



CORAL'iation
space debris recycling



2020 JACQUES ROUGERIE FOUNDATION AWARDS - Jules Verne Year

Award's category :

Project's Name

CORALLATION

Description

Space debris recycling

In the Beginning...

Raven made the world and the waters with beats of his wings. He had the powers of both a man and bird.

His earth was dark and silent. He had created water and mountains, and had filled the land with growing pea-pod plants. After five days, one of the pea-pods burst open; out popped a fully-grown human.

Raven had been soaring above his earth when he caught sight of the movement below.

He was astonished. He had made the pea plant himself without any idea that something like this would happen. However, he was pleased that his earth would now have inhabitants.

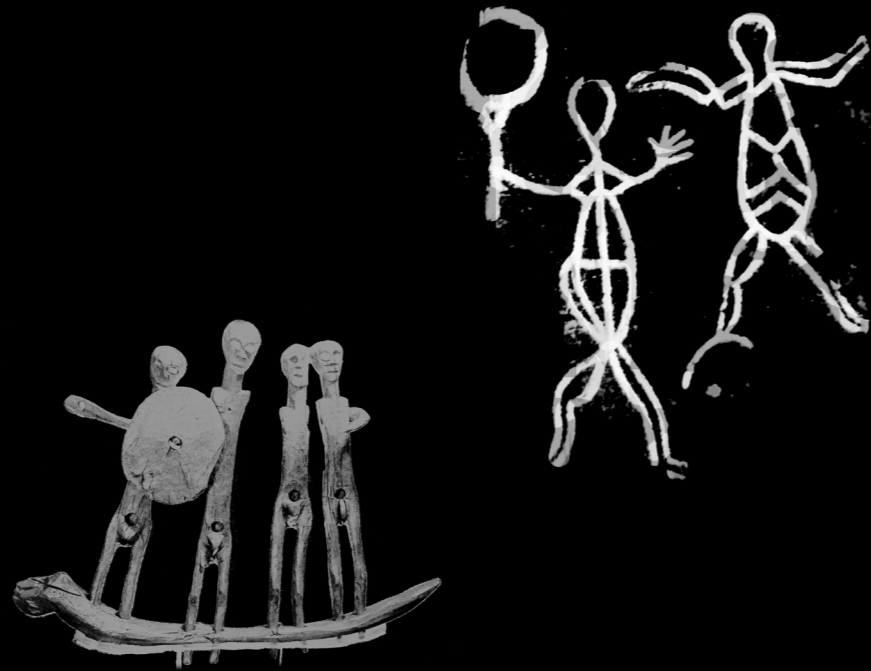
Raven brought them berries. And Mankind devoured the berries in one gulp; Raven realized that berries alone wouldn't be enough to feed his hungry creation.

Raven went on making fish, birds and other animals. Each one he put someplace out of Man's reach so that he wouldn't kill them all – fish in the rivers and birds in the air.

Inuit saw the world as having infinite possibilities. In their stories they could call or summon their spirit helpers.



the Raven



there was a Flood !

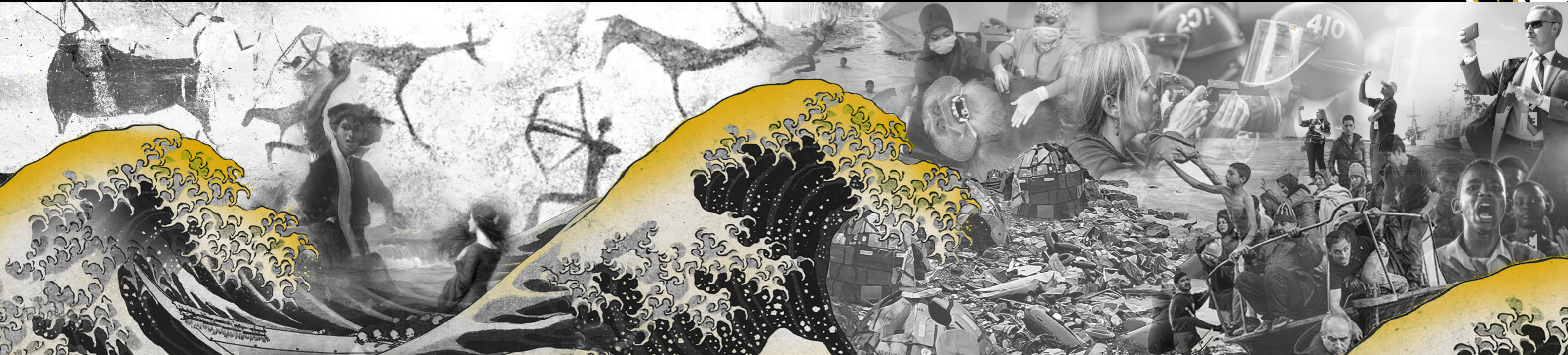
According to Inuit tradition, there was nothing but water when the world began. But as mankind emerged and grew hungry they created a tempest which led to numerous floods.

