100.

articulating such uplifting themes as "peace" and "co-existence." A society that had survived a fearfully destructive war at a considerable cost had acquired a keen sensitivity to life and death issues. This development reflected the reorientation of individual or collective Japanese values that had appeared after the summer of 1945.

After the war's end, the press carried reports about incidents that would not have appeared widely, if at all, in the wartime media. One such incident occurred in December 1945. An infant died of suffocation on its mother's back in a highly congested commuter train in Tokyo. When the police charged the mother with involuntary manslaughter, myriad responses from readers of the press generated a frank discussion about passenger safety in rail service as a social issue. One leading paper, the Asahi Shinbun, published comments by various citizens — female journalist, a male student, a mother, and others — on the matter. Under intense public pressure, the police withdrew the indictment.[112]

Public discouragement with rail service was exacerbated after numerous train accidents that betrayed a social expectation of safety in postwar travel. A populace sick of war hailed the Allied Occupation in 1945, and the immediate meaning of "liberation" for most Japanese was not strictly political but rather more psychological. The surrender to the Allies liberated ordinary

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[112] Sawako Noma, ed., *Haikyo Kara No Shuppatsu, Shôwa 20-21 Nen*, vol. 7, *Shōwa Ni Man Nichi No Zenkiroku* (Tokyo: Kōdahsha, 1989), 185.

citizens from death as previously experienced. Month after month, people during the war had prepared for the worst. When the tension was broken in August 1945, they were quite literally in many cases given back their lives.[113] But many people quickly learned that a major threat to their lives still lurked in the daily rail service. For instance, in November 1945, a cigarette fire burned rapidly out of control and eventually reduced six partially wooden cars to ashes. Sixty-five passengers were injured, and eight died in the ensuing inferno.[114] Apart from fire hazards, the fragility of the wooden construction was equally deadly. In June 1946, the centrifugal force of a congested commuter train running on a curve in Tokyo pushed passengers through a broken wooden door and off the bridge, into a river below. Five passengers died.[115] In February 1947, four wooden cars in the rear of another train were released fatally from the rest on a sharply declining curve, and fell off a cliff. This staggering accident injured 495 passengers and killed 184.[116] Evocative headlines in major national newspapers — such as "Unprecedented Catastrophe!" and "A Thousand Casualties" — alerted readers of the danger latent in daily rail service.[117] The Asahi Shinbun published an article on this tragedy and deridingly expressed

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[113] Dower, *Embracing Defeat: Japan in the Wake of World War II*,87-89.

[114] Hiroshi Kubota, *Tetsudō Jūdai Jiko No Rekishi* (Tokyo: Grandpri shuppan, 2000), 54.

[115] Kazuo Nishii, ed., *Shōwa Shi Zenkiroku* (Tokyo: Mainichi shinbunsha, 1989), 373.

[116] Kubota, *Tetsudō Jūdai Jiko No Rekishi*,83.

[117] Hiroshi Uno, ed., *Asahi Shinbun Ni Miru Nihon No Ayumi: Shōdo Ni Kizuku Minshu Shugi*, vol. 2

acute anxiety about the highly risky nature of recent rail service. "Doors fell off, congested trains derailed and often fell off cliffs," it announced.[118] An editorial denounced the railway's corporate leadership, demanding that the railroad companies as a whole address this tragedy.[119]

Some train accidents were a product of socio-political tensions existing at the time, even a product of terrorism directed at rail service. In June 1949, the President of the JNR disappeared mysteriously one day, and his body was later found in pieces on a stretch of railroad tracks. His active involvement in a heated labor dispute at the time had included massive layoffs of 95,000 railroad employees over a period of time. His death, either a suicide or more likely a homicide, preceded naked terrorism that involved even more human casualties in wooden cars. In July, an unmanned train crashed through a station into a residential area in Tokyo, killing six citizens and injuring about twenty more. The press reported this unprecedented accident widely; the Asahi newspaper focused on an excited man on the scene who ranted against JNR's recent policy regarding massive layoffs and against its use of the wooden, "problematic" car model 63 in its rail service.[120] Shortly after the incident, the police arrested about a dozen Communist

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(Tokyo: Asahi shinbunsha, 1973), 40.

118 *Asahi shinbun*, 26 February 1947.

119 Editorial, *Asahi shinbun*, 27 February 1947.

120 Uno, ed., *Asahi Shinbun Ni Miru Nihon No Ayumi: Shōdo Ni Kizuku Minshu Shugi*,85.

party members for sabotage. In the next month, several disgruntled JNR employees in the labor union reportedly sabotaged a track and derailed a fleet of 630 passengers, injuring and killing several.[121] Investigators and the media witnessed the disfigured partially wooden cars on the scene. A series of fatalities in the summer of 1949 alarmed American authorities in the Civil Transportation Section at General Headquarters; this was the section that supervised railway operations. On August 19, it instructed the JNR to report all the "accidents" aiming to damage the U.S. Occupation.[122]

3.2 Wartime Military Engineers as Technical Problem Solvers, 1945-1952

The JNR faced the most daunting task of restoring the sagging public confidence in the ground transportation system. In 1946, they thus formed a committee to investigate the causes of a series of derailment accidents. Among their research areas were rail cars' vibrations and physical infrastructure as in rails and crossties[123] — all of which developed a niche for wartime military engineers to join actively and solve the technical issues successfully. In the process, the

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[121] Sawako Noma, ed., *Senryôka No Minshu Shugi, Shôwa 22-24 Nen*, vol. 8, *Shōwa Ni Man Nichi No Zenkiroku* (Tokyo: Kōdahsha, 1989), 302-05. After a series of trials that attracted media attention, in 1963 the Supreme Court exonerated those arraigned for the derailment.

[122] Nihon kokuyū tetsudō, *Tetsudō Sengo Shorishi* (Tokyo: Taishō shuppan, 1981), 799.

[123] Nihon kokuyū tetsudō tetsudō gijutsu kenkyūjo 50-nenshi kankō iinkai, *Nihon Kokuyū Tetsudō Tetsudō Gijutsu Kenkyūjo 50-Nenshi*,184.

engineers showed considerable skill and, in several cases, became laboratory leaders with considerable autonomy.

3.2.1 Vibrations of Rolling Stock Laboratory as a Case Study

The rise of military engineers within the RTRI was often a contentious process as epitomized in the Vibrations of Rolling Stock Laboratory from 1945 to 1952. At center stage was the leader, Matsudaira Tadashi; he eventually developed the air suspension system of the running gear for the bullet train in the early 1960s. This laboratory deserves attention because it shows how the wartime military engineers rose to prominence in the industry. Matsudaira's experience during the Occupation years can best illustrate how military engineers applied their wartime knowledge and experience to the postwar railway industry.

Shortly after the war's end, the Vibration of Rolling Stock Laboratory was divided into the camp of wartime military engineers and that of wartime railway engineers. This schism was evident from the fall of 1945, when Matsudaira and his wartime colleagues embarked on second careers at the RTRI through the social networks they had formed. Knowing their technical competence, Matsudaira actively recruited the aircraft engineers into the laboratory. The resulting pattern was a classic chain migration via informal personal network contacts. He brought with him almost all of the wartime colleagues and research assistants who had conducted various experiments with wind tunnels at the Institute for Navy Aeronautics. His resulting research group in the RTRI laboratory before 1951 included at least six Navy engineers and two Army engineers.[124] Matsudaira's group constituted only a half of the entire laboratory work force; the other half was Dr. Musashi Kuraji's group of at least six railway engineers from the wartime era.

These two camps differed significantly in the ways they viewed vibrations of rolling stock, a chief source of discomfort and safety in long-distance travel. Dr. Musashi's group of railway engineers had clearly dominated earlier research and development in the field. When Matsudaira convened a round of first self-introductions in the laboratory, Dr. Musashi suggested that the wartime Navy engineer read his own publications on the vibration phenomenon. In Matsudaira's view, this self-confidence was unfounded. He found "quite surprising" what he saw as a dire lack of useful studies about the kinetics of rolling stock when moving at high speed.[125] As early as April 1946 Matsudaira, while leading his own research group, developed a mathematical model

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[124] Katsuto Uchihashi, *Zoku Zoku Takumi No Jidai: Kokutetsu Gijutsujin Zero Hyōshiki Kara No Nagai Tabi* (Tokyo: Sankei shuppan, 1979), 24,35.

[125] Tadashi Matsudaira, "Kōsoku Tetsudō Gijutsu No Raimei 2," *Railway Research Review* 50, no. 4 (1993): 30,32.

for investigating the vibrations of rail cars.[126] Meanwhile, the other half of the laboratory workforce, Musashi's group, continued to conduct similar research projects in response to official requests from the JNR headquarters. Both camps coexisted but apparently exchanged little, if any, technical information.

Matsudaira's initiative, separate from that of Musashi's group, was possible because the JNR expected wartime aeronautical engineers to shed new light on the cumbersome vibration issue. From December 1946 to April 1949, for instance, many engineers in the industry discussed the vibrations of running gear at high speed in a series of six study meetings.[127] The first meeting, held at an *onsen* inn, included twenty-six engineers; among them, *all* of the eleven speakers, including Matsudaira, had been wartime aeronautical engineers.[128] More wartime railway engineers, including Dr. Musashi, joined the subsequent meetings and discussed the vibration problem more actively. This fruitful initiative developed because the organizer, Shima Hideo, specifically chose the aeronautical engineers for presentations in the first meeting.[129] Shima may appear to have been an exceptional figure, in retrospect a visionary who expected the

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[126] Un'yushō, *Tetsudō Gijutsu Kenkyūjo: Shōwa 22-Nendo Nenpō* (Tokyo: 1947), 6.

[127] Tetsudō gijutsu kenkyūjō, *Kōsoku Daisha Shindō Kenkyūkai Kiroku, Dai Ikkai-Dairokkai*.

[128] Tadashi Matsudaira, "Kōsoku Tetsudō Gijutsu No Raimei 1," *Railway Research Review* 50, no. 3 (1993): 28.

[129] Hideo Shima, *D-51 Kara Shinkansen Made: Gijutsusha No Mita Kokutetsu* (Tokyo: Nihon keizai shinbunsha, 1977), 119.

wartime military engineers to solve the vibration issue, a significant challenge whose resolution was important to the reconstruction of the industry and the development of high-speed rail service.

Actually Shima's initiative was not so exceptional. The RTRI as a whole viewed the challenge as a pervasive technical conundrum and expected wartime military engineers to solve it. From 1947 to 1955, for instance, several wartime military engineers studied vibrations in bridges, in the ground, and in automobiles. Hashimoto Kōichi and Shinoda Jinkichi, wartime experts in building ships at Naval Technical Institute, examined vibrations of bridges across Japan.[130] Enomoto Shinsuke, a wartime expert in studying vibrations of aircraft parts at the Central Aeronautical Research Institute, examined the relationship between vibrations and fatigue of steel rails with many other former military engineers.[131] Vibration was also a problem in automobiles; this was also a subject to which Matsudaira's groups of aeronautical engineers partly devoted research.[132] Vibrations in artifacts, mobile or otherwise, were a pervasive issue in the industry.

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[130] Kōichi Hashimoto, "Kokutetsu Ni Okeru Kyōryō Kyōdo Shindō Shiken No Genjō to Shōrai," *Doboku gakkaishi* 33, no. 5-6 (1948): 31-34, Kōichi Hashimoto and Fumihito Itō, "Rosen Dōro Miyagino-Bashi No Kyōdo Sokutei," *Doboku gakkaishi* 37, no. 4 (1952): 13-17, Nihon kokuyū tetsudō tetsudō gijutsu kenkyūjo 50-nenshi kankō iinkai, *Nihon Kokuyū Tetsudō Tetsudō Gijutsu Kenkyūjo 50-Nenshi*,201-06.

[131] Shinsuke Enomoto, Letter to author, 5 April 2004.

[132] Masaharu Kunieda and Keiji Yokose, "Jidōsha No Norigokochi Siken to Sono Kōsatsu," *Tetsudō gyōmu kenkyū shiryō* 10, no. 18 (1953).

In retrospect, rampant vibration-related train accidents provided the aeronautical engineers with opportunities to rise to prominence in the industry. Matsudaira's group of wartime aeronautical engineers did not arrive at the RTRI on the red carpet; they encountered both high expectations and skepticism because they lacked a proven record of activity in the field. In this context, a devastating derailment accident in July 1947 marked a turning point for them. Musashi investigated the accident upon official request, while Matsudaira played a supporting role at the site.[133] The railroad engineering approach to the train vibration phenomenon remained largely empirical; equipped with hands-on experience, the railroad engineers focused their primary attention on the physical infrastructure of the transportation service. Understandably, they emphasized worn out rail lines that had survived the war as the primary cause of train vibrations and accidents. In their commonsense view, summer heat expanded the steel rail and caused it to buckle, a phenomenon that indeed played a major role in many train accidents.

Against this prevailing viewpoint, Matsudaira ascribed the cause of the derailment in July not to the railway infrastructure, but to self-induced vibration in the rail cars. In his view, the vibration manifested in aircraft and in trains was essentially the same. At higher speeds, train vibration — as in aircraft flutter — increased and became less stable; the only difference was

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[133] Un'yushō, *Tetsudō Gijutsu Kenkyūjo: Shōwa 22-Nendo Nenpō*,37.

that the source of energy causing the aircraft vibration was air, whereas direct contact with the rails induced train car vibration. Matsudaira intuited the cause of the accident by drawing upon his accumulated knowledge in the field of aircraft engineering. His view toward the accident was unprecedented in the industry. He thus experienced strong opposition from tradition-bound railway engineers, particularly those from the Bureau of Transport, who investigated the accident at the site.[134]

As it turned out, Matsudaira's hunch proved correct. To prove his theory about the cause of the 1947 derailment, Matsudaira developed experimental models to test vibrations of rolling stocks. The train cars, built to one-tenth scale, were placed on running rails to demonstrate their fluttering at the speed of roughly 50km per hour before railway engineers.[135] No such technical effort had been mounted in the Vibrations of Rolling Stock Laboratory before 1945. His visual presentation was also important symbolically. Detailed data attested to the self-induced nature of a railway car's lateral vibrations and the danger inherent in this phenomenon. By 1953, through a series of tests, he was able to diminish the lateral vibration of improved cars to half that of conventional cars at 65km/h. His research group enabled a freight

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[134] Matsudaira, "Kōsoku Tetsudō Gijutsu No Raimei 1," 29.

[135] Matsudaira, "Kōsoku Tetsudō Gijutsu No Raimei 2," 32.

car to safely operate at the speed of 85km/h after certain technical improvements were made.[136] At the RTRI, he successfully reproduced the self-induced vibrations of rail cars artificially and cheaply at any time with the concentrated resources of the RTRI. He successfully investigated many physical phenomena with fair accuracy in the controlled research environment of the RTRI. Overall, he contributed to the industry by focusing on reproducibility, affordability, and theoretical studies.

His work was reminiscent of his Navy years. Matsudaira built a career in the military by solving the highly technical problem of flutter in aircraft. In 1935, a type-96 twin-engine army bomber showed indication of elevators-tail flutter and it was — as he pointed out after his investigation — successfully solved by directly connecting the two separate ailerons. The next year was plagued with a series of flutter casualties that involved the type-96 carrier-landing fighter and the type-95 army fighter aircraft. In his research, Matsudaira emphasized the importance of the mass-balance weight and installed it to the aircraft's elevators, thus effectively preventing them from fluttering.[137] On earlier airplanes, which could not fly as fast, such weight was not necessary; but it became an indispensable attachment because fighter aircraft performance improved and speed increased particularly during a dive or a dogfight.

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[136] Tadashi Matsudaira et al., "Nijiku Kasha No Banetsuri Sōchi Kaizō Ni Yoru Kōsokuka," *Tetsudō gyōmu kenkyū shiryō* 10, no. 18 (1953): 5-9.

[137] Nihon kōkū gakujutsushi henshū iinkai, *Nihon Kōkū Gakujutsushi (1910-1945)*,390.

Matsudaira's wartime research in aerodynamics proved crucial for the successful development of the legendary Mitsubishi A6M carrier-based fighter, better known as the *Zero.* In 1940, a series of midair disintegration incidents with the Zero posed a major conundrum to aircraft designers. Investigations to pinpoint the exact cause of the Zero accidents reached a dead end because the pilots died almost instantly when the aircraft shattered into pieces in midair. A series of studies produced mixed results. Previous research indicated that the aircraft — at least theoretically — would not be in danger of fluttering until it reached a speed of over 470 miles per hour. Matsudaira proved this datum was optimistic and erroneous. His research showed that the prevailing flutter model failed to simulate exactly all aerodynamic characteristics of the full-size aircraft, including the distribution of stiffness, weight, and air loads. He conducted vibration and stiffness tests on the actual aircraft, and then incorporated actual research data in making the new experimental flutter model. His new calculations demonstrated that the critical flutter speed for the Zero with aileron balance tabs was only 375 miles per hour and 394 miles per hour for the aircraft without them.[138] By solving the Zero's flutter problem, he reduced the uncertainties of designing aircraft during the war.

Just as Matsudaira's wartime research was largely theoretical, his contribution to

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[138] Jirō Horikoshi, *Eagles of Mitsubishi: The Story of the Zero Fighter* (Seattle: University of Washington Press, 1981), 117-18.

railroad engineering after 1945 involved highly complex theories for wider uses in the industry. Before his arrival at RTRI in 1945, Musashi had developed mathematical equations for understanding the mechanism of a rail car's vibrations.[139] But his formulae were too complicated and practically useless. Moreover in 1949, Matsudaira pointed out inaccuracies in Musashi's theories and clarified basic issues about vibrations of rail cars.[140] In 1952, Matsudaira revised and simplified Musashi's mathematical equations, arguing that the vibrations of rail cars were irregular and self-induced by nature.[141] From this point, the schism in the laboratory virtually disappeared. Upon Musashi's retirement, the camp of wartime military engineers and that of wartime railway engineers merged into one under Matsudaira's new leadership for the years that followed.

3.2.2. Other RTRI Laboratories

Outside this laboratory, derailment issues provided other wartime military engineers with opportunities to demonstrate their technical competence. The activities of Satō Yutaka, a former Navy engineer in the Rail Laboratory, offer one such example. Although the Department

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140 Tadashi Matsudaira, "Kyakusha Oyobi Densha No Koyū Shindōsū," *Tetsudō gyōmu kenkyū shiryō* 6, no. 2 (1949): 3-14.

141 Tadashi Matsudaira, "Sharinjiku No Dakōdō," *Tetsudō gyōmu kenkyū shiryō* 9, no. 1 (1952): 16-26.

of Engineering at the JNR had studied rail vibrations in the late 1920s, serious research began with the formation of the Rail Laboratory at the RTRI in 1945.[142] There, his theory and highly sophisticated mathematics proved effective means of curtailing vibrations of rails. As an unprecedented initiative, he developed a theoretical framework to understand better how rails resisted lateral force exerted on them. This offered a way to prevent rails from experiencing vibration and damage under physical pressure.[143] Satō's further contribution to the field lay in his new way of thinking about constructing rails for high-speed rail service. Until 1951 or so, the maximum permissible limit for high-speed runs had depended on the strength of the rails. This was because the force exerted on the rails was imposed sideways and was widely — and as he proved, wrongly — believed to increase in proportion to the speed of the running train. Satō correctly emphasized the importance of the ballast, rather than the rails, for high-speed rail service. Subsequently, his theoretical and empirical studies successfully curtailed vibrations of rails.[144]

Wartime military engineers at the RTRI examined and curtailed vibrations in bridges as well. For instance Shinohara Jinkichi, a wartime expert in ship building at the Navy Technical

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142 Nihon kokuyū tetsudō tetsudō gijutsu kenkyūjo 50-nenshi kankō iinkai, *Nihon Kokuyū Tetsudō Tetsudō Gijutsu Kenkyūjo 50-Nenshi*,184.

143 Ibid.,185.

144 Ibid.,186-87.

Institute, paid close attention to the characteristics of vibrations in piers; his own theoretical understanding of vibrations in concrete bridge bearing proved highly useful.[145] His wartime colleague, Hashimoto Kōichi, physically examined the structures and vibrations of bridges across the country in 1954 and 1955. Perhaps the most illustrative, successful transfer of both human and material resources in the research field is demonstrable showed in the case of Tada Yoshiasa. Upon joining the Navy in 1936, he had accumulated his engineering experiences in welding while helping to develop formidable warships at the Kure Navy Arsenal, the birthplace of the legendary battleship "Yamato," among others. Upon migrating to the RTRI after 1945, Tada among others introduced the Navy's fast welding method in the railway industry.[146] His postwar research in the field capitalized on wartime physical assets inherited from the Kure Navy Arsenal. The wartime equipment and machinery proved highly useful for testing rail cars, bridges, rails, and other large structural objects in the railway industry.[147] As the leader of the Steel Structure Laboratory, for instance, he investigated bridge vibrations in 1952.[148] Research directed to solving vibration problems in the industry developed successfully on the basis of

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[145] Ibid.,201.

[146] Ibid.,585.

[147] Ibid.,169.

[148] Ibid.,202-06.

wartime military expertise. Developing the running gear and infrastructure for high-speed rail service was among the earliest research fields in which civilian application of military technology was partially complete.

3.3 Inheriting Wartime Research in Postwar Japan: Materials Engineering, 1945- 1955

In several cases, wartime military engineers essentially continued their research at the RTRI after 1945. In so doing, they successfully developed their niches in the postwar railway industry. Perhaps technological linkages in trans-World War II Japan are most clearly evident in the field of materials engineering. In the immediate postwar years, developing more durable wood and metals became a fairly urgent undertaking in an industry that faced many train accidents. The wartime military engineers became indispensable in this socio-technical landscape. The legacy of their wartime military research at the RTRI contributed markedly to the industry's materials engineering during the years that followed.

As the case of Yamana Naruo shows, military research for developing decay-resistant wood formed a technological pillar in the postwar railway industry. His wartime work included developing wooden military aircraft, such as the Navy training bomber D3Y1 — a wooden version of the Navy Type 99 Bomber — at the Institute for Navy Aeronautics.[149] The country's effort in this research area was reasonable; a diminished flow of metal resources — especially aluminum — from outside the country, and the use of sophisticated radar technology among the Allies, encouraged the Japanese Navy to look into the potential of wooden flying machines. In this situation, Yamana developed laminated wood.[150] He also built wooden propellers by mechanically pressing layers of wood into one.[151] Developing standards for controlling the quality of manufactured wooden propellers was also his wartime job.[152] The resulting wooden aircraft, as it turned out, was a technological failure; it was too heavy and unable to fly. This wartime experience and knowledge, however, proved crucial for developing wooden crossties in the postwar railway industry. Damaged crossties that survived the war were a source of derailment. In 1946, Yamana organized research projects to improve the durability of such wooden ties. Subsequently he tested various types of wood, warning that Kyūshū pine trees, used widely theretofore, proved less durable than previously recognized. In the following year, he

[149] Kaigun kōkū gijutsushō zairyōbu no kai, *Kaigun Kōkū Gijutsushō Zairyōbu Shūsen 50-Shūnen Kinenshi*,37.

[150] Nihon kōkū gakujutsushi henshū iinkai, *Nihon Kōkū Gakujutsushi (1910-1945)*,161.

[151] Kaigun kōkū gijutsushō zairyōbu no kai, *Kaigun Kōkū Gijutsushō Zairyōbu Shūsen 50-Shūnen Kinenshi*,182.

[152] Nihon kōkū gakujutsushi henshū iinkai, *Nihon Kōkū Gakujutsushi (1910-1945)*,162.

developed crossties with pieces of compound wood held together with glue.[153] In 1953 apparently drawing on his wartime research, he applied high- and low-frequency electric waves to crossties for preservation against decay. As he showed, drying crossties with electrical heat and then soaking them in cold creosote oil improved the gluing process.[154] As we will see later, Yamana's contribution in materials engineering formed an important part of the successful bullet train project.

Developing more sophisticated, durable metals was a crucial research topic before and after 1945. Kokubu Kinji, for instance, had conducted chemical experiments — such as cementing silicon onto light alloys for aircraft engines — at the Central Aeronautical Research Center from 1942 to 1945.[155] After joining the RTRI in 1945, he developed metal alloys for the contact strip, the part of the pantograph that touches trolley wires for collecting electricity. This research was a fairly urgent undertaking. Carbon metal plating in the contact strip often broke apart and cut the overhead wires, posing a serious safety issue. In the early 1950s, Kokubu developed bronze metal alloys with proven reliability in rain and snow, partly on the basis of his

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[153] Nihon kokuyū tetsudō tetsudō gijutsu kenkyūjo 50-nenshi kankō iinkai, *Nihon Kokuyū Tetsudō Tetsudō Gijutsu Kenkyūjo 50-Nenshi*,668-69.

[154] Ibid.,670. A few commercial companies in the railway industry developed a similar method at the time. See, for example, Seiichirō Tani, "Bōfu Makuragi Ni Tsuite," *Kōtsū gijutsu* 64 (1951): 30-31.

[155] Nihon kōkū gakujutsushi henshū iinkai, *Nihon Kōkū Gakujutsushi (1910-1945)*,152.

wartime research.[156] His theoretical and empirical research with statistical data elucidated the actual mechanism and the effect of abrasion, helping the industry better predict the abrasion limits of a contact strip with fair accuracy. In 1955, he refined his studies of contact strips and sintered black lead, aluminum, and bronze for more durable products.[157]

Wartime material engineering played a vital part for minimizing damage from metal fatigue in the postwar railway industry. During the war, research on steel for railway service stagnated because of a lack of the requisite material and human resources, while the military excelled in this field.[158] At the Central Aeronautical Research Center, for instance, Enomoto Shinsuke had conducted empirical and theoretical studies on metal fatigue and heat.[159] Kan'no Kōtarō and Nakamura Hiroshi had been exposed to advanced wartime research in metal fatigue in the Army. Upon migrating to the RTRI, these engineers faced the breaking down of many damaged wheel axels around 1947; in fact, approximately fifty percent of all the reported train accidents from 1947 to 1948 resulted from this issue.[160] But the precise cause — either load

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[156] Nihon kokuyū tetsudō tetsudō gijutsu kenkyūjo 50-nenshi kankō iinkai, *Nihon Kokuyū Tetsudō Tetsudō Gijutsu Kenkyūjo 50-Nenshi*,375.

[157] Ibid.,375-76.

[158] Ibid.,526.

[159] Shinsuke Enomoto, "Kinzoku Zairyō No Hirō to Naibu Masatsu Ni Kansuru Kenkyū," *Chūō kōkū kenkyūjo ihō* 2, no. 10 (1943), Enomoto, "Kinzoku Zairyō No Hirō to Naibu Masatsu Ni Kansuru Kenkyū."

[160] Hiroshi Nakamura, "Shajiku No Kyōdo I: Sekkei Hōshiki Ni Tsuite," *Tetsudō gyōmu kenkyū hōkoku* 8,

factor, material fatigue, or both — remained unclear because research dealing with stress analysis and material engineering proceeded separately.[161] A point to note was their application of high-frequency electric waves to damaged wheel axels as a way of measuring the severity of metal fatigue, a successful transfer of wartime research into postwar materials engineering.[162] Meanwhile, military research on welding bore fruit in the development of special steels, light alloys, and induction hardening for rail cars during the early 1950s.[163]

As the case of Satō Tadao shows, wartime aeronautical engineers contributed perhaps the most to the field of materials engineering in the railway industry after the war. Before 1945, he had chiefly studied metal fatigue at the Institute for Navy Aeronautics.[164] Among his wartime projects was a close analysis of what had occasionally been mysterious disintegrations of a few Zero fighters in midair.[165] He also conducted load tests for developing the wartime bomber P1Y Frances; in his experiments, loads were repeatedly imposed on ailerons to examine metal

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no. 7 (1951): 4.

[161] Hiroshi Nakamura, *Mono to Koto to Sei No Kenkyūshi: Shinkansen Daisha, Kinzoku Hirō Jumyō, Seimeikan* (Kyoto: Nagata bunshodō, 1997), 5.

[162] "Chōonpa Ni Yoru Sharyō Buhin Hirō Hanteihō No Kenkyū Hōkokusho," (Railway Technical Research Institute, March 1960), Nakamura, *Mono to Koto to Sei No Kenkyūshi: Shinkansen Daisha, Kinzoku Hirō Jumyō, Seimeikan*,26-27.

[163] Nihon kokuyū tetsudō tetsudō gijutsu kenkyūjo 50-nenshi kankō iinkai, *Nihon Kokuyū Tetsudō Tetsudō Gijutsu Kenkyūjo 50-Nenshi*,526.

[164] Kaigun kōkū gijutsushō zairyōbu no kai, *Kaigun Kōkū Gijutsushō Zairyōbu Shūsen 50-Shūnen Kinenshi*,4

[165] Yoshirō Ikari, *Kōkū Technology No Tatakai* (Tokyo: Kōjinsha, 1996), 261.

fatigue.[166] His research over four years demonstrated the devastating effects of repeated loads on metals, data that formed an essential ingredient in designing military aircraft.[167] Toward the war's end, Satō also developed substitute metals to compensate for the country's lack of vital natural resources, such as nickel, molybdenum, and tungsten.[168] In addition, he led a project for developing heat-resistant steel for Japan's first gas-turbine engine Ne-20.[169] These military projects bore fruit at the RTRI after 1945; there, his wartime research on metal fatigue helped solve many accident-related issues in the postwar railway industry. He, for instance, closely examined metallographs of the damaged bearings and in 1950 observed many cases of unusually overheated metals under high pressure. His research helped the industry develop metal alloys that prevented bearings from being damaged. This contribution proved indispensable for developing high-speed service in the years that followed.[170] Because of his contributions, he became head of the Laboratory of Steel Casting.

