



Tokyo & Kyoto, JAPAN
Moon Village Workshop & Symposium – 2019
December 5-8, 2019

FINAL REPORT

Section 1.0 Introduction

The Moon Village Association (MVA) was created as non-governmental organization (NGO) based in Vienna, Austria. The goal of the MVA is the creation of a permanent global informal forum for stakeholders like governments, industry, academia and the public interested in the development of the Moon Village. The MVA fosters cooperation for existing or planned global moon exploration programs, be they public or private initiatives. The Association comprises more than 200 individual and 25 Institutional members from some 40 countries around the globe, representing a diverse array of technical, scientific, cultural and interdisciplinary fields. MVA held the first International Moon Village Workshop at, and in cooperation with International Space University (ISU) in Strasbourg, France in October 2017. The second Moon Village Workshop & Symposium (WS&S) was held at the University of Southern California (USC) in cooperation USC and National Space Society (NSS) in Los Angeles, California in November 2018.

During December 5-8, 2019 the Moon Village Association organized the third Workshop & Symposium, which was held in Tokyo & Kyoto, Japan, in cooperation with Tokyo University of Science, Kyoto University, and Keio University Institute of Space Law. The third workshop & symposium had over 250 participants from across Japan and the world. See below for a “group photo” from the meeting.



Group Photo from the 3rd Moon Village Workshop & Symposium (December 2019)

There was a total of 234 registered participants, all of whom attended the Tokyo session, including 10 VIPs and 54 attendees from various Sponsors – of which there were some 19 organizations.¹ Individuals from more than 16 countries participated, including Japan, the USA, the United Kingdom, Luxembourg, Ukraine, Romania, South Korea, Thailand, Kuwait, Greece, China, Switzerland, Belgium, India, France, and Canada. Attendants of the session in Kyoto on December 8th numbered 159, including 82 registered attendants and 77 from students and general public.

This is the final report from the 2019 Moon Village Workshop & Symposium.

¹ Sponsors of the event included: Gold Sponsors (ASTRAX, IHI, MHI, Takenaka, Shimizu co., Fujikin, Spacebit, Katana); Silver Sponsors (inet, NEC, Arianspace, Bridgestone.); and, Bronze Sponsors (Obayashi, Outsense, SSD, Mitsubishi Space Software, JAMSS, TNL, Luxembourg Space Agency).

Section 2.0

Plenary Sessions

2.1 Opening Session in Tokyo

Day 1 Morning – Part 1. The opening session for the event occurred during the morning on Wednesday, December 5, 2019. It began with an introduction from the master of ceremonies (John C. Mankins, Vice President of the MVA), with opening remarks by MVA President, Giuseppe Reibaldi and the Chair of the Local Organizing Committee (LOC), Prof. Yoshifumi Inatani. The primary portion of the opening session comprised welcoming presentations that also addressed Japan's national space program and planning by Hiroshi Yamakawa (President of the Japan Aerospace Exploration Agency, JAXA), Shin'ichi Nakasuka (Space Policy Committee, Cabinet office & University of Tokyo).

The opening session also included welcoming remarks by the three co-hosts of the workshop & symposium: Chiaki Mukai of the Tokyo University of Science (TUS), who spoke on the topic of "Activities by Space Colony Center @TUS", Takao Doi of Kyoto University, who spoke on the topic of "Promotion for Human Space Activity", and Setsuko Aoki of Keio University, who spoke on the topic of on the "Legal Aspect of Moon Village".

Mr. Giuseppe Reibaldi presented an overview of the Moon Village Association (MVA) and its activities. His remarks were followed by a series of keynote presentations

2.2 Keynote Lectures

Day 1 Morning – Part 2. Morning keynote presentations addressed several national lunar programs. Koichi Wakata, Vice-President and Astronaut of the Japan Aerospace Exploration Agency (JAXA) made a presentation entitled "From ISS to the Moon and our Vision". Mr. Garvey McIntosh, representative of the National Aeronautics and Space Administration (NASA) from the USA made a presentation on the topic of "Gateway, Artemis and Beyond". Weiren Wu of the Chinese National Space Agency (CNSA) spoke about "Chinese Lunar Program", and Parameswaran Sreekumar of the India Space Research Organization (ISRO), discussed "Indian Lunar Program". These presentations were followed by a video message of welcome from Dr. Johann-Dietrich Wörner, Director General of the European Space Agency (ESA) who was unable to attend the meeting in Japan.

