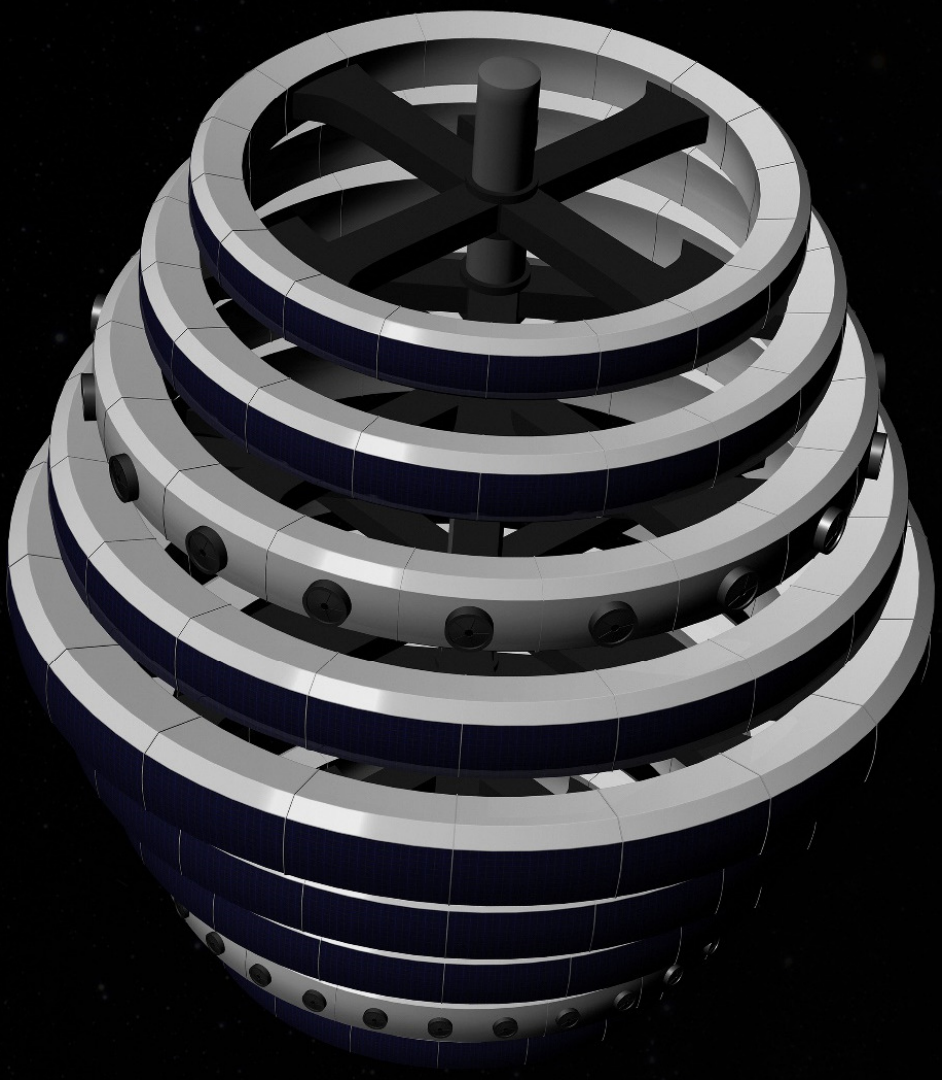
GREEN SPACE



NASA Space Settlement Contest

PROJECT

GREEN SPACE

Category: **11th grade, Small group**

The project is engineered, designed and described by a team of 11th grade students:

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2. **Ivan Popov**
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The participants are attending Astronomy courses at the **Astronomical Observatory and Planetarium "Nikolay Kopernik", Varna**
and
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The Leaders:
Dr. Veselka Radeva, Astronomical Observatory and Planetarium, Varna
Silviya Zaharieva, Physics teacher at High School of Mathematics "Dr Petar Beron" Varna

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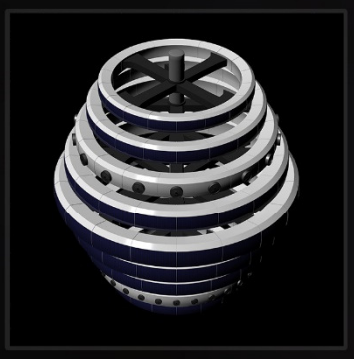
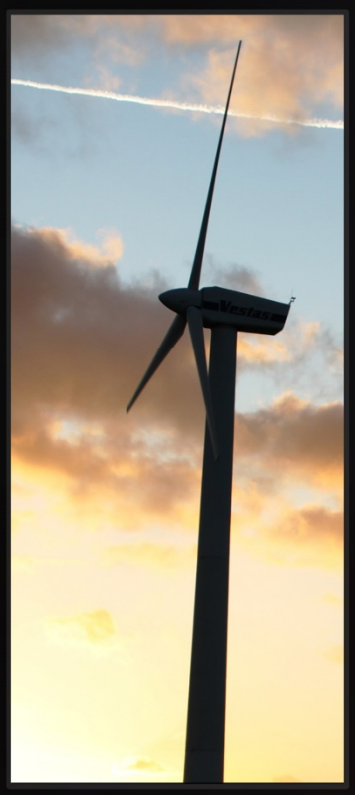


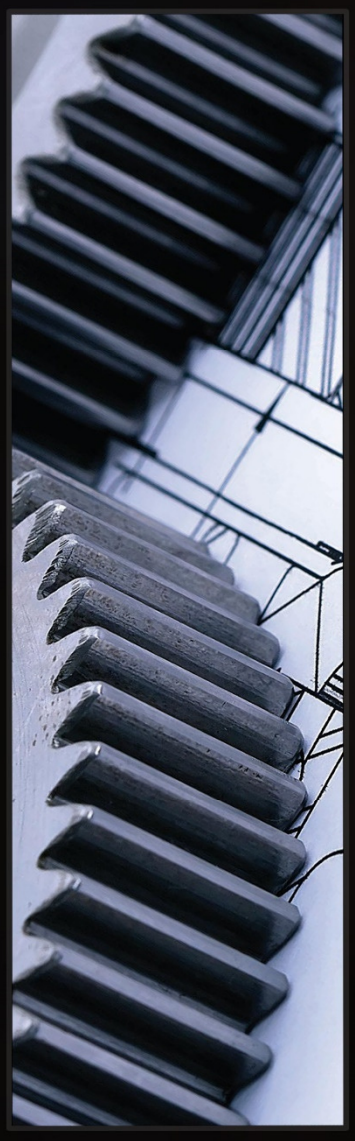
SCIENTIFIC RESEARCH

S.E.A.

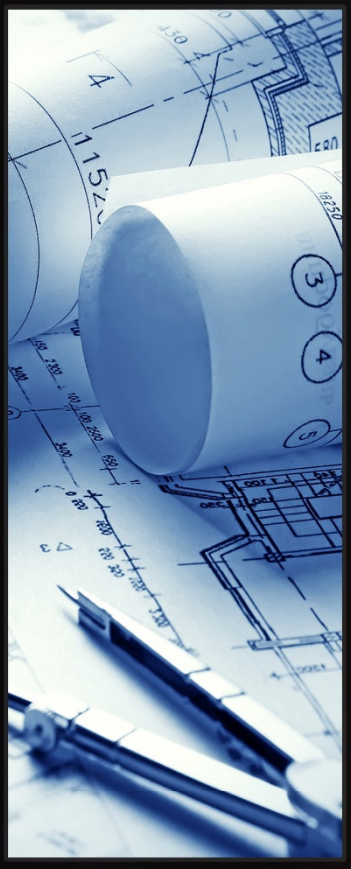
SPACE-ECOLOGICAL APPLICATION



ENGINEERING SECTION



ENGINEERING SECTION



ECONOMY AND SOCIETY

Space technologies are developing at a rapid pace and adoption of near and distant space becomes one of the most important and crucial tasks for mankind. Going out in space, people carry over not only their dreams, but also their problems. One of the biggest issues of our planet – its pollution – is transferred in near space. Space ecology is a topic that has been the center of our attention for the past few years. We found many theoretical solutions to the problem, we looked through many projects about how we can clean the already polluted near-Earth environment. In the end, we decided to propose an interesting way to clean the space near the Earth and preserve the clean state of the whole Solar system.

We called our project Greenspace, because we wanted to convey our idea for a clean environment everywhere in the Solar system. Because the green Earth is just a small planet, inhabited with sentient beings, who will have to adopt space with the thought that it is their bigger home that needs to be clean and welcoming.

We worked very enthusiastically and with great responsibility and interest we created our space settlement Greenspace. We design everything, so that it is highly effective and practical. For a clean, safe and beautiful space environment.

We are confident that our project Greenspace is just one of the many that will be implemented in the coming decades. This idea will unite and inspire all, who are captivated by the magic of space research.

The goals of our settlement

The society of the Greenspace settlement will be the first big group of people to live in space for a longer period of time. Their goal will be not only to survive in the dangerous space environment and to develop every branch of science – Physics, Biology, Chemistry and Medicine, but also to solve some of the biggest environmental issues our humanity faces. The citizens of the colony will all have various positions and everyone will have their contribution to its activity.

The colonists will be people who love challenges and are ready to accept the potential dangers of the life in space. They will be equal to one another and every inhabitant of the settlement will have access to everything that is produced on it. Communication with Earth will exist to allow the sharing of discoveries, results and other important data with the existing bases.

Our main goal: To create a space settlement, which will shelter 16 000 people and will solve some of the most serious environmental issues of humanity.

The main tasks of our settlement and the space program it is a part of are:

- To create a space program, which will be responsible for the removal of the space debris in the near-Earth environment and the preservation of its cleanliness after it;
- To catch and mine potentially hazardous for the Earth asteroids and use their resources;
- To propose an effective solution of the global warming;
- To conduct various scientific experiments in special laboratories in conditions, inaccessible on Earth;
- To create and maintain a biosphere and to take care of the physical and mental state of the colonists;
- To create a stable and effective defense system to protect us from space and solar radiation;
- To give the citizens of the settlement various options for entertainment to motivate them and to increase their productivity.

Name and logo of the settlement

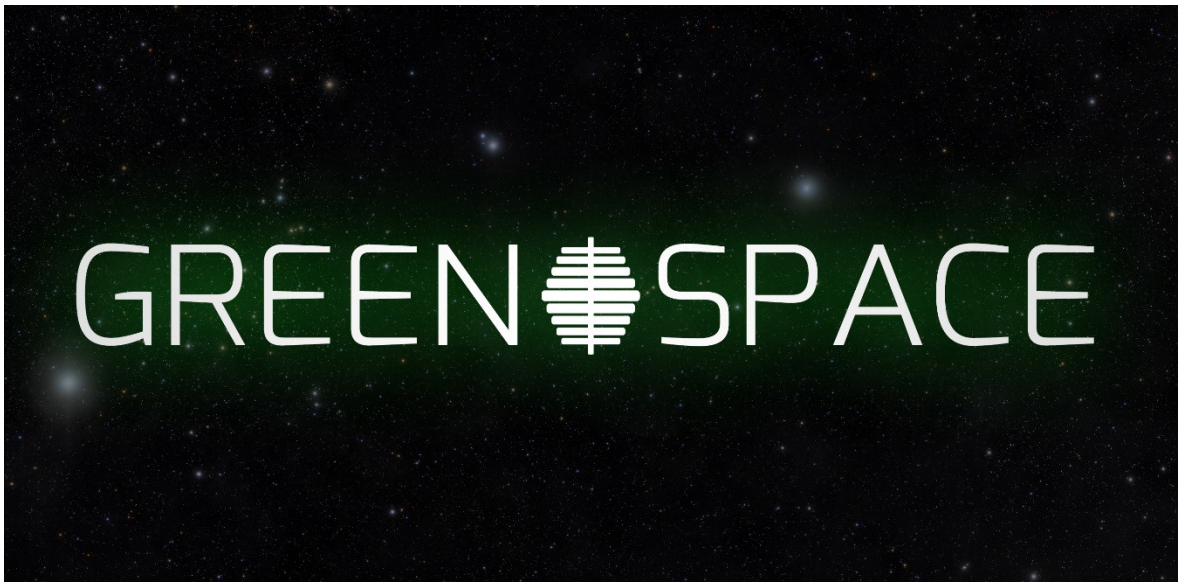


Fig.1. This is the logo of our settlement

We called our settlement Greenspace, because of our project's focus on space ecology. While making the project, we paid attention to the 'green' ideas not only while solving serious problems, but also while working on smaller details, like the daily life of the colonists or the interior of the settlement.


Scientific
Research

1.1. Space Debris

The launch of the Soviet satellite Sputnik in 1957 kicked off a series of launches that inspired people all around the world. But back then no one even imagined that those launches would lead to the creation of what we now call space junk. Just in 1978, the NASA scientist Donald J. Kessler was the first one to predict that the density of the objects in low Earth orbit is high enough to lead to a cascade.

What is Space Debris?

Together with global warming, the space debris are a symbol of the destructive human activity over the nature. What's more most humans don't know or don't care about it. This problem exists for fifty years now and has been exponentially growing all the time. Eventually it's going to reach a level when every action against it is pointless, dangerous and inefficient.

What does the space junk consist of?

- Satellites out of order or out of operation;
- Rocket stages and parts of rockets and Space Shuttles;
- Objects that astronauts let go or threw away.

Fig. 2. The spare thermal glove of Edward Higgins White is also one of the countless space debris. It floated away through the open hatch of the spacecraft

Low Earth Orbit

The biggest problem are the debris in Low Earth Orbit. They orbit the planet at highs from 200 to 2000 kilometers. They endanger the communications satellites and spaceships which are passing through LEO.

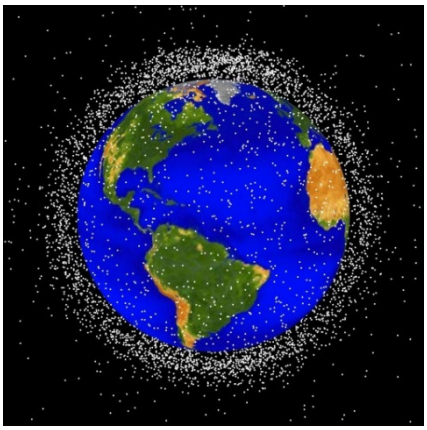


Fig. 3. LEO

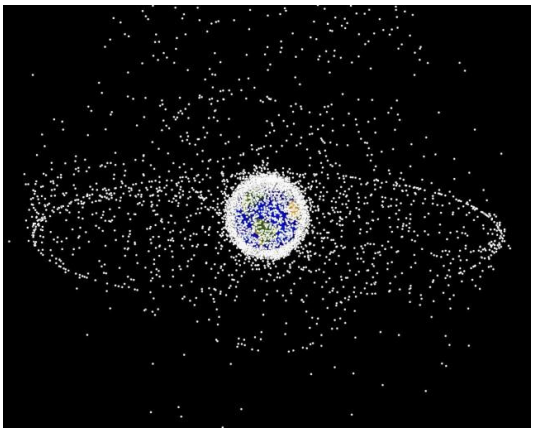


Fig.4. GEO

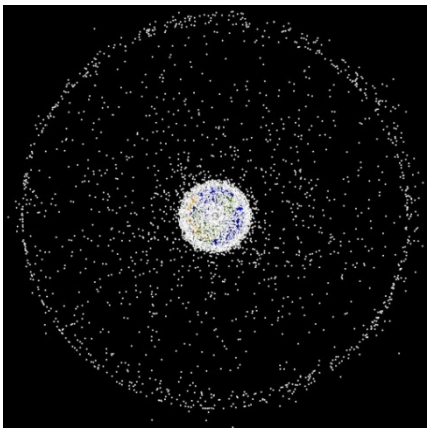


Fig. 5. GEO Polar

Count and size

Nobody knows the exact number of space debris because many of them are really small in size and because of the high speeds they orbit the Earth. The Space debris are hard to detect and observe and that makes them even more dangerous.
With every collision between two objects (no matter if they are debris or functional satellites) the count of the debris grows because parts of the objects fly away in every direction. That way the number of space debris around the Earth is constantly increases and nothing is done to prevent that or to remove some of the debris.

Roughly the count and the size of the space debris in Low Earth Orbit is:

- **100 000 000** objects less than 1cm in diameter;
- **500 000** objects between 1cm and 10cm in diameter;
- More than **21 000** debris bigger than 10cm;
- Another **6000** launched satellites (only 800 of them are still working);
- A large amount of debris are created by the project West Ford (1963). Its goal was to create an artificial ionosphere by launching **500 000 000** copper antennas in orbit;
- **300 000** debris were created by the explosion of the Pegasus rocket which is used to launch small cargos in LEO;
- **200** bags with organic waste thrown away by the astronauts of the Russian space station 'Mir' during the first 10 years of its operation.

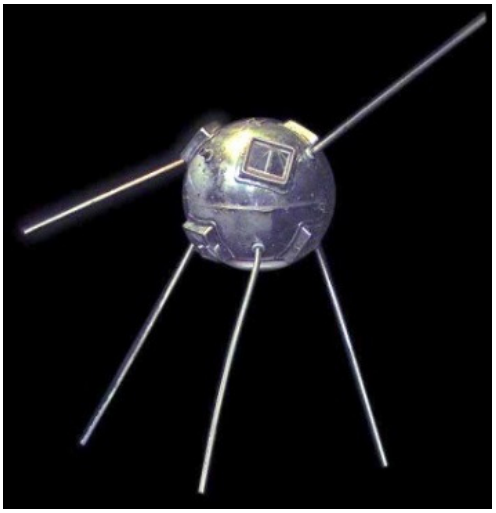


Fig. 6. ***Vanguard 1***

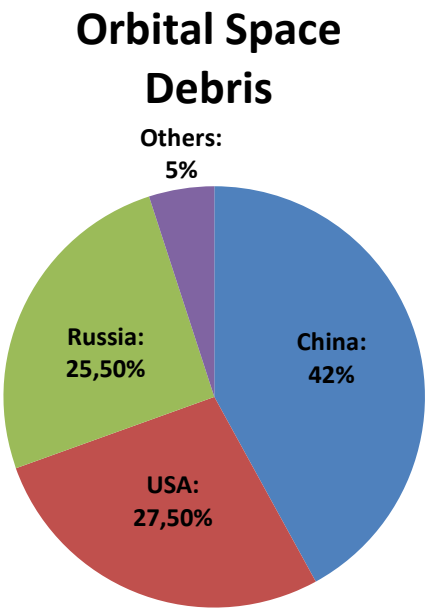
Vanguard 1 is the oldest piece of space junk that orbits the Earth. It is the second satellite launched by NASA in 1958. Vanguard 1 came out of operation in 1964 but it will continue to orbit the Earth another 240 years.

Two events in the last years made the situation even worse. They also demonstrate how irresponsible humans are.

- More than **1400** debris were created by the collision of the no longer functioning Russian satellite 'Kosmos-2251' and the satellite 'Iridium 33'. The collision happened on 11 February 2009 and was with speed of 42 100 km/h.

- Even worse was the event from 2007 when 150 000 new debris were created. This happened when China destroyed their own old satellite. 'Feng Yun 1C' was blown up just to demonstrate the power of their army (and probably to get rid of the information stored inside).

Chart 1.



Problems of Orbital Space Debris

Orbital space debris can give rise to a range of problems in four main areas:

- **Collisions**
  - With operational spaceships or satellites – from minor damage to total destruction, generating more debris and messing up human activity;
  - With other debris - generation of more debris, increasing the future collisions hazard.

- **Space Science**
  - Debris effects may mask other phenomena or may be mistaken for something else.

- **Astronomy**
  - Debris trails ruin a lot of astronomical images;
  - Produce radio astronomical events due to reflection of ground and space transmitters and mess up radio astronomical observations;
  - Over time debris will increase the background sky glow.

- **Other**
  - Reentry hazard from large debris objects - if it's big enough a piece of space debris can cause damage to property and even death on Earth.

Damage

The debris vary in size and form. They could be a few millimeters wide or bigger than 10 meters. Their speed varies as well. The average speed of a piece of space junk is between 7000 and 8000 m/s which is 23 times the speed of a 9mm bullet.

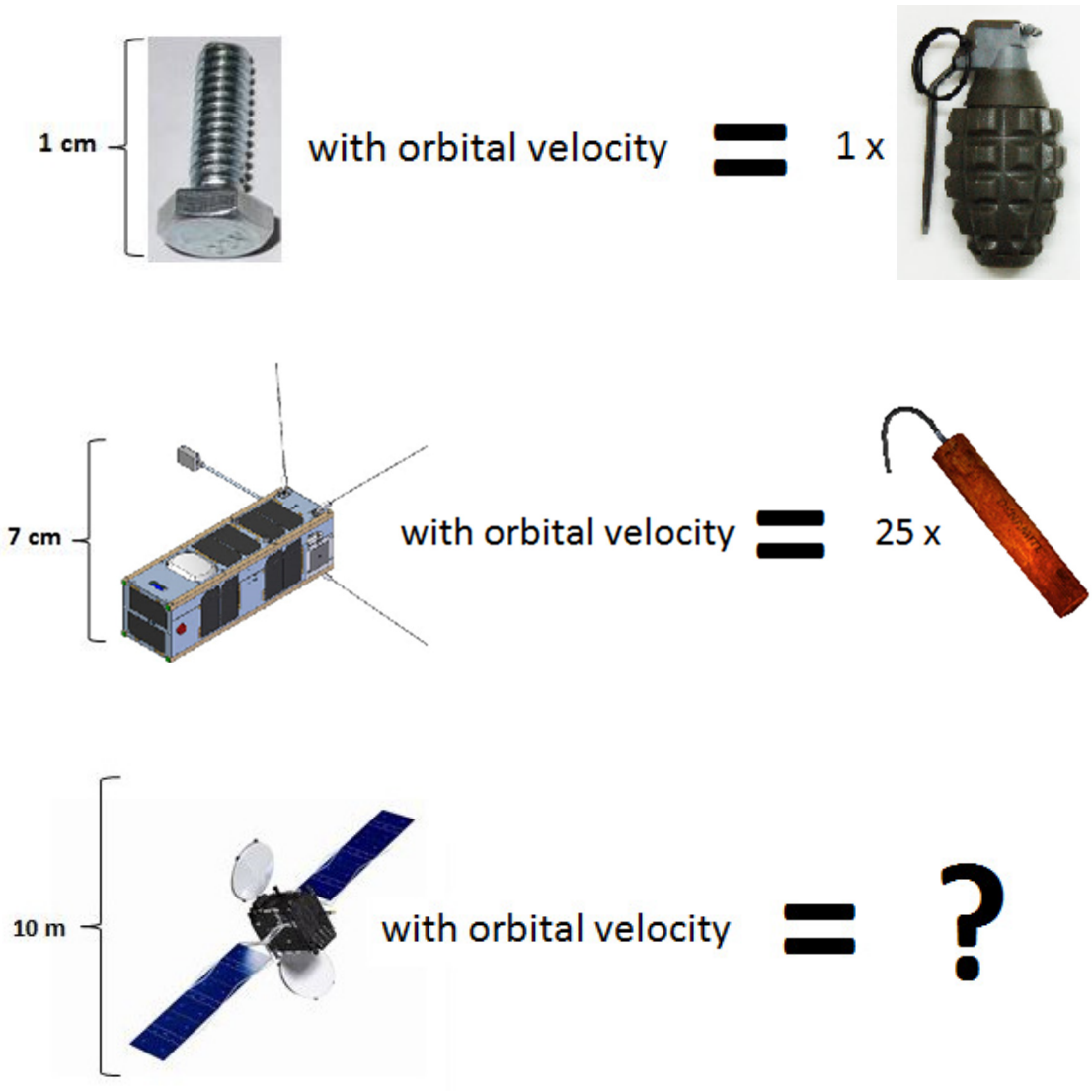


Fig. 7. Comparison of impacts with space debris

Collisions with that sort of power may damage or completely destroy satellites and to endanger the lives of astronauts in LEO or in the ISS.
The U.S. Space Surveillance Network regularly tracks the orbit of tens of thousands of debris. Roughly once a year the ISS has to change its position and orbit in order the avoid collision with a piece of space junk.

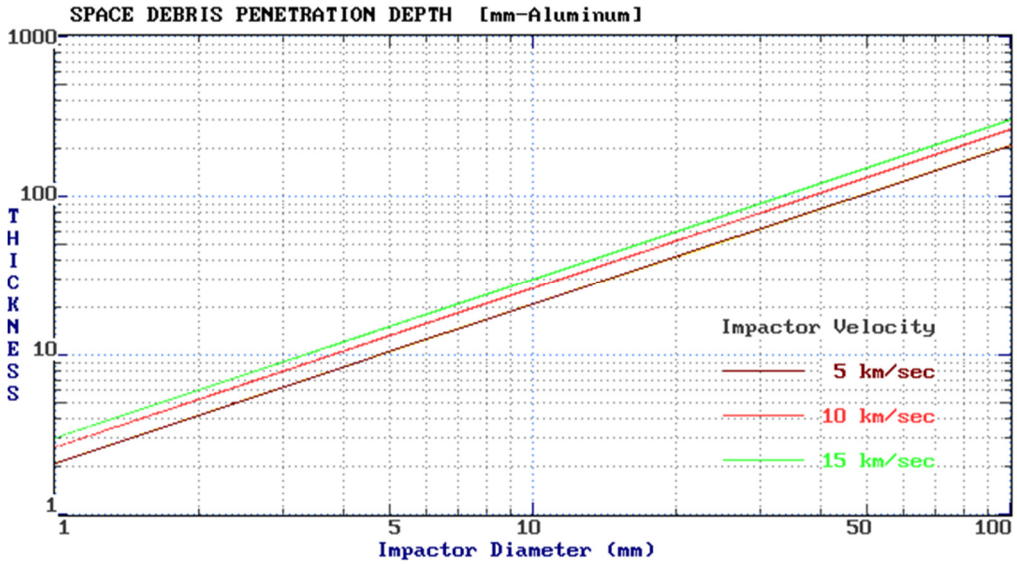


Fig. 8 Penetration depth of the space debris

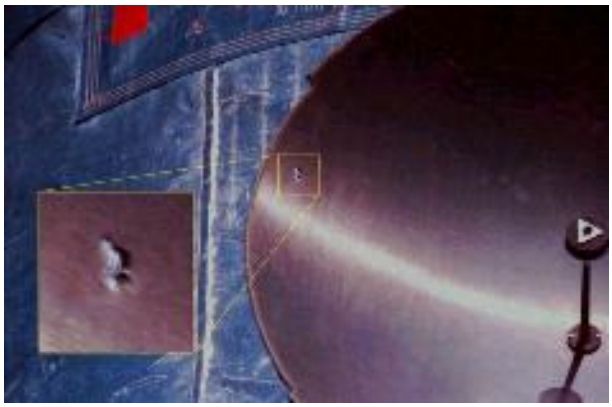


Fig. 9. Hubble's downlink antenna

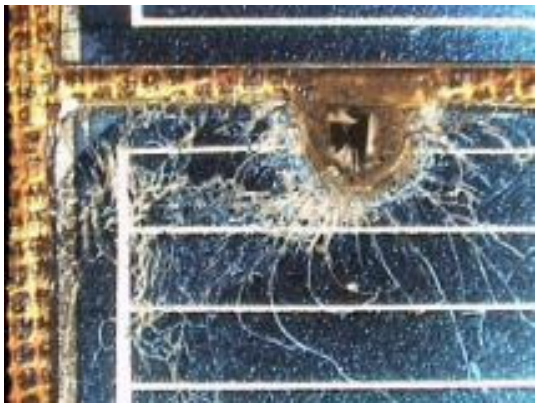


Fig. 10. Hubble's solar panel

Fig. 11. STS-118 radiator impact damage. The ingress hole is 10mm in diameter, but the exit hole is much larger and very irregular. This is typical of all penetrating impacts.

Currently taken measures

Tracking

Both the USA and Russia have set up tracking networks to monitor the orbital space object population. The European Union is now starting to develop its own capability in this area. The US Space Command and the Russian Space Agency maintain space object catalogs. The US Space Surveillance Network (SSN) employs about 30 global sensors.

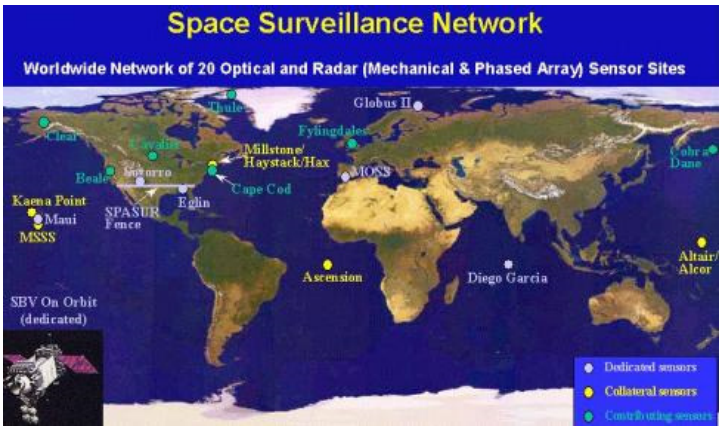


Fig. 12. Space Surveillance Network Sites

Fig. 13. Details of the Russian space tracking network are not as well known, but include mobile maritime platforms, such as this one

The primary SSN optical sensors are constituted in the GEODSS (Ground-based Electro-Optical Deep Space Surveillance) network. This consists of two one-meter telescopes and one 40 cm telescope. They are stated to be able to see baseball size objects. There are currently three operational GEODSS sites in New Mexico, Hawaii and Diego Garcia. These sites are also being augmented by smaller optical telescopes at various global locations.

Fig. 14. The Diego Garcia site

CleanSpace One

CleanSpace One is a project by EPFL. It is meant to grab individual pieces of space junk and to drag them into the atmosphere where the device and the debris both burn out. The devices are small and cheap. They have a robotic arm and are meant to be used only once.

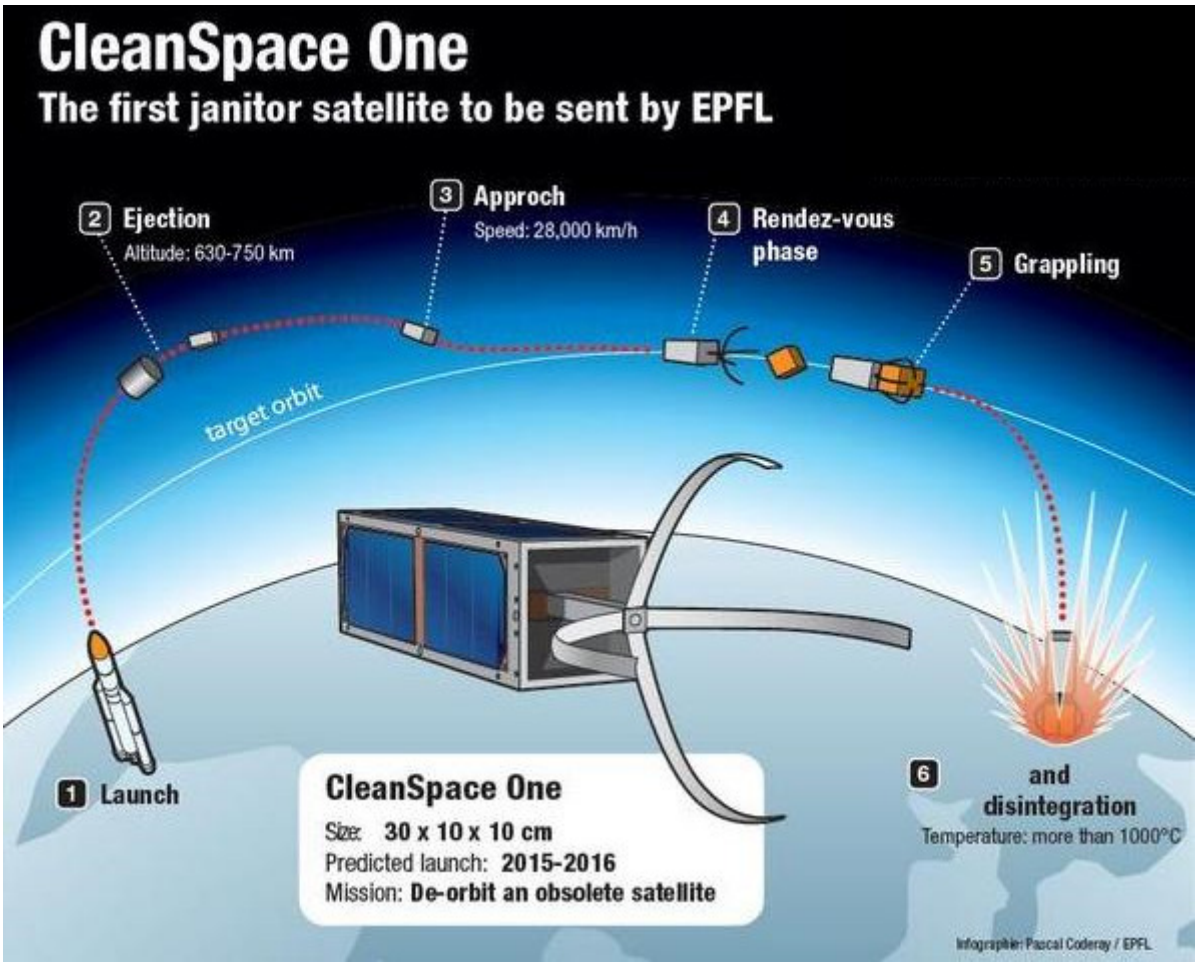


Fig. 15 The CleanSpace One project

Advantages:

- Fast and easy solution of the problem;

Disadvantages:

CleanSpace One has its disadvantages as well. We used them as an example for designing our solution. These are some of the most important points, which made us think that CleanSpace One is not the best possible solution. We wanted to make our suggestion better:

- The devices are practically kamikazes – they burn alongside with the piece of debris they are disposing of;
- There is no possibility to recycle any of the material or to use it again in any way;
- This method can work only on a small fraction of the space debris;

- Launching the CleanSpace One devices generates more space debris;
- Only one piece of space junk per a device;
- It actually pollutes the atmosphere of the Earth;
- This project is economic inefficient.

