Progress Plan for Maintaining Academy Center Certification
World Premier International Research Center Initiative (WPI)

Host Institution	National Institute for Materials Science (NIMS)
Research Center	International Center for Materials Nanoarchitectonics
Host Institution Head	Kazuhito Hashimoto
Center Director	Takayoshi Sasaki
Administrative Director	Tomonobu Nakayama

Please prepare this Progress plan based on your application for WPI Academy. Summarize the Center's future plans with regard to the following 8 items **within five A-4 pages**. (Also fill out the appendices at the end of this form.)

1. Overall Image of Your Center

* Describe the Center's overall image including its identity.

MANA was established in October 2007 with NIMS as host institution, under its vision of "creating a new paradigm in nanotechnology to form a world-class research center for new materials research and development". Since its establishment, MANA has forged that new paradigm based on its unique new concept of nanoarchitectonics, and has come to be recognized as a world-class research center utilizing nanotechnology. As a result, since 2017, as one of the WPI Academy centers, MANA has carried out research activities of top international level while enhancing its function as a hub for international circulation of the world's best brains. In 2017, MANA has been positioned as a center of NIMS specializing in basic fundamental research. Two strongly application-oriented research fields were moved out of MANA to another center of NIMS. MANA has since then been active in three consolidated fundamental research fields (Nano-Materials, Nano-Systems, and Nano-Theory) with young Independent Scientist doing cross-field research.

The originality and the level of research that MANA promotes are supported by the principles of nanoarchitectonics, the presentation of grand challenges, measures for promoting challenges and fusion research, international research networks and brain circulation networks. For example, MANA has published 5,251 papers so far, with 180 of all papers reaching the top 1% "most-cited" papers. The average Impact Factor (IF) of the papers published by MANA in 2019 (501) reached 6.95, and the figure has been steadily increasing after participating in the WPI Academy. In addition, MANA's Field-Weighted Citation Impact (FWCI) value of 2.18 objectively shows that it is a research center comparable to many top-level research institutions in the world, as this index was designed to fairly evaluate and compare the quality of papers published by research institutes around the world.

MANA already focuses on not only the promotion of world-class research (creation of various artificial new materials using nanosheet technology, basic to practical application of atomic switches, invention and practical application of highly sensitive/parallel molecular sensors, development of surface superconductors/local superconductors), but also on the creation of new and original research. Recent examples include the realization of optical topological materials and their application to surface emitting lasers, the control of molecular shapes by local excitation, the development of data-driven odor sensing, and the development of a decision-making device using ionics.

MANA places importance on the promotion of brain circulation and appoints world-renown researchers as MANA PIs to establish overseas satellites. In 2018, Prof. Gero Decher of Strasbourg University in France, and Prof. Thomas E. Mallouk of Pennsylvania State University, USA were newly appointed as satellite PIs. As a result, MANA is now an organization with seven overseas satellites after including the five satellites that it has traditionally operated. Including these satellites, MANA actively invites overseas researchers and promotes the dispatch of MANA researchers to overseas institutions. From 2018, to launch continuous international collaborative research with particularly close partners, we introduced a policy for special support of MoU-based invitation/dispatch. Additionally, to expand international brain

circulation, it is necessary to also expand the international network of researchers, for which we hold numerous international conferences and workshops (including co-sponsorships) for developing and discovering new international collaboration.

2. Mid- to Long-term Research Objectives and Strategies

* Describe new challenges in the Center's research objectives and plans after FY 2020.
* Describe your future research strategy and plans and research organization including your line-up of Principal Investigators, and your outlook for fostering and securing the next generation of researchers.

In light of our success so far with center formation and center management, as well as with the promotion of international brain circulation, MANA will essentially maintain/continue its current policy and continue activities within its host institution NIMS. As research guidelines, in addition to promoting world-class research, we will continue to place importance on challenging research and fusion research that brings new developments to basic research.