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[166] Kaigun kōkū gijutsushō zairyōbu no kai, *Kaigun Kōkū Gijutsushō Zairyōbu Shūsen 50-Shūnen Kinenshi*,152.

[167] Nihon kōkū gakujutsushi henshū iinkai, *Nihon Kōkū Gakujutsushi (1910-1945)*,142.

[168] Ibid.,144-45.

[169] Kaigun kōkū gijutsushō zairyōbu no kai, *Kaigun Kōkū Gijutsushō Zairyōbu Shūsen 50-Shūnen Kinenshi*,134, Nihon kōkū gakujutsushi henshū iinkai, *Nihon Kōkū Gakujutsushi (1910-1945)*,145-46.

[170] Nihon kokuyū tetsudō tetsudō gijutsu kenkyūjo 50-nenshi kankō iinkai, *Nihon Kokuyū Tetsudō Tetsudō Gijutsu Kenkyūjo 50-Nenshi*,536.

3.4 Developing a New Field of Research at the RTRI, 1945-1955

From 1945 to 1955, wartime military research paid commercial dividends perhaps impressively most in wireless communication within the railway industry. Wired communication was the norm in society before 1945, but wartime radar technology helped change the technological landscape in the postwar railway industry. A close look into the technological transformation process illustrates how wartime military engineers at the RTRI — most notably, Maruhama Tetsurō and Shinohara Yasushi — developed the new field of research and, in so doing, became the leaders of the RTRI laboratories.

Before 1945, the military excelled in the field when compared to the railway industry. Not that the railway engineers neglected to explore the field, but their works remained essentially experimental. From 1930 to 1931, for instance, railway engineers developed and tested wireless telephony for communication between running trains with little success. Observing the practical utility of the idea, the military mounted various types of wireless telephones in army tanks and airplanes for communication. In 1932, the JNR developed wireless telephones with ultra-short 30 mega-cycle (hereafter MC) bandwidth, but the device had severely limited practical use; in 1934, this device functioned only within a distance of one kilometer.[171] During the war, research in

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[171] Shun'ichi Sagawa, "Ressha Tono Tsūshin I," *Japan Railway Engineers' Association* 5, no. 1 (1962): 50.

wireless communication developed most fully in the military. Use in the civilian sector remained marginal at best, presumably because potential foes could listen in on the uuencoded communication about logistics within the country. By and large, the Navy was ahead of the Army in developing radio communication for aerial operations over vast territories. The most notable research establishment for the purpose was the Institute for Navy Aeronautics that employed Maruhama Tetsurō and Shinohara Yasushi, military engineers for developing avionics and flight instruments respectively.[172]

After 1945, migration into the RTRI brought their wartime experience and knowledge of communication technology to the railway industry. In retrospect, the end of many regulations that had governed wave lengths for wireless communication was fortuitous. At the RTRI Shinohara led the Wireless Communication Laboratory, devoting its research partly to medium-frequency wave lengths for communication between running trains.[173] From 1946 to 1947, a plan developed for medium- frequency wireless communication on the Tōkaidō line;[174] but it turned out, that extraneous noise was louder and more obnoxious than originally expected.

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[172] Kaigun Kōkū honbu, *Kaigun Kōkū Honbu Shōwa 20-Nen 3-Gatsu Denki Kankei Gijutsu Shikan Meibo* (n.p.: n.d.).); and Osamu Shinohara, Letter to author, 11 March 2004.

[173] Nihon kokuyū tetsudō tetsudō gijutsu kenkyūjo 50-nenshi kankō iinkai, *Nihon Kokuyū Tetsudō Tetsudō Gijutsu Kenkyūjo 50-Nenshi*,423.

[174] Sagawa, "Ressha Tono Tsūshin I," 51.

Consequently, Shinohara and his assistant engineer from the Navy, Amamiya Yoshifumi, measured various levels of audible noise.[175] Inheriting the research and laboratory leadership, Maruhama later focused his research on microwave devices for wireless communication in the railway industry. In 1950, for instance, he developed a wireless communication system that used 4000MC electric waves over the 80 kilometers distance of the Tsugaru Strait between Honshu and Hokkaido.[176] In the project, the magnetron tube— an electric tube used for high-voltage microwave energy for wartime radar — proved useful. It provided the technological basis for the country's first super-high frequency circuit communication.[177] This success rendered the once common wired communication system obsolete, freeing the industry from the influences of changing weather and natural disasters on communication.[178] By 1955 the wartime magnetron system was shown to have limited durability. Less effective for communication than once believed, it was replaced by the more advanced, high-power microwave generator based on the

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175 Yoshifumi Amamiya, "Kokutetsu Densha Yori Hassei Suru Chū-Tanpa Musen Zatsuon Ni Kansuru Kenkyū," *Tetsudō gyōmu kenkyū hōkoku* 58, no. 9 (1959), Yoshifumi Amamiya and Yoshitaka Maki, "Zatsuon Denryoku Ni Chakumoku Shita Zatsuongen Tanchiki," *Tetsudō gyōmu kenkyū hōkoku* 132, no. 23 (1960), Nihon kokuyū tetsudō tetsudō gijutsu kenkyūjo 50-nenshi kankō iinkai, *Nihon Kokuyū Tetsudō Tetsudō Gijutsu Kenkyūjo 50-Nenshi*,424, 29.

176 Tetsurō Maruhama, "Kokutetsu Shuyō Kansenkei Shf Kaisen O Kaerimite," *Kōtsū gijutsu* (September 1960): 22.

177 *Hattensuru Tetsudō Gijutsu: Saikin 10-Nen No Ayumi* (Tokyo: Nihon tetsudō gijutsu kyōkai, 1965), 70, Yasushi Shinohara and Hiroyuki Kimoto, "Osaka-Himeji Kan S.H.F. No Sekkei to Shaken Kekka," *Kōtsū gijutsu* 99 (1954).

178 *Hattensuru Tetsudō Gijutsu: Saikin 10-Nen No Ayumi*,71-72.

klystron tube.[179] The advanced military technology of wartime became obsolete in the civilian sector ten years after the initial technology transfer had taken place.

3.5 Success and Failure in Civilian Application of Military Technology

By 1955, many civilian applications of wartime technologies were successful in the railway industry. Wartime military engineers had helped to repair damaged infrastructure across the country while curtailing rampant train accidents. Their wartime experience and knowledge had proven to be vital for the reconstruction of the railway industry. At the most superficial level, the military engineers seem to have acted collectively for the national goal. But conspicuously lacking in their career transitions and postwar employment was any kind of techno-ideology or sense of conformity to pressures imposed from the top. Free from such artificial constraints, the wartime military engineers simply developed their own niches in the new postwar environment. They used their technical expertise very effectively to cultivate what for them were new fields after World War II. Their technology transfers were largely successful, making them leaders in industry despite the reflexive opposition to prior military experience.

My case studies suggest that the basic socio-technical structure for the civilian

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[179] Tetsurō Maruhama, "Kokutetsu Shuyō Kansenkei Shf Kaisen Wo Kaerimite," *Kōtsū gijutsu* (1960): 23.

application of wartime technology was firmly established during the first 10 years after the war's end. A point to note in retrospect was that the civil conversion of military technology in the railway industry took shape in a fairly optimal setting. For instance, neither ideology nor religion divided the railway communities irreparably. As in Matsudaira's case, some laboratories were initially divided into mutually suspicious camps of wartime military engineers and wartime railway engineers, but the schism became less tangible and less pervasive over time. Wartime experiences among military engineers formed the basis of successful technology transfers, at first creating but then solving tensions within the RTRI by the mid-1950s.

On the other hand, not all technology transfers were successful in trans-World War II Japan. Wartime research was by no means a panacea in retrospect to all technical problems in the railway industry after 1945. In some cases, wartime military engineers largely failed to develop a new niche in the new postwar environment. Research and development of the gas-turbine engine at the RTRI is a case in point. This method of aircraft propulsion, however promising during the war, lost its niche under the official ban on the aircraft industry in 1945. Some wartime engineers — who had developed the Ne-20 axial-flow turbojet for the Nakajima Kikka, essentially the Japanese version of the German Messerschmitt 262 in basic configuration — moved to the RTRI. The research institute also inherited research facilities for the aircraft engine — such as the air compressor and combustion tester — from the Central Aeronautical Research Institute.[180] A jobless engine expert from the Institute for Navy Aeronautics explored engine utilities for locomotives. His research found the engine promising at least initially. The relatively simple structure of the engine was a plus; and the engine could operate on low-quality fuels and without water. But research and development at the RTRI was short-lived and came to a halt entirely in April 1950 when the research facility was physically transported to the newly established Transportation Technology Research Center.[181] Subsequent research in the field was of little practical use for rail service.

Some other wartime expertise was also practically useless in the civilian-oriented postwar railway industry. Wartime engineers like Hayakawa Masashi experienced a radical career transition at the RTRI. He joined the Institute for Navy Aeronautics in 1932 where he developed various types of bombs, such as cluster bombs, for attacking enemy submarines, boats in amphibious operations, and the like.[182] One of his wartime projects was the development of an explosion mechanism for the suicide attacker MXY7 Ōka in 1944. He positioned its warhead

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[180] Un'yu gijutsu kenkyūjo-hen, *10-Nen Shi* (Tokyo: Transportation Technology Research Center, 1960), 275-76.

[181] Kin'ichi Nakata, "Tetsudō Gijutsu Kenkyūjonai Ni Okeru Gas Turbine No Kenkyū," *Tetsudō gyōmu kenkyū shiryō* 7, no. 17 (1950): 4.

[182] Bōeichō kaijō bakuryō kanbu chōsabu, *Nihon Teikoku Kaigun No Kenkyū Narabi Ni Kaihatsu (1925-1945)* (n.p.: 1956), 76-77.

in the nose, which weighed as much as 1,200kg (2,646 pounds); it was designed to detonate without failure upon crashing into an enemy target.[183] His wartime research in this field did little to help his career at the RTRI after 1945. On the contrary, Hayakawa chiefly developed machinery equipment for civil engineering projects prior to his retirement in 1961.[184]

At the RTRI, military engineers who had developed aerodynamic aircraft during the war faced similarly limited job prospects between 1945 and 1955. Maekawa Tsutomu, for instance, had studied airflows over wings and propellers theoretically and empirically at the Institute for Navy Aeronautics. From 1937 to the war's end, he had examined lift and stall phenomena in small-scale wings using high-speed wind tunnels. His greatest work during the war was a theoretical analysis of aerodynamics not in two, but in three dimensions.[185] This highly sophisticated research during the war contrasted markedly to his work at the RTRI; at one point, Maekawa borrowed a small-scale steam locomotive and a wind tunnel from outside and studied slow flows of smoke.[186] This wartime lieutenant commander left the RTRI in 1950 in

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[183] Masashi Hayakawa, "Kōkū Bakugeki Heiki," in *Kōkū Gijutsu No Zenbō* (Tokyo: Nihon shuppan kyōdōsha, 1955), 82, 120.

[184] Nihon kokuyū tetsudō tetsudō gijutsu kenkyūjo 50-nenshi kankō iinkai, *Nihon Kokuyū Tetsudō Tetsudō Gijutsu Kenkyūjo 50-Nenshi*,254-63.

[185] Bōeichō kaijō bakuryō kanbu chōsabu, *Nihon Teikoku Kaigun No Kenkyū Narabi Ni Kaihatsu (1925-1945)*,71, Nihon kōkū gakujutsushi henshū iinkai, *Nihon Kōkū Gakujutsushi (1910-1945)*,89-91.

[186] Nihon kokuyū tetsudō tetsudō gijutsu kenkyūjo 50-nenshi kankō iinkai, *Nihon Kokuyū Tetsudō Tetsudō Gijutsu Kenkyūjo 50-Nenshi*,36.

part because he was unable to deal with the dramatic career transition.

The field of aerodynamics, however promising for developing high-speed rail cars, was understandably among the neglected fields of study in the industry from 1945 to 1955. Wind-tunnel engineering at the RTRI offers a case in point. Wind tunnels had proven records of utility even before the war. During the 1930s, engineers from the RTRI repeatedly examined drag on high-speed locomotives at the Institute for Aeronautics at the University of Tokyo. After the war, however, many wind tunnels belonging to Japanese military organizations were physically transported to the United States. In this milieu, the newly established Transportation Technology Research Center inherited at least three types of wind tunnels from the Central Aeronautical Research Institute, a development contrasting markedly with many other similar assets that were transferred to the RTRI. With the removal of a small wartime wind tunnel from the compound in the late 1940s, military engineers at the RTRI lost the physical means to examine flows of air empirically.[187] Consequently, they visited either Tokyo University or the Transportation Technology Research Center for wind tunnel experiments.[188]

In summary, individual engineers figured prominently in the technological landscape

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[187] Un'yu gijutsu kenkyūjo-hen, *10-Nen Shi*,273.

[188] Three anonymous researchers who worked at the laboratory in the 1950s, conversation with and letter to author, 2003.

from 1945 to 1955. The former military engineers successfully solved many technical problems in the badly damaged railway industry. In the process of doing what was necessary, they developed a niche in the period of postwar reconstruction. By curtailing casualties in rail service, wartime military engineering became a means of saving lives after 1945. Indicative of this development were the Vibrations of Rolling Stock Laboratory and other RTRI laboratories, all of which contributed markedly to repairing wartime physical damages made to the railway industry during the war.

In the same way, from the mid-1950s onwards, research and development in aerodynamics progressed due to individual initiatives, radically altering the way the industry viewed the technical feasibility of developing high-speed rail service. Miki Tadanao's laboratory formed the nucleus of this development, as well as the resultant inter-disciplinary technology transfer from aeronautics to railroad engineering. His case illustrates the flexibility of engineering knowledge that did not accompany the adaptability of former military engineers in the new organizational setting. The wartime aeronautical engineers at the RTRI often resisted JNR management, a development that bore fruit in the Odakyū Romance Car that established high-speed world records in 1957. The underlying interdisciplinary technology transfer, as well as the resulting crucial drive to develop the country's high-speed rail service after 1945, developed rather unexpectedly. The next chapter examines this development in conjunction with other types of technology transfer from 1950 to 1957.

CHAPTER 4

TECHNOLOGY TRANSFER AND TECHNOLOGICAL INGENUITY, 1950-1957

This chapter examines observable patterns of technology transfer in the Japanese railway industry from 1950 to 1957. The JNR, as I will show, capitalized on successful technology transfers from abroad as well as domestic technological ingenuity. These technological developments were possible partly because former military engineers, particularly at the RTRI, utilized their engineering knowledge with remarkable adaptability and flexibility. Their decisions and actions were crucial at every point in the process, as illustrated in at least three types of technology transfer that made the high-speed bullet train possible in the 1960s. The first type was a planned, choreographed technology transfer from abroad, an aspect of the country's industrial growth to which much historical writing in English has paid attention. This scholarship has generally assigned credit for this technological success to systematic and organized efforts by government bureaucrats, or by top management in the industry. In the railway industry, this point is perhaps most obvious in the industry's effort to develop lightweight, all-steel rail cars during the early 1950s. The second type of technology transfer I examine involved a combination of technology transfer from abroad and inter-disciplinary technology transfer at home. An illustrative case was the JNR project to electrify the public railways by following a French model. The last pattern of technology transfer is what most Japan scholars have neglected to study: a transfer of aeronautical technology at home with an influence from abroad that was, at best, marginal. I analyze this process by looking into the case of a high-speed rail project that successfully established high-speed world records in 1957. The process reveals that former military engineers did not conform to conventional images of docile engineers. With these three case studies, I argue that former military engineers formed a crucial basis for technical development in the industry during the 1950s; their engineering knowledge demonstrated remarkable adaptability and flexibility for the development of high-speed rail service. The most successful technology had less to do with any deliberate, top-down attempt than with an unplanned, incidental diffusion of engineering knowledge at the grass-roots level.

4.1 Technology Transfer from Abroad: Development of Rolling Stock

Before the postwar technology transfer, lightweight, all-steel rail cars were rare in public railways; instead, wooden construction was dominant.[189] One can suggest at least several technical, cultural, and social reasons for the vitality of wood usage in the industry. First, wood was reasonably durable and fairly light. It was a suitable material for passenger cars because the light construction imposed minimal loads on the railroad's physical infrastructure. Rails and bridges, for instance, tended to last longer with a fleet of light wooden cars. Second, the wooden construction pervaded much of the railroad community because it gathered momentum along the way. Rail service began shortly after the Meiji Restoration of 1868, but after that no substantive changes took place. One order of cars followed another with little or no variation for decades. The first passenger car in Japanese rail service was imported from Britain and even it was, in part, a wooden product. The length and weight of the passenger rail car more than doubled by the turn of the century, but car design remained stagnant for years.[190] Third, wood was readily available in Japan. Because the fairly mountainous country was abundantly endowed with the natural resource, the wooden car was relatively cheaper to make — and easier to shape. The malleability of the material manifested itself in the prevalence of the 凸-shaped clerestory roof for air intake and ventilation, a style gradually replaced by the arched roof during the 1930s.[191] Carpentry

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[189] Nihon kokuyū tetsudō, *Tetsudō Gijutsu Hattatsu Shi (Sharyō to Kikai) Ii*, vol. 4 (Tokyo: Nihon kokuyū tetsudō, 1958), 802.

[190] Nihon kokuyū tetsudō, *Tetsudō 80-Nen No Ayumi, 1872-1952*,42.

[191] Atsuo Kawamura, *Kyaku Kasha No Kōzō Oyobi Riron* (Tokyo: Kōyūsha, 1952), 385.

craftsmanship for building wooden houses underlay such a construction style. Moreover, the climate in Japan favored wood rather than steel given its adiabaticity. Steel cars tended to absorb and emit more heat, thus they were not particularly comfortable in hot summer climates without air conditioning, or in cold winter climates even with a stove inside.[192]

After the war's end, most wooden passenger cars were in poor physical shape and needed urgent repairs. Coaches' lack of structural integrity and strength sounded an ominous knell to riders in many ways. In 1945, cars that had survived the war commonly lacked glass windows, *futon* cushions on seats, and adequate lighting inside.[193] The wooden floor and roof usually squeaked because loosened nails could no longer hold all of the parts tightly together. Water often dripped from the roof when it rained.[194] Passengers openly complained about the uncomfortable ride; they equated coaches to a swinery because of the smelly, unclean space.[195] The perennial shortage of necessary manpower for maintenance remained unsolved. A majority of passenger cars (5,949 cars) in service during the immediate postwar years had been

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[192] Hiroshi Kubota, *Nihon No Tetsudō Sharyō Shi* (Tokyo: Grandpri shuppan, 2001), 84.

[193] Kawamura, *Kyaku Kasha No Kōzō Oyobi Riron*,5

[194] Nihon kokuyū tetsudō, *Tetsudō Gijutsu Hattatsu Shi (Sharyō to Kikai) I*, vol. 4 (Tokyo: Nihon kokuyū tetsudō, 1958), 152.

[195] Katsumi Izawa, "Kyakusha Kōtai Ka," *Kōtsū gijutsu* 40 (1949): 15.

manufactured during the 1910s and 1920s.[196]

At the JNR, the Mechanical Engineering Department had traditionally taken charge of designing, building, and repairing rail cars and locomotives before the war years. The department was subdivided into sections to handle a wide array of activities efficiently. It underwent a few organizational transformations during and after the war. In March 1941, the department consisted of two sections, each of which took full responsibility for clearly defined tasks. In 1947 and 1949, the department faced the task of reconstructing the severely damaged industry under the leadership of Shima Hideo. In August 1952, the department was simplified and reconstituted with four sections, namely the Factory Section, Rolling Stock Section, Locomotive Section, and Repair Section.[197] Engineers in the Rolling Stock Section designed rail cars and/or approved the final product after inspection.[198]

After 1945, the department was able to capitalize fairly freely on railroad engineering knowledge from abroad. Building all-steel, lightweight rail cars in Japan was a corollary of this international development, for it depended on technology transfer from abroad, as from Sweden, Germany, or the United States. Because Japan did not share any national boundaries overland

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196 Kubota, *Nihon No Tetsudō Sharyō Shi*,153.

197 Nihon kokuyū tetsudō, *Tetsudō Gijutsu Hattatsu Shi (Sharyō to Kikai) I*,2-6.

198 Ibid.,37.

with other countries, it needed some artificially devised framework at the institutional level to encourage technology transfer from abroad. On the other hand, European nations were able to benefit from migration of engineers and their engineering knowledge across the continent. The Eurasian continent could serve well as the ground for active, informal exchange of technical information among engineers across national boundaries, a development that encouraged intercontinental commercial rail service. For instance, several European countries ― France, Belgium, the Netherlands, Luxembourg, West Germany, Switzerland, and Italy ― cooperated in developing a new cross-boarder rail service, known as the Trans Europe Express (TEE) in 1954. The project aspired to a high-speed, luxurious ride across the continent without the need to change locomotives or otherwise stop at national boarders.[199] This type of international project, and resulting knowledge diffusion, was not an option for the geographically isolated nation of Japan. Within this milieu, the JNR actively constructed a framework in which its personnel could gather technical information from liaison offices in Western Europe or North America.

The JNR's effort to develop its first all-steel, lightweight coaches capitalized on an international trend in the field and on technology transfer from abroad. Building lightweight rail cars was among several important topics discussed among participating countries, including

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[199] Jacob Meunier, *On the Fast Track French Railway Modernization and the Origins of the TGV, 1944-1983* (Westport, Connecticut: Praeger, 2002), 82-83.

Japan, at the International Railway Congress in 1947. The host nation, Switzerland, was a strong advocate for lightweight rolling stock because of its economic benefits. Understandably, some countries that had constructed rail tracks on steep slopes in mountainous areas valued lightweight cars because their lesser structural weight meant less energy required for the service. Especially after the war, Japanese private railway companies noted the overall financial savings from placing lightweight electric rail in service. The JNR actively sent its engineers from the Rolling Stock Division of the Department of Engineering to Europe and the United States for observation and research. One such engineer was Hoshi Akira. Traditionally trained as a railway engineer with brief wartime service in the Army, he studied technology for constructing lightweight rail cars in Switzerland and other European nations first hand for about a year. After his return, he presented detailed information on how railway industries in Switzerland, Germany, France, Italy, and the United States had produced lightweight vehicles.[200]

The following two design characteristics formed the basis of light, all-steel rail cars developed after 1945 and best illustrate successful technology transfer from abroad. First was the wide application of the monocoque construction in Japanese train cars especially after the end of the war. Originally established in German and American aircraft of the 1930s, this structural style

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[200] Akira Hoshi, *Sharyō No Keiryōka* (Tokyo: Nihontosho kankōkai, 1956).

could disperse the entire load on the sides, roof, and floor. The introduction of this design marked a significant departure from the traditional style for building housing that had heretofore prevailed in Japanese rail cars. Until this new application, the roof was not considered a vital part of the entire structural integrity in Japan; it was meant solely to protect passengers from sunshine or the elements. The introduction of the monocoque structure from abroad added another functional utility to the roof. As a result, central struts inside rail cars — for instance, the wartime car model 63 — became obsolete and unnecessary by 1955.

Secondly, a new strain gauge developed on the basis of technology transfer from abroad and invigorated Japan's rail industry after the war. Used to analyze the propellers of aircraft, or the screws of a submarine in Japan during the war, a strain gauge found its niche in railroad engineering after 1945. An engineer at the RTRI, with his wartime background in army aircraft development, studied different types of strain gauges imported from the United States, and developed a highly versatile one.[201] The postwar railroad community benefited immensely from this innovation. After its introduction, the device became a standard feature in conducting various load tests — bending, twisting, and compression —relating to the development of passenger cars. With such analysis, computing structural strength was no longer a formidable

[201] Kazuo Nakamura, "Hizumi Gauge Tanjō 50-Nen," *Kyōwa gihō* 370 (1988).

task.[202] Consequently, the engineers were able to introduce the monocoque construction widely and successfully.

Thirdly, craftsmanship skills in wartime aircraft development proved valuable in the postwar railroad industry. Only after the war was spot welding previously used in aircraft introduced in rail cars. Until then, house-building techniques were prevalent; rivets or often nails supported the structural integrity of passenger cars. The new technique from overseas removed the redundant crossing of steel plates and unnecessary heads. Consequently, a 10 to 15 percent reduction in weight was possible without sacrificing the structural integrity of rail cars. Furthermore, a corrugated metal sheet employed in wartime aircraft was utilized on the floor of a rail car. This type of sheet covered the surface of the main wings on aircraft until some detailed studies pointed out the surface roughness as a major cause of drag. As the speed of flight increased and necessitated care as meticulous as flush rivets, the corrugated metal sheet supported the inner structure of the wings.[203] This wartime technique to increase structural strength resurfaced in a newly developed niche after the war.

These technologies formed the basis for all the newly-developed steel rail cars after the

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[202] Nihon kokuyū tetsudō tetsudō gijutsu kenkyūjo, *Tokaido Shinkansen Ni Kansuru Kenkyū*, 6 vols., vol. 1 (Tokyo: Nihon kokuyū tetsudō tetsudō gijutsu kenkyūjo, 1960), 42, Shōichi Yokobori, "Kyaku Densha No Gijutsu Teki Mondai Ten," *Kōtsū gijutsu* 76 (1952).

[203] Tadanao Miki, "Kōzō Kyōdo Kara Mi Ta Densha No Dōkō," *Denki sha no kagaku* 10, no. 4 (1957).

immediate postwar years. The coach model naha-10, introduced first in 1955, exemplifies the triumph. The product — based on a light, steel rail car in Sweden — benefited from all of the aforementioned technology transfers. The coach consisted of steel from floor to roof, but was 31 percent lighter than the comparable, then mass-produced model suha-43.[204] During the conversion of rail cars from wood to all-steel construction, the postwar technology transfers rendered wood obsolete. In 1955, Japan became the first country in the world to complete the technological transition on a national scale.[205]

4. 2 Combination of Technology Transfer from Abroad and Inter-disciplinary Technology Transfer at Home: Electrification of Government Railways

Electrification of JNR lines was a crucial factor for developing rail service for mass transit after 1945, including the high-speed bullet train, because it offered substantial technological and economic benefits. Diesel and electric locomotives, for example, were more reliable and efficient than their steam-driven counterparts, capable of pulling heavier loads farther and faster in a day. Because electric trains did not carry their own fuel supply on board,

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[204] Shozō Hayashi, "Keiryō 3-Tōsha Naha 10-Keishiki," *Kōtsū gijutsu* 108 (1955), Kubota, *Nihon No Tetsudō Sharyō Shi*,201, Jūzō Unoki, "Zoku Keiryō Kyakusha Sonogo," *Kōtsū gijutsu* (1957).

[205] Kubota, *Nihon No Tetsudō Sharyō Shi*,141.

they were lighter, faster, and more powerful than steam locomotives. Electric rail cars offered passengers a more comfortable ride, especially in tunnels, because they produced no black smoke and cinders. Overall, they were relatively cheaper to operate and maintain.[206] Additionally, electrification permitted operations of multiple motorized cars as a unit. This method was preferable to a heavy electric locomotive at the head pulling a chain of non-motorized coaches. The electric multi-unit car (hereafter EMU) system distributed loads on axels and motive power evenly along the entire fleet length while increasing total output, causing less damage to the rail tracks. The EMU system also had the advantage of shortening turnaround at terminals.[207]

Electrification of the public railways was largely a product of the postwar years. Before 1945, it was limited mainly to urban areas surrounding Tokyo and Osaka. Understandably, the Army feared strategic air raids on power stations and catenaries, the Achilles' heel of the industry because these raids could incapacitate transports of war goods throughout the country. Only after the war did Japan promote electrification on the major trunk lines. By 1950, electrified government lines accounted for only 1,659 km (8 percent) of the total route length of 19,786

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[206] The French government railways also witnessed many economic benefits of electrifying rail service. For a informative French case study see, for example, Meunier, *On the Fast Track French Railway Modernization and the Origins of the TGV, 1944-1983*,25-30.

[207] Aoki et al., eds., *A History of Japanese Railways, 1872-1999*,130-31.

km.[208] By the mid-1950s, the country's economy had recovered to the prewar level and was entering a remarkable growth phase. The transport market depended heavily on railways, and faced the urgent need to increase passenger and freight capacities. The Tōkaidō line, the artery of the coastal plain between Tokyo and Osaka, experienced a surging demand for transport in the 1950s.[209] With no impending military threat from outside, electrification of the JNR railways across the nation seemed a promising alternative to accommodate expansion.

But electrification posed a safety hazard to the postwar railway industry. For instance, the number of accidents involving electric motor cars in government railways reportedly reached its peak in 1947 when there were ten times as many accidents as in the prewar period. Nearly 40 percent of these postwar accidents had to do with the car's main electric motor, presumably caused by overheating.[210] Many electric locomotives and self-propelled electric cars experienced damage from electricity-related fires. The Class EF13 electric locomotives, for example, lacked a circuit breaker that could turn off large electric currents instantly, a major cause of electric malfunctioning.[211] In March 1950, the Class 80 electric multi-unit car made its public debut and

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[208] Ibid.,127.

[209] Ibid.,132-33, 38.

[210] Nihon kokuyū tetsudō tetsudō gijutsu kenkyūjo 50-nenshi kankō iinkai, *Nihon Kokuyū Tetsudō Tetsudō Gijutsu Kenkyūjo 50-Nenshi*,36.