Fishing nets

In 2011 the Japan Aerospace Exploration Agency teamed up with Nitto Seimo, a manufacturer of fishing nets, to build a giant net that will sweep up space debris in LEO.
After a few weeks collecting debris, the net will be drawn back to Earth, and is going to burn in the atmosphere together with the collected space debris.

Advantages:

- It would solve the problem with space debris;
- It gathers more than one piece of space junk.

Disadvantages:

- Same as CleanSpace One, it doesn't offer the opportunity to recycle the space debris;
- Same as CleanSpace One, it contaminates the Earth's atmosphere;
- It cannot be produced in the near future.

Lasers

NASA plans to use lasers. But not to destroy the debris (eventually leading to more space junk) but to push it out of the way of satellites and the ISS. The laser is thought to cost around $1 000 000 and is planned to be mounted on one of the Earth's poles because of the thinner atmosphere there.

Advantages:

- Cheaper than every other suggested method;
- It can be manufactured really soon and can solve the problem fast.

Disadvantages:

- It doesn't actually solve the problem with space debris. It just deals with the consequences of the problem.

1.2. NEO Asteroids

1.2.1. Definition and characteristics

NEO stands for Near Earth Objects. These are all objects close to the Earth. For them is typical to have a perihelion smaller than 1.3 AU (around 194 477 231km). These objects include a couple of thousand asteroids, some comets and from time to time spaceships (from Earth). Their analysis began in the 1980s when the possibility of collision was realized.

We are most interested in Near Earth asteroids because of two things. On the one hand because the real possibility of a global catastrophe, and on the other hand because they could be used for industry purposes.

To this moment more than 9300 NEAs (Near Earth Asteroids) have been discovered and studied. Most of them are small asteroids between 1m and 32km. The ones with a diameter bigger than 1km are around 1000.

The Near Earth Asteroids do not tend to stay in their orbit for a long time (at least no longer than a couple of million years). Because of their closeness to the Sun and the planets, the NEAs eventually collide with one of the bigger objects in the Solar System. The main reason to observe asteroids so far away from the main belt is the Yarkovsky effect and the orbital resonance caused by Jupiter.

NEAs are classified in four groups according to their semi-major axis (a), Perihelion (q) и Aphelion (Q):

- Atiras – Q<0.983 AU, a<0.983 AU; between the Earth and the Sun;
- Atens – a<1AU, Q>0.983 AU; crossing the Earth's orbit;
- Apolos - a>1AU, q<1.017 AU; crossing the Earth's orbit;
- Amors - 1.3 AU>q>1.017 AU, a>1.017 AU; outside the Earth's orbit, some are crossing the orbit of Mars.

Chances of collusion

Every year an asteroid 4m in diameter hits the Earth. Once every 5 years a bigger one – 7m in diameter collides with our planet. The energy that is released is around the energy of the nuclear head used in Hiroshima or 15kt of TNT. However all of this happens in Earth's atmosphere and almost nothing actually hits the Earth.
It's very rare an event like the Tunguska event when a bigger asteroid hits the Earth and causes damage to the surface. Sometimes this leads to a massive eco-

catastrophes. Theoretically, objects bigger than 1km hit the Earth every half a million years, asteroids around 5km in diameter collide with Earth every 20 million years. For the last 100 years there are several events of relatively big asteroids collided with our planet:

- Tunguska event – 1908, 45-70m in diameter;
- Brazilian event – 1930, diameter unknown, mass between 1 and 25 thousand tones;
- Vela incident – 1979;
- Eastern Mediterranean event – 2002, 10m in diameter;
- Indonesian event – 2009, 10m in diameter;
- Chelyabinsk event – 2013, 10-20m in diameter, 11 000 tines of mass.

Many more asteroids have missed the Earth by little. The hazard is real and statistically speaking absolutely certain. That's why it is necessary to prepare ourselves and to do something about it. This is why NEAs are such a big part of our project.

1.2.2. Choosing an asteroid

We split the work on the asteroid in two. First was the research (both on paper and online) and then was the scientific part (observations and processing).

Fig. 16. Nedelcho Laskov processing images of the asteroid

Fig. 17. Nedelcho Laskov with one of the telescopes in the NAO 'Rozhen'

Research: While choosing the asteroid we had two main criteria.

A) The orbit of the asteroid – we wanted the asteroid to be NEA;
B) The size – the dimensions of the asteroid had to be in a specific interval 1000-2000m.

Based on these two criteria we chose the asteroid labeled 251346 (2007 SJ).

The Near-Earth Asteroid (NEA) 251346 (2007 SJ) was discovered by the LINEAR Sky Survey on 17 Sep 2007. The discovery was published in MPEC 2007-S17. The diameter of the asteroid is between 1.3 and 2.8km. This object has even been designated as a Potentially Hazardous Asteroid (PHA) by the Minor Planet Center. The asteroid was observed by M. Hicks (JPL/Caltech), S. Ebelhar (PCC) and students from Los Angeles City College at the JPL Table Mountain 0.6-m telescope. The photometry of 2007 SJ revealed the rotation period to be 2.718+/-0.007 hrs.

Discovery Circumstances:	**LINEAR - Lincoln Laboratory ETS, New Mexico 17 Sep 2007**	**Details**
Orbital Type:	AP	orbital type derived from osculating orbital elements
Diameter:(km)	1.3 - 2.8 km	diameter range derived from H and assumed albedo for C and S type - 0.04 and 0.20 respectively
H:(mag)	17.16	
Rotation Period:(hrs)	2.718	
Lightcurve Amplitude:(mag)	0.2	

Table 1. Some of the most important parameters of the asteroid 251346 (2007 SJ)

The orbital elements of 251346 (2007 SJ) are based on 858 observations.

Orbital Elements at Epoch 2456600.5 (2013-Nov-04.0) TDB
Reference: JPL 134 (heliocentric ecliptic J2000)

Element	Value	Uncertainty (1-sigma)	Units
e	.5345840693590473	9.126e-09	
a	2.014412034626643	2.5952e-08	AU
q	.9375394517900941	1.6501e-08	AU
i	8.192310859158274	2.9245e-06	deg
node	306.8829199890984	1.819e-05	deg
peri	174.9912497909334	2.1919e-05	deg
M	332.829613728698	2.0852e-06	deg
t_p	2456679.315965455222 (2014-Jan-21.81596546)	5.3165e-06	JED
period	1044.289443681884 2.86	2.0181e-05 5.525e-08	d yr
n	.3447320110129014	6.6618e-09	deg/d
Q	3.091284617463192	3.9825e-08	AU

Orbit Determination Parameters

# obs. used (total)	858
# delay obs. used	2
# Doppler obs. used	0
data-arc span	8498 days (23.27 yr)
first obs. used	1990-10-14
last obs. used	2014-01-19
planetary ephem.	DE431
SB-pert. ephem.	SB431-BIG16
condition code	0
fit RMS	.44445
data source	ORB
producer	Otto Matic
solution date	2014-Feb-01 06:44:10

Additional Information

Earth MOID = .0449053 AU
T_jup = 3.624

Table 2. The orbital elements of the asteroid 251346 (2007 SJ)

The Asteroid 251346 (2007 SJ) passed very closely to Earth on 21.01.2014 at a distance of 18.9 LD (LD means "Lunar Distance." 1 LD = 384,401 km).
With the help of JPL's software Small-Body Database Browser we made a model of the orbital diagram of the asteroid 251346 (2007 SJ) for 21.01.2014.

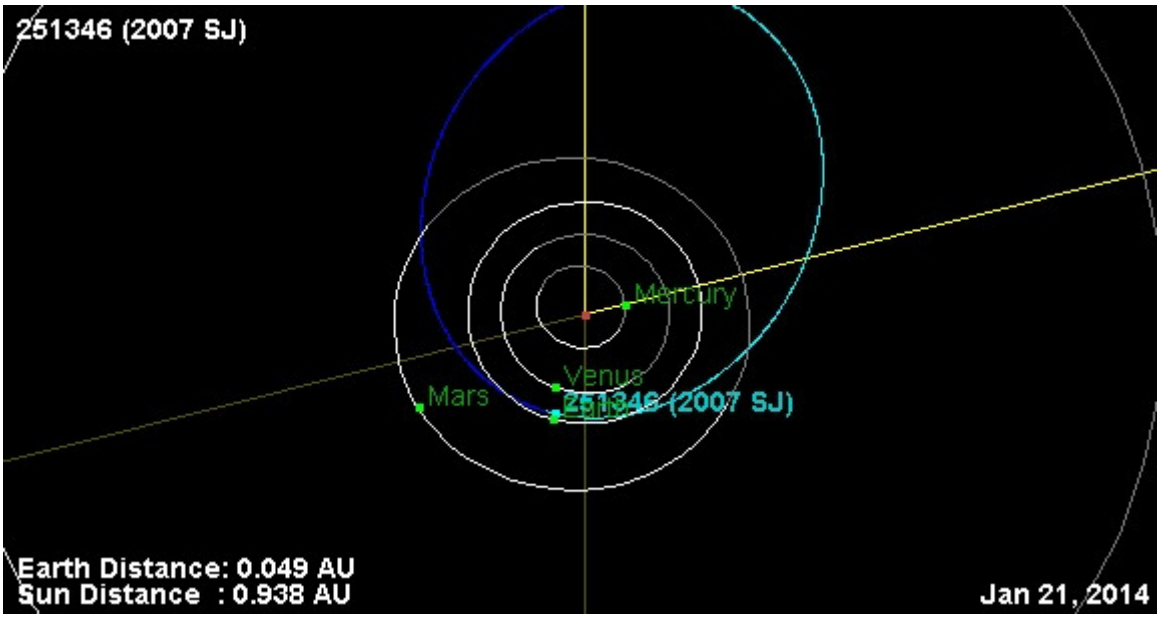


Fig. 18 . The orbital diagram of the asteroid 251346 (2007 SJ)

This asteroid is one of the Apollo asteroids. They are Near Earth Asteroids and cross the Earth's orbit. They have orbital semi-major axes greater than that of the Earth but perihelion distances less than the Earth's aphelion distance.
As of March 2013, there are 5229 asteroids known to be part of this group. The Apollo asteroid group is the largest group of NEAs.

1.2.3. Observation, processing and analysis

In the astronomy courses in the Astronomical observatory in Varna we learn to work with professional telescopes as astronomers. Together, with our supervisor Dr. Veselka Radeva participate in the observation campaign Target Asteroids, part of NASA's OSIRIS-Rex space mission. The asteroid 251346 (2007 SJ) was one of the many in the list of objects of the space mission that is sent to all participants. We prepared the ephemeris (the table with the coordinates of the asteroid for the period 21-27.10.2013) and decided to make astronomical observations of this asteroid with the Schmidt telescope in the National astronomical observatory - Rozhen.

We conducted the observations during the fall astronomical academy in the National astronomical observatory "Rozhen" in the nights of the 21st to 27th of October 2013 with the 50/70 Schmidt with the CCD-hardware. We made sure to always adhere to the requirement that the object of the observations is more than 30 ^{o} over the horizon at all times.

Fig. 19. Nedelcho Laskov in front of the Schmidt Telescope in NAO Rozhen

Fig. 20. Ivan Popov and Nedelcho Laskov with the students in the International Astronomical Summer School in NAO Rozhen (the picture is a part of V. Radeva's personal archive)

The participants from the team in the National astronomical observatory "Rozhen" during the astronomical academy, when the asteroid was observed
The optical parameters of the telescope are: diameter of the Schmidt-plate - 50cm; diameter of the spherical mirror - 70cm; focal length - 172cm, the CCD-hardware is type FLI PL 16803.

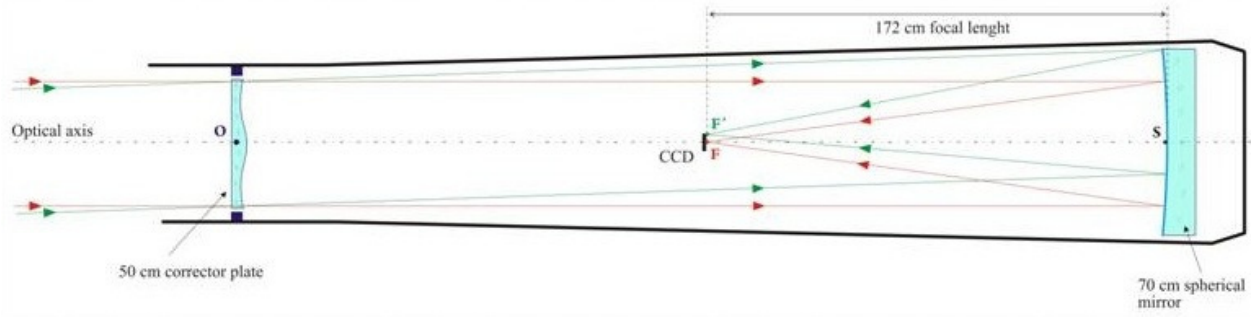


Fig. 21. Optical scheme of the Schmidt Telescope

We prepared the ephemeris with the coordinates of the object, and following the procedure for cooling of the CCD camera we pointed the telescope to the area of the sky, where the asteroid was. We got 96 images of the asteroid. We used a red "R" filter, in which the CCD-matrix has the highest sensitivity, and a "V" filter. Every image is shot with a 180-second duration. The control of the telescope and the camera for the obtaining of astronomical images were made with the program MaxIMDL, while using the computer software Astrometrica we identified the object. We measured it and calculated its equatorial coordinates - Right Ascension α and Declination δ.

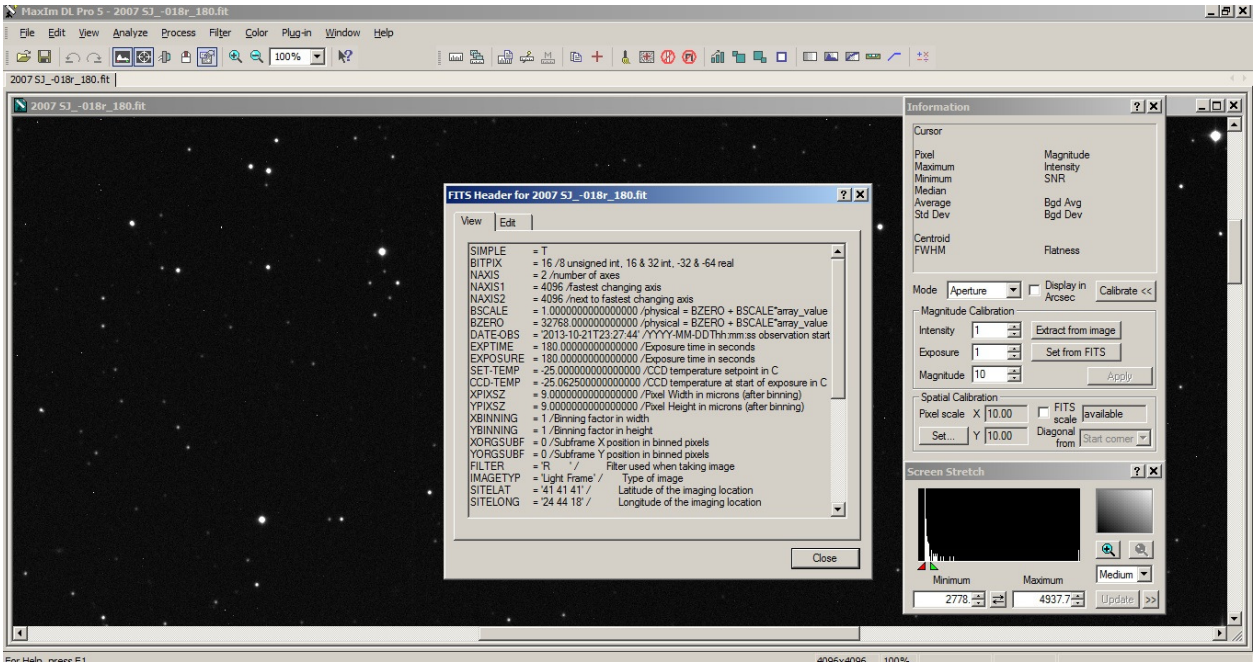


Fig. 22 . Screenshot of the MaxIMDL software

The preparation for the observation included activating the system that follows the movement of the stars on the telescope, cooling the CCD camera, preparing the star catalogues for identification of the star images, obtaining special images (of “dark frame” and “flat field”) for cleaning of the defects.

The control of the telescope and the camera for the obtaining of astronomical images were made with the program MaxIMDL. We used a red and a yellow-green filter and every image was obtained for 180 seconds.

Here is the asteroid in the observation night of:

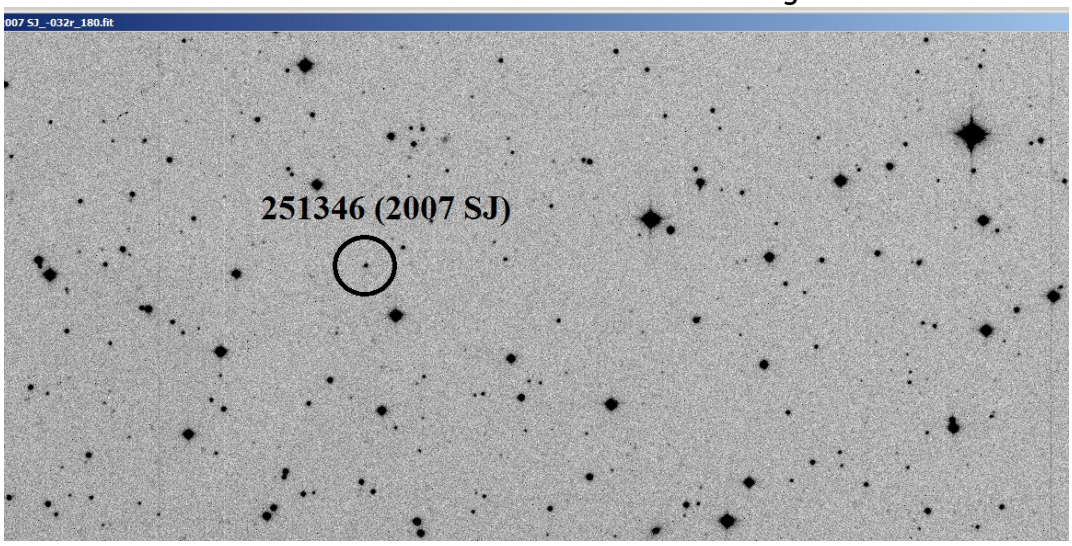


Fig. 23. The location of the asteroid during the observation night of 21.10.2013

We prepared a report for the Minor Planet Center in Harvard which contains information for the equatorial coordinated. Our results have become a part of the database for the movement of the asteroid and contribute to the more accurate identification of its orbital elements. As a result of the telescopic observations we obtained 96 digital images. To determine the equatorial coordinates of the asteroid and its rotational period we performed the following tasks:

1. Finding the asteroid in the star field. We used the Astrometrica software to identify the asteroid amongst the stars in every image.

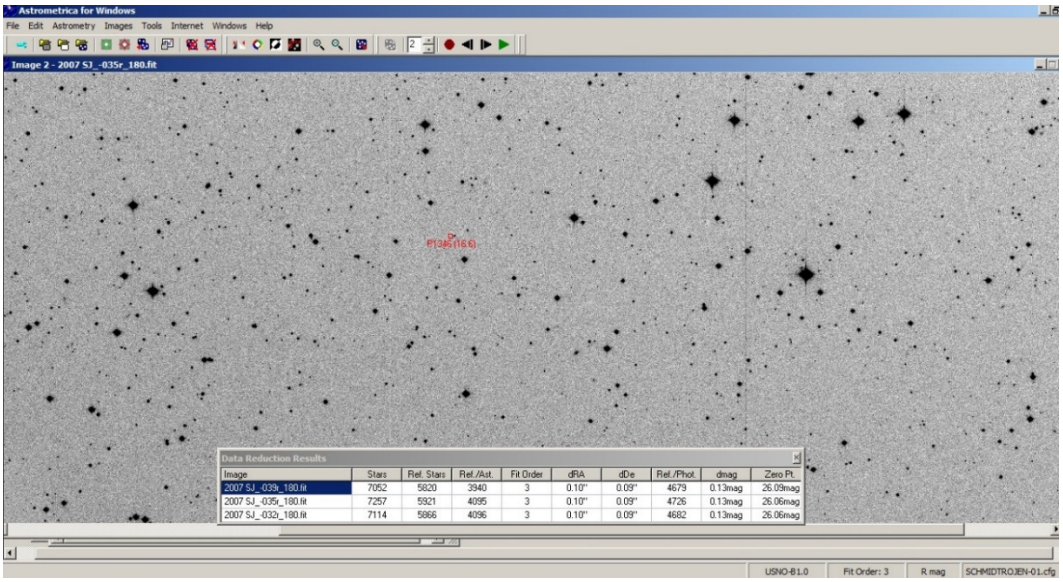


Fig. 24. The identified asteroid in the star field

2. Using Astrometrica, we determined the equatorial coordinates, Right Ascension α and Declination δ of the asteroid in all images.

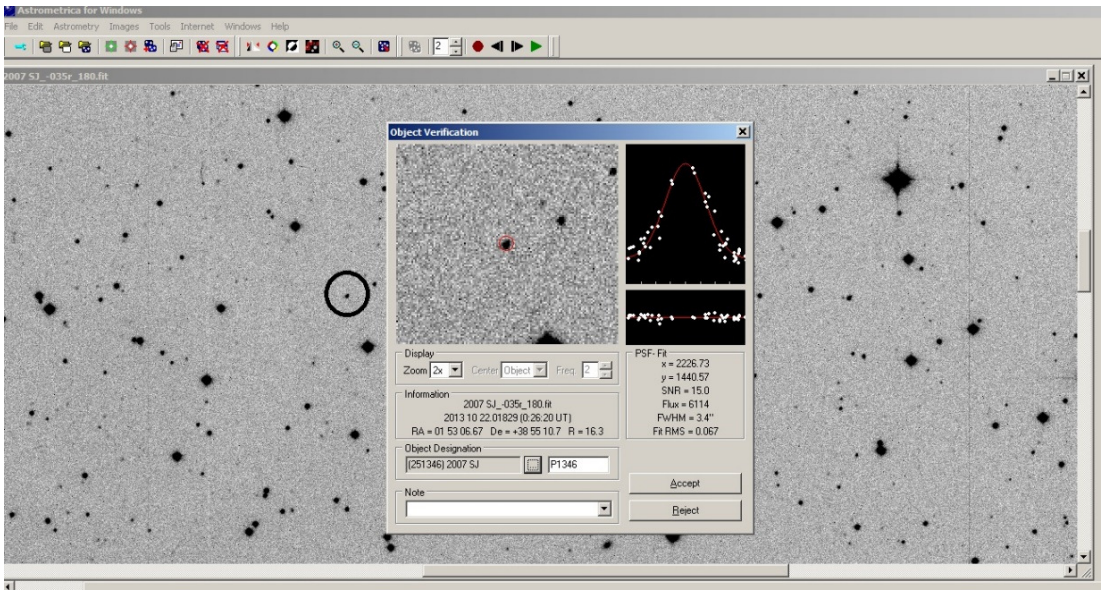


Fig. 25. The procedure for the determination of the equatorial coordinates of the asteroid for all 96 images.

We formed a report from our measurements and sent it to the Minor Planet Center in Harvard.

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COD 071
OBS V.Radeva & students
MEA V.Radeva
TEL 0.70-m f/3.44 Schmidt + CCD
ACK MPCReport file updated 2013.11.09 14:00:18
AC2 veselka.radeva@gmail.com
NET PPMXL
P1346          C2013 10 21.89686 01 51 40.36 +38 33 40.4          16.7 R      071
P1346          C2013 10 21.89921 01 51 40.16 +38 33 42.2          16.8 R      071
P1346          C2013 10 21.90154 01 51 39.89 +38 33 44.5          16.7 R      071
P1346          C2013 10 21.90389 01 51 39.62 +38 33 46.6          16.6 R      071
P1346          C2013 10 21.90858 01 51 39.19 +38 33 52.4          16.8 R      071
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P1346          C2013 10 21.91324 01 51 38.67 +38 33 54.7          16.7 R      071
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P1346          C2013 10 22.00429 01 51 29.06 +38 35 13.1          16.7 R      071
P1346          C2013 10 22.00662 01 51 28.83 +38 35 14.8          16.8 R      071
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Fig. 26. The report with a part of our astronomical measurements of the asteroid

1.3. Location of the settlement

Because of its specific tasks and the different work stages our settlement will not have a permanent location.
The momentary location of the settlement will be determined by its current task and that, what is necessary for best results.
Depending of the specific stages of development and work there will be a few key positions, where our settlement will be temporary located:

	Stage	Location
1.	Construction and cleaning of the space wastes	Orbit around the earth (height around 36 200 km – right above the graveyard orbit)
2.	Cleaning of Lagrange points	The corresponding Lagrange point
3.	Industrial mining NEO Asteroids	The surface of the corresponding asteroid

Table 3. Location of Greenspace in the different stages of development

Stage1
The space debris are located in the so called graveyard orbit, exactly above the geostationary orbit, between 35 900 and 36100 km. Since in this stage the settlement is going to clean the space it must be close to the most polluted orbits. That is why we chose for location of our settlement Earth orbit exactly above the graveyard orbit, so that the Space Cleaners can drop above the debris through decrease in their speed. Moreover when the orbit is higher the speed with which an object has to move is lower. This would ease much the construction of the settlement and the docking of spacecrafts.

Height of the orbit, velocity of the settlement
The Earth's gravitation field influences each and every object near the Earth itself and causes an acceleration pointed towards the Earth's center with numeric value calculated through the formula:

$$g = \frac{\mu}{(R + H)^2}$$

Where **R** is the average radius of the Earth (around **6371** km), **H** is the height of the object's orbit and **μ** is a constant, where **μ = G*M, G** is the gravitational constant (approximately **$6.673*10^{-11}$ $(N*m^2)/kg^2$**). On the other side an object moving around the Earth is also under the influence of the centrifugal force, causing acceleration, which can be calculated with the formula:

$$a_{cf} = \frac{v_0^2}{R + H}$$

Where v_0 is the linear velocity (taking the center of the Earth as a reference point). When g > a_{cf} the object is falling to the Earth's surface and when g < a_{cf} the object is leaving the Earth. When g = a_{cf} the object starts orbiting the Earth. Solving the equation which is achieved when g = a_{cf} we can easily see that the linear velocity of the object taking the center of the Earth as a reference point will be:

$$v_0 = \sqrt{\frac{M \times G}{R + H}}$$

Another two important quantities, characterizing and important for the orbit are the angular velocity of the object (**ω**) and the linear velocity (taking Earth's surface as a reference point) (**v**):

$$\omega = \frac{v_0}{\mathrm{R} + \mathrm{H}}$$

$$v = v_0 \times \frac{\mathrm{R}}{\mathrm{R} + \mathrm{H}}$$

Our settlement is exactly that type of object which should achieve a stabile orbit on the chosen by us height of **36 200** km. Using the formulas above we can easily calculate the linear velocity of the object taking the center of the Earth as a reference point:

v_0 = 3059 m/s = 3,059 km/s

The linear velocity taking Earth's surface as a reference point will be:

v = 457 m/s = 0,457 km/s

and the angular velocity:

ω = $7.1856*10^{-5}$ rad/s

The orbit of our settlement will be a circle with radius r=R+H, approximately 42571, its length will be **P = π *2*r,** approximately 267481,5 km and the time for which the settlement will make a full lap will be 24 hours and 45 minutes, a little bit more than the geostationary orbit (the higher a certain orbit is, the slower the object moves and the more time it takes for a full lap) and every 32 days the settlement will be right above the same place on the Earth's surface as 32 days before that (every 32 days the settlement will fall behind with one lap from the Earth).

Stage 2

After the complete cleaning of the Earth's vicinity, our settlement will start cleaning the Lagrange points. Because of their gravitational properties it is supposed that they will be filled with lots of small space objects. They make the Lagrange points practically unusable. Also among these space objects might be some valuable metals, minerals and other useful substances.

The cleaning of the Lagrange points will be performed in such sequence, depending on which one will be the closest to the settlement in the moment of the finishing of Stage 1 or depending on which one will be used in the near future.

Stage 3

During the third stage of its development our settlement will mine NEO asteroids. It will attach itself to the chose asteroid through a special device. While the settlement is mining the asteroid it will remain attached to it and will follow it on its way around the Sun. After depleting its resources, our settlement will find itself a new target and move towards it. The processing of ore and various substances will proceed simultaneously. The gather of recourses will be interrupted only by the switching of asteroids.

Movement of the settlement

The movement of the settlement between the different locations will be achieved through the mounted engines, which are described in 3.3.


Space-Ecological
Application

2.1. Space debris

Our project aims to find a solution to one of the most serious environmental issues we face right now - space debris (also called “space junk”).
Space debris are formed by parts from currently-nonfunctional satellites, rocket stages and other spacecraft. Huge clouds of those particles move in orbit around the Earth and although they may not seem harmful, at any time they can collide with functioning satellites and damage whole systems and networks.

2.1.1. Our solution for the debris problem - The Space Cleaners

Our aim was to simplify the production of the devices as much as we can and to minimize all costs. At the same time, however, we had to consider the various dimensions of the space debris – from a few millimeters (dust-like particles) to a few meters in size (whole parts from satellites) That meant that we needed to have different machines for the different kinds of space junk, in order to be able to clean the near-earth space quickly and easily.
Taking into account these requirements, we decided to have two types of cleaners with a maximum amount of common parts:

- **Type S –** cleans the debris smaller than 1 cm (nuts, bolts, dist-like particles);
- **Type L –** cleans the debris bigger than 1 cm (from small pieces to bigger portions of inactive satellites).

Shared components

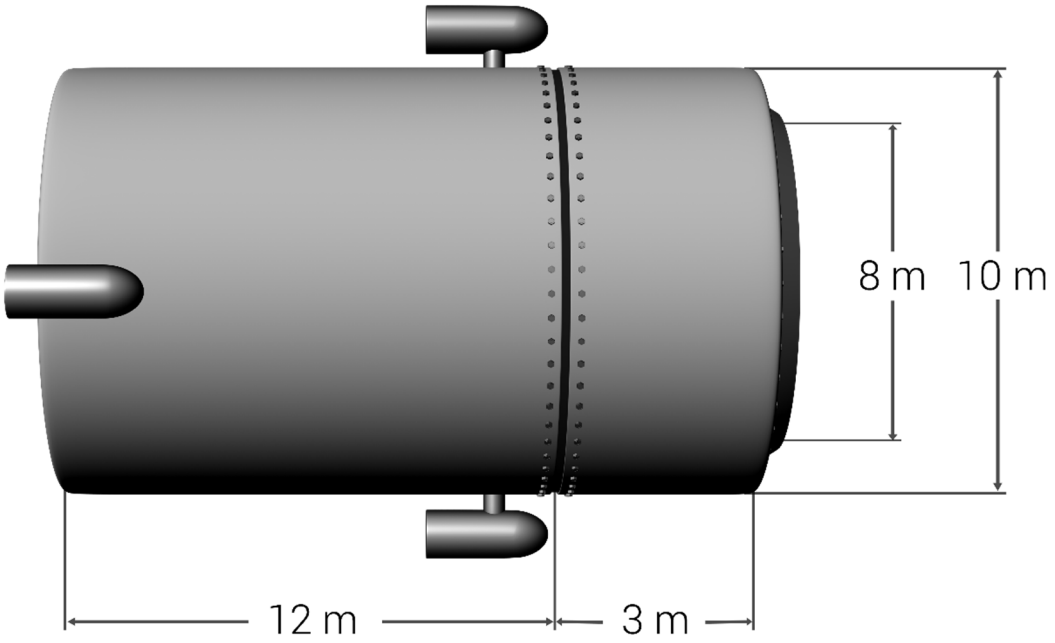


Fig. 27. Size of the shared components of the Space Cleaners

The variety of the debris is what calls for the two different types of cleaners. This means that the only necessary difference between the two devices is the method of its removal. The particle containers of the cleaners and the way they move is the same, no matter the type of junk they collect.

To insert a piece of debris in their containers, the cleaners have to move very close to it. For this to happen, they need to be very mobile and maneuverable. Both Type S and Type L are equipped with four rocket engines, whose specific placement helps the cleaners get their maneuverability and stability. That way they can easily move through the clouds of debris and always choose the optimal route.

The machine's container is separated from their front part with a special inner door, similar to the outer one. The inner door aims to prevent accidental release of the already collected particles during their chaotic movement. It also takes part in the particle compaction in Type L.

Type L

In order to cope with the bigger size of the debris, Type L is equipped with 4 robotic arms, each with 4 joints – for a maximal scope, and 8 fingers, for a better grip of the pieces of space junk. That way every L can carry a few small objects with the fingers of each hand, or use the 4 arms at the same time to hold a bigger piece from a satellite.

