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Kandor Space Settlement- An Overview Study

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***Abstract*:**

The advancement in space research has always made the human species curious and looking for more. Every day thousands of people are born, and the consumption rate of the Earth's resources is getting high unprecedentedly. The research and vision for making a sustainable human settlement in our solar system, be it on the highly promising lands of the moon or the dusty realms of our neighbour planet Mars are ongoing and hopeful . In light of the issue, there is a need to design a human settlement beyond Earth, possibly in the orbital region of the moon. The proposed settlement model "Kandor" is engineered, automated, operated, and decided upon the Human Resources required for building a sustainable settlement. In the process of such development the need to utilize extraterrestrial materials in these massive and distant designs also needs to be fully analyzed. Space is a large, dynamic and curious field to research and there are many factors and facts which have to be considered while exploring chances of life and survival of humans in the vast universe. Very few people talk about the upcoming significance of space settlements in the not-so-far future, so to contribute to this developing field about space settlements and its advancements, the topic was chosen. The proposed work is based on the research performed by NASA as high technology equipment is required for the topic chosen and nothing can be predicted based on assumptions.

Keywords: space settlements, NASA, high technology equipment, structural design, pseudo gravity

I. INTRODUCTION

Until a few billion years ago, there was no life on Earth. The slow and steady changes in climate, landforms and habitable structures on Earth led to the first bloom of life and subsequently through the processes of evolution, development and innovations, humans have gained the status that they have on this planet today. But there is little doubt in the fact that to survive in the long run, humans must settle beyond Earth. Space exploration has come a long way since the last century. The advancement in space research has made the human species more curious and hopeful about the future of life beyond Earth. And this hope has a solid foundation and reasons. Every day thousands of people are born, and the consumption rate of the Earth's resources is getting high unprecedentedly.

According to the United Nations Office for Outer Space Affairs, more people now live in urban areas than in rural areas. Urban populations are also expected to continue to grow and it is expected that by 2050 approximately two-thirds of the world's population will be urban. With increasing and sometimes rapid urbanisation and industrialisation, cities frequently face challenges with housing, water, sanitation, electricity, crime, pollution and transportation.

Space is a large, dynamic and curious field to research and there are many factors and facts which have to be considered while exploring the chances of life and survival of humans in the vast universe. Very few people talk about the upcoming significance of space settlements in the not-so-far future, so to contribute to this developing field about space settlements and its advancements, the topic was chosen. The proposed work is based on the research performed by NASA as high technology equipment is required for the topic chosen and nothing can be predicted based on assumptions. Space-based technologies provide unique tools for planning socially and environmentally sustainable human settlements. The model is engineered, automated, operated, and decided upon the Human Resources required for building a settlement. The settlement was named "Kandor" because, in the DC Universe, Kandor was a city on the planet Krypton before the planet's destruction.

The paper puts light on design, features, necessities for initiating structural design, operations, automation, and Human Resources. During the process of designing the concepts of physics behind the space settlement design were considered. A lot of designs were studied and considered for the settlement based on different criterias before one was

finalised. If the chosen structure was spherical, then construction is difficult but creating an atmosphere is easy. If the chosen structure was a ring then construction is easy but creating an atmosphere is difficult. If the chosen structure was cylindrical then construction is easy and so is creating an atmosphere. The rotation rate was calculated.

The Operation and Automation section covers a detailed analysis of the operational aspects and features of automation that will make KANDOR safe and well suited for life. It includes consideration of the most suitable orbital location of the settlement. The paper also highlights important sources of raw materials that can be accessed efficiently to facilitate the construction work on the settlement. The paper also looks upon various contingency plans and emergency services that need to be readily prepared to overcome any non-favourable conditions aboard such as asteroids, fire, and air leaks. The paper sheds light on the automation features that will be installed on the settlement including robots. All aspects of such facilities are well researched and processed to make their content and accessibility.

On the proposed settlement, the most important and fragile part would be the residents and other people who will be contributing to it in any way and through the means of our paper, the aim is to highlight the necessities and resources that are required and are crucial for the survival and existence of those people to lead a happy, healthy and comfortable lifestyle on the settlement.

II. LITERATURE SURVEY

Authors [1] suggested Space-based technologies provide unique tools for planning socially and environmentally sustainable human settlements. Authors engineered, automated, operated, and decided upon the Human Resources required for building a settlement [2]. Authors in [3] focus on design, features, necessities for initiating structural design, operations, automation, and Human Resources. Authors in [4] consider the process of designing the concepts of physics behind the space settlement design. A lot of figures were considered for the settlement before one was finalised. Authors [5] considered a cylindrical structure so construction is easy and so is creating an atmosphere. The rotation rate was calculated.