Our revels now are ended. These our actors,
as I foretold you, were all spirits and
are melted into air, into thin air;
And, like the baseless fabric of this vision,
The cloud-capp'd towers, the gorgeous
palaces,

The solemn temples, **the great globe itself**,
Yea, all which it inherit, shall dissolve,
And, like this insubstantial pageant faded,
Leave not a rack behind.

We are such stuff as dreams are made on
and our little life is rounded with a sleep

The Tempest



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Raven brought the Light!



When looking into Space, its even more important to show a more diversified approach; instead of colonialisation and demolition, humans ought look back, reflect and preserve ?

Space Debris forecast

We have created a flood. A hazardous concentration of space debris orbiting Earth. This ocean of Junk is enormous and increasing

There are about 2,000 spent rocket bodies; many of them are more than 1 metric ton Of the more than 5,000 spacecrafts, only 2,100 to 2,200 are operational.

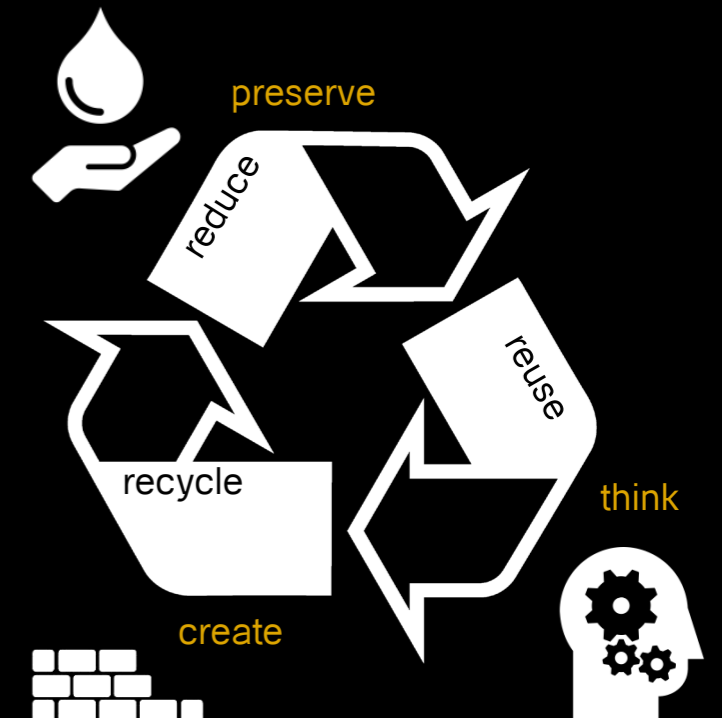
There are approximately 23,000 objects 10 centimeters and larger.

For debris one centimeter and larger the amount is about 500,000. And for debris one millimeter and larger, the population is estimated to be on the order of 100 million.

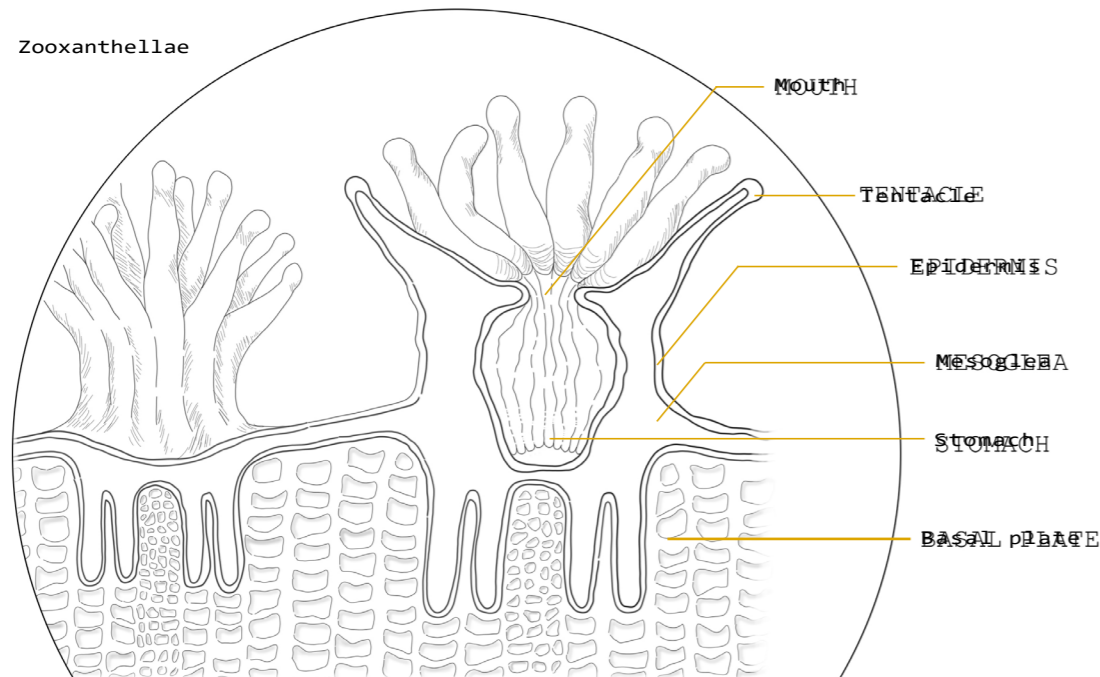
So in terms of mass, the amount of material in space has exceeded **8,000 metric tons**.