Just before luncheon on December 5th, an awards ceremony was held; it is described below.

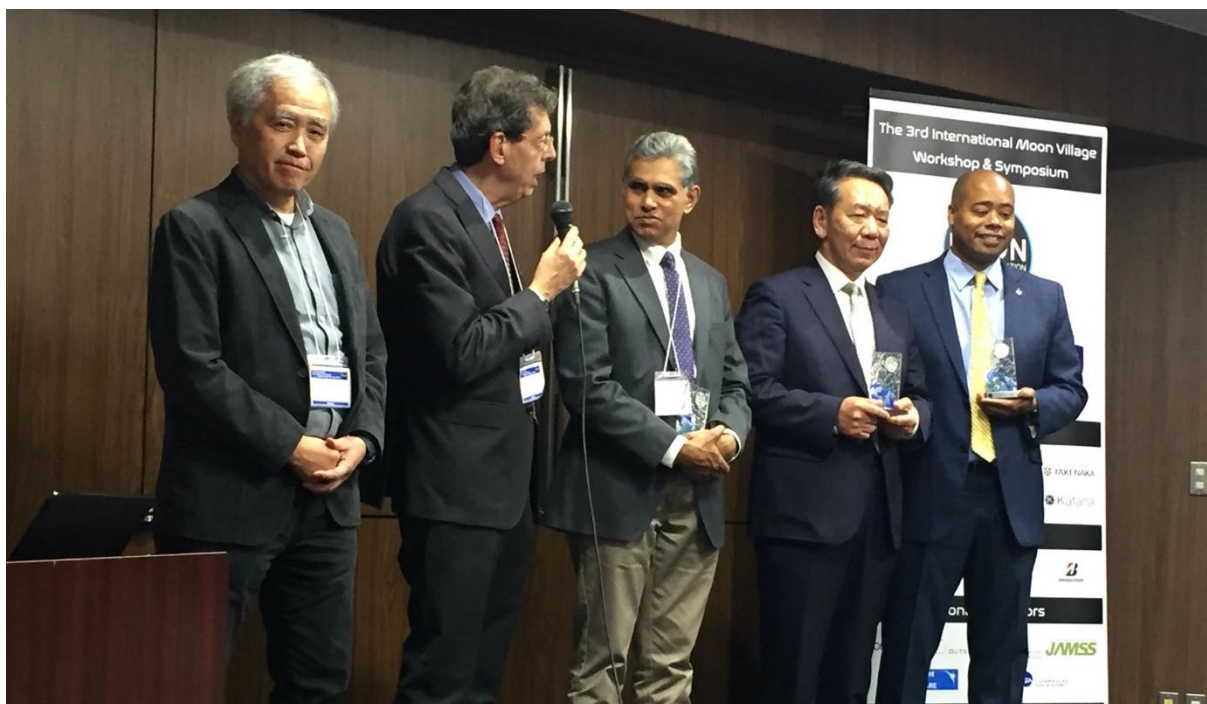
Day 1 Afternoon. Following lunch, keynote presentations continued in a plenary session chaired by Oleh Ventskovsky, member of the MVA Board. Bob Lamboray of the Luxembourg Space Agency made a presentation entitled "The Luxembourg Space Resource Initiative" (<http://spaceresources.lu>). Brent Sherwood of the Blue Origin Corporation made a presentation on the company's plans regarding lunar transportation and development entitled: "Getting There, Being There". Maksym Degtiarov of the Yuzhnoye State Design Office gave a talk on the topic of "Lunar Exploration and Utilization Activities" at Yuzhnoye.

The subsequent plenary session comprised a number of general technical talks; it was chaired by Munetaka Ueno (JAXA). The first talk was given by Shigeru Imai of JAMSS, who spoke on the topic of "How Lunar Society in 2040 will be Operated?". Then, Pavlo Tanasyuk of Spacebit gave a talk on the topic of "Spacebit Mission One: An International Partnership to Demonstrate New Walking Rover Technologies". Atsushi Uchida of Mitsubishi Research Institute (MRI) next gave a talk on "Business Promotion on the Moon". Finally, Shimpei Ishido, Attorney-at-law, Nishimura Asahi gave the final plenary session talk of the day, addressing "Legal issues arising from Utilization of Space Resources on the Moon".

