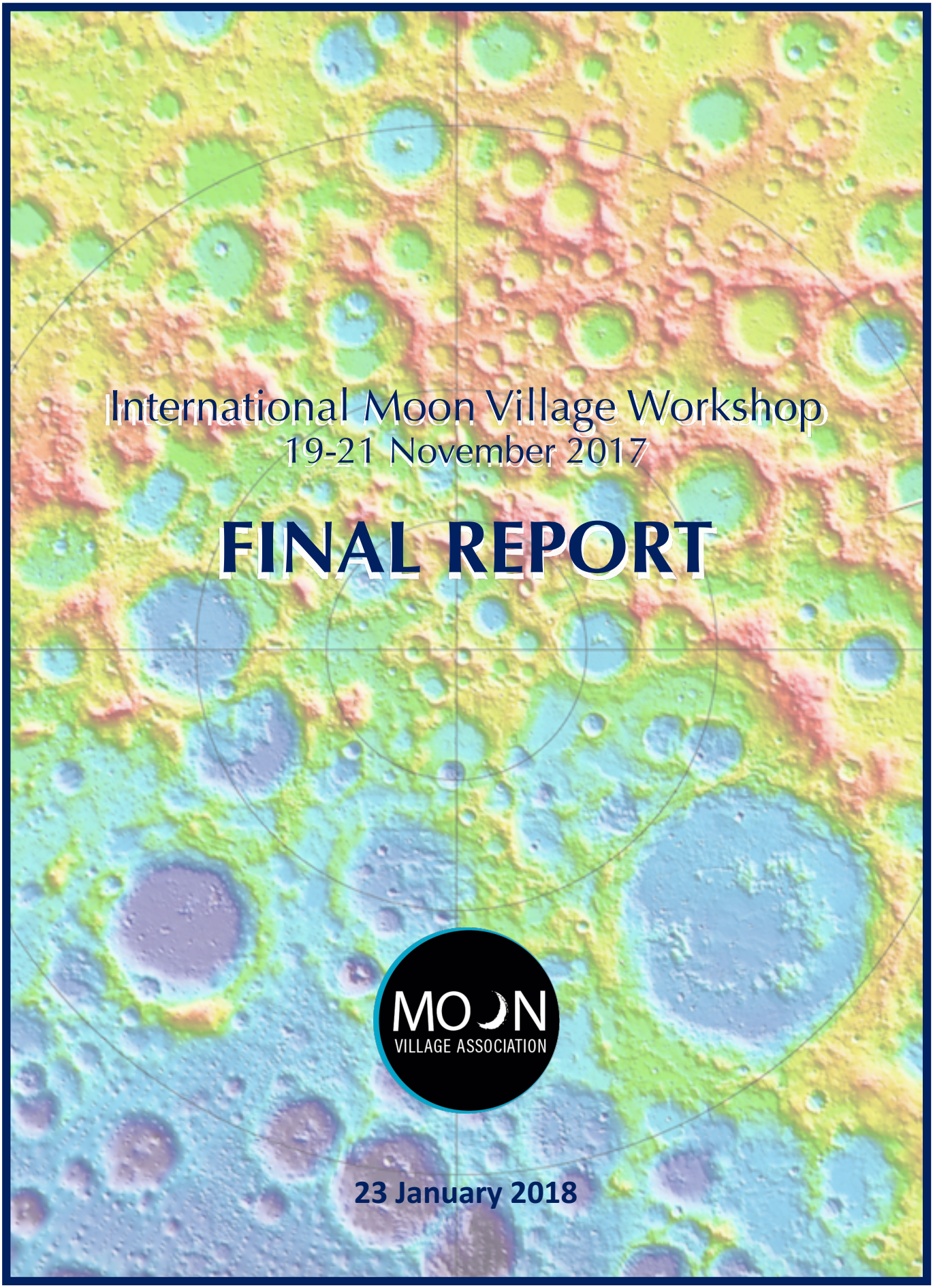

International Moon Village Workshop

19-21 November 2017

FINAL REPORT

MOON VILLAGE ASSOCIATION

23 January 2018

The cover of this Report includes an image derived from
NASA Lunar Reconnaissance Orbiter (LRO) laser altimeter data.

EXECUTIVE SUMMARY

More than 150 experts, engineers, educators and students from around the world gathered in Strasbourg, France to participate in the first International Moon Village Workshop during 19-21 November 2017. The Workshop was jointly organized by the recently-formed Moon Village Association (MVA) and the International Space University (ISU), and was held at the permanent campus of the ISU. The products of the two-day Workshop comprised some two-dozen Moon-focused presentations, as well as the results of eighteen working sessions during which participants discussed topics ranging from the technical framework of the Moon Village concept, prospective government missions and commercial markets for the Moon (including cis-lunar space), future coordination and cooperation vis-à-vis the Moon Village, and the ways in which human culture will influence choices and later be impacted by the expansion of humanity to the Moon.

The consensus of the participants is the Moon Village concept has immense potential to focus and communicate broadly an emerging focus on the lunar exploration and development and activities throughout cis-lunar space (i.e., outer space in the vicinity of Earth and the Moon). The Moon Village is not a single location nor a traditional space project, but is rather a broadly defined conceptual framework encompassing a diverse suite of planned and potential future human activities in space. Beginning now, and continuing into future decades the Moon Village represents a community comprising a wide range of future missions and emerging markets, including scientific research, commercial ventures, profound cultural developments and more.

This landmark event attracted policy makers, technologists and scientists from a number of space agencies, engineers and planners from major industry players, entrepreneurs from start-up companies and investors, and more than four-dozen faculty and students from various universities. A visionary keynote was presented, in the presence of Eurometropole Strasbourg Vice-President C. Trautmann, by European Space Agency (ESA) Director General Dr. Johann-Dietrich Woerner, followed by presentations on lunar-related activities and plans from global space leaders including Tom Cremins (NASA Associate Administrator for Strategy and Plans), Shizuo Yamamato (VP International Relations, JAXA), Silvio Sandrone (Airbus Defense and Space), Michel Tognini (President, Association of Space Explorers Europe), and Dave Murrow (Senior Manager Business Development, Commercial Civil Space from Lockheed Martin). The organization of the event was accomplished by an international team, led by Dr. Giuseppe Reibaldi (President of the Moon Village Association), Dr. Christopher Welch (Professor at the International Space University), and John C. Mankins and Max Grimard (of the MVA).

The gathering of Moon Village visionaries included participants from more than one dozen countries, including (in alphabetical order): Austria, Canada, China, England, France, Germany, Italy, Japan, Luxenberg, Russia, South Korea, Sweden, Ukraine, and the United States. Participating organizations included Airbus, Association of Space Explorers (Europe), Beijing University, ESA,

European Space Science Committee, For All Moonkind, Luxemburg Office of the Director for Space Affairs, International Space Exploration Research Institute, Ispace Europe, International Lunar Observatory Association, ISU, JAXA, Lockheed Martin, Lunar Station, Mankins Space Technology, MVA, NASA, PISCES (Pacific International Space Center for Exploration Systems), PTScientists, Pulispace, RUDN University, Spacebit, Team Indus, Yuzhnoye Design Office, and others.

At the end of the session, Buzz Aldrin (ISU Chancellor) addressed the participants by a surprise teleconference call explaining his vision of a future near-lunar concept.

ABOUT THE ORGANIZERS

Moon Village Association (MVA). The MVA is a recently formed non-profit organization chartered in Vienna, Austria and comprising approximately 100 members from numerous countries around the globe, representing a diverse array of technical, scientific, cultural and interdisciplinary fields. The MVA partners with non-space organizations to promote international discussion and formulation of plans to foster the implementation of a Moon Village, and is creating networks (international/national/regional) to engage civil society around the world. The Association works with other space and non-space organizations (commercial, non-profit, government, and others) to organize dedicated Moon Village and related events and makes the results available via traditional and emerging means. For information on how to become involved in realizing the Moon Village for the future of humanity, visit: https://www.moonvillageassociation.org/.

International Space University (ISU). ISU is a private non-profit institution, formally recognized as an institute of higher education in France by the French Ministry of Education. ISU is also recognized as a full member of EURASHE and is in the process of adapting its programs to the Standards and guidelines for quality assurance in the European Higher Education Area (ESG). The International Space University specializes in providing graduate-level training to the future leaders of the emerging global space community at its Central Campus in Strasbourg, France, and at locations around the world. In its two-month Space Studies Program and one-year Masters' program, ISU offers students a unique Core Curriculum covering all disciplines related to space programs and enterprises, space science, space engineering, systems engineering, space policy and law, business and management, and space and society. Since its founding, 30 years ago, more than 4400 students from over 100 countries graduated from ISU. See: http://www.isunet.edu.

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SECTION 1

INTRODUCTION

The Moon Village Association (MVA) is a new non-governmental / non-profit international organization founded to promote international discussion and formulation of plans concerning a "Moon Village". Through its activities, the MVA will advance the broad range of benefits for humankind that a Moon Village could establish, such as the utilization of lunar resources for civil space and commercial purposes, the accomplishment of important lunar scientific activities, and supporting progress toward longer term human and robotic space exploration, utilization and commercialization goals.

More than 150 experts, engineers, educators and students from around the world gathered in Strasbourg, France to participate in the first International Moon Village Workshop during 19-21 November 2017. The Workshop was jointly organized by the recently-formed Moon Village Association (MVA) and the International Space University (ISU), and was held at the permanent campus of the ISU. Annex 4 provides a complete listing of workshop participants.

Group Photo from the International Moon Village Workshop (19 November 2017)

The products of the two-day Workshop comprised some two-dozen Moon-focused presentations, as well as the results of eighteen working sessions during which participants discussed topics ranging from the technical framework of the Moon Village concept, prospective government missions and commercial markets for the Moon (including cis-lunar space), future coordination and cooperation vis-à-vis the Moon Village, and the ways in which human culture will influence choices and later be impacted by the expansion of humanity to the Moon. Annex 2 provides the final program for the workshop, including the schedule of events.

The MVA and the International Space University (ISU) organized this International Moon Village Workshop at the ISU central Campus in Strasbourg, France. This workshop was international and interdisciplinary in scope and focused around the production of a series of deliverables related to different aspects of the Moon Village that could be presented to the International Space Exploration Forum (ISEF) in Tokyo, March 2018 and to UNISPACE+50, in Vienna, June 2018.

The consensus of the participants is the Moon Village concept has immense potential to focus and communicate broadly an emerging focus on the lunar exploration and development and activities throughout cis-lunar space (i.e., outer space in the vicinity of Earth and the Moon). The Moon Village is not a single location nor a traditional space project, but is rather a broadly defined conceptual framework encompassing a diverse suite of planned and potential future human activities in space. Beginning now, and continuing into future decades the Moon Village represents a community comprising a wide range of future missions and emerging markets, including scientific research, commercial ventures, profound cultural developments and more. (Annex 3 addresses the question: what is the Moon Village?)

This landmark event attracted policy makers, technologists and scientists from diverse space agencies, engineers and planners from major industry players, entrepreneurs from start-up companies and investors, and more than four-dozen faculty and students from a variety of universities. A visionary keynote was presented, in the presence of Eurometropole Strasbourg Vice-President C. Trautmann, by European Space Agency (ESA) Director General Dr. Johann-Dietrich (Jan) Woerner, followed by presentations on lunar-related activities and plans from multiple global space leaders including Tom Cremins (NASA Associate Administrator for Strategy and Plans), Shizuo Yamamato (VP International Relations, JAXA), Silvio Sandrone (Airbus Defense and Space), Michel Tognini (President, Association of Space Explorers Europe), and Dave Murrow (Senior Manager Business Development, Commercial Civil Space from Lockheed Martin). The organization of the event was accomplished by an international team, led by Dr. Giuseppe Reibaldi (President of the Moon Village Association), Dr. Christopher Welch (Professor at the International Space University), and John C. Mankins and Max Grimard (of the MVA).

The exciting gathering of Moon Village visionaries included participants from more than one dozen countries, including (in alphabetical order): Austria, Canada, China, England, France, Germany, Italy, Japan, Luxenberg, Russia, South Korea, Sweden, Ukraine, and the United States. Participating organizations included Airbus, Association of Space Explorers (Europe), Beijing University, ESA,

European Space Science Committee, For All Moonkind, Luxemburg Office of the Director for Space Affairs, International Space Exploration Research Institute, Ispace Europe, International Lunar Observatory Association, ISU, JAXA, Lockheed Martin, Lunar Station, Mankins Space Technology, MVA, NASA, PISCES (Pacific International Space Center for Exploration Systems), PTScientists, Pulispace, RUDN University, Spacebit, Team Indus, Yuzhnoye Design Office, and others.

At the end of the session, Buzz Aldrin, ISU Chancellor, addressed the participants by a surprise teleconference call explaining his vision of a future near-lunar concept.

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SECTION 2

WORKSHOP GOALS & OBJECTIVES

Co-organized by the Moon Village Association (MVA) and the International Space University (ISU) gathered experts from industry, space agencies, academia and non-space fields met to discuss and define new approaches to foster the implementation of the Moon Village as a global cooperative program. The following were the goals and objectives of the meeting, its organization and the planned deliverables.

GOALS & OBJECTIVES

The following were the goals and objectives of the workshop.

- Gather major Moon exploration stakeholders to establish a permanent informal forum in line with the scope of the Moon Village Association
- Use Breakout Sessions to produce initial reports defining the technical, economical, cooperative and cultural implementation of the Moon Village.
- Create an integrated Workshop Report by the end of 2017 by MVA, with the involvement of its members and Workshop breakout participants
- Use this report as an MVA input to future international gatherings, such as Unispace+50 and the 2nd International Space Exploration Forum (ISEF 2) in Japan (March 2018)
- Be the first official gathering of the Moon Village Association

ORGANIZATION

The following is an overview of the organization of the meeting.

- First Part: Plenary Sessions
    - Major stakeholder presentations of their Moon programs
- Second Part, Breakout Sessions with 6 Teams each:
    - Session Group #1: Technical Framework
    - Session Group #2: Business Opportunities
    - Session Group #3: Coordination and Cultural Aspects
- Third Part, Plenary Sessions:

- Reporting from the Breakout Session(s)
- Conclusion of the Workshop
- And Discussion of Follow-up planning

DELIVERABLES

Planned deliverables from the meeting were: (1) a slide deck summarizing the meeting results; (2) a written report (this document), and (3) a database that captures the full set of issues and items raised by workshop participants.

SECTION 3

PRESENTATIONS

During the three-day meeting, a number of senior international space leaders and subject matter experts spoke on a variety of important topics. The following section provides a high-level synopsis of the various presentations over several plenary sessions; the actual presentations will be provided separately from this summary report.

Sunday, 19th November

KEYNOTE ADDRESS

The following keynote address was made to the participants in the workshop.

WOERNER, Johann-Dietrich 'Jan' (Director General, European Space Agency)

Presentation**: "Overview Perspectives on the Moon Village"**

Synopsis: Jan Woerner presented an overview of the vision of the Moon Village concept.

Selected Highlight(s): The Moon Village is not a single location, but rather a concept for humanity's future vis-à-vis the Moon.

Monday, 20 November 2017

OVERVIEW

Including senior level presentations by various key individuals including Dave Murrow – Senior Manager Business Development, Commercial Civil Space, Lockheed Martin – on the topic of the Deep Space Gateway concept; Tom Cremins - NASA Associate Administrator for Strategy and Plans; Michel Tognini – President, Association of Space Explorers Europe; Silvio Sandrone – Airbus Defence and Space. These talks were followed by a panel discussion on the topic of "Moon Village Implementation, Programmes and Policy: Challenges and Opportunities". This panel included the speakers listed above.

- Dave Murrow – Senior Manager Business Development, Commercial Civil Space, Lockheed Martin.
- Tom Cremins - NASA Associate Administrator for Strategy and Plans
- Michel Tognini – President, Association of Space Explorers Europe
- Silvio Sandrone – Airbus Defence and Space.

Special topic presentations were made, with invited presentations including

- Ian Crawford – Professor of Planetary Science and Astrobiology, UCL
- Kyle Acierno – Managing Director, ispace Europe, Luxembourg.

OPENING PRESENTATIONS

The following presentations were made at the opening of the MV workshop.

PEETERS, Walter (President, International Space University)

Presentation**: "Introductory Remarks"**

Synopsis: W. Peeters presented a welcome to the ISU to the participants at the International Moon Village Workshop.

Selected Highlight(s): N/A.

REIBALDI, Giuseppe (President, Moon Village Association)

Presentation**: "Introductory Remarks"**

Synopsis: Giuseppe Reibaldi presented a welcome and overview remarks to the participants at the International Moon Village Workshop, including the definition of the Moon Village.

Selected Highlight(s): N/A.

MANKINS, John C. (Lead, Technical Sessions, International Moon Village Workshop)

Presentation**: "Aims and Organization of the Workshop"**

Synopsis: J.C. Mankins presented a series of guidelines for the breakout sessions / working team discussions held during the workshop, including the overall goals of the workshop and details of the approach to capturing and documenting the results of the discussions (including the "Items / Issues to be Considered" (ITBCs) data form).

Selected Highlight(s): N/A.

MURROW, David (Lockheed Martin; USA)

Presentation**: "Deep Space Gateway: The First Dwelling in a Moon Village"**

Synopsis: Dave Murrow presented an overview of the key systems involved in the Deep Space Gateway (DSG), planning for major milestones during the coming decade and details regarding the DSG. He also highlighted capabilities to support lunar surface activities in the nearer term and evolutionary options for the far term.