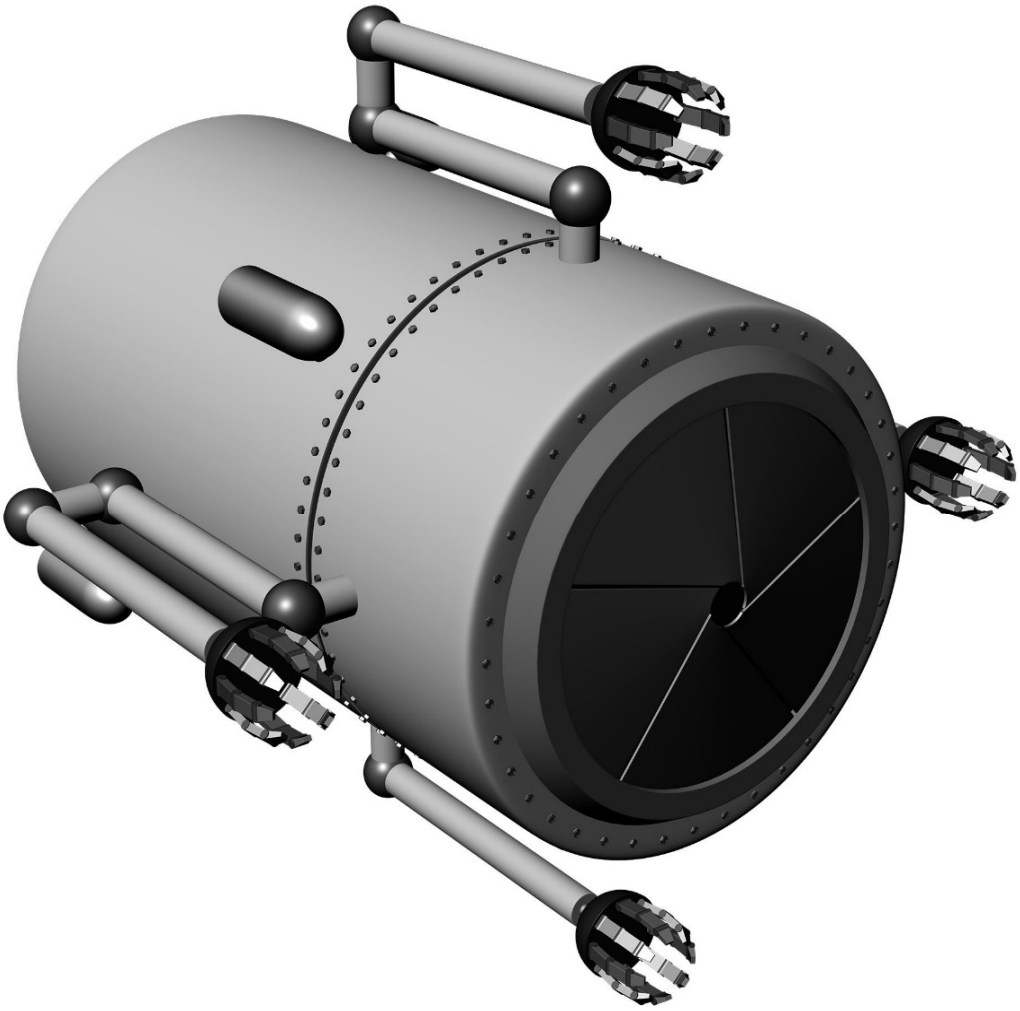


Fig. 28. Our design of the Type L Space Cleaner

In order to increase its capacity and reduce the number of courses needed to complete our goal, every cleaner from this type has a hydraulic press, similar to the ones found in garbage trucks. With it, the various particles will be pressed, so that they take less space and not move freely inside the container. When more than 90% of Type L's container is full, the press at the bottom is activated, which flattens the collected debris, allowing it to gather more afterwards.

Type S

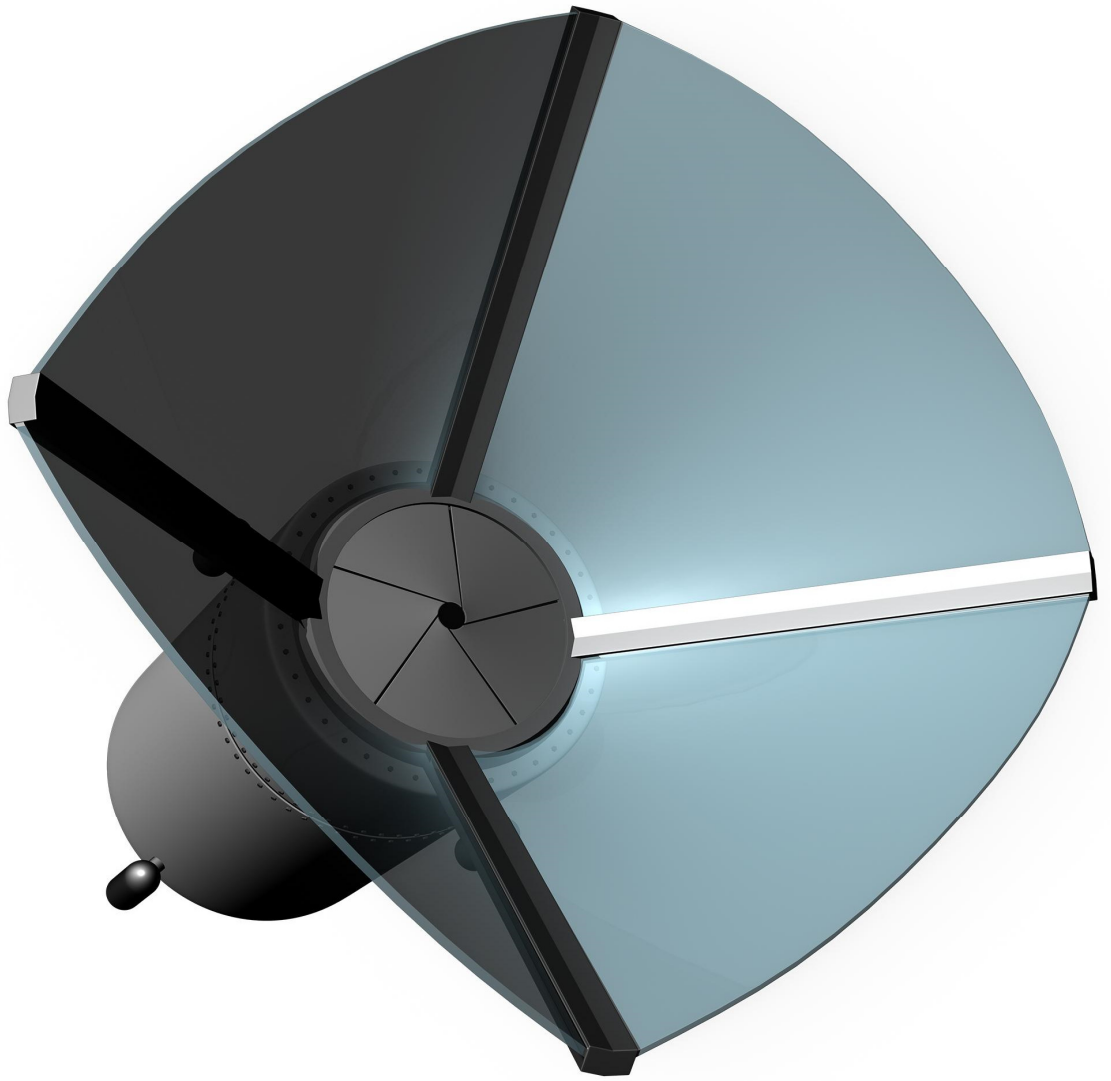


Fig. 29. Our design for the Type S Space Cleaner

With Type S, the particles are smaller and move more chaotically (even though they move into clouds). That suggest a different structure of the cleaner, so instead of robotic arms, S has an appliance at the front, which works as a funnel. The device overtakes the cloud of debris and with its funnel sends them through the door to the container, where they are held during their transportation to the settlement.

2.1.2. Space cleaning program

Collecting the space junk is only the first stage of the preservation of the near-Earth environment. For us it is important not only to clean it once, but also to keep it clean in the future.

In order to keep the Solar system pollution-free, we plan to bring in a system of rules, which regulate the long-term use of all types of spacecraft. That way, every owner of a satellite or another object in space is responsible for its maintenance. For the introduction and adherence of these rules will vouch the agency *Clear Sky,* composed of representatives of different international space agencies.

Clear Sky's activity is directly connected to the creation of our space settlement.

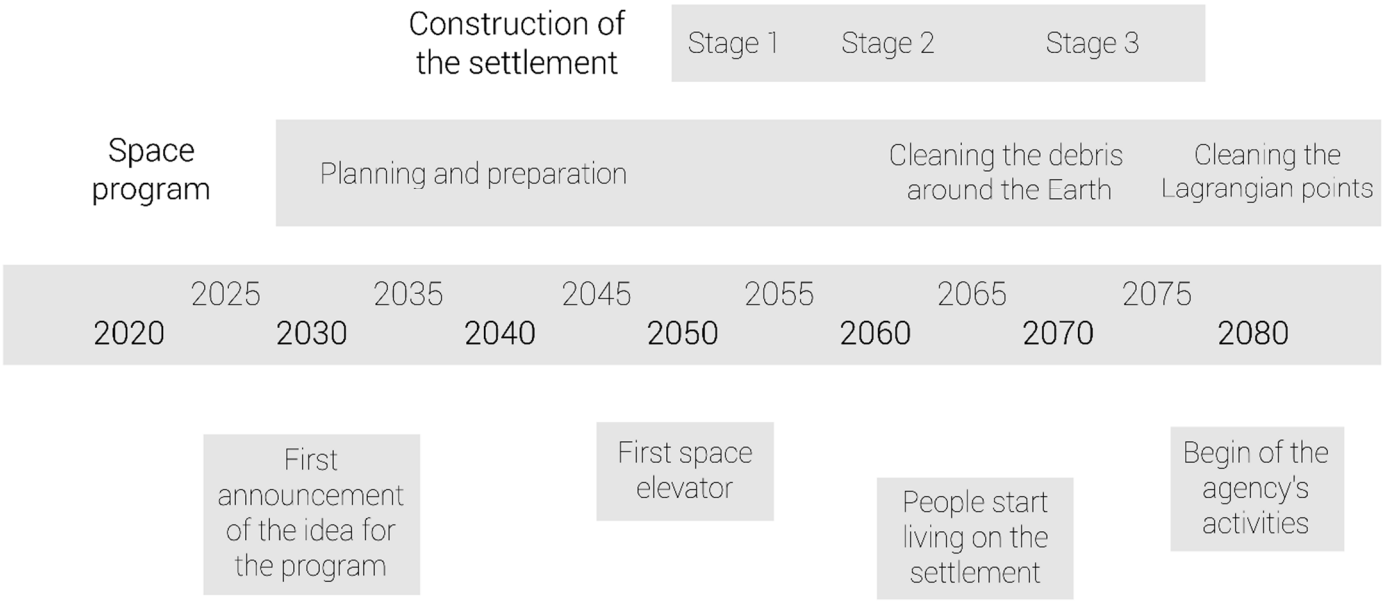


Table 4. Timetable of the settlement's development

The organization will work with strict rules and will watch for the adherence of laws, made specifically to preserve the clean and safe state of the near-Earth environment and space as a whole. It will be an international, independent organization, executing all spacecraft launches and keeping detailed records of all active devices, as well as of those that need to be cleaned.

The main principles that Clear Sky will follow are:

1. For every object launched into space, the respective responsible individual (enterprise, organization, country, etc.) will pay a “Space debris” tax, the size of which will be dependent on the volume, mass and type of the spacecraft – rocket, satellite, space station, etc. This tax will provide for the removal of the object’s remains, once it goes out of use.

2. For every launched spacecraft a detailed record will be kept, describing its qualitative and quantitative content, function, duration of use, orbit data et al. That way the precise coordinates and orbit of every object will be known at all times and the location of every object in LEO will be available.

3. Every action that will or could increase the amount of space debris will be prohibited. Such are: the purposeful destruction of an object, own or foreign; the uncoordinated change of an object’s orbit and others. After the end of a spacecraft’s usage, the settlement should take care of its removal and recycling. In case of violations, the responsible will have to pay special fines. Depending on the case and the size of the destruction, the fine will vary.

2.2. Asteroid mining

During the forming of the Earth, its gravity pulled all the heavy elements like gold, cobalt, iron, manganese, molybdenum, nickel, osmium, palladium, platinum, rhenium, rhodium, ruthenium, and tungsten closer to its core. This left the crust extremely poor in these very important for the human race elements.

Still we can find some of the mentioned elements in very small amounts. This is thanks to all the asteroids which hit the Earth after the crust cooled.

The important fact is that asteroids are rich in elements which are really hard to find and in small amounts on Earth. While the humanity develops, science progresses and the technology advances, these elements become more and more important and the need for them will grow.

The goals of asteroid mining

- **Space safety**

It's often very small in size asteroids (micro-asteroids) to fly close to the Earth (closer than a Moon Distance). These micro-asteroids are dangerous for the Earth and for its satellites.

Every day in the Earth's atmosphere enter thousands of micro-asteroids. While falling they burn out. The elements they were composed of oxidize and are practically lost to humans. Some of the micro-asteroids are big enough to reach the surface and could be dangerous to humans and could damage property.

If these small but close to Earth asteroids are retrieved it would be a great economic advantage and would contribute the Earth's safety.

Although less likely, it's possible for a larger asteroid to hit the planet. If the warning goes off soon enough, Greenspace can offer two solutions:

- The asteroid's orbit can be influenced with continuous operation of the settlements engines;
- Another option is to process the asteroid like it is a mining object, reducing its size to a point when it is no longer a danger.

But maybe the best solution would be a combination of the two mentioned. Reducing the asteroids size would make it easier to change its orbi.

- **Economic advantage**

With technology and science developing, the need for those rare metals will grow *(gold, cobalt, iron, manganese, molybdenum, nickel, osmium, palladium, platinum, rhenium, rhodium, ruthenium, and tungsten)*. The mining and extracting them are often too slow and not enough. And that's not going to change. And their price will go up all the time. Mining asteroids will result in a production of rare and expensive metals, which are widely used in industry. To bring the metal or the ore back to Earth might not be the smartest thing and could be inefficient. But if we use it in space to produce satellites, spaceships, shuttles, probes, etc. we will save a lot of money and resources from launching them into orbit.
The lack of gravity or the leaker one could also benefit the production of these metals.

The mining program

- **First stage**

Simultaneously with the cleaning of the space debris, micro-asteroids closer than one Moon Distance will be retrieved. They could be handled with the Space Cleaners Type L as the cleaners have everything that it takes to retrieve a micro-asteroid.

- **Second stage**

After the space debris are removed and the cleaning process is completed, the mining of big NEO asteroids will begin. The settlement will attach itself to the asteroid via a special device that we created – the Octopus (see 3.3 Engines and other constructions). The Octopus will catch the asteroid by enclosing it with its tentacles – many super strong ropes which will hold the asteroid and Greenspace together. While the settlement is mining the chosen asteroid it stays attached to it and follows its movement. In the long term Greenspace can start accelerating the asteroid in a specific direction in order to change its orbit around the Sun. After all the goods are completely extracted from the asteroid, another target is chosen and Greenspace moves to the new asteroid. The mining process and the manufacturing of spaceships, satellites, shuttles, probes, electronics, robots, smart-dust, etc. are done simultaneously and continuously.

2.3. Global warming

The global warming problem

Because the main goal of our settlement is to solve the ecological problems of the humanity, it was important for us to not only pay attention to the issues in space, but also to the ones on our planet Earth. We are talking about the global warming.

The global warming is the gradual increase of the average temperature of Earth's atmosphere and oceans. This effect has been observed since the end of the 19th century and since then, the temperature of Earth's surface has increased with 0.8 °C.

According to scientists' climate models, during the 21st century the temperature will likely undergo an increase of 1.1 – 2.9°C, which is the lowest emissions scenario, and 2.4 - 6.4°C, which is the highest. This may not sound like much, but scientists predict that an increase in temperature of more than 2.5°C could lead to huge losses in GDP. The increased temperatures will also affect hundreds of millions of people through the increased coastal flooding, the reduced water supplies and increased health impacts.

It's safe to say that we haven't got much time and we need to come up with an effective solution quickly.

Ideas for solution from space

To come up with the most functional solution, consistent with our settlement, we decided to go through all existing suggestions in the field. Here are some of them:

- Dragging a big asteroid (with a mass bigger than 500 000 tons) or a cloud of asteroid dust to L1, in order to hide a part of the sunlight;
- Whitening the upper parts of the clouds, in order to increase their reflectivity by 3% and reflect a bigger amount of sunlight;
- Launching a big mirror with a surface area of 1,600,000 km^2, or many smaller ones, around the Earth, which will reflect 1% of the sunlight. This would be enough to normalize the Earth's temperature.

Our proposal

We decided that using space mirrors would work best of all with our settlement.

Using radio controls, they will be launched from the colony and sent to L1, where they will be in the gravitational balance of the Earth and the Sun. That way they will not be able to scatter and turn into space junk.

A part of the mirrors will be manufactured on the colony itself, using the obtained resources from the mined asteroids and the reworked parts of the space debris. That way we will overcome one of the main disadvantages of this solution: the need for a huge amount of financial resources.

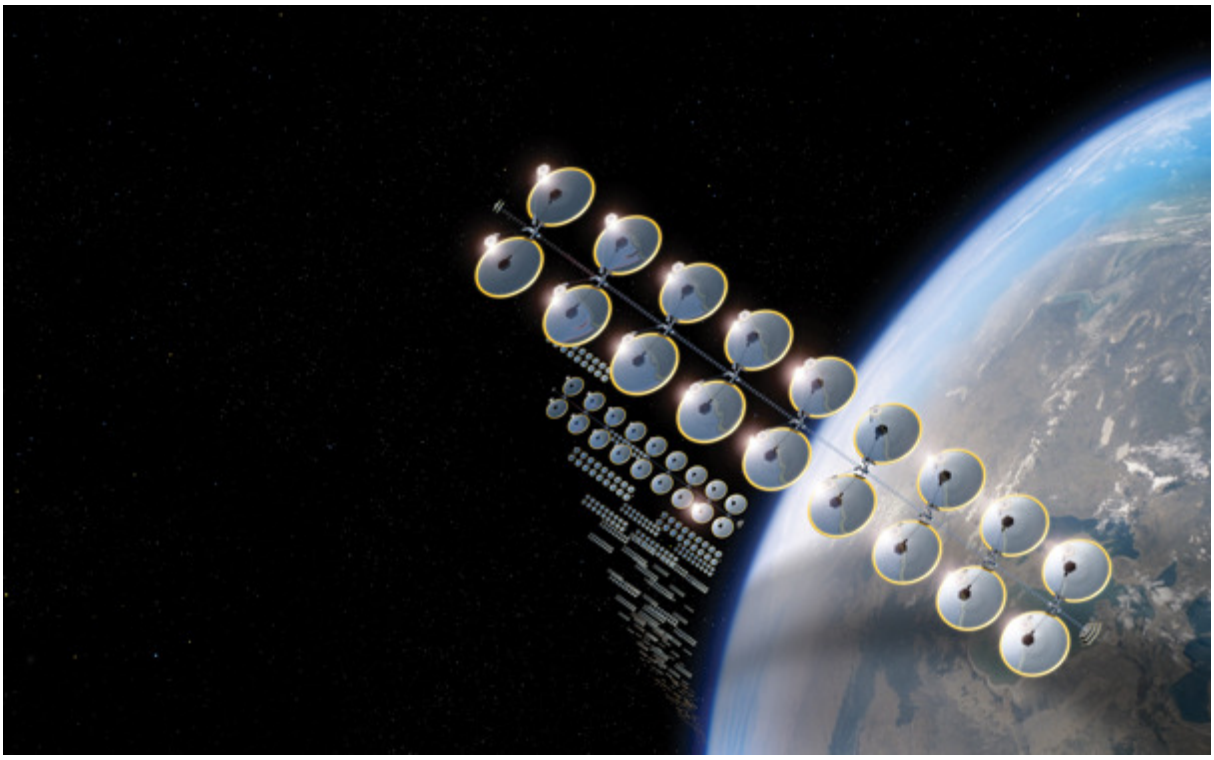
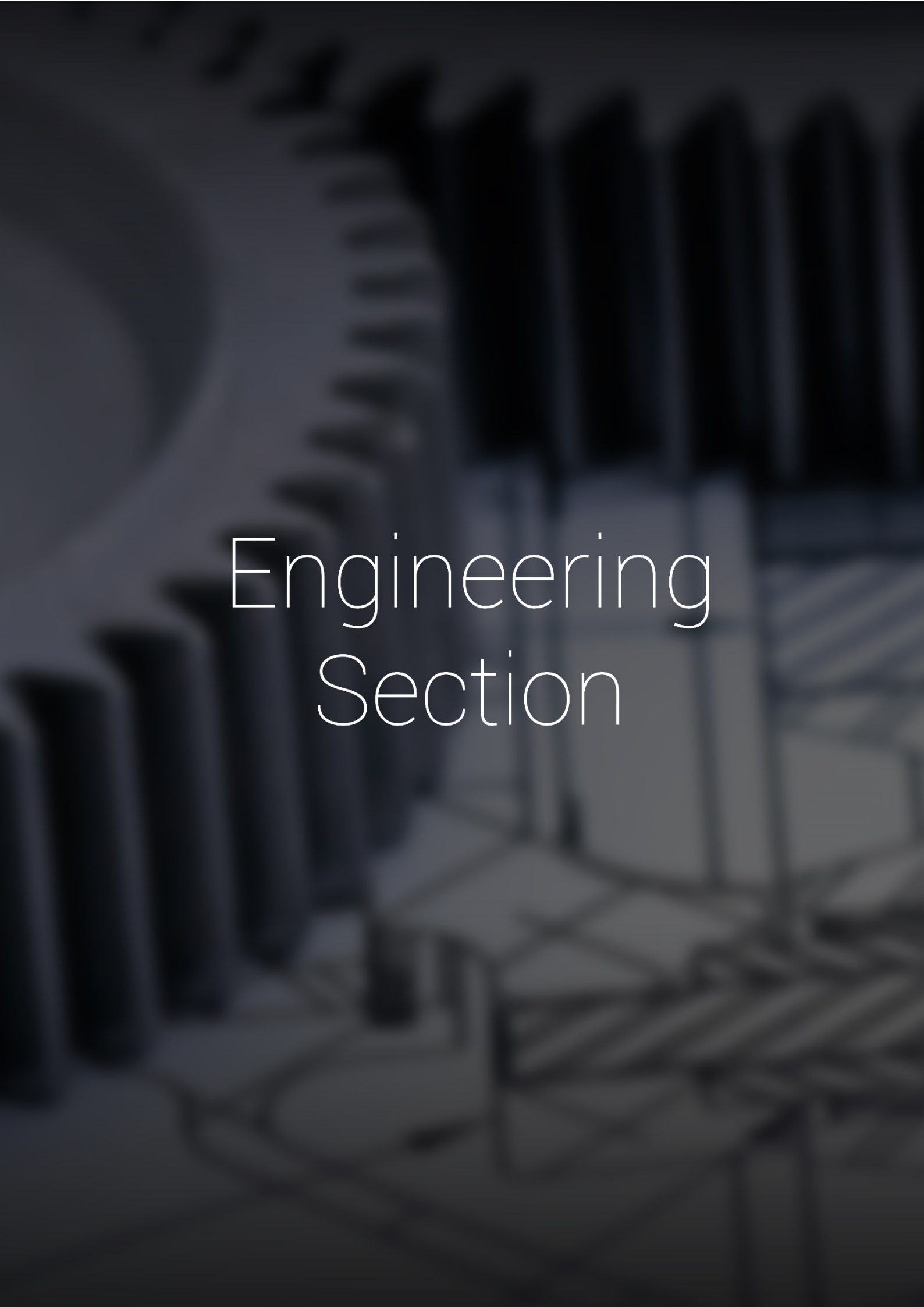


Fig. 30. Our proposal for solution of the Global warming problem

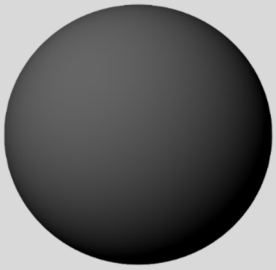


Engineering Section

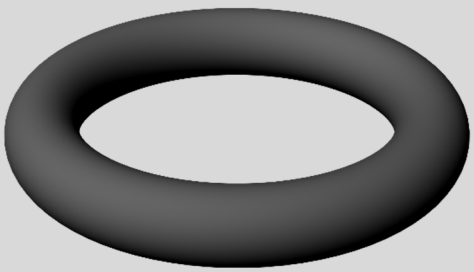
3.1. Form of the settlement

3.1.1. Choosing the form

While choosing the way our settlement would look, we went through all the basic shapes. That way we got to know their advantages and disadvantages so we could choose better. By combining basic shapes together we managed to put in use the good sides of each one and to neutralize.

Sphere	Advantages	Disadvantages
	• Easy access to different parts of the base	• Too complicated construction
	• Stable construction	• Too much material needed
	• Easy access to zero-gravity zone	• Really hard to seal off a part of the settlement, if a problem accrues

Dumbbell		
	• Easier to seal off a part of the of the settlement	• A problem with the connection between the two parts, could threaten the integrity of the settlement
		• The areas with appropriate gravity aren't used efficiently
		• Less living-space
		• Lack of contact between the main parts

Torus	Advantages	Disadvantages
	• Artificial gravity in the whole inner part of the settlement	• Construction must be completely finished to create the artificial gravity
	• Very good usable area/mass ratio	
	• Easy to build using segments	
	• Huge living space	
	• Full use of the areas with normal gravity	

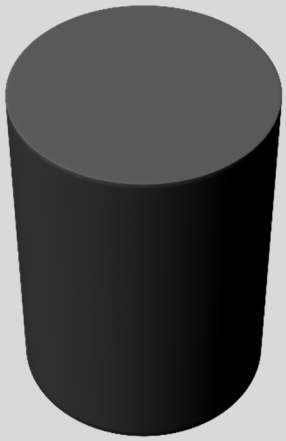
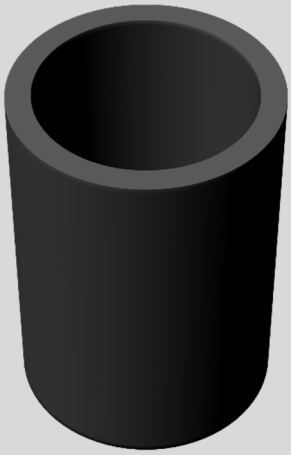
Cylinder	Advantages	Disadvantages
	• Easy access to every part of the settlement	• Changeable gravity in height
	• Using the zones with normal gravity at 100%	• The gravity weakens with the closing on the center so the solid cylinder has bad usable area/mass ratio
	• Easy to build using modules	
	• Easy construction	
	• Stable and secure	
	• The hollow cylinder has excellent usable area/mass ratio	

Table 5. Comparison of the different possible basic shapes

3.1.2. Primary Form

The primary form of our settlement will be a combination of a cylinder and a torus.

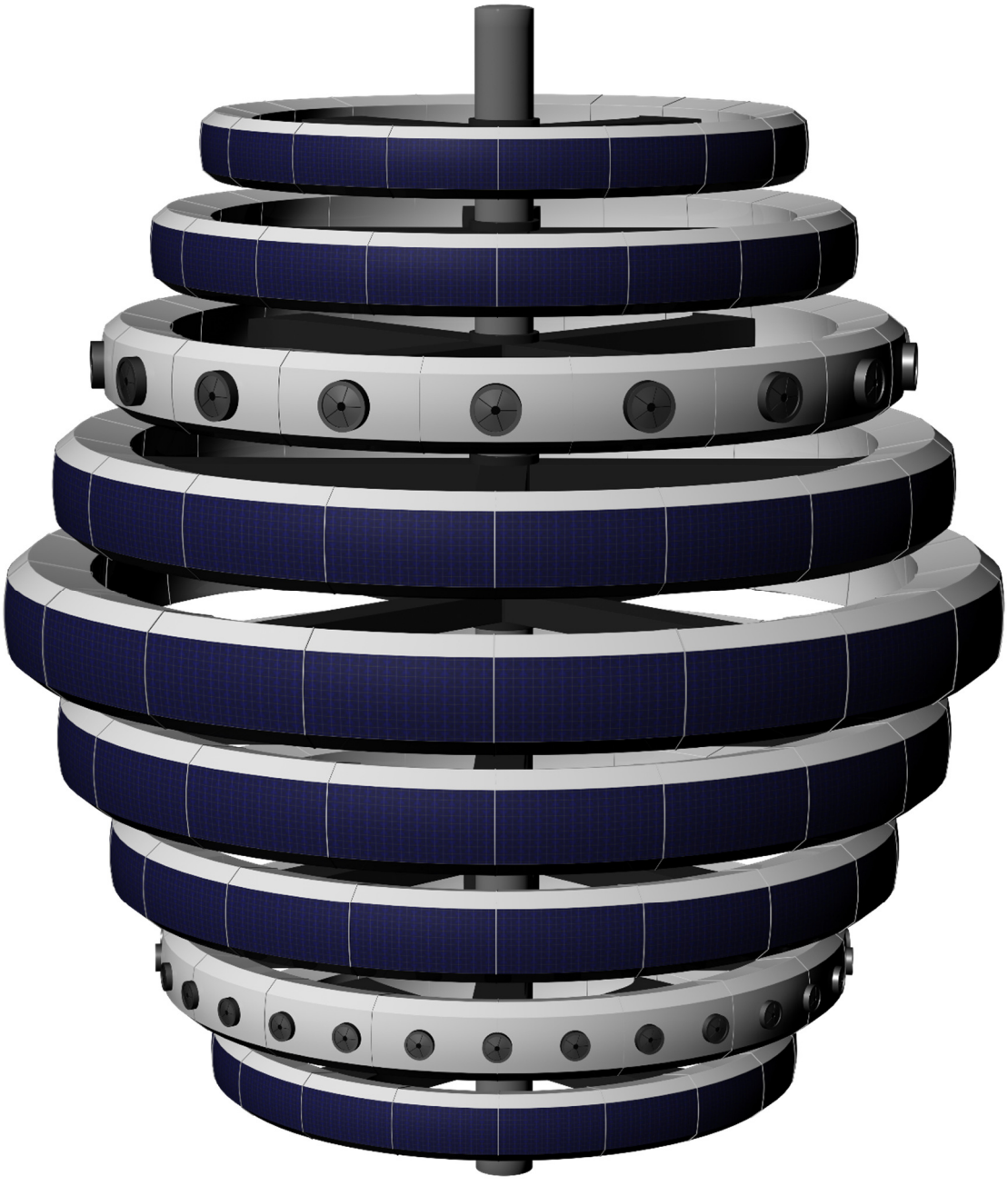


Fig. 31. A glance at the settlement

Greenspace is composed of 9 rings as we call them. The rings are different in size and are put in order so if you are in one of the rings, you won't be able to see the other rings as far as possible. That way we create an impression of vast space. We divided the settlement in nine rings in order to make is safer for the residents. Every ring has its own life-support systems, but they are not fully autonomous. If there is a malfunction in the life-support system in one ring, the systems of the other ring may support the problem ring for a while.

The rings are connected to the central axis by special modules which provide rotation by the Quantum locking effect. That way we stabilize the axis and eliminate all the friction. There is another advantage of that – we will be able to change the speed of rotation of every ring and that way we'll change the artificial gravity. That can be useful in the industry and may cut the expenses in some areas such as metallurgy, which will be the main industry in the settlement.

All the people in Greenspace live in the central and biggest ring – ring №5. Many of them also work there as well. In the other ring, where industry is developed, humans will interfere as less as possible. Often robots will be remotely controlled by humans sitting in their homes or offices.

