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Setting 'Moonshots' on Target: Summary of a Bilateral Symposium on National Technology Investment Program

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In 2018, the government of Japan announced establishment of an over-the-horizon technology development program that it called the Moonshot, to recall the goal-oriented space travel program of the United States in the 1960s. Japan outlined the new program's research goals in 2019 and secured an initial budget of nearly $1 billion to fund this innovation effort. From its inception, a key feature of the Moonshot program has been the emphasis placed on international cooperation in advanced science and technology R&D related to program goals, including a strong emphasis on potential collaboration with like-minded partners such as the European Union (EU), the United States, and other nations with common values, ethics, and norms. This was underscored by a Moonshot International Symposium held in Tokyo and Kyoto in December 2019 that featured considerable participation by scientists, engineers, technology experts, and policymakers from the EU, Japan, and the United States.

On May 28, 2020, the Japan program of the Carnegie Endowment for International Peace presented a webcast symposium titled, "Setting 'Moonshots' on Target: U.S.-Japan Strategies for National Technology Investment." This event was planned and executed in close consultation and coordination with the Japanese agencies and individuals responsible for launching this ambitious program and their European and U.S. counterparts. In a bow to the restrictions on travel at the time due to the coronavirus pandemic, Carnegie presented the symposium via two livestreamed sessions.

Session 1

Session 1, "Trends and Opportunities for Long-Term Science Investment," featured key thought leaders behind Japan's Moonshot program, the National Science Foundation's (NSF) "10 Big Ideas Program," the EU's Horizon programs, and related areas of international science and technology collaboration. The moderator for session 1 was James L. Schoff, senior fellow in Carnegie's Asia Program. Panelists included Sony Computer Science Laboratories President and Chief Executive Officer Hiroaki Kitano, NSF's

Deputy Assistant Director for Computer and Information Science and Engineering Erwin Gianchandani, EU Delegation to the United States Minister-Counselor for Research and Innovation Mary Kavanaugh, and Cabinet Secretariat of Japan's Vice Minister for Innovation Policy Koichi Akaishi.

Following Schoff's brief introductory remarks, Kitano presented an overview of the Moonshot program (see accompanying PDF slides). Kitano described the Moonshot program architecture, its present status, and the areas eligible for receiving program funding. He explained the role of the Visionary Council, of which he is a member, in defining the goals, mission and potential areas of R&D that may be supported, and he pointed out the role the Japanese government plays in selecting proposed R&D projects for funding, including the key role of the prime minister in this selection process.

Kitano then contrasted Japan's Moonshot program with the U.S. Apollo program for which this Japanese initiative was named. He stressed that the main difference between these programs is that while both involve high cost, high risk endeavors dependent upon basic as well as applied research, the Apollo program had a single, narrowly defined mission and goal (a manned lunar landing), but Japan's Moonshot covers a broader theme of "techno-social transformation" and targets a series of diverse goals aimed at solving some of Japan's and the world's most vexing problems. In seeking to leverage potential scientific and technological advances that address the issue of an aging society—with an eye to harnessing such advances to transform Japan—as well as "saving the earth and saving civilization" and exploring frontiers in science and technology Kitano stressed the importance of "making the wildest imaginings into reality." In closing, he quoted the late Steve Jobs who famously said: "the people who are crazy enough to think they can change the world are the ones who do."

Gianchandani discussed the NSF's 10 Big Ideas program that was launched in 2016. He stressed the importance of multi-disciplinary and cross-disciplinary R&D efforts to this program and, citing it as a being of key importance to success, emphasized the degree to which these efforts "compel innovation." In commenting on this point, Schoff observed and Gianchandani agreed that this is a feature of both the NSF's program and the Japan's Moonshot program.

Kavanaugh suggested that this is also true of the EU's seven-year-long and $80 billion Horizon 2020 program and its successor program, Horizon Europe, now getting underway. She also cited the importance of support for long-term R&D efforts.

After commenting on the meeting of the G7 science ministers that was taking place concurrently with Carnegie's symposium, Akaishi announced that the Moonshot program had just received an additional $150 million to support R&D work focusing on health and medical challenges in light of the global coronavirus pandemic.