Long term side effects of microgravity can include: Negative calcium balance resulting in the loss of bone, atrophy of antigravity muscles, decreased plasma volume, cardiovascular deconditioning that leads to orthostatic intolerance, fluid redistribution, fluid loss, electrolyte imbalances, muscle damage, bone damage, hypercalcemia, immune system changes and “aging”, vertigo and spatial disorientation, loss of exercise capacity etc. Humans cannot live in microgravity for several years without severely deconditioning. Because of this, artificial gravity or pseudo-gravity must be generated using rotation.The centrifugal force, a force which is directed towards the centre during spinning is the way through which pseudo gravity can be induced.

Under [6], the Operation and Automation section covers a detailed analysis of the operational aspects and features of automation that will make the settlement safe and well suited for life. It includes consideration of the most suitable orbital location of the settlement. In [7] authors have mentioned important sources of raw materials that can be accessed efficiently to facilitate the construction work on the settlement and look upon the various contingency plans and emergency services that need to be readily prepared to overcome any non-favourable conditions aboard such as asteroids, fire, and air leaks. Authors [8] focus on the automation features that will be installed on the settlement including robots. On the proposed settlement, Authors [9] mention the fragile behaviour of accommodating the residents and other people who will be contributing to it in any way. Authors [10] highlight the necessities and resources that are required and are crucial for the survival and existence of those people to lead a happy, healthy and comfortable lifestyle in the settlement.

III. PROPOSED APPROACH

The proposed settlement focuses on the proposal of Kandor, a space settlement that will include artificial gravity, choice of structure for the settlement, . Microgravity is the condition in which people or objects appear to be weightless. The effects of microgravity can be seen when astronauts and objects float in space. In microgravity, body fluids are redistributed away from the extremities, which results in puffiness in the face during flight as well as changes in cardiovascular physiology. Exposure to microgravity often leads to disorientation and decreased neuromuscular coordination upon return from prolonged missions.

A. Long term side effects of microgravity can include:

Negative calcium balance resulting in the loss of bone, atrophy of antigravity muscles, decreased plasma volume, cardiovascular deconditioning that leads to orthostatic intolerance, fluid redistribution, fluid loss, electrolyte imbalances, muscle damage, bone damage, hypercalcemia, immune system changes and "aging", vertigo and spatial disorientation, loss of exercise capacity etc. Humans cannot live in microgravity for several years without severely deconditioning. Because of this, artificial gravity or pseudo-gravity must be generated using rotation.
The centrifugal force, a force which is directed towards the centre during spinning is the way through which pseudo gravity can be induced.

B. Physical Quantities to be considered:

1. Angular momentum(L): the quantity of rotation of a body, which is producing its moment of inertia and its angular velocity(ω)
2. Acceleration(a): rate of change of velocity per unit of time
3. Inertia(I): property of matter to remain in the state of motion or rest unless an external force is applied
4. Force(F): product of mass(m) and acceleration of an object
5. Work(W): product of force and displacement(d) of an object

The value has to be equal to the value of g for human survival. **Creating 1g:**

g - Acceleration due to gravity= (ω^2)*R
R - Radius of the structure
rpm - rotation per minute
Ω - angular velocity

QUANTITY/ UNIT	FORMULA
1rpm	2□/60sec = 0.105/sec
g	$(0.105\omega)^2$ * R
R	$g/(0.105\omega)^2$

Table 1 Represents Physical Quantities and Units Used and Their Formulas

Since the NASA/Stanford space settlement studies of the 1970s the settlement design community has assumed that rotation rates must be no more than **1-2 rpm** to avoid motion sickness. Based on these studies and further research, **1.5 rpm** was decided upon as the rotation rate**..** The structure should be such that gravity is the same at all points along the surface. As *R increases, ω decreases*

C. Shapes Considered for the Structure of the Settlement

Shape	Advantages	Disadvantages
Spherical	• Creating a proper pressure and atmospheric condition would be easy. • Area covered would be less as well.	• Construction is difficult. • Gravity will not be constant and the apparent gravity would be lower at the poles than at the equator.
Ring	• Construction would be fairly easy. • Balanced symmetrical structure possible with maximum habitable space. • Better spin.	• Atmosphere creating would be difficult with much shielding required. • Largest surface area with least volume, not sustainable.