Following the conclusion of the plenary sessions on December 5th, five (5) concurrent working sessions were conducted; these are discussed in detail in Section 3, which follows this section. Next, in the paragraph below the Prizes awarded at the Japan event (mentioned previously) are discussed.

2.3 Moon Village Principles (MVP) Mission Prizes and Activities Award for 2019

The MVA established in 2018 the “Moon Village Principles” (MPV) – a set of ideals that define the characteristics of Moon-focused programs, projects and missions that advance the vision of the Moon Village. In 2019 for the first time the MVA – using high-level evaluation criteria – identified missions that comport with the MVPs and significantly advance the MV vision: the Moon Village MVP “Mission Prize”. The winners of the 2019 MVP Mission prizes were awarded the prize at the event in Japan. The winners were CNSA for the Chang’e 4 lander and rover mission (award accepted by Weiren Wu), ISRO for the Chandrayaan Mission (award accepted by Parameswaran Sreekumar), and NASA for the Lunar Reconnaissance Orbit (award accepted by Garvey McIntosh), The figure below depicts the award of the MVP Mission Prizes for 2019.



Presentation of the MVP Prizes for 2019

Shown, left to right: Prof. Yoshifumi Inatani (MVA LLOC), Giuseppe Reibaldi (MVA) Parameswaran Sreekumar (ISRO), Weiren Wu (CNSA), and Mr. Garvey McIntosh (NASA)

In addition to the first annual MVP “Mission Prizes”, discussed above another accomplishment was recognized: a Moon Village supporting Activity Award was given to a student team at the International Space University (ISU) for their study project concerning the adaptation of the UN sustainable development goals (SDG) to lunar exploration and development.

2.4 Plenary Sessions on Thursday, December 6, 2019

The second day of the event in Japan started with a special presentation by Paul Wooster of SpaceX that addressed the topic of ““Using Starship to Build a Base on the Moon””. Mr. Wooster was introduced by Giuseppe Reibaldi of the MVA). This special presentation was followed by a day-long series of plenary sessions, described in the paragraphs that follow.

Day 2 Morning. The morning plenary session on December 6th was chaired by Jan Kolar, Treasurer of the MVA, and addressed a number of architectural level considerations involved in the

Moon Village concept. The first talk was given by Michelle Hanlon of the For All Moonkind non-profit organization and the Center for Air and Space Law; she spoke on the topic of “Common Lunar Landing Pads – Built In-Situ – Are a Legal and Economic Imperative”. Huai-Chien Chang of the HelioX Cosmos Company spoke on the subject of “Universal Design for All Space Habitat (U-DASH): A Study on Architectural Planning Criteria of Moon Village”. This talk was followed by Yoji Ishikawa of Obayashi Company who addressed “General Rules on How to Live on the Moon and the Related Research.” The third talk of the session was given by Naoto Nishizuka (NICT) on the topic of “Solar Flare Prediction and Space Weather Forecast”. The first plenary session concluded with a talk on James Keravala of the Off-World Corporation, who spoke on the topic of “The OffWorld Solar System Toolkit – How to Build Civilization to the Stars”. This talk was followed by a brief morning coffee break.

Following the coffee break, the discussion of architectural level considerations continued, chaired by Kaori Sasaki of JAXA. Shoyo Hyodo of Mitsubishi Heavy Industries (MHI) discussed “Envision of Space Colony Construction via Moon”. Michio Isayama (IHI AEROSPACE Co., Ltd.) made a presentation on the topic of “Consumer and Producer in the Moon Surface Society”. Hirofumi Inoue of TOYOTA spoke on the topic of “TOYOTA Contributes to Human Exploration through Pressurized Crew Rover.” Makoto Ishiyama (Bridgestone) presented on the topic of “Elastic Wheel for Lunar Rover”. Taichi Yamazaki of ASTRAX discussed “ASTRAX Lunar City Development Project Overview”. Nelly Offord (Surrey Satellites Technology Ltd) made a presentation entitled: “To the Moon and back, your comms made simple: Relay communications services around the Moon in 2023”. The session concluded with a working luncheon.