The average impact speed between two orbiting objects in low earth orbit is about 22,000 miles per hour. This is more than 10 times the speed of a bullet.

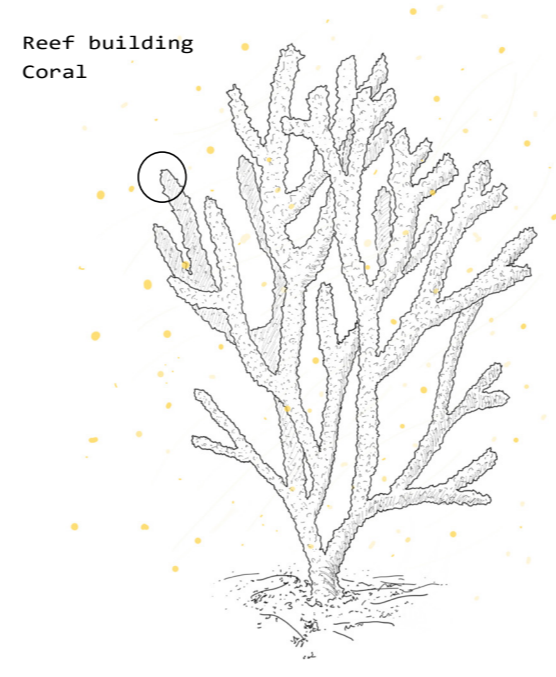
underlines the potential of a **collision cascade effect**, the Kessler Syndrome: the mass increase will lead to more accidental collisions which will generate more debris to trigger even more collisions.



Zooxanthellae



Reef building Coral



the Coral principle

Corals live in a symbiotic relationship with their ambience. They nourish trough polyps living in their structure, as well as from loose microscopic zooplankton floating in the ocean, **cleaning the waters** while simultaneously producing a rigid skeleton **providing habitat and protection** for other ocean live forms.

Reef-building corals are animals found in shallow tropical and subtropical waters at water temperatures between 22-29°C. The algae found in their tissues need light for photosynthesis. Colonial hard corals, consisting of hundreds to hundreds of thousands of individual polyps, are cemented together by the calcium carbonate 'skeletons' they secrete.

Some coral colonies give home to crabs and shrimps that live within their branches and defend their home against coral predators..

Corals feed in two ways:

- ° catching small particles using stinging cells on their tentacles
- ° obtaining energy and nutrients from photosynthetic unicellular dinoflagellates that live within their tissues. These are commonly known as zooxanthellae that give the coral color.

Due to the symbiosis between corals and their Zooxanthellae, **They are able to develop in waters poor in nutrients.**

Requirement Calculation

| | | | | | | | | | | | | |
|---------------------------------|---|-------------------|--------------------------------------|--|--------------------|-------------------------------|-------------------|---|--|--|---|---|
| <p>96 People 1/3 Guests</p> | <p>80 Rooms 16 double 64 single</p> | <p>32 offices</p> | <p>864m² solar-panels</p> | <p>16,8 m³ Li-ion batteries</p> | <p>power plant</p> | <p>thermal-or steam power</p> | <p>fuel cells</p> | <p>240 l + 4560 l drinking water /day + 127,68m³ water tank /month + 1532,16m³ water tank /year</p> | <p>5,38 m³ water ordnance/supply /month</p> | <p>14.400m² hydroponic fields</p> | <p>O2-Production and Aquaponic 19.300m² greenery</p> | <p>H₂O shield encircling the accommodation</p> |
|---------------------------------|---|-------------------|--------------------------------------|--|--------------------|-------------------------------|-------------------|---|--|--|---|---|

Capacity

96 Rooms
32 Guests (Tourists, Scientists, ...)
32 ShuttleCrew
32 HotelCrew

Energy

96 people
1,5kW / Pers average industry nation

96*9m² = 864m² solarpanels
96*17,5dm³ = 1.680dm³ Li-ion batteries

Water

96* 2,5l drinkingwater = 240 l per day
96* 47,5l hygienic water = 4560 l per day
4,56m³ per day

96% water recovery efficiency
96* 2l = 192 l /day are lost

Food

96*0,75 = 72kg per day
41 kg food per month

96*150 m² fields = 14.400m²

Air

O2-Production trough Plants and fields
simultaneously used for Watercleaning

Radiation

Water used as shield
water can be used
a. as greywater
b. in thermal power plant

Space^o requirements

To establish habitation we need to provide Air, Water, Energy, Food and Protection

