

ROADMAP TO PROMOTE NEPAL'S CONTRIBUTION TO THE SPACE INDUSTRY BY NEPALESE
SPACE RESEARCH ASSOCIATION

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Abstract

While the world is entering a new era of space exploration and technology, some developing countries are left underrepresented in the space arena. The Moon Village Association-Participation of Emerging Space Countries initiative gives opportunities to the under-represented countries to realize their potential to contribute to the space industry and help them initiate projects that are both relevant and practical within their potential. Nepal is also one of those countries which does not have a strong space program. However, Nepal is making some progress in the space industry with the help of subject matter experts and engineering students. Nepal has some organizations that are working to help kickstart the space sector of the country. Nepalese Space Research Association (NESRA) is a private non-profit organization dedicated to promoting space sciences and technology in Nepal. NESRA organizes various technical workshops and national conferences such as the National Space Meet of Nepal since 2018 to discuss about the importance of the space industry, how it touches our everyday lives and why should it be incorporated for our nation's development, analog astronaut missions in collaboration with international organizations to help astronauts from all around the world to come to Nepal and make use of its unique landscape and environmental conditions to advance aerospace science and research. Two of the most prestigious engineering colleges in Nepal have included aerospace engineering in their programs. But there are very few tangible projects that can enable space enthusiasts to implement what they learn in class into real life. We also lack proper outreach programs for both boys and girls in schools to motivate them to pursue a career in the space field. In this research paper, we have outlined projects which will promote the growth of the space sector in Nepal by utilizing Nepal's unique geographical features and promote the country's contribution to the New Space industry. Analog astronaut base in Nepal, one among the projects discussed in the paper, will provide a unique opportunity to rigorously test design, and facilitate research and development, which will potentially help improve operations on extra-terrestrial destinations. NESRA has also put together some policy recommendations for Nepal to consider in order to foster space activities in the country.

Keywords: Nepal in space, analogue mission, space habitat, outreach destination, space observatory, astro-tourism.

I. INTRODUCTION

While the world is entering a new era of space exploration and technology, some developing countries are left underrepresented in the space arena. The Moon Village Association - Participation of Emerging Space Countries initiative gives opportunities for these countries to kickstart their space industry and help them initiate projects that are both relevant and practical within their potential. Nepal is also one of those countries that do not have a strong space program. However, Nepal is making some progress in the space industry with the help of subject matter experts and engineering students. Nepal has some organizations that are willing to advance the space sector of the country.

Nepalese Space Research Association (NESRA) is a youth-led organization dedicated to promoting space sciences and technology in Nepal. NESRA organizes various technical workshops and national conferences such as the National Space Meet of Nepal since 2018 to discuss about the importance of the space industry, how it touches our everyday lives and why should it be incorporated for our nation's development, analog astronaut missions in collaboration with international organizations to help astronauts from all around the world to come to Nepal and make use of its unique landscape and environmental conditions to advance space science and research.

Recently, a space startup based in Nepal, named Orion Space, has manufactured SanoSat-1, which is a pico-satellite. This satellite is the first one of its kind to be fully designed and manufactured in Nepal. Moreover, Tribhuvan University in Nepal has started to offer aerospace engineering as one of their undergraduate programs in the Institute of Engineering (IOE) - Pulchowk Campus [1]. But there are very few tangible projects that can enable space enthusiasts to implement what they learn in class into real life. The country also lacks proper outreach programs for young students to motivate them to pursue a career in the space field. With Moon Village Association - Participation of Emerging Space Countries projects, NESRA aims to bring a change in the space programs of Nepal to give opportunities for young adults and inspiration for children to take Nepal into the frontier of the space industry.

II. POTENTIAL SCENARIOS OF THE SPACE INDUSTRY DEVELOPMENT IN NEPAL

Any sector needs to be worked on equally at a private as well as a governmental level if sustainable development is expected, and the space industry is no different. With the dawn of the New Space industry, private aerospace companies are rapidly developing aerospace technologies to make space more accessible. With the ground breaking discovery of

water ice on the Lunar South Poles and on Mars, there is a renewed interest in the space industry. Countries like the USA, China, India, and UAE aim to become a key player in the space industry. Private companies like SpaceX and Blue origin, which are backed by billionaires Elon Musk and Jeff Bezos respectively, see an immense opportunity in the space sector and are investing billions of dollars in their companies every year to make fully reusable rockets to make space accessible.