Day 2 Afternoon. The first plenary sessions of the afternoon on December 6th, chaired by Shinichi Kimura of the Tokyo University of Science (TUS) continued and completed the keynote presentations of the workshop & symposium. Takeshi Nikawa of Tokushima University made a presentation on the topic of “Functional space foods improve the QOL in moon village”. Secondly, Satoshi Iwase of Aichi Medical University discussed “Effect of hypogravity on human physiology on the Moon surface”. Then, Naoto Shiba of Kurume University gave a talk on the subject of “Effect of the Hybrid Training Method on the Disuse Atrophy of the Musculoskeletal System of the Astronauts Staying in the International Space Station for a Long Term”. Finally, Makoto Arai of Dentsu Inc. gave the last keynote address of the meeting, speaking to the topic of “Moon Olympics”.

Following a brief mid-afternoon coffee break, the final plenary sessions resumed with a panel discussion, chaired by Taro Asazuma (ispace) on the topic of How to “Make the Moon Village Happen”. Participants in the panel discussion included Naoko Yamazaki (Astronaut) Pavlo Tanasyuk (Spacebit) Dorin Prunariu (Astronaut and former Chairman of COPUOS) Shigeru Imai (JAMSS), Naohiro Uyama (Shimizu Co.), and Kae Masuhara (Dentsu Inc.).

2.5 Closing Plenary Session in Tokyo

At the end of the second day in Tokyo, there was a closing session, Chaired by Giuseppe Reibaldi of the MVA. This closing session comprised a summary presentation by John C. Mankins on the results of the break-out sessions from Day 1 (discussed in detail in Section 3 that follows), announcement of where the 4th MVA workshop & symposium will be held in Europe highlighted below), a summary of the results of the first two days of the event, and a quick sketch of the program planned for the third day of the meeting in Kyoto.

2.6 Sessions in Kyoto

Finally, following a travel day (Friday, December 7th) a third and final day of the workshop & symposium was held in Kyoto, Japan at Kyoto University. This portion of the event extended over about 7 hours (morning and afternoon).

Day 3 Morning. In the morning session on Day 3, chaired by Dorin Prunariu (Astronaut and former Chairman of COPUOS), participants gave an overview of MVA activities; these included Giuseppe Reibaldi (MVA), who spoke on the topic of ““MVA Overview”, John Mankins (MVA), who addressed on the topic of “Architecture needed for Moon Village”, Oleg Ventskovsky (MVA), who

spoke on the subject of “Making Business in the Moon Village” and Elissavet Koumi (Morpheus Avatar Systems), who spoke on the topic of “Education & Public outreach activities of MVA”. The figure below presents a photo of remarks at the Kyoto University session on December 8, 2019 by Takao Doi of Kyoto University.



Opening Remarks at the Kyoto Session (December 8, 2019)

Day 3 Morning – Part 2. Following a brief coffee break, the second part of the morning session on Day 3, chaired by Satoshi Iwase (Aichi Medical University) looked at the topic of Various activities aiming at building society on the Moon Government, Commercial sector and Ventures for Kyoto General Public. There were several speakers. Hiroshi Sasaki (JAXA) addressed JAXA’s space exploration plans. Kazuyoshi Kawasaki, also of JAXA addressed “Encouraging commercial sector’s activity for exploration”. Misuzu Onuki (Space Access) discussed “Building Businesses on the Moon”. Hideki Kanayama (Shimizu Co.) reviewed the subject of “Investing in Space”. Pavlo Tanasyuk (Spacebit) addressed “A Commercial Lunar Surface Exploration Program Including the First Lunar Cave Mapping Mission”. A luncheon followed.

Day 3 Afternoon – Part 1. The first portion of the meeting after luncheon comprised a competitive student poster session. Kyoto University Space Unit is promoting and encouraging activities of young students including high school boys and girls. In the poster session, they showed these student activities by 20-30 posters and on-site presentation. Discussions among professionals and students were facilitated. A coffee break followed the end of the poster session.

Day 3 Afternoon – Part 2. The final presentation session addressed the topic of Education, and was chaired by Takayuki Hoson (Osaka City University). There were five (5) speakers. Masahiro Terada (Kyoto University) who spoke about the “Introduction of space unit activities” at Kyoto University. Takeshi Nikawa (Tokushima University) who discussed “Establishing an international institute for the development of next-generation space nutrition researchers”. Setsuko Aoki (Keio University), speaking about “Space Law Education of Keio University”. Shinichi Kimura (Tokyo University of Science), who addressed the topic of the “Space Education Program of the Tokyo University of Science: Mission Oriented Space Education”. And, Kaoru Sasaki (JAXA), presenting on the subject of “JAXA space education: Space for humanity”.