Selected Highlight(s): Major new infrastructure is being planned for the vicinity of the Moon – to be deployed in the next 5-10 years.

SENIOR-LEVEL PRESENTATIONS

Senior representatives from key organizations with an interest in the future exploration and development of the Moon made presentations during the workshop plenary sessions, including NASA, ESA, JAXA,

CREMINS, Tom (Office of the Administrator, NASA; USA)

Presentation**: "Introductory Remarks"**

Synopsis: Tom Cremins of the Office of the Administrator at NASA Headquarters in Washington DC, offered introductory remarks concerning current US exploration planning.

Selected Highlight(s): N/A.

YAMAMOTO, Shizuo (Vice President, Japan Aerospace Exploration Agency, JAXA; Japan)

Presentation**: "JAXA's Current and Future Programs in Space Exploration"**

Synopsis: S. Yamamoto presented the overall organization of space activities in Japan, including the Lunar and Planetary Exploration Program and the Human Space Activities Program, including the International Space Station (ISS). He described both a past lunar program (SELENE) and future mission plans, including a lunar imaging / navigation lander (SLIM) and a lunar polar lander with a rover (SELENE-R). He also summarized Japan's plans to contribute to the International Space Exploration Program via a 20-year roadmap involving new technologies (e.g., fuel production on the Moon), infrastructure (e.g., involvement with NASA's Deep Space Gateway), reusable space transportation and surface systems (e.g., pressurized rovers for astronauts).

Selected Highlight(s): Japan is planning an ambitious program of government-sponsored lunar missions and systems, focusing on lunar resources and cooperation with diverse (space/non-space) stakeholders.

LINK, Mathias (Director of ICT and Space Affairs; Luxembourg Ministry of the Economy)

Presentation**: "SpaceResources.lu: Enabling Commercial Exploration of the Moon"**

Synopsis: M. Link presented an introduction to Luxembourg's national space goals, including segments of the space market that are priorities and the tools/instruments being employed to achieve engagement. He also presented an overview of Luxembourg's "Space Resources Initiative", which seeks to kick-start the space resources market. Link concluded with an overview of Luxembourg's perspectives and lunar exploration, including prospects for public-private partnerships and collaboration.

Selected Highlight(s): The demand for resources in space is growing rapidly, and technological capabilities are advancing. Key challenges include (a) technical, (b) regulatory, (c) financial, and (d) business development. And, private enterprise can play a key role in a Moon Village – if space-faring Nations implement their programs so as to create commercial opportunities.

SANDRONE, Silvio (VP Advanced Projects and Products, Airbus)

Presentation**: "Towards an Orbital & Cis-lunar Society"**

Synopsis: S. Sandrone presented an integrated and century-spanning perspective on exploration and development, drawing parallels between past ages and present / future events in space science,

exploration, development and settlement. The development of standards for 'moon-bound' missions could be a useful activity.

Selected Highlight(s): The era of the first and second Industrial Revolutions (1730-1900) are analogous to current developments in space – including in-space construction, large satellite constellations / services and eventual human settlements in space.

TOGNINI, Michel (President, Association of Space Explorers – Europe)

Presentation**: "Moon and Astronauts"**

Synopsis: M. Tognini introduced the Association of Space Explorers (ASE) and summarized its history and four regional chapters. He described what the ASE does, including support for the advancement of space exploration. M. Tognini emphasized the importance of human astronauts and their impact vs. robots (e.g., inspiration, education, etc.) in engaging a broad cross-section of society. He proposed the idea of a Moon Village Day – analogous to "International Asteroid Day."

Selected Highlight(s): "The Moon Village cannot stay a concept forever" – paraphrasing Konstantin E. Tsiolkovsky famous quotation: "The Earth is the cradle of humanity, but mankind cannot stay in the cradle forever."

KOTHANDHAPANI, Adithya (TeamIndus; India)

Presentation**: "Introduction to TeamIndus Programs"**

Synopsis: Adithya Kothandhapani (accompanied by Dhruv Batra and other members of TeamIndus) presented an overview of TeamIndus plans and activities independently and as part of the firm's effort vis-à-vis the Google Lunar XPrize competition.

Selected Highlight(s): TeamIndus has created a major outreach program in India fostering STEM (Science, Technology, Engineering & Mathematics) education; could be the first team to land a private spacecraft on the Moon.

SUN, Gongling (International Space University; formerly Chinese Space Program; China)

Presentation**: "Introduction to Chinese Lunar Program"**

Synopsis: Gongling Sun summarized Chinese lunar exploration program missions through 2014 (Chang'E-1, Chang'E-2 and Chang'E-3), plus the planned Chang'E-5 sample return. He presented a high-level Moon roadmap – indicating that plans beyond 2018 are still to be decided. However, prospects include lunar North and South pole missions in 2023 and 2026, with emphasis on lunar *in situ* resource utilization (ISRU).

Selected Highlight(s): Future directions for China's lunar programs include a progression from exploring for lunar resources, to establishing basic stations (on the surface and in-orbit), and to validating resource development and utilization technologies (perhaps by 2030?).

KOUPREEV, Sergey A., et al (RUDN University Moscow; Russia)

Presentation**: "Russian Participation in the Common Exploration of the Moon"**

Synopsis: S. Koupreev presented thoughts on humanity's past visions for, and future in space – and on the importance of the Moon for both. He articulated the emerging global character of lunar exploration – including multiple players not just national governments. He also summarized Soviet / Russian history vis-à-vis the Moon, and sketched recent Russian Federal Space Program plans for a series of lunar missions (landers, orbiters and sample return from the pole). The MVA Russian Network was also presented.

Selected Highlight(s): Navigation is a challenge of particular importance, including precision landing at a designated target and trajectories for returning crews urgently from lunar missions in the event of problems.

SPECIAL TOPIC PRESENTATIONS

The following is a brief synopsis of several "special topic presentations" that were made at the workshop.

CRAWFORD, Ian (Professor of Planetary Science and Astrobiology, University of London; UK)

Presentation**: "Multiple Reasons for a Moon Village"**

Synopsis: Ian Crawford discussed the reasons for a Moon Village including economic, geopolitical, cultural, scientific, etc. He described part research outposts (e.g., Antarctica), and detailed the science that could be supported at a Moon Village (results from a June 2017 International Academy of Astronautics Symposium), including various examples.

Selected Highlight(s): Consistent with the Global Exploration Roadmap (GER) of the International Space Exploration Coordination Group (ISECG), there is a need for greatly expanded scientific infrastructure on the lunar surface.

ACIERNO, Kyle (Managing Director, Ispace Europe)

Presentation**: "Ispace Lunar Missions – A Future Roadmap"**

Synopsis: K. Acierno presented an introduction to Ispace and its phased approach to lunar exploration and development; he discussed Team Hakuto (Japan) and the Google Lunar Xprize, as well as lunar prospecting and eventual lunar resource extraction, exploitation, production and storage. He presented an initial three phase approach, beginning with the Google Lunar XPrize, and encompassing an impressive array of early systems (landers, rovers, etc.). Acierno described how Ispace is working with Team Indus (India) regarding launch and a second rover. He also highlighted lunar prospecting opportunities, and described various capabilities (past and planned). Plans for missions beyond the Lunar Google X-Prize.

Selected Highlight(s): Lunar resources – including metals, energy, H_2O, regolith for construction and Oxygen for Atmosphere – are foundational to a future lunar economy.

FOING, Bernard (Advisor to the ESA Director General; Executive Director of the International Lunar Exploration Working Group, ILEWG)

Presentation**: "Moon Village Update"**

Synopsis: Bernard Foing presented an overview of lunar missions of the recent past (2003-2010), including SMART-1, Kaguya, Chang'E 1 & 2 and Chandrayan 1. He also summarized the discoveries about the Moon made by those missions (e.g., "skylights" piercing lunar lava tubes, water concentration on the Moon, etc.). He also sketched the ILEWG roadmap for the Moon, prospective Google Lunar XPrize missions, ESA cooperation with NASA's Moon program plans and various Earth-based lunar testbeds. Foing also discussed recent European Moon Village-focused activities.

Selected Highlight(s): There is a wealth of international lunar missions being planned, as well as numerous Moon Village activities. ESA concepts for the Moon Village presume "free and open access, multiple use and multiple users" to realize "sustainable Moon surface operations" (including exploration, science, mining, tourism and other objectives).

KRIENING, Torsten (Head of Business Development, PTScientists GmbH; Germany)

Presentation**: "The Mission to the Moon"**

Synopsis: T. Kriening described PTScientists 'first commercial mission to send a rover' to the lunar surface, in cooperation with Audi, Vodafone and others – including discussions with ESA – with the goal of returning to the Apollo 17 landing site. The mission would comprise both a lander (ALINA) and two rovers (including the Audi lunar quattro). T. Kriening presented a roadmap to 2030 with various PTScientists missions with the official Moon Village kick-off in 2030.

Selected Highlight(s): Private ventures will enable the Moon Village vision.

BAHOV, Bozhidar (Space Mining Technologies; Netherlands)

Presentation**: "Space Mining Technologies (Overview)"**

Synopsis: B. Bahov presented a summary of the Space Mining Technologies company and its business plans, with special emphasis on the importance of lunar water resources.

Selected Highlight(s): Technology exists to advance from early technology demonstrations c. 2021 to water production (H_2 and O_2) by 2029.

LEE, Tai Sik (ISERI, International Space Exploration Research Institute; South Korea)

Presentation**: "In Situ Resource Utilization – Technology for Moon Village Construction"**

Synopsis: T.S. Lee presented perspectives on (1) a new era of space exploration; (2) *in situ* resource utilization (ISRU); (3) the International Space Exploration Research Institute (ISERI); and (4) future

directions. He also provided background on himself and the organization. Lee discussed the importance of ISRU for construction and space settlement – and the connection of the technologies to terrestrial markets. He argued that the technology is ready for development for the Moon and Mars. He outlined a 10-year ISERI roadmap (2018-2028) for development, and connected it to international planning.

Selected Highlight(s): ISRU and construction capabilities will be game-changers for sustainable human house solutions on the Moon.

MEALING, Michael (Waypaver Foundation; USA)

Presentation**: "(Overview of the) Waypaver Foundation"**

Synopsis: M. Mealing described the purpose of the Waypaver Foundation, which is focused on enabling sustainable lunar settlement. Activities have included a lunar habitat feasibility study, development of a "lunar settlement index" (a database of lunar development hurdles), and cis-lunar economic analysis. The Foundation is also supporting a reboot of The Moon Society.

Selected Highlight(s): The Waypaver Foundation seeks to fund and execute the research necessary for permanent human lunar settlement.

DE MAY, Stephan (Human & Robotic Exploration, European Space Agency)

Presentation: **"ESA's European Space Exploration Envelope Program"**

Synopsis: S. De May described briefly three topics: (1) the overall ESA Exploration Strategy; (2) E3P (European Space Exploration Envelope Program) for Period 1 and later; and, (3) a focus on the Moon. He articulated the basic motivations for space exploration and summarized current international planning involving the International Space Station (ISS), operating in the vicinity of the Moon, asteroid missions, and eventually human missions to Mars. De May summarized the E3P program and mentioned the breadth of ISS, Mars and cooperative ESA programs with other space agencies. He mentioned the role of international and commercial partnerships and the development of innovative new capabilities for operations in space. De May described aspects of ESA's lunar mission plans (e.g., *in situ* resource utilization (ISRU) demonstration projects, human precursors by 2030).

Selected Highlight(s): ESA is contemplating competitive public-private partnerships based exploration services industry (e.g., ISRU) for the Moon (working with PTScientists).

PACHER, Tibor (Pulispace - Puli Space Technologies; Hungary)

Presentation**: "Exploration Rough Terrains: What Can Puli Contribute to the Moon Village"**

Synopsis: Tibor Pacher described Puli Space Technologies development of novel planetary mobility / rover systems, including six years of R&D and multiple planetary analogue environment field tests (at Mauna Kea, the Moroccan Desert and the Austrian Alps). He also described the durability and

scalability of the Puli rover concept, and plans for its launch in 2019 on-board the Astrobotics lunar lander.

Selected Highlight(s): A race on the Moon could be an early example of Moon Village entertainment that would provide global media exposure, accelerate technology development and promote international cooperation.

GRULICH, Maria (Space Generation Advisory Council, SGAC; ESA)

Presentation**: "Space Generation Advisory Council – In Support of the United Nations Program on Space Applications"**

Synopsis: M. Grulich made a remote presentation describing the SGAC and its activities, including the Space Generation Congress at the International Astronautical Congress in Adelaide, Australia (21-23 September 2017). She also described a Moon Village workshop organized by the Council that was held in Turin, Italy in June 2017, which explored topics such as key players, commercialization, a 25-year roadmap for Moon Village engagements, international partnerships, and more.

Selected Highlight(s): There are diverse ways in which non-traditional stakeholders could play a key role in advancing the Moon Village, including logistics, resources, and infrastructures (e.g., power, data, etc.). Government space agencies should facilitate these developments by defining clear goals/plans, support critical technology development, establish an open systems architecture, and by funding new business incubators.

NEAL, Clive R. (University of Notre Dame, and Chair, Lunar Exploration Analysis Group, LEAG; USA)

Presentation**: "Lunar Exploration Analysis Group Update"**

Synopsis: Clive R. Neal made a remote presentation providing a summary description of the LEAG, established in 2004 to support NASA science and human exploration planning), and the results of recent LEAG and NASA workshops held in early October 2017. He stated that these results included a number of key findings: (1) the Moon is an important strategic destination and should be the focus of NASA human spaceflight efforts over the next 5-10 years; (2) a Deep Space Gateway (DSG), if developed, should support long-term human and robotic presence on the lunar surface; (3) prospecting for and using lunar resources (through public-private partnerships) is essential; (4) developing the lunar economy – and beginning early – is crucial.

Selected Highlight(s): A feasible path forward for the Moon must comprise: permanence, sustainability, multilateral participations, surface and orbital infrastructure, use of local resources and economic benefits. NASA should expand its engagement with the private sector.

DURST, Steven (Founding Director, International Lunar Observatory Association, ILOA; USA)

Presentation**: "Overview - ILOA"**

Synopsis: S. Durst made a remote presentation describing the activities of the ILOA, including several upcoming Moon missions.

Selected Highlight(s): The presentation suggested a possible human lunar mission in 2020.

Tuesday, 21 November 2017

Senior level presentations and invited presentations were made; these are summarized below.

These presentations were followed by a panel discussion on the broad topic of science, technology and culture, including Mahesh Anand, European Space Science Committee, and Hagen Betzwieser – Independent Arts Curator.

SCIENCE, TECHNOLOGY AND CULTURAL PRESENTATIONS

The following is a brief synopsis of several presentations that were made on "science, technology and cultural" topics that were made at the workshop.

ANAND, Mahesh (European Space Sciences Committee; UK)

Presentation**: "Moon as a Keystone to Understanding the Formation and Evolution of the Solar System"**

Synopsis: M. Anand described the international environment (with a European focus) for future space / science planning; he emphasized changing views of the Moon and the global context for Moon exploration plans, including human and robotic missions *in situ* resource utilization (ISRU), world-class science and preparation for human missions beyond the Moon. Anand also stated the European context for the Moon including a number of example science goals (e.g., lunar formation). He described potential future Moon exploration objectives (exploring the poles, the far side), next steps (e.g., the Deep Space Gateway), and a lunar surface habitat. He also mentioned more ambitious targets that might be pursued beyond 2050, including industrial partnerships and ISRU for sustainable exploration.

Selected Highlight(s): "All civilizations become either spacefaring or extinct" – Carl Sagan.

VENTSKOVSKY, Oleg (Yuzhnoye Design Office; Ukraine)

Presentation**: "Lunar Industry and Research Base"**

Synopsis: Oleg Ventskovsky discussed several topics, including (1) the Yuzhnoye heritage of lunar projects; (2) a strategy for creation of a lunar base; (3) space transportation systems; (4) lunar base infrastructure; (5) lunar orbital elements; and also (6) international cooperation. He described a long-term roadmap comprising an initial / minimal lunar base (c. 2030s), local manufacturing (2040s), and a permanent base after 2050. Ventskovsky discussed several Earth-to-orbit (ETO), in-space and lander transportation options, with special emphasis on propulsion systems. He also discussed a range of other concepts created by the Yuzhnoye Design Office for the Moon, including orbiters, power systems, fuel depots, habitats and others.

Selected Highlight(s): International cooperation and a coordinated strategy are very important; and public-private engagement for the Moon – using the Moon as a stimulus and platform for technology R&D – is key to cost reduction for future interplanetary exploration.

BETZWIESER, Hagen M. (Artist / Designer / Film maker)

Presentation**: "We Colonized the Moon"**

Synopsis: In cooperation with Sue Corke (UK), aka "We Colonized the Moon" (WCTM) Betzwieser presented a history of lunar-focused artistic works (since 1865), followed by a discussion of why the Moon is compelling to humanity and citing examples of contemporary art concerned with space and the Moon.

He illustrated the multi-sensory character of this challenge by sharing with attendees an acrid scent – "The Smell of the Moon"; an internationally exhibited olfactory artwork by Betwieser and Corke created by MCTM by Steven Pearce at Omega Ingredients – that resembles the smell of lunar regolith according to a number of Apollo astronauts.

Selected Highlight(s): Artistic pursuits can play a key role in pursuing the goal of a Moon Village by creating "space awareness" among the general public.