Three potential trajectories of development of the global space industry and its implications to the growth of the space industry of Nepal are considered, viz. Scenario Alpha, Scenario Beta and Scenario Gamma. These scenarios are described in detail in table I. Scenario Alpha considers the development of the global space industry driven by government and human space flight-driven projects. Scenario Beta considers the development of the global space industry driven by government and science-driven projects. Whereas, Scenario Gamma considers the development of the global space industry driven by private venture projects. The scenario table is further classified in two sections, namely: near-term (2020-2030) and mid-term (2030-2040). With the scenario table, we have answered the 4'W's of the projects, which includes: 'What' - details of the project, 'Who' - potential partners and collaborators, 'Where' - potential locations of the projects, and 'Why' - the reasoning behind proposing the projects.

	Scenario Alpha	Scenario Beta	Scenario Gamma
Near Term	2020 - 2030	2020 - 2030	2020 - 2030
What	Set up an analog astronaut mission base in the Himalayas (low air pressure, high radiation environment) for scientific research	Conduct a feasibility study to build an observatory and search for potential collaborators interested in building the same	Set up an astro-tourism base (with physical similarities to a lunar habitation module) as a tourist attraction by providing astronaut-like living conditions
Who	Organizations dedicated to analog astronaut training missions (Austrian Space Forum, MMAARS, ESA, NASA, International MoonBase Alliance, etc)	International organizations working in the field of advanced astronomy	Tourism industry of Nepal and organizations working to provide unique excursions in Nepal
Where	In the Himalayas where the environment is analogous to that of extremities in space	On a high vantage point near the Himalayas located in Nepal	In the Himalayas which attracts thousands of tourists every year.
Why	Developing a detailed understanding of human biology and behavior and the way it reacts in a confined space-like environment and to test technologies for space missions in an extreme environment	Nepal is home to 8 of the world's 10 highest mountains, high altitude provides significant advantages for astronomy in terms of clarity due to reduced atmospheric reflections	To generate public interest in the idea of Nepal getting involved with the space sector and to provide a futuristic tourism destination to view the night sky
Mid-Term	2030 - 2040	2030 - 2040	2030 - 2040
What	Expand the analog astronaut base by including water extraction facilities, rocket fuel production using water extracted to further improve and validate the technology	Build an observatory in the Himalayas, one of the highest in the world	Expand the astro-tourism base to include space-related research experiments for outreach and promotion of local technology
Who	Same as near-term	Collaborate with international science project groups and observatories	Same as near-term
Where	In the Himalayas where the environment is analogous to that extremities in space	On a high vantage point near the Himalayas located in Nepal	In the Mustang area, where a lot of international tourists come every year
Why	To develop a detailed understanding of human biology and behavior and how it changes when living like an astronaut	Since Nepal has 8 of the world's 10 highest mountains, high altitude will provide significant advantages for astronomy	To generate public interest in the concept of Nepal getting involved with the space sector

Table I: Scenario Table.

III. SCENARIO ALPHA: ANALOG ASTRONAUT MISSION

Analog astronaut missions are the simulations of space missions here on the earth. They are carried out in a place on Earth that is analogous to the extremities of outer space. General public and specialists can both participate in these missions depending on their desired outcome from the mission, which can range from experiencing the life of an astronaut to conducting a scientific experiment. Analog astronaut missions are usually carried out in a confined living habitat to simulate space missions. These missions also help define the workflows of an actual astronaut mission in outer space along with the testing and validating the human-computer interaction during these missions [2]–[6].

Some analog astronaut mission training bases around the globe are:

- HI-SEAS, USA
- The Mars Desert Research Station Society (MDRS), USA
- Lunar Palace 1, China
- Desert Mars Analog Station (D-MARS), Israel
- The Lunares Research Station, Poland
- PolAres Program, Austria
- Concordia Station, Joint French-Italian inland Antarctic research.

III.I Roadmap

The following is a list of potential actions required to setup an analog mission base in Nepal:

Step 1: Organize webinars with international organizations to speak about their efforts in the analog missions, to increase the knowledge base, and to develop points of contact for collaborative efforts.
Step 2: Open a national-wide call for an analog-astronaut base design competition to select the best design of an analog astronaut base in Nepal considering key parameters such as habitat design, interdisciplinary research potential, etc.