Advantages	Disadvantages
• Stable construction	• Complicated construction
• Ability to control the properties of all the rings separately – gravity, atmosphere, etc.	• Construction of each ring must be completed to create artificial gravity
• Easy to seal off any problem areas	
• The industry is physically separated from the living areas	
• It's possible to inhabit the settlement before it's completely finished. Some of the settlement's functions may also be activated sooner	
• Using the zones with normal gravity at 100%	
• Easy to change the gravity in order to have an advantage in manufacturing	
• Frictionless rotation	

Table 6. Advantages and disadvantages of our design

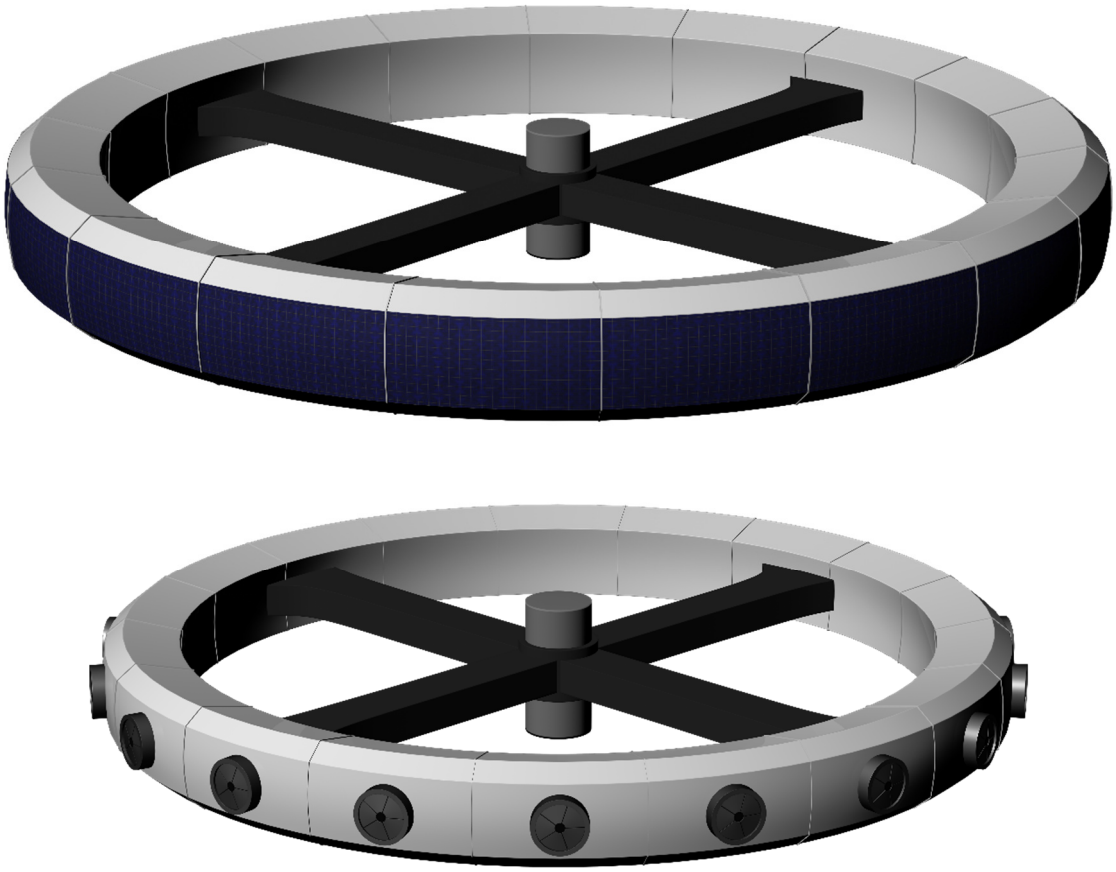


Fig. 32. Two of the rings of Greenspace

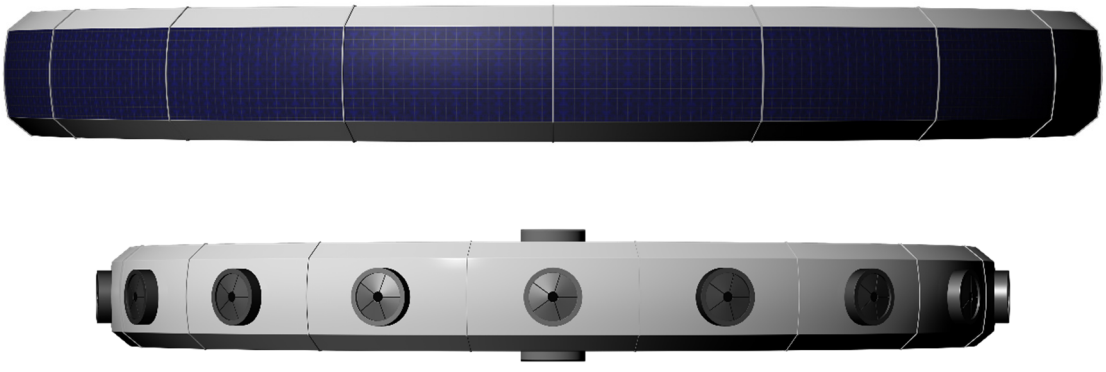


Fig. 33. Looking two of the rings of settlement from the side

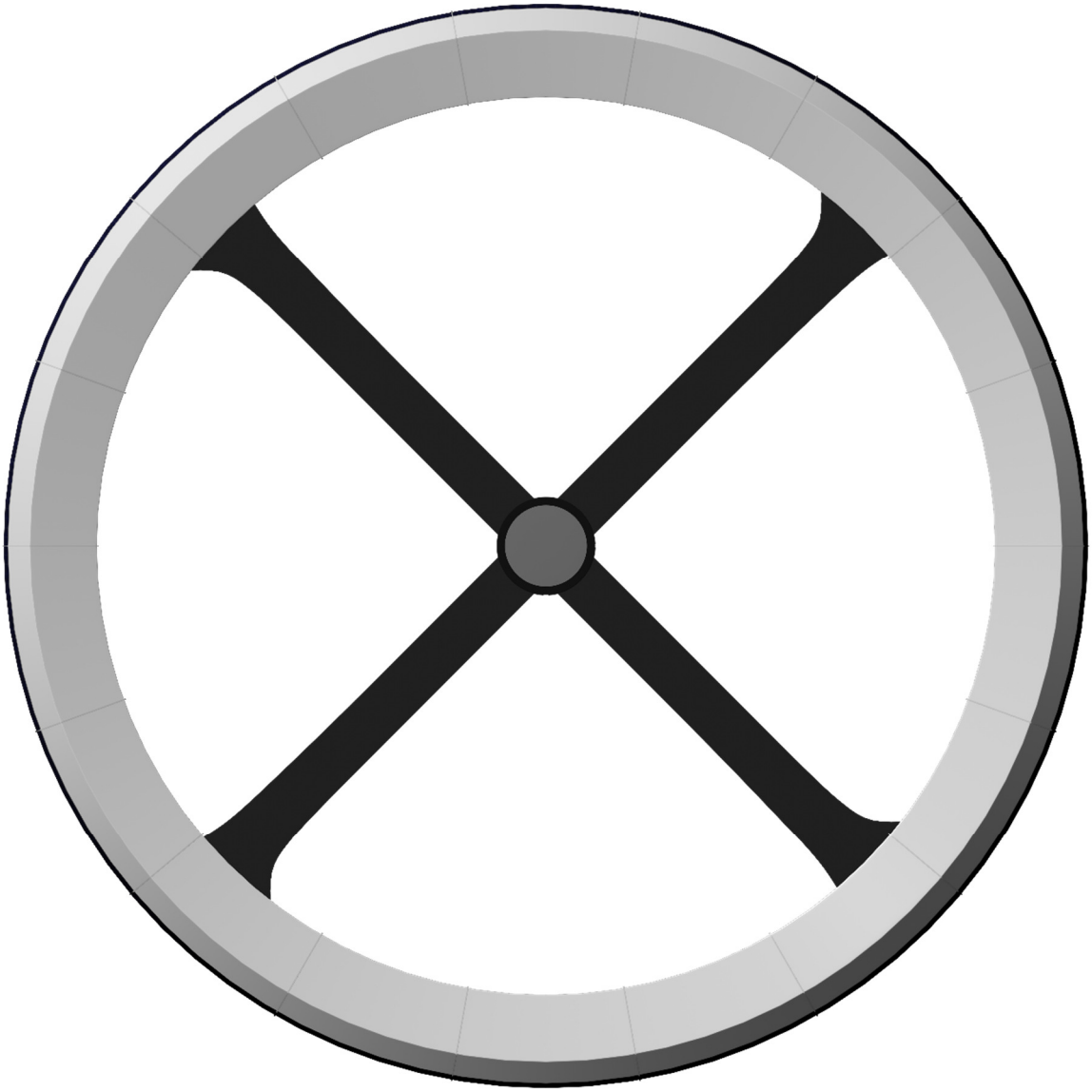


Fig. 34. Looking a ring from the top

The central ring, where the people live, is divided into two floors each 60m high. This increases the surface area almost twice which is important for the citizens and would make them feel more comfortably.

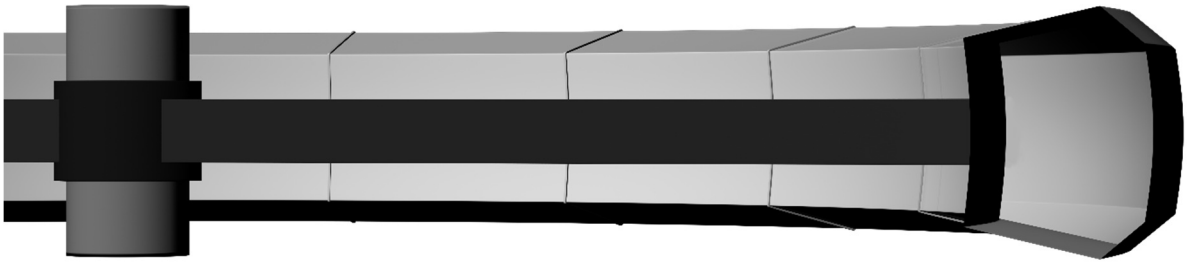


Fig. 35. A cut of one of the rings

3.2. Dimensions of the Settlement

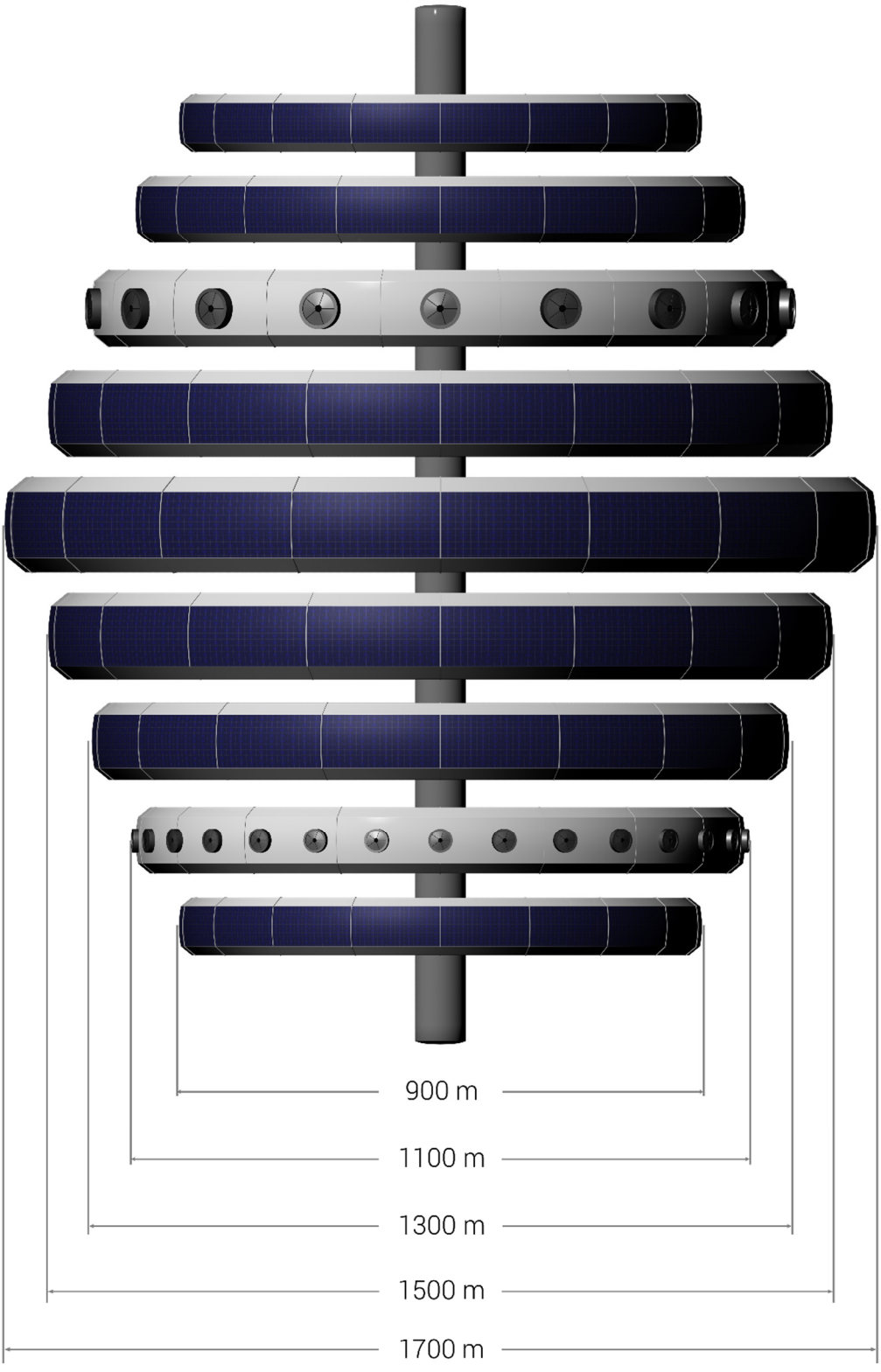


Fig. 36. The diameters of all the rings of Greenspace

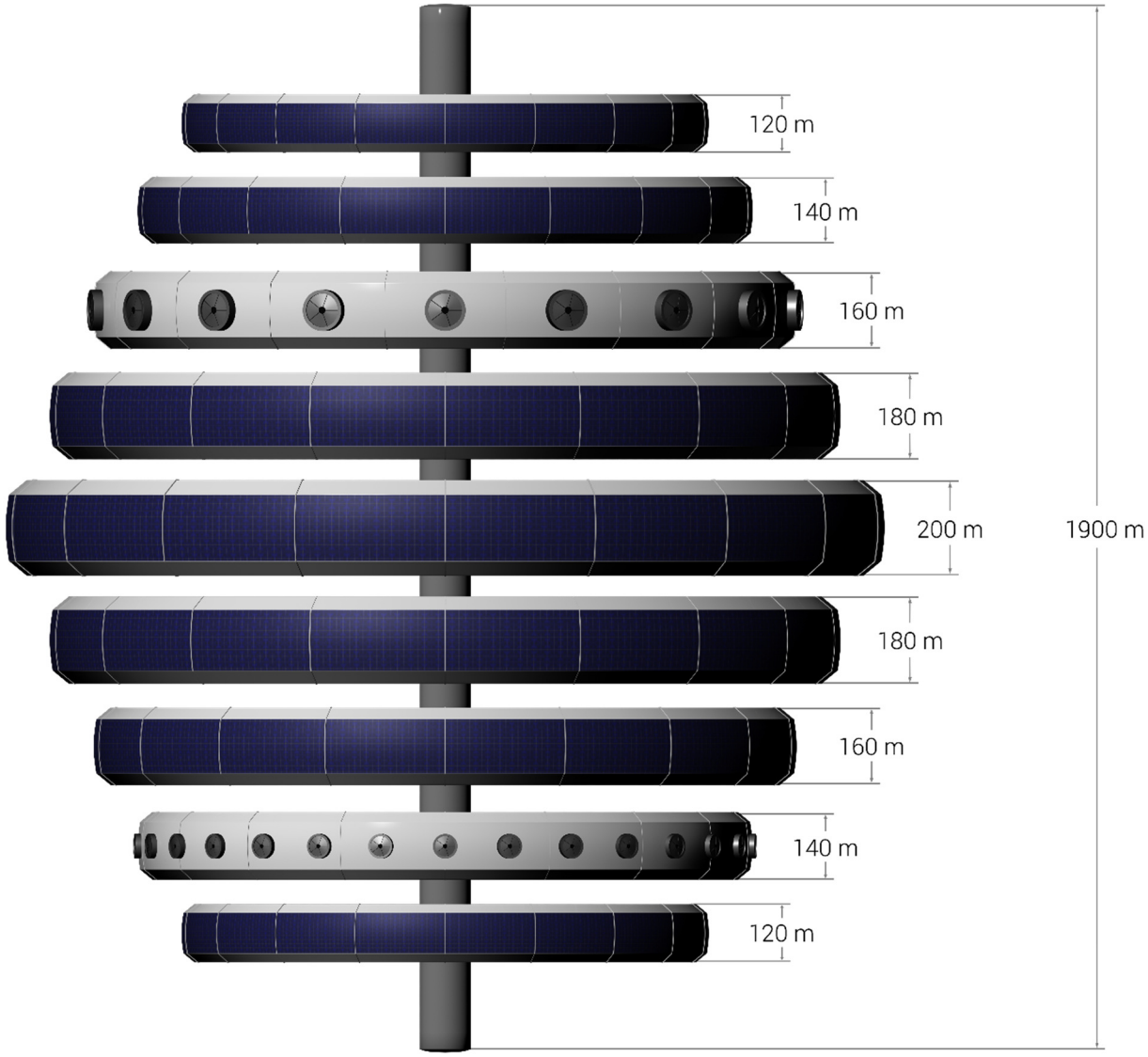


Fig. 37. Dimensions of the rings and the central axis

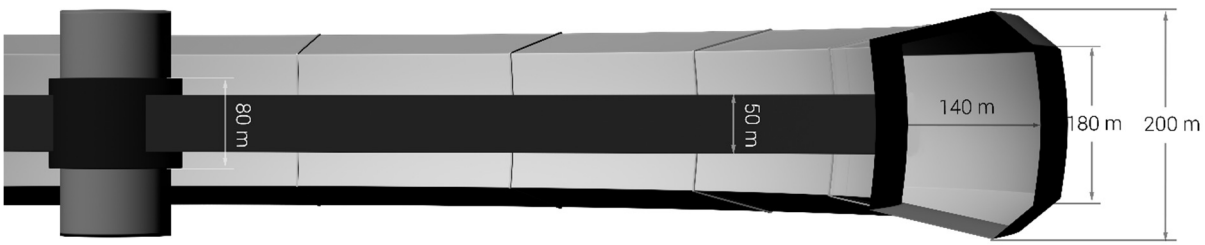


Fig. 38. Dimensions of the spokes and inside dimensions of the central ring

Dimensions of the Living Area:

The primary inhabitable area has a radius of 850m and a length of 180 m. The main ring is divided into 2 floors each 60m high.

The surface area of the first floor in km^2 is:

$$S_1 = C_1*0.18 = \pi*D_1*0.18 = \pi*1.7*0.18 = 5.338*0.18 = 0.96\ km^2$$

The surface area of the second floor in km^2 is:

$$S_2 = C_2*0.18 = \pi*D_2*0.18 = \pi*1.56*0.18 = 4.898*0.18 = 0.88\ km^2$$

So the total surface of the living area is:

$$S = S_1 + S_2 = 0.96 + 0.88 = 1.84\ km^2 = 1\ 840\ 000\ m^2$$

Geometry	**Cylinder**
Population	**20 000 top (15 000-16 000 optimal)**
Radius	**850m for the 1st floor and 780m for the 2nd floor of the main ring**
Length	**180 m**
Gravity	**1.1 g (on the first floor)**
Air Pressure	**0.5 atm**
Energy/person	**10 kW**
Area/person	**92m² for 20 000 people and 122.6m² for 15 000 people**
Surface area	**1 840 000 m²**
Shielding	**2,474 Mt**
Water-daily	**300 t**
Food-daily	**46.5 t**
Oxygen mass	**100 kt**
Nitrogen mass	**150 kt**
RPM	**1.075**

Table 7. Results from modeling the main ring, bearing in mind the population's needs

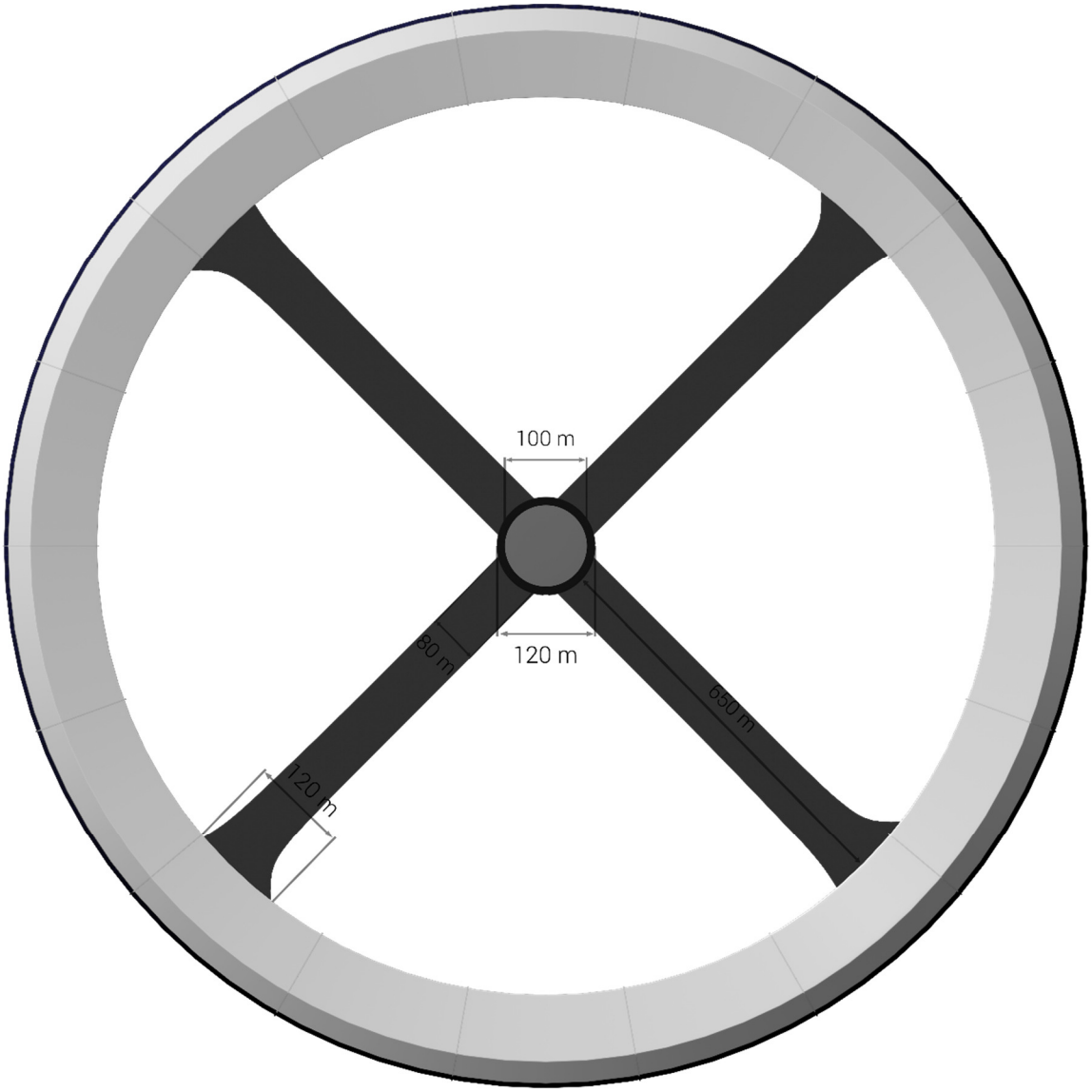


Fig. 39. Dimensions of the spokes and the central axis

3.3. Engines and other constructions

Engines for rotation maintenance and correction

We want every ring to have variable gravity, which to be able to change as we wish to. To do so every ring should have its own system for rotation maintenance. That's why every ring has two engines put diametrically. Every engine can rotate and is able not only to rotate the settlement, but also to accelerate the entire colony. When all the engines work together the settlement can move in space and change its location. Using more engines helps moving in space more precisely and more safely.

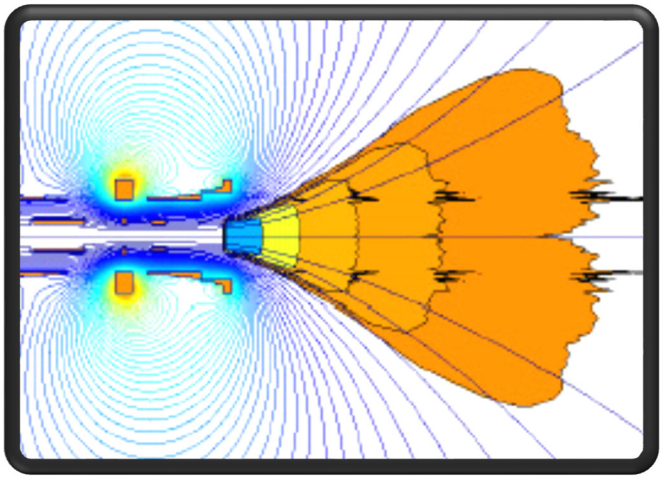
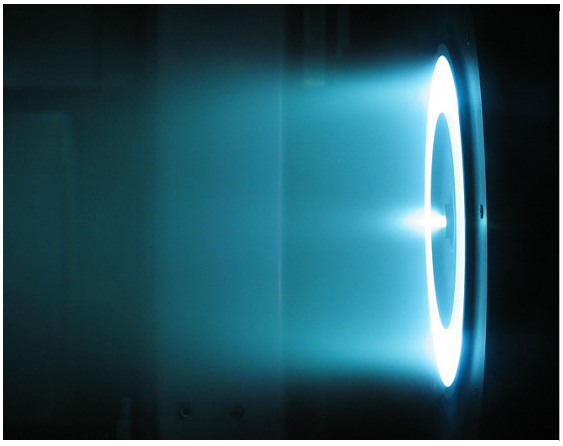


Fig. 40. Hall Effect thruster

For Greenspace we choose to use Hall Effect thrusters. They use radio waves and magnetic fields to heat hydrogen gas up to 1 000 000°C. Then it's used to propel the settlement. These engines are efficient and can have a significant thrust. Hall Effect thrusters have already be constructed and tested on Earth and also have been used for some satellites.



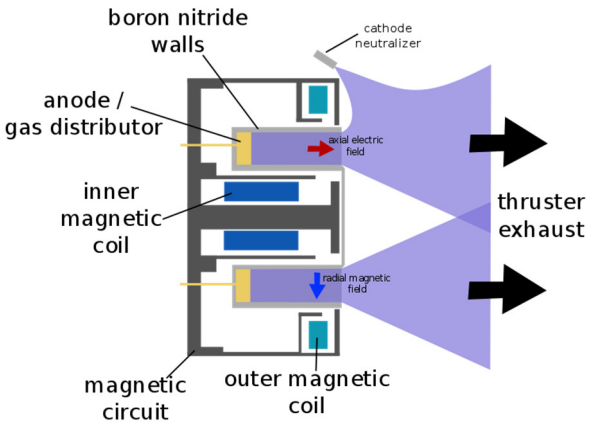


Fig. 41, 42. A 6 kW Hall thruster in operation at the NASA Jet Propulsion Laboratory and a Schematic of a Hall Effect thruster electric propulsion device

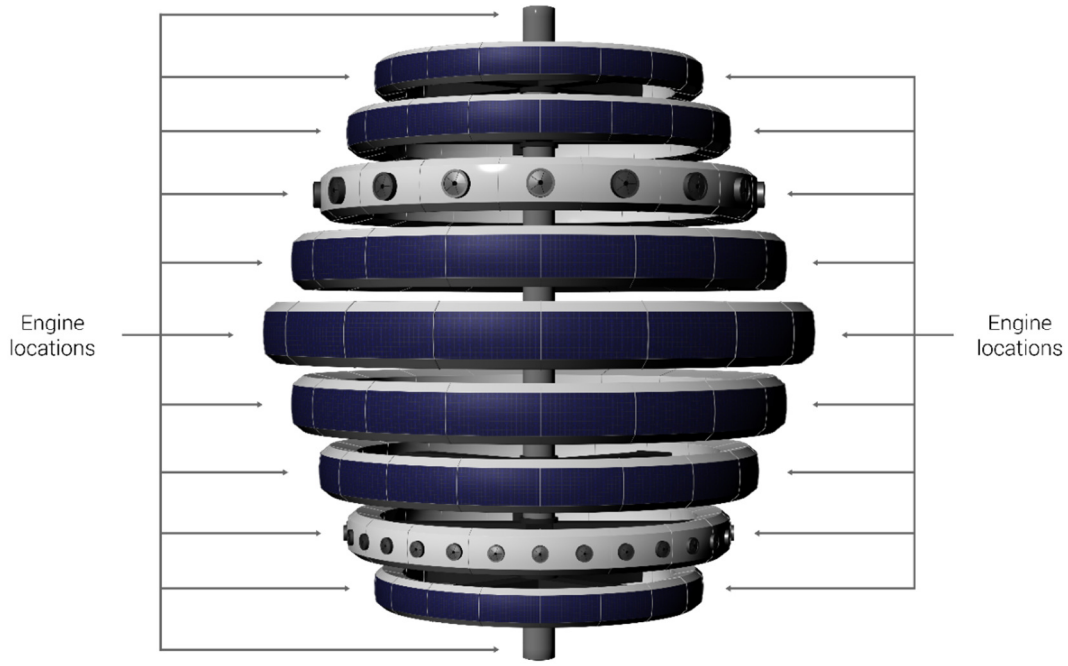


Fig. 43. Locations of the engines

Asteroid-catching mechanism

For the later stages of development of Greenspace it will have to be able to mine NEO asteroids. For that purpose the settlement will have to stay really close to the object. It would be great if Greenspace is able to change the asteroid's orbit.

To solve this problem de designed a special devise called the Octopus to retrieve asteroids. The device is inspired by the by the tentacles of the octopus and the cuttlefish. (This is where the device's name comes from.) When it's not been used the Octopus can be folded in or even to be entirely removed.

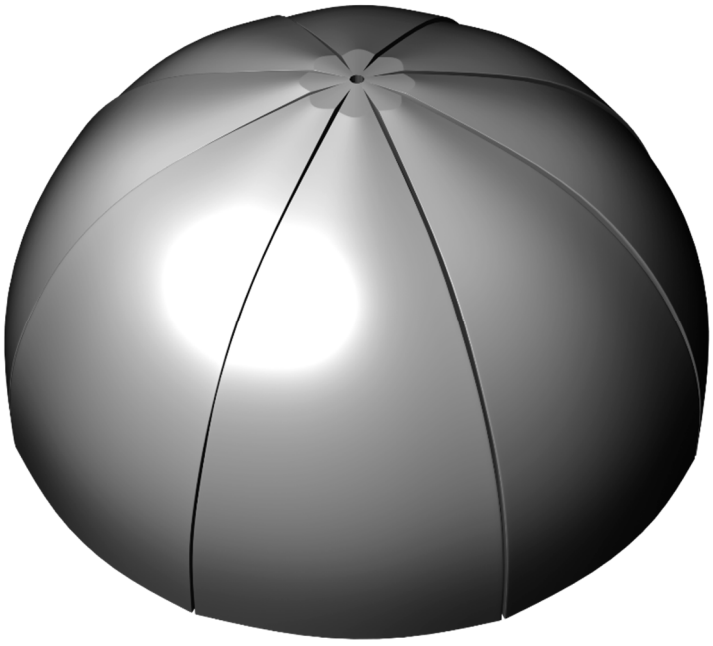


Fig. 44. The Octopus in folded position

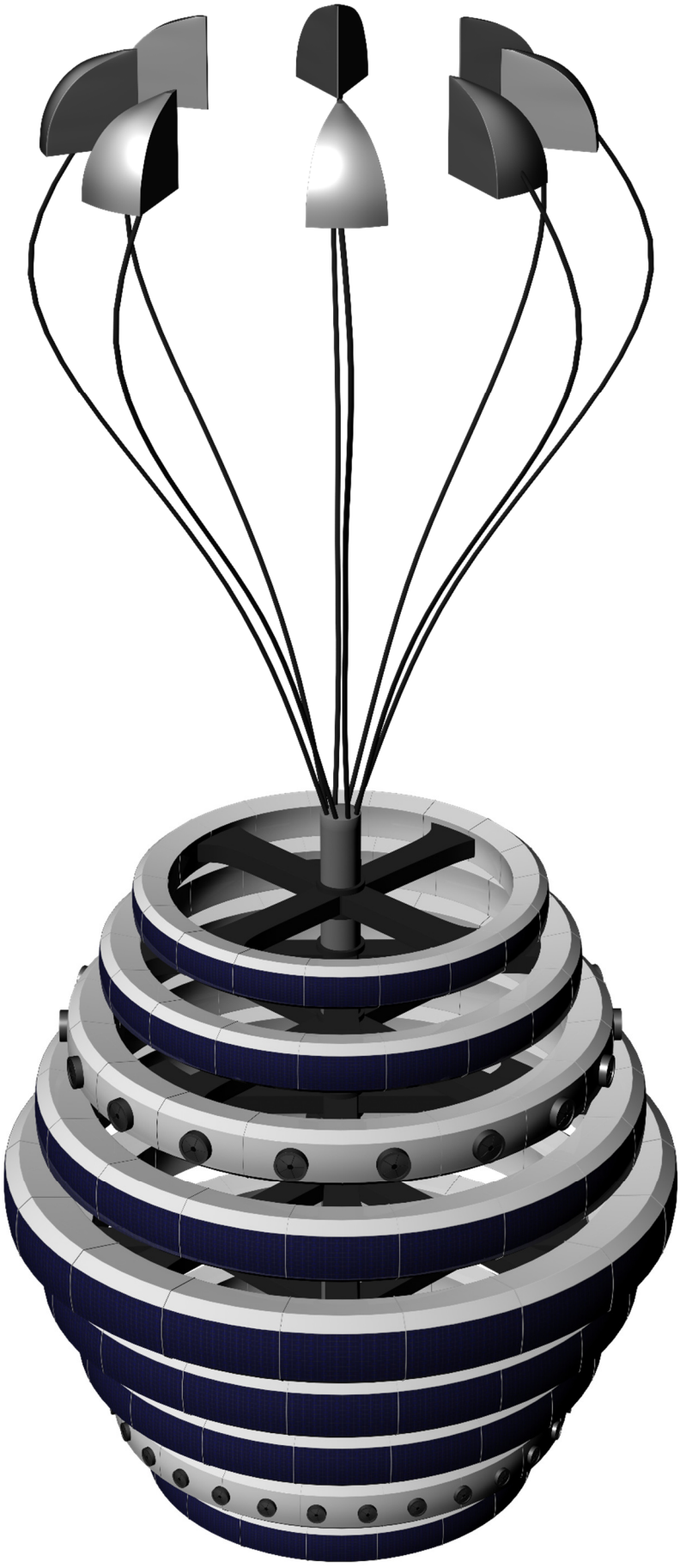


Fig. 45. The asteroid-catching mechanism – The Octopus

The device catches the asteroid by enclosing it with its tentacles from all sides. That way the asteroid is fixed in a stable position. The tentacles are made out of superstring carbon nanotubes. The tentacles are so many out of security issues – if a problem occurs with one of the tentacles, the other will still be enough to ensure a secure grip on the asteroid.