[211] Ibid.,378.

served on the Tokyo- Numazu line over the 126km distance. The fleet, consisting of as many as 16EMU cars, demonstrated the economic advantages of electrification. The rail project helped increase the medium-distance transport capacity on the Tōkaidō line. But initially, the vehicle failed to function properly and was fraught with many electricity-related problems. During a test run, for instance, the roof lacked insulation and caught fire from an overhead wire, and two EMU cars were reduced to ashes. Consequently the Shōnan electric car, as it was widely known because of the rail service along beautiful the Shōnan coastline, soon earned the disgraceful nickname of "disastrous (sōnan)" electric car. Only a few days after the introduction of the rail service, the JNR President Kagaya Tokuji announced that operations would end if accidents continued.[212]

A catastrophic fire in April 1951 symbolized the electricity-related safety hazard in the rail service in a most horrific way. As reported in the press, the highly combustible painting on the wooden roof of electric car model 63, and the high voltage above it, proved a deadly combination. A crowded fleet touched an ill-repaired overhead wire at the site, engulfing the passengers in flames in just ten short minutes.[213] Devised during the war, the car embodied

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212 *Asashi shinbun*, 3 March 1950.

213 *Asahi shinbun*, 25 April 1951.

design characteristics from the period of the national emergency. The product used a minimum amount of glass and metal parts; the remaining operable space in each window was subdivided so that only a few fortunate passengers could barely escape from the inferno. The automatic, electric-powered doors remained mercilessly closed, trapping hundreds of passengers in the fire. Consequently, the tragedy injured 92 passengers and killed 106.[214] National and local newspapers issued extra editions and reported "[horrific] scenes from the hell" vividly with evocative photographs.[215]

This event put tremendous social pressure on the JNR management. Editorials in major newspapers unanimously demanded that the public corporation take appropriate actions immediately against the combustible rail products of the war years. The press also heavily criticized what they viewed as the corporation's blatant lack of safety concerns, which culminated in this "human-made disaster."[216] The media simply translated the causes of accident, however many and technically complex, into layman's simple terms for wide readership. The JNR reacted expeditiously. Without any conclusive investigation or budget report, for instance, they officially announced that the incombustible steel should immediately replace wood in the

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214 Kubota, *Nihon No Tetsudō Sharyō Shi*,156, Nihon kokuyū tetsudō, *Tetsudō Gijutsu Hattatsu Shi (Sharyō to Kikai) I*,32.

215 Tomoyuki Hajima, ed., *Gōgai Sengoshi, 1945-1995*, vol. 3 (Tokyo: Ōzorasha, 1995), 103-04.

216 Editorial, *Mainichi shinbun*, 26 April 1951.

rail car roofs. This speedy initiative, a way of taming the intense public backlash, was announced the day after the tragedy.[217]

Yet the harsh social accusations against the JNR did not subside quickly, with far-reaching consequences along the way. A major weekly journal, for instance, continued to denounce the JNR even three weeks after the catastrophe, blaming it for fortifying its business operations at the expense of passengers' safety.[218] The intense social outcry put the JNR leadership on the defensive. Shima Hideo, the head of the Rolling Stock and Mechanical Engineering Department, resigned to take social responsibility. The JNR director and the head of the Operations Department followed suit. The unprecedented intensity of the social outcry ousted an incumbent JNR leadership for the first time in its history.

Electricity-related train accidents posed a formidable challenge to the industry. In this situation, wartime military engineers prepared the way for electrification. For instance Hirose Kengo, a wartime electrical engineer formerly in the Army, noted rightly that one major reason for the catastrophe of 1951 lay in the fact that electrical power had continued to flow to the site, posed considerable risk to firemen, and delayed their efforts. After his investigation, he

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217 *Asahi shinbun*, 26 April 1951.

218 Sawako Noma, ed., *Dokuritsu-Reisen No Tanima No Naka De: Shōwa 25-27 Nen*, vol. 9, *Shōwa Ni Man Nichi No Zenkiroku* (Tokyo: Kōdahsha, 1989), 150.

demonstrated before the suspicious eyes of many railway engineers that water, if treated properly, was safe and effective in extinguishing fire despite a continuous supply of power to an accident site.[219] In addition, Hirose curtailed hazards in rail service by developing a fuse for a circuit breaker that could handle currents of as much as 5,500 amperes. This was a significant contribution at the time because the commonly used fuse had been unable to handle electric currents of 1,200 amperes and more.[220]

A wartime military engineer at the Central Aeronautical Research Institute, Yamamura Tatsuo, developed thermometry at the RTRI and solved the overheating of the main electric motor that impeded the industry's electrification effort. He inserted many thermocouples into the most problematic part of the main motor; in so doing, he measured temperature distribution, studied the weakness of the insulating material, and developed a way to continuously measure the temperature of electric car motors then in service. In 1951, he improved the main electric motor's performance while decreasing its maximum internal temperature by 20 percent. In 1955, he conducted various experiments within and outside his laboratory, and successfully reduced a motor's weight for an electrical rail car by 50 percent.[221] Due to these technological

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[219] Nihon kokuyū tetsudō tetsudō gijutsu kenkyūjo 50-nenshi kankō iinkai, *Nihon Kokuyū Tetsudō Tetsudō Gijutsu Kenkyūjo 50-Nenshi*,385.

[220] Ibid.,380.

[221] Ibid.,363-64.

contributions, he became the leader of the Electric Drive System Laboratory.

Tamura Fumitoku, another wartime Army engineer, also solved an electricity-related problem in the industry. At the Army Aeronautical Research Institute, he developed the ignition mechanism of an aircraft engine for high-altitude flight.[222] At the RTRI after 1945, he conducted experiments on lightning and studied how to avoid it. At one point, he investigated rail cars that suffered from a lightning strike and studied the effects of the impulse voltage.[223] In 1951 and 1952, he examined abnormal voltage and electrical surges; more specifically, he studied induced voltage under normal and abnormal conditions, as well as surge protection from lightning strikes.[224]

These domestic research initiatives for the 1500-voltage, direct current (DC) system helped reduce electrical hazards in the industry, but technology transfer from abroad was indispensable for the bullet train project in the late 1950s and early 1960s. The electrical infrastructure for the bullet train required much higher voltage, 25k-voltage and an alternating current (AC) system. The AC system, which used a commercial frequency of 50 or 60 hertz, had a foreign lineage; it became commonplace first in postwar Europe, then in Japan from the late

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[222] Nihon kōkū gakujutsushi henshū iinkai, *Nihon Kōkū Gakujutsushi (1910-1945)*,117.

[223] Nihon kokuyū tetsudō tetsudō gijutsu kenkyūjo 50-nenshi kankō iinkai, *Nihon Kokuyū Tetsudō Tetsudō Gijutsu Kenkyūjo 50-Nenshi*,389.

[224] Ibid.,388.

1950s. The JNR chose to explore the possibilities of the AC system in the 1950s by promoting technology transfer from the West.

Railway management needed proven records of technological utility and economic savings from adopting the AC system, and a French example filled this need. Because electrification using 1.5kV DC was relatively cumbersome and expensive in postwar France, electrification using industrial AC current at 50Hz seemed a more feasible option.[225] Soon the French railway industry adopted industrial current — 25kV AC at 50Hz — which allowed aerial cables, known as catenaries, to be made thinner. The resulting lightweight infrastructure turned out to be a source of economic saving. In addition, the AC system in France made the trackside substations much simpler and affordable affairs; they could be unmanned and placed at greater intervals, every sixty kilometers instead of every ten to twenty kilometers.[226] Consequently, the French national railways initiated the electrification of the Paris-Lyon line and boosted the fastest commercial speed to an average of 106mph while doubling the tonnage to 400 tons. Behind the management decision was Louis Armand, an engineer and strong advocate for the industrial AC system rather than the DC to electrify the Paris-Lyon line. By 1952, the year in which the

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[225] Meunier, *On the Fast Track French Railway Modernization and the Origins of the TGV, 1944-1983*,28.

[226] Ibid.,23.

electrified Paris-Lyon line opened, all of the government's electrified lines in France were drawing their power from hydroelectric plants. Establishing 25kV AC at 50Hz as a world standard, Armand personally assisted the Indian and Japanese railways with their electrification projects.[227]

Obtaining technical data and advice from abroad was crucial for AC electrification of public railways in postwar Japan. For the choreographed technology transfer, the JNR used an artificial setting already in place. The flow of technical information extended across national borders, both through travels of engineers and in printed form. A carefully devised strategy by management was necessary because Japan lacked the option of hosting a migration of engineers and their technical knowledge from abroad. In this context, the JNR made active efforts at home to benefit first-hand from vibrant European colloquies on newly available railroad technology. For instance, in 1954 the JNR hosted an international railway conference in Tokyo where representatives from Western European nations gathered for sharing engineering knowledge. JNR's liaison offices in Western Europe were useful to observe the state of technology and to gather technical information from abroad. This strategy, however, was highly susceptible to misleading or inaccurate information available overseas. In retrospect, for instance, Japanese

[227] Ibid.,29.

railway engineers overestimated French reports and advertisements that knowingly or unknowingly exaggerated test results and economic benefits of AC electrification. But overall, the eventual adoption of the AC system was a success in the long run; it proved indispensable for the successful operation of the high-speed bullet train after 1964.[228]

Transferring the AC system from France to Japan was possible in part because of some technological preparation at the RTRI. Wartime military engineers at the establishment had developed AC-based electrical technology as early as the late 1940s. The cases of Hayashi Masami, a chief architect of the bullet train's power supply system, and two other RTRI engineers illustrate this point. Hayashi joined the Electricity Department of the Institute for Navy Aeronautics in 1943, where he was trained to be a system engineer. His wartime jobs included developing a power supply system for aircraft; for instance, he examined the durability of an electric motor connected to an engine susceptible to vibrations and acceleration. His wartime experience of constructing and checking the electrical system theoretically and empirically proved vital for the electrification of railways during the 1950s.[229] Hayashi's postwar projects in the Electrical Machinery Laboratory at the RTRI included how to convert frequency from 50Hz

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[228] Hiroshi Kubota, "Sengo Nihon Tetsudōshi No Ronten," *Tetsudōshigaku* 6 (1988): 42, 43.

[229] Masami Hayashi, "Kūgishō No Omoide to Sengo No Watashi," in *Kaigun Kōkū Gijutsushō Denkibu* (Tokyo: Kūgishō denkibu no kai, 1987), 91-94.

to 60Hz for rail service across the country.[230] This effort was necessary because from the 1890s, the western part of Japan used 60Hz and the eastern part used 50Hz. Hayashi conducted his research while Yamamura Tatsuo, a wartime engineer at the Central Aeronautical Research Institute, developed a sophisticated rectifier, the device for converting DC to AC. He also studied the new DC motor brushes that operated on AC, while Kokubu Kinji, also a wartime engineer at the Central Aeronautical Research Institute, developed a metal alloy for the device.[231] Such research on the AC system was fairly new in Japan at the time. In 1950, Hayashi went on to test an electrical system based on hydraulic and thermal power stations surrounding Tokyo. He was also involved in research for protecting high-voltage power transmission lines, as well as in the automatic distribution of the electric power load.[232] When France began research on commercial frequency and AC electrification, Japan had relatively little, useful technical information except for limited papers in German and French. But his own research from 1954 to 1956, particularly his fail-safe check method, contributed to electrification of the Senzan line based on the AC

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[230] Nihon kokuyū tetsudō tetsudō gijutsu kenkyūjo 50-nenshi kankō iinkai, *Nihon Kokuyū Tetsudō Tetsudō Gijutsu Kenkyūjo 50-Nenshi*,367.

[231] Ibid.,365-67.

[232] Hayashi, "Watashi No Sengo,"92-93, Nihon kokuyū tetsudō tetsudō gijutsu kenkyūjo 50-nenshi kankō iinkai, *Nihon Kokuyū Tetsudō Tetsudō Gijutsu Kenkyūjo 50-Nenshi*,367-69.

system.[233] Subsequently, the success formed the foundation for AC electrification of other local lines, such as Hokuriku line, Tohoku line, Jōban line, and Kagoshima line.

One should not, however, overstate the role of RTRI in the process. The adoption of the power system in 1958 required more than engineering knowledge alone at the peripheral research establishment. Electrical engineers at the JNR headquarters and official study groups — such as the AC electrification investigation committee (kōryū chōsa iinkai) in 1953 — were equally, if not more, indispensable for the process.[234] By the mid-1950s, the AC power proved a promising alternative for providing reliable energy transmission and for supporting the operations of electrical rail cars and locomotives.

4. 3 Inter-Disciplinary Transfer of Aeronautical Technology at Home: Miki Tadanao's Laboratory at the RTRI

In developing the monocoque, light, and all-steel coach cars, the JNR management largely neglected to utilize the domestic deposit of wartime aeronautical engineering. This was evident in the Rolling Stocks Structure Laboratory at the RTRI that played a supporting role from

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[233] Masami Hayashi, "Sekai Ni Hokoru Kōsoku Tetsudōyō Daideiryoku Kyōkyū Hōshiki, at Kiden Hōshiki," *Hatsumei* 76, no. 8 (1979): 51, Hayashi, "Watashi No Sengo,"97-98.

[234] Masami Nishida, "Saikin No Denka No Ayumi to Sūsei," *JREA* 11 (1962), Eiichi Nishimura, "Tokaidosen Zensen Denka Kaitsū Su," *Kōtsū gijutsu* 126 (1956), Shirō Seki, *Sengo Sekai Ni Sakigaketa Jōetsusen Denka* (Tokyo: Keizai rondansha, 1987).

1945 to 1957.[235] This laboratory offers a useful case study about how military technology for developing wartime aircraft proved essential for developing high-speed rail service. A close look into the political dynamics of the process reveals a turf battle over domestic technological ingenuity vis-à-vis technology transfer from abroad. Within the RTRI as of February 1956, the laboratory formed the largest work force with 23 engineers[236] — and they designed the rail cars of the Odakyū Romance Car and the *Shinkansen* bullet train that shocked railway industries around the world. Both products established high-speed world records; the Romance Car made a test run at the speed of 145km (approximately 90 miles) per hour in 1957, and the bullet train at 256km (160 miles) per hour in 1963.

A condition of these accomplishments was an unusually high concentration of wartime aeronautical engineers in the laboratory who utilized their accumulated knowledge and experience in the field. The leader of the work force was Miki Tadanao. This graduate from the department of Naval Engineering at Tokyo University was a highly experienced, able senior aeronautical engineer at the Institute for Navy Aeronautics from 1932 to 1945. He had been the leader of a group devoted to designing highly advanced, experimental aircraft on the basis of

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235 Tadanao Miki, "Naha 10-Keishiki Keiryō Kyakusha Kōtai Kajū Shiken," *Kōtsū gijutsu* 115 (1956): 39-41.

236 Nihon kokuyū tetsudō tetsudō gijutsu kenkyūjo 50-nenshi kankō iinkai, *Nihon Kokuyū Tetsudō Tetsudō Gijutsu Kenkyūjo 50-Nenshi*,63.

both practical and theoretical knowledge in aeronautics. His wartime accomplishments included upgrading an earlier model of the legendary A6M Mitsubishi Zero fighter, assisting the design project of the D4Y Judy dive-bomber, and designing the twin-engine dive bomber P1Y Frances as well as the rocket-propelled kamikaze glider MXY7 Ōka — all of which were deployed in one-way suicide missions as part of homeland defense during 1944-1945. Defeated psychologically and dejected from his acute sense of wartime guilt, he followed the custom of shaving his head to shed the past, but this action gave him no relief. He was able to pick himself up only after receiving Christian baptism and joining the RTRI officially, both events coincidentally occurring on his 36th birthday in December 1945. That day marked his spiritual conversion and, to a degree, epitomized the country's technological conversion from wartime to peacetime.

As it turned out, Miki was among many wartime aeronautical engineers who embarked on new lives as engineers in his laboratory. In 1950, he was the laboratory leader of over fourteen research associates. A remarkable point to note is an unusually high concentration of wartime aeronautical engineers in the research setting. In 1950, at least seven among fifteen research associates — 47 percent of the laboratory work force — had been introduced to the field of theoretical and applied aeronautics by the end of the war. Several actually designed army, navy, or civilian aircraft at least in part during the war. As several informants testified, this high concentration seemed coincidental on the surface. Many did not know each other before joining the RTRI, and none of them encouraged each other to come to Miki's laboratory, let alone the RTRI. In the next three years, the rate of concentration increased to 73 percent; an overwhelming majority in the laboratory thus shared the background in aeronautics. The pre-1945 backgrounds of the fifteen researchers are as follows (Table 4.1):

Group	Last Name	Education	RTRI entry	Wartime affiliation	Job
Innovator	Miki	Tokyo Univ. Navy Eng.	1945	Institute for Navy Aeronautics	Aircraft design
Adopter	Akatsuka	Ind. Academy Mech. Eng.	1946	Institute for Navy Aeronautics	Aircraft design
Adopter	Itonaga		1946	Central Aero Tech Research	Aircraft design
Adopter	Takabayashi	Ind. Academy Aeronautics	1946	Central Aero Tech Research	Aircraft design
Adopter	Ono	Kyoto Univ. Physics	1945	Institute for Army Aeronautics	Aircraft design
Adopter	Hasegawa	Tohoku Univ. Aeronautics	1946	Institute for Army Aeronautics	Aircraft design
Adopter	Nishimura			Army Technical Research Institute	
Adopter	Matsumoto			Army Technical Research Institute	
Adopter	Nakamura	Tokyo Univ. Aeronautics	1946	Nakajima Aircraft Co	Aircraft design
Adopter	Nakamura	Tokyo Univ. Mech. Eng.	1945	Student/ Osaka Army Arsenal	Fatigue analysis
	Mizushima				
	Tanaka		1947	Student	-
	Nakae	Ind. Academy Mech. Eng.	1949	Student	-
Laggard	Hayashi	Tokyo Univ. Mech. Eng.	1945	Student	-
Laggard	Yoshimine	Tokyo Univ. Mech. Eng.	Prewar	RTRI	Structural strength test

Table 4.1: Backgrounds of fifteen research associates at Miki's laboratory as of 1950[237]

The influx of wartime aeronautical engineers into Miki's laboratory created an observable pattern of knowledge diffusion. Here the adopter categorization — innovator/opinion leader, adopters, and laggards — is mechanically simple but analytically useful for encapsulating the process of engineering knowledge diffusion within an organizational setting.[238] Typically, knowledge diffusion occurs contagiously via social networks, among individuals from leader through adopters to laggards. This seems to have been the case in Miki's laboratory during the years 1950-1957.

The innovator/opinion leader plays a crucial role in the knowledge diffusion process, and in the RTRI laboratory, that leader was unquestionably Dr. Miki. He possessed the most salient value of the category, namely the spirit of being venturesome. He was fully able to understand and apply complex engineering knowledge in the railway industry. While an innovator might not be respected by the other members of an organization, Miki — as the

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237 *Kokutetsu Shokuin Meibo (Gijutsu Gakushi) Shōwa 25-Nen 8-Gatsu 10-Ka Genzai*, *Nihon Kokuyū Tetsudō Senpai Meibo: Shōwa 59-Nen 9-Gatsu 1-Nichi Genzai* (n.p., n.d.), Takeo Akatsuka, Letter to author, 10 December 2002, Tadanao Miki, Interview by author, 6 February 2003, Kazuo Nakamura, letter to author, 16 January 2003, Takabayashi.

238 Everett M. Rogers, *Diffusion of Innovations*, 4th ed. (New York: Free Press, 1995). See especially pages from 252 to 280. The author uses the five categories — innovators, early adopters, early majority, late majority, and laggards — depending on how and why each group incorporated new ideas. Here I treat early adopters, early majority, and late majority as one lump sum of "adopters" because I lack sufficient information to differentiate one group from the others.

officially appointed leader — had strong support from his coworkers. Miki was highly respected for being the oldest in the laboratory, for his technical competence and depth of engineering knowledge, and for his high military ranking of lieutenant commander during the war.

Sharing similar pre-1945 military backgrounds and forming the majority within the laboratory, the other former aeronautical engineers — whom I refer to as "adopters" — accelerated the pace of applying technology from wartime aircraft to postwar high-speed rail cars. They were quick to adopt new ideas that were derived from aeronautical technology. The civilian application of military technology in the laboratory owed its success to Miki as much as to this group. Together, they remained relatively free of the traditionally strong hierarchy and organizational culture often seen in the communities of railroad engineers. The number of "adopters" increased gradually as more research associates joined the laboratory in the 1950s.

In Miki's laboratory, laggards — those who did not adopt or did so belatedly — typically shared the common pre-1945 background in railroad engineering. The term may convey a somewhat pejorative overtone, but in the laboratory, they played a vital role in conducting physical experiments, such as load tests, on technological artifacts to observe their structural strength and gather data. Their lack of previous exposure to the field of aeronautics, however, seems to have raised their level of resistance to application of theoretical aerodynamics to railroad engineering. The laggards' exposure to the innovative ideas based on aeronautics was somewhat limited. Although not conspicuously hostile to one another, Miki and some "adopter" engineers, usually senior ones, maintained a non-interference attitude toward "laggards" in research projects. This schism persisted between the camp of wartime aeronautical engineers and that of the others into the 1960s.

The unusually high concentration of wartime aeronautical engineers in this laboratory reflected the industry's respect for their proven mathematical skills. Many of the technical difficulties in developing lightweight vehicles in the 1950s involved the weight analysis; the key issue was to save as much structural weight as possible without sacrificing strength and safety. Before the introduction of composite alloys into the field, conversion of wood designs to steel invariably increased the strength of the body structure. It also added weight, which then damaged the strength and durability of the physical infrastructure in the rail service, such as tracks and bridges. Given this unyielding technological parameter, minimizing the structural weight of the train car was a major part of the design project. Of all of the structural weight, the upper body of the car occupied the largest portion and much of the attention of design engineers. On average, the upper body and interior equipment constitute roughly 40 percent of the total car weight, the running gear about 30 percent, and the rest roughly 30 percent.[239]

Of course, meticulous weight control is the essential part of creating an airplane design at the developmental stage. The lighter the structural weight of the aircraft, the faster, the farther, and the higher it can fly. Wartime aircraft engineers had shown a proven ability to handle highly complex physical forces in three dimensions within an unyielding weight envelope. Advanced stress analysis of, and testing on, the strength of materials were indispensable in the postwar railway industry, and this created a niche for the former aeronautical engineers. The RTRI obtained Japan's first giant electronic calculator, Bendix G20, in 1962;[240] until then, the portable steel-made Tiger mechanical calculating machine was generally used. Young aeronautical engineers with wartime experience gained a reputation for their ability to calculate numbers. Overall, the accumulated wealth of knowledge in aircraft engineering proved indispensable for developing rail cars within the weight restrictions.

Japan's railway industry showed its expectations of the group of "human calculators" in Miki's laboratory in laborious research projects. These included (1) developing a vibration gauge for railway vehicles, (2) basic research on vibrations of springs and the trucks of the running gear,

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[239] Miki, "Kōzō Kyōdo Kara Mi Ta Densha No Dōkō," 7.

[240] *Tetsudō Gijutsu Kenkyūjo Kotei Shisan Ichiranhyō: Shōwa 46-Nen 3-Gatsu 31-Nichi Genzai`* (Tokyo: n.p., 1971), 96.

(3) examining the physical impact of running rail cars on rails, (4) developing a lightweight coach, and (5) improving ventilation in coaches and electric rail cars.[241] In September 1946, for instance, the former aircraft designers examined the structure and strength of the car body, the distribution of stress, as well as the fatigue aspect of welded metal parts. Among the many vehicles they studied were the automobile, large trailer bus, moha-80 rail car, moha-63 rail car, and some coaches that had been damaged at accident sites.[242] The engineers collected data through time-consuming experiments for the Rolling Stock Section of the Department of Engineering in order to inspect new coaches and develop new designs. This fairly rigid hierarchical relationship was a legacy from the prewar years. Initially Miki's group at the peripheral RTRI had little or nothing to do with designing vehicles.

A closer look into the Rolling Stock Section at the JNR headquarters points to a hidden source of smoldering tension between the center and Miki's laboratory on the periphery during the years that followed. As of 1950, the engineers at the headquarters appear to have been

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[241] Nihon kokuyū tetsudō tetsudō gijutsu kenkyūjo 50-nenshi kankō iinkai, *Nihon Kokuyū Tetsudō Tetsudō Gijutsu Kenkyūjo 50-Nenshi*,475-89, 518-20.

[242] Nihon kokuyū tetsudō tetsudō gijutsu kenkyūjo, *Shōwa 29-Nendo Kenkyū Seika Gaiyō* (Tokyo: n.p., July 1955); Tadanao Miki, "Ōgata Trailer Bus Shaken Hōkoku," *Tetsudō gyōmu kenkyū shiryō* 6, no. 1 (1949), Tadanao Miki, Takeo Akatsuka, and Shigeru Iai, "Jiko Kara Mita Kyakusha Densha No Kōzō Sekkei Shiryō," *Tetsudō gyōmu kenkyū shiryō* 7, no. 4 (1950), Tadanao Miki et al., "Shōnan Denshayō Tsūfūki Shiken," *Tetsudō gyōmu kenkyū shiryō* 7, no. 15 (1950), Nihon kokuyū tetsudō tetsudō gijutsu kenkyūjo 50-nenshi kankō iinkai, *Nihon Kokuyū Tetsudō Tetsudō Gijutsu Kenkyūjo 50-Nenshi*,475-89, 518-20.

considerably less educated when compared to the highly educated associates in Miki's laboratory. As employee directories of the time show, only one among a total of twelve senior designers in the design section at the headquarters had a university education. Curiously, this particular engineer — a graduate from Tokyo University's Aeronautics Department in 1946 — did not remain at the central headquarters. He was officially transferred to Miki's laboratory at a later time, apparently resulting in a complete absence of university-educated designers at the section in the headquarters![243] Apparently, this talent portrait changed somewhat later; presumably a few engineers moved in and out of the design section from time to time after 1950. This dominance of wartime railway engineers was understandable in the tradition-bound field that espoused seniority. How long they had served at the JNR seemed to matter considerably. The headquarters seems to have been a strong advocate for study abroad. At least some engineers from the Rolling Stock Section traveled to Europe for extended observation. This was presumably because technology transfer from abroad at the headquarters could provide the engineers with updated knowledge without disturbing the existing organizational structure.

But in retrospect, highly educated aeronautical engineers in Miki's laboratory were able

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[243] The section leader—Shima Hideo, widely known as the father of the bullet train—and his assistant were both from the department of Mechanical Engineering at Tokyo University. These managers had hands-on experiences in designing stream-run locomotives before 1945. Functionally, they played a crucial role in bullet train project management, rather than in actual hands-on engineering that I focus in this study.

to make technical improvements in many design features prepared at the central headquarters. The former aeronautical engineers used their wartime knowledge and experience as a means to launch "revolts" against the pre-existing center-peripheral power structure within the JNR. This challenge seems to have been unexpected. The resulting high-speed rail projects within the laboratory were never choreographed by non-technical management at the JNR. Miki, a maverick, played the leading role. Identifying himself as a "designer" instead of "researcher" before and after 1945, he single-handedly designed a series of rail cars against institutional norms and various forces of conformity. Miki actively sought opportunities in which he could capitalize on his wartime experience in aircraft design particularly as regards weight control and, above all, theoretical aerodynamics. By his own later account, he was "minding his own business [of designing], that's all." This was essentially a revolt, a welcome salvo among the other engineers with wartime experience in the field. The corollary, however, was a degree of organizational friction in high-speed rail projects. His initiatives were possible because he took advantage of a rule issued in March 1941. It effectively allowed the RTRI to accept requests from the public or civilian sector and co-opt their research projects as long as doing so did not impede duties assigned by the headquarters.[244] Within this framework, designing rail cars irrespective of the central design section required commercial niches—and his designs could

[244] *Un'yu Tsūshinshō Tetsudō Gijutsu Kenkyūjo Gaiyō: Shōwa 18-Nen 12-Gatsu* (Tokyo: n.p., 1944), 4.

only bear fruit outside the JNR. Highly successful — and quite popular ― locomotives of his design during the early 1950s included a roller coaster that made its debut at Kōrakuen amusement park in Tokyo. His meticulous weight control as practiced in wartime aircraft of his design proved its success in the unprecedentedly light-weight fuselage of the Tōkyū passenger locomotive model 5000. In the long run, Miki's research meant some duplication ― and redundancy― of the design function within the JNR. Subsequent rail projects took shape in the midst of some confusion, and the result was a smoldering turf battle between Miki's laboratory at the peripheral RTRI and the Department of Engineering at the JNR headquarters. The former military engineers were by no means conformists; such conventional images of engineers proved largely illusory.

4.4 First "Revolt" by the Aeronautical Engineers

The first major revolt took shape in 1951 when Miki's laboratory developed a monorail car freely and independently of central direction. This engineering success drew on German development sin the 1930s, especially the so-called *Schienenzepplin* or Rail Zeppelin. This experimental Nazi product had been developed parallel to new breakthroughs in the aircraft and automobile industries during the decade. The *Schienenzepplin* streamlined rail car, reminiscent of the Zeppelin airships, established a high-sped world record in June 1931. Equipped with a BMW engine (600 -horse power) and a four-blade wooden propeller in the rear, the aerodynamically refined car ran part of the stretch of land between Hamburg and Berlin within 98 minutes at the speed of 143 mile (230km) per hour.[245] No technical information about this vehicle seems to have been available in the Japanese railway industry at the time. Its success was essentially a black box; RTRI engineers could observe it in writing and pictures, but its inner mechanisms remained unknown to them.