[Promotion of world-class research]

The promotion of world-class research at MANA is supported by PIs who are internationally active top-level researchers. MANA regularly reviews its PI structure and will continue to do so. In particular, from FY2020, the host institution NIMS launched a research project to prioritize quantum material research. There are great expectations for MANA in this project and Dr. Takashi Taniguchi (NIMS Fellow and Highly Cited Researcher) has been invited to join MANA. He is well known for the synthesis under pressure of the world's highest quality h-BN and for his joint research and development with a number of world top-level research institutions. This has created a framework for MANA to lead quantum material research. In addition, an electro-active materials team has been established at MANA under the leadership of world-famous Professor Hideo Hosono from Tokyo Institute of Technology to develop new materials. We hope that the participation of Prof. Hosono, who has a wealth of experience and knowledge in world-class research, will be a positive stimulus for young researchers.

[Support for challenging research and fusion research]

An original and bold foundation for taking on risky research is indispensable to the center's medium to long-term research development. MANA will continue to encourage proposals for the "Challenging Research Program (CRP)" to receive research funding for outstanding ideas. Furthermore, through the "Theorist-Experimentalist Pairing Program (TEPP)", we will continue to gather proposals from Nano-Theory fields and existing fields (other researchers). These programs play a role in the generation of seeds and are not intended to lead directly to world-class research in the short term. However, nurturing and developing the research that MANA's proud young researchers have proposed as their own ideas leads to the development of world-leading next-generation researchers and also plays a major role in MANA's medium-long term center revitalization.

[Research organization, PI structure, training and securing of next-generation researchers]

MANA is responsible for creating seeds as a basic fundamental research center within NIMS, and the research leading up to the applied/practical application phase is transferred to other research centers and incorporated into the research activities of NIMS as a whole. MANA implements a structure which includes a deputy center director/administrative office head to support the leadership of the center director, and it responds to research progress and new development, and consistently reviews its research organization that supports the research of new members while maintaining its administrative office organization. In particular, regarding PIs, MANA makes sure to include not only already established world-class researchers, but also those who anticipate the research of the future and are highly active in the development of such research that can go on to be globally recognized, thus ensuring restructuring that considers overall balance.

3. Management System of the Research Organization

* Describe the system of organizational management via which the Center will execute the above-described research strategy and plans.

* In Appendix 1-3, list the Principal Investigators, enter the number of Center personnel (researchers, research-support staff, and administrative staff), and provide a diagram of the Center's organizational management system.

The basic operation of MANA's center is based on consensus of the center director, deputy directors and administrative director. For example, MANA's management policy, research support program, selection of MANA postdocs, etc. are decided by discussion under the leadership of the director. Through the MANA Center Meeting, the center director directly informs (or discusses with) PIs, Group Leaders, and Independent Scientists of matters to be passed on to the entire center. When implementing any measures, the administrative director is in charge of necessary administrative procedures and adjustment of the contents of implementation according to the situation, and the final confirmation and approval are carried out by the center director. For the implementation of the research strategies and plans shown above, there are situations in which coordination with NIMS is necessary, and in such cases, these are handled by the center director with support from the deputy director. Any information from MANA members may be important to the center's operation, and in addition to grasping the detailed situation of the research site at the group hearings that started in 2017, we maintain a flat system in which all MANA members are free to discuss their opinions and requests with the director/deputy director (or the administrative office), and constantly carry out preparations for the smooth implementation of research strategies and plans.

4. Plan for Promoting the International Circulation of World's Best Brains

* Describe your policy and concrete plan for promoting the international circulation of the world's best brains, which is an important function of the WPI Academy.

The promotion of international research collaboration and international brain circulation that we have implemented so far is an essential element for converting new research further into top-level research that leads the world, as well as a vitally important activity for the cultivation of young next-generation researchers. On the other hand, as it is also true that the COVID-19 outbreak which occurred at the end of 2019 unexpectedly revealed the vulnerability of the international collaboration system. To overcome this vulnerability, MANA will actively incorporate the use of virtual reality into its activities related to international brain circulation.
Specifically, we will first of all encourage online international conferences (including workshops and seminars). To do so, we will make it possible for the organizing committee, steering committee, program committee, etc. to hold meetings completely or partially online. We will develop a platform that can centrally manage conference announcements, speaker recruitment, program conferences, and the actual holding of conferences, provide a dedicated website for each conference to researchers, and support its operation. Going forward, we will strive to make this function as an opportunity to exchange information that is equivalent to or superior to international conferences where people actually gather in person, and thus shorten the time involved from planning to holding a meeting and facilitate preservation and utilization of data. We expect that the number of international research discussions, which were previously limited in number due to the large amount of time and effort involved in planning and execution, will increase and that this will in turn revitalize international brain circulation. While the time difference is inevitable, there are issues that are difficult to be addressed online. For example, overseas researchers who can't adapt to a conference program in Japan time or joint experiments within a scientific collaboration. For issues that can't be resolved until people actually gather, we will thoroughly examine the necessity and take advantage of the traditional measures to deal with it. MANA recognizes that the cross-cultural interaction involved in invitations, visits, and stays are one of the driving forces that create new research, thus we will make sure to incorporate the advantages of an online environment appropriately.