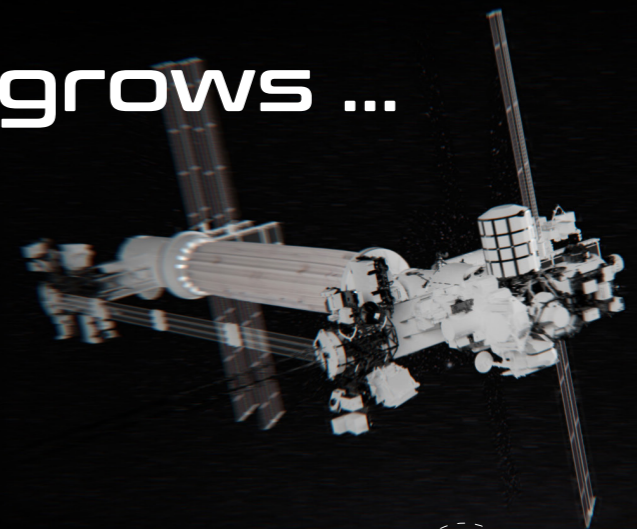
Only sustainable handling of the ressources can provide a reasonable Life in Space.

Tourism and Science Reflection and Research will pair to a more profound Perspective on preserving earths Ressources,

providing a perfekt Laboratory for Research on sustainable Systems to be reimplemented back on earth.

from the seed grows ...

Space is an indefinitely large, cold void.
Vacuum and -270 degree celsius.

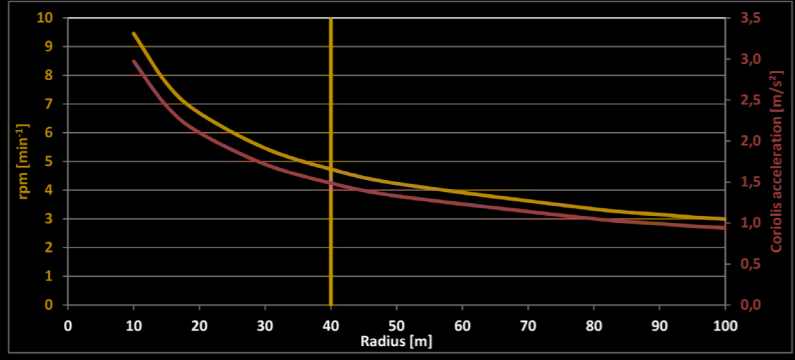


1. Design of gravitation wheel of space station Gravity

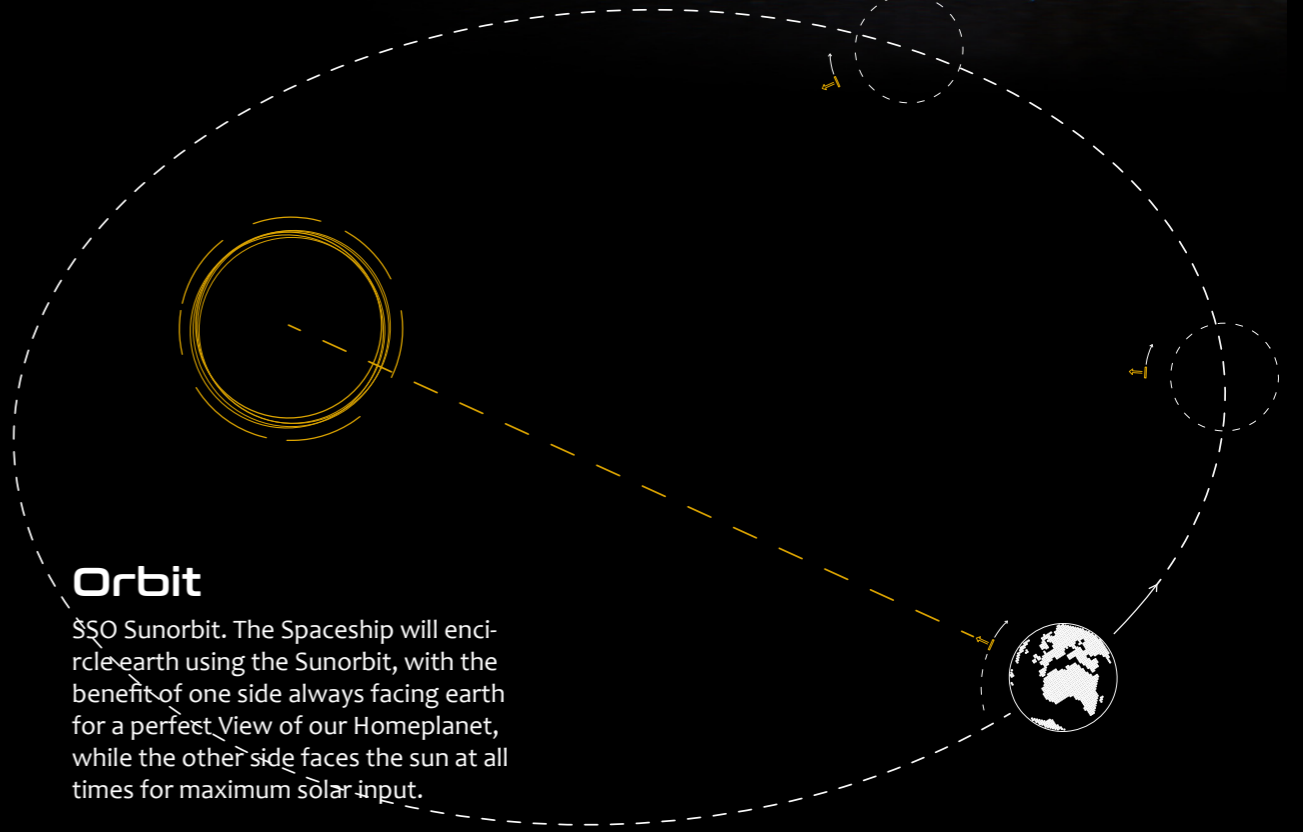
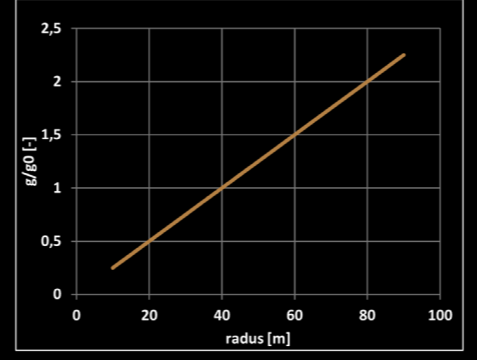
- Radial acceleration is generated by rotation: $a_{radial} = \omega^2 \cdot r$
- Rotation speed is limited by Coriolis acceleration when astronauts move in rotating wheel: $a_{coriolis} = 2 \cdot \omega \cdot v$
- Radius of 40m chosen as Coriolis acceleration during nominal walking still acceptable
- Gravity changes linear vs. radius for other parts of the rotating structure