Miki's idea capitalized on this experimental German project. In his thinking, an aircraft propeller and engine in the nose could pull a rail car on a monorail track from Tokyo to Osaka within roughly 2 hours. He calculated the structural weight, drag resistance, necessary horse power, and projected performance of the wingless airplane ―the subjects he was familiar with from developing military aircraft during the war. His plan for the "rail plane" took shape in the suspended-type mono-railroad system. A 500-horse power aircraft engine, and a 2.6m -diameter propeller, were to generate motive power. At least theoretically, an aerodynamically refined, light rail car was to carry as many as 46 passengers at the speed of 250km per hour on Tokyo-Osaka line in 2 1/2 hours. The vehicle was 19 meters long and 2.8 meters wide, and the structure

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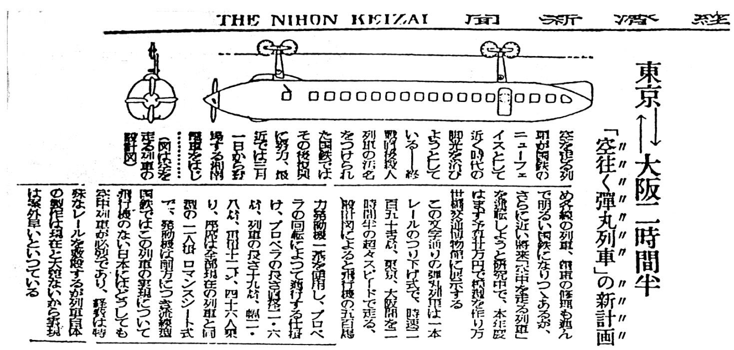
[245] Shunshuke Sumida, *Sekai No Kōsoku Tetsudō to Speed Up* (Tokyo: Nihon tetsudō tosho, 1994), 55.

weighed 12 tons. Major national newspapers carried reports about this idea.[246] For instance, Nihon Keizai Shinbun carried an article with the heading, “New Plan for a Bullet Train in the Air: Tokyo-Osaka in 2 1/2 hours” (see Fig. 4.1):


THE NIHON KEIZAI 經濟新聞

東京↑↓大阪二時間半
「空往く弾丸列車」の新計画

この文字通りの弾丸列車は一本レールのつり下げ式で、時速二百五十キロ、東京、大阪間を二時間半の超スピードで走る、

（図は空を走る列車の設計図）

Figure 4.1: Newspaper article reporting “the Rail Plane”

> This article introduces Miki’s engineering plan for the high-speed rail service. At least theoretically, the streamlined rail car as in the illustration, suspended on a newly-constructed single track, was to run the distance between Tokyo and Osaka within 2 hours and 30 minutes. The RTRI, as reported in the article, planned to construct a scale model within a budget and present the product at a transportation museum.

This idea bore fruit modestly in an unexpected setting. While the railway industry ignored this idea because it seemed unrealistic, the RTRI benefited from this misperception. The

[246] *Mainichi shinbun*, 19 February 1950.

then president of the Seibu Railway Company read this article and noted its optimistic outlook rather than its technological utility. He showed an interest in operating the product within the Toshimaen amusement park as a children's amusement vehicle. Subsequently, the RTRI took charge of developing the infrastructure and the rail car. After a series of tests, the end product was introduced in the park and widely reported in April 1951 as the "Flying Rail Car." The speed of operation was reduced significantly in this setting; contrary to the original design of high-speed rail service at 250km per hour, the amusement park vehicle ran on electrically motorized wheels at the speed of 15km per hour. Its dummy propeller in the nose lacked any mechanical function but was stylistically attractive.[247]

This development was a technological failure but was a political success in the long run. It firmly set a positive tone for subsequent projects to developing rail cars at the RTRI independently of the JNR headquarters. It represented a successful revolt against the tradition in which conservative railway engineers dictated the course of technological development in the industry. As it turned out, the RTRI's experience with the "Rail Plane" further divided the engineering community and created a turf battle within the center-periphery relationship.

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[247] Miki, "Monorail 45-Nen No Tsuioku," 1-5.

4. 5 A Second "Revolt" by the Aeronautical Engineers

The second revolt by former aeronautical engineers was more contentious but more successful than the previous one; their new vehicle established world records with its high-speed test runs of 1957. This was possible because Miki's laboratory developed the Odakyū SE Model 3000, better known as the Romance Car, on the basis of wartime aeronautical technology. The group's action openly challenged the existing center-periphery hierarchy within the JNR organization. After this success, designing rolling stocks was no longer a prerogative of the Department of Engineering at the headquarters.

RTRI's high-speed rail project had an innocent beginning. Almost habitually, Miki had been accustomed to jotting down ideas about technology for a high-speed rail car. In 1953, the technical feasibility of one of his ideas became evident after a series of mathematical computations. He concluded, rightly as it turned out, that a light, aerodynamically refined vehicle could run the Tokyo-Osaka line of 556km in 4 hours and 30 minutes. This conclusion formed the foundation for his journal article about high-speed rail service, the first solid work of its kind written and published after 1945.[248] The Asahi national newspaper on October 17, 1953 placed him at the center of the stage and carried a report on his idea; at least theoretically, a fleet of rail

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[248] Tadanao Miki, "Chō Tokkyū Ressha (Tokyo-Osaka 4-Jikan Han) No Ichi Kōsō," *Kōtsū gijutsu* (1954).

cars as aerodynamically refined and super-lightweight as sophisticated aircraft would be able to run on the Tokyo-Osaka line within a time frame of 4 hours and 45 minutes at an average speed of 120km per hour (see Fig. 4.2).

国鉄快速列車の設計成る

軽く小さい流線型

東京・大阪間4時間45分

Figure 4.2: Asahi Newspaper Article on October 17, 1953

In this article, the architect of the idea, Dr. Miki, briefly explained his engineering plan for the high-speed rail service. In it, he rightly emphasized the importance of streamlined, small-sized, and light-weight construction of the rail car for this purpose. To avoid derailment as a result of wind blowing upon it sideways, the resulting light-weight car had the lowest possible centers of gravity, so that boarding passengers actually stepped *down* from the station platform into the car. According to his calculations, an electric locomotive with non-powered cars would be able to run on the Tokyo-Osaka line within 4 hours and 45 minutes. His optimism, as reported in the article, was shared widely within the RTRI.

This publication became a major source of tension within the JNR. Developing this idea during his free time after his regular work was Miki's own business, but it was a different matter altogether when the RTRI turned to national newspapers without consulting the central headquarters in advance. Miki and the RTRI director did not follow the tacit protocol within the JNR organization. The newspaper article came out of the blue for the Department of Engineering at the headquarters. In their eyes, such an idea from the peripheral RTRI was not welcome. It was also untimely because the headquarters was leading a project to electrify the remaining part of the Tōkaidō Line west of Hamamatsu for the high-speed train, Tsubame to run the Osaka-Tokyo distance in 8 hours at the average speed of 72km per hour. In this setting, Miki offered a technologically promising alternative. The peripheral research establishment developed a more promising idea for fast train service than did the central headquarters. This center-periphery tension took a curious turn when the Ministry of Transport, pleasantly surprised by the newspaper article, financed Miki's high-speed rail project. The private railway company Odakyū also noticed the remarkable potential of Miki's design concept and co-opted the project.

The end product — later known as the Romance Car Model SE 3000 — was a technological triumph. In September 1957, the vehicle established a world record (145km) for its high-speed test run on the Tōkaidō line. The product was essentially a light, wingless airplane. One major reason for the accomplishment lay in Miki's rigorous weight reduction program for the vehicle. While keeping low centers of gravity, the former aeronautical engineers in his laboratory reduced the overall car size and employed the monocoque construction after meticulous calculations. A corrugated, thin metal sheet — a means of supporting wing structure of wartime aircraft from within — provided enough strength to support a floor from underneath. The body frame used metal sheets no thicker than 4.5 mm to save weight. After a series of stress analyses, the engineers drilled holes in the steel frames to reduce "fat."[249] Because passenger seats weighed the most among auxiliary equipment, they used aluminum alloys — a light, corrosion-resistant material ideal for car construction — and developed a new set of seats. The result of their weight engineering was phenomenal. A similar unit widely used in the industry at the time weighed 114kg; and even the lightest reclining seats used on buses weighted 39.4kg. In contrast, the product by Miki's group weighed only 33kg.[250] Moreover, they eliminated one truck per two rail cars to reduce the total weight of the undercarriage.[251] The vehicle initially

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[249] Odakyū dentetsu kabushiki gaisha, *Super Express 3000* (Tokyo: Odakyū dentetsu, 1957), 8-10.

[250] Tadanao Miki and Morihisa Takabayashi, "Keiryō Reclining Seat Shisaku Hōkoku," in *Tetsudō Gijutsu Kenkyūjo: Shōwa 30-Nendo Kami-Hanki Kenkyū Seika Gaiyō, Kōsakukyoku Kankei* (Tokyo: 1956), 16-17.

[251] This style inevitably fixed the units with little flexibility during high-speed run. The resulting vibrations were more complex in nature and more frequent than the common articulation in which each car had 2 trucks. Nobuo Matsui, "Se-Sha Ni Yoru Kōsoku Shaken," in *Tetsudō Gijutsu Kenkyūjo: Shōwa*

lacked air conditioning because the equipment was quite heavy.[252]

Another notable aspect of the vehicle was its streamlining, a characteristic with a prominent history in wartime science. The group of wartime aeronautical engineers under Miki's leadership conducted theoretical and empirical analyses of air flowing over the rail cars running at high speed. Because the RTRI lacked a wind tunnel, they used the then largest wind tunnel with a 3 meter-diameter test section at the Institute for Aeronautics at the University of Tokyo. The high-speed rail project earned support from the country's best in aerodynamics. During the war, Professor Tani Ichirō had developed the fastest experimental Army aircraft (Kensanki) and the fastest rocket-engine aircraft deployed in the Navy (the suicide glider Ōka). Drawing on his expertise, the research group prepared variously shaped car models at one-tenth scale to observe air resistance against their noses. The engineers tested on-fortieth scale model of the long fleet in the wind tunnel to examine skin friction and air turbulence. Many of these techniques derived from wartime research relating to aircraft development. During a test run, the research group closely examined the distribution of air pressure on various points of the nose. They also measured the thickness of the viscous layer of air adjacent to the surface, a chief source of drag

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32-Nendo Kenkyū Seika Gaiyō, Shisetsukyoku Kankei (Tokyo: 1958), 72-73. Presumably for this reason, the U.S. railway industry did not adopt this method of weight reduction.

252 As a solution, aeronautical engineers originally thought of mounting ice in the rail cars. After all, the vehicle obtained the air conditioning for more comfortable ride. I am grateful to RTRI engineer in the high-speed project, Takabayashi Morihisa, for sharing this anecdote with me.

on the vehicle's body. Because the surface roughness militated against a high-speed run, the engineers installed a hood over each space between the rail cars and enclosed the underbody for aerodynamic reasons.[253]

Ironically, this RTRI-led project took advantage of divisions in the industry and bore fruit outside the JNR. High-speed rail development typically involves not just rolling stock but also issues relating to electrification, physical infrastructure, signaling, and operation control among other matters. In this rail project, however, developing excellent rail car was decisive because the sponsor of the project, the Odakyū Railway, had other support elements ready for high-speed transportation. The project faced strong oppositions in the JNR, in the form of a turf battle especially from the Rolling Stock Section in the Department of Engineering, which also wanted to design rail cars. On the other hand, the Department of Operation supported the project regardless of who would design the vehicle. The resulting success marked a crucial milestone in Japan's effort to develop high-speed rail service. Consequently, this high-speed rail project formed the basis for developing aerodynamic, light rolling stock for the bullet train. By Miki's account, roughly eighty percent of the bullet train development in the field derived from the

[253] Tadanao Miki, "Kōsoku Sharyō No Kūki Rikigakuteki Kenkyū," *Nihon kikai gakkaishi* 61, no. 478 (1958), Tadanao Miki, "Kōsoku Tetsudō Sharyō No Kūki Rikigakuteki Shomondai, Part I," *Kikai no kenkyū* 12, no. 7 (1960), Tadanao Miki, "Kōsoku Tetsudō Sharyō No Kūki Rikigakuteki Shomondai, Part Ii," *Kikai no kenkyū* 12, no. 8 (1960), Tadanao Miki, "Kōsoku Tetsudō Sharyō No Kūki Rikigakuteki Shomondai, Part III," *Kikai no kenkyū* 12, no. 9 (1960), Tadanao Miki, "Odakyū 3000-Kei Se-Sha Sekkei No Tsuioku," *Tetsudō fan* 32, no. 375 (1992): 94.

Romance Car project; from this historical perspective, there should have been “nothing surprising” about the later, successful design of the bullet train car.[254]

The Romance Car thus represented a successful transfer of wartime aeronautical technology to the railway industry with marginal influence from abroad. Pursuing high-speed rail projects at the RTRI did require some technical information from overseas, at least for reference. Keenly aware of this, the engineers under Miki’s leadership gathered information individually and collectively. But the amount of information available within Japan in the late 1940s was scanty. Much of it was non-technical in nature. For these reasons, the engineers’ efforts to collect data, through strenuous, were rarely fruitful. The personal experience of Takabayashi Morihisa, a wartime technician at the Central Aeronautical Technology Institute, is a case in point. After joining Miki’s laboratory in 1945, he regularly bought LIFE magazine and circulated the issues among his colleagues. His diary noted such an effort in 1947:

> “Before getting one copy of LIFE magazine, I have to go to the Ginza district once or twice to know the first date of sales. The day before the sales, I have to prepare two lunchboxes [one for breakfast and one for lunch the next day]; on the day of the sales, I

[254] Tadanao Miki, Interview by author, 22 December 2002.

had to leave home at 4 o'clock in the morning to catch the first train bound for Ginza. My heart beat fast on the way. I dashed from the Yūrakuchō station to Kyōbunkan [where the magazine was sold]. I relaxed at the end of the waiting line. I heard the clock bell at 7:30 am, 8:00am [and every half hour] until 9:30am. I got up at 3:30 am and waited 6 hours only to get one copy of the LIFE magazine."[255]

The information gathered that day lacked technical details, but nonetheless circulated in the laboratory. Many issues he acquired only introduced luxurious, comfortable rail service in the United States and Western Europe.[256] Takabayashi's experience was apparently not an isolated incident. Miki had a similar experience when he developed lightweight seats for the high-speed Romance Car. In the mid-1950s, he visited Haneda Airport in Tokyo to examine seats installed in commercial aircraft, such as the Douglas DC4 and British Comet. His wife translated the English for him, but information gathered at the site was not very useful in the high-speed rail project.[257]

In sum, the JNR capitalized on at least three patterns of technology transfer from 1950 to 1957 as illustrated in my three case studies. The industry's effort to develop lightweight,

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[255] Morihisa Takabayashi, Letter to author, 7 July 2003.

[256] "Astra Dome Train," *LIFE: International edition* 3, no. 1 (1947), "Diesel Locomotives," *LIFE: International edition* 2, no. 12 (1947), "The Talgo," *LIFE: International edition* 26, no. 17 (1949).

[257] Miki, Miki and Takabayashi, "Keiryō Reclining Seat Shisaku Hōkoku,"16-17.

all-steel rail cars formed the first pattern; it was a successful product of the strategic, orchestrated transfer of technology from overseas. In electrifying the public railways, however, the JNR pursued a somewhat different pattern of technological transfer. Development in this case required a delicate combination of technology transfer from France and technological ingenuity nurtured before and after the war. The third pattern of technology transfer analyzed here was diffusion of wartime aeronautical technology within the RTRI. The end product, Odakyū Romance Car, was phenomenally successful and established world records for high-speed test runs in 1957. In all these cases, wartime military technology supported technological transformation in the industry; former military engineers demonstrated remarkable adaptability and flexibility in utilizing their wartime engineering knowledge at the grass-roots level. Their decisions and actions helped shape the contours of technology transfer in the three cases.

Placed in a larger framework, these findings serve as a warning for historians who focus solely on the top-down initiatives in explaining the technological development of modern Japan. Many Japan scholars have examined the extant records of patents, license agreements, budget records, memos, or any other quantifiable data that were part of a formal, top-down, and organizational attempt in industries to introduce technology from abroad.[258] Government officials, industrialists, and entrepreneurs have tended to document their decision over the years and activities in the process. These written records, if preserved safely and properly, can last fairly long for later historians to examine. Arguably, so much academic attention to this aspect of technology transfer helps perpetuate the overweening image of industrial Japan as a copier of foreign technology. I have suggested that informal and contingent diffusion of engineering knowledge had less chance to be documented and thus studied by later historians. This is unfortunate because the unplanned diffusion of technology and an explicitly planned technology transfer were equally vital for technological transformation, at least in the Japanese railway industry and quite literally like elsewhere. More often than not, idiosyncratic, incidental movement of engineering knowledge has been seen as a preordained outcome in management's and historian's retrospective thinking.

From 1950 to 1957, as I have argued, the former military engineers were vital not only in the postwar reconstruction but also in technology transfer. Their presence and role were vital in the three types of technology transfer for high-speed rail service, which I have highlighted. The planned technology transfer from abroad for developing lightweight, all steel rail cars, the

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[258] See, for instance, Katsuhiro Arai, "Gijutsu Dōnyū," in *Tsūshi: Nihon No Kagaku Gijutsu* (Tokyo: Gakuyō shobō, 1995).

combination of technology transfers from abroad and inter-disciplinary technology transfers at home for electrifying the national railways, and interdisciplinary technology transfers as in Miki Tadanao's laboratory — all formed the requisite bases for the subsequent high-speed rail project.

The somewhat limited effectiveness of top-down management in leading Japan's technology transfer and development during the early 1950s becomes more evident in the high-speed bullet train project. The next chapter will examine the crucial role of wartime military engineers in developing this potent symbol of technological modernity between 1957 and 1964.

CHAPTER 5

TECHNOLOGICAL MODERNITY AND THE BULLET TRAIN CONSTRUCTION, 1955-1964

In the fragmented political climate of 1945 to 1955, the foregoing chapters argue, former military engineers actively took steps in developing peace-oriented technology. In solving many technical problems that plagued the postwar railway industry, they adeptly drew on their wartime experience and successfully developed a niche in their new organization. The three cases of technology transfer demonstrated remarkable adaptability and flexibility on the part of the engineers involved, not to mention their knowledge. These circumstances help explain why the reconstruction of the industry from 1945 to 1955 was both fast and phenomenally successful. There is more to the story, however, in terms of the mutable nature of the engineering and engineers who contributed markedly to the nation's technological transformation after 1955. The Japanese bullet train development in the postwar era provides an illustrative case of ordinary engineers at the grass-roots level actively molding values for modern technological transformation in their society; their wartime engineering knowledge and experience provided them with a technical means to that end. This chapter continues to present the need for a focus on the engineers themselves — a perspective that stresses the actual agents of the technological development who tailored their wartime experiences to specific needs of the period with remarkable adaptability and flexibility.

A more reasonable understanding of the technological development during this period, as this chapter argues, needs to take into account the independent judgments of engineers, the political economy within which they made their choices, and the structure of decision making both in and out of the RTRI. The railway industry as a whole lacked a coherent, technically feasible, long-term traits of high-speed rail service before 1955. Only after that year did situations improve as a result of a change in JNR leadership and the rise of former military engineers in the industry. The engineers, the JNR, and government bureaucrats began to bring forth different yet reconcilable interests in high-speed rail service; after all, each player successfully capitalized on what the others could bring to the table. The bullet train project, as a result, embodied a successful but temporary marriage of convenience among parties on the developmental side. The process exemplifies the crucial role of decision-making and action by former military engineers. Irrespective of some linear, teleological path of modern technological development, the engineers actively shaped the process, being guided by such values as speed, safety, and reliability. These values, which seemed until that time technically irreconcilable, were empirically and successfully harmonized with the invaluable help of former military engineers' wartime knowledge and experience.

5.1 A Brief History of High-Speed Rail Service, 1918-1955

Before 1955, the industry launched engineering initiatives for long distance, high-speed rail service with limited success. Inter-city transportation over short- and medium-distances was dominant before 1945, while long-distance rail service made some steady progress. For instance speed increased on the main Tōkaidō Line, providing the most convenient, and the safest way of transportation from Tokyo to Osaka. From 1890 to 1916, the average speed increased annually by 0.83km per hour.[259] This gradual technological progress can be summarized as follows:

[259] Akemichi Takei, "Honkuni Tetsudō Ressha Sokudo No Hattatsu," *Kikai gakkaishi* 41, no. 251 (1938).

Year	Designation	Distance	Speed (km/hr)
1890		Shimbashi (Tokyo)－Kobe	30.1
1896		Shimbashi(Tokyo)－Kobe	34.8
1903		Shimbashi (Tokyo)－Kobe	39.4
1906		Shimbashi (Tokyo)－Kobe	44.2
1907		Shimbashi(Tokyo)－Shimonoseki	45.3
1912		Shimbashi (Tokyo)－Shimonoseki	47.3
1919		Tokyo—Kōbe	51.2
1923		Tokyo—Shimonoseki	53.3
1930	Tsubame (Sparrow)	Tokyo—Kōbe	67.5
1949	Heiwa (Peace)	Tokyo—Osaka	61.9
1950	Tsubame and Heiwa	Tokyo—Osaka	68.6

Table 5.1: Transformation of Rail Service on the Tōkaidō Line[260]

Apart from this gradual progress, the government launched a bullet train project before 1945 that had many political implications.[261] At the center stage was the Ministry of Railways that established the Committee for Constructing a New Trunk Line (Shin senro kensetsu junbi iin) in June 1939.[262] Subsequently, the Sub-committee for Investigating a New Trunk Line (kansen chōsa bunkakai) inherited the project and explored the technological feasibility of a new line between Tokyo and the western end of Honshu, that is Shimonoseki. In July 1939 the

[260] Tetsu Nishitani, "Tokaidō-Sen Ressha Sokudo No Hensen," *Kōtsū gijutsu* 126 (1956): 17-18.

[261] For a detailed, well-informed account of the prewar bullet train project, see Takanori Maema, *Dangan Ressha* (Tokyo: Jitsugyō-no-nihonsha, 1994).

[262] Nihon kokuyū tetsudō, *Kokutesu Rekishi Jiten* (Tokyo: Nihon kokuyū tetsudō, 1973), 71.

Research Committee for a New Rail Line (tetsudō kansen chōsakai) was formed with representatives from various ministries and specialists in the field. The resulting proposal argued for the need to build a new trunk line and was submitted officially to the Minister of Railways in 1939. This marked the beginning of the prewar bullet train project, a massive national plan based on the construction of the standard track gauge of 1,435 mm (4 feet 8 1/2 inch) in width. The initiative capitalized on the prevailing atmosphere of national emergency. That same year parliament approved the construction budget, allocating 560 million yen for its completion, which was expected by 1940.[263]

This project, however, failed in many respects. The technological blueprint embodied both realistic and unrealistic elements. On the realistic side, engineers planned for an electrical locomotive pulling coach cars from Tokyo to Osaka, then substituting a steam locomotive to haul coaches from there to Shimonoseki on a standard gauge track.[264] To that end, parts of the Tokyo-Shimonoseki distance were to be electrified. Consequently a study group (Shinkansen denki setsubi kenkyūkai) was established in December 1940, which planned for direct current electrification using a voltage of 3000 watts. An alternate current system was not adopted

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263 *Shinkansen 10-Nen Shi* (Tokyo: Nihon kokuyū tetsudō shinkansen sōkyoku, 1975), 4.

264 "Shinkansen Kakū Densha Senro Kenkyū Hōkoku," *Tetsudō gyōmu kenkyū shiryō* 2, no. 11 (1943): 2-3, Nihon kokuyū tetsudō-hen, *Tetsudō Gijutsu Hattatsushi*, 10 vols., vol. 1 (Tokyo: Kuresu shuppan, 1990), 151.

because the industry, lacking experience in the field, did not find reliable electrical motors overseas.[265] Developing a suitable domestic AC motor did not seem possible at the time.

Non-technical leaders at the time also lacked a realistic sense of what speeds were possible, and the engineers understood this. In retrospect, the plan reflected the wishful thinking of a nation at war. The locomotive vehicle was to run the Tokyo-Shimonoseki distance within 9 hours and 50 minutes, and the Tokyo-Osaka distance within 4 hours and 50 minutes.[266] The requisite speed would have been 150km/hr for cruising, and 200km/hr for maximum performance. Engineers believed that all the curtains should remain closed during high-speed run because fast-moving landscape would cause vertigo to passengers.[267] These numbers were set rather arbitrarily with little technical justification; the top speed seemed possible because European nations had attained that on experimental high-speed runs. Few in Japan seem to have been aware of the formidable engineering tasks ahead. For instance, the industry's obsession with streamlining was mostly a product of design fashion during the 1930s. There was little solid research in aerodynamics on which to base the project. The Tokyo University Aeronautical Research Institute welcomed the industry's requests for wind tunnel experiments to weather a

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[265] Nihon kokuyū tetsudō-hen, *Tetsudō Gijutsu Hattatsushi*,154.

[266] Ibid.,134.

[267] Shigeru Fujishima, "Shinkansen Jisoku 200-Kiro No Missitsu," in *Bungei Shunjū Ni Miru Shōwa-Shi* (Tokyo: Bungei shunjū, 1988), 568.

financially difficult time. Many assumptions employed in their empirical studies were questionable.[268] The prewar bullet train seemed promising for the industry, but the Japanese-American war ended the project and left behind little technological legacy for the future. After 1945, somewhat romanticized memories of the project resurfaced when they were useful for rhetorical, political purposes.

5:2 JNR Management, 1955-1956

Whether wartime or peacetime, society's leaders are free to dream about the contributions of technology to society and the roles of engineers in their collective "vision." They can imagine any world that they believe they could create if given the opportunity. Whether their visions are technologically possible to realize, however, is a different matter altogether. It is typically the management, not ordinary engineers, who write personalized accounts of such projects retrospectively. Their diaries, memoirs, and papers are available for later historians and popular writers alike to use in reconstructing the past. Within this context, management's vision, however unrealistic at the time technologically, may well emerge as a self-fulfilling prophecy in

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[268] "Ryūsenkei Sharyō Mokei No Fūdō Shiken Seiseki Ni Tsuite," *Gyōmu kenkyū shiryō* 25, no. 2 (1937).

the minds of writers of a Whiggish persuasion.

Many available bullet-train stories illustrate this point. Staunch advocates for the standard gauge, vis-à-vis the narrow gauge, commonly receive recognition as visionary architects of a high-speed rail project. However, all rail tracks for commercial service used the narrow gauge of 1,067mm (3 feet 6 inch) until the late 1950s. This cheaper alternative had a British lineage, as in South Africa and New Zealand. Japan's first rail track in 1872 adhered to the British style, forming the basis for extensions thereafter. Forces to counter this failed in the political arena. Military authorities of the first Itō Cabinet mounted the first effort to convert to standard gauge in the 1890s.[269] Gotō Shinpei (1857-1929), the first Director-General of the Railway Agency (Tetsudōin sōsai) in 1908, followed suit after the nationalization of the railways. His proposal for reconstructing railways to standard gauge garnered financial support, roughly 230 million yen, from the Railway Congress (Tetsudō kaigi). The bill, as it turned out, did not pass amid the intense political debate of the time. But Gotō did not leave the scene empty handed. The Committee for Reconstructing Railways on the Standard Gauge (Kōki tetsudō kaichiku junbi iinkai) was established to investigate technological and economic gains from converting to the standard gauge.[270] Shima Yasujirō (1870-1946) was appointed Chief Engineer in 1918 to

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[269] Nihon kokuyū tetsudō-hen, *Tetsudō Gijutsu Hattatsushi*.

[270] Shima, *D-51 Kara Shinkansen Made: Gijutsusha No Mita Kokutetsu*,41.

lead the project. In 1925, for instance, he pointed out the prospect savings from conversion to the standard gauge, arguing that this could provide industry with faster service and more transport capability.[271] The engineering issue generated a heated political battle with a ripple effect in the engineering community. Soon many civil engineers supported the standard gauge, whereas many rail car engineers embraced the other alternative.[272] But the government rejected the standard-gauge plan, effectively marginalizing its supporters along the way.

Nonetheless, the construction of the standard gauge received a top priority in the railroad industry after 1955. This was possible primarily because Sogō Shinji (1884-1981), a strong advocate for the standard gauge, headed the JNR from 1955 to 1964. The new President, a graduate of the Tokyo University Faculty of Law, accumulated management experience in various organizations, including the South Manchurian Railway. In 1955, Sogō brought back Shima Hideo (1901-1998), an engineer who had left the organization after the catastrophic train accident in 1951. Upon return, Shima advised the non-technical leadership as the highest ranking engineer in the industry, but lacked the authority to lead rail projects in any given year.[273]

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[271] Yasujirō Shima, "Tetsudō Kikan No Sunpō to Sharing No Kidō Ni Taisuru Atsuryoku No Kankei," *Kikai gakkaishi* 28, no. 95 (1925).

[272] Nihon kokuyū tetsudō-hen, *Tetsudō Gijutsu Hattatsushi*,86.

[273] Shima Hideo ikōshū henshū iinkai-hen, ed., *Shima Hideo Ikōshū: 20-Seiki Tetsudōshi No Shōgen* (Tokyo: Nihon tetsudō gijutsu kyōkai, 2000), 114.