Cylindrical	• Construction easiest with balanced surface area and volume. • Creating an atmosphere is easy. • Equal amount of gravity in most of the area.	• Not efficient at containing pressure • Propulsion support limited

Table 2 Represents the Advantages and Disadvantages of Choosing Various Structures

Based on the above tables it can be inferred that if a spherical structure is chosen then construction is difficult but creating an atmosphere is easy. If instead a ring structure is chosen then construction is easy but creating an atmosphere is difficult. Choosing a cylindrical structure would be thus most suited as the construction is easy and so is creating an atmosphere. Next, the Area and Volume of the Structure is discussed:

Cylinder: **w=1.5rpm so R=3160m**

$\mathbf{A_1}$ $2\pi Rh$
$=2\pi*3160m*5000m$
$=99224000\ m^2$

$\mathbf{V_1}$ $\pi(R^2)h$
$=\pi*(3160m)^2*5000m$
$=156.77 \times 10^9\ m^3$

Hemisphere: R= 3160m

$\mathbf{A_2}$ $2\pi(R^{2)}$
$=2\pi*3160m*3160m$
$=62709568\ m^2$

$\mathbf{V_2}$ $(⅔)\pi(R^3)$
$=(⅔)*\pi*(3160m)^3$
$=66.0541 \times 10^9\ m^3$

Cone: r= 100m, h=1000m

$\mathbf{A_3}$ $\pi r(h^2+r^2)^{1/2}$
$=\pi*100m*[(1000m)^2+(100m)^2]^{1/2}$
$=315566.0945\ m^2$

$\mathbf{V_3}$ $(⅓)*\pi*(r^2)*h$
$=(⅓)*\pi*100m*100m*1000m$
$=0.0104 \times 10^9\ m^3$

Total Area	$162249134.1\ m^2$
Total Volume	$2.228345 \times 10^{11}\ m^3$

Table 3 Total Area and Volume of the Figure Considered

D. Blueprint of KANDOR

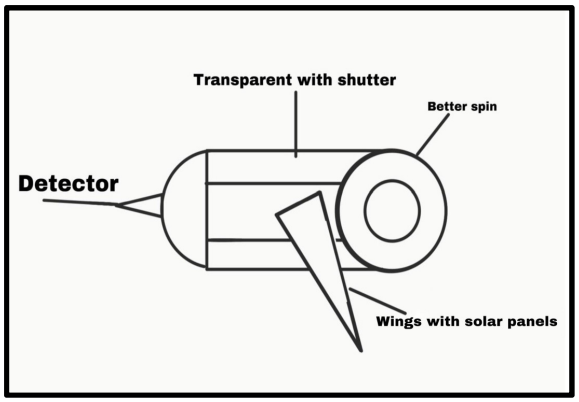

Fig 1 This figure shows the structural design of Kandor

E. Evaluation Criteria

The proposed settlement identifies a suitable orbital location for the space settlement, and reasons for its selection, sources of construction materials as well as the equipment to be used in construction, transportation, automation in contingency plans and human resources.

1. ***Orbital location***

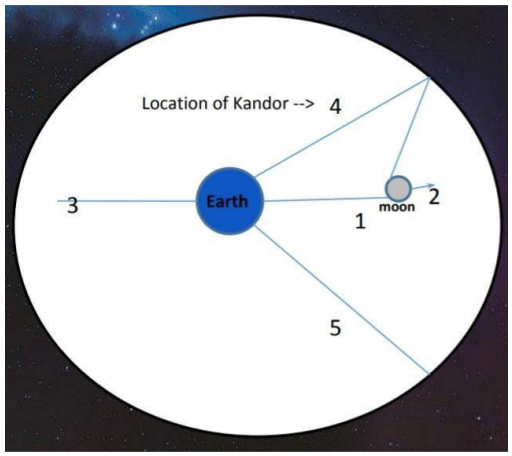

Fig 2 Proposed location of Kandor shown at point 4
Source-https://settlement.arc.nasa.gov/Contest/Results/2011/HYPERION.pdf

For the selection of a perfect orbital location, various studies have to be performed before concluding on the result as the location should be near to the resources needed for survival, then the location should be danger free and have good stability. The above location was well researched and thought upon. The justification are as follows**:**

After much observation, the realisations are that the positions 1,2 and 3 are not at all stable and even though position 5 provides stability. But it still cannot be considered as it contains interplanetary dust, and few more conditions are not fulfilled by position 5. Position 4 is decided and the reason for the selection of position 4 for the location of the space settlement is because of its super stability, proximity from the sources of raw material, possibility of the eclipse and other assets like – building solar power satellites, research works on mars and its orbit as well as the extraction sources.