Step 3: The team, with the best design, works together with a group of experts put together by NESRA and its partners to further develop the idea.

Step 4: A team of individuals from NESRA perform research and analysis of the best sites in Nepal to build an analog astronaut base considering various criteria such as geography, landscape, emergency health services, remoteness of the location, the research potential of the site, etc.

Step 5: Publish a call for support and approach partners and investors who could help materialize the idea of building an analog astronaut base in Nepal.

Step 6: Conduct experiments and host teams representing international organizations in the newly built analog astronaut base and collaborate with

national and international organizations to perform research in various sectors such as human-computer interaction, space science, and technology, etc.

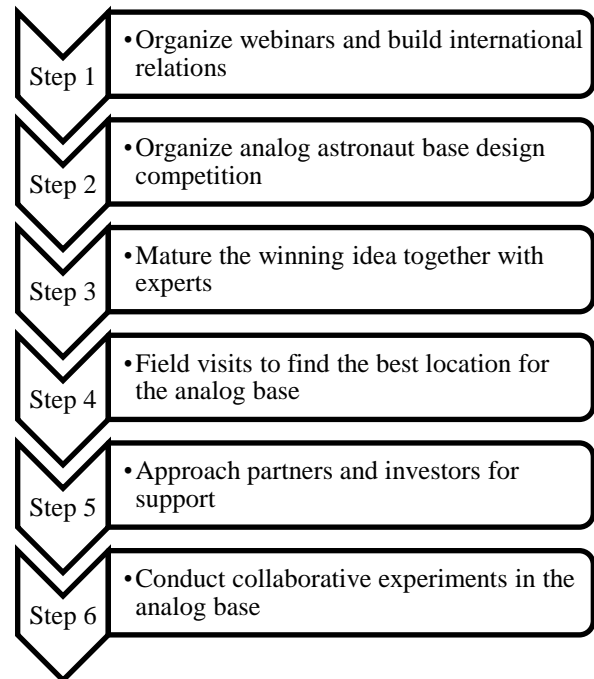


Fig. I: Roadmap for Analog Astronaut Missions.

With the help of MVA and other international partners, an analog mission base could potentially kick off, given there is sufficient interest and support from the national and international scientific community.

An analog mission base in the Himalayas will enable Nepal to contribute to the international space industry by exploiting its unique geographical landscape. Given the ambitions of multi-billionaires to land humans on Mars [7], it is important to train future astronauts and help them familiarize with living conditions in space with the help of analog astronaut mission bases. Given the high altitude and low-pressure conditions of Nepal and its extreme environment, Nepal is an ideal place to conduct analog astronaut missions.

IV. SCENARIO BETA: HIGH ALTITUDE OBSERVATORIES

High altitude astronomical observatories are the infrastructures used to view various astronomical events and objects. They contain telescopes and other supplementary equipment to help study astronomy.

Less distorted view of starlight, reduced absorption of infrared energy, unobstructed view of the horizon in all directions, and close to zero light pollution are some of the criteria which are essential for an observatory. Reduced light pollution due to sparsely populated regions and clear night skies in

regions of Nepal like the Khumbu Glacier, Lo Manthang, Dho Tarap, and Phopagaun, make them some of the best locations to build an observatory. Among the aforementioned locations, Lo Manthang of Mustang district stands out because it is a major tourist destination of Nepal and has a great view of the night sky. It is at an altitude of 3840 m and is in a rural municipality with a low population (i.e. 1899) [8]. Lo Manthang is connected to China and attracts a lot of tourists from China. It has developed a hospitality sector and a clear view of the horizon from the terrain which makes it one of the best locations to build the observatory.



Fig. II: Mustang landscape [9].

The different high-altitude observatories existing all around are listed below along with their corresponding altitude:

- Indian Astronomical Observatory, India – 4500 m
- Mauna Key Observatory, USA – 4050 m
- High Altitude Water Cherenkov (HAWC), Mexico – 4100 m
- Magdalena Ridge Observatory, USA – 3244 m
- Mauna Loa Observatory, USA – 3394 m

There is an existing high-altitude laboratory/observatory in the Sagarmatha National Park at the Nepali side of the Mt. Everest. It is called the Pyramid International Laboratory/Observatory high altitude scientific research centre and it is located at an altitude of 5050 m (16,568 ft.) in the Khumbu Valley, Sagarmatha National Park. This research centre facilitates the study of the environment, climate, human physiology and geology in a remote mountain protected area. [10] Given that the research centre is focused on studying terrestrial phenomenon on a high altitude in the Himalayas, NESRA could potentially collaborate with the Pyramid laboratory as an intermediary step in the roadmap which aims to build a high-altitude astronomical observatory. The area of collaboration could potentially be a joint

astronomical research study at the Pyramid laboratory or a research exchange program.



