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Yasushi Sato, *NASA and Its Engineering Cultures: Human Qualities in Grand System Building (NASA*を築いた人と技術：巨大システム開発の技術文化）

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Yasumoto Fujita

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Established in 1958, the year following the Soviets' launch of Sputnik, by the late 1960s, the US National Aeronautics and Space Administration (NASA) had become a giant organization with 11 major field centers across the nation and more than 30,000 employees. Focusing on the diversity of the "engineering cultures" in the geographically scattered organization, Yasushi Sato presents a new study of NASA.

What lies at the core of this book is a historical description of conflicts at a time when ideas and methods regarding systems engineering were introduced into the field of space development. In the 1960s, engineers and managers at NASA headquarters adopted systems engineering to carry out various projects, above all, the Apollo program. However, engineers at the field centers did not accept systems engineering easily. Sato argues that engineers at the different field centers had adopted different localized engineering cultures, which were generally incompatible with the formalizing and depersonalizing nature of systems engineering.

Sato defines an engineering culture as the overall foundation of engineering practices; it consists of engineering methods and approaches, basic views of technology, a social space where engineers live, and so on. In order to clarify this point, Sato considers four case studies of the following field centers, devoting one chapter to each: the Marshall Space Flight Center, the Manned Spacecraft Center, the Jet Propulsion Laboratory (JPL), and the Goddard Space Flight Center.

It may be stated that the most impressive is the case of the Marshall Center for its strong solidarity. At the Marshall Center, Director Wernher von Braun and his staff undertook the development of the Saturn launching vehicles for the Apollo program in the 1960s. Sato argues that von Braun's team, whose core members had come to the United States from Germany after the end of World War II, formed a stable community where they valued their organic and collaborative relationship based on

Y. Fujita (✉)
Social Science Institute, International Christian University, Tokyo, Japan
e-mail: RXM05777@nifty.com

trust and mutual understanding. Further, they placed emphasis on subtle engineering decisions and hardware-oriented practical experience.

What makes the argument persuasive is the dynamic description of the various engineering practices adopted by von Braun's team. The principle of automatic responsibility that requires the engineers to engage in activities in which they possess expertise, a communication tool among von Braun and his staff called "weekly notes," consensus building through meetings, and von Braun's leadership in urgent situations, all of which, Sato argues, formed "the Marshall's Principles" that enabled the integration of the diversified knowledge and expertise required for rocket development. Moreover, examples of the high in-house engineering capability vis-à-vis the increased volume of subcontract as well as the technically conservative approach to reliability also illustrate the unique engineering culture of the Marshall Center.

Another aspect that highlights the uniqueness of von Braun's team is its contrast with the promoters of systems engineering at NASA headquarters, who adopted a completely different engineering culture. Sato reveals this contrast by presenting characters such as Joseph F. Shea, George E. Mueller, and Samuel C. Phillips. In the early 1960s, Shea, a young talented system engineer from the missile industry, attempted to strengthen the management and supervision of the field centers by demanding detailed progress reports. Sato highlights the difference between Shea and von Braun's manner of viewing technology as the difference in whether or not they considered the technical aspects as being verbally or mathematically expressible.

At NASA headquarters, Phillips and his boss, Mueller, also promoted the implementation of the formalized and standardized methods of systems engineering. In particular, Phillips attempted to apply configuration control to the Apollo program. Configuration control is a systematic method of the management of design changes. However, von Braun expressed his strong disapproval of the implementation of the configuration management, defending his more human-dependent approach. With well-documented descriptions of such engineering practices at the Marshall Center, Chapter One provides the story of how the engineering culture at the Marshall Center held out against the external pressure during the early 1960s; however, eventually, in the late 1960s, it came to change because of personnel and budget cutbacks and the diversification of operations.

Similar to the case study of the Marshall Center, the other three case studies also depict conflicts between the field centers and NASA headquarters. However, none of these stories is quite the same. Following the tradition of the National Advisory Committee for Aeronautics (NACA), where engineers had stressed communication with users of hardware, namely, pilots and ground controllers, engineers at the Manned Spacecraft Center near Houston also had their own human-oriented engineering style. In this case, the conflicts occurred not only between the center and NASA headquarters but also within the center. In October 1963, Joseph F. Shea came to the center from NASA headquarters as the new manager of the Apollo Spacecraft Program Office. At the center, Shea became a leader of a group of system engineers from the missile industry. Chapter Two describes how the two engineering cultures interacted with each other.

The two case studies of the JPL and the Goddard Center are not directly related to the Apollo program. The JPL is part of an elite university, California Institute of

Technology, and its mission has been to develop lunar and planetary probes under a contract with NASA. In the 1960s, engineers at the JPL formed an individualistic organizational culture, preferring to focus on risky but academically valued work. Chapter Three illustrates how the JPL's academic people were forced by NASA headquarters to reform the organization for the purpose of uniformity and how they were able to reach a compromise.

The Goddard Center was a place where two cultures were confronted with one another. At the center, there were space scientists from the Naval Research Laboratory and engineers from NACA. Chapter Four traces the story of how the scientists defended their identity against the technology-centered project planning of NASA headquarters and the paternalistic manner of management by the director of the center at the time, Harry J. Goett, who was from NACA.

Throughout the chapters, Sato not only provides historical descriptions of the various interactions between the different engineering cultures but also presents sociological analyses of the differences. In other words, he correlates the differences in the engineering styles with the differences in the social structure of the engineering communities or engineers' career views and educational backgrounds. Typically, Sato correlates systems engineers with high academic education, meritocracy, and upward career mobility. With regard to human-dependent styles, the von Braun's method is partly attributed to his aristocratic roots and humanistic sophistication. Further, the engineering tradition of NACA is related to its engineers' comparatively low level of academic education and the pluralistic structure of the community.