5. Plan for Disseminating the WPI Program Achievements

* Describe your policy and concrete plan for disseminating WPI center achievements both within the host institution and to other universities, especially their experience and know-how accumulated on establishing top world research institute and advancing system reforms.

MANA has been positioned as the research center for responsible for nanomaterials research within NIMS since 2009, and since the beginning of the Fourth Mid-term Plan of NIMS in 2016, it officially became one of the research centers of NIMS. This is because from a relatively early stage, MANA and its host institution NIMS were not completely independent, but had a system for sharing information on

research policy to operation. Therefore, if MANA engages in new activities that cause obstacles to comply with NIMS rules, MANA will develop experience and know-how within its host in ways that encourage changes and adjustments to the NIMS rules. Outside the host institution, we will place importance on cooperation with the WPI Academy activities for situations involving the whole country. Regarding the horizontal development of experience and know-how in organizational management, we published a well-received book (which is still popular today) that summarizes experiences at MANA and ICYS. On the other hand, since practical problems in operating the center depend largely on the organization, such as general affairs and accounting, we believe it is appropriate to carry out horizontal development through the WPI Center website in the form of a Q&A. MANA plans to publish "opinions and experiences from a researcher's perspective" in 2022-2023, as a reference for organizations setting their own rules.

6. Plan for Sustaining the WPI Brand

* Describe your plan for sustaining and enhancing the WPI brand.

In addition to the initiatives that MANA has been implementing so far, including issuing MANA e-bulletins, holding international symposiums and workshops, utilizing the MANA alumni association, and conducting science enlightenment activities for the general public, we will strive to renovate visitor accommodation.

MANA e-bulletin uses a press wire distribution service to introduce MANA's findings, which enables immediate posting to many news sites and a broad viewer reach. Viewers access the "for reading" information, making this useful not only for disseminating results, but for also promoting the WPI brand. Additionally, regarding the holding of international symposiums and workshops mentioned above, they are particularly useful for improving WPI awareness as a WPI center in the research community. Therefore, we focus on topics of high interest and plan opportunities for active researchers to gather. Further, the MANA alumni association network is an important asset that MANA has built up as a WPI center so far, and some of its alumni have already taken up important positions in Japan and overseas. As its utilization is becoming the key to improving WPI reputation and brand name, and revitalizing international brain circulation, joint research support measures are being examined to raise "alumni awareness". Regarding science enlightenment activities, the "reform of presentation techniques" led by MANA Outreach is necessary. In the past, the Outreach team practiced presentation techniques from the perspective of researchers. In the future, we will work to interpret MANA findings and present them in novel ways through collaboration between researchers and Outreach from an Outreach staff perspective. To that end, we have increased the number of Outreach staffs in FY2020. We will also continue to call attention to the use of WPI nomenclature. WPI-MANA notation is used in most research papers and other copyrighted works, but we would like to make it used even more so.

Lastly, we would like to touch on the renovation of visitor accommodation. It is very important to have visitors from both in and out of the country observe research sites and directly convey activities in their presence. On the other hand, many visitors cannot enter due to space or safety issues. Furthermore, we never expected to face a situation in which people's actions would become so restricted, as seen with the recent COVID-19 epidemic. We consider creating research videos as an outreach tool that can be offered online and implementing virtual laboratory tours on demand (using AR and VR technology for real-time infiltration of laboratories) as methods that can possibly solve these problems all at once.

7. Support by Host institution

* Describe measures that the host institution is and will take to support and sustain your Center.