Akaishi then turned to what he characterized as "the most difficult parts" of implementing the Moonshot program. He defined this effort as one of "revolutionizing" science and technology R&D, not only in the selection of Moonshot targets, but also "in Japan's R&D process." In this regard, he highlighted five issues associated with the selection of Moonshot targets:

1. How to set a proper target
2. How to accommodate failure
3. How to involve relevant stakeholders
4. How to choose Project directors
5. How to make the most of international collaboration

In discussing these issues, Akaishi underscored the importance of "spin-ins and spin-offs," such as incorporating cutting edge commercial technologies into Moonshot research and leveraging Moonshot breakthroughs for outside applications. He also cited the importance of governments protecting collaborations through legal mechanisms such as the U.S.-Japan agreement on collaboration in quantum information science and technology, signed at the December 2019 Moonshot International Symposium, and a more recent letter of intent between Japan and the EU signed just days before Carnegie's event.

In the discussion that followed, Gianchandani remarked that collaboration based on shared goals and interests that involves a step-by-step approach is desirable. Akaishi commented that data sharing has always been important, but the pandemic was creating an even greater impetus to share data and collaborate more extensively and effectively. Echoing the late Steve Jobs in defining the key factors to the Moonshot program's success, he said: "The most important thing is the existence of crazy guys with intelligence."

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Session 2

Session 2 focused on "Examples of U.S.-Japan Science Collaboration: High Energy Density Science and AI." The moderator for this session was Douglas Rake, president and chief executive officer at Racke Strategies & Technologies Inc. Panelists for this session included: Science Counselor at the Embassy of Japan in the United States Seiichi Shimasaki, Lawrence Livermore National Laboratory's (LLNL) Chief Technology Officer and Science and Technology Deputy Director Patricia Falcone, the University of Osaka's Institute for Laser Engineering (ILE) Director Ryosuke Kodama, and U.S. Department of Energy's Deputy Undersecretary for AI and Technology Dimitri Kusnezov.

Rake introduced the panelists and turned to Shimasaki as the first speaker. Shimasaki's presentation included additional information on the present status of the Moonshot Program as well as his experience in working to support Japanese collaboration with U.S. national laboratories, particularly LLNL.

Shimasaki began by reviewing the three areas of society, environment, and the economy to be addressed by the Moonshot program and enumerated the six attendant goals, announced in January 2020, as targets for completion by 2050. The six original goals are:

1. Realization of a society in which human beings can be free from limitations of body, brain, space, and time;
2. Realization of ultra-early disease prediction and intervention;
3. Realization of AI robots that autonomously learn, adapt to their environment, evolve in intelligence and act alongside human beings;
4. Realization of sustainable resource circulation to recover the global environment;
5. Creation of the industry that enables sustainable global food supply by exploiting unused biological resources; and
6. Realization of a fault-tolerant universal quantum computer that will revolutionize economy, industry, and security.

Shimasaki also mentioned Akaishi's earlier announcement that, in response to the coronavirus pandemic, health and medical R&D has been selected as a seventh goal. Shimasaki emphasized the importance of international collaboration in achieving these highly ambitious goals.

Shimasaki then focused on the question of "how to craft international collaboration within this framework." Suggesting one possible model for such collaboration, he outlined his experience working between Japanese parties and LLNL. He first cited the collaboration in high energy density (HED) science and high energy laser R&D, an area in which the University of Osaka and LLNL began their twenty-year collaboration by signing a memorandum of understanding. Shimasaki then stressed the importance of the "upgrading" of this collaboration in 2019 by means of executing a project agreement between the U.S. Department of Energy and Japan's Ministry of Education, Culture, Sports, Science and Technology. Although this differs from the NSF's usual approach, involving joint funding by NSF and an international counterpart, it is consistent with Gianchandani's suggestion that utilizing an incremental approach is often a wise way to build institutional ties and lasting collaborations. Shimasaki's second example of working with LLNL involved enabling Japanese students to participate in LLNL's Data Science Summer Institute. LLNL's cross-sectoral approach, involving engagement with academia and private industry, is a particularly attractive aspect of this program to Japan where there are currently unrealized aspirations to develop such working relationships.

Next, Falcone briefly described the role and distinguishing characteristics of the Department of Energy national laboratories, highlighting the importance of both collaboration and competition between and among these organizations as well as the vital role that partnerships with academia, private industry, and international partners play in carrying the mission-driven science and technology work of these unique institutions. She argued for greater emphasis on the development of strategic partnerships "between international partners that are like-minded, partners with special relationships and shared values, that are allied and purposeful." Falcone stressed the importance of such partnerships being "enduring and purposeful beyond individual scientists." She also remarked that in addition to the importance of best practices, our countries should be actively supporting "exceptional people… [who have] a holistic view of the system."