2. ***Materials for construction***

The material that is considered for construction of Kandor are as follows:

1)Aluminum oxynitride: ALON is a transparent ceramic, composed of Aluminium, oxygen and nitrogen. Nearest Availability - moon

2) M5 fiber: M5 fibre is a high strength synthetic fiber. Nearest Availability - earth

3) Asbestos filter: Asbestos filters are the filters made from the material asbestos which are naturally occurring fibrous silicate material. Nearest Availability - moon

4) Superadobe: Superadobe is an earth-bag-like construction, technique uses layered long fabric tubes or bags filled with adobe. Nearest Availability - moon & earth

5)Radiation protection materials are twaron, polyethene foam, silicone rubber, nitinol, sealant gel. Nearest Availability - earth

3. ***Transportation***

Spokes are areas with no pressure in the settlement. It is just like a free vacuum space and to travel in such an area a pressurized vehicle for mass transportation - vacuum pod system is required. Pods having glass tubes and spherical shape are to be built for transportation. These pods shall use magnetic and gravitational force fields between the steel pod and the glass tube resulting in steady placement of passengers. There will be three case stations in every section. These cases have a brilliant association framework which will play the client's selection of tunes or news or any live game proceeding to make the excursion agreeable and offer a reprieve from the exhausting working timetable.
Magnetic Pod Tracks are situated at the edges of the streets. By tapping the Pod button present on the individual's very own wristband, It gives a text to the switch which chooses which pod to send at all time. The pod will contact the individual inside no-time furthermore, the individual will choose the wanted area. The mechanism will be the same as a cab being followed currently on the earth. Below figure is just an example of how the vacuum pods may look like:

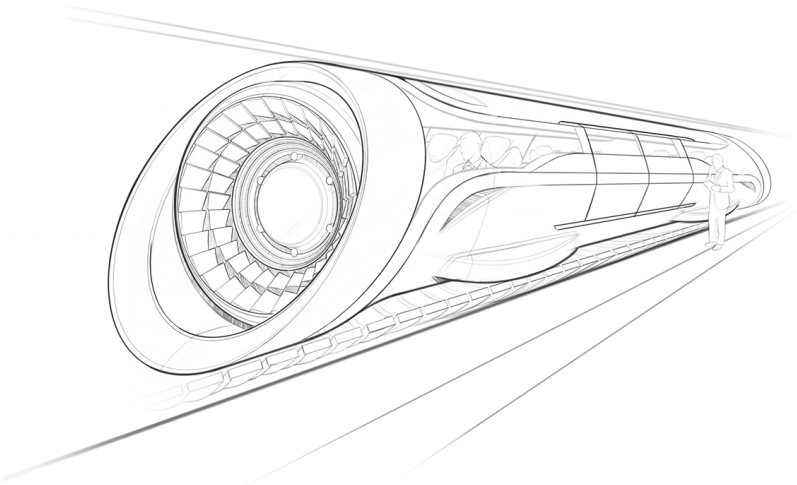

Fig 3 A sketch design of hyperloop which follows similar model of our transportation system Source- https://in.pinterest.com/pin/553168766713522473/

4. ***Contingency Plans***

The settlement would be a host to numerous people and to handle any unprecedented situation, proper risk management and analysis is most important. The first security measure would be to constitute an Evacuation Authority of highly trained and equipped professionals. These managers would be given adequate training and experience in situation handling along with hands-on training on various emergency equipment.
In a situation of an emergency, every person would leave the affected area in an orderly fashion with the aid of these pre-selected and trained emergency managers. These managers will make sure of the safe and fast evacuation of all residents, the saving of important documents, salvaging of property and other situations related to evacuation. The threats can be either from inside the settlement or from outside. Some of the possible threats are analysed and the precaution plans are given below.

- **Radiation**

The vast vacuum of space is home to various kinds of lethal radiations such as harmful cosmic rays along with high solar flare events. In absence of any shielding, such radiation exposure may cause serious health effects on the human body, apart from genetic mutations. Material shielding such as aluminium walls and liquid hydrogen are found not to be much effective against galactic cosmic rays. Instead, lunar or Martian regolith can prove to be a much better and economical shield against radiation. The regolith could be filled into the structural cavity or else moulded and compacted along the walls of the settlement to provide strong micrometre shielding.