While the MANA system is incorporated into the NIMS management system as appropriate, NIMS contributes 100 million yen annually to MANA from its grants for operational expenses subsidy as a discretionary expense for the Center Director. In addition, "Support System for Curiosity-driven Research," unique to NIMS, has been established to support primarily basic fundamental research. Although this is not a system specifically for MANA, it is considered to be effectively a research support measure for MANA, as MANA's mission is to conduct basic fundamental research within NIMS. NIMS continues to allocate 90 permanent staff members as research resources and appropriate research space, and it provides maximum support in MANA's center operations while ensuring that this policy remains unchanged in the future.

8. Resource Allocation Plan

* Describe your plans over a 5-year period for allocating resources acquired from the host institution (e.g., financial resources and positions) and from external research funding to use in carrying out the Center's functions and activities described above.
* In Appendix 4, enter concrete numbers in the Resource Allocation Plan.

NIMS is currently operating according to it's the Fourth Mid-term Plan (2016-2022) with MANA clearly positioned in it. Going forward, in 2023, NIMS, as a whole, plans to shift to the research management approach in line with the next Mid-term Plan, but MANA, the world-class research center cultivated by the WPI program, will continue to be supported by the host institution. In particular, this support includes the following.

1) Allocation of about 90 permanent employees with MANA
2) Research support through the Mid-term Plan research projects and important projects operated by NIMS
3) Allocation of special expenses to support the leadership of MANA's center director
4) Support for Support System for Curiosity-driven Research through the NIMS internal research funding system
5) Appropriate assignment of new employees and Independent Scientists
6) Maintaining the names of the WPI-MANA Building, MANA Building and Theoretical Research Building and appropriate allocation of space.

In line with the policy of maintaining the WPI center, the next Mid-term Plan of NIMS would contain appropriate resource measures for MANA.

Although MANA has already acquired large research budgets, such as the JST-Mirai Program and CREST, we need to further increase external funding. MANA uses its challenging and fusion research together with the NIMS internal research funding system, to perform preliminary experiments necessary to prepare proposals to increase the external funding. At the time of application, experienced researchers give advice.

Appendix 1

List of Principal Investigators

・ If the number of principal investigators exceeds 10, add columns as appropriate.
・ Give age as of 1 April 2020
・ For investigators who will not participate in the Center project at the time of submission of this Progress Plan, indicate the time that their participation will start in the "Notes" column.

	Name	Age	Affiliation (Position title, department, organization)	Academic degree, Specialty	Effort (%)*	(Notes) Enter "new" or "ongoing"
1	Director Takayoshi Sasaki	64	Director, International Center for Materials Nanoarchitectonics (MANA), National Institute for Materials Science (NIMS)	Ph.D. in Science, The University of Tokyo, 1985, Nanosheet and Soft Chemistry	100	ongoing
2	Deputy Director/ Administrative Director Tomonobu Nakayama	58	Deputy Director/Administrative Director, International Center for Materials Nanoarchitectonics (MANA) , National Institute for Materials Science (NIMS)	Ph.D. in Physics, The University of Tokyo, 1999, Scanning Probe Microscopy	100	ongoing
3	Takao Mori	53	International Center for Materials Nanoarchitectonics (MANA) , National Institute for Materials Science (NIMS)	Ph.D. in Science, The University of Tokyo, 1996, Materials Science, Solid State Chemistry & Physics	100	ongoing
4	Yusuke Yamauchi	39	Professor, Australian Institute for Bioengineering and Nanotechnology (AIBN), The University of Queensland	Ph.D. in Engineering, Waseda University, 2007, Inorganic Synthetic Chemistry, Inorganic Materials Chemistry	20	ongoing (Cross-appointed with UQ / MANA)
5	Dmitri Golberg	59	Professor, Science and Engineering Faculty, School of Chemistry & Physics, Queensland University of Technology	Ph.D. Moscow Institute for Ferrous Metallurgy, 1990, Nanotubes and nanowires	20	ongoing (Cross-appointed with QUT / MANA)
6	Katsuhiko Ariga	57	International Center for Materials Nanoarchitectonics (MANA) , National Institute for Materials Science (NIMS)	Ph.D., Tokyo Inst. Tech., 1990, Supramolecular Chemistry and Surface Science	80	ongoing (Cross-appointed with The University of Tokyo / MANA)
7	Junichi Takeya	53	Professor, Department of Advanced Materials Science, Graduate School of Frontier Sciences, The University of Tokyo	Ph.D. in Physics, The University of Tokyo, 2001, Organic semiconductors	20	ongoing (Cross-appointed with MANA / The University of Tokyo)
8	Jinhua Ye	57	International Center for Materials Nanoarchitectonics (MANA) , National Institute for Materials Science (NIMS)	Ph.D., The University of Tokyo, 1990, Photocatalyst, Eco-materials	100	ongoing
9	Naoki Fukata	49	International Center for Materials Nanoarchitectonics (MANA) , National Institute for Materials Science (NIMS)	Ph.D. in Engineering, University of Tsukuba, 1998, Semiconductor physics and engineering	100	ongoing
10	Kazuya Terabe	57	International Center for Materials Nanoarchitectonics (MANA) , National Institute for Materials Science (NIMS)	Ph.D. in Materials Science, Nagoya Institute of Technology, 1992, Nanoionics, Solid State Electrochemistry and	100	ongoing
11	Kazuhito Tsukagoshi	52	International Center for Materials Nanoarchitectonics (MANA) , National Institute for Materials Science (NIMS)	Ph.D., Osaka University, 1995, Nano Electronics	100	ongoing