At the beginning of this review, I introduced this book as a book of NASA. However, in fact, it also has a chapter that deals with the contrast between the Japanese and American styles by referring to two case studies of Japanese organizations. Until they were recently integrated, the following two organizations had been in charge of space development in Japan: the Institute of Space and Aeronautical Science (ISAS) and the National Space Development Agency of Japan (NASDA). Focusing on the origin and early history, in Chapter Five, the author illustrates the distinct engineering cultures of ISAS and NASDA that were different from that of the systems engineers at NASA.

From its foundation in 1964, ISAS, as an academic institution, continued with the development of independent technologies of solid rocket; the institution was initially led by Hideo Itokawa. On the other hand, NASADA, a governmental corporation whose mission was the development of launch vehicles for application satellites, shifted its policy from independent development to the introduction of the US technology including systems engineering immediately after its foundation in 1969. While these are well-known facts, there has been no study that highlights the engineering cultures of the two organizations. Although the engineering cultures of the two organizations were considerably different, Sato argues, that they shared a common basic view of technology: engineering had to be people-dependent.

Sato concludes the chapter with some theoretical discussions of the Japanese human-oriented engineering cultures. Referring to the well-known argument of Japanese vertical relationships made by a Japanese social anthropologist, he emphasizes the anti-contractual norm inherent in the Japanese society as opposed to the contractual norm present in the American society. Further, he states that the

people-dependent styles of Japanese engineers are attributed to the former, while the people-independent style of systems engineering is attributed to the latter.

In Chapter Six, the final chapter, Sato further extends the discussion of the theoretical implications of the study. The trend toward the depersonalization of technology, which is evident in systems engineering, is, he asserts, consistently observed in the history of technology. Based on this acknowledgment, Sato raises the following question: Is the consistent tendency toward the depersonalization of technology the universal essence of technology?

The book is, thus, highly readable and interesting with a careful observation on specific characters. However, this does not imply that I agree with all of the discussions in this book. In particular, I have some questions concerning the discussion about the theoretical implications of the study.

First, I think that Sato's discussion on the role that social and technical factors play in shaping an engineering culture appears to be ambiguous. If the kind of technology that engineers work on is not a crucial factor, and only social factors are crucial, any technology can be perfected by a number of engineering cultures. However, that is not the case. For instance, Sato himself states that the Apollo spacecraft would not have been perfected without the combination of the human-oriented engineering approach of NACA and systems engineering, given the nature of the project. The fact is that the entire description in the book suggests the technically and socially co-constructed nature of technology, which is, I think, a standard view of technology and society, given the last two decades of discussion in technology studies. However, the discussion of the book eventually becomes a kind of simplistic social deterministic view, which proposes that macro social factors such as meritocracy and contractualism play a crucial role.

Sato, I am afraid, may say that my above-mentioned critique results from a complete misinterpretation of his intention. In the final chapter, he actually explains his intention that is to find out whether or not the depersonalization of technology is the universal essence of technology. Further, Sato criticizes the approach of the social construction of technology (SCOT) as being narrowly focused on the interaction between the relevant social groups involved with the formation of a technology. On the contrary, he favorably introduces the recent scholarly efforts to create a new approach that is beyond the myopic view of SCOT, including the philosophical discussion of the essential nature of modern technology by Andrew Feenberg. Thus, Sato's discussions may superficially appear to go beyond the social deterministic approach into a newer one. However, as already noted, his view is eventually socially deterministic, and I am unaware of the extent to which he is aware of this fact.

Sato's social deterministic view is also evident in his speculation that technology is a function of social conditions and frameworks, and that the apparent tendency of depersonalization of technology may be the effect of the stability of a major social parameter, namely, contractualism. This leads to another question: Where can such stability of contractualism be observed? Is it found only in America, or more broadly in the West, excluding Japan? Let us assume that the answer to this question is yes. In that case, Sato's speculation does not hold. To explain the consistency of the trend of depersonalization of technology, Sato provides examples of engineering innovation such as scientific management, the introduction of interchangeable parts,

and the automation of production. Surely, such innovations are, more or less, widely employed in the world today. However, how could this universal trend be the effect of the stable contractualism in society which in itself is not universal? Hence, theoretical refinements are required, along with a more dynamic view of technology and society.

Ultimately, Sato's project to identify the essential nature of modern technology as being associated with certain social values appears to be unsuccessful, virtually employing the static bijection principle. I believe that things cannot be so simplistic. In fact, the entire description in this book is in no manner simplistic. Further, while it is not erroneous for Sato to critically examine the essential aspects of technology and society, which are typically found in the field of space development, since I positively believe that he has every right to do so, the following question still arises: Why depersonalization and contractualism over gigantism, militarization, nationalism, or progressivism, per se?

Finally, the lack of theoretical maturity, of which Sato is conscious in a way, cannot debase the value of this book. Its main purpose of elaborating the different engineering cultures is completely achieved. The informative notes and annotated bibliography at the end of the book are perfect.

This Japanese book is based on Sato's Ph.D. dissertation in History and Sociology of Science, submitted to the University of Pennsylvania. For non-Japanese readers, the following papers by Sato are recommended:

Sato, Y. (2005). Local engineering and systems engineering: Cultural conflict at NASA's Marshall Space Flight Center, 1960–1966. *Technology and Culture*, *46* (3), 561–583.

Sato, Y. (2007). Systems engineering and contractual individualism: Linking engineering processes to macro social values. *Social Studies of Science*, *37*(6), 909–934.