Trained as a mechanical engineer, Chief Engineer Shima shared Sogō's view toward the standard gauge. Shima inherited this mindset from his father, Shima Yasujirō, and Sogō from his protégé Gotō Shinpei.

The new JNR management adhered to the standard-gauge thinking as a way to increase transport capacity. Under Shima's leadership, the Committee for Increasing Transport Capacity on the Tōkaidō Line (Tokaido kansen yusō zōkyō chōsakai) was established on in May 1956. The 23 committee members held a series of meetings, analyzing the future economic prospects of the transport service. Their investigation painted a grim picture. Parts of the major trunk line had already attained 90 percent of their maximum carrying capacity; by 1965, passenger service was expected to increase by 40 percent and, cargo operation by 32 percent; this meant an increase of 30 to 40 percent overall.[274] Sogō and Shima apparently tried to build consensus for the construction of the standard gauge. From late 1955 to early 1956, for instance, the JNR President essentially became a sales representative. He stored a stack of thin pamphlets for the standard gauge in his car, and hand-delivered them whenever he met pertinent officials.[275] For Shima, it seemed convenient to combine the prewar bullet train project on the standard gauge

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[274] *Shinkansen 10-Nen Shi*,5

[275] Sōkichi Ariga, *Sogō Shinji* (Tokyo: Sogō Shinji-den kankōkai, 1988), 499-501.

and electrical rail cars.[276] But their attempts failed. The committee proposed plausible alternatives, including doubling all the narrow-gauge government lines, converting to the standard gauge, and electrifying all the rail lines.[277] The impending task seemed to focus on how to add rail tracks in the most congested areas, or devising ad hoc solutions in the industry nationwide. On the other hand, the JNR leadership announced a highly optimistic plan for high-speed rail service on the Tokyo-Osaka line within two and half hours.[278] The planning on paper apparently lacked solid, technical justification. Virtually no one in management envisioned anything like the way the bullet train actually developed after 1957.[279]

5.3 Engineers at the Railway Technical Research Institute, 1955-1957

Management and engineers often acted independently to maximize their gains, developing different alternatives for technological development. Their projects essentially co-evolved at various points in time. In the process, several senior engineers at the RTRI capitalized on their wartime experiences for their own needs. They bridged the gap between the

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[276] Shima, *D-51 Kara Shinkansen Made: Gijutsusha No Mita Kokutetsu*,113.

[277] Nihon kokuyū tetsudō, *Kokutesu Rekishi Jiten*,71.

[278] *Asahi shinbun*, 14 February 1956.

[279] Shima Hideo ikōshū henshū iinkai-hen, ed., *Shima Hideo Ikōshū: 20-Seiki Tetsudōshi No Shōgen*,148.

wishful thinking of the top leadership and technological reality with their wartime expertise. Neither Sogō nor Shima alone determined the path of technological development leading to the bullet train, nor did the technology's internal logic define its use. As shown in Chapter 4, former military engineers were initially ineffective in promoting the needs for high-speed rail service within the industry. In 1957, they found it necessary to reach out further beyond the industry for effective, public expression of their thinking. The engineers believed that the world could change to their advantage; for them, the bullet train was the transformative agent.

This development derived partly from Ōtsuka Seishi, the head of the RTRI from 1949 to 1957. This graduate from the Tokyo University Department of Engineering accumulated experience mainly on the factory floor. He encouraged new research initiatives, actively seeking ways to utilize relatively young laboratory leaders fully. Recalling Ōtsuka's efforts, Matsudaira Tadashi credited him highly for developing the basic research needed for a high-speed train.[280] The director had many qualities that made him a leader — including paternalistic concern for younger associates. For instance he hired part-time, young female assistants to support many time-consuming physical experiments. Occasionally, he illicitly channeled small sums of money from an office fund in the compound to the RTRI, purchased snacks for business meetings, and

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[280] Tetsudō gijutsu kenkyūjo-hen, *Tetsudō Gijutsu Kenkyūjo Sōritsu 70-Shūnen: 10-Nen No Ayumi*,281, 84.

solicited projects from outside. He eliminated much of the bureaucratic paper that had impeded research projects.[281]

Ōtsuka's efforts accentuated the increasingly incompatible perspectives between the periphery RTRI and JNR headquarters. For one, he encouraged articles about the high-speed rail projects in major newspapers without consulting the headquarters ahead of time. The resulting Toshimaen monorail vehicle and the Odakyu Romance Car created thorny issues within the JNR structure (see Chapter 4). The two discordant parties also remained at loggerheads over how to renew the RTRI. In May 1956, they discussed three alternatives — either to centralize all the dispersed RTRI facilities in Hamamatsu-cho or Kunitachi city, or decentralize them in three different locations — as a way of fortifying the research foundation. Chief Engineer Shima promoted the remote location of Kunitachi as the main center for research. The renewal plan, as formulated in 1956 for two-year period of construction, met strong opposition from some RTRI engineers and Ōtsuka.[282]

In January 1957, a new RTRI director inherited the shabby research system. Upon his first visit, Shinohara was flabbergasted by "the utterly dismal, disorderly state of research and

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[281] Miki, Hiroshi Nakamura, Interview by author, 29 April 2004, Kazuo Nakamura, Interview by author, 07 November 2002. Needless to say, personal experiences with the Director are inherently subjective, ranging from pleasant to unpleasant. But my characterization seems fairly reasonable even given some personal accounts by anonymous informants who opposed to him in various ways.

[282] Nihon kokuyū tetsudō tetsudō gijutsu kenkyūjo-hen, *10-Nen No Ayumi: Sōritsu 60-Shūnen* (Tokyo: Tetsudō gijutsu kenkyūjo, 1967), 212.

development.” “Principal laboratories,” his memoir reads, “were small, dark, depressing.” He found no researchers in the building, but soon learned that they were behind the walls of stacked dusty books, busy conducting experiments. The experience made him think seriously about quitting his directorship altogether. But research blossomed at the RTRI after the arrival of the new director. This graduate from the Department of Civil Engineering at the University of Tokyo was, in his words, “a complete novice in research and development.” With managerial experience, he actively sought ways to utilize former military engineers more fully.[283]

In this milieu, a major, initial momentum developed at the RTRI for the subsequent bullet train project. The 50th anniversary of the establishment provided a timely opportunity. For the occasion, Shinohara integrated various, separately conducted research projects for a public forum about high-speed rail service. In May 1957, the four laboratory leaders — Miki Tadanao, Matsudaira Tadashi, Kawanabe Hajime, and Hoshino Yōichi — argued for technological feasibility of operation over the Tokyo- Osaka distance within 3 hours. Their project did not counter the headquarters’ thinking, but supported it. The task force originally aimed for high-speed operation throughout the country; but to avoid a quixotic image, they restricted their

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[283] Takeshi Shinohara and Hideshige Takaguchi, *Shinkansen Hatsuansha No Hitorigoto: Moto Nihon Tetsudō Kensetsu Kōdan Sōsai Shinohara Takeshi No Network-Gata Shinkansen No Kōsō* (Tokyo: Pan research shuppan, 1992), 82-83.

plan to the inter-city operation.[284] This strategy proved effective. Each senior engineer covered his own domain of technical expertise, explaining in turn an optimistic yet feasible prospect of the project. Each speaker used many visual aids, such as tables and diagrams, and explained his technical rationale in lay terms. Shinohara's opening statement was followed by Miki Tadanao's presentation. The former aeronautical designer rightly emphasized the crucial role of aerodynamically refined, light vehicles for the project. Hoshino Yōichi followed suit, arguing that newly developed steel rails could effectively sustain the high-speed operation. Kawanabe Hajime, a wartime Army engineer, proposed a sophisticated signaling system for providing unprecedented safety. Lastly, Matsudaira Tadashi, a former aeronautical engineer, maintained that train vibrations were reducible for the high-speed operation. At the end of the forum, a short documentary film showed an experimental high-speed run in France that established the world record of 331km/hr.[285] The tool helped convince the lay audience that the presentations were both realistic and technically feasibility. The forum was a phenomenal success. An ovation from the over 500 people in attendance attested to a social expectation for more convenient, faster overland travel.

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[284] Yōichi Hoshino, "Kidō No Kōzō," *Kōtsū gijutsu* 135 (1957), Tadashi Matsudaira, "Anzen to Norigokochi," *Kōtsū gijutsu* 135 (1957), Tadanao Miki, "Sharyō Kōzō," *Kōtsū gijutsu* 135 (1957), Shinohara and Takaguchi, *Shinkansen Hatsuansha No Hitorigoto: Moto Nihon Tetsudō Kensetsu Kōdan Sōsai Shinohara Takeshi No Network-Gata Shinkansen No Kōsō*,85.

[285] Nihon kokuyū tetsudō tetsudō gijutsu kenkyūjo, *Tokaido Shinkansen Ni Kansuru Kenkyū*,5-6.

The success created a windfall opportunity for the RTRI and enabled it to sell the project directly to the top leadership. By invitation, the engineers made the same presentation, this time primarily for President Sogō who could not attend the forum. Shinohara unintentionally, but effectively capitalized on the top leadership's faith in the standard gauge. He rightly pointed out the need for the internationally standard gauge as a means of helping the industry's export in years to come.[286] This thinking essentially proved convenient for selling the project to Sogō. During the presentations, his interest lay in the width of the gauge for the project; in fact he made this clear sure through direct questioning. At least for the President, the construction of the standard gauge was apparently the end, rather than the means, of the high-speed rail service. To sell the project, Miki Tadanao, the most vocal and senior among the four engineers, took advantage of the increased competition from other modes of transportation. Commercial air travel began in July 1951 with the establishment of Japan Air Lines, Inc. The automotive industry was also displaying signs of growth in a revitalized postwar economy. The planned construction of major highways, such as one over the Tokyo-Kobe distance, alarmed the railway industry. Appealing to Sogō, Miki strongly argued that the bullet train project was the only way to combat this growing competition, salvage the railway industry, and keep it from going deeper

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[286] Shinohara and Takaguchi, *Shinkansen Hatsuansha No Hitorigoto: Moto Nihon Tetsudō Kensetsu Kōdan Sōsai Shinohara Takeshi No Network-Gata Shinkansen No Kōsō*,96.

into the red.[287] His belief, or tactic, proved successful. Sogō endorsed the proposal entirely, and consequently garnered political and economic support. The RTRI engineers and the JNR leadership who wanted to promote technological modernization had completely agreed on the best means to do so.

One curious, unintended consequence was essentially the reversal of the original center-peripheral relationship between the RTRI and the JNR headquarters. The RTRI became the center and the leader of the technological transformation, whereas the headquarters provided requisite support. Many of the technological blueprints as presented in 1957 formed the basis of the development in the years that followed. Based on a series of meticulous calculations, the original RTRI proposal articulated detailed features for high-speed operation, such as the motor system, the main motor device, the control system, the brake mechanism, the average axel weight, the material used in constructing rail cars, car body size, the maximum speed of operation, wheel diameter, the distance between axels, the running gear mechanism, and the signaling system. As Table 5:2 shows, with some modifications aside, most of the mechanics as in the brake system, the car features, the running gear, and the signaling system have remained essentially the same across the different models of the bullet train since 1957.

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[287] Miki, interview by author, 1 August 2003; and Uchihashi, *Zoku Zoku Takumi No Jidai: Kokutetsu Gijutsujin Zero Hyōshiki Kara No Nagai Tabi*.

	Original RTRI proposal (1957)	Model 0 (in service since 1964)	Model 300 (since 1990)
Motor system	All motor electric cars	All motor electric cars	10 motor cars and 6 non-motor cars
Main motor (kw)	DC125-160V	DC180V	AC300V
Control system		Low pressure tap-control	Variable voltage variable frequency inverter
Brake system	ATC/dynamic regeneration brake	ATC/dynamic brake	ATC/regeneration brake
Car body size (height x width)	3.0m x 3.0m	4.0m x 3.38m	3.65 x 3.38m
Average axel weight	12-13 ton	15 ton	11.3 ton
Car body material	Anti-corrosive light alloys・plastic	Anti-corrosive steel plate	Aluminum alloy
Maximum speed	250 km/hr	220 km/hr	270 km/hr
Wheel diameter	Flexible wheels with rubber	910	860
Axel Distance	Interlocked	2500mm	2500mm
Running Gear	hydraulic air spring air-filled bellow with leveling valve	Metal spring air-filled bellow	Metal spring air-filled bellow
Signaling System	Automatic Train Control	Automatic Train Control	Automatic Train Control

Table 5.2: The Blueprint of the High-speed Rail Project in 1957 and Beyond[288]

[288] Shin'ichi Tanaka, "Shinkansen Sharyō: Sono Kaihatsu No Zengo," *Denki gakkai kenkyūkai shiryō* (2002): 20.

Sogō helped the RTRI engineers gain what they had wanted, namely modern research and development facilities. Shinohara originally planned for 10-story high rise buildings to provide housing for more than 200 families, and a recreation center.[289] To this end he argued that the world's best rail service would be possible only with the world's best research institute. After the groundbreaking in 1958, it took only one year for up-to-date research and development facilities to be relocated to the new, modern institute in Kunitachi. Remaining facilities became functionally operational and ready for use in June 1963.

5.4 Marriage of Convenience: The Japan National Railways and the Government, 1957-1961

A national project as expensive and massive as the bullet train inherently required government support. The construction was projected to cost 172.5 million yen (roughly 4.8 million dollars), more than one-tenth of the general account budget for the year 1957. This enormous expenditure, some claimed, would be a waste in the modern age of highway and airborne transportation. Critics claimed that the bullet train project was quixotic as the Great Wall of China, the Pyramids of Egypt, and the giant battleship Yamato — all historic and

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289 Nihon kokuyū tetsudō tetsudō gijutsu kenkyūjo-hen, *10-Nen No Ayumi: Sōritsu 60-Shūnen*,213.

grandiose, but very costly and practically meaningless.[290] The government nonetheless provided the JNR with some support because the project offered a promising, convenient way to solve certain legal problems of the time. Put simply, the government largely took advantage of an opportunity. The promising engineering project by the RTRI drew together disparate actors — the engineers, the JNR management, and government officials. Only after a genuine convergence of political interests did the three parties deploy their expertise in developing the mutually beneficial proposal. Overall, the JNR and the government did not lead, but rather facilitated the process after the fact.

The JNR management devised ad hoc plans to improve the industry's development. Following the government's five-year plan that aimed at economic growth, the JNR implemented its own 5-year plan beginning in 1957. They contemplated a total expenditure of 598,600 million yen (1.6 billion dollars) for replacing worn out facilities and rolling stock; providing more comfortable, safer, and faster service; and increasing the transport capacity of the time to 139 percent of passenger and 134 percent of freight traffic.[291] The bullet train was not part of the picture. However, the First Five-Year Plan soon failed to accommodate the accelerated pace of

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[290] Shinohara and Takaguchi, *Shinkansen Hatsuansha No Hitorigoto: Moto Nihon Tetsudō Kensetsu Kōdan Sōsai Shinohara Takeshi No Network-Gata Shinkansen No Kōsō*,4 98.

[291] Japan National Railways, "General Statement Supporting the Loan from International Bank for Reconstruction and Development," (1959), 11; Kubota, "Sengo Nihon Tetsudōshi No Ronten," 43.

industrial growth. Industry's phenomenal development was beyond management's expectation. Consequently, the JNR aborted the First Five-Year Plan after four years. In 1961, they launched a Second Five-Year Plan. The budget doubled for constructing the bullet train and for increasing transport capability on the then existing railways. But this initiative again fell short in the fourth year as the bullet-train construction costs increased.[292]

These unsuccessful plans were a product of the industry's understandable concern over the Tokaido Line. It carried an annually increasing volume of passengers and freight as the nation's main artery of inland traffic. The line handled 24 percent of passenger traffic and about 23 percent of freight traffic within the JNR's total volume. Transport capacity had almost reached its limit. The route length of this line was only 590km (367 miles), or about 2.9 percent of the total kilometer length of the entire system. But the districts served by this line accommodated roughly 40 percent of the country's entire population, and helped produce over 60 percent of the nation's total industrial output. The rate of annual increase, both in population and production, was higher in these districts than the nationwide average.[293] The then available railway infrastructure was unable to accommodate projected growth. When compared to the 1957 figures,

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[292] Kubota, "Sengo Nihon Tetsudōshi No Ronten," 44.

[293] Japan National Railways, "General Statement Supporting the Loan from International Bank for Reconstruction and Development,"36.

the volume of passenger and freight traffic on the Tokaido Line in 1975 was expected to increase by 200 percent. The range of plausible solutions remained severely limited. Operating additional trains, increasing the number of cars per train, speeding up trains through electrification, raising the hauling capacity of locomotives, and constructing additional tracks in some sections — all these initiatives essentially shared the same parameters. Within this constraint, the maximum frequency of train operations one way per day was limited to about 120.[294] Delayed completion of the bullet train project could incapacitate the trunk line as a whole, and would likely paralyze national transport with a serious effect upon the national economy.

About 1957, a legal dispute over land pushed the JNR to carry out the bullet train project speedily. In July 1958, the judges in the Supreme Court unanimously concluded that landowners were entitled to the use of their landed property when it was not used by the JNR for "public" use at the time. This legal case had its genesis in particular legislation, the Special Measure for Independent Farming (Jisakunō tokubetsu sochihō), part of the land reform during the Allied Occupation. Originally, the JNR obtained remote farm lands though a 3-year loan for use in food production to feed its employees. Under the aegis of the law, the government purchased lands across the country from December 1946 to July 1952. They did this as a way to

[294] Ibid.,39.

help dismantle the landlord system and encourage owner-occupied farming. The local landowners filed a civil lawsuit, arguing that the purchase agreement between the two parties was null. The JNR fought back by turning to the legality of landownership. In July 1958, the Supreme Court ruled that the JNR had used the contested land for “private” use—and that the land usage should be limited only to enterprise activities.[295] This court decision essentially required the JNR to return to owners all the lands that did not fall within these parameters.

In this fairly urgent situation, the government finally decided to assist the bullet train project. In August 1957, a consultative body was established in the Ministry of Transportation. The resulting Committee for Investigating the Trunk Line (Nihon kokuyū tetsudō kansen chōsakai) consisted of 35 experienced members and 10 secretaries. They produced their first recommendations in three months; and in July 1958, they submitted a final report to the Minister. It urged the construction of the high-speed rail service with the AC electrical system, and a new standard-gauge track on the Tokaido Line.[296] In the meantime, Prime Minister Kishi set up the Council of Ministers Concerned with Transportation; it consisted of the Finance, Agriculture and Forestry, International Trade and Industry, Transportation, Construction Ministers, together with

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[295] Hōmu daijin kanbō shihō hōsei chōsabu shihō hōsei-ka, *Saikō Saibansho Hanreishū*, vol. 12 (Tokyo: n.p., 1958), 123-39.

[296] *Shinkansen 10-Nen Shi*,6, Japan National Railways, "General Statement Supporting the Loan from International Bank for Reconstruction and Development,"41.

Director-Generals of the Board of Hokkaido Development, and Economic Planning Agency, and the Secretary General.[297] The Council submitted a plan called the "System of Land Transportation between Tokyo and Osaka" to the Cabinet for approval in December 1958.[298] In March 1959, the 31st session in the Diet approved the budget for the bullet train project, appropriating 3 billion yen.[299] Probably no one was more elated by the approval than President Sogō. At the solemn Shinto-based groundbreaking ceremony the following month, he struck the ground with a riding hoe. At this powerful swing, a chrysanthemum fell off from his chest pocket, and the hoe's head flew off.[300]

Constructing the new Tokaido Line would have been impossible had the JNR leadership depended entirely on domestic funds. They actively sought financial support from the World Bank. A World Bank loan required the government's commitment to the monumental engineering undertaking; with approval, regardless of the amount, the government would be obligated to finance the project continuously until its completion.[301] The JNR leadership took

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297 Japan National Railways, "General Statement Supporting the Loan from International Bank for Reconstruction and Development,"41.

298 Ibid, Nihon kokuyū tetsudō, *Kokutesu Rekishi Jiten*,70.

299 *Shinkansen 10-Nen Shi*,8

300 Ariga, *Sogō Shinji*,580-81, Nihon kokuyū tetsudō Shinkansen sōkyoku, *Shinkansen: Sono 20-Nen No Kiseki* (Tokyo: Nihon kokuyū tetsudō Shinkansen sōkyoku, 1984), 43.

301 Shima Hideo ikōshū henshū iinkai-hen, ed., *Shima Hideo Ikōshū: 20-Seiki Tetsudōshi No Shōgen*,146.

advantage of this requirement, rather than the actual financial support, of the World Bank to advance its needs. Their political suasions were successful. The then Minister of Finance, Satō Eisaku, officially asked the World Bank for a loan in November 1959. In May 1960, the JNR hosted a team from the World Bank that investigated the railroad industry's economic viability and the future prospects of the bullet train project. At least initially, they were openly dubious about the industry's technical capabilities. President Sogo took them on a tour at the RTRI, showing them the state-of-the-art research equipment for relevant engineering fields. This helped the JNR earn more confidence from the World Bank team.[302] Eventually, Sogo and President of the World Bank signed on to the loan agreement in May 1961 for over 80 million dollars (28.8 billion yen), the largest amount theretofore granted to Japan.[303] Annual interest of 5.75 percent was to be due in full within 20 years, but the arrangement seemed reasonable.[304] After all, the JNR management provided the government with appropriate administrative guidance, not the other way around.

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302 Ariga, *Sogō Shinji*,602.

303 Yoshihiko Satō, "Sekai Ginkō Ni Yoru Tokaido Shinkansen Project No Hyōka," *Tetsudō shigaku* 19 (2001): 70.

304 *Shinkansen 10-Nen Shi*,8

5.5 Configuring Technological Modernity, 1957-1963

Arguably, no product gives as graphic a reminder of the technological modernity of postwar Japan as the bullet train. This image of modernity was pluralistic and collectively produced. Many different types of accounts surround modern technological experience, and the particular vehicle was no exception. Modernity can be seen as the inscription of a pattern of 'modern' technological values, a means specified to guide decisions and actions in different spheres. In the case of the bullet train, producers of such values were chiefly former military engineers at the RTRI. The military heritage of the bullet train has been, albeit superficially, written in Japanese, but the remaining chapter aims to show how the engineers as introverted problem solvers helped construct this potent symbol of technological modernity. The following bullet train story, at best, represents only one account of technological modernization. It nonetheless offers an instructive case about how experts constructed a particular physical artifact with little regard to similar technological developments overseas.

Much of the requisite technology for the high-speed rail service derived from eight research groups at the RTRI. They amply demonstrated their skills in solving a large number of technical issues, by some accounts a total of 173 such challenges:

Research Topics	Number
Rails	25
Vehicle	29
Operation	17
Brake system	18
Overhead wire mechanism	25
Alternate Current system	18
Signaling system	19
Automatic operation system	22
Total	173

Table 5.3: List of Major Research Topics for the Bullet Train Project[305]

During the years 1957-1963, the bullet train was still experimental, and even the experts had only a vague notion of the shape it would have. The process embodied specified guiding values — namely speed, safety, and reliability — which reflected their military lineage in considerable degree. These values were admittedly a biased, somewhat institutionalized version of modern technology, but the configuration differed slightly from that of the JNR management. For instance, a cost variable was conspicuously absent among the engineers but occupied Chief Engineer Shima's mind to a considerable degree.[306] Groups

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305 Nihon kokuyū tetsudō tetsudō gijutsu kenkyūjo, *Tokaido Shinkansen Nikansuru Kenkyū*, 6 vols., vol. 4 (Tokyo: Nihon kokuyū tetsudō tetsudō gijutsu kenkyūjo, 1964), 1.

306 3S (speedy, safe, and sure) + 3C (comfortable, carefree, and cheap) 3S (speedy, safe, and sure) + 3C (comfortable, carefree, and cheap) Hideo Shima, "Shinkansen No Kōsō," in *Sekai No Tetsudō* (Tokyo:

naturally shared specific beliefs about what technology ought to be like. Those who wrestled with this puzzle thought of the vehicle as doing duty in their familiar domain of expertise. In the bullet train project, military engineering played a crucial role in reconciling often competing logics of experience. Former military engineers crystallized the set of guiding values and, above all, helped construct a solid technological basis for the period and beyond. It therefore seemed appropriate to look closely into how the engineers helped form concepts of speed, safety, and reliability.

5.5.1 Speed

Experts look forward to a new world of speed by elaborating an old one under the aegis of President Sogō. He once declared that the industry’s mission was primarily about speed. Wasting time and space would be minimized as a result, and efficiency would improve. This, wrote Sogō, was part of the needed modernization of ground transportation.[307] For more speed, former aeronautical engineers drew freely on the intellectual capital they had accumulated. Their scientific inquiry underwent no radical departure. At the speed of 200km/hr, roughly 70 to 80

Asahi shinbunsha, 1964), 145.

[307] Shinji Sogō, "Shingijutsu to Speed Up," *JREA* 2, no. 1 (1959): 1.

percent of the horse power would be wasted in drag resistance even in a stream-lined vehicle.[308] A series of wind-tunnel experiments helped determine the shape of the front and rear ends of the high-speed train. The result was phenomenally successful. Following the pattern of development for the Odakyu SE train, Professor Tani cooperated with Miki in the theoretical and empirical studies conducted at the Tokyo University Aeronautical Research Institute. Its wind tunnel, largest in the country, provided a controlled environment in which researchers measured air resistance to various train heads, the thickness of the boundary layer, and the distribution of air.[309]

Some features of the modern scientific inquiry were surprisingly traditional. For wind tunnel experiments, former military engineers handmade various clay figures, one of which closely resembled the U.S. passenger airplane, Douglas DC 8. At one point, Miki sent one junior engineer to a distant woodworking plant near the Institute for Navy Aeronautics for malleable wood; the material proved useful for creating wartime aircraft propellers as well as scale models of high-speed vehicle.[310] The result was a major triumph. The drag co-efficient of the Odakyu Romance Car was 0.25, better than 0.34 of the Business Express Train that was developed

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308 Tadanao Miki, "Kōsoku Ressha No Kūki Rikigakuteki Shomondai," *Kōtsūgijutsu* 113 (1950): 30.

309 "Kōsoku Sharyō Mokei No Fūdō Shaken," in *Tetsudō Gijutsu Kenkyūjo Itaku Kenkyū Hōkoku, Showa 36-Nendo* (Tokyo: n.p., 1961).

310 Shin'ichi Tanaka, Interview by author, 28 November 2002.

concurrently during the years 1957-1959. In contrast, the archetype of the bullet train marked the notable drag co-efficient of 0.22.[311] The aerodynamically cleanest, least drag resistant, and most energy efficient design at the time capitalized freely on the wealth of wartime expertise in the field, an asset readily available to Miki's laboratory at the RTRI and Professor Tani's research group at the University of Tokyo.

Experiences in the field of aerodynamics gave the former military engineers bargaining leverage over civil engineering projects. This was because the theoretical study of air flow was indispensable for initiating construction. Air resistance proved a cumbersome issue when a train entered a tunnel and passed alongside another train in that limited space at the speed of 200km per hour. Some useful data derived from the Odakyu Romance Car project,[312] but many unexplored issues remained. A chief concern was the thickness of the layer of viscous air — called the boundary layer — adjacent to the surface of the running train. This variable determined the space between rail tracks, cross sections of tunnels, and the width of land strips the railways needed to buy from local residents; and all such data dictated the overall construction cost.[313] As a result of wind tunnel experiments, a pantograph was mounted on the

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[311] Japan National Railways, *Data on Engineering: Submitted to International Bank for Reconstruction and Development* (May 1960), 3.

[312] Akio Yasuda et al., "Shinkansen No Kensetsu Kijun," *JREA* 2, no. 1 (1959): 8.

car following a thick boundary layer, rather than on the leading car.[314] Because a rough surface militated against high-speed operation, all the tunnels featured on a smooth surface inside.[315] Civil engineering helped to make higher speeds possible geographically. Many newly constructed tunnels made it possible to connect Tokyo and Osaka using the shortest distance. By design, the curves of the track were gentle for high-speed operation. The smallest radius of curve theretofore had been 400m, but that for the bullet train was set at 2,500m. The standard-gauge line between the two cities was 40 kilometer shorter than the narrow-gauge line; raised ground occupied 44 percent, viaducts 22 percent, bridges 11 percent, tunnels 13 percent, and cutting sections 9 percent.[316]

In pursuit of speed, former military engineers supported civil engineering projects. For instance, wartime Navy engineer, Satō Hiroshi, developed the durable ballast structure after theoretical and empirical investigations.[317] He developed a highly useful theory about the

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313 Ryōhei Kakumoto, *Shinkansen Kaihatsu Monogatari* (Tokyo: Chuō kōronsha, 2001), 36-37, Shima, "Shinkansen No Kōsō,"149.

314 Japan National Railways, *Data on Engineering: Submitted to International Bank for Reconstruction and Development*,41.