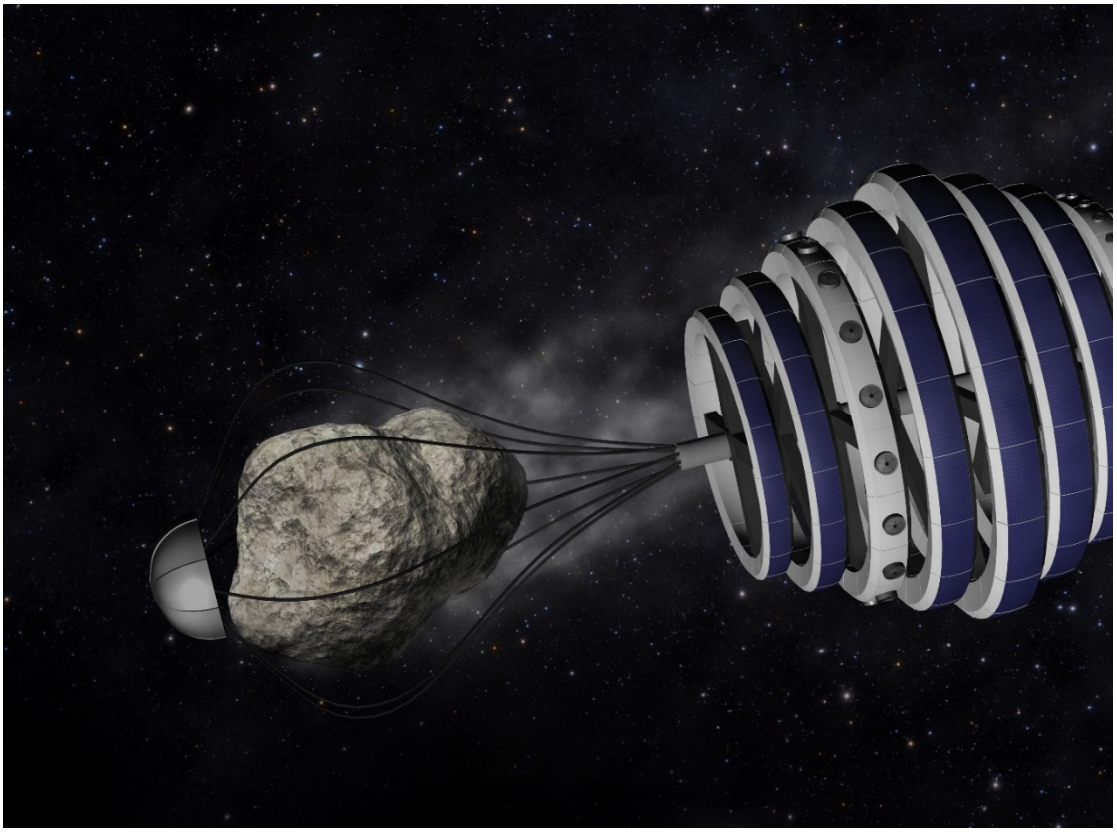


Fig. 46. The Octopus in action

Solar panels

Solar panels are used to excessively power the settlement. That way Greenspace will consume less power produced by the helium reactors. The panels can power the settlement while the maintenance of the reactors.

The solar panels are mounted on the outside of the rings. The less accessible parts are painted in solar paint, which although less efficient, will also help power the settlement.

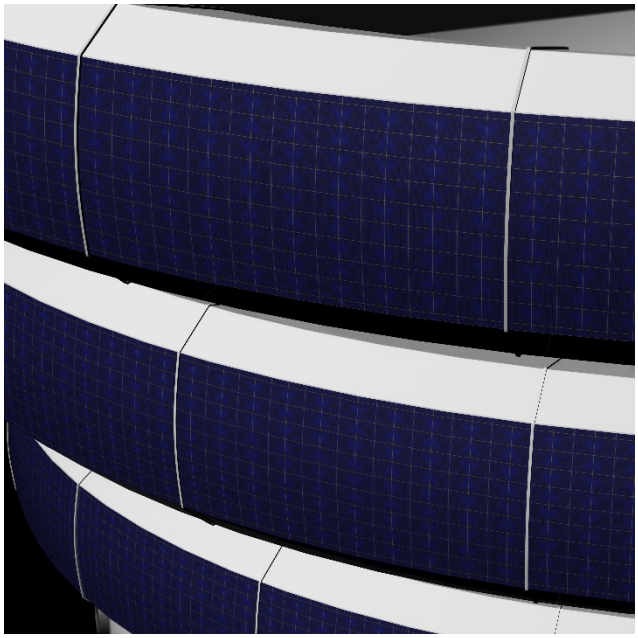


Fig. 47. The solar panels

Docks

Due to its special goals, Greenspace will constantly be interacting with the space around it. That makes the docks one of the most important and busiest places in the settlement.

Two of the settlement's rings have docks. These are the ring which manufactures and services spaceships (ring №3) and the ring where the debris are unloaded and sorted.

The docks at ring №3 will be used not only for manufacturing spaceships but also for handling loads for and from the settlement. Passenger ships will also dock here. These docks will be the main connection between Greenspace and the other space settlements and bases on Moon, Mars and other planet. They will be the connection with Earth as well.

Unlike the docks at ring №3, those in ring №8 will be used only by the Space Cleaners. This is where the Cleaners will unload the debris they have collected. Then the debris will be sorted by type and forwarded for further treatment.

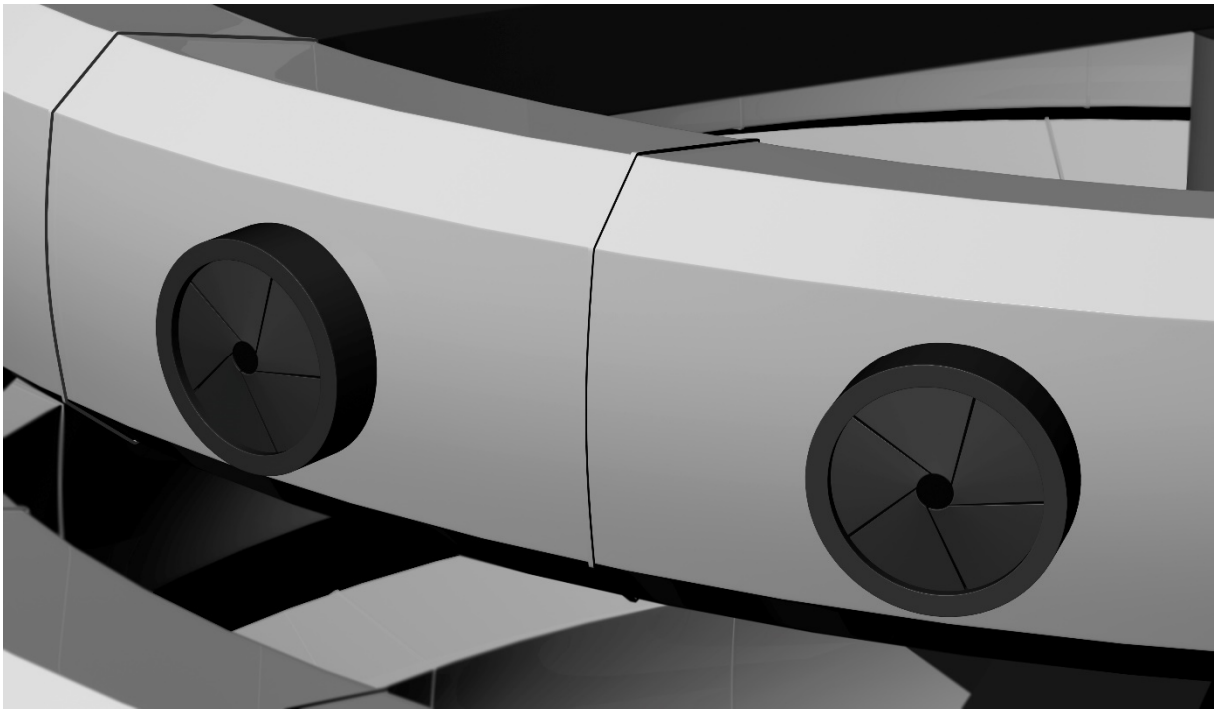


Fig. 48. The docks of the settlement

3.4. Different types of modules

The easiest way to build the settlement is by assembling it from ready parts which we call modules. Each module is made and is almost completely equipped on Earth. Then the modules are transported to the space elevator and then to the construction site. The settlement consists of three main parts – **central axis**, **spokes** and **the rings** themselves.

The central axis is made of two types of modules. The modules which stand between the rings are the first type. There are 10 of these. The second type of modules stand at the center of each ring and ensures that it's turning. These modules are slightly bigger than the previous because they contain the **superconductor bearings** which provide the frictionless motion. There are 9 of those modules. On each of them the spokes are mounted – four for each ring.

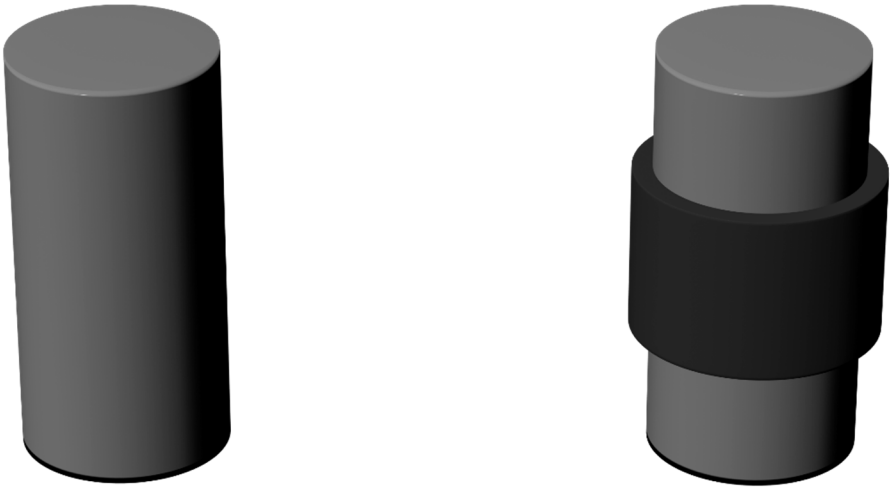


Fig. 49. Modules of the central axis

Every **spoke** consists of 5 modules. The first of them provides the connection between the axis and the spoke. The last is splayed and connects the spoke with the modules of the rings.

Fig. 50. Modules of the spokes

The modules of the rings are different in size, because the ring themselves are different. But their form and construction are the same. Each ring is built from 36 modules. Some of the modules are equipped with solar panels and some of have docks. Every module of the rings №3 and №8 has a dock.

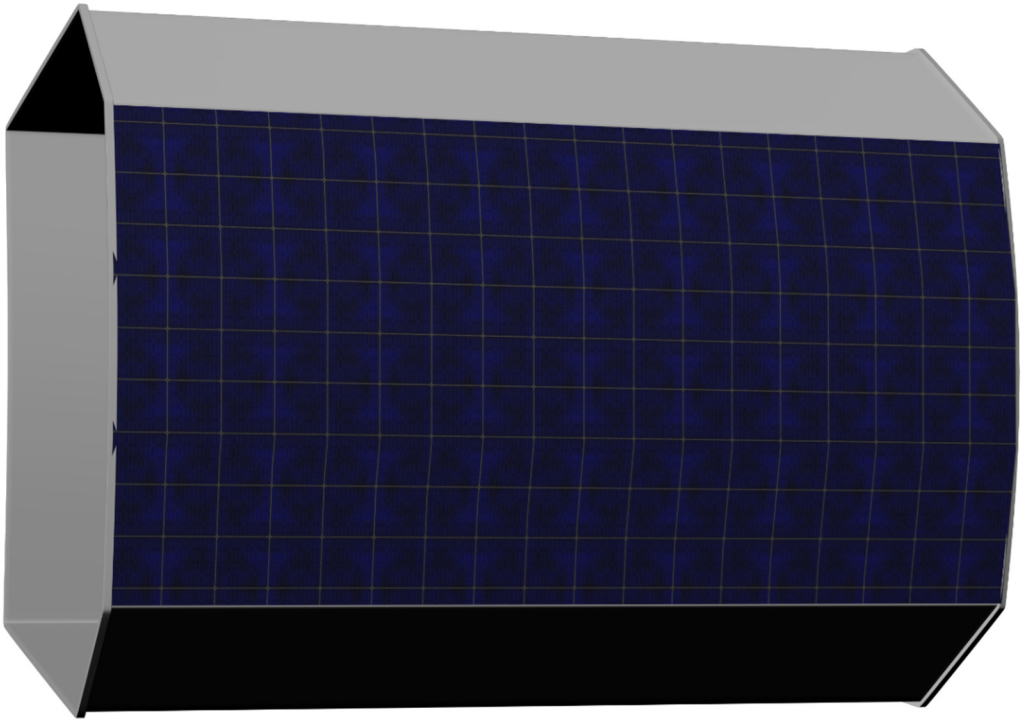


Fig. 51. A module of the rings with solar panels

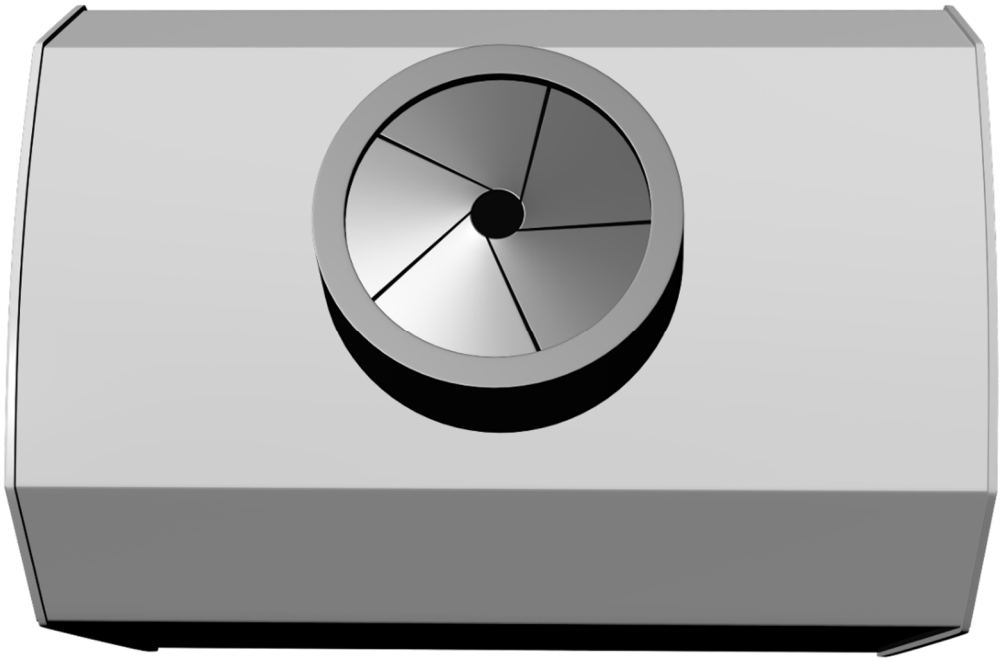


Fig. 52. Module of the rings with docks

3.5. Building sequence

The settlement will be built in a strict order which has to be in line with the goals and tasks of Greenspace. The sequence in which the rings will be built is defined by their purpose. The main goal is to start cleaning the space as soon as possible – even before the completion of the settlement.
Three are the main stages of assembly. But before we start assembling the settlement, there is an important thing to do – preparing the construction site.

Preparation

The preparation of the place where the settlement will be built is extremely important. In our case this is High Earth Orbit. To prepare the site, we have to explore the exact orbit, to check if it's safe and to remove any objects if there are any. We also have to make sure that the orbits lower and higher are empty as well. The settlement is a big construction which requires a lot of empty space to be built. Assembling the settlement will be the most dangerous stage. At that point the colony will be most vulnerable to any objects that may fly by. That's why it's so important to make sure that there isn't even the slightest chance of a collision.

Transporting the modules to LEO

There are several options for launching the modules. The most perspective ones being the cosmic elevator, through several carrier rockets, or an ion thruster. We chose the space elevator as most efficient way to take the large and heavy modules into Earth's orbit.

The space elevator is a platform, connected via carbon nanotubes to a station in a low orbit around Earth. There isn't one in existence yet, but all the necessary technology is available. The carbon nanotubes need the biggest development, but that is just a matter of time. With the support of this elevator, the modules can easily and cheaply be transported into a low orbit.

Fig. 53. ***The Space Elevator***

First stage

The first stage of construction of the settlement is the building of the central axis. Starting from the center module by module the axis is assembled. The modules with superconductor bearings are separated by each other by the still modules. After the central axis is completed, the spokes are attached to it.

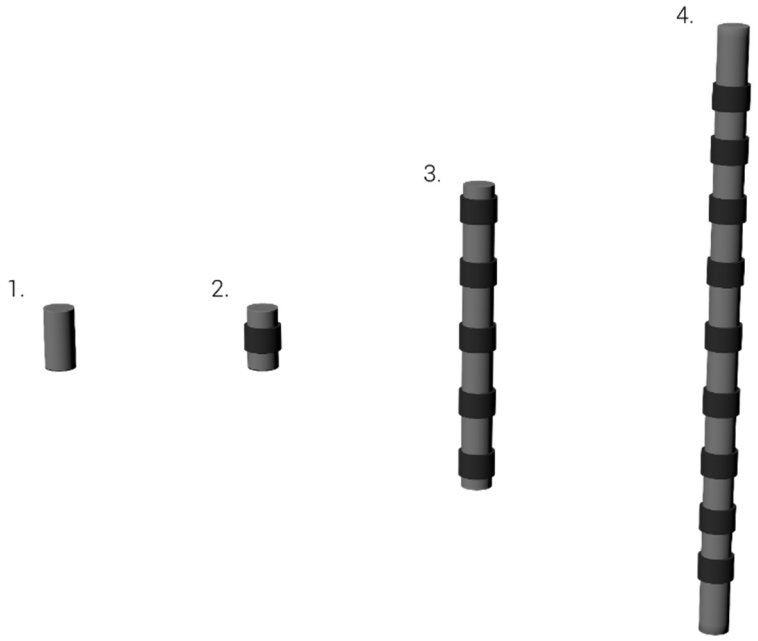


Fig. 54. First stage – assembling the central axis

Second stage

The second stage is when the first three rings. These will be the rings №3, №5 and №8 because they are essential for the cleaning process. There are two sub steps at this stage. The first one is building the spokes and the second is assembling the rings themselves. After the second stage is competed the rotation of the ring can be launched. Then the cleaning process may start.

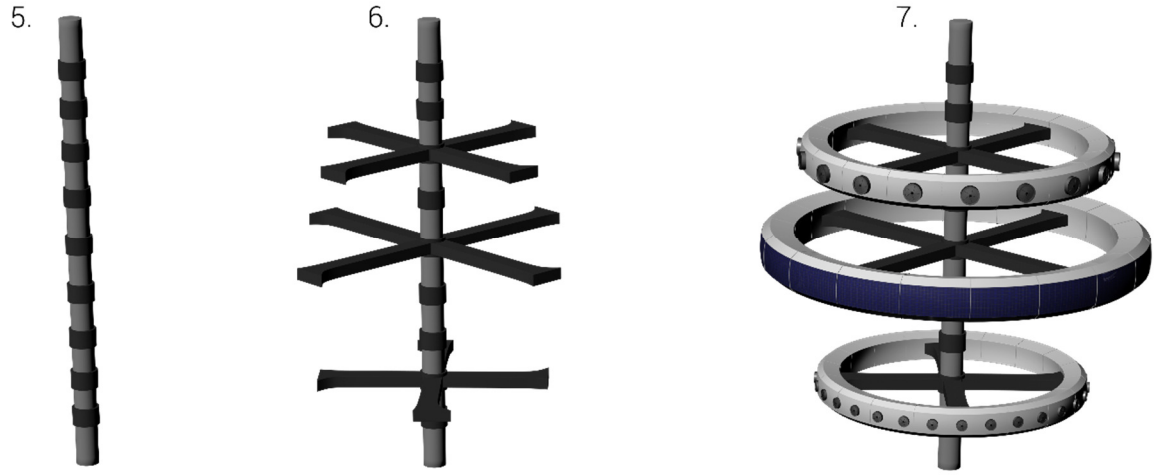


Fig. 55. Second stage – assembling tings №3, №5 and №8

Third stage

The third and last stage of construction is the longest. There are last 6 ring to be assembled. These ring are divided in two groups. The first to be built are rings №2, №6 and №7. Finally the last three ring are assembled - №1, №4, №9. This is done for a couple of reasons. First, that will make building faster. Also it's safer to build three rings at a time than to build six rings at once. The rings are divided by priority and importance to the task which Greenspace is currently doing.

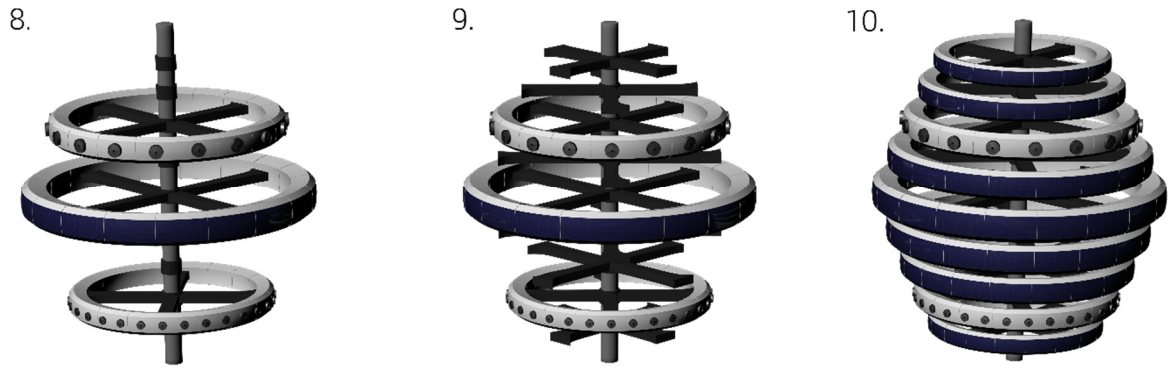


Fig. 56. Third stage – assembling the last six rings in group of three

3.6. Interior design and infrastructure

3.6.1. Division of the settlement

The way our settlement will be divided is of extreme importance for the execution of its activities. With the form of Greenspace we have 9 physically separated rings. This increases the security and stability of the colony, and enables the easier conduction of activities, which require special conditions.

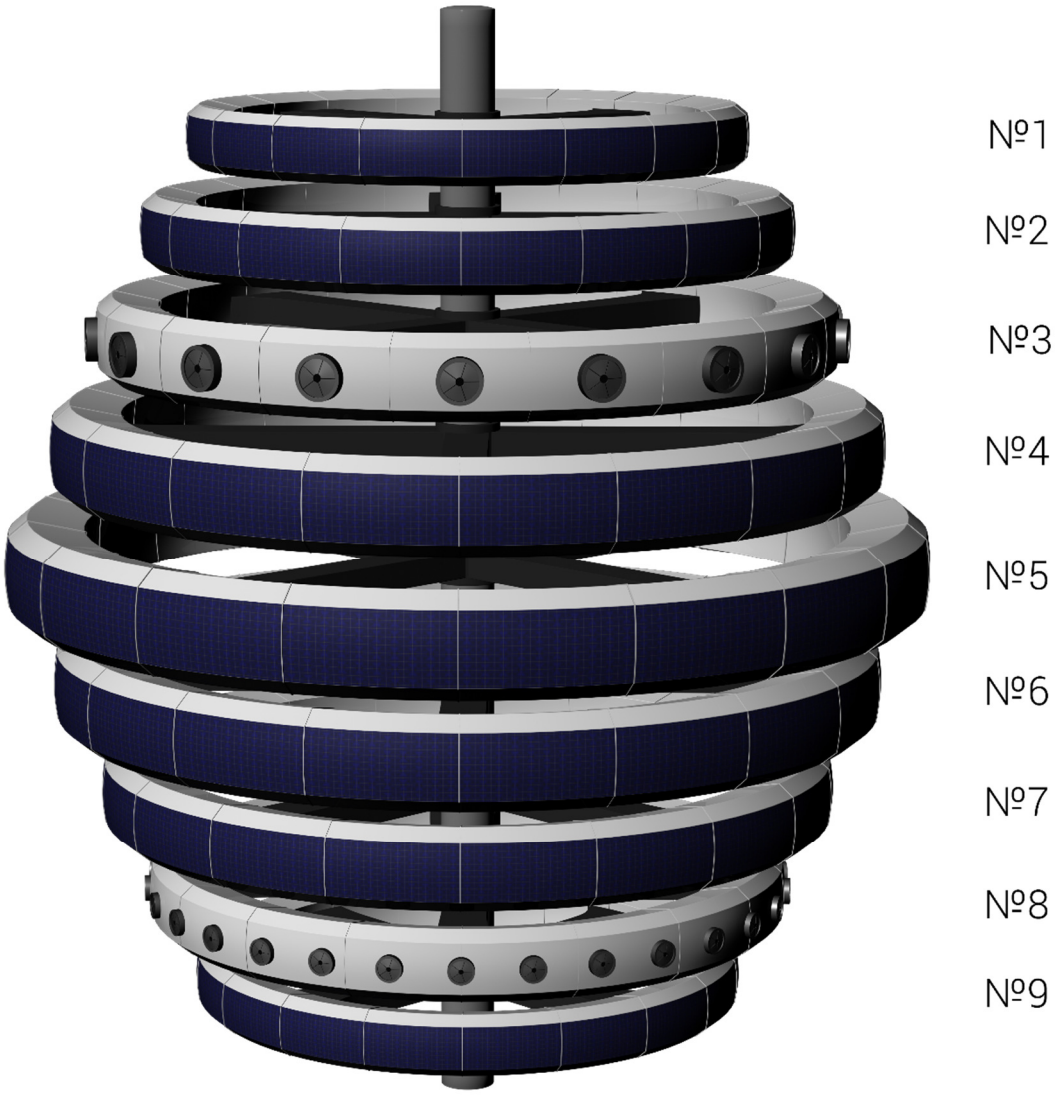


Fig. 57. The rings of Greenspace

Every ring of the settlement has its own purpose. Sometimes the activities that are performed in each ring are more than one, but are connected to each other. That is why there is always interaction between the different rings.

Ring	Activity	Details
№1	Initial processing of the ore mined from the asteroid; extracting the metals in it	Around 300 workers; most of them work remotely from their home or office; everything is highly automated; there are many robots and automated machines
№2	Heavy industry – metallurgy, manufacturing of machine elements, spacecraft components	Roughly 800 work here; mainly engineers and technicians who program and maintain the robots and production lines, design new machine parts and elements
№3	Manufacturing, service and repair of spaceships, probes, telescopes, rovers, the Space Cleaners, etc. This is the connection between Greenspace and the rest of the Universe	800 people work in this ring; they are specialists in servicing and maintaining spacecrafts; some of them work in Transportation – they are responsible for all the goods coming to the settlement and the production that leaves Greenspace
№4	Biosphere; in this ring all the food for the residents is produced; the ring also participates in the circulation of oxygen and water in the settlement	Around 200 employees will be needed to maintain the hydroponic installations; they will provide the food for the settlement; the production must be on 24/7; the vegetation in the ring is used not only for food, but also for producing 0_2 and decomposing $C0_2$
№5	Living area; here are all the hospitals, all the schools, the parks, sport centers; here all the residents live; some of them also work here	The central ring is the biggest; this is where all the people live and spend most of their time; only the workers whose job requires personal presence will leave the ring from time to time; here are all the public buildings and institutions; roughly 700 people work in the tertiary sector – teachers, medics, etc.

№6	A research center; here scientists receive data from satellites, probes, telescopes, smart dust, etc. there is a team of people who track the space debris; special experiments are designed and conducted here	1000 scientists do their research and process the data from experiments and probes; experiments which can happen only in space are conducted; here new technologies are invented and developed
№7	Electrical industry; manufacturing of electronics like computers, circuit boards, smart dust, robots, etc.	Only 400 people work in this ring; the manufacturing process is highly automated; engineers develop new technologies and improve the current ones
№8	Unloading, sorting, and dispatching the collected debris	Here almost all of the work is done by robots; around 300 people are supervising the process, remotely control the Space Cleaners and create their program and design their course
№9	Management, administration, government, diplomacy	The managers, CEOs, heads of departments, members of the parliament, ambassadors, diplomats, etc. live and do their job in this ring (around 500 people)

Table 8. Description of the activities in every ring of the settlement

The colony will have about 5000 active workers, though their numbers will vary in different periods. Depending on the size of the worker's family, their salary will vary. Along with the families of the workers, the total population of the settlement will be between 15 000 and 16 000 people. Naturally, the settlement's capacity is bigger than the average population. We intend for the population to never exceed 20 000 individuals.

3.6.2. Interior design

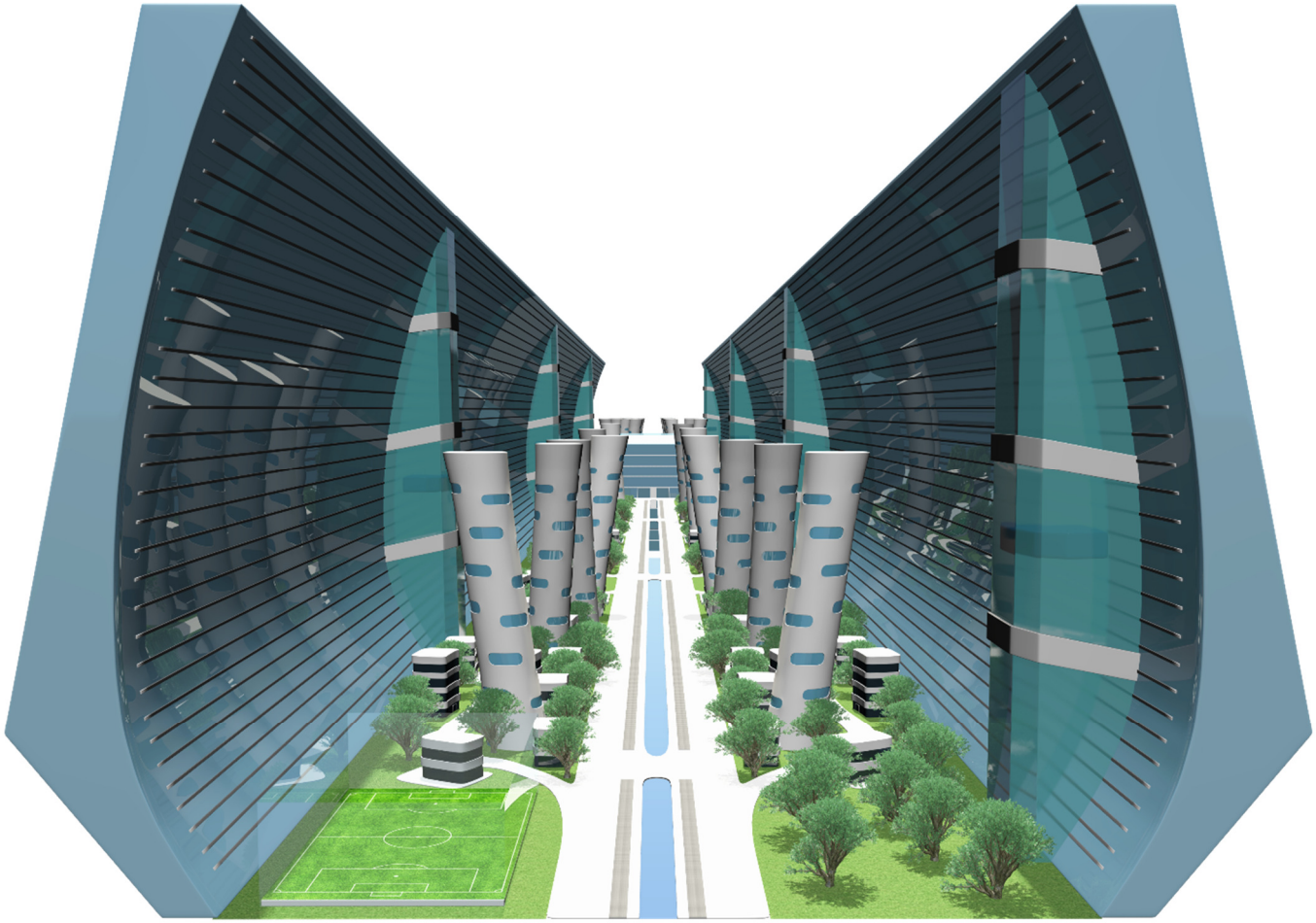


Fig. 58. Our design for the interior of Greenspace

While conceiving the interior design of our settlement, we took inspiration from the latest trends in the field of architecture and design. At the same time, however, we wanted to differentiate ourselves, to have an original style for our colony. To create an interesting design we had to pay attention to two very important questions:

- *How will modern architecture look like in 50-100 years when the settlement is being built?*
- *How would architecture develop when we start building in space?*

Trying to answer those questions, we created our idea of how one day the man's home in space could look like.