WALTEMATHE, Michel (Department of Protestant Theology; Ruhr-University Bochum, Germany)

Presentation**: "Building a Village on the Moon: Religious Dimensions of Settling in Space"**

Synopsis: M Waltemathe discussed the truly diverse religious aspects of Space Settlement – beginning with a village on the Moon. He mentioned past religious artifacts that have traveled in space and to the Moon, and the implications of these events. He also cited religious observances (e.g., Christmas), that have occurred in space – and the challenges therein (e.g., "which direction should I pray?"). The Moon presents a profound challenge to human thought – religious considerations much follow (i.e., "The Overview Effect"). The Moon Village idea "reifies" complex social ideas – i.e., makes them concrete.

Selected Highlight(s): A (Moon) Village will "reify" (i.e., make tangible what was previously immaterial) concepts such as community, world view, social structures, communal support, outside relations, and internal economy.

ARKLESS GRAY, Kate (Advisory Council, For All Moonkind; UK)

Presentation**: "Building a Sustainable Future on the Moon"**

Synopsis: Kate Arkless Gray introduced the organization 'For All Moonkind' by discussing the cultural issues that motivate them, including the importance of preserving and learning from World Heritage Sites – first on Earth and later on the Moon (e.g., the Apollo 11 landing site). All of the Apollo sites are unique: frozen in time and represent a profound advancement for humankind: they must be protected. There are governing agreements vis-à-vis space (e.g., the Outer Space Treaty), however no nation can "claim" (or protect) a location on another body, such as the Moon. "For All Moonkind"

is a non-profit organization that supports space exploration and universal heritage sites on the Moon and elsewhere.

Selected Highlight(s): The goal of preservation of humanity's lunar heritage sites should/must be built into planning for the Moon Village.

ROGERS, Henk (International Moonbase Alliance; Pacific International Space Center for Exploration Systems; Hawaii, USA)

Presentation**: "Overview of International Moonbase Alliance"**

Synopsis: Henk Rogers presented remotely an overview of activities by PISCES and the International Moonbase Alliance, including the results of a workshop held on the topic in Hawaii (October 2017).

Selected Highlight(s): The International Moonbase Alliance and PISCES are working toward the creation of a lunar base analogue in Hawaii that could provide testing and operations validation for a wide variety of global organizations.

CLOSING SESSION

During the closing session of the workshop, impromptu remarks were offered remotely from the Chancellor of the ISU. In addition, closing presentations were made by various representatives from the breakout session teams, and by the President of the MVA. These are summarized below.

ALDRIN, Edwin Eugene (Buzz) (Apollo 11 Astronaut; Chancellor International Space University; USA)

Presentation**: "Closing Remarks"**

Synopsis: Buzz Aldrin remotely offered a series of comments at the close of the workshop, discussing his views on their efforts in general, and the importance of sustainable "cycling" infrastructures for both Mars and Moon human access.

Selected Highlight(s): There are viable lunar "cycler" options that should be considered going forward.

MANKINS, John C. (Lead, Technical Sessions, International Moon Village Workshop)

Presentation**: "Closing Presentations"**

Synopsis: J.C. Mankins summarized the process used during the workshop discussions; he also introduced a series of brief summary presentations by each of the six teams (across three distinct breakout sessions each).

Selected Highlight(s): The team representatives (with comments as appropriate from team members in the audience) summarized their results and identified those "ITBCs" that the team in question regarded as being of higher priority.

REIBALDI, Giuseppe (President, Moon Village Association; FRANCE)

Presentation**: "Closing Remarks"**

Synopsis: The "Moon Village" is a common destination for multiple users and uses where different organizations may collaborate together for sustainable operations on the surface of e Mon as well as in cis-lunar space. (See Annex 3 for a more complete presentation of what the Moon Village is and is not.) Considerable interest and even passion was shown by the participants at the workshop. Aspects that need to be discussed in greater detail include Cultural and Educational considerations; both will be discussed as the project moves forward. Future workshops will involve to a greater degree non-space / global stakeholders with relevant skills and interests. The ISU has been an ideal location for this event – particularly in view of its education aspects and global reach.

Selected Highlight(s): Next year, there will be another global Moon Village workshop; details are to be decided.

SECTION 4

WORKING DISCUSSIONS

OVERVIEW

In addition to the plenary sessions, the workshop participants also contributed to six separate / concurrent teams, each within three breakout sessions (for a total of 18 breakout sessions). Figure 4.1 presents a photo of one of the breakout sessions.

Figure 4.1 Photo from one of the Breakout Sessions

The six teams / breakout session groups all addressed the following topics of interest in framing the challenge of the Moon Village:

- Technical Framework (i.e., Architecture) of the Moon Village Concept
  - What comprises the “Moon Village”?
- Missions & Markets for the Moon Village
  - What are the government missions that may be implemented on / near the Moon (science, human space flight, etc.)? What commercial markets are most promising and when (including commercial services as well as direct-to-market commercial opportunities)?
- Cooperation and Coordination among Moon Village Participants
  - What are the terms of “Governance” for the Moon Village?

- Cultural Considerations
  - What are the prospective Cultural Impacts and Opportunities associated with the Moon Village?
  - Including diverse topics such as the Arts, the heritage of humanity, religion, and others

ISSUES / ITEMS TO BE CONSIDERED

The workshop breakout sessions employed a standardized data collection tool to gather the results of discussions in each of the six concurrent team discussions (with the support of ISU students who served as volunteer rapporteurs during the sessions). These forms – known as "ITBC" forms (i.e., "Issue/Item To Be Considered") – captured the following types of information:

- The **originator**(s) of the ITBC
- The originator(s) **contact information** organization and
- The **title** of the ITBC (a short statement of the topic)
- The **broad area** into which the Topic should be classified (e.g., "Technical Framework")
- Identification of the **timeframe** – i.e., whether the ITBC falls into the "Near-Term", the "Mid-Term" or the "Far-Term"
- A longer **description** of the ITBC (perhaps one or two paragraphs, maximum)
- A suggestion as to what might be done – i.e., **how to address** the ITBC
- A suggestion as to what might be done – i.e., the **near-term action(s)** to begin addressing a given ITBC

Almost 200 ITBCs were developed by the six teams over three concurrent breakout discussions during the Moon Village Workshop. These will be integrated and posted on-line for use by the MVA working groups. Annex 5 presents a listing of the ITBCs produced at the workshop.

BREAKOUT SESSION HIGHLIGHTS[1]

The following paragraphs present selected example "Issues to be Considered" (ITBCs) generated by the participants the 18 breakout sessions – emphasising topics that were of particular interest or importance. They are organized into four sub-sections:

(1) technical framework;
(2) missions and markets;

[1] These highlights are reflective of the ITBCs from the workshop; they have been edited slightly. A detailed dataset of the ITBCs will be available to members of the MVA and the several MVA working groups

(3) coordination and cooperation; and,

(4) cultural considerations.

The inputs provided in the presentations (in the previous Section) and in the ITBCs provide the foundation for the key findings (Section 5) and the recommendations (Section 6) that follow.

Technical Framework

ITBC TITLE**: "Need for Moon Village Systems Interface Standards"**

Summary of the Issue: Realizing essential coordination and cooperation among the diverse national, commercial and academic projects requires clear and executable interface standards that do not currently exist.

Suggestions for Action: An independent organization should orchestrate efforts among relevant organizations to define and promulgate the interface standards to enable development and deployment of Moon Village systems -- initially and to evolve over time. Action should be started in the near term.

Notes: MVA should consider taking the lead in accomplishing this objective.

ITBC TITLE**: "Lunar Dust Mitigation"**

Summary of the Issue: Lunar surface dust is highly hazardous, sharp micro-scale edges; it can affect both many systems and astronauts and their equipment. Need to get rid of moon dust from any moon installation or hardware. For example, astronaut visors can be blocked by the dust. However, there is business potential in dust mitigation hardware and potentially dust reuse, and in solar panel cleaning

Suggestions for Action: The primary challenges of lunar dust mitigation involve both robotic and human systems, both surface operations and habitat environmental management. There is a need for further research to define the requirements for dust mitigation. These should be followed by systems analysis and technology R&D planning -- leading to a technology demonstration in the coming handful of years. Options for technologies including both magnetic and electrostatic control; however, more samples are needed. Human related medicine research is needed to help overcome dust-related health hazards. Also, there is a need to discover/develop Look new materials to protect habitats, rovers and humans from dust hazards. Action should be started in the near term.

Notes: This could be a topic for future workshops.

ITBC TITLE**: "Precision Landing Objectives and Infrastructure to Support Them"**

Summary of the Issue: Accomplishing pin-point landings to desire locations It is very important to 'getting it right' to support initial and subsequent Moon missions – particularly with no equivalent of the Global Positioning System (GPS) in orbit around the Moon.

Suggestions for Action: The primary challenge of precision landing in rocky terrains – establishing a GPS type navigation aid around the Moon – can be accomplished readily using Cubesats. Details, however must be resolved, including variations in the lunar surface density/gravity that will impact satellite orbital paths, and others. Action should be started in the near term.

Notes: There is a need for mission / market studies to define the requirements for precision landing. These should be followed by systems analysis and technology R&D planning -- leading to technology demonstration in the coming handful of years.

ITBC TITLE**: "Data Management"**

Summary of the Issue: Moon village likely to generate huge amounts of data; as a result, there will be a need a centralized data storage and management software including specialized Data Analytics.

Suggestions for Action: Development of a Moon Village Data Management System should begin in the immediate future to provide a centralized repository for non-proprietary data of general importance.

Notes: MVA should address this topic in future workshops.

ITBC TITLE**: "Establishing a Set of Coordinated Protocols for Lunar Operations"**

Summary of the Issue: The diverse governmental and private sector plans for mission activities on the Moon and in cis-lunar space are generally uncoordinated and operational protocols inconsistent; there is no over-arching mechanism to enable more-effective and efficient operations planning.

Suggestions for Action: An independent organization should define an integrated framework for the documentation of various operations protocols for lunar and near-Moon mission and market activities -- and communicate them among various participants, and orchestrate its evolution as MV programs and projects are accomplished. Action should be started in the near term.

Notes: MVA should consider taking the lead in accomplishing this objective.

ITBC TITLE**: "Systems Analysis of Moon Village Systems / Infrastructure Options"**

Summary of the Issue: The potential value of diverse future space transportation systems options for the Moon Village can only be evaluated through consistent and transparent systems analysis studies; such studies are not being performed.

Suggestions for Action: An independent organization must orchestrate the definition of the high-level standards for needed systems analysis studies (metrics, transparency, etc.). Within this framework, studies should be conducted by various organizations, including ISU, Space Agencies, etc. to enable diverse proposals / projects to be compared. Action should be started in the near term.

Notes: MVA should consider taking the lead in accomplishing this objective.

ITBC TITLE**: "Establishment of Lunar Observation and Communication Systems"**

Summary of the Issue: Dedicated, high capacity lunar communications and observations systems will be needed in future. A stationary orbit around the moon is far away with a large communication lag and Libration Points present interference problems; other orbits / locations are needed for future lunar settlements.

Suggestions for Action: Requirements need to be defined, and system options examined, including Lunar-terrestrial communications link and examination of Reference past studies on lunar communication architecture. Molniya Type Orbits are one option. Studies should be started in the nearer term, but action is not needed until the mid- to far-term.

Notes: Systems analysis / design studies are needed; these should reference past studies on lunar communication architecture. This should be discussed at future workshops.

ITBC TITLE**: "Radiation Hardening and Protection"**

Summary of the Issue: Moon has no magnetosphere/ general atmosphere, need protection from the solar wind and possibly cosmic rays. There is danger of solar flares/CMEs directed towards Earth and the moon. This is both an issue on the Moon and enroute to/from the Moon.

Suggestions for Action: Hardening of all electronic and electrical equipment may be required. Also, for humans, consideration may include: wearable material to protect from radiation; shielding of habitat, utilise layer of water in craters or smart materials; underground habitat (i.e., dig deep and use surface of the moon to shield or build base within a buried trench utilizing regolith to form lunar concrete shielding), and a shielded location in any habitat for waiting out 'solar storms'. Will need to continue/ increase monitoring of the sun with sufficient warning system, including monitoring of individual astronauts. Needed activities include: Research into radiation shielding, interesting avenue could be electrodynamic shielding some form of active radiation mitigation. First step would be to utilise existing tech which would be to test boring on the moon/ moon concrete for base. Action should be started in the near- to mid- term.

Notes: This is a topic for future discussion.

ITBC TITLE**: "Life Support Systems for the MV – getting the Moon village inhabitants what they need to survive"**

Summary of the Issue: Efficient, reliability and cost-effective Life Support Systems are key to long-term human presence on the Moon. Requirements include personnel modules and cabins, as well as a comfortable place to stay in transit to/from the Moon. One vision is that these accommodations should be more like a cruise ship cabin than an airplane seat. A number of consumables are required, but key questions remain: Should everyone "bring" everything (water, oxygen, food, CO2 extraction means)? Should it be provided by the "Moon Village"? Will there be synergies with ISRU (water/oxygen)? And, what will be done with the waste (treatment/return2Earth)?

Suggestions for Action: Several Life Support System options should be considered: (1) For MV atmosphere management (O2, CO2 levels), ISS technologies could be used (Molecular sieves for CO2, water electrolysis for O2 production, Sabatier for CO2 treatment), as well as alternatives; (2 For water management there is potential synergy with ISRU, however water treatment will be required, to avoid accumulating waste water. ISS-type technologies might be used, but others may be considered. General technology goals include reduction of complexity, maintenance & spares requirements and others; (3) For food management, food could be imported from Earth. However, depending on the duration of the human presence, local food production might be needed – including plants or algae, which could also extract CO2 and produce O2. Combinations of biological systems and food imports might also be considered; (4) For waste treatment: it will be important minimize waste, but to ensure any produced is properly stored to avoid contaminating the Moon.

In the near-term, Further R&D on ISS life support tech. is required to increase reliability / reduce maintainability, as well as further development of other technologies as alternatives (e.g. brine treatment); also, Further R&D on biological systems (plants and algae) is needed. Currently there are several research projects, but the SOA is still far away from having a biological Life Support System (scale, controls, etc.); and, Further R&D on waste treatment strategies (e.g., human waste+bio systems). Solving these challenges will take time: near-term action needed.

Notes: MVA should include these topics in future workshops.

ITBC TITLE**: "Cosmic Impact Protection"**

Summary of the Issue: In seven years of operation the Lunar Reconnaissance Orbiter has seen more than 200 new craters, some more than ten meters in diameter. The Moon is vulnerable to impacts because there is no atmosphere. There are various classes of asteroid and potential for problems from class 1 "Ignore" to class 5 "Extermination". 1000s of small meteorites impact Earth every day with no consequences because they burn up. Medium sizes commonly occur, and the biggest can have significant impact (such as extinction of dinosaurs). Vis-à-vis planetary defence, it may be necessary to intercept a potential impactor to protect Earth.

Suggestions for Action: Need definitions of Impact Threats for the Moon Village; for example, these might be framed as: 1st class – no big deal, 2nd class – send rover to fill hole, 3rd class – isolate lunar village, send robot to repair damage, 4th Class – instantly react or lives will be lost – isolate village and move people to undamaged area, and 5th Class – extermination, finishes Moon Village. We need to determine likelihood of each class occurring and determine the curve of likelihood and severity. We also need to consider potential steps to mitigate the risk, such as burying the Moon Village or using materials to protect it (e.g., reinforcement, hardened materials, Kevlar, etc.) Another possible solution is to use a Distributed Architecture, with Habitats, work zones, agricultural volumes isolatable and/or inflatable, with repair kits provided. We should plan for Robotic repair if possible, with EVA optional. Other options: Multiple meters of regolith cover, Ballistic regolith installation by wire wheel, Interconnected airlocks, Acoustic isolation in habitats, and Interiors changeable.

Commercial service may be required together with many others Action should be started in the near- to mid- term.
Notes: There is a need to begin systems analysis studies to better understand the risks and approaches to mitigate them.

ITBC TITLE**: "Electric Power on the Moon"**

Summary of the Issue: Pursuing ambitious goals and objectives on the Moon, such as development of lunar resources -- including discovery and development of resources in permanently shadowed regions -- space settlement, and others will require significant amounts of available and affordable electrical power.

Suggestions for Action: Options are limited -- primary solar and nuclear. In various cases, Solar may not be the best option. Nuclear power could be a good option, but has limitations due to its cost and dependence on radioisotopes that must be imported from Earth. Regenerative fuel cells for storage are an option, as are thermodynamic energy storage. Action should be started in the near term.

Notes: Continue ongoing research (e.g., 5 kw fission reactors being studied by NASA); examine other options in systems analysis studies.

ITBC TITLE**: "Debris and Waste from Operations"**

Summary of the Issue: Lunar explorers, developers and settlers to be careful that their operations to not result in leaving debris in orbit, or waste / debris on the surface of the Moon from operations.

Suggestions for Action: Governments, industry and universities involved in operating systems on or near the Moon should take responsibility for systems designs so as to minimize the generation of waste and/or debris. Action should be started not later than the mid-term.

Notes: MVA should consider raising this issue in future meetings to assure that it is incorporated into the planning of diverse Moon Village participants. Possible that MVA should define Moon debris mitigation guidelines.

Missions & Markets

ITBC TITLE**: "Multiple Site Sample Return"**

Summary of the Issue: There is a need to better understand lunar materials at various locations of interest to develop future Moon construction concepts, and to understand interactions between lunar surface and systems we would implement. There will be a need for coordination among many planned missions.

Suggestions for Action: There is a need to implement a series of lunar sample return missions, involving kilograms per returned sample from targeted potential settlement destinations. These

missions should also examine the effect of temperature fluctuations at the sites. Action should be started in the near term.

Notes: The MVA should include this topic in future workshops.