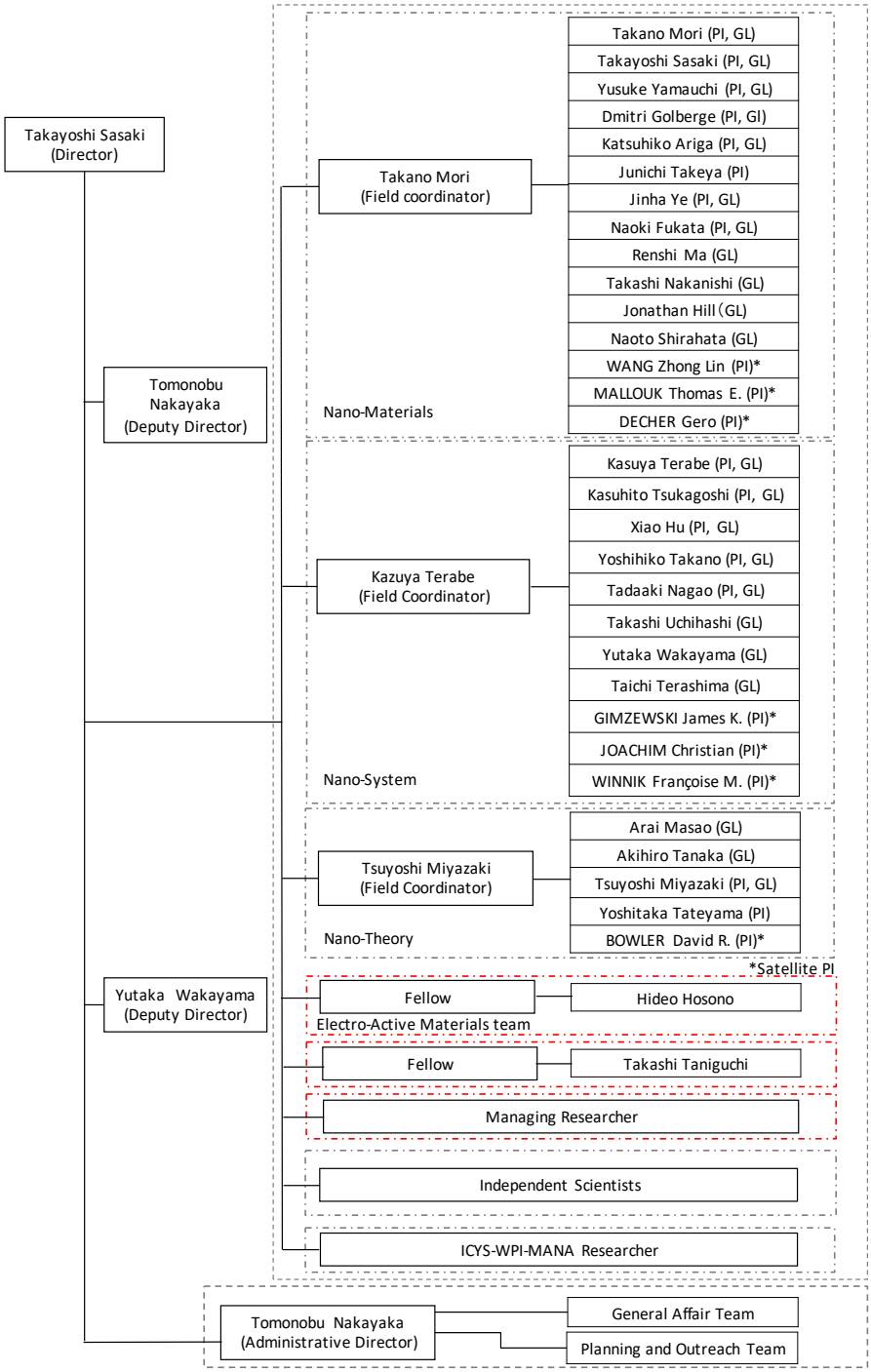
12	Xiao Hu	58	International Center for Materials Nanoarchitectonics (MANA) , National Institute for Materials Science (NIMS)	Ph.D. in Physics, The University of Tokyo, 1990, Condensed Matter Physics	100	ongoing
13	Yoshihiko Takano	54	International Center for Materials Nanoarchitectonics (MANA) , National Institute for Materials Science (NIMS)	Ph.D., Yokohama City University, 1995, Superconducting Materials, Nanomaterials, Physics	100	ongoing
14	Tadaaki Nagao	53	International Center for Materials Nanoarchitectonics (MANA) , National Institute for Materials Science (NIMS)	Ph.D., Waseda University, 1995, Surface and Interface Nanoscale Physics, Plasmonics, Nanoscale Materials Optics	100	ongoing
15	Tsuyoshi Miyazaki	53	International Center for Materials Nanoarchitectonics (MANA) , National Institute for Materials Science (NIMS)	Ph.D., The University of Tokyo, 1995 first-principles calculation	100	ongoing
16	Yoshitaka Tateyama	49	Center for Green Research on Energy and Environmental Materials, National Institute for Materials Science (NIMS)	Ph.D., The University of Tokyo, 1998, Condensed-matter Theory, Computational Physical Chemistry	5	ongoing
17	Zhong Lin Wang	58	Professor, School of Materials Science and Engineering, Georgia Institute of Technology	Ph.D. in Physics, Arizona State University, 1987, Emerging Devices for Energy Generation	10	ongoing (satellite)
18	James K. Gimzewski	68	Professor, Chemistry and Biochemistry, University of California, Los Angeles	Ph.D. in Physical Chemistry, University of Strathclyde, 1977, Neuromorphic Network	20	ongoing (satellite)