| formulas | r [m] | ω [rad/s] | rpm [min ⁻¹] | average [m/s ²] | jogging [m/s ²] | sprint [m/s ²] | av/g0 | alpha [°] |
|---|-------|------------------|--------------------------|-----------------------------|-----------------------------|----------------------------|------------|-----------|
| $a_{radial} = \omega^2 \cdot r$ | 10 | 0,99045444 | 9,5 | 2,97 | 6,93 | 19,81 | 0,30289127 | 16,9 |
| | 15 | 0,80870266 | 7,7 | 2,43 | 5,66 | 16,17 | 0,24730968 | 13,9 |
| | 20 | 0,70035705 | 6,7 | 2,10 | 4,90 | 14,01 | 0,21417647 | 12,1 |
| $a_{coriolis} = 2 \cdot \omega \cdot v$ | 30 | 0,57183914 | 5,5 | 1,72 | 4,00 | 11,44 | 0,17487435 | 9,9 |
| | 40 | 0,49522722 | 4,7 | 1,49 | 3,47 | 9,90 | 0,15144563 | 8,6 |
| | 50 | 0,44294469 | 4,2 | 1,33 | 3,10 | 8,86 | 0,13545709 | 7,7 |
| g0 [m/s ²] | 90 | 0,35017853 | 3,3 | 1,05 | 2,45 | 7,00 | 0,10708823 | 6,1 |
| v_average [m/s] | 100 | 0,33015148 | 3,2 | 0,99 | 2,31 | 6,60 | 0,10096376 | 5,8 |
| v_jogging [m/s] | 150 | 0,3132092 | 3,0 | 0,94 | 2,19 | 6,26 | 0,09578263 | 5,5 |
| v_sprint [m/s] | 200 | 0,25573424 | 2,4 | 0,77 | 1,79 | 5,11 | 0,07820619 | 4,5 |
| | 250 | 0,22147235 | 2,1 | 0,66 | 1,55 | 4,43 | 0,06772855 | 3,9 |
| | 300 | 0,19809089 | 1,9 | 0,59 | 1,39 | 3,96 | 0,06057825 | 3,5 |