ITBC TITLE**: "Robotic Systems for Exploration of Lava Tubes"**

Summary of the Issue: Non-conventional systems will be needed; for example, there is a need for an autonomous vehicle or vehicle that deploys communications relays as it travels. Must move in rough terrains. Also, must generate power with RTGs or other non-solar means. Special instruments will be needed such as Sounding or imaging devices, LIDAR, etc.

Suggestions for Action: Begin design and development of appropriate systems, beginning current technologies. Action should begin in the near term.

Notes: Existing agency programs (for example, such as a recent NASA proposal using flexible balls.)

ITBC TITLE**: "Definition of Candidate Lunar Commercial Markets"**

Summary of the Issue: A broadly-based, non-proprietary understanding of candidate Moon and near-Moon commercial markets is needed to enable the "de-confliction" of science, commercial and human/cultural Moon activities (e.g., avoiding interference of space resource extraction operations with radio-astronomy).

Suggestions for Action: An independent organization should work with appropriate entities to create and periodically update both an assessment of forecast future commercial markets and activities at or near the Moon. MVA should communicate this forecast to other prospective lunar "actors" to promote timely and effective coordination. Action should be started in the near term.

Notes: MVA should take the lead in accomplishing this objective.

ITBC TITLE**: "Realizing Reusability and Recycling"**

Summary of the Issue: The goal of the MV should be a culture on the Moon that moves toward a respectful and economic usage of the natural resources there. Equipment materials should be recyclable and the equipment need to be reusable. On the Moon there needs to be a maintenance area (perhaps enclosed) where robots, AI's and astronauts repair equipment and develop / construct new equipment. They will use reusable equipment and recycling material as far as possible for this work. To develop recyclable and reusable equipment needed for the Moon Village (on the moon or in lunar orbits), there should be a development and test area on Earth.

Suggestions for Action: In the mid-term, to next 10-15 years, the approach should focus on up Starting to build a maintenance and construction area/hall on the moon where robots, AI's and astronauts repair equipment and develop and construct new equipment. They will use reusable equipment and recycling material as far as possible to do this work. Machines like 3D printer will be used as well. In the short term, efforts could focus on: 1. Ground based recyclable and reusable

development and construction for any equipment which will be designed for the use on the moon or the moon orbits; 2. Development of strategies and tools how to recycle and re-use the equipment which is already on the moon; 3. Standards (interfaces, size, protocols, etc.) / agreements for an international usage of all equipment; 4. Development of machines like 3D printer and similar construction robots or machines which use the recycling able materials successful; and, 5. Building prototypes of reusable / recyclable equipment. Action should be started in the near term.

Notes: MVA should consider how to achieve these goals in future activities.

ITBC TITLE**: "Market Development"**

Summary of the Issue: In order for a healthy commercial sector around lunar infrastructure, some government input is required to guarantee the market so companies can secure investment. Evolution of space sector will occur, slowly, but surely. (Also, Government-Industry cooperation is needed.)

Suggestions for Action: Short term: commitment to Moon from public agencies in order to spark investment. Mid-term: Hybrid public/private partnerships will increase. Action should be started in the near term. Long-term: Governments can hand over "dull" infrastructure requirements to commercial companies and focus on pushing boundaries further.

Notes: In the near term, there is a need to better define what is meant by the phrase "Moon Village" (saying that it is an "open concept" is not enough).

ITBC TITLE**: "Definition of Candidate Lunar Science Missions"**

Summary of the Issue: A broadly-based, non-proprietary understanding of candidate lunar science missions is needed to enable the "de-confliction" of science, commercial and human/cultural Moon activities (e.g., avoiding interference of science missions with appropriate lunar resource utilization).

Suggestions for Action: An independent organization should work with appropriate entities to create and periodically update both an assessment of current lunar science activities and a forecast of future activities. MVA should communicate this forecast to other prospective lunar "actors" to promote timely and effective coordination.

Notes: MVA should consider including these topics in future activities / workshops.

ITBC TITLE**: "Definition of Candidate Humans-to-Mars Mission Preparation Activities"**

Summary of the Issue: A broadly-based, non-proprietary understanding of candidate Moon and near-Moon humans-to-Mars preparatory missions is needed to enable the "de-confliction" of science, commercial and human/cultural Moon activities (e.g., avoiding interference of future human-to-Mars testbeds with radio-astronomy and/or space resources development).

Suggestions for Action: An independent organization should work with appropriate entities to create and periodically update both an assessment of forecast future humans-to-Mars preparatory

activities at or near the Moon. MVA should communicate this forecast to other prospective lunar "actors" tpo promote timely and effective coordination.

Notes: MVA should consider including these topics in future activities / workshops.

ITBC TITLE**: "Business Opportunities"**

Summary of the Issue: The following are various business opportunities identified along two main categories: infrastructure components that can be monetized and actual end applications that use lunar locations or resources to create a new product or service. NEAR-TERM EXAMPLES: Science, Comms – local and cislunar, Entertainment, Prospecting, Human remains burial, Precious metals, Tourism, and Navigation – as infrastructure provided by Agencies or commercial service. MID-TERM business opportunities identified along two main categories: infrastructure components that can be monetized and actual end applications that use lunar locations or resources to create a new product or service, including: Habitation – Short term: DSG, orbital and surface, Construction, Power, Water for fuel for cislunar transportation, Transportation and EVA. And, FAR-TERM business opportunities identified along two main categories: infrastructure components that can be monetized and actual end applications that use lunar locations or resources to create a new product or service, including: Localized manufacturing (Beer and Pizza), Locally sourced products that are sold on earth, Religious services, Waste management, Medical care, Ice mining, He-3, Water transported to Earth, Technology and access protection (assets, IP, people), Planetary Protection, Lunar surface protection, Entertainment and media (VR, racing, advertising, citizen exploration).

Suggestions for Action: Each of the above need to be investigated for feasibility. Feasibility criteria are potential market size, barriers to entry, technology risk, market risk, market trends, and capital availability. Action should be started in the near term.

Notes: MVA should engage its working group(s) to quantify the market opportunity, economic conditions necessary for them to close, any capabilities that need to exist, and validate the timeframe evaluation above.

Coordination & Cooperation

ITBC TITLE**: "Establishing an Integrated Roadmap for the Moon Village"**

Summary of the Issue: The diverse governmental and private sector plans for activities on the Moon and in cis-lunar space are uncoordinated and inconsistent, and there is no over-arching mechanism to enable e more-effective and efficient development of technologies and systems.

Suggestions for Action: An independent organization should identify and document the various independent National / Industry roadmaps, and define an integrated "framework roadmap" for the development and deployment of "The Moon Village", communicate it among various participants and orchestrate its evolution as MV programs and projects are accomplished. Action should be started in the near term.

Notes: MVA should consider taking the lead in accomplishing this objective.

ITBC TITLE**: "International Cooperation"**

Summary of the Issue: International cooperation is essential; ultimately this may require the development of new political institutions, perhaps even a world space agency. International cooperation may even lead to greater trust among governments and so can have positive geopolitical benefits on Earth. Issues include: cooperation between all nations in regards to moon, International law enforcement for the moon; crime response responsibility, Inter-space agency working committees to coordinate action rather than at the top level, Authority to enforce the basic laws moon village wants to implement, subsidiary to the UN or perhaps to the states with people on the moon (e.g. those contributing to the moon village), Emergency response responsibility, and Conflict resolution responsibility.

Suggestions for Action: Build on the ISECS "Global Space Exploration Strategy" and the "Global Space Exploration Roadmap". These already contain the potential foundation of a World Space Programme, which could/should be built upon. Action should be started in the near term.

Notes: MVA should discuss this in future workshops.

ITBC TITLE**: "Moon Emergency Response Plan"**

Summary of the Issue: Once astronauts return to the Moon (at least 3 days distant from Earth) and begin to operate there for extended periods of time, there will be a potential need for not just national but coordinated international "emergency response plans". Some of the issues that might arise that would benefit from such a plan could involve a violent solar mass ejection, an impactor striking at or near lunar surface facilities, or others.

Suggestions for Action: Some of the elements of a Moon Emergency Response Plan might include Lifeboats for the moon, enabling emergency departure if necessary; Separate, functionally-independent facilities; Emergency shelters; a Search and rescue system; and Remote sensing coverage of settled or other areas where humans are present. Action should be started in the near term.

Notes: Include this concept be included in requirements during mission definition and development; define the basic rules for a Moon Village. The Association might play a role in framing this discussion in future workshops.

ITBC TITLE**: "Earth-Based Lunar Analogues"**

Summary of the Issue: Human factors are of importance for mission success and crew safety. What are the requirements for the astronauts to have a decent quality of life? The habitat design should be useful for the particular mission and its goals. It has to support the logistics and operations, ergonomics and psychological well-being of the astronauts, including size and layout of the base, and connection to the outside, e.g. windows. (Mid-term, depending on when people are again sent to the moon. More important the longer the stay, but also important for shorter missions.) In addition, structures have to be put on the moon, either by transporting them from Earth or by

producing them on site on the moon, or a combination. Since it's very expensive to send anything to the moon from Earth, size and mass have to be minimized. Trade-off between mass/volume restrictions and the usability of the structures once they are in place. Complication and cost of in-situ production has to be traded against the cost of transporting from the Earth. Transportation Aspects to be considered include: (1) Launch from Earth, (2) Earth orbit to moon orbit, (3) Landing on the moon, (4) Transportation on the moon, (5) Launch from moon back to Earth, (6) Construction on the moon, and (7) Space Transportation system construction with lunar materials.

Suggestions for Action: From the start of mission planning, include human factors and architecture, designing with the human and the activities at the centre. Near-Term Steps: Analogues on Earth (whole lunar bases and of separate parts). Lessons learnt from previous space missions and other extreme environments such as Antarctica. Include these issues from the start of the mission planning by including architects, psychologists and ergonomic experts from the start, and have them work together with the engineers. Test lunar base designs on shorter lunar missions as preparation for longer term missions. Tests of use of lunar material analogues, e.g. sintering regolith Earth equivalents. Analogues on Earth for trying of operations of transportation and construction could be very useful.

Notes: MVA should consider this in future.

ITBC TITLE**: "Potential Approaches for Cooperation and Coordination"**

Summary of the Issue: Need to consider: What are potential approaches for cooperation and coordination to accomplish the Moon Village? What are the possible models for interactions? Partnerships? Competition

Suggestions for Action: Might build upon Model of the standardization of the internet: No membership requirements, Standards formed as needed – problem driven, Governance by rough consensus, MV might start as an open information sharing organization, with oversight/governance later if needed. Might consider various examples: Antarctic, pre-Colonial India, etc. May need to avoid a central global organization Non-interference rule – has not been tested. May inhibit activity. Action should be started in the near term.

Notes: - MVA might act as a facilitator to start this process.

Cultural Considerations

ITBC TITLE**: "What Comprises the Moon Village?"**

Summary of the Issue: There is an immediate need to better define and communicate what comprises the "Moon Village" concept. Many people find the Moon Village concept hard to grasp; we should be able to describe its scope and boundaries in a clear way.

Suggestions for Action: Develop a "Moon Village hierarchy and/or architecture" – including what is contained within the Moon Village, and Identifying sites on/near the Moon that might be included in the concept. This is a topic that should be started in the near-term.[2]

Notes: This is a topic for future Moon Village Association Workshops.

ITBC TITLE**: "Religion and Religious Liberty on the Moon"**

Summary of the Issue: There will be diverse countries, representing many faiths involved in Lunar exploration, development and settlement. It will be extremely important to assure that Liberty in Religious Practices is assured -- beginning with robotic missions in the Near Term.

Suggestions for Action: This could prove a complex problem – not readily in the realm of government regulation. Consideration should be started in the near term.

Notes: MVA should discuss this in future, addressing how parties involved in Moon Village efforts have opportunities to coordinate religious interests.

ITBC TITLE**: "Access to the Moon (for all Humanity)"**

Summary of the Issue: Getting to the Moon -transport will be discussed by many others- we need to consider how to ensure not-currently space faring nations are not left behind -metaphorically or practically. For this to be truly global and diverse we need to actually consider access.

Suggestions for Action: Near term: translation of materials, meeting in different locations, active outreach to underrepresented areas/nations. Mid-term: Partner programs with UN backing (like Kibo cube), reduced cost from greater competition, greater co-operation. Long-term: Knowledge transfer, infrastructure development partnerships, truly global approach to exploration, shared benefits from space to Earth. Action should be started in the near term.

Notes: The MVA should make more of an effort to include diverse people and less traditional players (for example "Space nations", "SGAC", etc. This should be considered in future activities.

ITBC TITLE**: "Novel Cultural Opportunities and Impacts"**

Summary of the Issue: What are some of the novel cultural opportunities (art, media, etc.) that might arise from the MV? These might include: Reality TV; Need entertainment for MV occupants; Need connection back to the larger terrestrial community; Maybe not too much as it may affect 'unit' cohesion; Need for protocol to support range of communication methods; Space-flown or moon created art; Can use the lunar environment – unique to the moon; Religion – moon temples/churches; Lunar sports; Education opportunities Moon back to the Earth; Allocate a place on the MV for a 'cultural' specialist; Support for and/or from other MV participants; and, Creating content for Earth.

[2] ANNEX 3 presents the current MVA definition of what the Moon Village is, and what it is not.

Suggestions for Action: Need to identify better What cultural impacts might result from the MV, including Possible negative impacts – Occupants returning back to Earth (PTSD); Detachment from terrestrial culture; May have 'permanent' lunar residents; Promote more groups like asgardia – micro-nations. Should including both Positive impact for terrestrial education, and Negative impact of loss of human life (that might kill the MV project; but may be Possibly solved by commercial access to space -- society may care less if someone who pays for the opportunity dies). Action should be started in the near term.

Notes: MVA should consider including these topics in future activities / workshops.

SECTION 5

KEY FINDINGS

The key findings are based on: major observation from the several presentations, and Key findings from the breakout / working discussions at the workshop. The following are the key findings from the workshop.

HIGHLIGHTS FROM THE PRESENTATIONS

A number of presentations were made by senior leaders from the international lunar community, as well as talks by various subject matter experts in key fields. In these talks (see Section 3), a number of key observations were made that are important to planning for the Moon Village and by the MV Association. The following are selected highlights from the two dozen presentations made during the workshop plenary sessions.

- Numerous meetings on the topic of the Moon (and the Moon Village) have taken place around the world during the past 2-3 years
- Earlier lunar science missions have validated the existence of water ices or hydrated minerals in various locations (e.g., permanently shadowed regions) of the Moon
- Various robotic lander missions (with rovers, in many cases) are planned by both governments and commercial sector actors to occur during the coming 5+ years
- Terrestrial analogs and/or testbeds are also being developed that can play an important role in lunar mission / technology development (e.g., in Hawaii and elsewhere)
- The vision of a Moon Village has emerged as an important new paradigm for Lunar exploration planning – with the goal of Free and open access, multiple uses and multiple users
- Sustainable lunar operations may comprise:
    - Exploration (human & robotic); public & commercial lunar science / cosmology / astronomy Fundamental research;
    - Transportation Resource management;
    - Mining;
    - Communication Technology;
    - Pioneering as a Stepping stone;
    - Tourism; and,
    - Outreach /STEAM (science, technology, engineering, art, and mathematics)
- Architectures for various testbeds and missions are being defined

- A key observation: in order to accomplish profound science at the Moon, a greatly expanded lunar surface / vicinity infrastructure is essential
- Development is now being planned of major infrastructures that might operate in the vicinity of the Moon – facilitating lunar surface access, lunar surface and vicinity science, commercial developments and preparations for humans to go beyond the Moon – the Lunar Gateway is one such concept
- There are unique ”heritage sites” on the Moon – such as the Apollo 11 landing site – that represent a legacy for a humanity that must be preserved despite new and ambitious activities on the lunar surface
- There are diverse considerations under international law that enable / constrain future lunar surface activities (e.g., the Outer Space Treaty) – these must be taken into account in planning future government, commercial and academic lunar activities
- In many cases, lunar mission / market planning is part of a larger framework of solar system / space exploration and development

TECHNICAL FRAMEWORK RELATED FINDINGS

- Architectures & Standards (interfaces, protocols, etc.) must be defined in the near-future to inform future systems architecture definition and development
- Global Data are needed – including knowledge of resources, mapping, special locations (e.g., lava tubes), etc.
- Core Services are needed early, including Navigation (e.g. “lunar-GPS”), Communications & global lunar Surveillance
- Transportation from Earth to/from Moon is clearly a crucial capability – and must evolve in future to employ lunar resources (e.g., to refuel of reusable systems), and to drive down costs and/or increase reliability
- Intellectual Property and Technology Transfer Restrictions must be accommodated in pursuing all MV technical activities

OVERALL MOON VILLAGE ROADMAP

In addition, based on the diverse presentations and discussions in the breakout sessions, a very high-level “Moon Village Roadmap” was assembled; this roadmap follows.