- **Space Debris**

A large amount of space junk floats around the Earth orbit at high velocities. Therefore, a debris shield will be installed outside the residential area which will protect it from direct impact by space debris. Since only larger such objects can be catalogued and tracked, only these can be avoided through active measures and proper shielding or by manoeuvring the station. Two basic types of shields, monolithic and Whipple are used as shields against space debris. The more suitable Whipple shield will be used to provide protection against higher velocity objects that can cause more damage to the structure.

- **Asteroids in the path**

The type of asteroid threat (large or small in diameter) will determine the kind of emergency plan the concerned authority will take up.

Contingency Type	Problem fixations
Minor sized asteroid	• If the asteroid size is not significant, it can be nuked and broken apart from a safe distance to the settlement. The nukes can be denoted near the asteroid heating it up and eventually vapourize. The speed and direction of the asteroid will play a major role in this plan to be successful and thus has to be analyzed efficiently. • Laser Heating will also be used as alternatives to alter the trajectory of the asteroid by heating and changing its mass. • Sets of parabolic reflectors with large apertures will be installed in various directions on Kandor. The reflectors will focus sun rays to a point on the asteroid. Due to very high temperature at this point, the asteroid will melt and this loss in mass can lead to it changing its trajectory.
Major sized asteroid	• For asteroids of much bigger dimensions, the settlement would be translated from its position using thrusters. The settlement will be accelerated towards an already planned backup location with a steady speed, thus not causing any discomfort to the residents.

Table 4 Classification of Contingency Plans for Minor and Major Asteroid

One major prospect of small asteroids being detected around the settlement can be capturing these chunks of rocks onboard using suitable robotic arms and carrying out Asteroid mining in the research base of Kandor.

- **Fire**

The fire protection will be kept in mind from the beginning itself. During construction, for efficient fire prevention mechanism, a thick silicon cellular panel along with silicone fibreglass on the ceiling will be installed along the walls of the settlement. The need is also for light and strong floor deck elements as well as interior wall elements which are fireproof. Smoke detectors and Automatic LED signals will be installed as well in the walls of the settlement. Flame retardant thermoplastic poly-olefins compositions will be automatically sprinkled and alarms will be sent to the closest fire department.
Some more contingency measures are listed below

Contingency	Risk Factor	Emergency measures
Air Leak	Potentially harmful on large scale	AMT will take control. As part of checking for air leaks, the first step would be to identify the area of the leak using sensors that detect a change in airflow. The affected area will be isolated from the rest and the residents will be wearing masks/space suits and will be evacuated away till the breach is fixed.
Power Failure	Minimal	Power backup will be maintained and checked from time-to-time. Emergency power generators will be activated to recover order if the blackout is permanent.
Cyber Security Breach	Compromise can be risky	Encrypted devices and data will be used with effective two-factor authentication to avoid any unauthorized access. Required security audit and an internal investigation will be carried out.

Food and Water shortage	Can be life threatening at large scale	Essential back-ups like nutrient pills and packed water will be maintained and immediate access to the residents will be provided.
Automation System failure	Minimal	Will be repaired by specialized engineers on immediate basis, not life-threatening

Table 5 Additional Contingency Plans

- **Human Resources**

The most important aspect of Kandor being a habitable and sustainable settlement would be providing flawless facilities to the residents be it housing structures, public spaces, access to food and water etc.

Food is the basic need of all living beings and is crucial for survival. High nutrition diets would be very important for the residents living in Therefore, residents will be provided the option to buy a variety of cuisines having high nutritional value to sustain their appetite and growth requirements. Food will be bought by each resident through special outlets, so it will be her decision what to buy and when. Food and water will be contained in plastic containers, so that there is no danger of spoilage. Perishable foods will be stored separately and distributed fresh to the consumers. All other consumables shall be produced from raw materials in the different parts of the settlement and transported to the residential area.Water is the most essential commodity and its requirement shall be sustained well on the settlement. Drinking water will be distributed in bottles with straws so no spilling will occur and the bottles will be recyclable so nothing is wasted. Part of the water can be obtained from the atmosphere by the process of condensation. Such water will be made potable using ultra-violet equipment that purifies the water of germs and viruses. Each residential area has its own water management system, with individual recycling and waste treatment facilities available.. Incase of supply disturbances, backup tanks will be managed and accessed therefore lessening the danger of water shortages.