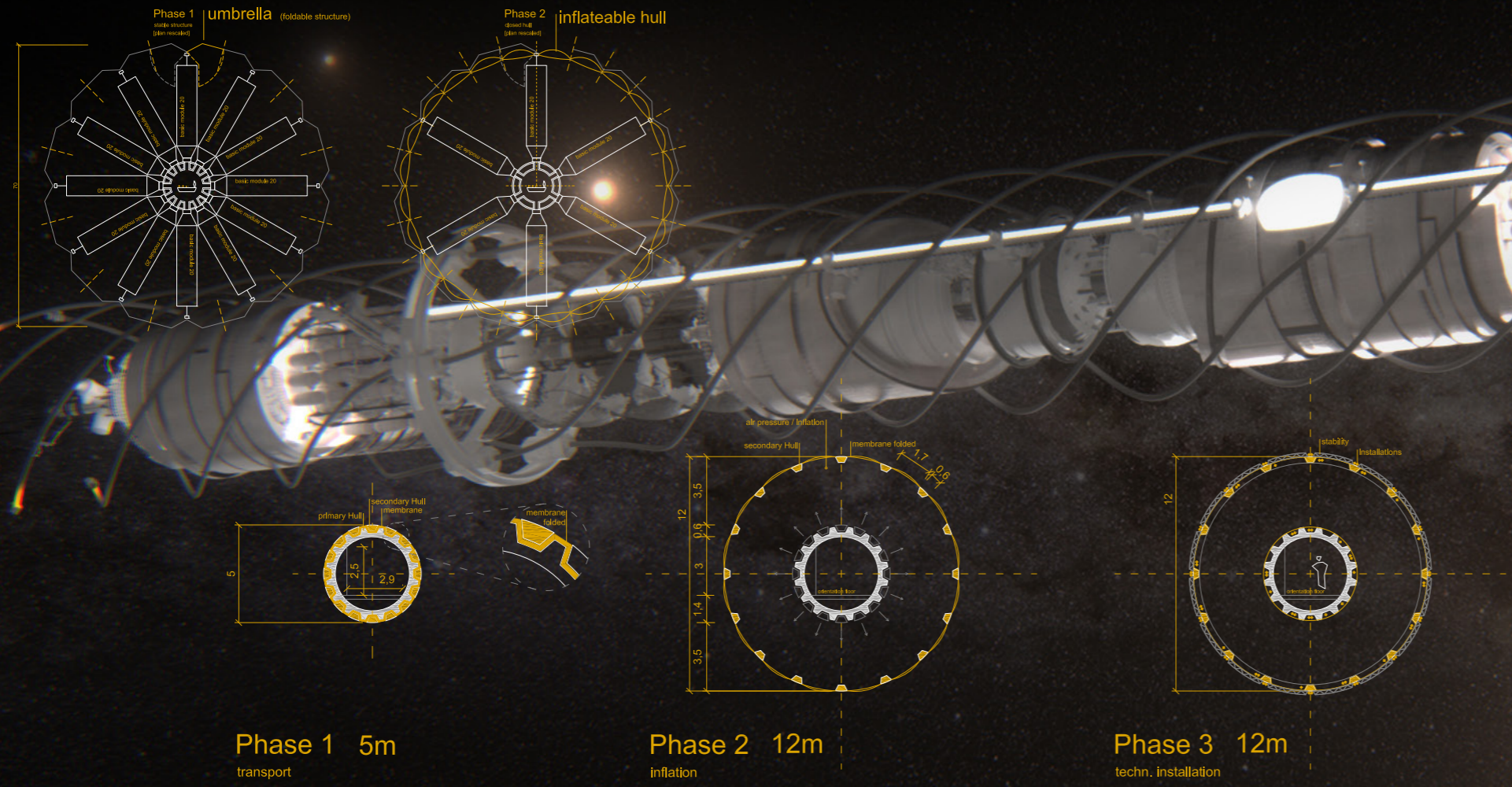
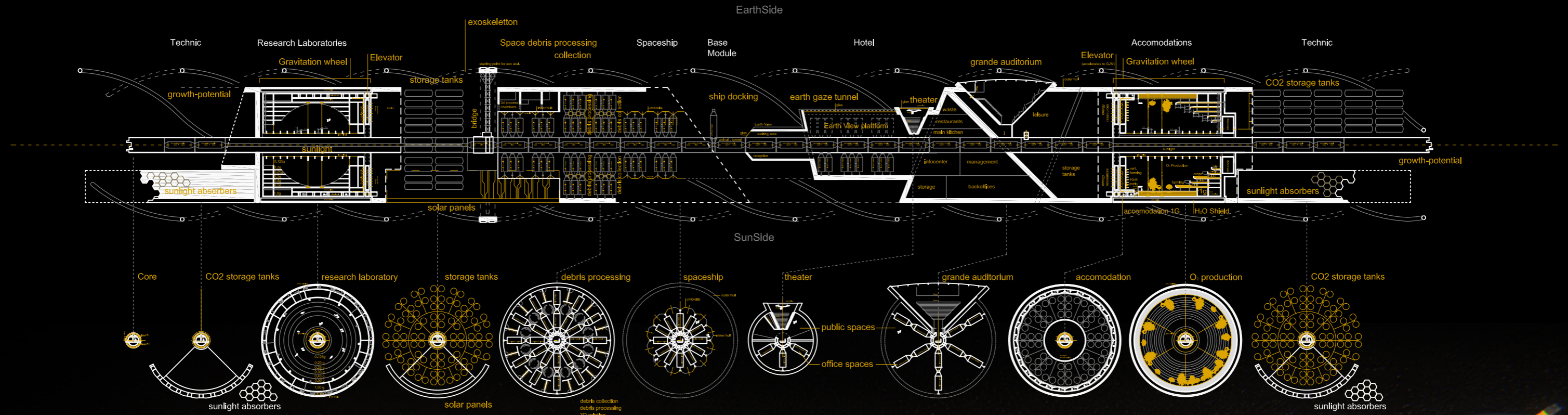
| mean living | quarter radius [m] | min radius [m] | max radius [m] | n [-] | radius [m] | g [-] |
|-------------|--------------------|----------------|----------------|-------|------------|------------|
| 40 | 10 | 20 | 30 | 1 | 48,3333333 | 1,20833333 |
| 10 | 2 | 3 | 4 | 2 | 56,6666667 | 1,41666667 |
| 90 | 3 | 4 | 5 | 3 | 65 | 1,625 |
| | 4 | 5 | 6 | 4 | 73,3333333 | 1,83333333 |
| | 5 | 6 | 7 | 5 | 81,6666667 | 2,04166667 |
| | 6 | 7 | 8 | 6 | 90 | 2,25 |