- Near-Term (Next 5-7 Years)
  - Early robotic missions to the Moon’s surface by various countries and companies
  - Early build-up of orbiting transportation, communications and observation

infrastructure

- Mid-Term (through 2030)
  - Ongoing robotic missions to the Moon, including resources prospecting
  - Technology development / demonstration missions to / near the Moon
  - Deployment of initial infrastructures in the vicinity of the Moon or in lunar orbit, including supporting systems such as navigation / communications, etc.
  - Human mission(s) to the Moon
- Far-Term (through 2040)
  - Extensive lunar missions / demonstrations – robotic and human
  - Lunar development activities – commercial services and ventures
  - Possible permanent installations / operations – to be determined

POLICY / PUBLIC CONSIDERATION FINDINGS

- Moon Village Economics are crucial – including commercial opportunities, government programs and projects, public-private partnerships
- Coordination, Cooperation & Governance of diverse Moon Village activities – whether of government, commercial or other private "actors" – must be considered and defined, spanning international boundaries
- Engaging the Public and sharing the benefits of lunar activities is an especially important challenge for realizing the Moon Village – including advocacy, communicating with the general public, politicians, corporate leaders, and others – for both space-faring and non-spacefaring countries, for space and non-space stakeholders

GENERAL / CROSS-CUTTING FINDINGS

- There is a need for a Broadly-based Forum for Cooperation, even though Organizations such as the ISECG (space exploration coordination group) are providing a forum for cooperation among government space programs
- Intellectual Property and Technology Transfer Restrictions must be accommodated in pursuing all MV technical activities
- Science-focused Lunar Missions can play a critical role in providing the "ground truth" data needed to develop and validate commercial business plans for the Moon

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SECTION 6

RECOMMENDATIONS FOR MVA ACTION

OVERVIEW

The following are specific recommendations based on the results of the November 2017 Workshop:

- Develop and disseminate the Workshop report to various international organizations (this is that report).
- Develop approaches to allow coordination and cooperation while assuring the proper care for technology transfer (government) and intellectual property (company) restriction.
- Organize and hold a second International Moon Village Workshop during 2018 (location and precise timing to be decided).
- Create and put online an "Integrated Moon Village Data Set" – documenting workshop results in detail and providing a basis for future work; this will be based on the "ITBCs" developed by workshop participants.
- Restructure the initial MVA Working Groups to better address the issues raised; this restructuring involves adding a number of more focused Working Groups, and refining somewhat the topic areas for the current MVA working groups (i.e., "Architectures" and "Economics").

WORKING GROUP UPDATES

Based on the results of the workshop, a number of adjustments are being considered for the prior MVA Working Groups (Architectures and Economics); the following is the proposed update of the list of MVA Working Groups – focusing on topics identified at the Workshop. This update retains the already existing Architecture working group (WG), augmenting it with several detailed sub-groups; it focuses the Economics WG on Markets & Missions, and augments it with two sub-groups; and, adds three additional working groups:

- **Moon Village Architectural Concepts & Issues WG**
  - Identification of Architectural concepts
  - Identification of key environmental issues (e.g., dust mitigation)
    Within the Architectural Concepts & Issues WG, the following detailed topic Working Groups are planned:
  - **Moon Village Standards WG**
    - ✓ Definition at a high-level of relevant standards and potential interfaces for various Moon Missions & Markets
  - **Human Factors WG**

  - ✓ Definition at a high-level of the human factors considerations of the MV, and paths to address these
- **Moon Markets & Missions – Forecasts and Financials WG**
  - Identification & development of an integrated summary of actual and/or planned Lunar / Lunar Vicinity Missions / Markets
  - Identification of actual / potential funding sources of current / planned missions
  - Identification / facilitation of potential "match-making" between sources and developers

    Within the Moon Markets & Missions WG, the following detailed topic Working Groups are planned:
  - **Lunar Data Harmonization WG**
    - ✓ Focus on coordination among the business-driven data requirements of private sector players and the lunar mission plans of science / government / private sector players
  - **Moon Village Critical Services WG**
    - ✓ Characterization of selected high-priority services that are needed (e.g., navigation)
    - ✓ Coordination with Standards WG, Forecasts & Financials WG
- **Coordination & Cooperation WG**
  - Identify, assess and provide inputs to international activities related to MV cooperation & coordination
- **Moon Village & Exploration Analogues WG**
  - Provide a forum for identifying and coordinating activities related to terrestrial analogues for the Moon Village, and the associated topic of the use of the Moon as an analogue/testbed for future exploration of Mars and other destinations
- **Cultural Considerations WG**
  - Provide a forum for raising and promoting consideration of cultural factors concerning the Moon Village concept
- **Outreach WG**
  - Focusing on outreach to the aerospace and non-aerospace communities vis-à-vis the Moon Village

Final decisions on the restructuring of the working groups will be made by the Moon Village Association Board of Directors, taking into account feedback from the participants in the workshop to the proposals presented in this report, and MVA members who did not attend the workshop. The MVA will invite volunteers to participate in the several working groups once these have been approved by the Association Board.

SECTION 7

CONCLUSIONS

The Moon Village Association (MVA) and the International Space University (ISU) co-hosted a successful first Moon Village Workshop in Strasbourg, France during 19-21 November 2017. During the workshop, it was clear that there is a great deal of private sector activity, along with various government / science-driven mission planning regarding the Moon; however, business planning depends upon validating key data regarding the Moon and Moon Village activities in the future. Hence, although science on the Moon is a very exciting prospect, with many key questions to be addressed; these should also include acquisition of data to validate industry business plans.

There is a need for a broadly-based forum to promote coordination and cooperation vis-à-vis the Moon Village concept, even though organizations such as the ISECG (International Space Exploration Coordination Group) are providing a forum for cooperation among government space programs. The Moon Village Association can play a useful role by providing a non-governmental forum for government-commercial-academic international cooperation and data-sharing as efforts to realize the "Moon Village" progress. Examples of activities that would be highly useful (in no particular order):

- Harmonization of the business-driven data requirements of private sector players and the lunar mission plans of science / government / private sector players;
- Development of an integrated summary of all current and potential Moon Village related projects and Missions;
- Identification of Architectural concepts / Issues for the Moon Village;
- Definition of relevant standards (high-level);
- Examination of key environmental issues (e.g., dust mitigation);
- Identification of selected candidate Missions / Markets; and,
- Characterization of selected high-priority services that are needed (e.g., navigation services), and others.

Accomplishing an appropriate sub-set of these activities will be considered by the MVA during the coming months, particularly through a planned restructuring of the several Association working groups (see Section 6 above), and at a second Moon Village workshop being planned for next year.

The 2017 International Moon Village Workshop set the stage for real progress toward the exploration, utilization, development and eventual settlement of the Moon. On the basis of these results, the MVA will engage individual and organizations around the work to contribute to the accomplishment of these goals.

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ANNEX 1

GLOSSARY OF ACRONYMS

CAST	China Academy of Space Technology
DSG	Deep Space Gateway
ESA	European Space Agency
ETO	Earth to Orbit
IAA	International Academy of Astronautics
IAC	International Astronautical Congress
ILOA	International Lunar Observatory Association
ISECG	International Space Exploration Coordination Group
ISEF	International Space Exploration Forum
ISERI	International Space Exploration Research Institution
ISRU	In Situ Resource Utilization
ISS	International Space Station
ISU	International Space University
ITBC	Issue / Item to be Considered
JAXA	Japan Aerospace Exploration Agency
KARI	Korean Aerospace Research Institute
LEAG	Lunar Exploration Advisory Group
MVA	Moon Village Association
NASA	(USA) National Aeronautics and Space Administration
PISCES	Pacific International Space Center for Exploration Systems
R&D	Research and Development
SGAC	Space Generation Advisory Council
TBD	to be determined
UK	United Kingdom
WCTM	We Colonized the Moon
WG	Working Group

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ANNEX 2

INTERNATIONAL MOON VILLAGE WORKSHOP PROGRAM

The following is the program for the International Moon Village workshop. Please note that this is the adjusted program; there were several adjustments in real time – including substitutions for some speaker that were originally planned.

Sunday 19 November

[1200-1700 MVA Working Group Meetings]

[1700-1900 MVA Board Meeting]

1800-1900 Registration + Coffee

1900-2200 Welcome Reception and Buffet

Keynote Address by ESA Director General Dr Johann-Dietrich Woerner

Monday 20 November

0800-0830 Registration + Coffee

0830-0850 Welcome by MVA and ISU Presidents

Walter Peteers, President, International Space University

Giuseppe Reibaldi, President, Moon Village Association

0850-0900 Aims and organization of the workshop

John C. Mankins, Vice President Moon Village Association

0900-0930 Dave Murrow – Senior Manager Business Development, Commercial Civil Space, Lockheed Martin - Deep Space Gateway

0930-1020 Senior level presentations; invited presentations including

Tom Cremins (Office of the Administrator, NASA; USA)

Shizuo Yamamoto (Vice President, Japan Aerospace Exploration Agency, JAXA; Japan)

Mathias Link (Director of ICT and Space Affairs; Luxembourg Ministry of the Economy)

Silvio Sandrone (VP Advanced Projects and Products, Airbus)

Michel Tognini (President, Association of Space Explorers – Europe)

Adithya Kothandhapani (TeamIndus; India)

Gongling Sun (International Space University; formerly Chinese Space Program; China)

	KOUPREEV, Sergey A., et al (RUDN University Moscow; Russia)
1020-1100	Panel - Moon Village Implementation, Programmes and Policy:
	Challenges and Opportunities; Chair, Chris Welch
	Participants: See speakers list above.
1100-1130	Coffee
1130-1300	Special topic presentations; invited presentations including
	Ian Crawford, Professor of Planetary Science and Astrobiology, UCL
	Kyle Acierno, Managing Director, ispace Europe, Luxembourg
	Bernard Foing, Advisor to the ESA Director General; Executive Director of the International Lunar Exploration Working Group, ILEWG)
	Torsten Kriening, Head of Business Development, PTScientists GmbH; Germany
	Bozhidar Bahov, Space Mining Technologies; Netherlands
	Tai Sik LEE, ISERI, International Space Exploration Research Institute; South Korea
	Michael Mealing, Waypaver Foundation; USA
	Stephan De May, Human & Robotic Exploration, European Space Agency
	Tibor Pacher, Pulispace - Puli Space Technologies; Hungary
1300-1400	Networking Lunch
1400-1600	Breakout Sessions Group #1 – Technical Framework for the Moon Village
	(There will be several breakout sessions in parallel; at the workshop, participants will be asked to participate in a specific breakout session.)
1600-1630	Coffee
1630-1700	Remote presentations
	Maria Grulich (Space Generation Advisory Council, SGAC; ESA)
	Clive R. Neal (University of Notre Dame, and Chair, Lunar Exploration Analysis Group, LEAG; USA)
	Steven Durst (Founding Director, International Lunar Observatory Association, ILOA; USA)
1700-1800	Report back from breakout sessions #1
1800	Close

Tuesday 21 November

0800-0830	Registration + Coffee
0830-0840	Summary of Day #1
0840-0920	Senior level presentations; invited presentations including

	Mahesh Anand, European Space Science Committee
	Oleg Ventskovsky, Yuzhnoye Design Office
	Hagen Betzwieser, Artist (*We Colonized the Moon*)
	Michel Waltemathe, Department of Protestant Theology; Ruhr-University Bochum, Germany
	Kate Arkless Gray, Advisory Council, For All Moonkind; UK
0920-1000	Panel - Moon Village Science, Technology and Culture: Challenges and Opportunities; Chair, Michael Simpson (Secure World Foundation)
	Participants: see speakers list above
1000-1030	Coffee
1030-1040	Special Topic Presentation:
	Henk Rogers, Moon Base Alliance; Hawaii, USA – remote presentation
1040-1230	Breakout Sessions Group #2 - Business Opportunities of the Moon Village
	(There will be several breakout sessions in parallel; at the workshop, participants will be asked to participate in a specific breakout session.)
1230-1330	Lunch
1330-1400	Report back from breakout sessions #2
1400-1600	Breakout Sessions Group #3 – Governance Coordination and Cultural Aspects of the Moon Village
	(There will be several breakout sessions in parallel; at the workshop, participants will be asked to participate in a specific breakout session.)
1600-1630	Coffee
1630-1700	Report back from breakout sessions #3
1700-1730	Results of the workshop and forward plans
1730-1745	Workshop conclusion
1745	Close

The Workshop took place at the ISU Central Campus, Parc d'Innovation, 1 rue Jean-Dominque Cassini, 67400 Illkirch-Graffenstaden.

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ANNEX 3

WHAT IS "THE" MOON VILLAGE?

What the Moon Village Concept IS …

- The "Moon Village" is a common destination for multiple users and uses where different organizations may collaborate together for sustainable operations on Moon surface as well as in cis-lunar space
- Including (but not limited to) governments, companies, universities and non-governmental organizations
- The MV encompasses all infrastructure and systems supporting surface operations or stand-alone activities in lunar orbits
- The MV may serve as a catalyst for government, scientific research, education and industry activities, stimulating a virtuous cycle of investments
- The Moon Village may become the proving ground for the proposed Mars exploration Roadmap
- The Moon Village has as its ultimate goal the human settlement of the Moon

What the Moon Village Concept Is NOT …

- A particular national or international Lunar-focused project or program
- Limited to activities on the surface of the Moon
- A "Moon Base" located at a particular location on the Moon
- A specific lunar development commercial venture
- Limited to a particular timeframe nor is it an objective that might be accomplished at some particular time

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ANNEX 4

WORKSHOP PARTICIPANTS

SURNAME	FIRSTNAME	ADDRESS	POSITION-INFORMATION
ACIERNO	Kyle	Luxembourg	Managing Director, ISPACE Europe
AGUILAR	Alam	USA	Co-Founder at Lunar8, a student at Cornell University
ALAM	Sabrina	UK	ISU MSS 2018
ALDRIN	EDWIN (BUZZ)	USA	ISU, Chancellor
ANAND	Mahesh	UK	ESSC lunar expert
ARKLESS GRAY	Kate	UK	For All Moonkind
BAAH NTIM	Einstein	UK	ISU MSS 2018
BABERWAL	Sonal Santosh	India	ISU MSS 2018
BAHOV	Bozhidar	NL	Software Development and Outsourcing specialist
BALTAZAR GARDUNO	Ana Cristina	Mexico	ISU MSS 2018
BARS	Kristell	France	ISU STAFF
BATRA	Dhruv	India	TeamIndus
BENGTSSON	Anders	N/A	N/A
BERNARD	Robert	Canada	ISU MSS 2018
BESSAT	Sebastien	France	ISU STAFF
BETZWIESER	Hagen	N/A	Artist
BIENHOFF	Dallas	USA	Space Architect for Human Space Exploration and commercial Space development
BONK	Antonia	Germany	PT Scientists
BRECHENMACHER	Nicolas	France	ISU MSS 2018
BULTITUDE	James	Australia	ISU MSS 2018
BULUT	Güzide Dilsen	N/A	N/A
BURKE	James	USA	Retired JPL lunar settlement and exploration expert
BURKE	Margaret C.	USA	James Burke's daughter
BURKHARDT	Zachary	USA	ISU MSS 2018
BUTFERING	Peter	N/A	N/A
BUTLER	Andrew	Australia	Teaching Associate
BYRSKI	Claire	France	ISU STAFF
CAIAZZO	Antonio	Italy	ISU MSS 2018
CHAHLA	Cynthia Mary Ann	France	ISU MSS 2018
CHAN	Edward Gee Guan	USA	ISU MSS 2018
CHEN	Xi	China	ISU MSS 2018
CHEN	Changyuan	China	ISU MSS 2018
CLANTON	Michael	N/A	N/A
COUTINHO	Diogo	Portugal	ISU MSS 2018

SURNAME	FIRSTNAME	ADDRESS	POSITION-INFORMATION
CRAWFORD	Ian	London, UK	Professor of planetary science and astrobiology at Birkbeck, University of London
CREMINS	Tom	USA	NASA - Associate Administrator for Strategy and Plans
DE ANTONIO	Emeline	N/A	N/A
DE MEY	Stefaan	N/A	ESA
DELAYAT	Vincent	France	ISU MSS 2018
DETRELL	Gisela	Germany	Stuttgart University
DEWITT	Blair	US	Lunar Station
DUFRASNES	Emmanuel	FRANCE	Sustainable Engineering Teacher Ecole Supérieure Nationale d'Architecture Strasbourg
DURDEVIC	Stefan Alksa	Serbia	ISU MSS 2018
EHRESMANN	Emmanuel	GERMANY	PHD Candidate & Research Assistant University of Stuttgart Institute of Space Systems
ERIKSSON	Katarina	Sweden	Founder of Marka Design
FADDOUL	Antoine	USA	Project Manager at ABB
FERNANDEZ	Angelika	N/A	N/A
FINGER	Sonja	N/A	N/A
FLEITH	Patrick	FRANCE	
FOING	Bernard	FRANCE	ESA
FRANKS	Erik	N/A	N/A
GENTA	Giancarlo	Italy	Professor of Machine Design and Construction at the Polytechnic University of Turin.
GHOSE	Essna	India	ISU MSS 2018
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GOLEMIS	Aris	N/A	N/A
GONGLING	Sun	France	ISU STAFF
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GORHAM	Christopher	UK	ISU MSS 2018 - Module 2
GRACIEUX	Serge	N/A	N/A
GU	Wenhua	China	ISU MSS 2018
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HEISER	Laurence	France	ISU STAFF
HENNARD	Benjamin	FRANCE	Consultant - Smart Capital
HERRERA	Lorenzo	N/A	N/A
HERRMANN	Joël	France	ISU STAFF
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HIGASHIO WEINREICH	Susan	Canada	ISU MSS 2018
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HU	Wenjing	China	ISU MSS 2018