The living space of the citizens of Greenspace is the fifth and the largest ring of the settlement. It consists of two large floors, each with a height of 60 meters and a width of 180 meters. The connection between the two levels of the colony are the panoramic lifts, situated on both sides of the living area. While the colonists can freely walk and cycle on the streets of Greenspace, moving walkways are available on the main road, should they want to reach their end point more quickly.

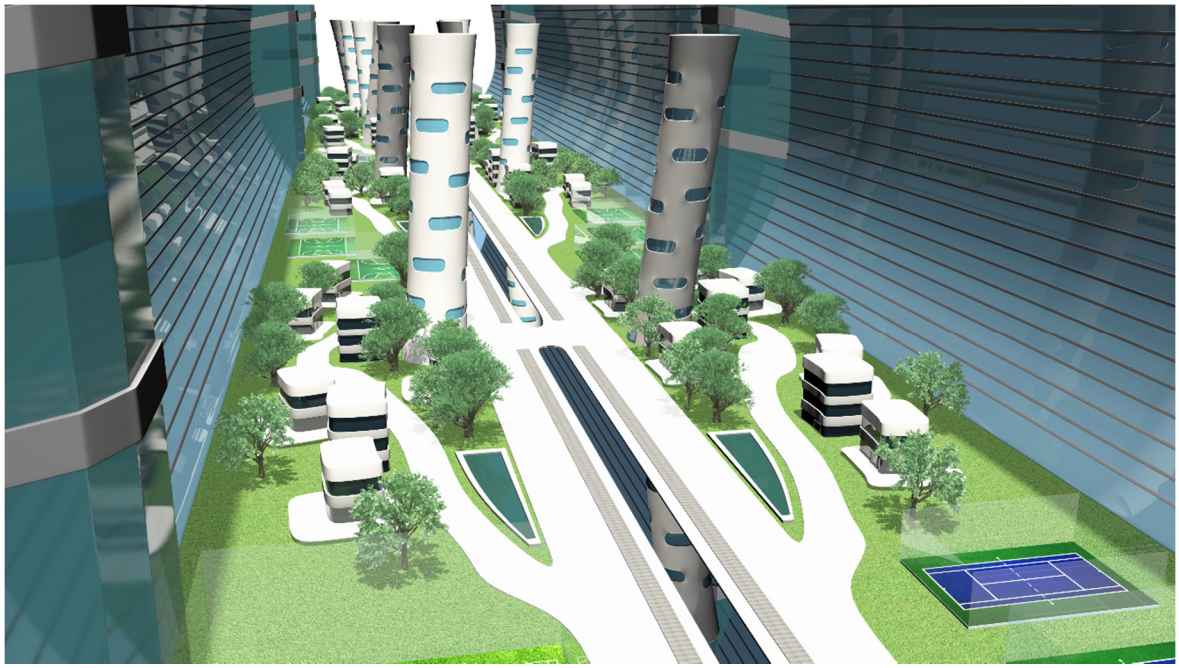


Fig. 59. Our design for the interior of Greenspace

The inhabitants of the colony will be able to choose between three main types of buildings, when they decide where to live:

- Duplex/Small condominium – small buildings with 2,3, or 4 floors for bigger families, or a few smaller ones;
- Big condominium – 15 floors, with one- and two-floor apartments;
- Side buildings – the apartments at the two sides of the residential area.

The future of architecture lies in the creation of eco-cities. Those are cities built off the principles of living within the means of the environment. They are not only ecologically-clean and self-sustaining, but they also solve some problems of our daily life like traffic jams and crowded public transport. Furthermore, the goal is that their citizens live actively and do sports daily, which is often a problem for many working people nowadays.

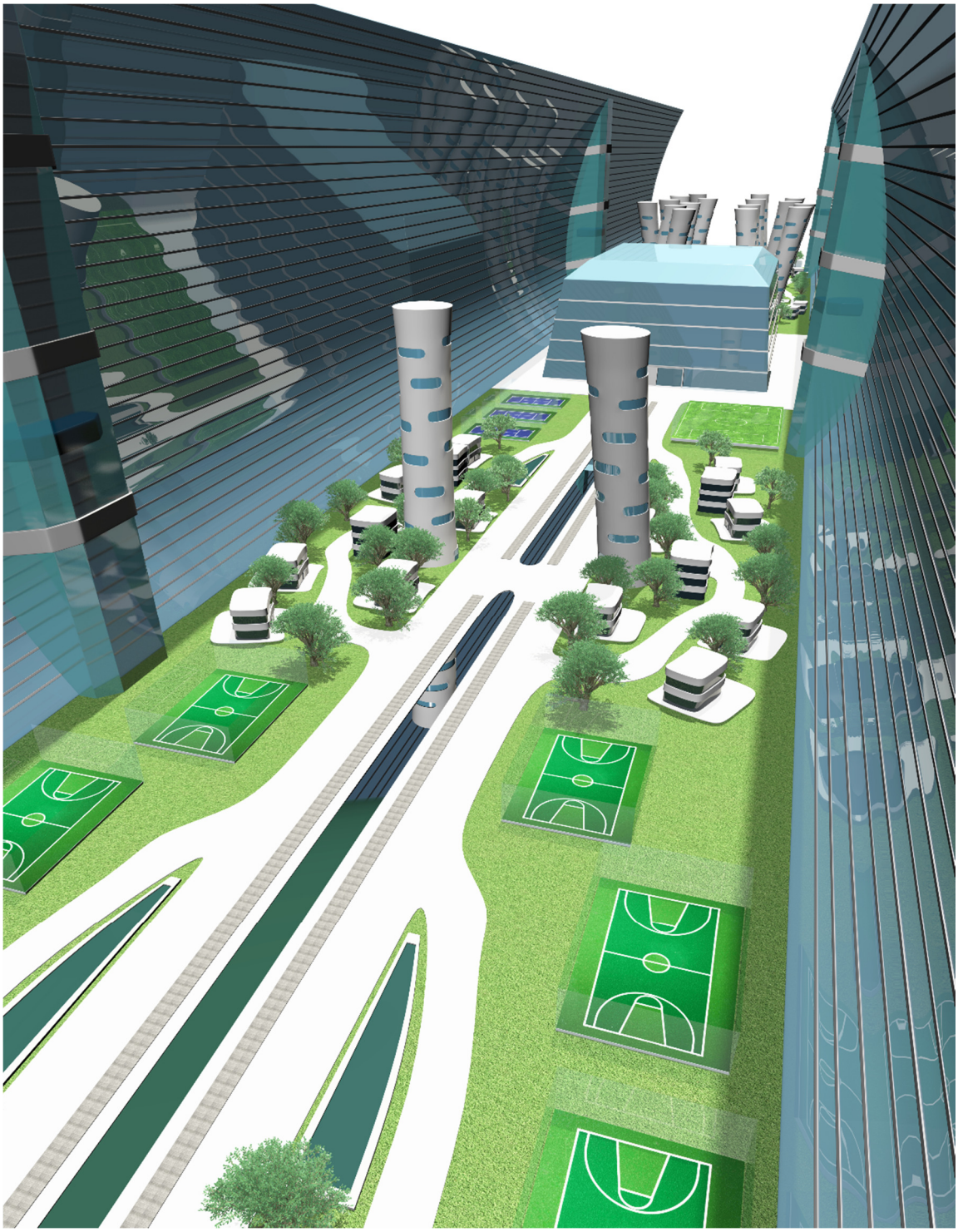


Fig. 60. Our design for the interior of Greenspace

That's why all residential buildings in Greenspace are surrounded by green areas and multifunctional sports centers, as well as football pitches, basketball and tennis courts are scattered throughout the whole living area.

For us it was very important that the inhabitants of the colony are well connected to each other and spend a lot of time outside their homes. That's why the living space is filled with places, where people can gather and spend time together. Each floor has several squares with different functions, where the main places for coming together with other colonists are. We have a shopping center, similar to the ones on Earth, with a movie theater, restaurants and shops. We have a square with a concert stage, where there will be events every week.

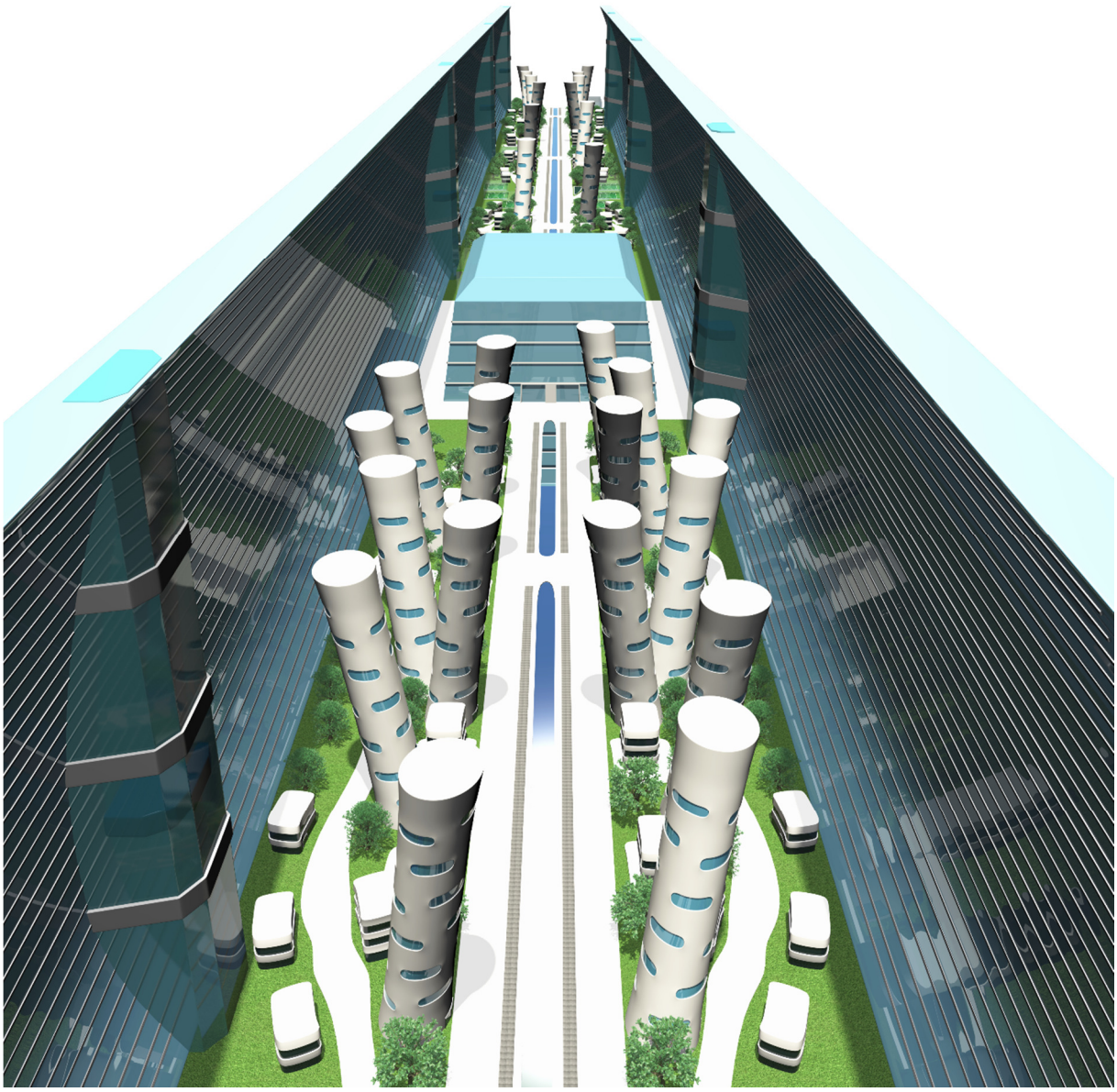


Fig. 61. Our design for the interior of Greenspace

When we were thinking about the interior of the buildings in the residential area themselves, we were wondering how we could develop the furnishing, compared to what it is now. How would our apartment look like in 50-100 years?

The furnishing of the apartment is very important for people, one must be able to do it their own way, so that it suits them, but so it is comfortable for the others that visit their home. But imagine what it would be like, if we could almost instantly change the way our looks. Thanks to the new technologies, we think that this might be actually possible.

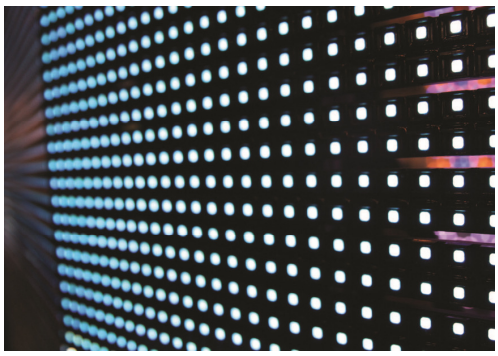


Fig. 62. LED walls

- The walls will be made of LEDs. That way you can easily change their color, form patterns, or even pictures any time you like.
- Most of the furniture will be hidden inside the walls and will come out only when it is needed. This allows for multifunctional rooms. For example, if you have friends coming over to watch a football game, you won't need all your furniture, only a sofa, a table and a TV set. If you are organizing a party, you will only need a table and lots of empty space, not libraries and cupboards.
- Don't like the view from the window? Change it – it can look like you are in a forest, or in the mountains.
- You enter your home after a long working day and you need a long break? Your biometric watch will report your higher heart-rate to your home computer, which will then turn down the lights and play some calming music.

Fig. 63. Our design for the citizen's homes

LIFESUPPORT SYSTEMS

3.7.1. Artificial Gravity

Evolution has adapted humans for life in an environment with constant feeling of weight or otherwise said – gravity, more precisely gravity around 1 g. When a human is forced to live in weightlessness, a lot of physiological complications take place. By longer abidance in zero-gravity environment, humans lose approximately 1.5% of their bone mass **monthly**. Reason for this is the decrease of calcium in blood, because of which the organism extracts calcium from bones and redirects it to the blood. By this monthly loss a longer abidance in weightlessness leads to serious physiological traumas and in the end – death. This is the major cause of death for colonists, who live in zero-gravity. There are a lot more minor causes, which we will enlist here:

- By weightlessness the body fluids pass from the lower limbs to the brain. From this follow two major consequences:

  1. The brain thinks, that there is an increase in the body fluids, which leads to dullness of the smell and taste buds and demineralization of the bones. But the body fluids are actually lowering and blood level can drop by up to 10%, which causes cardiovascular problems. Because of that the colonists, will have to beware from dehydration, which leads to difficulties in the everyday life.

  2. The sodium and potassium balance in the body is disturbed, which leads to additional fixation of the diet.

- The concentration of neutrophils increases, the number of eosinophils, monocytes and B-cells decreases and the number of steroid hormones increases, the T-cells lose their functions, which leads to weakening of the immune system, including the cancer protection, which with the help of the high-radiation environment will lead to a huge number of cancer-sick.

- Because of the lack of load, muscle atrophy is obtained. The proteins, which help for the contraction of the muscles, slowly begin to disappear and the tissue rapidly contracts and relaxes. This leads to a major weakening of the human organism. In order to prevent this, the colonists will have to have a strictly organized day with a lot of training and specially prepared diets, which could lead to major discomfort for the colonists.

- In weightlessness humans easy lose their conception of the surrounding environment, including their conception of direction. As the human organism is adapted to see objects from one angel, when this angel is changed (which

is inevitable by zero-gravity) the human brain harder recognises the object. This results in constant dizziness and disorientation.

- A longer abidance in zero-gravity environment causes a trend towards increasing of the height and conservation of mass, due to the lack of load on the posture of the spine.

Because of all these reasons, pseudo gravity is necessary. There are a few ways of assurance of pseudo-gravity (electro-magnetic fields and others, which are similar), but all of them complicate our colony and cause unnecessary problems. The only possible option for the colony is therefore the centrifugal force. It occurs by rotation of an object and represents a force of attraction with different direction and size, depending from the way and speed of rotation. Thanks to the design of our colony it can rotate around the axis of the cylinder and generate gravity, making major part of the cylinder habitable. The gravitation, which a normal human being needs for permanent life, is between 1.2 g and 0.8 g.

The pseudo gravity is calculated with the formula $a = v^2/r$, where v is the linear velocity of the body and r – the rotation radius.

Thanks to the unique construction of our space settlement every single torus will be able to rotate with different speed, therefore generating pseudo gravity with different strength, depending on the purpose of the specific torus. We assume approximate values for the gravity in the different sectors and based on them we calculate the rotation speed. Of course these values can and will be changed, depending on the specific situation and the needs of the colony.

Torus I (initial processing of ores) – weak to zero gravity (under 0.5 g in most of the time).

Torus II (heavy industries) - weak to zero gravity (under 0.5 g).

Torus III (manufacture/repair of space ships) - weak to zero gravity (under 0.5 g).

Torus IV (biosphere) – the gravity here will be a little bit higher than the Earth's gravity (for example 1.2 g) so that the plants, which will be grown there, can reach bigger sizes.
Rotation velocity – approx. 94 m/s or 1.195 rpm.

Torus V (residential sector) – Earth gravity, 1 g
Rotation velocity – approx. 91 m/s or 1.02 rpm.

Torus VI (Science & Research sector) – again Earth gravity, 1 g.

Rotation velocity – approx. 85.7 m/s or 1.09 rpm.

Torus VII (electro-technical industries) – weak gravity (around 0.5 g).

Torus VIII - weak to zero gravity (under 0.5 g in most of the time).

Torus IX (Settlements Parliament) – Earth gravity, 1 g.
Rotation velocity – approx. 66.4 m/s or 1.41 rpm.

3.7.2. Atmosphere

The lighter the atmosphere is the better (it will be much easier AND cheaper to get it in outer space). But the human organism has specific requirements for atmospheric composition and pressure, but the lighter the atmosphere of the colony is the better. The atmosphere must contain partial oxygen pressure, high enough to provide partial pressure above the lung vesicles and low enough to prevent decrease in the mass of blood cells and major changes in the number and distribution of microorganisms. This pressure must be at least 13.4 kPa. In comparison - the pressure at sea level is 22.7 kPa. Variations are allowed, but not more than 9 kPa in any direction.

The presence of inert gas is desirable, then it would prevent the decompression in the body cavities and the sinuses. Also it would provide relative safety in the case of sudden drops of pressure or oxygen dilution. The most appropriate gas for this purpose is nitrogen for two reasons. First of all, our atmosphere is composed of 80% nitrogen and a lot of organisms need it for their normal growth. The same organisms, when forced to live in an environment without nitrogen, begin to rapidly produce it, which leads to accumulation of significant quantities. The second reason is, that if plants are included to the colony's biosphere (more precisely the nitrogen fixating species), the level of each gas in the colony can be biologically controlled through the process of conversion of nitrogen into proteins (nitrogen-fixation). Therefore, it is recommended to include nitrogen in the colony's atmosphere with 68.1 kPa pressure (approximately three times more than the oxygen).

The level of carbon dioxide must also be controlled and it must be below the OSHA standard (i.e. 0.4 kPa). Simultaneously it must be enough to allow maximum levels of photosynthesis by the plants. A compromise can be made, if the plants are placed in a separate module. Consequently the carbon dioxide level there will be higher and the oxygen level will be lower (this module will represent the "lungs" of the space station).
It is also advisable to maintain temperature around 22° Celsius and 40% humidity, as these levels are comfortable for humans.

Although the transport of gas-transport is problematic (and expensive), an atmosphere with a presence of inert gas (nitrogen) is much better than a 100% oxygen one, because it will lower the risks of fire, explosions and so on. There will be constant atmosphere in the 4th, 5th, 6th and 9th torus. In the rest of the tori depending on the activities there will be a much lower pressure atmosphere, since there won't be any human beings there, at least not for long time periods and it will be much cheaper.
Oxygen pressure in torus 4, 5, 6 and 9 – 22.7 kPa.
Hydrogen pressure in torus 4, 5, 6 and 9 – 68.1 kPa.
That means we're going to need 2307.5 kg oxygen per square meter and 6922.5 kg nitrogen per square meter in each one of these zones. Knowing the surface area of the different tori we easily calculate that for the sectors, which are going to require constant earth-like atmosphere we're going to need approximately **12 581 464 898.89 kg oxygen (12.581 megatons) and 37 744 394 696.69 kg nitrogen (37.744 megatons).**

In the rest of the tori the atmosphere will be variable and we much lower pressure. In all sectors, where the danger of fire and explosions is high (in the industrial sectors otherwise said) there will be an inert gas in the air.

3.7.3. Water

Water is vital for the existence of humans. Every vital process in our body is connected with water. It dissolves nutrients and derives waste product.

The water is also the environment, where each bio-chemical process takes place and thanks to it the exchange of substances in the human body proceeds.

Approximately 70-75% of our body consists of water (of course this proportion depends from many factors).

The only substance, which is more important than water is oxygen. In the following we list some reasons for the essential importance of water:

1. Water is responsible for the temperature regulation in the body and helps for its cooling with the sweating.

2. It transports the toxins and waste products and helps the organism by their disposition.

3. Water is, along with nutrients and oxygen, the main component of the blood as well as of every cell in our body.

4. It provides favorable environment for many tissues, then water is the main component of the mucosa, saliva and other mucous fluids for joint lubrication. It is also the main component of the digestive juices and the mucous fluids of the nose and eyes, which play the role of “protectors”.

5. Water is also in the composition of those tissues, which protect the organs from damage and concussions.

6. Water helps for the maintenance of a healthy weight. Often it is difficult for humans to recognize the hunger and thirst signals and the brain is misled. Therefore the nutritionists recommend, to drink 200-300 ml warm water when we feel hunger and then wait 20-30 minutes before we trust the signal.

7. The importance of water for the body functions requires constant “refuel” of the body fluids.

8. 2.5 - 3.5 l water per day are needed to maintain the water-balance of the organism. It is important, that these quantities are being taken in for not more than 100-150 ml per hour.

Thanks to these facts we understand the actual importance of water for humans, but we should not forget how important it also is for the plants.

Therefore, we have decided to supply the colony with water by two different means:

1. Through chemical reactions.

There are a lot of ways for water manufacture. We will enlist only the easiest and most beneficial for the colony method – decay of four molecules HO_2: $2HO_2 + 2HO_2 \rightarrow 2H_2O + 3O_2$
As a result we will not only obtain water, but also oxygen, the two most important elements for the living humans (especially if these humans want to remain living).

2. Through almost 100% recycle of waste water.

Knowing that our population will be around 15 000 people it’s easy to calculate that we’re going to need 300 tons of water per day (average of 20 l per person). Thanks to the water recycle system with approximately 0% water loss equilibrium will be easily achieved. Of course there will be a water reserve for emergency cases.

3.7.4. Waste water treatment

Since the Earth is going to be the only source of elements, vital for the agriculture (carbon, nitrogen, hydrogen), and their transmission from the Earth is (and will always be) too expensive, these elements will have to be imported in advance and recycled with a minimal loss. If our colony recycles the waste water effectively, the loss will be almost negligible.

There are many types of treatment for waste water. Let's analyze them:

1. Biological treatment

This method is used for water recycling in terrestrial societies. Unfortunately, it is too ineffective for alien conditions, as it only provides an incomplete oxidation and furthermore produces a residual sludge, which creates a risk of biological contamination.

2. Dry incineration – also ineffective as by alien conditions many of the remaining substances, which could be utilized if applying other treatment, would be unusable. Furthermore, the process requires an external energy source to maintain combustion and it produces atmospheric pollutants.

3. Not yet fully developed futuristic methods - they would be suitable, but all of them are still underdeveloped and are therefore automatically rejected

3.1. Electro dialysis

Method:

This is a process, by which under the effect of a constant electric current in a multichamber ion device (electrodialysator) the salts from the waste water are being extracted.

Where is this method used?

By the production of drinkable water in small and medium scales, in the production of salt, waste water recycle (of course), repeated demineralization, agricultural water, glycerin purification.

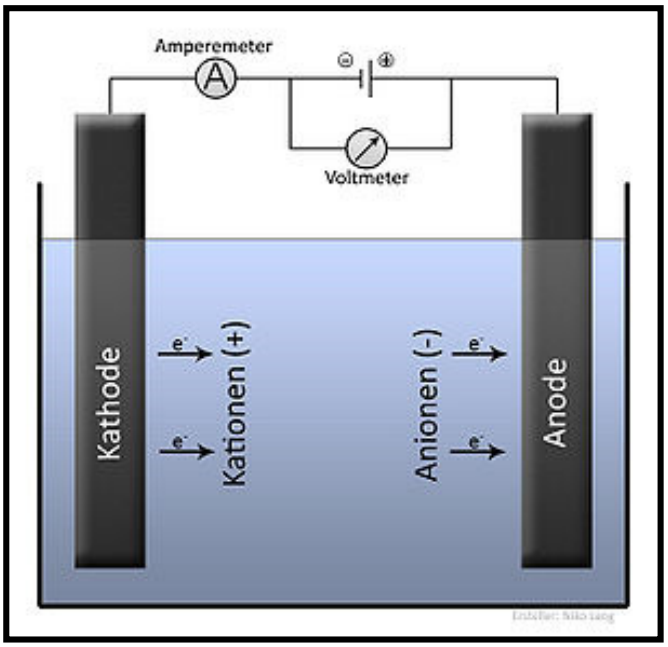


Fig. 64. Electrolysis

3.2. Electrolysis

Method:

This is a process, by which, again, under the effect of an electric current a solution is dissolved into its constituent substances or substances, produced by secondary reactions, and these are subsequently accumulated on the positive electrode (anode) and the negative electrode (cathode).

Where is this method used?

Widespread in the industry, practically the only method to produce aluminum, used for infliction of metal surfaces; also with different types of electrolysis, different substances can be gained (in our case with chlorine-alkaline electrolysis in water solution hydrogen, chlorine, sodium hydroxide, sodium chloride, bleach, etc. can be obtained).

3.3. Reverse osmosis (hyper filtration)

Method:

This is a process of percolation under high pressure (to 10MPa by small concentrations) through fine-porous membranes, which lets water molecules pass and holds the bigger and hydrated molecules of the impurities.

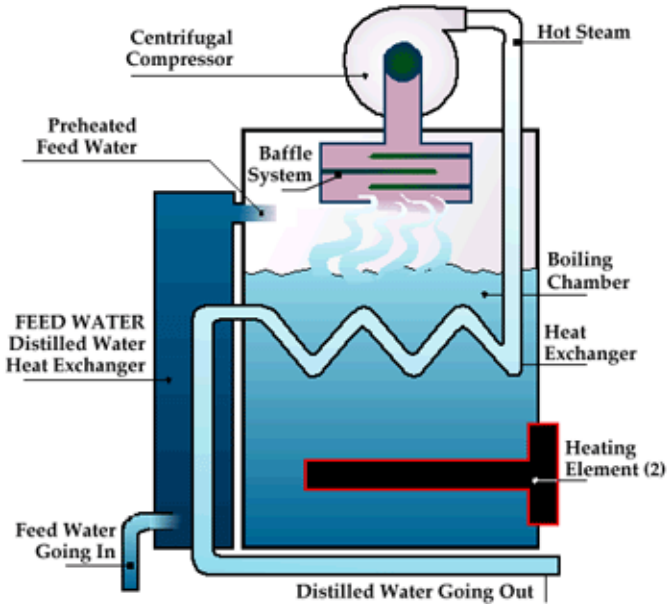


Fig. 65. Vapor distillation

3.4. Vapor distillation – this method is used for division of different liquids and impurities through evaporation. Some of the traditional Bulgarian drinks with high alcoholic content (rakia) are created this way. Unfortunately, this method is ineffective for big quantities of waste water.

4. Our choice – wet oxidation (Zimmerman process)

This process has none of the already mentioned deficits. The treatment continues from half an hour to 1 hour, under pressure of 10^7 MPa and temperature of 260°C, and results in:

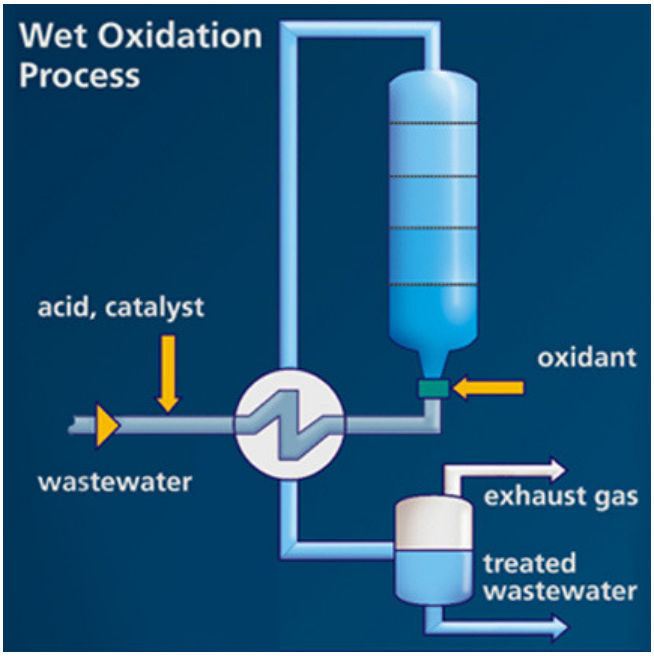


Fig. 66. Wet oxidation (Zimmerman process)

- Waste gas, free of nitrogen, sulfur and phosphoric oxides;
- High-quality water with evenly distributed phosphate dust and ammonium.

Both the gas and the water are sterile. By concentrations of sludges higher than 1.8 % the process is exothermic and the temperature of the waste water is increased by 56%. Because of the apparent advantages and its completed stage of development, we choose this treatment for the colony.

3.7.5. Food and biological waste

It has been calculated that a human under stress, performing hard labor, needs 2000 grams of water, 470 grams of dry weight various carbohydrates and fats, 60 to 70 grams of dry weight proteins and the appropriate amount of vitamins and minerals. Otherwise said, the colony will need a minimum of 30000 kg water, 7050 kg carbohydrates and fats and 900 kg proteins daily. Of course the variety and psychological aspects of the food should not be underestimated. The people wouldn't like to feed themselves with the same food every day or if the food is mostly tablets in cellophane wrappers.

Fig. 67, Fig. 68 and Fig. 69. Pressure boosting system and plants grown that way

The diet of the colonists will be mostly of vegetable origin, because the rearing of animals will involve a lot of problems and complications. The plants and algae will be grown in a special pressure boosting system, as the use of earth soil will lead to problems, mostly risk of biological contamination – for the soil are needed insects and other organisms, which (except the risk to transfer few sicknesses) can also mutate and/or multiply themselves unnoticed and damage the station and/or the colonists. The algae can be "cooked" either like pills (for the humans who don't like algae) or like soups, meals and other culinary surprises.

Fig. 70. Pressure boosting system and plants grown that way

The plants will be mostly vegetables like potatoes, legumes, peas, soy, green salads, herbs and spices, for which has been proved, that low gravity doesn't affect their growth.

There will be also a special biosphere with tenuous atmosphere and lower gravity, where flowering plants will be grown (mostly flowers and small trees – dwarf acacia, fir dwarf and others) and... bees! It has been proved that bees don't have problems with low gravity and honey is one of the most useful (and delicious) substances on our planet. It contains 70-80% carbohydrates, 10-20% water, 1.5% proteins, a lot of minerals, amino acids and organic acids. Otherwise said, honey has high energy content, it supports the immune system and provides the necessary vitamins and minerals.
The best of all about honey is that we can control the environment so, that it will be always favorable for the bees and they will increase their productivity. On the Earth the "honey season" continues only a few days, after it passes, the bees can produce honey only enough the feed themselves. Actually for one year on the Earth a beehive produces only 55 kg honey for trade and selling. But with precisely chosen environmental conditions we can increase the production of honey to 5 kg/day per hive!

Fig. 71. Bees can live and produce honey in 0g conditions

Unfortunately, our colony will need a rich source of proteins. The proteins are vital for the human organism, especially for the adolescent one. They are the main integral part of the body and are contained in products of animal or plant origin, but only the animal products contain a "complete set" of proteins. The plant products have only a limited quantity of proteins in themselves and if the food is going to be only from plants, a special diet will have to be created, which will create a major discomfort for the colonists and also the psychological aspect of the food will be disregarded – there isn't a human who wouldn't want from time to time to taste a tasty pork steak! Because of all these reasons, we will have to find a way to supply the colonists with meat, if not for all of them, at least for the young ones – 15-16 years old.

There is one reliable way to realize this – using genetics. Our colony will have a few genetic laboratories, in which (except everything else) meat will be breaded from stem cells, more precisely red veal and fish, because they are the healthiest types of meat.

Scientists from the university in Maastricht have improved the technology for production of artificial meat. They have synthesized meat strips from stem cells, and are convinced that their product is absolutely identical to the "natural" meat.

The process of cultivation of artificial meat in a laboratory is very complex and tricky. The scientists hope to manage to make the process itself easier so that the artificial meat may become available.

The mass production of beef, pork and chicken meat in a laboratory may even satisfy the growing search of meat around the world, which is expected to increase twice for the upcoming 40 years. The artificial way of producing also causes a lot less damage to the environment than the animal farming.

This autumn the scientists from the Maastricht University have declared that they have managed to grow small pieces muscle tissue from pig's stern cells and serum from horse fetus.

From each animal in a laboratory is received more than million times more meat than with the conventional method. For the manufacture itself the stern cells are placed in a "broth", which contains nutrients and serum from beef fetus. It makes them multiply themselves more than 30 times!

The meat strips also contract like true muscle cells. They are fastened and stretched so that the process may be accelerated and they're flexibility–contained. The meat, produced by this method, has specific fibers and has pink to yellow color.