315 Yasuki Nakayama, "Tunnel Nai Ni Okeru Ressha No Kūki Teikō," *Tetsudō gijutsu kenkyū shiryō* 16, no. 6 (1959): 38.

316 Shima, "Shinkansen No Kōsō,"149.

317 Yutaka Satō, "Kidō Ni Kuwawaru Suichoku Shōgeki Atsuryoku," *Tetsudô gijutsu kenkyû hôkoku* 16 (1958): 1-3, Yutaka Satō, "Kurikaeshi Kajû Ni Yoru Dōshō Chinka No Jikken," *Tetsudō gijutsu kenkyû hōkoku* 65 (1959), Yutaka Satō, "Rail No Kyokubu Ōryoku," *Tetsudō gijutsu kenkyū hōkoku* 27 (1958): 1-3, Yutaka Satō, "Yokoatsu Ni Taisuru Kidō Kyōdo No Kenkyū," *Tetsudō gijutsu kenkyū hōkoku* 110 (1960): 1-7, Yutaka Satō and Masayoshi Toyoda, "Kakushu Dōryokusha No Kyokusen Yokoatsu No Rail

vibration of rails; using it, he computed the optimum hardness for the rubber pad underneath the rails as an effective shock absorber. The resulting rail structure could support high-speed operation as fast as 300km/hr.[318] Ōta Seisui, a materials engineer at the Institute for Navy Aeronautics, assisted the development. During the war, he had developed organic bullet-proof glass for military aircraft. His accumulated knowledge and experience in polymer science proved useful in developing the rubber shock absorber.[319] Another important engineer in the field was Yamana Naruo, a former Navy expert in materials engineering (see Chapter 3) who examined the strength and durability of different types of wood for optimum sleepers.[320] The vehicle ran chiefly on steel rail mounted on concrete sleepers, but his product, durable for an average of 20 years, occupied roughly 10 percent of all sleepers on the track, such as bridges and concrete ballast.[321] To improve strength and anti-wear characteristics, all steel rails for the track were heat treated, a technique used for developing weapons during the war.[322]

Yokomage Ni Yoru Sokutei Kekka," *Tetsudô gijutsu kenkyû hôkoku* 57 (1959), Yutaka Satō et al., "Ressha Ni Yotte Kidō Ni Shōzuru Shindō," 85 (1959).

[318] Yoshirō Ikari, *Chō Kōsoku Ni Idomu: Shinkansen Kaihatsu Ni Kaketa Otokotachi* (Tokyo: Bungei shunjū, 1993), 244-45.

[319] Ikari, *Kaigun Gijutsushatachi No Taiheiyō Sensō*,256-58.

[320] Nihon kokuyū tetsudō tetsudō gijutsu kenkyūjo-hen, *10-Nen No Ayumi: Sōritsu 60-Shūnen*,64.

[321] "Ki Makuragi," in *Kōsoku Tetsudō No Kenkyū: Shu to Shite Tokaido Shinkansen Ni Tsuite*, ed. Nihon kokuyū tetsudō tetsudō gijutsu kenkyūjo kanshū (Tokyo: Kenyūsha, 1967), 134, Nihon kokuyū tetsudō tetsudō gijutsu kenkyūjo, *Tokaido Shinkansen Nikansuru Kenkyū*,175-207.

[322] Shinsuke Enomoto, letter to author, 5 April 2004, Hiroshi Nakamura, interview by author, 29 April 2004. For the same reason, the bullet train's axels were heat treated.

Not surprisingly, the significance and value of speed generated a sharp debate. The first test run over the 37km distance achieved 70km/hr in June 1962; and eventually in March 1963, the vehicle established its high-speed world record at 256km/ hr. Subsequently, speed was set at a continuous rating of 168km/h, and a maximum at 250km/h for daily operations.[323] This was not terribly fast, but there was a cultural rejection of speed outside the industry. One month before the commercial service began, a newspaper surveyed 6,000 responses and revealed that 2 percent feared high-speed runs at 210 km per hour; they replied that probably they would not ride on the bullet train.[324] Chief Engineer Shima did not seem particularly enthusiastic about speed. His mode of thinking was quite understandable. He left the industry once in 1955 under intense social pressure, held accountable for a catastrophic train accident. Such a nebulous, non-technical constraint surrounded the high-speed rail project.

Likewise, the pursuit of speed was effectively subordinated to economic concerns. The original bullet train proposal, aiming for a minimal surface area, called for the 4-seat a cross-sections, 3000mm width for the vehicle. But eventually, the vehicle came to have 5 seats with a width of 3,400mm for economic reasons.[325] Because of this, the floor space of a bullet

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[323] Japanese National Railways, *Technical Aspects on the Tokaido Line* (n.p.: 1963), 76.

[324] Nihon kokuyū tetsudō Shinkansen sōkyoku, *Shinkansen: Sono 20-Nen No Kiseki*,46.

[325] Shin'ichi Tanaka, "Sharyō," *Tetsudō gijutsu* 42, no. 1 (1985): 19.

train car was 40 percent larger than a regular rail car. Consequently, vigorous weight reduction became paramount.[326] The normal weight was not to exceed 60 tons with passengers, or approximately 54 tons when empty. The train head also embodied economic concerns. The more spear-shaped the train, the fewer seats would occupy the front car, thus reducing the monetary gain from rail service. Originally, an archetype of the bullet train had a sharper front end.[327] A decade or so after successful operations began, the industry, with more financial security, incorporated light hollow axels and a more needle-sharp head for velocity.

5.5.2 Safety

Speed was rightly sacrificed for safety. In the process, the high-speed rail project did not incorporate some promising ideas of military origin. For the emergency brakes, engineers in Miki's laboratory calculated the effectiveness of using a parachute at the rear end of the fleet;[328] some proposed a jet propulsion of the train against the running direction.[329] Miki proposed to use air resistance brakes, whereby the equipment would effectively increase air drag and reduce

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[326] *Shinkansen-Yō Shisaku Ryokyaku Densha* (Tokyo: Nihon kokuyū tetsudō, 1962), 4.

[327] Tanaka, interview by author, 28 November 2002.

[328] Ibid.

[329] Shūishi Sawano, "Shinkansen No Sharyō," *JREA* 2, no. 1 (1959): 15.

the velocity of the high-speed train. A series of wind tunnel experiments revealed that the drag increased in a fleet of three rail cars by 2.3 times.[330] The lighter the vehicle, showed the studies, the more effective the air brake was particularly at speed greater than 200 km per hour.[331]

Former military engineers helped reconcile speed and safety in a constructive manner. An illustrative case is the contribution of the wartime experts to solving flutter phenomenon. Their work effectively prevented self-induced vibrations of the high-speed train. The fastest trains at the time, running at top speeds of roughly 60 miles per hour, lacked an adequate, flexible device for resisting truck rotation and preventing rail cars from wiggling and eventual derailing. In this situation, Matsudaira's laboratory successfully developed a two-axel rolling stock equipped with air-filled bellows and leveling valves. This air-suspension system, however, was not his original creation. He derived it from the mechanism used in American Greyhound buses. He read an article about it, but was unable to obtain technical information from the United States. Undaunted, he developed the mechanism largely through trial and error, applying it to the express trains of the time, Asakaze and Kodama.[332] For the bullet train project, his laboratory

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330 "Kōsoku Resshayō Fūatsu Brake No Kenkyū," in *Tetsudō Gijutsu Kenkyūjo Itaku Kenkyū Hōkoku: Showa 35-Nendo* (Tokyo: n.p., 1960).

331 Miki, "Kōsoku Tetsudō Sharyō No Kūki Rikigakuteki Shomondai, Part III," 26-27.

332 Matsudaira, "Kōsoku Tetsudō Gijutsu No Raimei 2," 31.

built a testing stand and empirically observed how a full-scale car truck behaved at high speed.[333] The resulting air spring mechanism proved effective for curtailing both lateral and vertical vibrations of the bullet train, enabling it to run safely at the speed of 160 miles per hour.

At times, civilian aeronautical technology helped reconcile speed and safety by effectively alleviating the impact of a crash. Because the vehicle ran twice as fast as a regular train, the impact of a collision would increase inherently by some 400 percent.[334] For safety, the bullet train track lacked all grade crossings and ran on underpasses or overpasses, contrasting markedly to over a thousand crossings on the regular Tokyo-Osaka line.[335] But this precaution was insufficient. The safety issue became particularly alarming even in the high-speed test section. This was because, surprisingly enough, some miscreant left rocks on the rails, and someone jumped into the path of a running bullet train to commit suicide. Subsequently the rail guard of the front car, in part designed to prevent lift from generating during a high-speed run, gained more thickness and strength for protection.[336] But birds posed another threat during the

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333 Tadashi Matsudaira, "Tokaido Shinkansen Ni Kansuru Kenkyū Kaihatsu No Kaiko: Shu to Shite Sharyō No Shindō Mondai Ni Kanren Shite," *Nihon kikai gakkaishi* 75, no. 646 (1972): 105.

334 Takashi Shima and Masao Tani, "Shinkansen Sharyō No Haishō Sōchi," *JREA* 7, no. 4 (1964): 45.

335 *Shinkansen-Yō Shisaku Ryokyaku Densha*,7; Shima, *D-51 Kara Shinkansen Made: Gijutsusha No Mita Kokutetsu*,111.

336 Nihon kokuyū tetsudō-hen, *Nihon Kokuyū Tetsudō 100-Nenshi*, 14 vols., vol. 14 (Tokyo: Nihon kokuyū tetsudō, 1973), 611.

project. In 1963, engineers borrowed a giant air gun that proved vital for developing the windshield of Japan's first commercial airplane, YS-11. They obtained dead birds, stuffed them with whale meat, and weighed each creation carefully. In so doing, they simulated the two most common types of bird in the country, a crow (0.8kg) and a black kite (1.2kg). Subsequently the air gun projected the bird bullets onto tempered glass. In this way, the engineers empirically decided the optimum thickness of the bullet train's windshield.[337]

To improve safety, wartime military engineers had developed a mechanism that functioned as effectively as the faculty of eye-sight. During the 1950s, conventional signaling equipment was inadequate for high-speed operation at 200km/hr. The operator's sight depended dangerously on topography and weather. Greater velocity resulted in less time available for the operator to recognize a distant signal by sight.[338] Moreover, faster operation inherently required more distance for a train to come to a complete stop. At least theoretically, a train running at 200km/hr would require roughly 1,500-2000m in order to stop.[339] Speed and safety seemed irreconcilable. In this situation, a wartime expert on physiology audio-signaling argued in 1957 for a reliable, electronics-based brake system. For the purpose, Kawanabe Hajime successfully

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[337] Fujishima, "Shinkansen Jisoku 200-Kiro No Missitsu,"570-71.

[338] Hajime Kawanabe, "Atarashii Shanai Shingō," *JREA* 2, no. 4 (1959): 2.

[339] Tadanao Miki, "Ressha No Speed-up Wo Habamu Mono," *Shindenki* 12, no. 1 (1958): 24.

combined audible frequency (AF) electric wave and warning signals to develop sophisticated track circuits.[340] The resulting Automatic Train Control (ATC) system was a technological triumph. The speed meter indicated the top speed for each section of the Tokyo-Osaka distance through the track circuits. For the operator, electronics automatically compared the operating speed and the speed specified by the signal, immediately bringing the train at a fixed rate of deceleration down to or below the specified speed.[341] This technological contribution continues to protect passengers' safety. In 2004, for instance, the ATC system successfully replaced an inattentive operator during the train's 270km/hr operation. When the train came to a complete halt after a safe and automatic deceleration, the chronically narcoleptic operator was fast asleep.[342]

But in another instance, former military engineers failed to develop a mechanized "eye" for safety. Illustrative of this was Amamiya Yoshifumi's experience. This wartime expert in avionics developed a radar detection system for the vehicle, an idea that seemed promising at the time. The front car transmitted electric waves 20 cm above the ground along the rails; subsequently, the radar detected an object on the way, computed the distance between that and

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[340] Hajime Kawanabe, "Jidō Ressha Seigyo," *Denki gakkai zasshi* 84, no. 10 (1964): 43.

[341] Japanese National Railways, *Technical Aspects on the Tokaido Line*,84.

[342] *Yomiuri shinbun*, 27 February 2004.

the approaching train automatically, and showed the resulting graph on a television screen. But this technology turned out to be practically useless. Regular electric waves could not handle curves and tended to spread outside the 3km range.[343] Radar successfully detected an object as small as a soccer ball, but it also detected crows that rested their wings on rails in the midst of rice paddy fields. The radar could not distinguish a rock from a crow, thus failing to provide needed safety for high-speed operation.[344]

5.5.3 Reliability

Japanese society embraced the bullet train in part because it provided rail service with reliability and clockwork punctuality. The Centralized Traffic Control (CTC) system seems an appropriate example of modernity as embodied in functional reliance. This efficient, highly centralized system controlled all the bullet train operations without a time lag. Equipped with a bird-eye view, a dispatcher at the central office in Tokyo remotely choreographed traffic patterns via communication with each train's operator. This automated mechanism placed as many trains as possible on the track, enabling the system to maximize transport capacity, and reduce delays.

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[343] Nihon kokuyū tetsudō tetsudō gijutsu kenkyūjo, *Tokaido Shinkansen Ni Kansuru Kenkyū*, 6 vols., vol. 3 (Tokyo: Nihon kokuyū tetsudō tetsudō gijutsu kenkyūjo, 1962), 492-506.

[344] Ikari, *Chō Kōsoku Ni Idomu: Shinkansen Kaihatsu Ni Kaketa Otokotachi*,268.

The resulting punctual, reliable daily rail service owed its success partly to former Navy engineers, Shinohara Yasushi (expert in aircraft instrumentation) and Hobara Mitsuo, a wartime electrical engineer. The system they implemented was hardly their original creation; it derived initially from the single-track railway community in the United States. The system had effectively freed American train operators from a need to understand complicated time tables and exchange written massages in the field. Consequently it reduced management costs and increased transport capacity, thus attracting the railway industries in Europe and Japan thereafter.[345]

Some technical features of military lineage helped increase social reliance on modern technology. The experience of an electrical engineer at the Institute for Navy Aeronautics, Hayashi Masami, offers an illustrative case. From 1959 to 1964, he developed a power supply system that constantly fed an unprecedentedly large amount of electrical power to the running vehicle. His task, as he recalled, proved particularly daunting. This was because a bullet train operation at the speed of 200km/hr required 3 times as much power as that required for a regular express train. In fact, the high-speed project adopted electric traction with 25kv of alternating current. The faster the speed and the greater the electrical power required for the purpose, the

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[345] Mark Aldrich, "Combating the Collision Horror: The Interstate Commerce Commission and Automatic Train Control, 1900-1939," *Technology and Culture* 34, no. 1 (1993), Mitsuo Hobara, "Ressha Shūchū Seigyo," *Denki gakkai zasshi* 84, no. 10 (1964): 51.

more problematic the issue of reliable power feeding became.[346] As a result, two cars made one unit electronically. The distribution of electrical motors across the entire fleet was a way of providing reliable service in case of technical trouble in one car.[347]

Equally important for reliable high-speed service were reliable mechanisms for receiving the electrical power. Former army engineer Kumezawa Ikurō played a crucial role. Developing a sophisticated structure for the overhead trolley wire was indeed unprecedented; the problem was how to maintain the contact wire over the entire 515 km (322 miles) distance between Tokyo and Osaka at a fixed height without any undulations.[348] By his own account, Kumezawa was initially unprepared for the task. The high-speed rail project goal of 250km/hr surprised him greatly in 1957; his reaction to what he called "a serious matter" was understandable. The pantograph was to run with the velocity of 250km/hr, or 70m/sec, meaning that the device could jump up and down, through each gantry support set 70m apart, at each and every second![349] Temporary separation of the pantograph from the wire could easily cause an electrical spark, damaging the wire and contact strip with tremendous heat. The electrical circuits

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[346] "Kōryū Kiden," in *Kōsoku Tetsudō No Kenkyū: Shu to Shite Tokaido Shinkansen Ni Tuite*, ed. Nihon kokuyū tetsudō tetsudō gijutsu kenkyūjo-kanshū (Tokyo: Ken'yūsha, 1967), 463, Hayashi, "Sekai Ni Hokoru Kōsoku Tetsudōyō Daideiryoku Kyōkyū Hōshiki, at Kiden Hōshiki," 52.

[347] *Shinkansen-Yō Shisaku Ryokyaku Densha*,1.

[348] Japanese National Railways, *Technical Aspects on the Tokaido Line*,82.

[349] Sawano, "Shinkansen No Sharyō," 14.

of the train could face power suspensions with damage to the motor's rectifier.[350] In 1957, Kumezawa had just determined how to increase the speed of regular rail operation from 95km/hr to 120km/hr. The speed of 250km/hr seemed too big a leap.[351] Many assumptions theretofore employed proved untenable.[352] The result of his theoretical and empirical studies was a highly sophisticated contact line structure. For reliable power transmission at high speed, a series of wind-tunnel experiments exposed the pantograph to a wind velocity of 100m/sec. This research capitalized in part on wartime aerodynamics studies. The device employed an attack angle as a way of generating lift at high speed for its constant contact with the overhead trolley wire. The pantograph was made small and relatively light,[353] and the resulting mechanism enabled the system to minimize the number of pantographs across the fleet. In the end, only one of the two cars was equipped with this power-collecting device.

5.5.4 Technical difficulties

Outside the realms of speed, safety, and reliability, former military engineers seemed

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[350] Nobuhiko Ishizawa, "Sekkei to Shūzen (1) Pantograph," *Tetsudō kōjō* 88.

[351] Ikurō Kumezawa, "Kasen to Shūden," *Denki gakkai zasshi* 84, no. 10 (1964): 35.

[352] Ikurō Kumezawa, "Kakū Denshasen No Kyōdo Oyobi Sei Oshiageryō Keisanhō," *Tetsudō gijutsu kenkyū hōkoku* 120 (1960): 1.

[353] Hiroshi Arimoto and Masaharu Kunieda, "Pantograph Fūdōnai Shiken," *Tetsudō gijutsu kenkyū hōkoku* 125 (1960): 1-3, Ikurō Kumezawa, "Shinakansen No Shūden Ni Tsuite," *Kōtsū gijutsu* (1963): 11.

more successful at the experimental stage of the project than beyond that. They were not free of an engineering oversight, and their work required investigations and modifications. This was evident when they tried to make the rail cars airtight. During test runs, the former aeronautical engineers, among others, experienced an unpleasant sensation in their ears when entering tunnels. This was due to changes in air pressure within the vehicle, depending on the speeds of the trains as well as on the length and shape of each tunnel.[354] Some engineers jocularly proposed providing chewing gum to passengers at each tunnel. But this solution proved impractical given the sheer number of tunnels on the Tokyo-Osaka line, 67 in total.[355] The cars subsequently became airtight, as in commercial aircraft, to protect the passengers from the noxious phenomenon. Useful data for the purpose derived partly from wartime aeronautical medicine.[356] Although the resulting vehicle was not free of engineering oversight, several passengers at least paid dearly until the problem was solved. The initially mass-produced bullet train cars lacked the airtight structure in restrooms, and were the root of the problem. Some passengers were trapped behind the door that remained shut under a particular air pressure. When the train entered a tunnel and changed the internal air pressure of the confined space, some passengers received an

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354 Masao Tani, "Shinkansen Sharyō No Kimitsu," *JREA* 7, no. 7 (1964): 5.

355 Fujishima, "Shinkansen Jisoku 200-Kiro No Missitsu,"568-69.

356 Miki, "Kōsoku Tetsudō Sharyō No Kūki Rikigakuteki Shomondai, Part III," 30.

unwanted shower of human waste.[357] This called for urgent scientific investigation. With the necessary sanitary protection, the engineers observed the phenomenon first hand. At one point, their research needed to measure the obnoxiousness of the odor. Lacking a scientific method of inquiry, they actually smelled the human waste, ranking the odor in five levels from "bearable" to "unbearable."[358] One engineer filed a detailed research report:

> Today's weather is fine. Temperature is normal [for the season]. We got on the rail car, type Moha 1523, and left Ôgaki station at 7:32AM as scheduled. We are to examine use of the rest room facility closely, to collect and bring back samples of feces and urine. Passengers used the facility frequently after lunch and dinner, before arriving at major train stations. Ten passengers [we observed] used the restroom once every hour. The shortest duration of occupation was 20 seconds; the longest was 6 minutes and 10 seconds. If we assume that those who occupied the space for more than 3 minutes excreted feces, it was only 9 users out of 98, or only 9 percent of the total. The average amount of human waste per person was 0.3 litter, and the average amount of clearing water was 1.5 litter. After [manually] blending feces and urine in the deposit tank, we

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[357] Nihon kokuyū tetsudō-hen, *Nihon Kokuyū Tetsudō 100-Nenshi*,547.

[358] Fujishima, "Shinkansen Jisoku 200-Kiro No Missitsu,"574.

> obtained 2 specimens and submitted them to the Bureau of Hygiene in Tokyo for chemical testing. We returned to Ôgaki at 23:22 [after working all day].[359]

Only after such serious research did the bullet train adopt the airtight structure in restrooms. Human waste was stored in the tank underneath the floor and disposed of at the destination station.[360] The result was more pleasant rail service and more social acceptance of the vehicle.

Likewise, former military engineers were vital at the experimental stage rather than later in solving environmental concerns. This was evident in the field of aerodynamics. Upon entering a tunnel, air pressure increased before the train head, and the resulting air-wave front exited the tunnel as fast as the speed of sound. Former aeronautical engineers lacked useful empirical data, hence they examined this phenomenon theoretically.[361] Primarily after the commercial operation, the engineers learned that the wave front posed another kind of technical challenge; it caused a fairly large, obnoxious popping noise upon exiting the tunnel. This became a source of protest from local residents, pointing to a larger social issue of historical interest. Arguably, the world view that seemed most familiar to the pre-1964 engineers did not resonate

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[359] Ibid.,573.

[360] Japanese National Railways, *Technical Aspects on the Tokaido Line*,79.

[361] Tomoshige Hara, "Ressha Ga Kōsoku De Suidō Ni Totsunyū Suru Baai No Ryūtai Rikigakuteki Shomondai," *Tetsudō gijutsu kenkyū hōkoku* 153 (1960): 1-3.

comfortably with post-1964 society. The engineers' notions were, to a degree, imposed on society through the bullet train as a product of the railway industry. In retrospect, the environmental concerns were seriously underestimated and proved more serious than originally expected in the years that followed. Since then, one major factor against the pursuit of greater speed has been the severe topographical and geographical constraints that limit flat areas available for residents and the bullet train's route system.

Military technology pervaded almost all aspects of the bullet train's engineering, but its contribution should not be overstated. Limitations were particularly evident in the field of civil engineering. Hoshino Yōichi, an expert in rail structure from the prewar era, amply demonstrated his particular — non-military — skill in the high-speed rail project. The faster the vehicle, the larger the amplitude of rail vibration tended to become, producing critical damage to the rails. Hoshino concluded that the rails for the bullet train would require 5 to 10 times more maintenance than did conventional rail sections of 10 meters in length.[362] For the bullet train, he developed a new theory according to which each rail would be welded so as to measure about a mile in length. These sections would then be linked together by expansion joints with double elastic fastenings on pre-stressed concrete ties. The resulting steel rail was heavy, weighing

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[362] Yōichi Hoshino, "Shin Kōzō Kidō," *JREA* 1, no. 7 (1958): 10.

53.3kg per meter as compared to 50kg for a conventional rail section. Other civil engineers pursued a similar research initiative concurrently at the JNR headquarters, and fully supported Hoshino's effort at the RTRI.[363]

After all, the speedy construction of the bullet train was possible in part because of lands and tunnels purchased before 1957. In retrospect, it was fortunate that the JNR had already purchased 95 kilometers of the 515 kilometers, or roughly 20 percent of the land for the Tokyo-Osaka line during World War II. Land acquisition within the limited budget and time frame was among the most arduous and time-consuming part of the entire project. In fact, one retired professor adamantly refused to give up his land at the foot of the Mount Fuji for the project as late as in January 1964. This expert in agriculture demonstrated his uncommon personal attachment to his countless tulip bulbs under the ground.[364] This extreme case aside, emotional and cultural attachment to certain lands was understandable. Schools and Shinto shrines were strongholds of local cultures, and graveyards were deemed the eternal resting place of the ancestral spirits. For this reason, the JNR management had to take into account not only topography but also the locations of schools, hospitals, shrines, and temples in their planning. The wartime bullet train project laid the groundwork in the land acquisition and property as part

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[363] Ikari, *Chō Kōsoku Ni Idomu: Shinkansen Kaihatsu Ni Kaketa Otokotachi*,242-43.

[364] Shima Hideo ikōshū henshū iinkai-hen, ed., *Shima Hideo Ikōshū: 20-Seiki Tetsudōshi No Shōgen*,163.

of civil engineering.

Since its introduction in October 1964, the bullet train has become a builder of national confidence and enthusiasm for modern technology. The project played a part in educating the public about the modernity and importance of speed, safety, and reliability that had not theretofore existed. In the process, however, the actual builders of the technology were consigned to oblivion. Politics obscured their technological accomplishments. The President was held responsible for the total expenditure that had far exceeded the original estimate. The projected figure for the project had been originally 30 billion yen, but the President intentionally reduced the amount by half to win approval from the Diet.[365] Even so, his machinations backfired in the end. The total construction cost increased steadily, from 197.2 billion yen to 380 billion yen; in 1963 alone, the project fell short by 90 billion yen. The remarkable economic growth of the time inflated the costs for materials, labor, and land acquisition.[366] When President Sogo resigned in 1964, Chief Engineer Shima and other senior management at JNR also left the industry in protest. None of the senior RTRI engineers, let alone Shima and President Sogo, was invited to the opening ceremony for the bullet train.

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[365] Ariga, *Sogō Shinji*,546.

[366] Shima, *D-51 Kara Shinkansen Made: Gijutsusha No Mita Kokutetsu*,135.

In summary, this chapter has outlined the decisions made independently by the engineers, the organizational decision-making, and the external politico-economic environment surrounding the *Shinkansen* project from a bottom-up perspective. The successful high-speed service in modern Japan was a cumulative effect of contingent sequences, representing pluralities of transformation and individuals in the process. The end product, realized in 1964, mostly resulted from a marriage of convenience among all the parties involved. After all, the long-term thinking behind the country's postwar technological transformation seems to have been an exaggerated characterization or even a myth. This was evident in the postwar rail industry and most likely elsewhere. The bullet train project, completed roughly within seven short years, was by no means the preordained product of sophisticated, long-term planning, nor a product of any teleology. The JNR leadership failed to crystallize their wishful thinking prior to 1957. The RTRI engineers, JNR leadership, and government bureaucrats pursued their own well-defined political interests for concrete gain under economic and socio-political pressure. After all, the engineers and JNR leadership chiefly directed the government's efforts during the project. The extent to which national government policies purportedly mobilized technology, engineers, and industry in the postwar years seems to have been overstated.

The foregoing bullet train story has illuminated the crucial action and decision of engineers who successfully materialized particular engineering values in the bullet train project. Wartime expertise was evident in almost all aspects of the engineering undertaking, and the military contributions were wider and deeper than previously understood. The engineers defined and specified the guiding values — namely speed, safety, and reliability — fairly independently of external influence. The driving ethos for the engineering project was less of an extroverted "catch-up" and "surpass" mentality than a professional determination to solve problems, and so it seems the engineering community was more introverted than previously portrayed. To be sure, the values of speed, safety, and reliability existed before the introduction of the bullet train, but former military engineers successfully demonstrated that these often-competing variables could co-exist — what had otherwise been a conundrum until 1964. In so doing, they turned to military technologies that had empirically proven their utilities during wartime — hence explaining, to a great extent, the bullet train's successful completion within seven short years. As the sole owner of the requisite technical expertise, the engineers essentially molded the configuration of the bullet train. In so doing, they helped the society, and later the rest of the world, accept the vehicle as an incarnation of technological modernity. The next chapter will examine this issue, and will be followed by concluding remarks.

CHAPTER 6

CONCLUSION: SHINKANSEN IN THE WORLD

The *Shinkansen* continues to be a phenomenal technological success in modern Japan. Its operational speed reaches 300km/hr while providing reliable and punctual service on a daily basis. Since the beginning of its business operations in October 1964, the service of this high-speed phenomenon has become more frequent. In August 2004, for instance, the earliest train departs at both ends of the Tokyo-Osaka line at 6:00a.m., and the latest ones arrive at 11:18p.m. every day. During those approximately seventeen hours, there are 99 *Shinkansen* running each way on every weekday, meaning that the train leaves Tokyo and Osaka every 10 minutes![367] Over the past fifteen years or so, the *Shinkansen* has gradually become the choice for the daily commute of many salaried workers who live in the countryside and work in the metropolitan areas. In 2001, for instance, as many as 36 million passengers reportedly commuted

[367] Japan Tavel Bureau, *Jikokuhyō* (Tokyo: Japan Travel Bureau Foundation, August 2004), 65-90.On holidays, the *Shinkansen* runs the Tokyo-Osaka distance more frequently to provide home-coming passengers and tourists with high-speed rail service.

on the bullet train.[368] In a way, these recent developments produced an ironic result. The social value of speed, safety, and reliability originally generated the bullet train technology, but society as reduced to the time tables was adjusted to the machine.

Since 1964, the *Shinkansen* has elevated the status of Japan to a harbinger of modernity in the world. The bullet-train operation changed the world's view toward speed, safety, and reliability, the successful configuration of which has not been easily attainable. For instance, British journal *Economist* called attention to this issue. Even considering delays as a result of snow, rain, and earthquakes, the average deviation from schedule is only 36 seconds per train. If all the bullet train passengers switched to car travel, at least 1,800 extra deaths and 10,000 serious injuries are estimated to result every year.[369] The bullet train operation was particularly surprising to the railway industry of Western Europe, evoking a strong sense of techno-nationalism among, for instance, French railway engineers. This phenomenon, which one historian calls the "Tokaido complex", accelerated the pace at which the French national railways developed their technologies, resulting in the French high-speed train *à grande vitesse* (TGV).[370] Similarly, nations in Asia, such as Taiwan, recently began to examine the Shinkansen model for

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[368] Infrastructure and Transport Ministery of Land, "Heisei 13-Nen Do Tetsudō Yusō Tōkei No Gaiyō," (2001).