There will be 2 types of used water: The water that comes out of our home consumption and the one that comes out of the industrial consumption Water management practices will be taken into consideration to recycle and reuse water wherever and whenever possible. From the waste treatment center, purified water is released into separate water pipes that are also connected into every residential area. With such management practices, all types of water needs will be fulfilled in Kandor.

A clean, pollution and dust free and oxygen-rich atmosphere shall be provided for maintaining hygienic and healthy living. For that, automated air purification systems shall be installed in the walls of the residential areas.The control of both pressure and air composition will create a habitable man-made atmosphere for the residents. Since air is a critical component of life, a special Air Monitoring Task force (AMT) will be established to supervise the maintenance of the whole atmospheric conditions of Kandor. Oxygen masks would be provided to one and all in case of any emergency.Afforestation drives will be carried out monthly for the people of the settlement.

Sunlight will also be one of the main aspects of the environment in Kandor. Due to the strategic location of Kandor Settlement i.e. Earth-Moon L4 Lagrange Point, sunlight shall be available to the settlement at all times.It will be harnessed, distributed and consumed by the residents easily.

Proper health care treatment centres with adequate medical facilities, ointments, and infrastructure will be established for people. The health care system must be supported by every inhabitant through a fee. This money will be used for the welfare of hospitals, the salaries of medics, and drugs or different treatments. Well-functioning clinics and qualified robots, as well as doctors, would be there in each part of the settlement for easy and early medical assistance. First-aid booths will be maintained across the settlement.

All residents will have access to telemedicine facilities for emergency and remote appointments. In addition, robots and other mechanical machines will be used heavily in the medical care centers. Medical Assistance areas are also in the four rotating domes. Medical facilities will include hospitals and emergency centers. Advantages of having robust medical facilities at short distances will be huge and beneficial for the health care system. The medical facilities will overall be high-tech, efficient, clean and sufficient for residents.

Like any city on the planet Earth, our space cities will also produce garbage and we won't be able to recycle most of it. The parts that can't be recycled will be burned and the ashes would be compressed and treated. Thus almost no pollution will occur on the settlement. To survive in outer space, recycling is necessary and so the waste that can be recycled will be collected and brought to a recycling unit on the settlement itself, where it will be thoroughly treated and be made fir for further use.

We humans can not do away with entertainment. We need something or the other to keep ourselves engaged. Fitness centres will be maintained having facilities ranging from sports ground to gardens to a gymnasium. Lounges and resting places, just like society clubs and country clubs, will include the same luxuries as enjoyed on Earth. Cinemas and theatres will be built for recreation purposes. Fun activities like zero-gravity games and theme parks with Earthly adaptations will be made available to the public. For more social interactions amongst the residents, competitions and festivals will also be regularly organised for the residents. Tourism will also be promoted within as well as outside if required.

The key to any form of success is education and it is crucial for one's growth and development. One of the two types of educational practices that we will undertake on the settlement is In-Ground Education Facility which will include an automated teaching system as well as the traditional style of schools. Regular physical classes will be conducted for the real-time study. One teacher per class will keep the records and will keep track of the students' attendance and assessments. The other is Distance Education. Kandor would also have long-distance education programs connecting it to the best schools, colleges,

The social structure would primarily emphasise on having a smooth and well-functioning social environment with regards to the implementation of equal rights and restrictions applicable to all. Democracy is said to be the most popular form of government hence a proper unbiased political regime to regularly monitor its citizens should be established. They will keep a check of all the rights and orders, whether they are being obeyed by people properly or not. Segregation of powers at various levels of the social structure such as legislative, executive, and judiciary. Well-functioning sectors and work-centric domains to ensure sustainability and appropriate services such as healthcare, the judicial system, education sector, industrial domains, technology, and advancements.

IV. CONCLUSION

Space colonization is desirable because of the hope it offers mankind. A sense of the limits of Earth has been heightened in recent years by a growing awareness of the delicate ecological balance of the planet, its limited resources and its growing human population. On the settlement, the most important and fragile part would be the residents and other people who will be helping in contributing to it in any way. Thus, specific attention needs to be given to the living ones and their necessities. The life on the settlement will have to be comfortable and safe from any kind of threat from the challenging surroundings as well as sufficient resources would have to be available for the people to live a life with ease and comfort.

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