19	Christian Joachim	62	Professor, CEMES, Centre National de la Recherche Scientifique (CNRS)	Ph.D. in Applied Mathematics, Ph.D. in Quantum Physics, Molecular Device Engineering	20	ongoing (satellite)
20	Françoise M. Winnik	68	Professor, Faculty of Science, Department of Chemistry, University of Helsinki	Ph.D. in Chemistry, University of Toronto, 1979, Functional Nanoparticles and Nanointerface	20	ongoing (satellite)
21	David R. Bowler	49	Professor, Department of Physics & Astronomy, University College London	Ph.D., University of Oxford, 1997, Large-scale Order-N DFT Calculations	20	ongoing (satellite)
22	Thomas E. Mallouk	65	Professor, Department of Chemistry, University of Pennsylvania	Ph.D. in Chemistry, University of California, Berkeley, 1983, Nanoscale Chemistry	10	ongoing (satellite)
23	Gero Decher	63	Professor, the Faculty of Chemistry, University of Strasbourg	Ph.D., Johannes Gutenberg University Mainz, 1986, Fazzy Assembly	10	ongoing (satellite)

*Percentage of time that the principal investigator will devote to his/her Academy center work vis-à-vis his/her total working hours.

Appendix 3　Diagram of Organizational Management System

- Diagram **separately** the Center's organizational management system **and** its position within the host institution in an easily understood manner. If you are planning to change your organization management system and/or its position within the host institution in or after FY 2020 compared to their description in Appendix 3-1 of Activities report, show the changes in the diagram.

Since FY2020, the electro-active material team has established. Also, the Independent Scientist, NIMS Distinguished Fellow and NNIMS fellow are collaboration to research with three fields.



Organization (as of Apr.1, 2020)