[369] "A Better Way to Fly," *Economist* 346, no. 8056 (1998): 22.

[370] Meunier, *On the Fast Track French Railway Modernization and the Origins of the TGV, 1944-1983*.

their high-speed rail service. In 1980, for instance, the South Korean government launched a high-speed rail plan to modernize transportation. Subsequent engineering studies favored the French-TGV model over the *Shinkansen* alternative. The result was a massive national project that aimed in 1996 for technology transfer and domestic production of the French railway technology.[371] Through testing, the Korean engineers questioned TGV technology — designed for high-speed operations over vast, flat, and open fields in France — and in 2004, officially asked Japanese engineers for technical assistance about safety issues.[372]

Outside these countries, the bullet train became a conspicuous cultural symbol of technological modernity in daily lives as represented in, for instance, postage stamps. At least thirty-three nations in the world — mostly developing and third-world nations but, curiously no other G7 nations — have commemorated the birth and continuous operations of railway systems by issuing national postage stamps (Table 6:1):

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[371] Yong Song Yi and Seiji Abe, "Higashi Asia Ni Okeru Kōsoku Tetsudō Kensetsu to Kankoku Kōsoku Tetsudō No Tenbō," *Un'yu to keizai* 63, no. 12 (2003): 56-60.

[372] *Sankei shinbun*, 23 September 2000.

Names of countries	Year	Title of the postage that included the Shinkansen
Bhutan	1988, 1996	Means of Transport
Cambodia Kampuchea	1989	Trains
Central Africa	1999	Locomotive Means
Chad	1997, 1999	Means of Transport
North Korea	1981	An image of the bullet train printed on the margins
Comoros	1977	An image of the bullet train printed on the margins
Congo	1982	Bicentenary of the Birth of George Stephenson
Diibouti	1981, 1999	Bicentenary of the Death of George Stephenson
Gabon	2000	Locomotives
Grenada	1995, 1999	Trains of the World
Grenades of Grenada	1982	The Railway throughout the World
Guinea	1999	Trains
Guinea Bissau	1979	International Year of the Child
Equatorial Guinea	1978, 1995	Antique Locomotives
Guyana	1991, 1999	International Philatelic Exhibition
Hungary	1979	Railway Transport International Exhibition
Lesotho	1996	Locomotives
Liberia	1999	Trains of the World
Madagascar	1998, 1999	From the Steam Engine to the TGV
Maldives	1994, 1999, 2000	Asian Trains, Locomotives
Mali	1973, 1980, 1996	Retrospective of the Railway, Locomotives
Marshall Islands	1999	The 20th Century, 1960-1969
Mongolia	1979, 1992, 1997	Locomotives, Great Trains of the World

Nevis	1984, 1991	Locomotives, International Philatelic Exhibition
Niger	1998	World Trains and Locomotives
Nieu	1995	50th Anniversary of the end of the WWII
Paraguay	1972	Visit of the President of Paraguay to Japan
Paraguay	1979	Century of the Electric Train
Saint Vincenti	1991	Electric Trains of Japan
Saint Thomas and Price Islands	1995	Locomotives
Sierra Leone	1991, 1995	Phila Nippon 91 World Stamp Expo, World Trains
Somalia	1999	Locomotives
Surinam	1985	Locomotives
Umm Al Qiwan	1972	Locomotives

Table 6.1: List of 33 nations that have issued postage stamps of the bullet train[373]

The bullet train's broad appeal in popular culture around the world effectively effaced the train's deep military heritage. The integration of individual and collective wartime experience with postwar Japan was complete and very successful. Traces of technology conversion from wartime to postwar remain hardly recognizable. The role of former military engineers at the RTRI and JNR was indispensable at every point of the socio-technical landscape within the railroad industry after 1945. Former wartime engineers, especially aeronautical engineers, freely

[373] *Ferro Carriles: Catálogo De Sellos Temáticos* (Barcelona: DOMFIL, 2001).

capitalized on their accumulated knowledge and experience in wartime technology, constructively applying it to the development of the high-speed bullet train. The peace-oriented postwar society did not welcome former military engineers with open arms during the Occupation years, but society did capitalize on their wartime expertise in the long run.

The preceding chapters have argued that behind the successful civilian conversion of wartime military technology was the remarkable degree of fluidity, adaptability, and flexibility of actual agents of technological transformation in society, engineers. In my bottom-up examination, the JNR and RTRI were the loci of the conversion. The decentralized nature of the process from wartime to peacetime in Japan after 1945 required heavy involvement of engineers at the grass-roots level. The process was highly contingent on a configuration of agents with purpose, motive, and expectation. The *Shinkansen*, and most likely other products, resulted mostly from numerous decisions and actions among individual engineers. Local and individual conversion initiatives from wartime to peacetime manifested themselves in remarkable pluralities of wartime engineering knowledge, all configured with little centrally-orchestrated effort.

The resulting engineering community was neither fixed nor docile; the members continued to be actively and constructively flexible. A case in point we have examined was the fluid domestic migration of the former military engineers into the railway industry, particularly to JNR. This development — and the country's conspicuous lack of a major brain-drain pattern among engineers— provided the defeated nation with the requisite human recourses needed for the technological transformation that would occur in the years that followed. Faced with chaos in the immediate postwar years, former wartime engineers concluded in on way or another that they could neither wait for nor rely on the essentially dysfunctional government to act and care for their lives. The engineers subsequently draw up their own plans, individually and collectively, and tailored their skills, experiences, and machines to various demands of the time. In so doing, especially from 1945 to 1955, the former military engineers successfully solved many technical problems in the badly damaged railway industry. In the process of doing what was necessary, they developed a niche of curtailing casualties and saving lives in rail service. The postwar conversion went beyond a mere shuffling of human and financial resources; many efforts came from grass-roots activities among engineers. The society as a whole beat swords into plowshares, renouncing war with peace-oriented technology.

Even after the period of postwar reconstruction, the engineers continuously and actively molded the techno-cultural values of the organizational environment in which they found themselves. Much of tradition-bound organizational culture either changed or disappeared as a result. Tangible outcomes included the planned technology transfer, inter-disciplinary technology transfer at home, and the combination of both — all formed the flexible and requisite knowledge bases for the bullet train development. With their previous exposure to wartime engineering and refined sense of speed, safety, and reliability, the engineers inscribed their values of technological modernity on post-1945 Japan. The bullet train was mostly a byproduct of a struggle of the engineers to create a future out of their past. After all, they engineered the R&D environment for rail service in postwar Japan — and technology was their means in the process.

Examining individuals as agents of socio-technical transformation raises issues about the history of modern Japan. As my study has shown, the sequences of action and reaction between the human agents on the one side and their contextual institutions, norms, and values on the other were diverse, contingent, idiosyncratic, and often unexpected. The real existence of the tension between the two seems mostly irreducible to statistical data or abstract theories about, for instance, laws and stages of evolutionary development in the socio-technical landscape. Actual agents of changes in postwar Japan viewed and experienced society in diverse ways; they produced alternative and often competing proposals in solving what they saw as problems and securing their niche. Perhaps we, historians of modern Japan, need to examine ordinary citizens more seriously because their activities and experiences contributed markedly to progressive modern developments. As John Dower astutely notes, crediting ordinary Japanese for constructing their fate and the fate of their country after 1945 is a tricky issue. If they can be given credit and responsibility, likewise they must bear at least some responsibility for society before 1945.[374] To what extent and how much wartime military engineers contributed to trends in the socio-technical landscape before 1945 is an issue of historical interest and importance, but it is a different issue altogether worth detailed investigation.

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374 John Dower, "Sizing up (and Breaking Down) Japan," in *The Postwar Development of Japanese Studies in the United States*, ed. Helen Hardacre (Leiden: Brill, 1998), 28.

References

Japanese Sources

The following is a list of archives in Japan that I visited for research. For the locations of the Japanese primary sources used, see designated abbreviations placed following their titles.

Abbreviations	Names of Archives Used
BKL	Bōei Kenkyūjo Library (National Institute for Defense Studies Library), Tokyo
DAL	Department of Aeronautics Library, Tokyo University, Tokyo
EJR	East Japan Railway Company Archive, Tokyo
KH	Kōtsū Hakubutsukan (Transportation Museum), Tokyo
RTRI	Railway Technical Research Institute Library, Tokyo
SGK	Senpaku Gijutsu Kenkyūjo (Ship Research Institute), Tokyo
SA	Shōwakan Archive, Tokyo

Amamiya, Yoshifumi. "Kokutetsu Densha Yori Hassei Suru Chū-Tanpa Musen Zatsuon Ni Kansuru Kenkyū." *Tetsudō gyōmu kenkyū hōkoku* 58, no. 9 (1959): 1-10. RTRI

Amamiya, Yoshifumi, and Yoshitaka Maki. "Zatsuon Denryoku Ni Chakumoku Shita Zatsuongen Tanchiki." *Tetsudō gyōmu kenkyū hōkoku* 132, no. 23 (1960): 1-11. RTRI

Aoki, Eiichi, Imashiro Mitsuhide, Shin'ichi Kato, and Yasuo Wakuda, eds. *A History of Japanese Railways, 1872-1999*. Tokyo: East Japan Railway Culture Foundation, 2000.

Arai, Katsuhiro. "Gijutsu Dōnyū." In *Tsūshi: Nihon No Kagaku Gijutsu*, 158-69. Tokyo: Gakuyō shobō, 1995.

Ariga, Sōkichi. *Sogō Shinji*. Tokyo: Sogō Shinji-den kankōkai, 1988.

Arimoto, Hiroshi, and Masaharu Kunieda. "Pantograph Fūdōnai Shiken." *Tetsudō gijutsu kenkyū hōkoku* 125 (1960).

Bōeichō kaijō bakuryō kanbu chōsabu. *Nihon Teikoku Kaigun No Kenkyū Narabi Ni Kaihatsu (1925-1945)*. n.p., 1956. SA

"Chōonpa Ni Yoru Sharyō Buhin Hirō Hanteihō No Kenkyū Hōkokusho." Railway Technical Research Institute, March 1960. RTRI

Doi, Takeo. *Hikōki Sekkei 50-Nen No Kaisō*. Tokyo: Suitōsha, 1989.

Enomoto, Shinsuke. "Kinzoku Zairyō No Hirō to Naibu Masatsu Ni Kansuru Kenkyū." *Chūō kōkū kenkyūjo ihō* 2, no. 10 (1943): 305-24. SGK

———. "Kinzoku Zairyō No Hirō to Naibu Masatsu Ni Kansuru Kenkyū." *Chūō kōkū kenkyūjo ihō* 2, no. 7 (1943): 177-89. SGK

Fujishima, Shigeru. "Shinkansen Jisoku 200-Kiro No Missitsu." In *Bungei Shunjū Ni Miru*

Shōwa-Shi. Tokyo: Bungei shunjū, 1988.

Gunji Gijutsu Kara Minsei Gijutsu Heno Tenkan: Dainiji Sekai Taisen Kara Sengo Heno Waga Kuni No Keiken. 2 vols. Tokyo: Nihon gakujutsu shinkōkai, 1996.

Hattensuru Tetsudō Gijutsu: Saikin 10-Nen No Ayumi. Tokyo: Nihon tetsudō gijutsu kyōkai, 1965.

Hajima, Tomoyuki, ed. *Gōgai Sengoshi, 1945-1995*. Vol. 3. Tokyo: Ōzorasha, 1995.

Hara, Tomoshige. "Ressha Ga Kōsoku De Suidō Ni Totsunyū Suru Baai No Ryūtai Rikigakuteki Shomondai." *Tetsudō gijutsu kenkyū hōkoku* 153 (1960): 1-22.

Hashimoto, Kōichi. "Kokutetsu Ni Okeru Kyōryō Kyōdo Shindō Shiken No Genjō to Shōrai." *Doboku gakkaishi* 33, no. 5-6 (1948): 31-34.

Hashimoto, Kōichi, and Fumihito Itō. "Rosen Dōro Miyagino-Bashi No Kyōdo Sokutei." *Doboku gakkaishi* 37, no. 4 (1952): 13-17.

Hayakawa, Masashi. "Kōkū Bakugeki Heiki." In *Kōkū Gijutsu No Zenbō*. Tokyo: Nihon shuppan kyōdōsha, 1955.

Hayashi, Masami. "Kūgishō No Omoide to Sengo No Watashi." In *Kaigun Kōkū Gijutsushō Denkibu*, 91-100. Tokyo: Kūgishō denkibu no kai, 1987.

———. "Sekai Ni Hokoru Kōsoku Tetsudōyō Daideiryoku Kyōkyū Hōshiki, at Kiden Hōshiki."

Hatsumei 76, no. 8 (1979): 51-57.

———. "Watashi No Sengo." In *Kaigun Kōkū Gijutsushō Denkibu*. Tokyo: Kūgishō denkibu no kai, 1987.

Hayashi, Shozō. "Keiryō 3-Tōsha Naha 10-Keishiki." *Kōtsū gijutsu* 108 (1955): 260-63.

Hobara, Mitsuo. "Ressha Shūchū Seigyo." *Denki gakkai zasshi* 84, no. 10 (1964): 51-56.

Hōmu daijin kanbō shihō hōsei chōsabu shihō hōsei-ka. *Saikō Saibansho Hanreishū*. Vol. 12. Tokyo: n.p., 1958.

Hoshi, Akira. *Sharyō No Keiryōka*. Tokyo: Nihontosho kankōkai, 1956.

Hoshino, Yōichi. "Kidō No Kōzō." *Kōtsū gijutsu* 135 (1957): 9-11.

Hoshino, Yōichi. "Shin Kōzō Kidō." *JREA* 1, no. 7 (1958): 10-14.

Ikari, Yoshirō. *Chō Kōsoku Ni Idomu: Shinkansen Kaihatsu Ni Kaketa Otokotachi*. Tokyo: Bungei shunjū, 1993.

———. *Kaigun Gijutsushatachi No Taiheiyō Sensō*. Tokyo: Kōjinsha, 1989.

———. *Kōkū Technology No Tatakai*. Tokyo: Kōjinsha, 1996.

Inayama, Kenji. "Soshiki Katei to Shite No Gijutsu Tenkan: Chōkyori Kōsoku Densha No Hatten Katei." Ph. D dissertation, Hitotsubashi University, 2003.

Ishizawa, Nobuhiko. "Sekkei to Shūzen (1) Pantograph." *Tetsudō kōjō* 88: 16-17.

Itokawa, Hideo. *Kyōi No Jikan Katsuyōjutsu: Naze Koredake Saga Tsukunoka?* Tokyo: PHP kenkyūjo, 1985.

Izawa, Katsumi. "Kyakusha Kōtai Ka." *Kōtsū gijutsu* 40 (1949): 15-17.

Japan Tavel Bureau. *Jikokuhyō*. Tokyo: Japan Travel Bureau Foundation, August 2004.

Kagaku gijutsu seisakushi kenkyūkai hen. *Nihon No Kagaku Gijutsu Seisakushi*. Tokyo: Mitō kagaku gijutsu kyōkai, 1990.

Kaigun kōkū gijutsushō zairyōbu no kai. *Kaigun Kōkū Gijutsushō Zairyōbu Shūsen 50-Shūnen Kinenshi*. Tokyo: Kaigun kōkū gijutsushō zairyōbu no kai, 1996.

Kaigun Kōkū honbu. *Kaigun Kōkū Honbu Shōwa 20-Nen 3-Gatsu Denki Kankei Gijutsu Shikan Meibo*. n.p., n.d. SA

Kaigunshō. *Gen'eki kaigun shikan meibo* vol. 3. Tokyo: Kaigunshō, 1944. SA

Kakumoto, Ryōhei. *Shinkansen Kaihatsu Monogatari*. Tokyo: Chuō kōronsha, 2001.

Kanematsu, Manabu. *Shūsen Zengo No Ichi Shōgen: Aru Tetsudōjin No Kaisō*. Tokyo: Kōtsū kyōkai, 1986.

Kawamura, Atsuo. *Kyaku Kasha No Kōzō Oyobi Riron*. Tokyo: Kōyūsha, 1952.

Kawanabe, Hajime. "Atarashii Shanai Shingō." *JREA* 2, no. 4 (1959): 5-9.

———. "Jidō Ressha Seigyo." *Denki gakkai zasshi* 84, no. 10 (1964): 43-50.

Kimura, Hidemasa. *Waga Hikōki Jinsei*. Tokyo: Nihon tosho center, 1997.

"Ki Makuragi." In *Kōsoku Tetsudō No Kenkyū: Shu to Shite Tokaido Shinkansen Ni Tsuite*, edited by Nihon kokuyū tetsudō tetsudō gijutsu kenkyūjo kanshū. Tokyo: Kenyūsha, 1967.

Kishida, Junnosuke. "Sengo Gijutsu No Taishitsu O Kimeta Mono." In *Nihon No Gijutsuryoku: Sengoshi to Tenbō*, 41-72. Tokyo: Asahi shinbunsha, 1986.

Kōgaku kōgyōshi henshū-kai. *Nihon No Kōgaku Kōgyōshi*. Tokyo: Kōgaku kōgyōshi henshū-kai, 1955.

Kōkūkai Kaiin Meibo 1973. n.p., 1973. DAL

Kōkūkai Kaiin Meibo 1976. n.p., 1976. DAL

Kokutetsu Shokuin Meibo (Gijutsu Gakushi) Shōwa 25-Nen 8-Gatsu 10-Ka Genzai. Tokyo: n.p., 1950.

"Kōryū Kiden." In *Kōsoku Tetsudō No Kenkyū: Shu to Shite Tokaido Shinkansen Ni Tuite*, edited by Nihon kokuyū tetsudō tetsudō gijutsu kenkyūjo-kanshū. Tokyo: Ken'yūsha, 1967.

"Kōsoku Resshayō Fūatsu Brake No Kenkyū." In *Tetsudō Gijutsu Kenkyūjo Itaku Kenkyū Hōkoku: Showa 35-Nendo*. Tokyo: n.p., 1960. RTRI

"Kōsoku Sharyō Mokei No Fūdō Shaken." In *Tetsudō Gijutsu Kenkyūjo Itaku Kenkyū Hōkoku, Showa 36-Nendo*. Tokyo: n.p., 1961. RTRI

Koyama, Tōru. "Shinkansen Kaitsū: Tetsudō to Sono Gijutsu No Saininshiki." In *Tsūshi: Nihon No Kagaku Gijutsu*, 270-77. Tokyo: Gakuyō shobō, 1995.

Kubo, Masaki. "Tetsudō Gijutsu Kenkyūjo No Genzai to Shōrai Heno Michi." *Kōtsūgijutsu* 30 (1949): 10-15.

Kubota, Hiroshi. *Nihon No Tetsudō Sharyō Shi*. Tokyo: Grandpri shuppan, 2001.

———. "Sengo Nihon Tetsudōshi No Ronten." *Tetsudōshigaku* 6 (1988): 39-46.

———. *Tetsudō Jūdai Jiko No Rekishi*. Tokyo: Grandpri shuppan, 2000.

Kumezawa, Ikurō. "Kakū Denshasen No Kyōdo Oyobi Sei Oshiageryō Keisanhō." *Tetsudō gijutsu kenkyū hōkoku* 120 (1960): 1-12.

———. "Kasen to Shūden." *Denki gakkai zasshi* 84, no. 10 (1964): 35-42.

———. "Shinakansen No Shūden Ni Tsuite." *Kōtsū gijutsu* (1963): 10-14.

Kunieda, Masaharu, and Keiji Yokose. "Jidōsha No Norigokochi Siken to Sono Kōsatsu." *Tetsudō gyōmu kenkyū shiryō* 10, no. 18 (1953): 10-17.

Kuroiwa, Toshirō. *Gendai Gijutsushi Ron*. Tokyo: Toyō keizai shinpō, 1987.

Maeda, Yūko. *Senjiki Kōkū Sangyō to Seisan Gijutsu Keisei: Mitsubishi Kōkū Engine to Fukao Junji*. Tokyo: Tokyo University Press, 2001.

Maema, Takanori. *Dangan Ressha*. Tokyo: Jitsugyō-no-nihonsha, 1994.

———. *Man Machine No Shōwa Densetsu: Kōkūki Kara Jidōsha E*. 2 vols. Tokyo: Kōdansha, 1996.

———. *Ys-11 Kokusan Ryokakki Wo Tsukutta Otokotachi*. Tokyo: Kōdansha, 1994.

Maruhama, Tetsurō. "Kokutetsu Shuyō Kansenkei Shf Kaisen O Kaerimite." *Kōtsū gijutsu* (September 1960).

Matsubara Keiji. *Shūsenji teikoku rikugun zen gen'eki shōkō shokumu meikai*. Tokyo: Senshi Kankō iinkai, 1985.

Matsudaira, Tadashi. "Anzen to Norigokochi." *Kōtsū gijutsu* 135 (1957): 5-8.

———. "Kōsoku Tetsudō Gijutsu No Raimei 1." *Railway Research Review* 50, no. 3 (1993): 25-39.

———. "Kōsoku Tetsudō Gijutsu No Raimei 2." *Railway Research Review* 50, no. 4 (1993): 28-34.

———. "Kyakusha Oyobi Densha No Koyū Shindōsū." *Tetsudō gyōmu kenkyū shiryō* 6, no. 2 (1949): 3-14.

———. "Sharinjiku No Dakōdō." *Tetsudō gyōmu kenkyū shiryō* 9, no. 1 (1952): 16-26.

———. "Tokaido Shinkansen Ni Kansuru Kenkyū Kaihatsu No Kaiko: Shu to Shite Sharyō No Shindō Mondai Ni Kanren Shite." *Nihon kikai gakkaishi* 75, no. 646 (1972): 100-08.

Matsudaira, Tadashi, Yasuharu Aizawa, Yoshio Mukaide, and Keiji Yokose. "Nijiku Kasha No Banetsuri Sōchi Kaizō Ni Yoru Kōsokuka." *Tetsudō gyōmu kenkyū shiryō* 10, no. 18 (1953): 5-9.

Matsui, Nobuo. "Se-Sha Ni Yoru Kōsoku Shaken." In *Tetsudō Gijutsu Kenkyūjo: Shōwa 32-Nendo Kenkyū Seika Gaiyō, Shisetsukyoku Kankei*. Tokyo, 1958.

Matsumoto, Miwao. "Gunji Kenkyū to Heiwa Tenkan: Radar Kaihatsu O Chūshin Ni." In *Tsūshi: Nihon No Kagaku Gijutsu*, edited by Shigeru Nakayama, Kunio Goto and Hitoshi Yoshioka, 94-102. Tokyo: Gakuyō shobō, 1995.

Meikū Kōsakubu No Senzen Sengoshi: Moriya Sōdanyaku, Watashi to Kōkūki Seisan. Nagoya: Mitsubishi jūkōgyō kabushiki kaisha Nagoya kōkūki seisakujo, 1998.

"Miki Tadanao: Shinkansen O Tsukutta Otoko." In *Lifeline*. Japan: Taiheiyō hōsō kyōkai, 2003.

Miki, Tadanao. "Chō Tokkyū Ressha (Tokyo-Osaka 4-Jikan Han) No Ichi Kōsō." *Kōtsū gijutsu* (1954): 2-6.

———. "Kōsoku Ressha No Kūki Rikigakuteki Shomondai." *Kōtsūgijutsu* 113 (1950): 30-32.

———. "Kōsoku Sharyō No Kūki Rikigakuteki Kenkyū." *Nihon kikai gakkaishi* 61, no. 478 (1958): 34-43.

———. "Kōsoku Tetsudō Sharyō No Kūki Rikigakuteki Shomondai, Part I." *Kikai no kenkyū* 12, no. 7 (1960): 17-24.

———. "Kōsoku Tetsudō Sharyō No Kūki Rikigakuteki Shomondai, Part II." *Kikai no kenkyū* 12, no. 8 (1960): 13-18.

———. "Kōsoku Tetsudō Sharyō No Kūki Rikigakuteki Shomondai, Part III." *Kikai no kenkyū* 12, no. 9 (1960): 25-30.

———. "Kōzō Kyōdo Kara Mi Ta Densha No Dōkō." *Denki sha no kagaku* 10, no. 4 (1957): 6-10.

———. "Monorail 45-Nen No Tsuioku." *Monorail* 82 (1994): 1-13.

———. "Naha 10-Keishiki Keiryō Kyakusha Kōtai Kajū Shiken." *Kōtsū gijutsu* 115 (1956): 39-41.

———. "Odakyū 3000-Kei Se-Sha Sekkei No Tsuioku." *Tetsudō fan* 32, no. 375 (1992): 91-99.

———. "Ōgata Trailer Bus Shaken Hōkoku." *Tetsudō gyōmu kenkyū shiryō* 6, no. 1 (1949): 5-12.

———. "Ressha No Speed-up Wo Habamu Mono." *Shindenki* 12, no. 1 (1958): 18-24.

———. "Sharyō Kōzō." *Kōtsū gijutsu* 135 (1957): 2-5.

Miki, Tadanao, Takeo Akatsuka, and Shigeru Iai. "Jiko Kara Mita Kyakusha Densha No Kōzō Sekkei Shiryō." *Tetsudō gyōmu kenkyū shiryō* 7, no. 4 (1950): 4-10.

Miki, Tadanao, Tsutomu Maekawa, Yasushi Hasegawa, and Takeo Akatsuka. "Shōnan Denshayō Tsūfūki Shiken." *Tetsudō gyōmu kenkyū shiryō* 7, no. 15 (1950): 4-10.

Miki, Tadanao, and Morihisa Takabayashi. "Keiryō Reclining Seat Shisaku Hōkoku." In *Tetsudō Gijutsu Kenkyūjo: Shōwa 30-Nendo Kami-Hanki Kenkyū Seika Gaiyō, Kōsakukyoku Kankei*. Tokyo, 1956. RTRI

Ministery of Land, Infrastructure and Transport. "Heisei 13-Nen Do Tetsudō Yusō Tōkei No Gaiyō." 2001.

Ministry of Land, Infrastructure and Transport. 2004. Kokudo Kōtsū Getsurei Hōkoku (Heisei 16-Nen, 7-Gatsu). In *Kokudo kōtsū getsurei hōkoku*, Http://www.milt.go.jp/toukeijouhou/toukei04/geturei/07/geturei04_07_.html. (accessed August 7, 2004).

———. 2002. Seibi Shinkansen Gaiyō Zu. In *Shinkansen tetsudō no seibi*, Http://www.mlit.go.jp/tetudo/. (accessed December 2, 2004).

———. 2001. Tetsudō Iroiro Data Shū. In *Tetsudō iroiro*, Http://www.milt.go.jp/tetudo/nandemo/13_03a.html. (accessed August 7, 2004).

Mizusawa, Hikari. "Rikugun Ni Okeru 'Kōkūkenkyūjo' Setsuritsu Kōsō to Gijutsuin No Kōkū Jūtenka." *Kagakushi kenkyū* 42, no. 225 (2003): 31-39.

Nihon Kokuyū Tetsudō Senpai Meibo: Shōwa 59-Nen 9-Gatsu 1-Nichi Genzai: n.p., n.d. KH

Nakagawa, Yasuzō. *Kaigun Gijutsu Kenkyūjo: Electronics Ōkoku No Senkusha Tachi*. Tokyo: Nihon keizai shinbunsha, 1987.

Nakamura, Hiroshi. *Mono to Koto to Sei No Kenkyūshi: Shinkansen Daisha, Kinzoku Hirō Jumyō, Seimeikan*. Kyoto: Nagata bunshodō, 1997.

———. "Shajiku No Kyōdo I: Sekkei Hōshiki Ni Tsuite." *Tetsudō gyōmu kenkyū hōkoku* 8, no. 7 (1951): 4-11.

Nakamura, Kazuo. "Hizumi Gauge Tanjō 50-Nen." *Kyōwa gihō* 370 (1988): 1-11.

Nakata, Kin'ichi. "Tetsudō Gijutsu Kenkyūjonai Ni Okeru Gas Turbine No Kenkyū." *Tetsudō gyōmu kenkyū shiryō* 7, no. 17 (1950): 4-9.

Nakayama, Shigeru. "Haisen Chokugo No Kagaku Gijutsukai No Jittai." In *Nihon No Kagaku Gijutsu*. Tokyo: Gakuyō shobō, 1995.

———. "Kagakusha No Kaigai Haken." In *Nihon No Kagaku Gijutsu*. Tokyo: Gakuyō shobō, 1995.

Nakayama, Yasuki. "Tunnel Nai Ni Okeru Ressha No Kūki Teikō." *Tetsudō gijutsu kenkyū shiryō* 16, no. 6 (1959): 38.

NHK Project X seisaku-han. In *Project X: Chōsensha Tachi*, 14-52. Tokyo: Nihon hōsō shuppan kyōkai, 2000.

Nihon kagakushi gakkai-hen. *Nihon Kagaku Gijutsushi Taikei*. Vol. 5. Tokyo: Daiichi hōii shuppan, 1969.

Nihon kōkū gakujutsushi henshū iinkai. *Nihon Kōkū Gakujutsushi (1910-1945)*. Tokyo: Maruzen, 1990.