There will be also a bio-chemical laboratory, which will synthesize eggs, milk, cheese and other types of proteins.

In summary, the meal of our colonists will consist mostly of plant products and chemically synthesized proteins. For the adolescents meat will be included as well. For the adults – rarely, only when the laboratories exceed their norms.

3.7.6. Energy supply of the colony

Among the potential energy sources of our space settlement were lots of real, not yet invented and almost-invented technologies, among which antimatter reactors, reactor, that uses the background space radiation, laser systems, placed at strategic points in the Solar system and much more. In the end we decided to use a lining of solar panels as a main energy source and a helium reactor as a secondary energy source.

The helium reactor is a relatively new technology, which is not much different than the typical thermo-nuclear fusion with TRISO fuel, but it is helium cooled. This system has many advantages, but the main are that first of all, the efficiency is almost 48% higher than the efficiency of a conventional reactor and second of all – the chances for the whole thing to just blow up and send our settlement straight into oblivion are much, much lower (thanks to the helium cooling system, as we all know helium is an inert gas, which makes it perfect for this purpose). It is known with the name GT-MHR (Gas Turbine Modular Helium Reactor) and is currently under development, but experiments are very promising. Of course we should not forget also that when successfully "launched", the GT-MHR will be much cheaper than any other thermo-nuclear reactor.
Of course since our settlement is in outer space and the lives of more than 15000 people will depend on their ability to avoid risks, we have decided to use the helium reactor as a secondary energy source. That way, the chances for it to blow us up will be much lower.

For main power source we decided to use solar panels. They convert solar energy in electrical energy. Their biggest advantage is that in space, far away from the Earth's atmosphere, their efficiency is much higher, because when the sun rays reach the Earth's surface, most of their energy has been absorbed by the atmosphere. And in outer space there is only vacuum. That's why the base amount of energy will be much higher. To construct solar panels, one needs mainly sand (silicium) + basic electronic components, which means that they are going to be cheap, efficient and reliable, since the sun is 100% going to shine in the next few billion years.
For our settlement we are going to use solar paint, which is like a nano-version of the solar panels. Currently solar paint is just a project, but probably in the next decade it's going to become part of our everyday life. Furthermore it will be much easier to use.

Today the best solar panels can power approx. 175 W per square meter and have degree of efficiency around 21.5%. Knowing that they aren't using the energy of all sunlight frequencies and that using monochromatic light the acquired energy will be much more, a new innovative solar panel design has been created, by which the light gets divided into beams with different frequencies and every beam is directed to different solar cell. This way the degree efficiency will be around 50% and 1 square meter will be able to power approx. 400W. The mere fact that the panels will be in space means that the basic energy they're converting is higher and they will be able to power much more than 400W. If we give every person in the settlement around 10kW, the calculated electrical power will be more than enough to power all systems and even some will be spared for

emergency cases. Using the data above we can easily calculate that we're going to need approx. 375 000 sq. meters of paint, around 0.375 sq. km.
Knowing that our settlement will be constantly rotating, it will be best if we have twice as much and only half of it will be illuminated by the Sun at a given time, which means approx. 0.7 sq.km.

Knowing the perimeter of the nine tori (altogether more than 71000 m) a solid solar paint band with 10 m width, encircling every single torus, will be more than enough for powering our space settlement

3.7.7. Protection from adverse space conditions

Space offers a variety of dangers to our space settlement, because of which we're going to need a special shielding, protecting the settlement from both radiation and random drifting particles/objects. The ideal Shield would decrease the radiation down to below 0.5 rem/yd., without restricting the space settlers access to their environment. There are two types of shielding – active and passive.

PASSIVE

The passive shielding is most reliable, since we wouldn't exist if it wasn't for that – the earth atmosphere provides us human beings with exactly that kind of protection. With more than 10 tons per square meter it grants us background radiation less than 0.2 rem/yd. It is easily calculated that for radiation under 0.5 rem/yd. we're going to need approximately the half – 4.5 tons per square meter.

ACTIVE

When charged particles pass through magnetic field their direction changes. That's why through smart placed force lines we could secure a given region of space. Since the power needed for the curvature of one particle's direction is inversely proportional to the particle's energy and acceleration, the region will be protected only from particles with energy under certain magnitude. All particles with higher energy will be able to penetrate the shielding.

The problem with this type of shielding becomes obvious when we choose the so called "magnitude" . For example heavy ions and solar flares protection is acquired through a limitation of 0.5 GeV/nucleon. Unfortunately in order to protect the settlement from the most secondary particles we're going to need a field with a limitation of at least 2 GeV/nucleon. That is why when we have a field around a torus with 0.5 GeV/nucleon limitation and structural mass 0.5 t/m² the radiation will be around 20 rem/yd., which is highly unacceptable. Only adding a small passive shield

(around 1.3 t/m²) will help to solve this problem, but even then we're going to need a safe house against the secondary particles from the strongest solar flares.

When the limitation is 10 GeV/nucleon no existing particle will be able to penetrate, but unfortunately the structural mass will be so high, that it will be impossible to be achieved through any of the 4 basic forms (sphere, torus, dumbbell, cylinder).

If electromagnetic field is used, there won't be problem with the mass, but we're going to need a constant voltage of at least 10 billion V, which is also highly unacceptable.

That's why the use of charged plasma will be much more effective – it will do the same work and it doesn't need so high voltage. The technology itself is being developed, although only for small objects. The concept is that a cloud of electrons will be kept around the settlement with the help of a magnetic field and it will repel all particles that come too close. The idea is similar to the electromagnetic field, but it doesn't need such a strong field. For the protection of 1 cubic meter will be needed approximately 100 kg substance + the weak magnetic field, which will keep the electrons in place.

For our space settlement we have chosen the active protection using plasma shielding.

Economy and Society

ECONOMY AND SOCIETY

4.1. ECONOMY

Essentials:

Our settlement will be the first of its kind and as such it won't have many trade possibilities in its first few decades, until other settlements are constructed. That's why the settlement's economy is going to be closed (inner) except in the rare occasions when we'll trade with the Earth. Later, when more attractive, beneficial and not so hard to reach trade destinations are created, we're going to turn to market economy.

Our settlement WILL have a specific currency, the same currency, which is going to be used on all other potential space settlements, planets and as a whole, places populated by civilized human beings. The reasons for the currency introduction are:

1. To ease trade.
2. In case a settler decides to emigrate he/she is going to need a tradable equivalent of what the settlement owes him/her for his/her work, so that he can make a fresh start in his new home.
3. Every single colonist will get for free food, water and electricity cost-free (otherwise said they will be withheld from his/her salary), but many other "luxury items" won't be for free. They will be paid.

And a lot of other reasons, but mainly so we can sustain a healthy and stable society, whose members don't ask themselves the question "For God's sake, why the hell do I work?!". The answer will be simple – so that I can live comfortably with everything I need and a little bit more.

Now to the core economy of our settlement – as every Earth economy, it's going to be divided into three major sectors – Primary (Extracting), Secondary (Industrial) and Tertiary (Service).

4.1.1. Primary (Extracting) Sector of Economy

Matter in space is crucial, since researches show, that Earth's natural resources can and will be easily depleted. Therefore it is extremely important that our settlement will be able to utilize every possibility for gather of matter. During its existence our settlement will make use of a few main matter sources.

The first few years the settlement is going to collect and recycle all materials, circling in LEO, which are all known under the common name **space junk**. According to recent calculations, more than 22 000 objects with size above 5 cm and 300 000 smaller objects are in Earth's orbit. They weight more than 5 500 tones, their qualitative and quantitative structure varies and each year they become more and more, their number growing exponentially. This means that when our settlement is launched, there will be a whole treasure circling around the Earth, just waiting for someone to gather it (and recycle it in our case).

The debris alone will be collected thanks to two specialized space ships, described in **2.1.** After we're finished cleaning the Earth's vicinity, our settlement will also clean the five Lagrange points, where because of their physical properties lots of matter is accumulated, mostly gases, carbon or dust. Rarely rock pieces.
After we finish cleaning AND the Lagrange points, our settlement will start mining asteroids and sometimes, once in a decade or 2 decades, will sweep over the Earth to collect the new space junk.

But why exactly asteroids?

Asteroids – as there are more than 100 000 asteroids in our Solar system, they are an unending source of matter. Researches show, that most of them are composed of granular carbon material and even elements, which are very rare on the Earth and Moon. These elements can be used for highly specialized functions and will be very useful for our colony in certain cases. The asteroids are divided depending from their composition into three main types – carbon, silicon and metal. The nearest asteroid belt to our colony is the one between Mars and Jupiter.

Our settlement is going to attach itself to an asteroid thanks to the device, described in 3.3. After depleting the sources of the asteroid it is going to move on to the next asteroid and so on, the process will repeat itself.

These are the main matter sources our settlement is going to utilize.

4.1.2. Secondary (industrial) sector of economy

Processing of resources

Our colony will acquire massive quantities of raw materials, which will have to be first processed, then used. Depending on their composition, processing and use these raw materials can be divided into three groups:

1. **Ores** – these are in general compounds of metals in rocky form. The processing includes separation of the pure metal from the impurities. There are different methods for processing and separating metals. Depending from the ores, which have to be processed, each of the enlisted methods will be used:

   1.1. Pyro-metallurgical method – used for separation of copper, zinc, lead and others. The ores are "fried" on temperature, not high enough to melt them, than they are melted and the raw metal is purified. The "frying" affects the sulphides, whereas the metals often oxidize. The general chemical equation of this method is

   $$2MS + 3O_2 \rightarrow 2MO + 2SO_2 + Q \text{ (M – copper, zinc...)}$$

   Unfortunately this method causes a lot of environmental damage, which can be (hardly) prevented.

   1.2. Hydrometallurgical method – used for separation of zinc, gold, uranium and others. Different solvents are used (mostly H_2SO_4 or NH_3) to extract the metal. After the reaction the metal is extracted as a soluble salt. The general chemical equation of this method is $MO + H_2SO_4 \rightarrow MSO_4 + H_2O$.

   1.3. Electrometallurgical – used for zinc and others. The ore is put through electrolysis.

   1.4. Bio-metallurgical – used for almost every known metal. Thereby the ore is processed with microorganisms (bacteria) and the sulphides are oxidized to sulphates. The fragmented ore is irrigated with mix of biomass and sulfur-acid solution $Fe_2(SO_4)_3$. After a long stay the metal sulphides become soluble and through extraction, cementation and other methods the pure metals are extracted from this solution. The advantages of this method are that, it can be used by almost every known metal and it doesn't pollute the environment. The only disadvantage is that the process is much longer than the others.

2. **Industrial minerals** – like gypsum, rock salt, fireclay and others. They are created through precipitation and stuffing of the silts. By processing of the industrial minerals we can partially use the metal methods described above. As the colony isn't going to acquire these minerals in big quantities, we won't use a special method for them.

3. **Water** – as we all know, water is vital for the colony (mostly for the humans in it), but it won't be acquired in big quantities, as it will be repeatedly recycled and processed. The goal thereby is to lose as less as possible. Of course when "new" water comes in, it is going to be tested for radiation and microorganisms and then put through the waste water treatment system – this will be more than enough to process it.

Manufacture and repair of spacecrafts

The Earth has a very strong gravitation field, which makes the launching of objects from it very hard, costly and energy-intensive. The best place for preparation of deep space missions will be therefore our colony, because the construction of spacecrafts will be easier in zero-gravity environment and the launch would require a lot less energy.

The materials needed for the construction of spacecrafts will be easily acquired from the Moon or the asteroid belts and the machines required therefore will be anyway part of the ordinary equipment in the special shipbuilding and ship repair zone. After the construction of the main parts, the spacecrafts will be assembled in the open space near the colony.

The reparation of space ships also won't be a difficult operation. The damaged ships will be able to dock in our colony and a crew of repair robots will diagnose the problems and repair the ship. If there is something, which this crew can't handle, a robot-specialist, controlled by a human, will be sent.

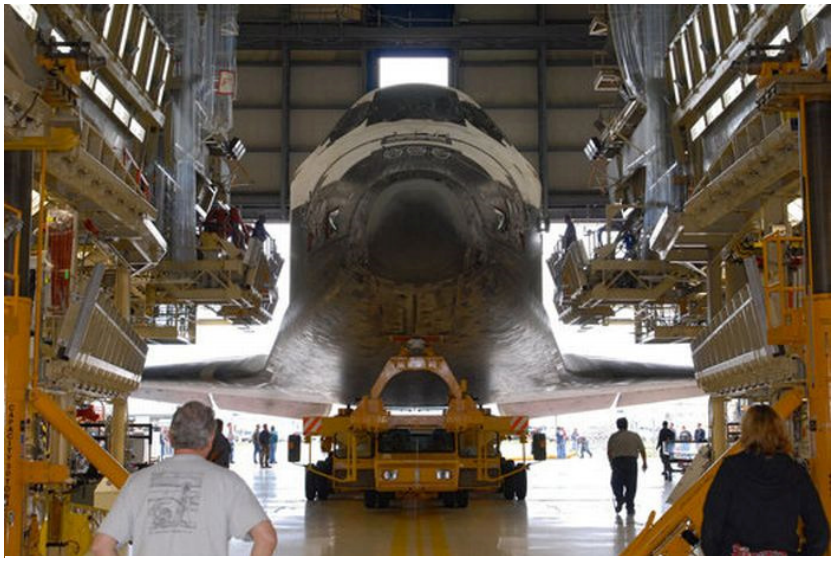


Fig. 72. In the Settlement spaceships will be produced, repaired and maintained

Manufacture of advanced technology

As we all know, every "advanced technology" sooner or later becomes old-fashioned. That's why our colony must have a module for manufacture of the most important for life- and colony-support technologies. This production will require mostly metals (conductors), which can be easily acquired from the Moon and asteroids or otherwise be synthesized. The group of advanced technologies includes the following:

Computers, computer systems and networks – each system onboard the colony will be controlled by computers, from the work of the people to their homes and the public buildings. Every wall and every house will be covered with so called computer wallpapers. They are extremely thin and can be put everywhere. Through them humans will be able to use internal and external internet everywhere and control the manufacture and research processes. They will be able to monitor and control the activity of each system and device.

Nowadays the manufacture of this kind of equipment requires silicon, but with the growing computing power and development of nanotechnologies, silicon will be most likely replaced with some other element. Unfortunately, no one currently knows or even suggests which this element will be. Of course as for the manufacture of these technologies won't needed any equipment, which has not been developed yet, our colony won't have any problems with their mass production. Only the machines needed for fine work on molecular level will have to be imported from the Earth.

Solar panels – the material needed for their construction is silicon, which will be derived in big quantities from the Moon. Its manufacture is not complicated; in the future it will be even simpler so that our colony will be able to produce silicon in industrial quantities.

Robots – workers, producers, "specialists"- they take care that everything in our colony works the way it has to. They can even fend environmental incidents, are dangerous for humans. Their manufacture will be easy, then they consist of chips with complicated programs, different for each type of robots, and an artificial body. It is a matter of time until they become part of our everyday life.

Nanobots, nanosensors and other nanotechnology – their manufacture will be the hardest, because it will require extremely precise equipment. Also the technology for their mass production will be ready in the near future.

Devices, which can be controlled through a person's mind – nowadays this is one of the many futuristic technologies on the edge of becoming part of our everyday life. Today, thanks to simple electro-neural links people are able to command machines with their minds. Although for now only simple actions have been conducted through the "mind control", this technology has great potential and can be used in all sorts of devices, beginning with exosuits, which humans will be able to control only with their

minds, going through artificial prosthetics, serving better than real organic limbs and reach wireless access in various computer systems with a single eye blink.

Each specific type of technology will be manufactured in different sector of the colony; the sectors will be unified in one module. These sectors will have two things in common:

1. The manufacture everywhere will be mechanized and robotic – as in an industrial factory. When needed a robot specialist controlled by a human will be sent.

2. The machines in each sector will be imported from the Earth.

The module itself will be somewhere in the zones with gravity between 0.6 and 0.2 g. The lower gravity will help by the work with massive and weighty objects.

The more specific division of the economy activities is described in **3.6.1**.

4.1.3. Tertiary sector

1. Transport

The colony will not be big enough to need very fast mass transport and vehicles, that is why we will use mostly alternative vehicles, powered either with electricity (Segway, electro cars and others) or with physical power (mostly bicycles). Of course there will be different paths for the different vehicles. The two floors in every torus will be connected through elevators and stairways, in the biggest tori (IV, V and VI) will have moving walkways, as explained in 3.6.2 Interior Design.

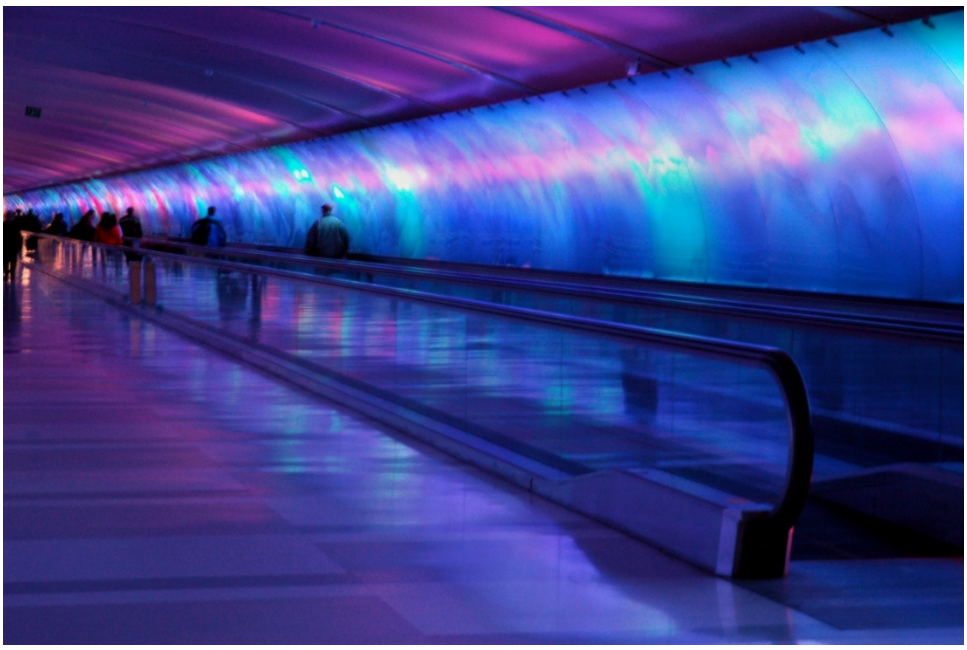


Fig. 73. A moving walkway

*Fig. 74. Classical **SEGWAY***

*Fig. 75. **The Tong City Bike***
(perfect for the colony's conditions)

1. Tourism

The cosmic tourism will be one of the most important parts from the colony's economic. The Earth inhabitants, Moon base inhabitants and humans from other colonies will be very interested in visiting our colony.

The special tourism module in sector B1 will provide lots of entertainment and sport activities. In this module we plan to have 10 hotels for 500 people each. The hotels will have also a zone for low-gravity activities like Luna Park, zero-gravity sport fields and others.

Sport will be very popular among the guests and the inhabitants of the colony. There will be team sports, individual sports and fitness. The goal is to give the colonists an opportunity to keep good physical form and health. Competitions and olympiads will be regularly organized. The main habitable zone will have lots of gyms.

2. Education

The education will actually be almost like the one on Earth. There will be a colonial school which will be visited from every child. They will go to school from year 5 and will first do a test, which will show their abilities and specificities. The students will be then divided in classes depending on their results. For a certain number of years the children will study general education subjects: natural and humanitarian science, but in the different classes the study will be focused on certain subjects, depending on the students' abilities (mathematicians, physicians…). The teachers will be humans and human-like robots. The process of studying will be very different from the current one, because in the near future computer and internet technologies will be much more advanced and will occupy even the education. After graduating this educational stage (equivalent to secondary education) each student will be tutored individually or in couples by an elder representative of a professional guild (scientists, robo-controller…). This educational stage will continue for a couple of years depending on the profession and after it's graduating the young man/woman will begin his/hers professional carrier.

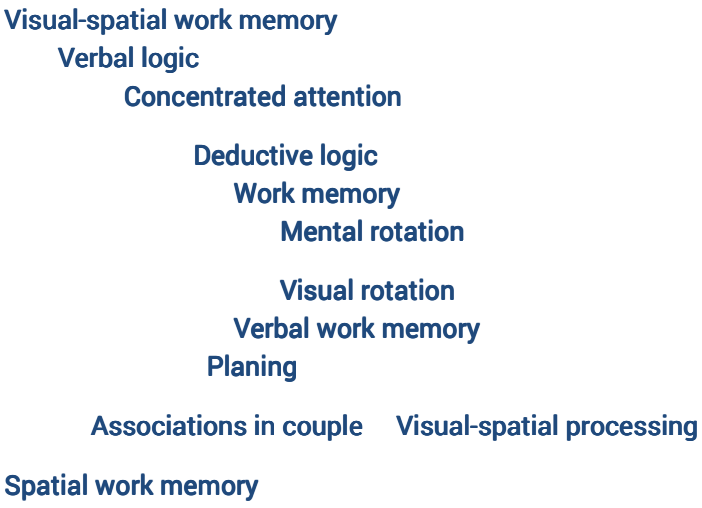


Table 9. Table of some of the most important things in the secondary education

Fig. 76 . Education in Greenspace

The education in the colony will be aimed at developing of the individual. It isn't important to identify if someone is intelligent or not, it is better to find how apply the abilities of this individual.

4. Medical services

Nowadays, technologies step more and more into medicine and with every new year new levels of security and safety are accomplished. In the near future our prophylaxis will be only robotic. Our colony is going to be launched in or after this near future, so we are going to apply the currently-developing technologies.

The prophylaxis of our colonists will be done at their homes thanks to the so called intelligent mirrors and bathrooms. In them lots of sensors will track the health condition of the colonists when they take a shower, brush their teeth and so on. When something wrong happens in their body, they will be informed through an appropriate interface and will be told what to do by a virtual robot doctor. When needed, an operation is done from the same robot doctor or specialized nanobots.

In the next pages – pictures, illustrating theoretical concepts:

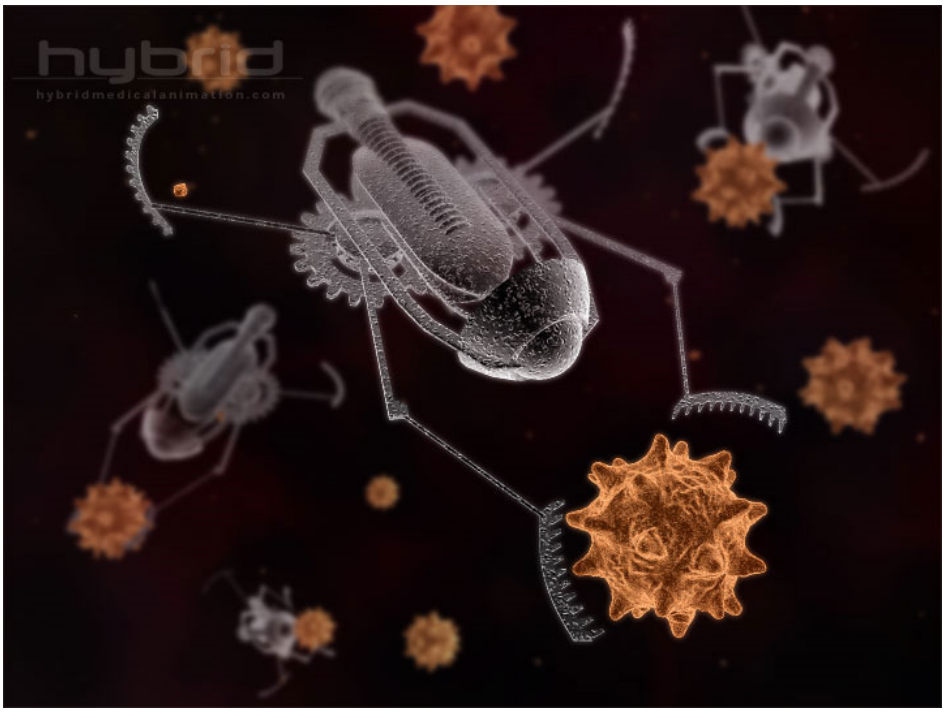


Fig. 77. Fictional Nanobot

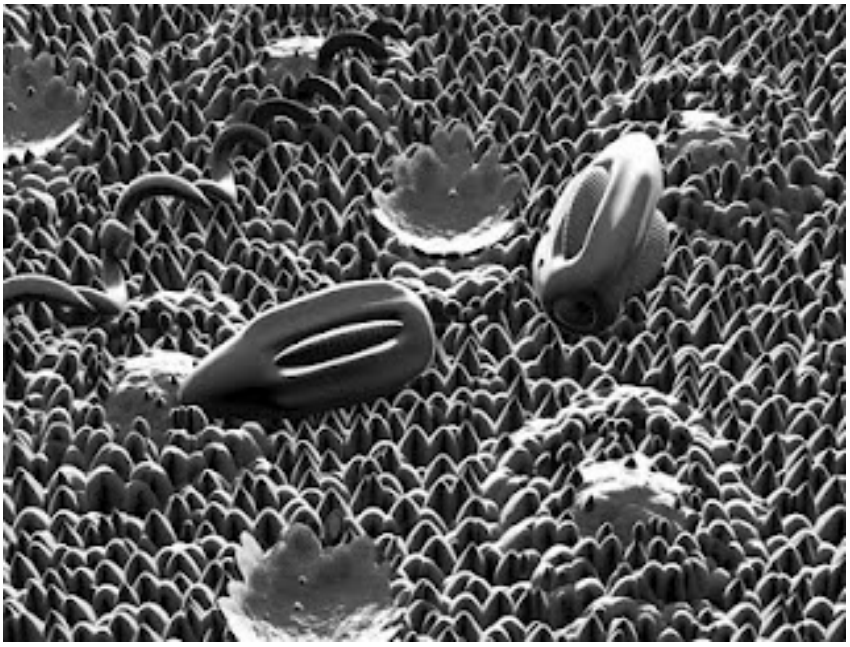


Fig. 78. Fictional illustration of the Oxford nanobots. This illustration does not indicate that the nanobots crawl along DNA.

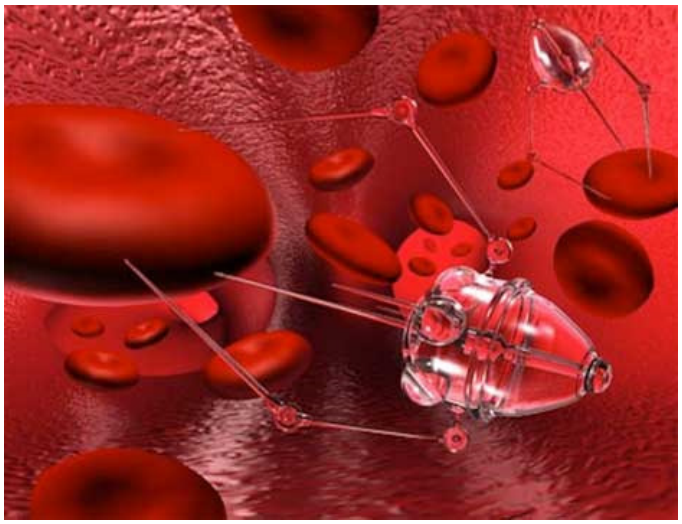


Fig. 79. Nanobots Can Turn Off Cancer Cells

Each colonist will be examined everyday from sensors in the bathroom and the toilet. If the sensors indicate cancer cells in very early phase or mutation in the gene p-53, which leads to cancer, in the blood of the colonists will be injected nanoparticles. They will provide the needed medicines to the cancer cells. Each person will have a bank of stern cells, from which can be bred new organs, which can replace ill or damaged ones in the body. Each colonist will also have an integrated in the system personal doctor, which will be always "online" for questions and advices. Also the colonists will live young for almost ever. This is accomplished following the methods, described by Michio Kaku:

- Growing through tissue engineering stern cells and new organs, which will replace the damaged or sick ones;
- The injection of an enzyme cocktail, which are made to improve the restorative mechanisms of the cells, regulate the metabolism, turn back the biological clock and reduce the oxidation;
- Use of gene therapy for changing of genes, which speed up or slow down the process of aging;
- Healthy life through exercises and good diet;
- Use of nanosensors, which spot illnesses like cancer before they have turned into a problem.

Recently the giant SONY has patented a new biometric sensor, which is made to collect biometric data: skin humidity, pulse and muscle movement.
The Chinese LENOVO has already created a laptop, which the users can control only with their eyes. Actions like opening of pages, enlargement of text and document rotation is now accomplished without a single move.

The Dutch company PHILIPS is working on a sensor for detection of pulse and rate of breathing. Their camera can notice the delicate changes in human skin, which are

invisible for the human eye, but exist when the heart pumps out more blood. The fast breathing is detected through the lifting and lowering of the chest. With the integrating of this sensor the colony will have information for the health conditions of each person wherever he/she is! By this method one always current biometrical passport will exist for everyone.
(The Big Brother 2.0,"Objects" Magazine, 01.12.2011)

The health of the colonists

Modern scientists claim, that the combination of genetics, nanotechnology and robotics will allow humans to live much longer, almost forever. The development of science shows, that in the 21st century nanobots will be able to repair damaged organs or even correct the DNA code.
In the time when our colony is going to be built, the regeneration of organs will be a routine operation thanks to the stern cells. They have the potential to turn into every possible cell in our body. One day in the future people will go to the doctor once in a few decade just to have all their organs replaced.
Nowadays scientists are working very hard in the field of aging, mostly how to prevent it. The first "cure" for aging will appear in less than 15 years. Ronald de Pihno, president of the Texas University cancer center in Houston, and his colleges have managed to create the medicine 4-OHT, which was tested on genetically modified mousse with short telomeres. The results are that all symptoms of aging have been reversed! Two companies have developed such researches – Life Length in Spain and Telome Health in the USA. One of the awarded with Nobel Prize in 2009 is Elisabeth Blackburn for the discovery of telomeres, which are responsible for the length of the human life. ("Forever Jung" by Nick Fleming, "Knowledge" Magazine, 01 2012)
In case of unexpected physical injury the victim will be led to a specialized medical module, where he will be placed on the surgical table and will be injected with nanobots, which will heal him. These nanobots will be highly specialized microscopic robots with size, not bigger than a single cell, will have a preset program, by which they begin to heal the person.

Fig. 80. Robot doctor: Da Vinci at the Kent and Canterbury Hospital

These are the robotic medical services. Of course every person in the colony will be taught of first aid in an emergency case. There will also be highly specialized, special trained human doctors, but they will be more researchers. There are three cases, in which they will use their knowledge:

1. A “brand new” disease appears in the colony, with which the robot doctors can not cope. The human doctor will have to study this disease on cell/molecular level and find cure as fast as possible. After they find cure, they transfer it to the database, the robots fast and efficient spread it and the disease is no longer a problem.

2. In case of accident/breakdown and the electricity stops or the robots are damaged. Then if many people need first aid or urgent operation, they are sent to the human doctors, which will diagnose them and do whatever treatment is required until the electricity/robots are restored.

Fig. 81. Da Vinci Si Surgical Robot

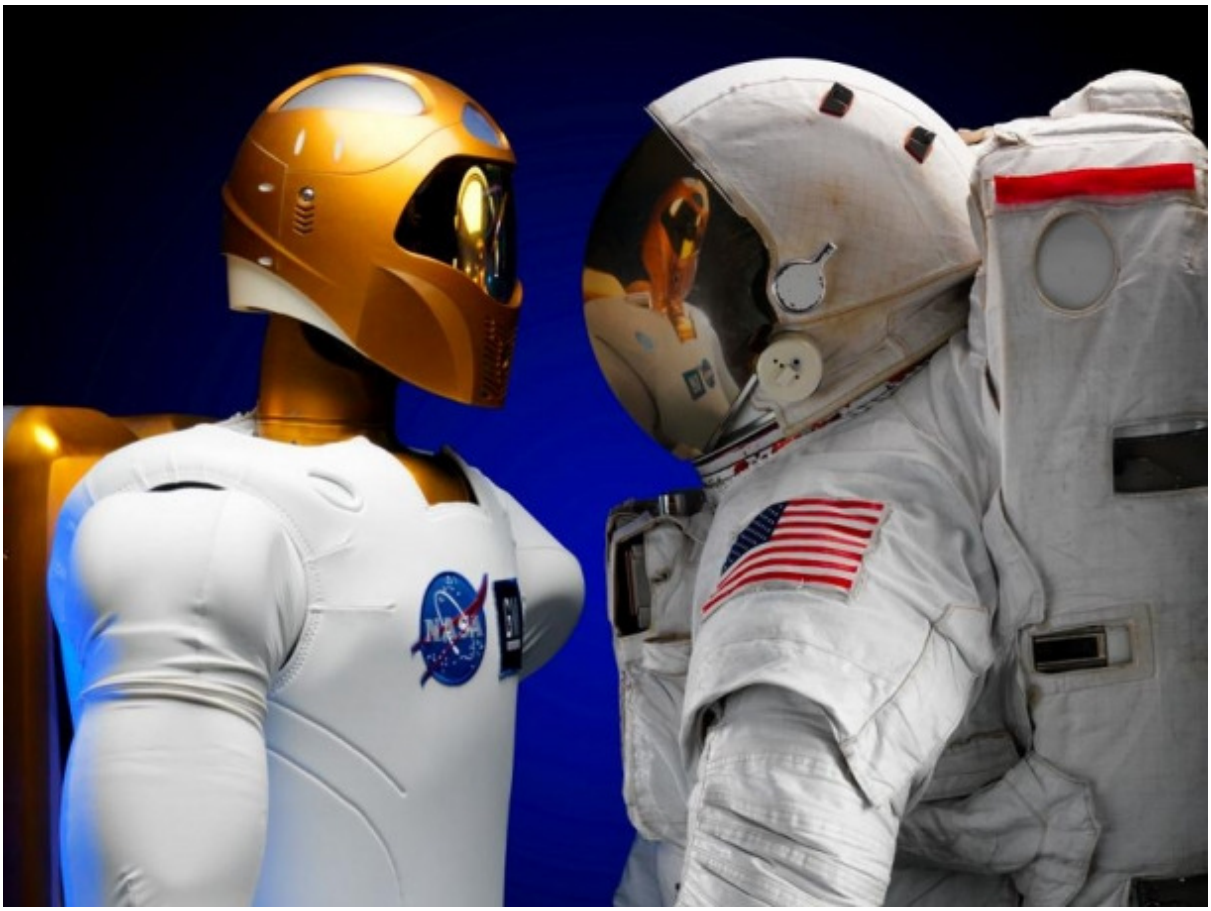
5. Robotic presence in the settlement

Hundreds of robots will work in the colony. They will be absolutely safe. Every intelligent robot will be equipped with safeguard mechanism, which can be always turned on from a human when the robot is showing strange or wrong behavior. Otherwise said, the robots will be friendly. Major part of the unsolvable with human genetic problems will be solved with partial merge with artificially created devices with human body, like: chips for regeneration of bad/lost vision, hearing, mechanical devices, which will strengthen the limbs and spine. In the time when our colony is going to be built the fusion of silicon and living cells will already be accomplished not only for curing of certain sicknesses or body impairments, but also for slowly improvement of our abilities. Sounds with different frequencies will be heard, the ultraviolet, infrared and X-ray spectrum will be seen and much, much more. Even the capability of our brain to learn and remember will be enlarged with placing of additional neuron layers!