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HUANG	Shan	China	ISU MSS 2018
HURREL	James	UK	ISU MSS 2018
IBRAHIM	Rami	Jordan	ISU MSS 2018
INOCENTE	Daniel	N/A	N/A
JOHNSON	Christopher	N/A	N/A
JONES	William	UK	N/A
KAESMANN	Oriane	N/A	N/A
KAPOGLOU	Angeliki	Greece	Moon Village Association
KASI	Rama Theertha	India	ISU MSS 2018
KINSOSHITA	Yoshiaki	Japan	Coming with Yamamoto
KOLAR	Jan	República Checa	Director, Czech Space Office
KOROLEV	Pavel	Moscow	University of Russia (RUDN University)
KOTHANDHAPANI	Adithya	India	Team Indus
KOUMI	Elissavet	Greece	ISU MSS 2018
KRIENING	Torsten	N/A	N/A
KUMIRE	King	Zimbabwe	ISU MSS 2018
KUPREEV	Sergey	Russia	N/A
KYUNGHWAN	Kim	FRANCE	
LALONDE	Josue Joshua	Canada	ISU MSS 2018
LEE	Tai Sik	N/A	ESA
LEE	John	N/A	N/A
LINK	Mathias	Luxembourg	Policy Officer
MAKTHOUM	Peer	N/A	ISU Alumus
MANFREDI	Vittorio	Italy	Astronautics and space engineering
MANISCALCO	Matthew		Astronautical Development, LLC
MANKINS	John	USA	Founder / President of Mankins Space Technology, Inc.
MARBOE	Irmgard	Austria	Universität Wien
MARTENS	Timothée	France	New Technologies, Space Systems Engineering, Physics
MATEO	Karine	France	N/A
MEALLING	Michael	USA	Waypaver Foundation
MELLINGER	Sylvie	France	IUS STAFF
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MONCUSSI	Nicolas	France	ISU STAFF
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MURROW	Dave	USA	SPONSOR - Lockheed Martin - Senior Manager Business Development, Commercial Civil Space
NAEF	Samuel	UK	ISU MSS 2018
NAIK	Kunal Pradipbhai	India	ISU MSS 2018
NAJJAR	Alexandre	FRANCE	Space Consultant at Euroconsult ?
NEMO	Grégoire	France	ISU MSS 2018
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NTINOS	Christos	Greece	ISU MSS 2018
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OQAB	Haroon	Canada	N/A
PACHER	Tibor		http://www.pulispace.com
PAIGGE	Adam	N/A	N/A
PETEERS	Walter	France	IUS STAFF
QURESHI	Anisa	UK	ISU MSS 2018
RAVICHANDRAN	Aravind	India	ISU MSS 2018
REIBALDI	Giuseppe	FRANCE	President, Moon Village Association
REINHOLD	Ewald	France	ESA
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ROSSELLO	Vittorio	Italy	ISU MSS 2018
ROUSEK	Tomas		A-ETC Space Architecture and digital design
SANDRONE	Silvio	N/A	N/A
SHELVANKAR	Veena	France	ISU STAFF
SIMPSON	Michael	USA	Executive Director of Secure World Foundation
SIMPSON	Carol	USA	Spouse
SINGH	Rishank	India	ISU MSS 2018
SOWERS	Georges	USA	Professor, Space Resources, Colorado School of Mines - Sowers Space Solutions LLC
STUPAR	Danijela	France	ISU STAFF
SWEET	Randy	USA	Lockheed Martin / Aerospace and defense company
TANASYUK	Pavlo	N/A	N/A
TANG	Baitao	China	ISU MSS 2018
TANIER	Guillaume	N/A	N/A
TAYLOR	Giorgio	UK	Cranfield University
TOGNINI	Michel Ange-Charles	France	ASE-Europe President
TRAUTMANN	Catherine	FRANCE	Ex Strasbourg Mayor
VENTSKOVSKY	Oleg		N/A
VICARI	Arnaud	N/A	N/A
WALTEMATHE	Michael	N/A	Ruhr-universität Bochum
WALTER	Olivier	N/A	N/A
WELCH	Chris	France	ISU STAFF
WEPPLER	Johannes	Germany	N/A
WOERNER	Jan	FRANCE	SPONSOR - ESA director general
YAMAMOTO	Shizuo	Japan	JAXA VP International Relations
YUAN	Yuan	China	ISU MSS 2018
ZUND	Cornelius	N/A	N/A

ANNEX 5

"ITBCS" – ITEMS/ISSUES TO BE CONSIDERED

The following Annex presents a portion of the "raw data" collected during the workshop on a wide variety of topics that were discussed, organized by timeframe.

TITLE	TIME FRAME	DESCRIPTION (and any working notes)
Need for Moon Village Systems Interface Standards	Near-term & Later	Realizing essential coordination and cooperation among the diverse national, commercial and academic projects requires clear and executable interface standards that do not currently exist.
Systems Analysis of Moon Village Systems / Infrastructure Options	Near-Term & Later	The potential value of diverse future space transportation systems options for the Moon Village can only be evaluated through consistent and transparent systems analysis studies; such studies are not being performed.
Establishing a Set of Coordinated Protocols for Lunar Operations	Near-Term & Later	The diverse governmental and private sector plans for mission activities on the Moon and in cis-lunar space are generally uncoordinated and operational protocols inconsistent; there is no over-arching mechanism to enable more-effective and efficient operations planning.
Establishing an Integrated Roadmap for the Moon Village	Near-Term & Later	The diverse governmental and private sector plans for activities on the Moon and in cis-lunar space are uncoordinated and inconsistent, and there is no over-arching mechanism to enable more-effective and efficient development of technologies and systems.
Debris and Waste from Operations	Mid-term & Later	Lunar explorers, developers and settlers to be careful that their operations to not result in leaving debris in orbit, or waste / debris on the surface of the Moon from operations.
Whole Earth Ambassador Residency	Near-Term & Later	There is a need for an ongoing "Cultural Mission" for the Moon Village - the goal of which would be to promote and advertise the concept; thereby sparking inspiration among the public in diverse countries.
Data Management	Near-term & Later	Moon village likely to generate huge amounts of data; as a result there will be a need a centralized data storage and management software including specialized Data Analytics.
Launch Sites on the Moon	Far-Term	Used as a launching point for exploration missions Could be rocket launch sites, electromagnetic launch sites, electric propulsion, space elevator, etc
Robotic Systems for Exploration of Lava Tubes	Near-Term	Non-conventional systems will be needed; for example, there is a need for an autonomous vehicle or vehicle that deploys communications relays as it travels. Must move in rough terrains. Also, must generate power with RTGs or other non-solar means. Special instruments will be needed such as Sounding or imaging devices, LIDAR, etc.
Scientific Exploration of Lava Tubes	Near-Term	There is a need for near-term exploration of the lava tubes that recently been confirmed to exist on the Moon.
Traffic Infrastructure for the Moon	Mid-Term & Far-Term	New transportation methods wil needed for travel on the lunar surface; these may include magnetic levitation, cable cars, ballistic transit etc. There will also be a need for supporting infrastructures, including Traffic management, a Moon Global Navigation Satellite System (GNSS) and others.
3D Printed Designs Available to Moon Residents	Mid-Term & Later	3D data files to drive Additifve Manufacturing on the Moon should be developed by Designers on Earth (creating 3D models that can be printed on the moon). Like Thingiverse, but addressing the needs of the Moon Village. Such services could be based on "Request services and pay per request".
What Comprises the Moon Village?	Near-Term	There is an immediate need to better define and communicate what comprises the "Moon Village" concept. Many people find the Moon Village concept hard to grasp; we should be able to describe its scope and boundaries in a clear way.
Transportation from Earth Orbit to the Moon	Mid-Term & Later	In space vehicles and shuttles to the surface; separation of in space transit and surface to space transit Liquid oxygen and liquid hydrogen propulsion, could use moon resources 25 tons to surface Electric is also an option for cargo

TITLE	TIME FRAME	DESCRIPTION (and any working notes)
Large-scale Energy Storage with by-product Oxygen	Mid-Term & Later	Except for the peaks of eternal light the lunar surface experiences a day and night cycle. Where during the night solar energy is not available for approximately two weeks. A crewed Moon Village has a minimal power consumption requirement, making energy storage for night cycle supply vital. Metal/Silicone extraction from lunar materials produces large quantities of oxygen. Condensing/Evaporation of oxygen, can be utilized as large scale energy storage concept.
Planetary Defense Support	Mid-Term & Later	Asteroids are a persistent threat to life on Earth. Defense capabilities are dependent on the time between threat determination and predicted impact. The Moon is a strategic asset for quick and effective response. Space is reached more easily, due to reduced gravity and lack of atmosphere. At least one point of the Moons orbit, gives an additional Δv advantage for an intercept. Large quantities of impactors/deflectors can be produced on the Moon and launched conventionally or by electromagnetic means.
Thrust Devices from Lunar Sources	Mid-Term & Later	Vital resources for chemical propulsion systems are scarce or missing on the moon (Hydrogen, Nitrogen, Carbon). Suborbital launching is easily achieved by electromagnetic means, but a landing should be cushioned by thrust devices to avoid the production of harmful ejectas. It is likely that thrusters from regolith or extracted metals can be produced. Also, Oxygen is a potential propellant to be used as cold gas or in resistojets. An unconventional propellant might be lunar dust itself. Processing and storage is simple and the material is readily available in abundance.
Lunar Radioisotopes	Mid-Term & Later	Power supply on the Moon can be achieved either by using solar radiation or nuclear reactors. It is unlikely that frequent shipment of radioactive material to the Moon from Earth is cost effective or political acceptable. The discovery of radio-isotopes on the Moon for use in nuclear reactors / power generation would be a game changer for lunar activities and potentially later space application.
Cold-welding Additive Manufacturing	Mid-Term & Later	Cold welding is a phenomenon, when identical (or similar) materials form an atomic bond naturally. Some energy is released during the process. A technical vacuum is required as an atom layer of foreign atoms will prevent the process from happening. The Moon is rich in materials and has a vacuum atmosphere. Large scale additive manufacturing on cold welding should be possible. Current technical problems of additive manufacturing, like heat expansion, large energy demand and bad scalability can be bypassed.
Lunar Deep Mining	Far-Term & Beyond	The Moon is a differentiated celestial body. As a result, dense and potential rare and valuable materials are likely to be found deep beneath the surface of the Moon. Such a discovery would make more materials available -- adding to the material mix of the lunar production and manufacturing industry, extending technical capabilities and allowing new business models to be created. It might also reduce rare element shortages on Earth.
Cis-Lunar In-Orbit Manufacturing Material Supply	Mid-Term & Beyond	Silicone, Aluminium, Titanium are bulk components of modern space craft and structures. These materials are common on the Moon. Transport of material from the Moon into space is fairly easily achieved (electromagnetically or via conventional rockets). An on-orbit processing or manufacturing facility could use the provided resources to produce unprecedented structures and spacecraft (fleets).
Space Debris Clearing	Mid-Term & Beyond	Space debris is an ever-increasing issue for medium to higher Earth orbits. Clearing debris from Earth is connected with significant costs and efforts and currently not undertaken. Catch and bring down missions for individual satellites can be achieved more cost effectively from the Moon. Large aerogel-like structures for debris fragment clearing can be produced from lunar sources on the Moon and assembled on the surface or in space.

TITLE	TIME FRAME	DESCRIPTION (and any working notes)
Moon Bridge (Transit to Moon without Rockets)	Far-Term (Very)	In the very far term, the integration of the Moon into the terrestrial economcy may require the equivalent of a "Moon Bridge" -- i.e., being able to travel between Earth and Moon without (almost witout) the use of rocket propulsion. This would Allow for an easier ride to the moon without rockets, and would enable the Moon to become "the hub" for all satellite and space mission activity.
North Pole to South Pole and Orbit Transit	Far-Term	Two areas of particular importance on the Moon are expected to be the shadowed regions at the North and South polies; as a results, transit between those regions -- without going by ground across the hot / cold equatorial belt would be highly useful.
Lunar Space Elevator	Far-Term	In the far-term a "lunar space elevator" providing propellantless transport from the Moon's equator to/from the Earth-Moon L1 Libration Point woiuld be highly useful.
Establishment of Lunar Observation and Communication Systems	Far-Term	Dedicated, high capacity lunar communicaitons and observations systems will be needed in future. A stationary orbit around the moon is far away with a large communication lag and Libration Points present interference problems; other orbits / locations are needed for future lunar settlements / cities
Airbnb / Condos / Timeshare Cohabitation on the Moon	ALL	A novel approach to sharing facilities -- perhaps similar to "Airbnb", Condominiums, or Timeshares on the Moon -- could enable more affordable access by private individuals and organizations. This might also invovle a multinational space sharing.
Electric Power on the Moon	Mid-Term & Later	Pursuing ambitious goals and objectives on the Moon, such as development of lunar resouirces -- including discovery and development of resources in permanently shadowed regions -- space settlement, and others will require significant amounts of available and affordable electrical power.
Radiation Protection: Electromagnetic shield	Far-Term	A novel approach to protecting human crews from radiation during long-duration missions uses a large electromagnet to deflect radiation. It is expected to be more difficult for the Moon than for Mars because there is no suitable Lagrange point
Online Knowledge Network to Connect Moon Village Stakeholders (Moon Village Labs)	Near-Term	An online "knowledge network" that interconnects diverse Moon Village stakeholders would be highliy valuable, allowing them to share information about topics such as services needed and services offered, etc.
Lunar Crater Habitats	Mid-Term & Beyond	Human habitats that are based in appropriately-chosen lunar surface craters could prove highlyi attractive for future outposts and/or settlements. Such locations offer a subsantial degree of protection from radiation. Issues sushc as access could be solve by elevating vertically up and down the crater with columns, that might be used to erect a cover. Could be chosen to be Meters, not km in diameter
Allocation of Orbital Slots at the L1 and L2 Earth-Moon Libration Points	Mid-Term & Beyond	There may need to be some international management process to accomplish the oversignt and allocation of orbital slots at the L1 and L2 Earth-Moon Libration Points. This might be similar to the processes used by the International Telecommunications Uniton (ITU) but for the Earth-Moon L1 and L2 points.
Moon Emergency Response Plan	Mid-Term & Beyond	Once astronauts return to the Moon (at least 3 days distant from Earth) and begin to operate there for extended periods of time, there will be a potential need for not just national but coordinated international "emergency response plans". Some of the issues that might arise that would benefit from such a plan could involve a violent solar mass ejection, an impactor striking at or near lunar surface faciliteis, or others.
Lunar "Mass Driver": Utilizing Strategic Position of Moon for Cost Effective Space Access	Mid-Term & Later	Electromagnetic accelerator as a launch system to provide access to cis-lunar orbit.
Moving Water Uphill from Craters	Mid-Term & Later	Excavating ice/water and transporting it up the crater walls into a sun-lit area
Allocation of Radio Fequencies used near and on the Moon	ALL	Due to use of lunar orbit, it may be necessary to distribute the frequencies.
A Demonstration: the "First" Crewed Moon Village	Near-Term	We can't stay long at the Moon.
Early Polar landing sites?	Mid-Term	It is posed if it is better to consider a landing on a polar landing site or not.
Communications Requirements?	Near-Term & Later	What kind of bandwidth and latency are we expecting for the first Moon Village?

TITLE	TIME FRAME	DESCRIPTION (and any working notes)
Precision Landing Objectives and Infrasttructure to Support Them	Near-Term & Later	Accomplishing pin-point landings to desire locations It is very important to 'getting it right' to support initial and subsequent Moon missions – particularly with no equivalent of the Global Positioning System (GPS) in orbit around the Moon.
Lunar Dust Mitigation	ALL	Lunar surface dust is highly hazardous, sharp micro-scale edges; it can affect both many systems and astronauts and their equipment. Need to get rid of moon dust from any moon installation or hardware. For example, astronaut visors can be blocked by the dust. However, there is business potential in dust mitigation hardware and potentially dust reuse, and in solar panel cleaning Note: two ITBCs combined for this entry in the dataset.
Multiple Site Sample Return	Near-Term	Need to better understand lunar materials at various locations of interest to develop future Moon construction concepts. Need to understand interactions between lunar surface and systems we would implement. Coordination between many planned missions.
Fresh Deposits of Volatiles	ALL	It may be difficult to land on the surface due to volatile deposit on the surface of the Moon.
Standards and interfaces	Near-term & Later	When bringing together the various companies, space agencies all do it differently. For the Moon VIllage, we will need to build an understanding between them in collaborative missions. Too much time and effort spent linking different systems from different countrles.
Prevent the hazards of Lunar Dust (technical and human aspect)	Near-Term & Later	Lunar dust is the number one hazard on the Moon. It causes overheating of the instruments and destroys them. Opaque dust clouds make lunar capsule descent manoeuvres dangerous. It causes abrasion on moving parts and brings dust-related health hazards associated with moon exploration.
Cosmic Impact Protection	Near-Term & Later	In seven years of operation the Lunar Reconnaissance Orbiter has seen more than 200 new craters, some more than ten meters in diameter. The Moon is vulnerable to impacts because there is no atmosphere. There are various classes of asteroid and potential for problems from class 1 "Ignore" to class 5 "Extermination". 1000s of small meteorites impact Earth every day with no consequences because they burn up. Medium sizes commonly occur, and the biggest can have significant impact (such as extinction of dinosaurs). Planetary defense – move or intercept from Earth impact
Radiation Protection	Mid-Term	Moon has no magnetosphere/ general atmosphere, need protection from the solar wind and possibly cosmic rays Danger of solar flares/CMEs directed towards Earth and the moon. Both an issue on the moon and enroute to the moon.
Life Support System – getting the Moon village inhabitants what they need to survive	Near-Term & Later	Efficient, reliability and cost-effective Life Support Systems are key to long-term human presence on the Moon. Requirements include personnel modules and cabins, as well as a comfortable place to stay in transit to/from the Moon. One vision is that these accommodations should be more like a cruiseship cabin than an airplane seat. A number of consumables are required, but key questions remain: • Should everyone "bring" everything (water, oxygen, food, CO2 extraction means)? • Should it be provided by the "Moon Village"? • Will there be synergies with ISRU (water/oxygen)? • What will be done with the waste (treatment/return2Earth)?