Closing Session. The chair of the closing summary discussion at the 2019 Moon Village Workshop & Symposium was Sin Mineshige (Kyoto University). Speakers during the closing session were Takao Doi (Kyoto University), Setsuko Aoki (Keio University), Yoshifumi Inatani (LOC), and Giuseppe Reibaldi (MVA).

Section 3

Breakout Sessions

There were five (5) Breakout Sessions during the workshop portion of the event; these included: (1) Moon Village Architectural Considerations; (2) Humans on the Moon Topics (including Cultural Considerations); (3) Roadmap to the Moon Market; (4) Cooperation and Coordination (including Legal topics); and, (5) Science on the Moon & the First MVA Payload. The following are the summary results from each of these discussions.

3.1 Moon Village Architectural Considerations (Breakout Session #1)

Co-Chairs of the breakout session were John C. Mankins and Dr. Yoshifumi Inatani. There were approximately 25 Participants at the session, and five presentations were made. The presentations included the following topics: MVA Architecture WG White Paper; Membrane Distillation of Water; Using the Moon's Craters and Soil; Centrifugal Force Architecture on the Moon; and, Social Optimization of Space Habitation.

The MVA architecture working group continues to believe that it is impossible to know the future. However, a scenario-based approach to thinking about the future can provide useful insights – and inform key decisions. Three scenarios were discussed in the session: Scenario Alpha – activities on the Moon and in cis-lunar space driven by Government / Human Space Flight programs; Scenario Beta – the Moon and in cis-lunar space driven by Government Science programs (e.g., lunar surface astronomy, lunar laboratories, etc.); and, Scenario Gamma – lunar surface and cis-lunar space will be driven by Private Venture activities (including but not limited to very low cost launch systems, lunar surface resources developments). The figure below is a photo of the session in progress.



Moreover, at this time, the potential of the Moon is emerging rapidly. In this light, a Moon Village “Reference Architecture”, based on new developments has been defined, with specific key assumptions. These include:

- 1) The assumption that low-cost commercial access to low Earth orbit will transform cis-Lunar space operations during the next decade; the only question: precisely when? (Options: maybe before 2025, however certainly before 2030); and,
- 2) The assumption that massive new commercial and government market / mission opportunities will be the result from assumption #1. Examples of these developments include space-based global connectivity affordable megawatt power systems (solar, wireless and potentially

nuclear), development of physical space resources – beginning with the Moon (and initially focused on volatiles), and sustainable permanent human presence in cis-Lunar space.

Based on these assumptions, the Moon Village “Reference Architecture” discussed by the breakout session would comprise six (6) zones: (1) at the South Pole of the Moon in a ‘Peak of Eternal Light’ (PEL); (2) at the South Pole of the Moon in a ‘Permanently Shadowed Region’ (PSR); (3) near the South Polar region on the far-side in the Aiken Basin; (4) in lunar orbit; (5) in an Earth-Moon Libration Point; and (6) in low Earth orbit. (Additional details will be provided in an updated version of the Architectural Working Group position paper, to be posted on the MVA website.)

A number of important topics were identified for which key interfaces and standards need to be defined. These included: (1) Fluids & Gases (such as Propellants, Life Support, Fixed/Mobile, Surface & Orbital); (2) Crew / Human Systems (including Mechanical Interfaces: Airlocks, Pressurized Vehicles, EVA Systems, Electrical and Thermal Management, Dust Management, Data & Information Systems, and the Path to Settlement); (3) Landing Systems & Vehicle Support Systems (e.g., Reusable, Expendable, etc.); (4) Recycling and Waste Management (such as Human wastes, expendable systems, etc.); (5) Information Systems (including Interfaces / Evolution / Cyber-security); (6) Surface Operations / Utilities (Particularly power, mining / ISRU etc.); (7) Surface Mobility and Exploration; (8) Science Missions / Payloads (ranging across Science of the Moon, from the Moon and on the Moon); (9) Advanced Launch / Space Transportation Concepts; and, (10) Entertainment (e.g., Amusements!); and potentially others.