Teufelsrad
rpm 23
omega 2,4085544
r 1,7
a_r 9,861928



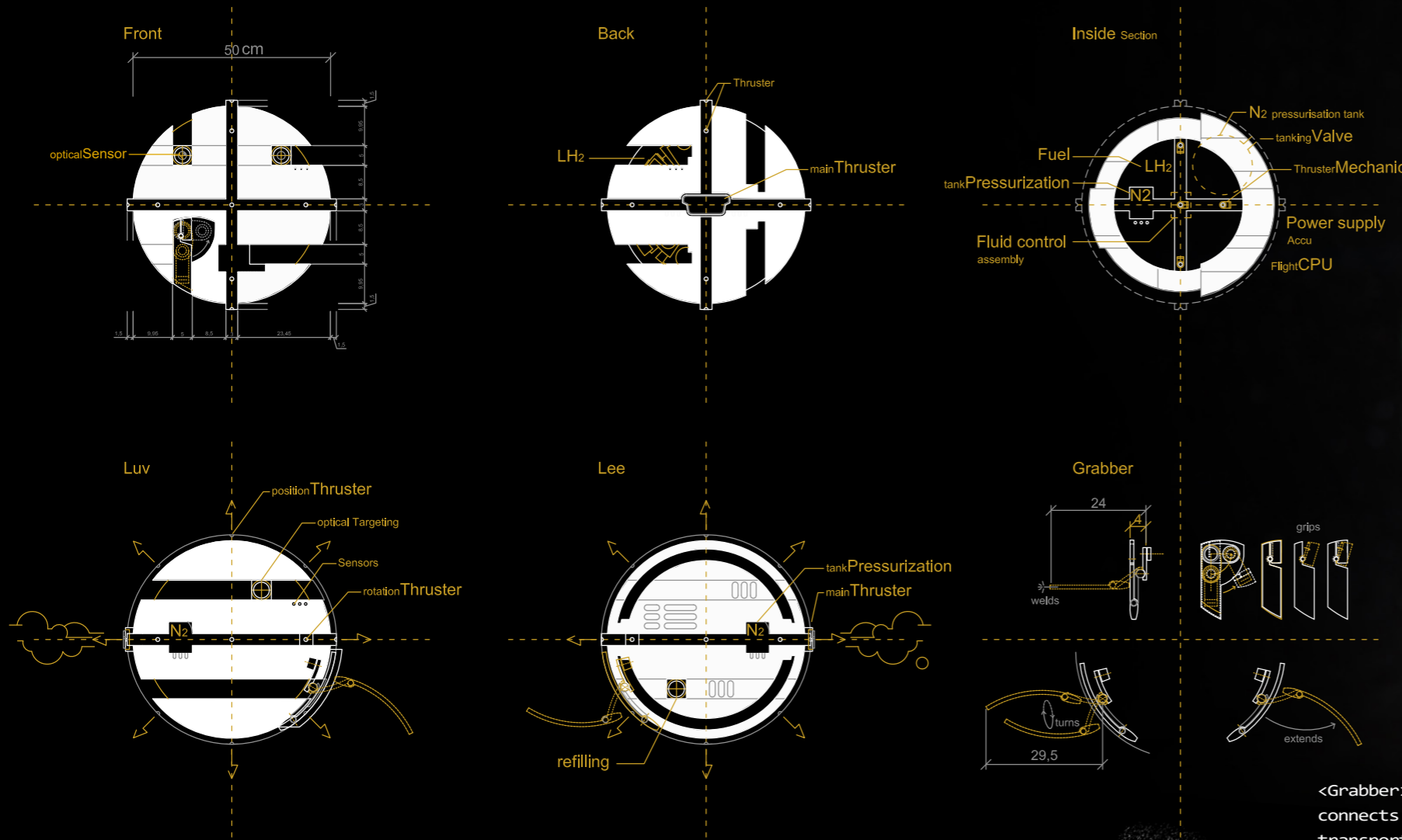
Ship Design Raven III



...a modular ship

We propose a growing structure, inspired by coral reefs and sponges. It will capture the orbiting space debris and grow by using them as construction material for itself. It will start as a minimal structure with a dock, basic Module1 (our SEED), linked with basic Modules 2, additional necessary sections coming from the Earth. These will inflate and connect to a greater structure.