Fig. III: Pyramid Observatory [10]



Fig. IV: Side-view of the pyramid laboratory [10]

IV.I Roadmap

Step 1: Invite people from international observatories to talk about their work to build up the knowledge base and to develop points of contact for collaborative efforts.

Step 2: Conduct a feasibility study to build an observatory in the Himalayas and the benefits of the same to the international scientific community.

Step 3: Pursue interdisciplinary research containing details of the observatory such as structural design, telescopic capabilities, potential areas of research, etc.

Step 4: Build a proposal for the observatory

Step 5: Approach government officials, international organizations, and NGOs to collaborate with them and work together to materialize the idea of a high-altitude observatory in Nepal.

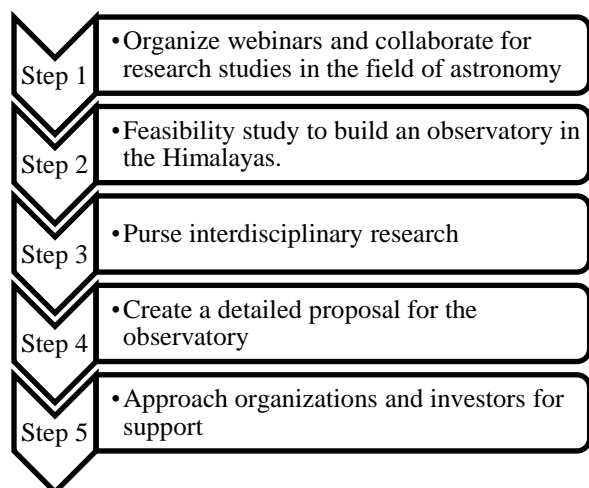


Fig. V: Roadmap for High Altitude Observatory.

There are logistical as well as policy challenges for the construction of a high-altitude observatory in Nepal. Given that Nepal is a landlocked and developing nation, the required infrastructure and skilled manpower may not be available locally, therefore to counter these obstacles, resources will be required to be imported from other countries. In order to ease the importing of resources, a national policy to reduce import costs should be put in place to facilitate such scientific initiatives. A regular power supply is often a hindrance in Nepal; therefore, a regular power supply must be ensured to successfully run the observatory or the observatory must be designed in a way that it can operate in a self-sustained manner.

V. SCENARIO GAMMA: ASTRO-TOURISM BASE IN NEPAL

V.I Tourism Industry in Nepal

The tourism industry is one of the main foundations of the Nepalese economy, being the main source of foreign exchange and revenue. Nepal is a prime destination for mountaineers, rock climbers, and other adventurers [13]. Every year, the Nepalese government makes significant efforts to promote the tourism industry of the country and to create new strategies and to put in place marketing campaigns to attract tourists from all over the world.

The government of Nepal declared 2011 as Nepal Tourism Year and aspired to draw in millions of tourists to the country. According to statistics published by Nepal Tourism Board (NTB), a total of 598,204 foreign tourists entered the country via the aerial route in 2012 [13]. The number of tourists who enter the country has been increasing every year ever since due to increasing tourist attractions in Nepal.

The base camps located in The Himalayas attract thousands of tourists every year. The Everest Base Camp (5364 m), Annapurna Base Camp (4130 m), Kanchenjunga Base Camp (5143 m) and Makalu Base Camp (5000 m) are few of the many camps located in higher altitudes of Nepal. These high-altitude destinations in the Himalayas also offer one of the clearest views of the night sky, therefore an astro-tourism base at one of these sites would promote both the tourism sector of the country as well as promote the space outreach to national and international tourists. An astro-tourism base in the Himalayas will give a unique opportunity to blend two sectors, namely the tourism sector and the space sector, and will attract tourists as well as space enthusiasts from around the world to gain this unique experience of star-gazing right next to the Himalayas.

V.II Existing Similar Projects around the World

Some of the similar projects around the world are listed below.