Recommendations for Action from Breakout Session #1 included:

- We need to update the Moon Village Scenarios based on recent events; continue development of the consensus-based MV Reference Architecture discussed at the working session;
- We need to further develop a projected Sequence of Major Milestones ... nearer term focus, but extending to roughly ~2045; and,
- We need to identify and Refine “Top-10” Topics for the MVA to Address that will support realization of the Moon Village Vision – spanning from the nearer-term through the farther-term.

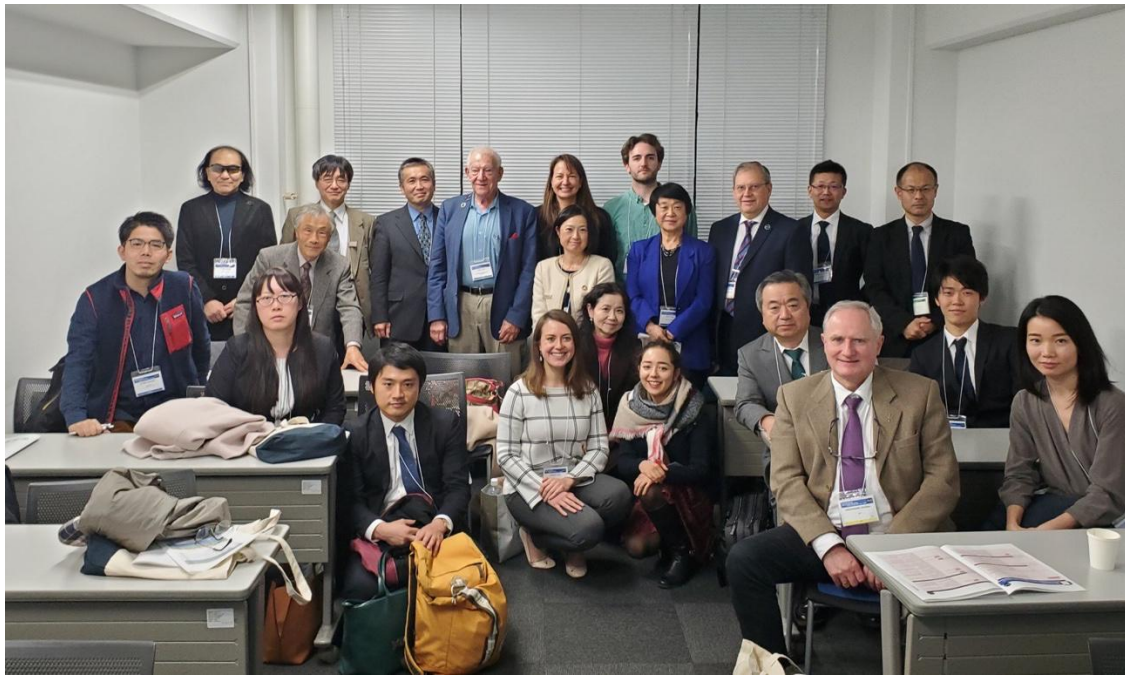
3.3 Humans on the Moon Topics, including Cultural Considerations (Breakout Session #2)

Co-Chairs of the breakout session were Prof. Chiaki Mukai and Dr. Michelle Hanlon. There were approximately 20 Participants at the session, and four presentations were made. The presentations included the following topics: Introduction to the MVA Cultural White Paper; ILOA (International Lunar Observatory Association) Moon Missions; Entangling Imagination and Environment at the MV; and, Radiation-driven Cancer Risks at the MV.

The ‘humans on the Moon’ working group discussed the ‘new overview effect’ – comprising the following perspectives:

- Cultural diversity is an important part of space exploration. We work better -- and achieve better results -- when we come together.
- The community we define for ourselves grows broader, we are not simply from a city or a country or a region. We are from Earth.
- Looking back made me feel proud to be from Earth, proud of us.
- Earth is not the center of the Universe. Our perspective shifts depending on where we are in space.
- The farther we get from Earth the closer we are together.

The figure below presents a photo of the breakout session group.



Recommendations for Action from Breakout Session #2 included the following; we need to:

- focus on increasing diversity at all levels of the MVA but especially in cultural considerations;
- use cultural considerations (history on the Moon and about the Moon) to guide all community development; and,
- consider the cultural impact of health issues/ways to address health through culture.