Nihon kokuyū tetsudō-hen. *Nihon Kokuyū Tetsudō 100-Nenshi*. 14 vols. Vol. 14. Tokyo: Nihon kokuyū tetsudō, 1973.

———. *Tetsudō Gijutsu Hattatsushi*. 10 vols. Vol. 1. Tokyo: Kuresu shuppan, 1990.

———. *Tetsudō Gijutsu Hattatsushi Dai 6-Hen (Senpaku), Dai 7-Hen (Kenkyū) Dai 8-Hen (Nenpyō)*. Tokyo: Nihon kokuyū tetsudō, 1958.

Nihon kokuyū tetsudō. *Kokutesu Rekishi Jiten*. Tokyo: Nihon kokuyū tetsudō, 1973.

———. *Tetsudō 80-Nen No Ayumi, 1872-1952*. Tokyo: Nihon kokuyū tetsudō, 1952.

———. *Tetsudō Gijutsu Hattatsu Shi (Sharyō to Kikai) I*. Vol. 4. Tokyo: Nihon kokuyū tetsudō, 1958.

———. *Tetsudō Gijutsu Hattatsu Shi (Sharyō to Kikai) II*. Vol. 4. Tokyo: Nihon kokuyū tetsudō, 1958.

———. *Tetsudō Sengo Shorishi*. Tokyo: Taishō shuppan, 1981.

Nihon kokuyū tetsudō Shinkansen sōkyoku. *Shinkansen: Sono 20-Nen No Kiseki*. Tokyo: Nihon kokuyū tetsudō Shinkansen sōkyoku, 1984.

Nihon kokuyū tetsudō tetsudō gijutsu kenkyūjo-hen. *10-Nen No Ayumi: Sōritsu 60-Shūnen*. Tokyo: Tetsudō gijutsu kenkyūjo, 1967.

Nihon kokuyū tetsudō tetsudō gijutsu kenkyūjo 50-nenshi kankō iinkai. *Nihon Kokuyū Tetsudō Tetsudō Gijutsu Kenkyūjo 50-Nenshi*. Tokyo: Ken'yūsha, 1957.

Nihon kokuyū tetsudō tetsudō gijutsu kenkyūjo. *Shōwa 29-Nendo Kenkyū Seika Gaiyō*. Tokyo: n.p., July 1955. RTRI

———. *Tokaido Shinkansen Ni Kansuru Kenkyū*. 6 vols. Vol. 3. Tokyo: Nihon kokuyū tetsudō tetsudō gijutsu kenkyūjo, 1962.

———. *Tokaido Shinkansen Ni Kansuru Kenkyū*. 6 vols. Vol. 1. Tokyo: Nihon kokuyū tetsudō tetsudō gijutsu kenkyūjo, 1960.

———. *Tokaido Shinkansen Nikansuru Kenkyū*. 6 vols. Vol. 5. Tokyo: Nihon kokuyū tetsudō tetsudō gijutsu kenkyūjo, 1964.

———. *Tokaido Shinkansen Nikansuru Kenkyū*. 6 vols. Vol. 4. Tokyo: Nihon kokuyū tetsudō tetsudō gijutsu kenkyūjo, 1964.

Nishida, Masami. "Saikin No Denka No Ayumi to Sūsei." *JREA* 11 (1962): 2-5.

Nishii, Kazuo, ed. *Shōwa Shi Zenkiroku*. Tokyo: Mainichi shinbunsha, 1989.

Nishimura, Eiichi. "Tokaidosen Zensen Denka Kaitsū Su." *Kōtsū gijutsu* 126 (1956): 1.

Nishitani, Tetsu. "Tokaidō-Sen Ressha Sokudo No Hensen." *Kōtsū gijutsu* 126 (1956): 17-19.

Noma, Sawako, ed. *Dokuritsu-Reisen No Tanima No Naka De: Shōwa 25-27 Nen*. Vol. 9, *Shōwa Ni Man Nichi No Zenkiroku*. Tokyo: Kōdahsha, 1989.

———, ed. *Haikyo Kara No Shuppatsu, Shôwa 20-21 Nen*. Vol. 7, *Shōwa Ni Man Nichi No Zenkiroku*. Tokyo: Kōdahsha, 1989.

———, ed. *Senryôka No Minshu Shugi, Shôwa 22-24 Nen*. Vol. 8, *Shōwa Ni Man Nichi No Zenkiroku*. Tokyo: Kōdahsha, 1989.

Odakyū dentetsu kabushiki gaisha. *Super Express 3000*. Tokyo: Odakyū dentetsu, 1957.

Rokuda, Noboru, and NHK project seisakuhan. *Shūnen Ga Unda Shinkansen*. Vol. 2, *Project X Chōsensha Tachi*. Tokyo: Chū shuppan, 2001.

"Ryūsenkei Sharyō Mokei No Fūdō Shiken Seiseki Ni Tsuite." *Gyōmu kenkyū shiryō* 25, no. 2 (1937): 1-34.

Sagawa, Shun'ichi. "Ressha Tono Tsūshin I." *Japan Railway Engineers' Association* 5, no. 1 (1962).

Sasamoto, Masao. "Gun No Kaitai to Manpower No Heiwa Tenkan." In *Tsūshi: Nihon No*

Kagaku Gijutsu, 85-93. Tokyo: Gakuyō shobō, 1995.

Satō, Yoshihiko. "Sekai Ginkō Ni Yoru Tokaido Shinkansen Project No Hyōka." *Tetsudō shigaku* 19 (2001): 69-80.

Satō, Yutaka. "Kidō Ni Kuwawaru Suichoku Shōgeki Atsuryoku." *Tetsudô gijutsu kenkyû hôkoku* 16 (1958).

———. "Kurikaeshi Kajû Ni Yoru Dōshō Chinka No Jikken." *Tetsudō gijutsu kenkyû hōkoku* 65 (1959): 1-13.

———. "Rail No Kyokubu Ōryoku." *Tetsudō gijutsu kenkyū hōkoku* 27 (1958): 1-28.

———. "Yokoatsu Ni Taisuru Kidō Kyōdo No Kenkyū." *Tetsudō gijutsu kenkyū hōkoku* 110 (1960): 1-78.

Satō, Yutaka, and Masayoshi Toyoda. "Kakushu Dōryokusha No Kyokusen Yokoatsu No Rail Yokomage Ni Yoru Sokutei Kekka." *Tetsudô gijutsu kenkyû hôkoku* 57 (1959): 1-3.

Satō, Yutaka, Masayoshi Toyoda, Satoru Kobayashi, and Goto Hirata. "Ressha Ni Yotte Kidō Ni Shōzuru Shindō." 85 (1959): 1-29.

Sawano, Shūishi. "Shinkansen No Sharyō." *JREA* 2, no. 1 (1959): 14-16.

Seki, Shirō. *Sengo Sekai Ni Sakigaketa Jōetsusen Denka*. Tokyo: Keizai rondansha, 1987.

Shima, Hideo. *D-51 Kara Shinkansen Made: Gijutsusha No Mita Kokutetsu*. Tokyo: Nihon keizai shinbunsha, 1977.

———. "Shinkansen No Kōsō." In *Sekai No Tetsudō*. Tokyo: Asahi shinbunsha, 1964.

Shima Hideo ikōshū henshū iinkai-hen, ed. *Shima Hideo Ikōshū: 20-Seiki Tetsudōshi No Shōgen*. Tokyo: Nihon tetsudō gijutsu kyōkai, 2000.

Shima, Takashi, and Masao Tani. "Shinkansen Sharyō No Haishō Sōchi." *JREA* 7, no. 4 (1964): 45-48.

Shima, Yasujirō. "Tetsudō Kikan No Sunpō to Sharing No Kidō Ni Taisuru Atsuryoku No Kankei." *Kikai gakkaishi* 28, no. 95 (1925): 129-36.

Shinkansen-Yō Shisaku Ryokyaku Densha. Tokyo: Nihon kokuyū tetsudō, 1962. RTRI

Shinkansen 10-Nen Shi. Tokyo: Nihon kokuyū tetsudō shinkansen sōkyoku, 1975.

"Shinkansen Kakū Densha Senro Kenkyū Hōkoku." *Tetsudō gyōmu kenkyū shiryō* 2, no. 11 (1943): 2-31. RTRI

Shinohara, Takeshi, and Hideshige Takaguchi. *Shinkansen Hatsuansha No Hitorigoto: Moto Nihon Tetsudō Kensetsu Kōdan Sōsai Shinohara Takeshi No Network-Gata Shinkansen No Kōsō*. Tokyo: Pan research shuppan, 1992.

Shinohara, Yasushi, and Hiroyuki Kimoto. "Osaka-Himeji Kan S.H.F. No Sekkei to Shaken Kekka." *Kōtsū gijutsu* 99 (1954): 32-35.

Shōwa 25-Nen 12-Gatsu 15-Nichi Genzai (Honchō) Nihon Kokuyū Tetsudō Shokuinroku. Tokyo: n.p., n.d. EJR

"Shūnen Ga Unda Shinkansen: Rōyū 90-Sai, Sentōki Ga Sugata O Kaeta." In *Project X*: Nihon hōsō kyōkai (NHK), 2002.

Sogō, Shinji. "Shingijutsu to Speed Up." *JREA* 2, no. 1 (1959): 1.

Sumida, Shunshuke. *Sekai No Kōsoku Tetsudō to Speed Up*. Tokyo: Nihon tetsudō tosho, 1994.

Tada, Masatada. "Kōsoku Fūdō Ni Yoru Tubasakata No Jikkenteki Kennkyū." *Nihon kōkū gakkaishi* 4, no. 29 (1956): 5-10.

Takahashi, Dankichi. *Shinkansen O Tsukutta Otoko: Shima Hideo Monogatari*. Tokyo: Shōgakukan, 2000.

Takei, Akemichi. "Honkuni Tetsudō Ressha Sokudo No Hattatsu." *Kikai gakkaishi* 41, no. 251 (1938): 113-19.

Tanaka, Shin'ichi. "Sharyō." *Tetsudō gijutsu* 42, no. 1 (1985): 18-21.

———. "Shinkansen Sharyō: Sono Kaihatsu No Zengo." *Denki gakkai kenkyūkai shiryō* (2002): 17-22.

Tani, Masao. "Shinkansen Sharyō No Kimitsu." *JREA* 7, no. 7 (1964): 5-7.

Tani, Seiichirō. "Bōfu Makuragi Ni Tsuite." *Kōtsū gijutsu* 64 (1951).

Teratani, Takeaki. "Kaigun Zōheikan No Kōsatsu." In *Kigyō Keiei No Rekishiteki Kenkyū*, 344-63. Tokyo: Iwanami shoten, 1990.

Tetsudō gijutsu kenkyūjo-hen. *Tetsudō Gijutsu Kenkyūjo Sōritsu 70-Shūnen: 10-Nen No Ayumi*. Tokyo: Nihon kokuyū tetsudō tetsudō gijutsu kenkyūjo, 1977.

Tetsudō gijutsu kenkyūjō. *Kōsoku Daisha Shindō Kenkyūkai Kiroku, Dai Ikkai-Dairokkai*. Tokyo: n.p., n.d. RTRI

Tetsudō Gijutsu Kenkyūjo Kotei Shisan Ichiranhyō: Shōwa 46-Nen 3-Gatsu 31-Nichi Genzai`. Tokyo: n.p., 1971. RTRI

Tetsudō Gijutsu Kenkyūjo Senpai・Genshokusha Meibo: Shōwa 52-Nen 1-Gatsu 1-Nichi Genzai. Tokyo: n.p., n.d. KH

Tomita, Tetsuo. "Gijutsu No Juyō Ni Oyobosu Shijōkōzō Oobi Fūdo Kankyō Ni Kansuru Jisshōteki Bunseki." Ph. D dissertation, Tokyo Institute of Technology, 1999.

Tsukahara, Shūichi. "Kokuritsu Shiken Kenkyū Kikan No Taisei Seibi." In *Tsūshi: Nihon No Kagaku Gijutsu*, 147-57. Tokyo: Gakuyō shobō, 1995.

Tsuruno, Masayoshi. "Ente-Gata Kyokuchi Sentōki." In *Umiwashi No Kōseki*. Tokyo: Hara shobō, 1982.

Uchihashi, Katsuto. *Zoku Zoku Takumi No Jidai: Kokutetsu Gijutsujin Zero Hyōshiki Kara No*

Nagai Tabi. Tokyo: Sankei shuppan, 1979.

Uno, Hiroshi, ed. *Asahi Shinbun Ni Miru Nihon No Ayumi: Shōdo Ni Kizuku Minshu Shugi*. Vol. 3. Tokyo: Asahi shinbunsha, 1973.

———, ed. *Asahi Shinbun Ni Miru Nihon No Ayumi: Shōdo Ni Kizuku Minshu Shugi*. Vol. 2. Tokyo: Asahi shinbunsha, 1973.

Unoki, Jūzō. "Zoku Keiryō Kyakusha Sonogo." *Kōtsū gijutsu* (1957): 306-10.

Un'yu gijutsu kenkyūjo-hen. *10-Nen Shi*. Tokyo: Transportation Technology Research Center, 1960.

Un'yu Tsūshinshō Tetsudō Gijutsu Kenkyūjo Gaiyō: Shōwa 18-Nen 12-Gatsu. Tokyo: n.p., 1944. RTRI

Un'yushō. *Kokuyū Tetsudō No Fukkō: Tetsudō 75-Nen Kinen Shuppan Daiisshū*. Tokyo, 1948.

———. *Kokuyū Tetsudō No Genjō: Kokuyū Tetsudō Jissō Hōkokusho*. Tokyo, 1947.

———. *Tetsudō Gijutsu Kenkyūjo: Shōwa 22-Nendo Nenpō*. Tokyo, 1947. RTRI

Yamamoto, Mineo. *Jidōsha Kōgaku Kōza I: Sōsetsu Oyobi Kōzō*. Tokyo: Sankaidō, 1956.

Yamaoka, Shigeki. "Mitsubishi Zc707 Chijō Ni Orita Engine." *Tetsudōshigaku* 11 (1992): 7-13.

Yamashita, Sachio. "Nihon Zōsengyō Ni Miru Gijutsu No Keishō: Senzen Kara Sengo E." In *Kigyō Keiei No Rekishiteki Kenkyū*, edited by Keiichirō Nakagawa, 364-411. Tokyo:

Iwanami shoten, 1990.

Yasuda, Akio, Hiroo Yokoyama, Tsuyoshi Sakamoto, and Tetsu Hirooka. "Shinkansen No Kensetsu Kijun." *JREA* 2, no. 1 (1959): 5-14.

Yi, Yong Song, and Seiji Abe. "Higashi Asia Ni Okeru Kōsoku Tetsudō Kensetsu to Kankoku Kōsoku Tetsudō No Tenbō." *Un'yu to keizai* 63, no. 12 (2003): 53-61.

Yokobori, Shōichi. "Kyaku Densha No Gijutsu Teki Mondai Ten." *Kōtsū gijutsu* 76 (1952): 438-39.

Newspapers

Editorial. *Asahi shinbun*, 27 February 1947.

———. *Mainichi shinbun*, 26 April 1951.

Asahi shinbun, 26 February 1947.

Asashi shinbun, 3 March 1950.

Asahi shinbun, 25 April 1951.

Asahi shinbun, 14 February 1956.

Mainichi shinbun, 19 February 1950.

Yomiuri shinbun, 15 August 2002.

Yomiuri shinbun, 27 February 2004.

Sankei shinbun, 23 September 2000.

English Sources

"Astra Dome Train." *LIFE: International edition* 3, no. 1 (1947): 36-37.

"A Better Way to Fly." *Economist* 346, no. 8056 (1998): 21-23.

Abel, Theodore F. *The Nazi Movement: Why Hitler Came into Power*. New York: Atherton Press, 1966.

Abrams, Philip. *Historical Sociology*. Ithaca: Cornell University Press, 1982.

Aldrich, Mark. "Combating the Collision Horror: The Interstate Commerce Commission and Automatic Train Control, 1900-1939." *Technology and Culture* 34, no. 1 (1993): 49-77.

Anderson, John David. *A History of Aerodynamics and Its Impact on Flying Machines*. Cambridge: Cambridge University Press, 1998.

Aoki, Eiichi, Imashiro Mitsuhide, Shin'ichi Kato, and Yasuo Wakuda, eds. *A History of Japanese Railways, 1872-1999*. Tokyo: East Japan Railway Culture Foundation, 2000.

Bilstein, Roger E. *Orders of Magnitude: A History of the Naca and Nasa, 1915-1990*.

Washington, DC: National Aeronuatics and Space Administration, 1989.

Blackford, Mansel G. *The Rise of Modern Business in Great Britain, the United States, and Japan*. Chapel Hill: University of North Carolina Press, 1988.

Braun, Hans-Joachim. "Technolgy Transfer under Conditions of War: German Aero-Technology in Japan During the Second World War." *History of technology* 11 (1986): 1-23.

Coombs, Gary. "Opportunities, Information Networks and the Migration-Distance Relationship." *Social Networks* 1 (1979).

Cusumano, Michael A. *The Japanese Automobile Industry: Technology and Management at Nissan and Toyota*. Cambridge: Harvard University Press, 1985.

Dees, Bowen C. *The Allied Occupation and Japan's Economic Miracle: Building the Foundations of Japanese Science and Technology 1945-52*. Surrey: Japan Library, 1997.

"Diesel Locomotives." *LIFE: International edition* 2, no. 12 (1947): 25-31.

Does Technology Drive History? The Dilemma of Technological Determinism. Edited by Merritt Roe Smith and Leo Marx. Cambridge: MIT Press, 1994.

Dower, John. "Sizing up (and Breaking Down) Japan." In *The Postwar Development of Japanese Studies in the United States*, edited by Helen Hardacre, 1-36. Leiden: Brill, 1998.

Dower, John W. *Embracing Defeat: Japan in the Wake of World War II*. New York: W.W. Norton

& Co./New Press, 1999.

———. *War without Mercy: Race and Power in the Pacific War*. New York: Pantheon Books, 1986.

Drucker, Peter. "The End of Japan, Inc.? An Economic Monolith Fractures." *Foreign Affairs* 72, no. 2 (1993): 10-15.

———. "Trade Lessons from the World Economy." *Foreign Affairs* 73, no. 1 (1994): 99-108.

Ericson, Eric. *Identity, Youth, and Crisis*. New York: W.W. Norton, 1968.

Ericson, Steven J. "Importing Locomotives in Meiji Japan: International Business and Technology Transfer in the Railroad Industry." *Osiris* 13 (1998): 129-53.

———. *The Sound of the Whistle: Railroads and the State in Meiji Japan*. Cambridge: Harvard University Press, 1996.

Francks, Penelope. *Technology and Agricultural Development in Pre-War Japan*. New Haven: Yale University Press, 1984.

Freeman, Christopher. *Technology, Policy, and Economic Performance: Lessons from Japan*. New York: Pinter Publishers, 1987.

Fukasaku, Yukiko. *Technology and Industrial Development in Pre-War Japan: Mitsubishi Nagasaki Shipyard, 1884-1934*, *The Nissan Institute/Routledge Japanese Studies Series.*

London: Routledge, 1992.

General Headquarters, United States Army Forces, Pacific, Scientific and Technical Advisory Section. "Report on Scientific Intelligence Survey in Japan: September and October 1945." United States National Archives, Maryland, 1 November 1945.

Gerlach, Michael L. *Alliance Capitalism: The Social Organization of Japanese Business*. Berkeley: University of California Press, 1992.

Gimbel, John. *Science, Technology, and Reparations: Exploitation and Plunder in Postwar Germany*. Stanford: Stanford University Press, 1990.

Gluck, Carol. *Japan's Modern Myths: Ideology in the Late Meiji Period*. Princeton: Princeton University Press, 1985.

Gordon, Andrew. *The Evolution of Labor Relations in Japan: Heavy Industry, 1853-1955*. Cambridge: Harvard University Press, 1985.

———. *The Wages of Affluence: Labor and Management in Postwar Japan*. Cambridge: Harvard University Press, 1998.

Gotō, Akira, and Hiroyuki Odagiri. *Innovation in Japan*. Oxford: Oxford University Press, 1997.

Grunden, Walter. "Science under the Rising Sun: Weapons Development and the Organization of Scientific Research in World War II Japan." Ph. D dissertation, University of California, Santa Barbara, 1998.

Hayashi, Takeshi. *The Japanese Experience in Technology: From Transfer to Self- Reliance*. Tokyo: United Nations University Press, 1990.

Hecht, Gabrielle. *The Radiance of France: Nuclear Power and National Identity after World War II*. Cambridge: MIT Press, 1998.

Horikoshi, Jirō. *Eagles of Mitsubishi: The Story of the Zero Fighter*. Seattle: University of Washington Press, 1981.

Hughes, Thomas P. *Networks of Power: Electrification in Western Society, 1880-1930*. Baltimore: Johns Hopkins University Press, 1983.

"Japan." In *Technological Independence: The Asian Experience*, edited by Chamarik Saneh and Susantha Goonatilake, 294-352. New York: United Nations University Press, 1994.

Japan National Railways. *Data on Engineering: Submitted to International Bank for Reconstruction and Development*, May 1960.

———. "General Statement Supporting the Loan from International Bank for Reconstruction and Development." 1959.

Japanese National Railways. *Technical Aspects on the Tokaido Line*. n.p., 1963.

Jedlicka, Davor. "Opportunities, Information Networks and International Migration Streams."

Social Networks 1 (1979).

Johnson, Chalmers A. *MITI and the Japanese Miracle: The Growth of Industrial Policy, 1925-1975*. Stanford: Stanford University Press, 1982.

Kinmonth, Earl H. "Japanese Engineers and American Myth Makers." *Pacific Affairs* 64, no. 3 (1991): 328-50.

Koizumi, Kenkichirō. "In Search of Wakon: The Cultural Dynamics of Manufacturing Technology in Postwar Japan." *Technology and Culture* 43, no. 1 (2002): 29-49.

Levine, Solomon Bernard, and Hisashi Kawada. *Human Resources in Japanese Industrial Development*. Princeton: Princeton University Press, 1980.

Low, Morris. "The Useful War: Radar and Mobilization of Science and Industry in Japan." In *Science and the Pacific War: Science and Survival in the Pacific, 1939-1945*, edited by Roy M. MacLeod, 291-302. Dordrecht: Kluwer, 2000.

Lynn, Leonard H. *How Japan Innovates: A Comparison with the U.S. In the Case of Oxygen Steelmaking*. Boulder: Westview Press, 1982.

McCormick, Kevin. *Engineers in Japan and Britain: Education, Training, and Employment*. London: Routledge, 2000.

Merkl, Peter H. *Political Violence under the Swastika: 581 Early Nazis*. Princeton: Princeton

University Press, 1974.

Meunier, Jacob. *On the Fast Track French Railway Modernization and the Origins of the TGV, 1944-1983*. Westport, Connecticut: Praeger, 2002.

Minami, Ryōshin. *Acquiring, Adapting, and Developing Technologies: Lessons from the Japanese Experience*. New York: Macmillan, 1995.

Molony, Barabara. *Technology and Investment: The Prewar Japanese Chemical Industry*. Cambridge: Harvard University Press, 1990.

Moritani, Masanori. *Japanese Technology: Getting the Best for the Least*. Tokyo: Simul Press, 1982.

Morris-Suzuki, Tessa. "Sericulture and the Origins of Japanese Industrialization." *Technology and Culture* 33, no. 1 (1992): 101-21.

———. *The Technological Transformation of Japan: From the Seventeenth to the Twenty-First Century*. Cambridge: Cambridge University, 1994.

Murata, Jun'ichi. "Creativity of Technology: An Origin of Modernity?" In *Modernity and Technology*, edited by Thomas J. Misa, Philip Brey and Andrew Feenberg, 227-53. Cambridge: MIT Press, 2003.

Ohnuki-Tierney, Emiko. *Kamikaze, Cherry Blossoms, and Nationalism: The Militarization of*

Aesthetics in Japanese History. Chicago: University of Chicago Press, 2002.

Okimoto, Daniel I. *Between MITI and the Market: Japanese Industrial Policy for High Technology*, *Studies in International Policy.* Stanford: Stanford University Press, 1989.

Ōkōchi, Akio, and Shin'ichi Yonekawa. *The Textile Industry and Its Business Climate: Proceedings of the Fuji Conference*. Tokyo: University of Tokyo Press, 1982.

Ouchi, William G. *Theory Z: How American Business Can Meet the Japanese Challenge*. Reading, Mass.: Addison-Wesley, 1981.

Patrick, Hugh T., Larry Meissner, and Committee on Japanese Economic Studies (U.S.). *Japan's High Technology Industries: Lessons and Limitations of Industrial Policy*. Seattle: University of Washington Press, 1986.

Peattie, Mark R. *Sunburst: The Rise of the Japanese Naval Air Power, 1909-1941*. Annapolis: Naval Institute Press, 2001.

Robertson, Andrew. "Mobilizing for War, Engineering the Peace: The State, the Shop Floor and the Engineer, 1935-1960." Ph. D dissertation, Harvard University, 2001.

Rogers, Everett M. *Diffusion of Innovations*. 4th ed. New York: Free Press, 1995.

Samuels, Richard J. *"Rich Nation, Strong Army": National Security and the Technological Transformation of Japan*. Ithaca: Cornell University Press, 1994.

"The Talgo." *LIFE: International edition* 26, no. 17 (1949): 83-90.

Tsutsumi, William M. *Manufacturing Ideology: Scientific Management in Twentieth-Century Japan*. Princeton: Princeton University Press, 1998.

United States Naval Technical Mission to Japan. "Reports of the U.S. Naval Technical Mission to Japan, 1945-1946." Washington D.C.: Operational Archives, U.S. Naval history division, microform, 1975.

Wittner, David G. "Iron and Silk: Progress and Ideology in the Technological Transformation of Japan, 1850-1895." Ph. D dissertation, Ohio State University, 2000.

Yamamoto, Hirofumi. *Technological Innovation and the Development of Transportation in Japan*. Tokyo, Japan: United Nations University Press, 1993.

Yonekura, Seiichiro. *The Japanese Iron and Steel Industry, 1850-1990: Continuity and Discontinuity*, *Studies in the Modern Japanese Economy.* New York: St Martin's Press, 1994.

Young, Louise. *Japan's Total Empire: Manchuria and the Culture of Wartime Imperialism*. Berkeley: University of California Press, 1998.

"Zero Inspired Today's Innovations: Warplane's Engineers Later Excelled in Auto, Rocket Sectors." *The Japan Times*, January 14 2004.

German Source

Koch, Matthias. *Rüstungskonversion in Japan Nach Dem Zweiten Weltkrieg: Von Der Kriegswirtschaft Zu Einer Weltwirtschaftsmacht*. Tokyo: Deutsches Institut für Japanstudien, 1998.

Spanish Source

Ferro Carriles: Catálogo De Sellos Temáticos. Barcelona: DOMFIL, 2001.

Appendix A

List of Informants

The following is a list of all the former military engineers and their relatives whom I contacted from 2002 to 2004. My dissertation is based on extensive archival research, as well as on a series of interviews with such informants. The main text, however, does not refer to all the information that I had gathered from them, though they provided me with ample, invaluable information about the contours of institutional organizations and their cultures in which the engineers worked during and after World War II. My means of communication with the informants varied, depending on their preferences and physical conditions (such as hearing ability). See Chapter 1 for information regarding my approach to implementing interviews.

Names	Dates	Means of communication
Akatsuka, Takeo	December 10, 2002	Letter
Aoki, Yoshirō	May 10, 2004	Telephone
Enomoto, Shinsuke	April 5, 2004 May 10, 2004 June 2, 2004	Letter Letter Letter
Fujita, Kōmei	April 7, 2004 June 25, 2004	Letter Letter
Hirose, Kengo	April 5, 2004	Letter
Kanō, Yasuo	March 22, 2004	Oral interview in Tokyo
Kawanabe, Hajime	April 3, 2004	Letter
Kimura, Shōichi	May 25, 2004 June 16, 2004 July 7, 2004	Letter Letter Letter

Kumezawa, Yukiko	March 6, 2004 March 22, 2004	Letter Letter
Miki, Tadanao	December 22, 2002 June 19, 2003 August 1, 2003	Oral interview in Zushi Oral interview in Zushi Oral interview in Zushi
Nakamura, Hiroshi	March 14, 2004 March 17, 2004 March 24, 2004 March 28, 2004 April 29, 2004 June 4, 2004 August 9, 2004	Telephone Telephone Telephone Letter Oral interview in Kyoto Telephone Telephone
Nakamura, Kazuo	November 7, 2002 January 16, 2003 January 21, 2003 March 3, 2004 March 8, 2004	Oral interview in Tokyo Letter Letter Letter Letter
Shinohara, Osamu	March 11, 2004	Letter
Takabayashi, Morihisa	November 25, 2002 December 14, 2002 June 18, 2003 July 7, 2003 July 17, 2003 July 22, 2003 July 26, 2003 August 4, 2003 August 14, 2003 February 20, 2004 April 21, 2004 July 23, 2004	Letter Letter Letter Letter Letter Letter Letter Letter Letter Letter Letter Letter
Tanaka, Shin'ichi	November 28, 2002	Oral interview in Tokyo
Ueda, Toshio	April 29, 2004	Oral interview in Tokyo
Umeno, Takeyasu	April 13, 2004 April 14, 2004 April 18, 2004	E-mail E-mail E-mail

	April 26, 2004 May 1, 2004	E-mail E-mail
Watanabe, Saburō	July 16, 2003	Interview in Tokyo