- Wadi Rum Night Luxury Camp, Jordan
- Modular Analog Research Station (MARS), Poland
- Dome Village, Taif by Freedomes, Saudi Arabia
- Dome for Green Expo, Austria
- Craters of the Moon National Monument and Preserve, USA
- Torri Del Vajolet, Italy
- Namib Naukluft Park, Namibia
- White Desert, Egypt

Apart from the locations mentioned in the above list, there are few other notable locations like Aurora viewing locations in Norway which are considered as one of their kind in providing a unique perspective of this planet. Forbes has also listed Finland to see Aurora Borealis as one of the incredible outdoor adventures for stargazers. Taking inspiration from these locations, a similar exemplary astro-tourism destination can be created in the Himalayan region of Nepal.

V.III Roadmap

Step 1: Perform a field review of potential Astro-tourism sites in Nepal based on the clearness of sky at these locations, the average number of days of the clear sky of that region, infrastructural facilities, etc.

Step 2: Conduct research and financial study to determine the most suited structural design of the astro-tourism base, its capabilities, capacity, required capital and infrastructure to build this base, potential revenue streams, and other financial parameters.

Step 3: Proceed according to the results of the feasibility study

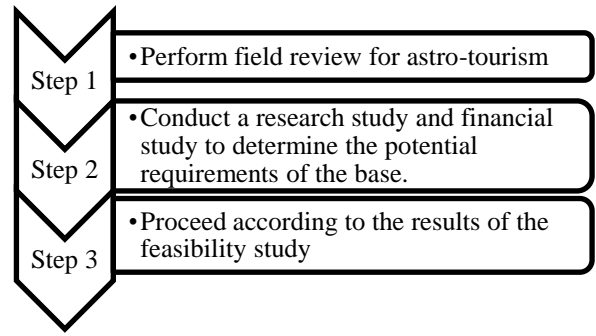


Fig. VI: Roadmap for Astro-Tourism base.



Fig. VI: The Milky Way galaxy from Annapurna Base Camp-picture [16].



Fig. VII: 'Calmness of Eternity' showing the Milky Way in Gosaikunda [17].



Fig. VIII: Langtang National Park after sunset and Beautiful Galaxy [18].

Locations in the mountain region of Nepal such as Manang, Mustang, Annapurna Circuit Area, Rara Lake, Mugu, Mardi Himal region, and Sri Antu can potentially host astro-tourism bases due to the clear night sky. For example, Sagarmatha National Park was listed as one of the world's five best-stargazing sites on the planet by National Geographic in 2016 [19]. Several papers have been published regarding the study for the preservation of the Dark Sky in different parts of Nepal [20].

There are some locations in Nepal such as the Sagarmatha National Park which offers one of the best stargazing experiences (Tafreshi, 2016). Building an astro-tourism base in one of these locations could potentially kick off a new project which could bring together the space industry as well as the tourism industry.

VI. POLICY RECOMMENDATIONS

In all of the above-mentioned scenarios and the corresponding projects, government support will be crucial in terms of helping non-profit and commercial organizations to enable them to utilize the unique resources of Nepal to promote both the economy and the space sector of the country. One of the many hindrances encountered while pursuing such projects is the high cost and lengthy processes to import

infrastructure in the country. If Nepal wants to see itself joining the league of nations that are utilizing the space industry for their economy, proper regulations and incentives should be set in place in order to foster the growth of the space sector in the country.

With the emerging New Space industry around the globe, private organizations have started to take the lead in promoting the space industry, however, support to private organizations from the government remains crucial as national policy defines the extent to which private organizations can move ahead in regards to promoting the local space industry. Nepal Academy of Science and Technology (NAST) [11] is an autonomous body that is working to promote science and technology in the country and the Ministry of Education, Science, and Technology (MoE) [12] is branch of government who oversees the development of the education, science, and technology sector of the country, therefore support and assistance to non-profit organizations such as NESRA from governmental and non-government organization will be crucial to foster the growth of space industry in Nepal.

VII. CONCLUSION

With the help of the Moon Village Association's PESC project, NESRA was able to put together its aims, objectives and the potential of the space industry it sees in Nepal. Depending on the trajectory of developments in the future space industry, the above-mentioned projects will enable Nepal to contribute to the global space industry and foster national space activities. NESRA was established to bring together people and resources to promote the space sector of Nepal with the means of research projects, conferences, events, and workshops. NESRA aims to work together with other national and international organizations to be able to materialize these ideas.

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