In summary, the working group felt that *now* it is time to recognize the Moon as our stepping-stone to our future selves, both literally and figuratively.

3.3 Roadmap to the Moon Market (Breakout Session #3)

Co-Chairs of the breakout session were Misuzu Onuki and Oleg Ventskovsky. There were approximately 40-50 Participants at the session. A white paper entitled “MVA Roadmap for establishing the Moon Market” that was prepared by M. Alain Dupas (who was unable to attend the meeting) was presented and briefly commented. Six (6) very diverse and interesting presentations containing their authors’ views and suggestions on how to approach the session’s subject were made; these included: (1) Intro to Business and Commercial MVA White Paper; (2) Marketing Strategies to build Moon Society; (3) Sustainable Business Construction; (4) Supply Chains and End Users Business Case; (5) Blockchain Systems supporting Moon Society; and, (6) Legal challenges for space ventures. In addition to the presentations, there was a significant discussion during the session. The figure below presents a photo of the breakout session group.



The following were the major findings and results from that working group breakout discussion.

Marketing of space and through space is a problem to be addressed. Lessons could be learned from sport marketing in what concerns media, ad/promotion, sponsorship, tourism; emphasis to be done on creation of civilization (marketing of space) and creation of culture (marketing through space); some positive examples from Japan: SORA tourism promotion council, JAXA's J-SPARC project launched.

Business models for construction-scale printing that could contribute to achieving the UN sustainable development goals (SDG) were presented at the meeting. Doing business on a digital platform connecting customers to architects/engineers, 3D printers is suggested; needs for innovative/unknowable materials and structures using the extraordinary abilities is emphasized, hyper-connectivity (based on 5G) is a promising tool.

The business case for the Lunar Frontier is related to critical needs to be identified. One of them - energy overconsumption (climate cliff); holistic approach & radical redefinition of technological solutions suggested; technology axes to advance human and industrial frontiers named, program sequence selection to be based on engineering/market maturity. Fundamentally, there is no special "Lunar Market" there is only one market for the expansion of human civilization into the Solar System to improve quality of life ("QOL") on Earth.

Blockchain use cases for the space industry – including Space financing, space asset tokenization, space industry procurement, manufacturing supply chain management, secure satellite communication and DLT (distributed ledger technology) were discussed as a powerful tool. Significant potential was emphasized (new markets for space assets, cost optimization, right on time, lean production).

New international laws and domestic regulations for new space exploration must be developed with development of technology and can lead it; UNCOPUOS consensus system is difficult, "soft" approaches needed; International business registry as a new business chance is particularly suggested.

Utilization of appealing nature of art to tackle problems such as lack of culture and economy in space and "boring space" suggested; including Case studies demonstrating the principle: "Create opportunities for arts – others will follow" presented; integration of space & non-space industries needed.

Recommendations for Action from Breakout Session #3 included:

- Continuation of the work on governance for space activities, to facilitate investments in space;

- Address specific problems and suggest mechanisms to bridge the market and investment gaps (ex.: International business registry, resource claims registry, loan securitization mechanisms, civil governance, police powers, etc.);
- Possible project (study): Assessment of the solar power impact on the Earth from environmental perspective rather than financial one; and,
- Disruptive Mega-Projects like large scale SSPS industrial development, lunar resource development, O'Neill Class Space Colonies etc. are the potential drivers for rapid and robust development of the cis-lunar economy

3.4 Cooperation and Coordination, including Legal topics (Breakout Session #4)

Co-Chairs of the breakout session were Giuseppe Reibaldi and Setsuko Aoki. There were some 16-18 Participants at the session. Two (2) Moon Village Association (MVA) White Papers were presented: Registration/Sharing Information, and Harmonization of Interfaces for Moon Exploration. In addition, four (4) presentations were given, including: (1) Closing the gap in Space Law: an implementation agreement for the Moon Treaty, (2) Jurisdiction and nationality on the Moon, (3) Applying space law to the community on the Moon, and (4) Realizing the Moon Village participation of emerging space countries. The figure below provides a photo of the group.