Fig. 82. Asimo

Everyone from the engineering and technical staff of the colony will have his personal avatar-robot, which will either work independently on previously given task or synchronously with the human. Special contact lenses will be used from the people in order to see what the robot sees for example when the robot must do a very hard

repair or something similar, which requires imagination and logical thought. All humans and robots in the colony will be connected through an internal wireless network. Thanks to this network will be realized the control of robots. In this way the avatar-robots will be able to work in dangerous for humans environment, for example – by rescue operations. (“Physics of the Future”, Michio Kaku).



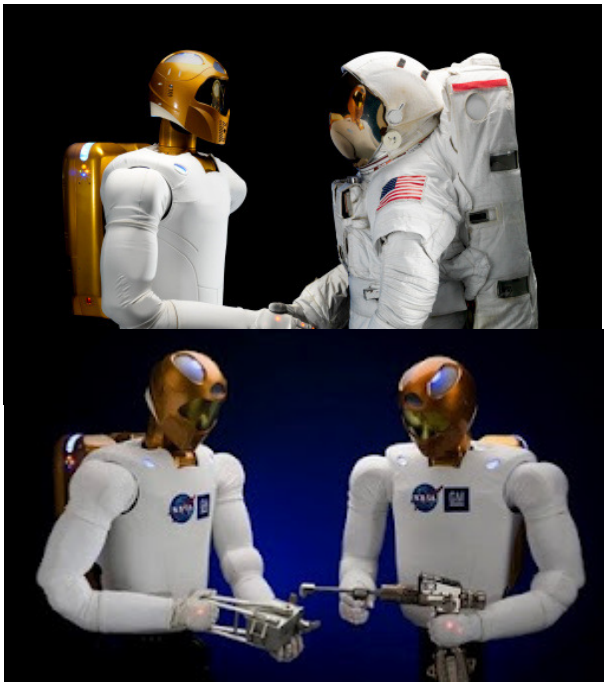


Fig. 83, 84, 85 & 86. Robonaut 2, who passes challenges in the International Space Station

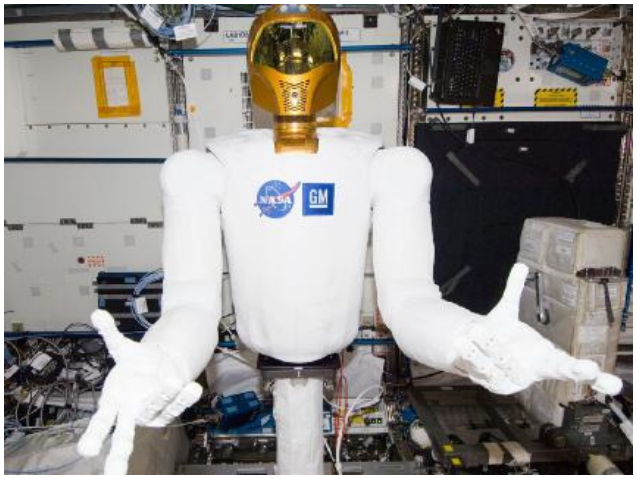


Fig. 87. The Roomba is a robot that can vacuum the house

Fig. 88. ASIMO is one of the most advanced humanoid robots in the world. It's designed to perform a wide variety of tasks, like flip on light switches and many others

Fig. 89. This robot serves as a teacher to human students, although we're not sure how much the kids are learning right there. Credit: Koji Sasahara

Fig. 90 . It's a robotic justice of the peace! This robot conducts a wedding ceremony.

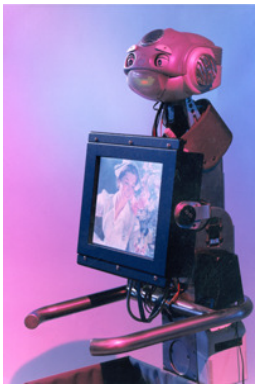


Fig. 91. Nursebot was designed to assist the elderly with everyday tasks, such as reminding them to take medications

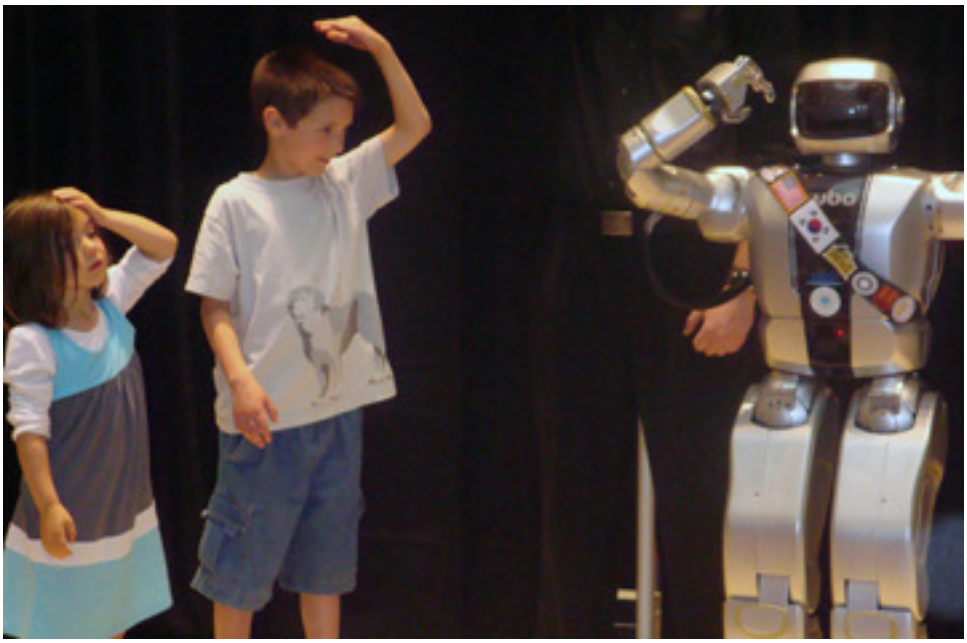


Fig. 92. Jaemi, a humanoid robot, plays "Simon Says" with a group of children at his unveiling.
Courtesy: National Science Foundation

4.1.4. Scientific research department

Onboard the colony there will be mainly three types of scientific work research:

1. Experiments in zero-gravity environment

These will be complex physical, chemical and biological experiments. Their goal will be to define the physical properties, chemical reactions, DNA and live organisms' behavior in weightlessness. There are a few possible places for these laboratories in our colony – in the middle of the cylinder or in the research laboratories in B1, one of the modules in the interrupted torus.

2. Observatory

There are a two ways for monitoring of the space and objects around the colonies. The first one (the traditional one) is through one big observatory which will use all advantages of its location (lack of light pollutants, atmosphere and so on) and will be able to see more distantly and with better details.

The other way, more futuristic, is that our observatory to be a system of the so-called "intelligent dust". This is actually a cloud of nanosatellites which will go round the colony and will monitor the space in every direction. They will track asteroids around the colony, damage from the "micro-meteorites" and everything strange inside or outside the colony; they will also make pictures of distant and near objects. The technology for their manufacture has already been developed by the organization Interorbitel Services in 2011, but until they are ready for cheap and mass production a few decades will be needed (maximum 4).

SmartDust, the robotic intelligent dust

March 9th, 2010

Fig. 93. Smart Dust

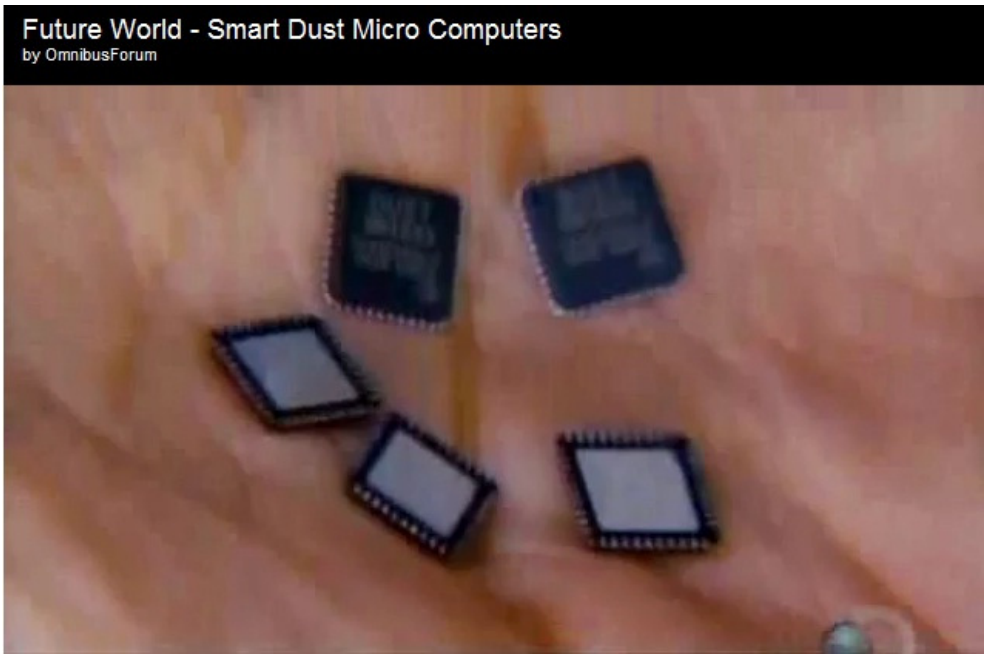


Fig. 94. Smart Dust

Network, created from such satellites around the colony will gather various information for the Sun, the stars and all objects in the Solar system. The advantages of the microsatellites from the observatory of "astronomical ants" are that they are cheap, easy for creation, cover a huge perimeter, create detailed three-dimensional pictures of different objects and phenomenons, give information from thousands viewpoints and the damage or destruction of some of them will not lead to malfunction of the system as whole, then each of the satellites in the swarm will be independent. Of course there must be created a station, where the will send the information and it will be processed. These nano-satellites will also be part of the communication infrastructure of the colony.
("Spreading of intelligent dust in the Space", 01.12.2011 "Objects" Magazine)

3. Laboratories, producing materials, vital for the colony

These laboratories will be two types:

"Clone" departments – modern genetics with each next day get farer and farer in their attempts to clone complex organisms. Knowing their current achievements, we can guess that in the near future single cells will be easily mass produced. How can this help us? As explained in chapter LifeSupport (4.5.2) the human beings need a rich animal protein source and the growing of animals is too hard. The best solution of the problem is to clone chicken and veal stern cells, thanks to which the colonists will receive ready for cooking meat. The goal of these "clone" departments will be to do this. Their number will depend from the people aboard the colony and productivity of these departments.

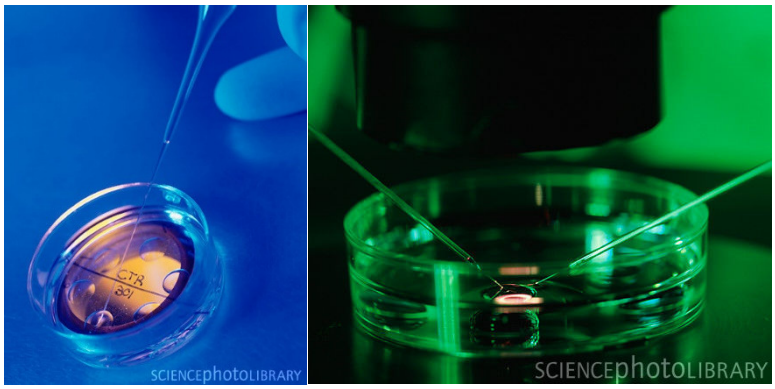


Fig. 95, 96. Cloning research. Pipette manipulating cloned cow embryos

Research departments – there will be few types of these depending from their science field. Their main goal will be to develop the colony's technologies, but also create new ones. For example medical research departments – they will have only human personal with full medical education. Their work will be to find cure for any foreign pathogens and meanwhile do research for new medicine, the human genome and so on.

4.2. Society

4.2.1. Basic assumptions in Space law, which will govern the Space Colony

Because of the specific position of the space Colony in outer space, the human community of the settlement will be strongly connected with the terrestrial and (possible) lunar communities. Connections of different nature will be establishing with other (potential) colonies around the Earth and Moon.
New relationship of commercial, scientific, research, tourist and entertaining nature will be created between the communities living in different areas in the Solar system. Ethnically based relationships, political partiality and other new unknown for now relationships aren't excluded.

This will require a specific government and laws, corresponding to the features of conditions and needs of the colony and the negotiations with the Earth and Moon communities.

New type of human law – the international space law will govern all activities of the human communities in the Solar system.

The international space law is a combination of principals and standards which establish the legal regime of space, Moon and other celestial bodies and also establish the collaboration of countries for a peaceful research and usage of space.
A subject of the international space law is the outer space, Moon and other celestial bodies as well as activities of the countries for a peaceful research and use. Certain powers in this domain are given from the countries in the international intergovernmental and interplanetary organizations. The exercise of the mentioned powers is also covered by the international space law.
When constructing our Colony international organizations will take part, such as organizations from the system of the United Nations and specialized international, colonial and planetary organizations: the present ones – The international organization for satellite system, for maritime links and INMARSAT, The European Cosmic Agency, NASA, RosCosmos, The China National Space Administration and other.

The legal regime of the outer space, celestial bodies, cosmic objects and status of the astronauts are respectively specified
The outer and inner boundaries aren't specified. The analysis of the co-operation between the countries in space allow us to deduce that the communities have conventions which describe the outer space as a vast region, beginning from the outer boundary of the atmosphere /for example 100 110 km from Earth's surface/ and extending beyond the orbit of the Moon. The region between the inner boundary of space and Moon's orbit (i.e. 384 000 km from the Earth's surface) is adopted to be called "Near space" and beyond the orbit of the Moon "Distant space". The legal regime of space and celestial bodies specifies by the universally accepted principles of international law and the special principles of space law, stipulated in contractual and common norms.
A significant role in the development of space law and creation of favorable conditions for international collaboration in the domain of space science and space technologies plays and will play The United Nations. The main intergovernmental body in this domain is the Committee of UN for use of outer space for peaceful purposes (Space Committee), established by the General Assembly of UN in 1959. As a result of its actions there are principles for space activities approved by GA of UN. These principles will act also at the moment of building and exploitation of our space Colony.
The principles of international space law are incarnate in the Outer Space Treaty from 1967, as follows: Exploration and use of Space for welfare and in interest of the whole humanity, based on equality between the nations without any discrimination (article I); Prohibition against appropriation of outer space and fall within national jurisdiction (article II); Outer space is free for independent exploration and use in conformity with space law (article III); -The Moon and other celestial bodies are used only for peaceful purposes, it's forbidden to bring out and settle nuclear weapons or other type of weapons for mass destruction anywhere in space and on celestial bodies – a

principle for demilitarization of outer space and celestial bodies (article IV); The countries bear responsibilities for detriment caused by cosmic objects registered by them and also for their national space activities, including activities performed by juridical persons (article VI and VII); the countries retain their jurisdiction and control over registered cosmic objects and all type of equipment on them (article VIII); the countries must NOT pollute Space (article IX).
Together with the principles, the Outer Space Treaty from 1967 contains norms, determining rights and duties of the countries and other subjects of the international law. In conformity with the provisions it determines: right of free exploration of outer space and celestial bodies (article I); right to consult with other countries about their activity in outer space, right to visit different stations, space crafts on celestial bodies and others (article X and XII).

The treaty impose the obligation on countries to perform their cosmic activities in conformity with space law (article III); to help astronauts/colonists from other countries in case of disaster or forced landing as well as immediate return and information of other countries or UN for the cosmic occurrence which would be a danger for astronaut's/colonist's life (article V); to consider the interests of other countries when exploring the outer space, to take measures against the harmful pollution of outer space and unfavorable changes in terrestrial environment (article IX); To inform the secretary general of UN, the international community and the scientific communities about the nature, place, progress and result of their cosmic activities (article XI).
The listed international acts and rules of the international and intergovernmental organizations specify the negotiations in the domain of cosmic activities in conformity with the universally accepted principles of space law.
They ensure the progressive development of the whole field according to problems – a struggle for peace, for a universal safety and conservation of environment.
For the work and life in outer space, a special significance has the principle for not applying force and treats. In the outer space and on celestial bodies is prohibited to lead military actions, to create and install military bases and outfit, to do military maneuvers (article IV).
To use satellites with an aggressive purpose and to perform actions which threaten the peace is illegal. The Moon and celestial bodies are fully demilitarized, it's completely prohibited to lead any military activities on them and also taking in Earth's orbit, nuclear or other weapons for mass destruction.

Leaving aside the general task for conservation the environment and outer space for the future generation, according to the Outer Space Treaty from 1967, the subjects of space law which perform cosmic activities are obliged to avoid any pollution and unfavorable changes in the cosmic environment.

The countries are obliged to take the appropriate national and international measures for destroying any cosmic objects which are out of order and to minimize the damaging consequences when using cosmic apparatus and conducting research experiments.

Legal status of the colonists and cosmic objects – the colonies

The legal status of the colonists represents a combination of the concrete legal rights and duties which every individual have in possession at a given time and moment.

In space law it will be required a special regime of the colonists in the space colonies. The status of the colonists is specified by the space law which describes them as individuals living and working in space colonies that are citizens of their countries and come within the jurisdiction and control of the country or organization which has created and registered the colony.
The specifications of legal status of the colonists will be specified by international agreements.

1. Legal status of the colonists

The colonists are inhabitants of the space colony.
According to the Outer Space Treaty from 1967 (article V) the colonists are described as “envoys of the human race in Space”. This doesn’t mean that they have some special, supranational legal status.
The colony will be governed by a Council of the colony.

In the Council will be elected up to 30 representatives of the main professional directions (research, trade relations, defense and safety, control and management of computer systems and robots).

The Council will be governed by a mayor with two deputy mayors who will make decisions if it’s needed.

The colonists will have certain rights and responsibilities. Being in the colony, the colonists will perform their work when they are in space and also when they are on a natural celestial body.

The colonists are obliged to help astronauts/colonists/inhabitants of bases and planets, being in outer space or on celestial bodies in a variety of ways; to help foreign objects for their work or arrival, located in outer space, on the Moon or other celestial bodies.

All individuals living in the colony, located in outer space have the status “colonist”.

The issue about saving of colonists will have to be described in details about different circumstances by the international space law. Similar provisions about astronauts are stipulated in the Outer Space Treaty from 1967 (article V), also in the Agreement from 1968 for saving and return of astronauts and objects launched in outer space, and in the Agreement for activities of countries on the Moon from 1979. From these acts follow some obligations for the countries as helping in case of emergencies, disaster, emergency landings on national or international territory (open sea, the Antarctic and others) of astronauts and cosmic objects (article 2 and 4 of Agreement for saving from 1968); instant return of crew of the country registrar (article 3); taking necessary measures for saving astronauts' life and health, to inform the Secretary-general of UN and the country for finding the astronauts and taking life-saving measures (article 2 and 3); To inform the Secretary-general of UN and other countries for the found out occurrences and celestial bodies which could endanger the life and health of astronauts and other. The countries which have carried out the launch have the right to require fulfillment of the specified obligations. The international space law stipulates life-saving help from the astronauts in space and on celestial bodies; mutual aid of astronauts during their stay in outer space and on celestial bodies, to give a shelter to individuals in case of disaster and other. All these conditions could be relevant to the colonists in the colony.

2. Legal status of space colony

We'll use the existing status of cosmic objects as a base for the status of our colony. Under cosmic objects we'll understand artificial celestial body together with the means for its delivery and parts, launched or constructed from a country or a group of countries in outer space or on celestial bodies for exploration and use of space for peaceful purposes. These are apparatus with different functions created by the human civilization. According to international space law the work of cosmic objects is determined from the beginning of their stay in space until they land in the country where they're registered. When the cosmic objects leave the countries as well as come back from space, they ensure a peaceful, harmless passing through the airspace of the neighbor countries. The creation and bringing out of cosmic objects in space is specified for now by the domestic law of the country, except for cases when a collaboration of several countries is performed according to an agreement.

For a successful collaboration in assimilation of space, a mutual aid is required for search, identification of cosmic objects and indemnification for damages, that's why the countries register every launched object (article II); and also from 1969 they're registered in the world organization – international registration on the recommendation GA of UN.

The regulation and registration fulfills in the convention for registration of objects, launched in outer space from 1975, where it's established the order for registration and the volume of necessary information, provided by the Secretary-general of UN for

inscription in the Central register of the organization (article III and IV). Under the signification of the Convention "country of registration" means a country which launches an object or gives its territory or equipment to another country for the same purpose where the cosmic object is registered (article I). The main purpose of registration of a cosmic object is to establish a legal connection between the apparatus and the launching country.

The building of space colony will be within the reach of a group of countries.

Active space law:

The Convention stipulates situations when two countries take part in bringing out a cosmic object. When two or more countries launch a cosmic object only one of them has the right to register it. These countries can conduct an agreement concerning issues of jurisdiction and control over that object and its crew (article II of Convention for registration and article VIII from Outer Space Treaty from 1967). The country registrar has to put a sign or a registration number on the cosmic object (article IV), to record it in the national register and the Central register of UN, to require a return of cosmic object or its parts found beyond its territories, to collaborate with other countries for saving and return of the object, to bear responsibilities for damages caused by cosmic objects of third countries, to fulfill jurisdiction in relation to the crew which is in the cosmic object. The jurisdiction of the country in relation to the registered object is maintained during the whole period when the object is in outer space or on other countries' territory. This means that all possibilities for fulfillment of jurisdiction and all juridical consequences are connected entirely with the registered cosmic object. It's possible that the ownership of a cosmic object, its parts and apparatuses belong to a few countries as a result they take full advantage together, but also they bear responsibilities for any damages caused by their cosmic object to third countries.

(Convention for international responsibility for damages caused by cosmic objects from 1972)

According to the Convention, an international intergovernmental organization could be presented as a launching country. In this case the registration of cosmic objects fulfills by one of the countries – members or a private register will be created and one of the countries will fulfill the jurisdiction and control. It's not excluded also that in some cases the cosmic objects could be under the jurisdiction of other countries when they finish their flight. This situation is current in our case, for example when the construction of the colony is completed space crafts with international crews will be sent to it, including orbital flights with space tourists on board.

In accordance with the active norms of international space law all cosmic objects (stations, space crafts and equipment) located on celestial bodies are free for visitations from third countries after a preliminary notification and respecting certain rules.

In the present space law – the right for visitations doesn't spread to orbital cosmic objects located beyond the limits of celestial bodies.

This casus has to be changed and an opportunity has to be given to representatives from different countries, colonies and bases to visit our space colony after a preliminary notification and respecting certain rules.

International collaboration for practical exploration and use of outer space

It's necessary all activities in outer space of the countries to be negotiated legally for their proper fulfillment. In practice a new type of international collaboration is arranged in the practical use of cosmic objects, navigation, geology, energetics, technics and technology, remote probing of Earth and other through developing of special legal regimes for use of cosmic technics.

The collaboration of the countries in the field of cosmic communication is conditioned by the growing needs of humanity from means of communication on Earth and the maintenance of communication in space between over ground stations and Earth's artificial satellites, between the artificial satellites, between orbital stations, etc. In 1982 the GA of UN approved the Resolution of principles for use of artificial satellites on Earth for international direct broadcasts. The resolution is based on the principles of international law. The countries have the right to broadcast and to profit from the goods, the collaboration and progress peacefully. It's necessary within the framework of UN the regime to be negotiated, resolving the issue which broadcasts are unlawful and how to be controlled.

International legal responsibility for cosmic activities

The main subject responsible for cosmic activity is the launching country/s (article 6 of the Outer Space Treaty from 1967 and article 2 from the Convention from 1972). When international organizations take part in cosmic activity responsibility parallel with them take the states members when it's necessary. The country is responsible for every national activity in space which its citizens, public or non-governmental bodies perform (article 3 from Convention for international responsibility). In cases when two or more subjects of the international law perform a mutual cosmic activity they take joint responsibility as the extent of guilt is reported concretely (article 4 and 5 of Convention from 1972).

The principle for absolute responsibility in international space law is universally accepted, including not only the right of the suffering country to require indemnity for the damages (articles 8 and 12) but also a right to require help from countries – defendants or from third country if the damage is on a large scale and threatens the life of people or there are dangerous consequences for the conditions of life of inhabitants or vital centers (article 21). The launching country takes full responsibility to pay off the compensation for damages, caused by its cosmic object on the surface of the Earth or aeronautical vehicle in flight. According to the Convention form 1972 a compulsory condition for a material responsibility is the causation of direct damage on cosmic objects.

The launching country can dispense from responsibility only if it can prove that the damage has arisen in result of a gross negligence but it cannot dispense if the damage has arisen in result of illegal activity (article VI).
The country takes responsibility if the damage is caused in the outer space or on objects located on celestial bodies only in cases when the damage is caused by individuals that the country is responsible for. Normally the interests of physical persons taking part in cosmic activity are protected by the country which they are citizens (article III).

4.2.2. The human community in Greenspace

Government

Considering the development of science and technology on Earth, the space colony which we are planning, could be constructed soonest after 150-200 years. The assimilation of near and distant outer space will be one of the priorities of all nations. The human community of the colony will be a part of a big space community, including bases on Moon, Mars in outer space.

Our colony will have relatively small sizes in comparison with the towns and countries on our native Earth.

Because of these two points – relatively small size and affiliation to space community, we consider our colony not as small country but as a medium sized town with all special features of governing.

The head of the colony will be a human – mayor of that cosmic town. He'll dispose of executive and legislative power and will be elected through democratic elections for a period of 5 years. In case that he governs extremely badly, he'll be changed with the help of preliminary elections.

This post requires the candidate to be 35 years old and to master very well politics.

To avoid abuse in politics two main bodies will exist which will limit, observe and in case of abuse – remove the abuser.

The first body will be an artificial intellect (the Main computer of Space colony) which will have the possibility to observe everything and all in the colony. In case of abuse it will send a warning signal to the group of security and safety of the colony.

The other governing body will be the so called Senate. It will be composed of representatives of every professional community of the colony. Every professional community will have a director and a sub director. They'll coordinate the corresponding guilds, their directions of research/development and will represent the corresponding community in the Senate. They'll be elected democratically for 5 years from the members of the community and will have to vote with all of them i.e. to take into consideration the opinions of the members.

Specific laws referring to space debris

Today the environmental issues are quite popular – global warming, CO_2 emissions and so on, but nobody dares to look into the problems in low earth orbit, since it doesn't cause too much problems. No measures are taken for the increasing amount of space debris and it is much more than all the polluters on the Earth's surface counted together. Therefore soon when humanity reaches Space, the satellites become even more and even space settlements start to emerge, special laws referring to the future of the objects in Earth orbit will be needed. If there isn't an institution responsible for their collecting and safe disposal lots of problems will occur like:

- Lots of these objects are small sized, moving with high velocity and are able to puncture metal causing lots of structural damage. They could easily disable some of the functions of the objects they pass through, causing therefore the launch of a repair mission (which of course will cost a whole damn lot) or the total destruction of the objects. Furthermore events like the described in the 2013 blockbuster Gravity would become something usual.
- Sooner or later each most of the debris will fall back down on the Earth, especially these with bigger sizes and higher mass, causing incredible amount of collateral damage and maybe even an ecological disaster.
- Every year more and more space junk encircles the Earth creating something like a mine field, whose density is getting higher and higher, therefore the chances of it causing problems to all space missions and to the movement of human-controlled objects near our planet.

These are just some of the heavy consequences, which the deterioration of the near Earth environment may cause. Bearing all that in mind we made a few sample rules, laws, taxes and fines, which will be imposed by the future organization, responsible for the space debris (since we are not familiar with the price of specific services and we can only assume what the economic policy after 50 years will look like, we are not giving specific numbers for the taxes and the fines, just sample criteria which should be used by their calculation).

Proposals:
1. For every launched in space object, regardless if in Earth orbit or sent somewhere in the solar systems, the owner (or responsible organization, country, institution, etc.) is going to pay tax "Space junk", the size of which is going to be calculated when to some sort of an initial amount of money is added more, depending on the volume and the mass of the object. Also it will depend from the type – rocket, satellite, space settlement etc. This will be valid for all objects, launched in space, except for these, the destination of which will be outside the solar system (our settlement will not be able to "collect" them). This law will be needed in order for our settlement to gather the remains of this object after its purpose is fulfilled. When someone decides not to pay this tax (which means by unauthorized launch of object) a fine will be necessary – for example five times bigger than the tax alone.

2. For every launched object specific documents regarding its qualitative and quantitative structure, its purpose, its estimated life and so on will be filled up. When a discrepancy is found or the object's lifespan becomes shorter than expected, a fine will be forced, depending on seriousness of the fraud and the case itself. For example there will not be any fine if the guilt doesn't lie in the hands of the owner/s. Well, there will be fine, but it will be for the causers of the unexpected event.

3. In some cases special fines will be required. For example by intentional destruction of an object, owned or not owned by the "destroyer", without notification to the responsible institutions. The space settlement with the purpose to gather and recycle space wastes is created exactly to avoid such cases!!! The size of the fine will depend on the case itself and the caused damage.

These are the most important parts of our settlement's society and law stances.

Conclusion

Humanity constantly pollutes the nature. We pollute the soil, the water, the air… Tons of waste are released every minute, clouds of thick exhaust gases… But that's not everything! Now even space is polluted!

If we do not take any action soon we might lose the GEO because of the space debris! The chances of a collision between a piece of space junk and a functioning satellite or spaceship constantly increases. In the next 20 years the most important orbit of them all – the GEO, may be completely blocked with space debris. The place where all the communication satellites and the missile shields operate may be unusable.

The problem is so serious that even if we stop launching satellites in orbit, the polluting will continue and will get even worse. Like a domino effect satellites and debris will keep colliding producing more and more debris, which will hit another satellites and so on and so on. In the end there will be nothing else but debris.

That's why it is essential for us to establish an international community to deal with the problem with space debris.

Guided by this we created our Greenspace. For over a year we were designing a space settlement which would keep the space clean. We strongly believe that Greenspace can be built in the next decades.

Space is our future! It is our children's future! And we have to hand it over to them clean, safe and sound!

Bibliography

PAPER BASED:

Michio Kaku - "Physics of the future"

Michio Kaku - "Physics of the impossible"

Гаро Мандиросян – „Въведение в космонавтиката“ (Garo Mandirossian - "Introduction to cosmonautics")

"Knowledge" Magazine (multiple issues)

WEB:

http://settlement.arc.nasa.gov/Kalpana/KalpanaOne.html

http://orbitaldebris.jsc.nasa.gov/photogallery/beehives.html

http://orbitaldebris.jsc.nasa.gov/newsletter/pdfs/ODQNv16i1.pdf

http://www.satflare.com/track.asp#TOP

http://neo.jpl.nasa.gov/risk/

http://neo.jpl.nasa.gov/stats/

http://neo.jpl.nasa.gov/cgi-bin/nhats

http://neo.jpl.nasa.gov/images/

http://www.space.com/17830-asteroid-dust-geoenineering-global-warming.html

http://www.spaceacademy.net.au/watch/debris/gsd/gsd.htm

http://www.popularmechanics.com/science/environment/4290084

http://gizmodo.com/how-the-usaf-keeps-tabs-on-space-junk-911163630

http://www.wired.com/wiredscience/2009/03/howtojunk/

http://www.space.com/16518-space-junk.html

http://www.asterank.com/3d/

https://www.youtube.com/watch?v=K88HFdTNa8U&feature=youtu.be

http://arc.aiaa.org/doi/abs/10.2514/3.29306?journalCode=jsr

http://neo.jpl.nasa.gov/

http://www.zeitgeistaustralia.org/

http://gajitz.com/