TITLE	TIME FRAME	DESCRIPTION (and any working notes)
Recycling & Reusability: Organic Waste	Near-Term	The goal of the MV should be a culture on the Moon that moves toward a respectful and economic usage of the natural resources there. Equipment materials should be recyclable and the equipment need to be reusable. On the moon there needs to be a maintenance area (perhaps enclosed) where robots, AI's and astronauts repair equipment and develop / construct new equipment. They will use reusable equipment and recycling material as far as possible for this work. To develop recyclable and reusable equipment needed for the Moon Village (on the moon or in lunar orbits), there should be a development and test area on Earth.
Recycling & Reusability: Souvenirs	Near-Term	The goal of the MV should be a culture on the Moon that moves toward a respectful and economic usage of the natural resources there. Equipment materials should be recyclable and the equipment need to be reusable. On the moon there needs to be a maintenance area (perhaps enclosed) where robots, AI's and astronauts repair equipment and develop / construct new equipment. They will use reusable equipment and recycling material as far as possible for this work. To develop recyclable and reusable equipment needed for the Moon Village (on the moon or in lunar orbits), there should be a development and test area on Earth. Recycling of organic waste. As a heating source and a source of organic for plants. Plants will be used as food source. Maybe it's possible to find some organic material among the plants for construction or glue or colors (also helpful for creating art). There will be biogas used for heating some buildings.
Recycling & Reusability: Near-Term	Near-Term	The goal of the MV should be a culture on the Moon that moves toward a respectful and economic usage of the natural resources there. Equipment materials should be recyclable and the equipment need to be reusable. On the moon there needs to be a maintenance area (perhaps enclosed) where robots, AI's and astronauts repair equipment and develop / construct new equipment. They will use reusable equipment and recycling material as far as possible for this work. To develop recyclable and reusable equipment needed for the Moon Village (on the moon or in lunar orbits), there should be a development and test area on Earth.
Recycling & Reusability: Mid-Term	Mid-Term	The goal of the MV should be a culture on the Moon that moves toward a respectful and economic usage of the natural resources there. Equipment materials should be recyclable and the equipment need to be reusable. On the moon there needs to be a maintenance area (perhaps enclosed) where robots, AI's and astronauts repair equipment and develop / construct new equipment. They will use reusable equipment and recycling material as far as possible for this work. To develop recyclable and reusable equipment needed for the Moon Village (on the moon or in lunar orbits), there should be a development and test area on Earth.
Recycling & Reusability: Far-Term	Far-Term	The goal of the MV should be a culture on the Moon that moves toward a respectful and economic usage of the natural resources there. Equipment materials should be recyclable and the equipment need to be reusable. On the moon there needs to be a maintenance area (perhaps enclosed) where robots, AI's and astronauts repair equipment and develop / construct new equipment. They will use reusable equipment and recycling material as far as possible for this work. To develop recyclable and reusable equipment needed for the Moon Village (on the moon or in lunar orbits), there should be a development and test area on Earth.

TITLE	TIME FRAME	DESCRIPTION (and any working notes)
Human Factors Considerations	Mid-term & Later	Human factors are of importance for mission success and crew safety. What are the requirements for the astronauts to have a decent quality of life? The habitat design should be useful for the particular mission and its goals. It has to support the logistics and operations, ergonomics and psychological well-being of the astronauts, including size and layout of the base, and connection to the outside, eg windows. (Mid-term, depending on when people are again sent to the moon. More important the longer the stay, but also important for shorter missions.)
Transportation and logistics Considerations	ALL	Structures have to be put on the moon, either by transporting them from Earth or by producing them on site on the moon, or a combination. Since it's very expensive to send anything to the moon from Earth, size and mass have to be minimized. Trade-off between mass/volume restrictions and the usability of the structures once they are in place. Complication and cost of in-situ production has to be traded against the cost of transporting from the Earth. Treansportation Aspects to be considered include: (1) Launch from Earth, (2) Earth orbit to moon orbit, (3) Landing on the moon, (4) Transportation on the moon, (5) Launch from moon back to Earth, (6) Construction on the moon, and (7) Space Transportation system construction with lunar materials.
Managing Orbital Space – Space Situational Awareness (SSA)	Mid-term & Later	Orbital and traffic management and tracking of satellites and spacecraft in the vicinity of the Moon.
Habitat Durability	Mid-term & Later	Structural durability is challenging due to potential moonquakes, meteor impacts or extreme(ly) [low] temperatures that could cause material failure.
Power Generation, transmission & storage	Mid-Term & Beyond	How energy is created, used and stored on the Moon will be very important. The most logical source of power is of course solar. However since the moon has alternating 14 day periods of night/day, and power needs will essentially be constant, solar will be insufficient.
Managing orbital space- Space Situational Awareness	Far-Term & Beyond	As many different nationalities and organizations will be vying for time on the Moon in parallel, it will be very important to properly manage orbital congestion and to be aware of satellites and debris that are in orbit.
Disposal management-Tracking / catalogue / solutions	Far-Term & Beyond	Depending on the nature of the human or robotic activity, it is possible that debris / objects / robots & tools are left behind. We should have a means to track, catalogue and manage debris. What if some exploratory & expendable drones breakdown? What if a cubesat crashes into the Moon?
Roads	Far-Term & Beyond	Roads formed of sintered regolith to mitigate dust within the Moon Village. Needed Once the elements of Moon Village become separated by approximately >100m.
Extending autonomous mobility on Earth to the Moon	Near-Term & Later	Extending autonomous mobility on Earth to the Moon
Extending autonomous mobility on Earth to the Moon	Near-Term	Using LIDAR technique to map out the moon surface required for transportation Machine learning data systems to improve efficiency, with navigation and communications support
Lunar Maglev / Hyperloop	Far-Term & Beyond	A maglev/hyperloop network around the moon to key locations (observatory to M.V., M.V. to solar panel fields). Thus establishing an infrastructure for movement of personnel and/or cargo.
Moon Hopper	Far-Term	Moon transportation – Moon surface hopper idea (12 year idea) - Mini-rocket propulsion from place to place
"Cislunar Space Station" – Deep Space Gateway	Mid-Term & Beyond	"Cislunar Space Station" – Transfer/Transportation of material Stop-off point Next step advancing human exploration International interest Architecture affordable Recycling Debris recycling ISS recycling Science use Manufacturing

TITLE	TIME FRAME	DESCRIPTION (and any working notes)
Surface transport	Mid-Term & Beyond	Surface transportation - with Life support system in the vehicle and habitat
Available approach of transportation	Mid-Term & Beyond	We need to build launching sites, available rockets and shuttle, as well as relay space stations and landing system. Also the route should be settled. In terms of some emergency situations during the transportation, we need some kind of rescue means. Artificial Gravity could be produced during the flight, make this comfortable and also a good way to reduce time for passenger training. 1 year for rocket and shuttle manufacturing, 2 months for preparation, 2 weeks for transportation and return
Energy Sources	Near-Term & Later	Need to ressolve energy sources for Moon Village actvities.
Lunar Science	Mid-Term & Beyond	Lunar Science *astronomy *geology *biological experiment: plant growth, human physiology
Transportation	Mid-Term & Beyond	Transportation topics for consideration include: Launch (Earth to Moon) Surface transportation Space elevator TBD How to get to the moon and how to move around when we get there? Key issues: Cost Reliability Availability Safety Power efficiency Speed Payload Capacity Life support Navigation Sustainability
Cis-Lunar Space Traffic Control	Mid-Term & Beyond	*Cis-lunar space situational awareness, “air traffic control” (Chris Welch)
Moon Awards & Prizes: paradigm shift for agencies and governments to enable Lunar Exploration and Settlement	Near-term & Later	• Lack of budget by agencies and governments • Programs with delays, over-budget (e.g. JWST) • Lack of innovation, technology breakthroughs, lack of some NewSpace startup in some regions Multiple timeframe are regarded. Short term for development of technologies, mid-term for “normal” mission on the Moon, and long-term for more complex missions.
Self-Driving (Autonomous) Moon Surface Vehicles	Near-term & Later	Teleoperations and tele-robotics consumes a lot of resources (mission control, astronaut time, time due to communication delay). Also, human drivers make errors which may lead to the crash of rover. To ensure that the rover is not crashed the amount explored (covered) regions is scarified for safety. In the following years, several rovers will drive on the Moon Surface. Additionally, the Deep Space Gateway is justified by teleoperation of surface vehicles. Self-Driving technologies would strongly reduce those constraints in the short-term AND mid-term. This will drastically increase our space exploration capability, and development of ISRU systems.

TITLE	TIME FRAME	DESCRIPTION (and any working notes)
Interoperability Standards	TBD	Issue: Requirements for capabilities are driven by the combination of the needs of each participant. The Moon Village is an emergent property of those combined capabilities only when those capabilities can be combined with each other to enable novel uses. Standard interfaces and practices are the rules that allow capabilities to be combined.
Definition of Candidate Lunar Commercial Markets	Near-Term & Later	A broadly-based, non-proprietary understanding of canidate Moon and near-Moon commercial Markets is needed to enable the "de-confliction" of science, commercial and human/cultural Moon activities (e.g., avoiding interference of space resource extraction operations with radio-astronomy).
Moon Tax, Insurance on the Moon (Self-Sustaining Economy) M	Mid-Term & Beyond	cryptal currency .lunar base block-chain technology. They distribute data and you get paid back for it for interacting with the network. Human data protection on the moon . LUNAR OPERATION SYSTEM. OPERATES EVERYTHING ON THE MOON. CONNEC TTO THIS NETWORK ON T HE MOON AND TRANSACT WITH THIS SYSTEM
Transaction	ALL	How to pay like an individual on the moon (like using credit card on Earth). Nothing is set to assure the validity of transactions on the Moon.
Definition of Candidate Lunar Human Presence leading to Settlement Activities	Near-Term & Later	A broadly-based, non-proprietary understanding of candidate Moon and near-Moon human presence is needed to enable the "de-confliction" of science, commercial and human/cultural Moon activities (e.g., avoiding interference of future human outposts leading to settlements with radio-astronomy and/or space resources development).
Definition of Candidate Humans-to-Mars Mission Preparation Activities	Near-Term & Later	A broadly-based, non-proprietary understanding of candidate Moon and near-Moon humans-to-Marsd preparatory missions is needed to enable the "de-confliction" of science, commercial and human/cultural Moon activities (e.g., avoiding interference of future human-to-Mars testbeds with radio-astronomy and/or space resources development).
Definition of Candidate Lunar Science Missions	Near-Term & Later	A broadly-based, non-proprietary understanding of canidate lunar science missions is needed to enable the "de-confliction" of science, commercial and human/cultural Moon activities (e.g., avoiding interference of science missions with appropriate lunar resource utilization).
Lunar Sample Return	Near-Term	In a business way, it is interesting to touch people to get a return on investment for example.
Quality Improvement Products	Mid-Term & Later	Jump between floors rather than stairs or elevators, thrilling architecture Sports of the moon, tennis would be a good choice Comfortable space suits Furniture, utensils, every day tools made on the moon Souvenirs from the moon
Imenite Extraction and Processing	Mid-Term & Later	Found in basaltic regions on the moon, contains iron, titanium and oxygen. Can extract materials and sell for commercial applications on the moon
Potential Moon Village Businesses	Near-Term	What could be done in the Moon Village to provide incomes
Power Generation, Supply, and Storage	Mid-Term & Later	Land as much power generation capacity on the moon as possible and then sell to whoever wants it Start producing power storage and generation components on moon Establish a power grid for the moon Mana electric: Converting regolith to solar cells
Lunar Crater Astronomy	Mid-Term & Beyond	Lunar craters are numerous and various in their size. Due to physics crates have a more or less paraboloid shape in common. Thus allows (with more or less work) to use craters as natural main reflectors for astronomical use. The corresponding central receiver is calibrated to the specific crater shape. Experience and heritage over time would allow to expand this principle to larger and more irregular craters.

TITLE	TIME FRAME	DESCRIPTION (and any working notes)
Lunar Economy Processing and Development Plan	Mid-Term & Beyond	The Moon is rich in spaceflight relevant materials (Silicone, Oxygen, Aluminium, Titanium, Iron etc.) and compounds thereof. Lunar production capabilities will likely follow a route from simple (brick shaping, raw element extraction), to intermediate (alloying, refining) to advanced (payload production). Industry needs should be met by focusing on creating of production capability for products of immediate need and demand. Economic sustainability will be achieved in minimal time.
Virtual Reality for Moon (Holodeck)	Near-term & Later	Make people more comfortable on the moon with a VR apparatus allowing them to simulate an Earth-like environment Could use apparatus to see family Quality of the experience on the moon is a huge point influencing people's desire to go there. Early space tourism is a luxury market
Virtual Tourism	Near-Term & Later	Can virtually visit heritage sites on the moon, could strengthen movement to conserve these places. Can integrate existing moon surface maps Need high resolution places Rover with HD cameras linked to VR systems on Eartth
REFUELING	TBD	FUEL DEPOS EITHER ON THE MOON, OR SOME KIND OF TRANSFER
INTER-GALACTIC CITIZEN	TBD	BILLIONARES WANT TO STAY ON MOON AND TAX ADVANTAGES . THEY GET CERTIFIED AND EVADE TAXES ON EARTH
TELE EDUCATION ON MOON	ALL	WEB RESOURCES –MAKING ENTERTAINMENT VIDEOS ,
Space Awareness Centers	Near-term & Later	Combine fine art and science to spark interest in space Orchestral music with space images included Sell space related souvenirs in a gift shop
Transportation to the Moon	Mid-Term & Later	Space to space transport and space to moon transport; Earth to space Personnel modules and cabin, comfortable place to stay in transit. More like a cruise cabin than an airplane seat
Burial Services on the Moon	ALL	A Spanish artist has suggested to use the moon as a cemetery for all mankind. Do we fly corpses back to Earth from a moon base? If we bury them on the moon, how do we do it in accordance with religious traditions? Should we recycle people's bodies? Redefining what burial is. From the Earth or just on the moon
Place to Place Transportation on the Moon	Near-Term & Later	Cable cars or magnetic rails Rental rover facilities; convertibles on the moon Ballistic hoppers
Satellite Disposal	Mid-Term & Later	Need a disposal method because there is not atmosphere to burn up spacecraft. No ocean for dumping
Online Marketplace of ITBCs	Near-Term	Online interface where companies can see moon village ITBCs and match them with the work that they are doing Open to the public Include proposer's name so that investors or interested parties can contact
Construction Market Technology Transfer between Space and Construction	ALL	A bidirectional transfer of construction technologies Lessons to space construction from terrestrial industry, additive manufacturing How can we make money from this technology transfer? NOTE: Two slides Integrated; same source
Connect Moon to Internet	Near-Term & Later	Use communication satellites to broadcast entertainment and communication platforms Verizon over the horizon

TITLE	TIME FRAME	DESCRIPTION (and any working notes)
Local Data for Future Mission Requirements	Near-Term & Later	DO WE WANT TO SNED HUMANS OR DO WE WANT TO STUDY THE ENVIRONMENT FIRST SND SEE HOW TO FACILITATE THE LIVING OF HUMANS THERE..FIRST AND FOREMEOST CONDUCT EXP ON THE TARGET LANDING SITES NAD COONDUCT EXP
Local Data for Future (Human) Landing Sites	Near-Term & Later	HAVE TO IDENTIFY LANDING SITE WHICH MAKES ECONOMIC SENSE- ONLY THEN WILL IT BE FUNDED WHY PRIVATE SITESHOULD PUT MONEY?-GREG?- ISRU-WILL-EXPLORE THE POLES AND LAVA TUBES WHY POLES?-WATER AND VERTICAL SOLAR PANELS WHY /WHY NOT POLAR? MOBILITY, TEMEPRATURE,NOT FIXED LANDING BUT MOVING ROVER LANIDNG AT POLES-HAS MANY ADVANTAGES BUT VERY DIFFICLUT-BECAUSE YOU HAVE TO BEGIN TERMINAL DESCENT ...REQUIRE POLAR ORBIT-EXPENSIVE(FUEL)-INDUS DOING POLAR ORBIT-NOT EXORBITANTLY EXPENSIVE EQUATOR-MUCH EASIER-OXYGEN FROM REGOLITH
Habitat	Near-Term & Later	Setting a habitat can be complicated. Techniques are not set yet and we need to find the most optimal way to do so.
Outside the box economies	Near-Term & Later	Finding a way to finance several items such as naming building or any side costs
Private companies	Near-Term & Later	We must attract the most private investor as possible. And we must care about Insurance.
Space burials	Near-Term & Later	Some people are bringing their ashes in space to re entry on Earth after.
Habitat	Near-Term & Later	How do you build habitats on the moon? apart the ISRU solution
Gene Bank –biological archiving	TBD	protecting the earth life on the moon. Anything that requires persistence and inert environment, moon facilitates that
Bitcoin	Mid-Term & Beyond	cryptal currency .lunar base block-chain technology. They distribute data and you get paid back for it for interacting with the network. Human data protection on the moon . LUNAR OPERATION SYSTEM. OPERATES EVERYTHING ON THE MOON. CONNEC TTO THIS NETWORK ON T HE MOON AND TRANSACT WITH THIS SYSTEM
Sport	ALL	Bringing sport to the Moon as it exists on Earth. And maybe develop new sport available only on the Moon but impossible on Earth.
memory of mankind on the moon	Near-Term & Later	they make microfilm putting 4-5 million characters on one table. Put some first
Moon Village Association	Near-Term	TBD
NGO	Far-Term (Very)	Toaday, states are responsible of their launch. But what if launch takes place on the Moon ?
space tourism, marriages on moon	Mid-Term & Later	moon exploitation
EDUCATION	TBD	SETTING UP SCHOOLS
CUBESAT NETWORK	TBD	OFFERS VARIOUS SERVICES, CULTURAL ASPECT AND THE GAME DEVELOPED ON THE EARTH. IN-ORBIT FILM-MAKING. VERSION OF BIG-BROTHER ON THE MOON
MOON SHOT 1, INFRASTRUCTURE SHOULD BE DONE BY THE GOVT. (HEALTHCARE)	Far-Term & Beyond	SELLING BY SEATS AND VIRTULLY MAKE PUBLIC HOW IS IT LIKE TO WALK ON THE MOON. A LOT OF INJECTIBLES USED WHERE VACUUM IS USED. MASS PRODUCTION OF MEDICINE ON SURFACE OF THE MOON-VACUUM TO POWDERED FORM SO MOON IS THE IDEAL SITE FOR IT.
CSR IN INDIA	TBD	SIMILAR CONCETPS IN EVERY COUNTRY CAN FUND THE CONCEPT OF THE MOON VILLAGE
Framework	ALL	TBD
Regulations	Near-term & Later	The human nature will make rules coming. It will always be regulations