In addition to the presentations, there was a limited discussion during the session. One highlight from that working group breakout discussion was the note that MVA will become Observer Member of United Nations (UN) COPUOS (Committee on the Peaceful Uses of Outer Space) at the beginning of 2020. As such, MVA will be able to bring forward to COPUOS issues of general importance for Moon related issues.

Recommendations for Action from Breakout Session #4 included:

- MVA should decide, following input received by the session and workshop participants, what specific actions should undertake in 2020, in particular: For the Registration/Sharing of information how to improve the gaps identified and who will need these information; and, For the Harmonization of Interfaces, if there is enough industrial support to start a global harmonization especially for private organizations.
- The approach for involving Emerging Space Countries was endorsed and MVA will make it a priority for 2020 activities. It will be decided if to bring this issue to the STSC of UN-COPUOS next February.

- The 9 Moon Village Principles need to be revised in order to insure a proper COPUOS language; these principles will need to include Governance issues as they are missing.
- Considering that The Hague International Space Resources Governance Working Group has come to an end by publishing the Building Blocks, it is proposed that a Working Group is formed within MVA to deal with Governance issues and foster the implementation of the Building Blocks and inclusion of part of them in the MV principles.
- COPUOS has adopted 21 Guidelines about long-term sustainable space activities last June, however they are generic.
- It is proposed that MVA define an implementation of the approved guidelines for the Moon, this could be done in coordination with COPUOS.

3.5 Science on the Moon & the First MVA Payload (Breakout Session #5)

Co-Chairs of the breakout session were Junichi Haruyama and Elissavet Koumi. There were approximately 20 participants at the session; and some four (4) presentations were made, including: (1) MVA Payload Phase A results; (2) Moon Villages in Lunar Caverns; (3) Astrophysics on the Lunar Surface; and, (4) Gravitational-wave observatory on the Moon. The figure below provides a photo of the breakout session participants.



In addition to the presentations, there were discussions during the breakout session. One topic was that of What science can we do with the MVA first payload? A number of ideas possibly doable in this mission were suggested and will be followed up with more investigation by the team. Some examples included: measure seismic activity by detecting movement of stars on the camera; take differential images to detect small daily changes on Earth; and plume analysis during landing. In addition, input was received before the breakout relating to using this and future missions to research space weather.

Another topic discussed was: What science can we do in future missions? Some possibilities for future missions included: look at the inside of lava tubes, to detect magnetism and water; and, build gravitational wave detectors benefits from lower seismic activity compared to Earth. In general, missions can take advantage of the absence of an atmosphere to detect waves of frequencies filtered on Earth, as well as the near vacuum and possibility of using lunar night for low temperature applications.

Finally, the discussion touched on the question of What science outreach can we do? Simple science experiments that people can follow at low cost, but that are interesting to them, rather than to specialized scientists. Also, “edutainment” is a good way to educate people in an interesting way. Technologies like VR and games can be used. Simple instrument kits like antennas that can be set up for school projects. In addition, targets of opportunity should be found, like taking images of Earth and Mars, of asteroids passing by, of the ISS in front of Earth etc.

Recommendations for Action from Breakout Session #5 included:

- The MVA must continue the momentum of the conversation; A science communication channel will be set up for the participants of the group – to which they can also invite other people.
- Concerning the MVA Payload: the team must investigate what filters can be used with the camera we have and what benefits we can get from them.
- Lastly, there are already outreach programs that relate to space, so we should look for synergies. The team will put together a list of such programs, as well as a list of surveys for Moon related scientific activities.

Section 4

Summary Highlights

The following are selected summary highlights from the event.

- There were a number of specific actions identified during the breakout sessions on Day 1, reviewed in the afternoon of Day 2; these are discussed in Section 3 above.
- At the conclusion of the Tokyo portion of the event, it was announced that the 4th International Moon Village Workshop & Symposium will be held in Cyprus; the specific date will be determined early during 2020.
- Throughout the workshop and symposium both in Tokyo and Kyoto, the program was broadcast live via Youtube™; these videos are still available for viewing through the MVA website; see <http://moonvillageassociation.org/>.
- There was a press conference at the end of the event in Tokyo, with participation by 8 media/press journalists in the Q&A, which were addressed by Giuseppe Reibaldi, John Mankins (MVA), Chiaki Mukai (TUS), Takao Doi (Kyoto University), Setsuko Aoki (Keio University), and Yoshifumi Inatani (LOC, JAXA).