Falcone added, "I think it is important to think about values, the values of open science," and she stressed the importance of accountability to norms and standards, particularly around intellectual property rights and stewardship of this innovation. She went on to observe that "all nations are looking to innovation for national prosperity and national strength, but it may be that not all nations are observing the same norms and standards." Falcone then suggested this is a part of why it is so important for like-minded nations,

particularly allies like Japan and the United States, to forge institutional, enduring partnerships for advancing science and technology.

In commenting on the long-term relationship with the University of Osaka in HED science, as well as the potential for doing advanced work in AI, Falcone cogently made the case for thinking about: "institutional engagement as well as PI-to-PI [meaning scientist to scientist] engagement" in imagining how to broaden scientific collaboration to include "deliberately [structuring] a part of our collaborative relationships to have a view toward sustained support." She also suggested that in concentrating on strategic areas common interest Japan and the United States can "build ties so that in crisis we can really bring the shared strength of our systems of science and technology to national needs." Many of the issues Falcone highlighted have been explored in more detail in Schoff's working paper titled *U.S.-Japan Technology Policy Coordination: Balancing Technonationalism with a Globalized World* available on Carnegie's website.

Kodama expanded on the history of collaboration between LLNL and the University of Osaka, noting milestones such as an award winning collaboration in 2006 (the American Physical Society's John Dawson Award for Excellence), collaborative astrophysics experiments making use of LLNL's National Ignition Facility, the opening of a University of Osaka Office at LLNL in 2017, and the 2019 "upgrade" of the U.S.-Japan agreement mentioned earlier by Shimasaki. After explaining some unique aspects of HED Science and how it contributes to a wide range of other scientific progress in areas such as industrial use and medical science, Kodama highlighted the interaction between HED science and the emergence of AI and machine learning. He said that there is an important relationship between AI capabilities and the development of new high-energy and high-repetition-rate lasers that "can lead to a paradigm shift in HED science." He further suggested that leveraging AI and machine learning, combined with linking the University of Osaka's planned high-power-high repetition-rate laser and the National Ignition Facility at LLNL, could open the way to new and impressive advances in HED science.

Kusnezov offered his reflections on what had been said by the other speakers throughout the day and provided his "technical opinions on some of these remarkable goals of the Moonshot." Echoing Akaishi's interest in "revolutionizing" Japan's R&D and the associated processes, Kusnezov remarked that some of the Moonshot goals are "so nontraditional that one has to reflect on things and ways things may be done that are also nontraditional." He continued by saying that the Moonshot program "is uniquely ambitious and

one has to think about ways to cooperate that can stand the test of time and think about long-term challenges that will emerge." He offered the view that "as it evolves, the Moonshot could help frame the purpose of several generations of [Japanese] scientists, engineers and technical experts." He further observed that the Moonshot goals are "so cross-cutting with societal focus on one side and deep technical roots on the other that it will require specialists but also generalists." He went on to suggest that this requirement for generalists to be involved "is a place where partnerships could be important."

Noting the launch of the Moonshot program against the backdrop of the coronavirus pandemic, Kusnezov reflected that "there are probably things that we could take away that in the near-term could be of value." As an example, in considering data, he said "at the more abstract level there is an appetite surfacing for new ways to process very complex information and extract person-specific actions." He also noted the similarities between Kodama's point regarding the use of data-driven AI and machine learning capabilities to have a dramatic impact on HED science. He further noted the increasing recognition of the importance of modeling in many areas.

Turning his attention to the six Moonshot program goals, Kusnezov suggested that consideration of the technological barriers to achieving these goals is called for at this stage. In considering the "richness of the technologies" that will be required to achieve these goals, he opined "there are technologies that surround ecosystems that you want to create and there is probably going to be a need for economic ways to develop, what I would call, mass customization." He suggested that this, as well as the requirements for complex and automated systems, will call for frontier science and collaborative R&D efforts. Kuznesov also remarked that the role quantum mechanics will play is a "very intriguing" facet of the Moonshot Program goals.

In closing, Kuznesov returned to the HED science and laser applications discussed by Kodama and offered the view that "creating abstractions of what is being done specifically for the laser applications, abstractions that are of much broader utility will be essential . . . you have to find a way to find specific problems but abstract them and nurture and encourage the development of those who can find your way through the rest of the problems." He closed by saying he wants to "applaud Japan for standing up such ambitious goals," observing that "the technologies are marvelous, and I welcome thinking about them with you." This forward-looking statement was indicative of the spirit and the substance of this symposium.