TITLE	TIME FRAME	DESCRIPTION (and any working notes)
Space Art	ALL	Space offers new opportunities to express art and it would be important to encourage space art and the use of microgravity for example to create new sculpture or piece of art.
possibility to do art completely different from earth	ALL	sculptors different in micro-gravity
Interest of the people	Near-Term & Later	People are not interested to deep space or things they don't see directly. But they can see the Moon
Digital archives	TBD	Culture can be easily destroyed by war or disaster
MVA IMPROVEMENT	Near-Term	LOOK AT ANY ONE ASPECT OF THE MOON VILLAGE
communication and outreach	TBD	involve the public and work on the outreach and promote the MV Concept
Space Architecture	TBD	SACRED GEOMETRY-MEANING SAME THING FOR ALL HUMANITY, WE DON'T HAVE TO LOOK A THE OUTSIDE
OVERVIEW EFFECT	TBD	THE IDEAS SHOULD BE CONSIDERED FOR LONG-TERM THE EARTH CAN BE LOOKED AT AN DIFFERETN ANGLE FROM SPACE
NEW INFRASTRUCTURE	TBD	MOON IS A MIRROR OF THE PLANET-PEOPLE CAN USE THEIR IMAGINATION-IT CAN HELP YOU GET GLOBAL CONSIOUSNESS-PEOPLE SEE THINGS INA DIFFRETN CONTEXT-IF POSSIBLE-THEN JUSTA MATTER OF PROBABILITY
INTERNATIONAL CULTURE	TBD	DEVELOP INTERNATIONAL CULTURE LIKE ISU AND RESPECT THE DIFFERENCE AND INTEGRATE ALL THE CULTURES TOGETHER. EVEN THOUGH WE BELONG TO DIFFERETN CULTURES WE DON'T FEEL ANY DIFFERENT FROM ONE ANOTHER
UN-CULTURE	TBD	IN ADELAIDE FOR THE IAC , THERE WERE PEOPLE PROTESTING THAT THEY DON'T WANT TO SEE BULL-DOZERS ON THE MOON AND WHEN THEY LOOK AT THE MOON , THEY ONLY WANT TO SEE THE PRISTINE MOON AND NO CONSTRUCTION
CULTURAL DIVERSITY	TBD	WE SHOULD MOVE AHEAD AND WE SHOULD BE THERE AND WE CAN TAKE IT FROM THERE
ONLINE COMMUNITITES	TBD	WE CAN CREATEA CULTURAL COMMUNITY FOR THE MOON VILLAGE-DIFFFICULT-NOT IMPOSSIBLE. UN SPACE AGENCY TO SEE HOW THEY MANAGE THE COMMUNITY
Interest of the People	Near-Term	People are not interested to deep space or things they don't see directly. But they can see the Moon
Infrastructure building of the settlement- particularly Water	TBD	Water is necessary but cannot capture any economic benefit yet. Must be mindful of businesses that can improve life on Earth and serve ppl on this planet, to build an economy in space.
Capital, requiring money and risk involved	Near-Term & Later	Say MVA has access to $400M dollars, MVA can give grants to access this money? Who would we give it to? Startup vendors of water on moon? There's 1000 ways for this to fail. Someone wins, someone loses. We all have our own ideas, there's not one path to success. There's risk in the diversity, and genetically we like to walk together bc it is less risky. Economy is the same way. How do we stay together yet have unique opportunities benefit the economy? If MVA were to become a fund, having access to funds would be interesting. Chris: Some accelerate the future, some slow you down, some lead nowhere. The future is not certain, so what makes it easier? companies like Blue Origin have lots of money and can inject millions of dollars (no risk), but other end of spectrum, startups must also be assured of future where they can keep developing their technologies.
Exploration Missions (Both Governmental and Commercial)	Near-term & Later	Before deciding if the Moon has exploitable resources continued scientific exploration missions will be required.

TITLE	TIME FRAME	DESCRIPTION (and any working notes)
Commercial LUNAR SAMPLE RETURN missions	Mid-Term	Collect and return samples from the Moon (Medium Term Business) flying sample return back to Earth. Flying products around the Moon for in-orbit gifts for the general public. Regolith from far side of the Moon, multiple near and farsides targets with different locations.
Branding for Moon Village using videos and images from Moon missions using V/R	Near-Term & Later	Use captured videos and live streams to encourage public participation and improve outreach
Self-sustainable Green House	Far-Term & Beyond	In the long term there should be a self-sustainable green house in anticipation of human arrival. China is working on a manned version; however, unmanned missions using bacteria should be looked into.
Lunar Toursim	Far-Term & Beyond	Setting up a hotel business model where clients can experience the overview effect and reduced gravity.
Cybersecurity	Mid-Term & Beyond	Data Center/Archive on the Moon
OVERVIEW EFFECT (Space Tourism)	Far-Term & Beyond	Enabling space tourists to experience an extra-Earth-perspective to fulfill spiritual or religious urges Long term (more than 25 years) (Product might be sellable before/ in advance)
R&D - Commercial aspects of Moon Village / Telecommunications services on the Moon	Near-Term	Short term (5 years) for research and investigation. Telecommunication infrastructure and services on the Moon. How do tele companies get fund and investments for building and managing these services. How to determine the price for telecommunications?
Development - Commercial aspects of Moon Village / Telecommunications services on the Moon	Mid-Term	Mid term (10 years) to build concept Telecommunication infrastructure and services on the Moon. How do tele companies get fund and investments for building and managing these services. How to determine the price for telecommunications?
Services - Commercial aspects of Moon Village / Telecommunications services on the Moon	Far-Term & Beyond	Long term (25 years) to build and run Telecommunication infrastructure and services on the Moon. How do tele companies get fund and investments for building and managing these services. How to determine the price for telecommunications?
Market Development	Near-Term & Later	In order for a healthy commercial sector around lunar infrastructure, some government input is required to guarantee the market so companies can secure investment. Evolution of space sector will occur, slowly, but surely. (Also Government-Industry Cooperation)
Commercial Market opportunities (Habitats)	Far-Term & Beyond	Long term commercial mission for sustainable existence and development of habitats
Government to encourage upcoming funding and financing models	Mid-Term & Beyond	Crowdfunding needs to be encouraged and endorsed. Governments can also crowdfund. Upcoming financing models such as blockchain, ICOs do not need to be over regulated.
Assurance of Religious Liberty on the Moon	Near-Term & Later	There will be diverse countries, representing many faiths inovled in Lunar exploration, development and setllement. It will be extremely important to assure that Liberty in Religious Practices is assured -- beginning with robotic missions in the Near Term.
Sharing of Science / Mission Data	Near-Term & Later	The open sharing of results from Government (and potentially commercial) missions would greatly faciliate the realization / emergence of the Moon Village
Sparking Public Interest	Near-Term & Later	How can we spark the interest of the public in going to space and to the Moon?

TITLE	TIME FRAME	DESCRIPTION (and any working notes)
International Cooperation Organization	ALL	Cooperation between all nations in regards to moon International law enforcement for the moon; crime response responsibility Inter-space agency working committees to coordinate action rather than at the top level Authority to enforce the basic laws moon village wants to implement, subsidiary to the UN or perhaps to the states with people on the moon (e.g. those contributing to the moon village) Emergency response responsibility Conflict resolution responsibility
A Currency for the Moon	Far-Term & Beyond	Back to basics: what defines a currence? A closed economy with abundance; rather than returning resources to Eaerth, Moon contributes resources to future colonization of the Moon and space. Implies more strict econoimc laws, not more lax. Opportunity for a new economic pareadigm: redefine "economy" completely.
Create Free Moon Economic zone	Mid-Term & Later	Enable ownership of property on the moon, renting facilities, etc. Ownership of buildings, not lands
Unfair coordination and cooperation between participating countries	Near-Term	Given that few nations up until this point have had strong power in space faring MV ideal is open to all nations, not individual. Is this a reality? Can we decouple the idea of a mv from the main space players, will US or china get involved and not be the main co-ordinators? -In terms of co-ordination, someone will lead but seems ideal in everyone have input, all leading.
Internal organisation of MV	Near-Term	Get MVA team together, diverse working groups together to apply and start making them work together and co-operate. Understand differences and Institutional support for MVA from for example from enusa, physical office space
How are rules stated for doing business/progress?	Near-Term & Later	What do we need for the basic cooperation between nations. Allowing use of shared space. Basic minimum requirements, non binding but normative framework. Should observe to be a good partner. Countries might see how they do a particular activity and take offence
System to deal with unknown unknowns?	Near-Term & Later	How to take a future idea and have a system to feed it into existing rules. A system to allow each player to contribute to it.
International Cooperation	ALL	International cooperation is essential; ultimateliy this may require the development of new political institutions, perhaps even a world space agency. International cooperation may even lead to greater trust among governments and so can have positive geopolitical benefits on Earth.
Business Opportunities- Near-Term	Near-Term	The following are various NEAR-TERM business opportunities identified along two main categories: infrastructure components that can be monetized and actual end applications that use lunar locations or resources to create a new product or service. EXAMPLES: Science Comms – local and cislunar Entertainment Prospecting Human remains burial Precious metals Tourism Navigation – as infrastructure provided by Agencies or commercial service

TITLE	TIME FRAME	DESCRIPTION (and any working notes)
Business Opportunities- Mid-Term	Mid-Term	The following are various MID-TERM business opportunities identified along two main categories: infrastructure components that can be monetized and actual end applications that use lunar locations or resources to create a new product or service. EXAMPLES: Habitation – Short term: DSG, orbital and surface Construction Power Water for fuel for cislunar transportation Transportation EVA
Business Opportunities - Far-Term	Far-Term & Beyond	The following are various FAR-TERM business opportunities identified along two main categories: infrastructure components that can be monetized and actual end applications that use lunar locations or resources to create a new product or service. EXAMPLES: Localized manufacturing (Beer and Pizza) Locally sourced products that are sold on earth Religious Waste management Medical Ice mining He-3 Water transported to Earth Technology and access protection (assets, IP, people) Planetary Protection Lunar surface protection Entertainment and media (VR, racing, advertising, citizen exploration)
Potential Approaches for Cooperation and Coordination	Near-Term & Later	o What are potential approaches for cooperation and coordination to accomplish the Moon Village? What are the possible models for interactions? Partnerships? Competition? - Model of the standardization of the internet o No membership requirements o Standards formed as needed – problem driven o Governance by rough consensus o Start as an open information sharing organization… oversight/governance later if needed - Antarctic as an example? - Pre-colonial India? - Avoid having a central global organization - MVA act as a facilitator to start this process - Non-interference rule – has not been tested. May inhibit activity?
Sharing of Resources	Near-Term & Later	o What about the sharing of resources among "players" on the Moon? - ISS, Antarctic research base o Free sharing of resources o Need standards (to allow interfacing/sharing) – need to identify where needed though - Burning man – example of free open sharing o General social rules – be responsible o There is no money at these events - Bartering system o Allows fair sharing of responsibilities o General agreements of responsibility sharing amongst partners
International Community of Interest	Near-Term & Later	What about the concept of an International Community of Interest?

TITLE	TIME FRAME	DESCRIPTION (and any working notes)
Relevant Legal Regimes and Regulations	Near-Term & Later	o What are relevant legal regimes and regulations that could impact MV planning and implementation? - Question of the legal process for damages on the moon? OST applies here? o Better approach is a cross-waiver (similar to ISS) - There is a need for technology protection o Avoid ITAR? Expect international agreements to be generated - Do we need regulation of business activities, ethical - Use of lunar resources – generate commercial benefit… need to revisit the legality of this to facilitate business activities - Is ownership needed – Need some level of protection of resources/commercial activity etc… maybe another mechanism to ensure this? - Aspects of the sea treaty may be applicable
Possible Feedbacks and/or Benefits for Earth	Near-Term & Later	What are the possible feedbacks and/or benefits for Earth?
Model for coordination amongst the different players part of the Moon Village	Near-term & Later	The proposed Moon Village needs a framework for engagement. Too many regulations can inhibit new entrants/prospective players from investing time and capital into a new business environment. Compliance to standards cannot be forced without any precedent being established on or around the Moon.
Moon Monument	Mid-Term & Later	Moon village will not be visible from Earth at early stages; however, We could build a large obelisk or pole to cast a shadow to make the moon village visible from Earth. This would connect people visually with the moon village. It should ideally also be useful in some way (e.g. Dust science)
History of the Moon Village	Near-term & Later	Document the History of Whole Process of the Moon Village in an Interesting Way.
Moon Conservation	Far-Term (Very)	Eventually the moon is going to separate from Earth
Space for Humanity	Near-Term & Later	Include all nations in the Moon Village
Religious Centers	Mid-Term & Later	Religious facilities present on the moon Perhaps similar to multifaith areas in airports Inclusive of all religions
Lunar HAM Radio	Mid-Term & Beyond	Public approval of the Moon Village is vital for continued support. One way of achieving it is to provide an all-time opportunity for interested groups and people to interact with the Village. As a success and reference story the Amateur radio on-biard the ISS can be used. Due to technical reasons only communication from the Earth to the Moon is likely to be possible via Amateur radio. High-power amateur radio communication from the Moon might violate ITU regulations. Messages are to be displayed on the Moon or the link from Moon to Earth is achieved by conventional means.
Lunalympia	Far-Term & Beyond	The unifying aspect of competing in physical prowess is human trope that can be rethought in the lunar environment. The reduction of gravity to a sixth in comparison to Earth changes a significant number of sport activities. Moon Villagers should represent their country or region of origin, which will very likely ignite the passion and interest of the public for this event and beyond. Recommended: To be performed indoors. Name wise: Maybe better refer to Mons Huygens, the largest lunar mountain, instead of Olympus.
Education on (FROM) the Moon	Near-Term & Later	Lectures while on the way to the moon and on the moon Use virtual reality to educate about the moon Need schools in a moon village

TITLE	TIME FRAME	DESCRIPTION (and any working notes)
"Cosmic Perspectives" (aka, "The Overview Effect")	ALL	A Moon Village will have a major cultural impact by helping to engender a "Cosmic Perspective" on human affairs that may help unite humanity and stimulate international cooperation. This could become the most important cultural legacy of the Moon Village. This could/should be a secular prespect -- does not require a religious aspect.
Access to the Moon (for all Humanity)	ALL	Getting to the Moon -transport will be discussed by many others- we need to consider how to ensure now-space faring nations are not left behind -metaphorically or practically. For this to be truly global and diverse we need to actually consider access.
Novel Cultural Opportunities	Near-Term & Later	o What are some of the novel cultural opportunities (art, media, etc.) that might arise from the MV? • Reality TV • Need entertainment for MV occupants • Need connection back to the larger terrestrial community • Maybe not too much as it may affect 'unit' cohesion • Need for protocol to support range of communication methods • Space-flown or moon created art • Can use the lunar environment – unique to the moon • Religion – moon temples/churchs • Lunar sports • Education opportunities Moon back to the Earth • Allocate a place on the MV for a 'cultural' specialist • Support other MV participants • Create content for Earth
Cultural Impacts	Near-Term & Later	o What are some of the novel cultural opportunities (art, media, etc.) that might arise from the MV? • Reality TV • Need entertainment for MV occupants • Need connection back to the larger terrestrial community • Maybe not too much as it may affect 'unit' cohesion • Need for protocol to support range of communication methods • Space-flown or moon created art • Can use the lunar environment – unique to the moon • Religion – moon temples/churchs • Lunar sports • Education opportunities Moon back to the Earth • Allocate a place on the MV for a 'cultural' specialist • Support other MV participants • Create content for Earth
Possible negative cultural impacts because of the MVA's activities	Far-Term	a. Moon Village occupants returning to Earth may show signs of PTSD b. Occupants/settlers may feel detached from terrestrial culture once permanent residence is feasible The negative impacts on individuals may be temporary, but the impact it has on the terrestrial view of the Moon Village (or vice-versa) may be permanent.
Negative impacts in case of the loss of human life in the MVA context	Mid-Term & Later	Like the Apollo-1 fire, loss of human life can be a major setback to efforts to have a permanent presence on the Moon. It is harder to sustain commercial activities when death is associated with it. Governments can still deal with such incidents, though it does affect public opinion.