A starshaped modular construction brings in the 3d-Printers and creates space for the debris-processing.



<Grabber> with °Welding tip connects to metalparts enabling transportation regardless of the SpaceDebris size

Drones° generic information

- °Pressure fed cold gas system using liquid hydrogen as propellant and nitrogen as pressurization gas
- °Electrical driven valves for pressurization and thruster activation
- °Total starting mass ~14kg
- °Usable propellant mass ~2kg
- °Max velocity ~400m/s
- °Up to 200kg recoverable mass (from similar orbit)

<Mission> Collect space debris & bring it back to the station
 <Detailed mission steps>
 >Detach from station
 >>Initiate interception orbit
 >>>Align orbit and velocity with target debris
 >>>>Catch target
 >>>>>Initiate return orbit
 >>>>>>Dock with station and deliver debris
 <go to> / 3D-Prozessing //

A flock of Drones collect SpaceDebris

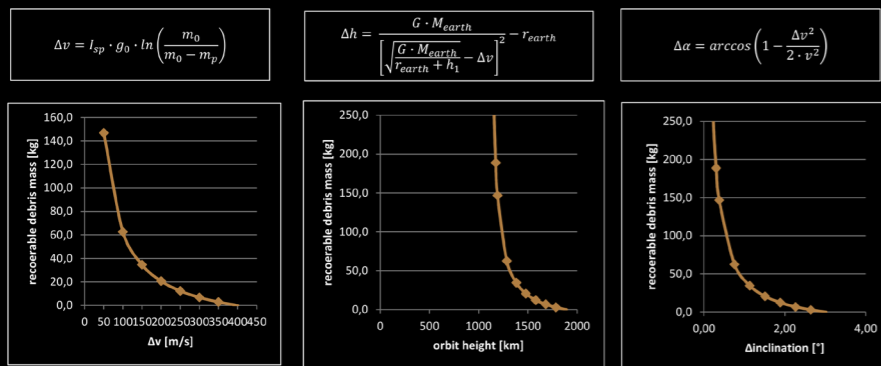
Upper limit of drones: ~1900km

Nominal station orbit 550km

lower limit of drones: ~250km

<limit A> by limited capability of drones
 <limit B> by increasing drag of remains of atmosphere

Inclination change of ± 3° possible by drone
 Usable range depending on max. allowable mission time
 nominal SSO @ 98.5



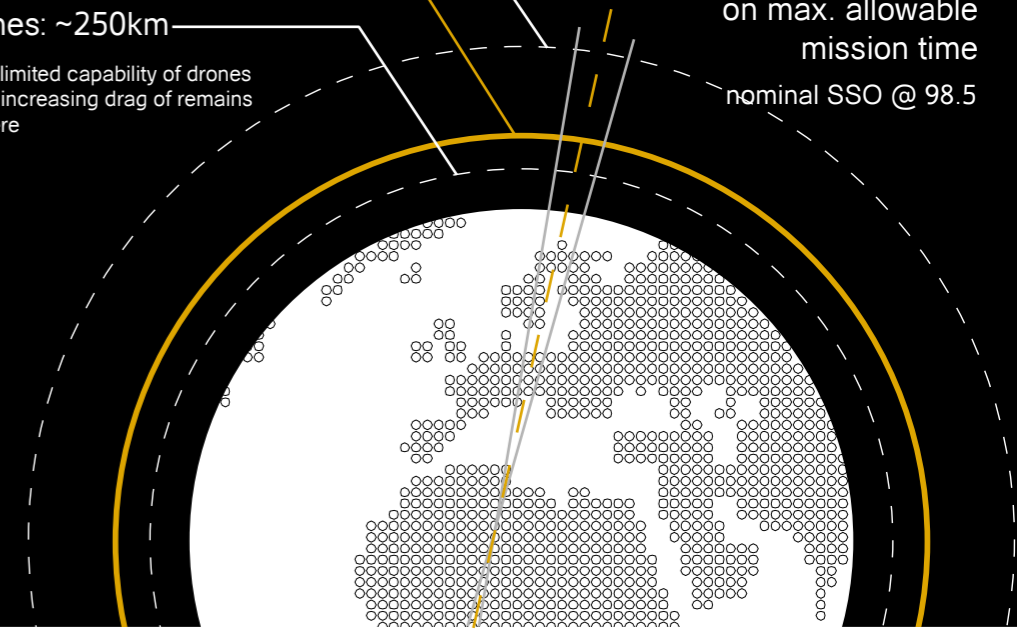
GM_earth 3,99E+14
 r_earth [km] 6371,00
 StationsOrbitöhe [km] 550
 Orbitalgeschwindigkeit [m/s] 7589

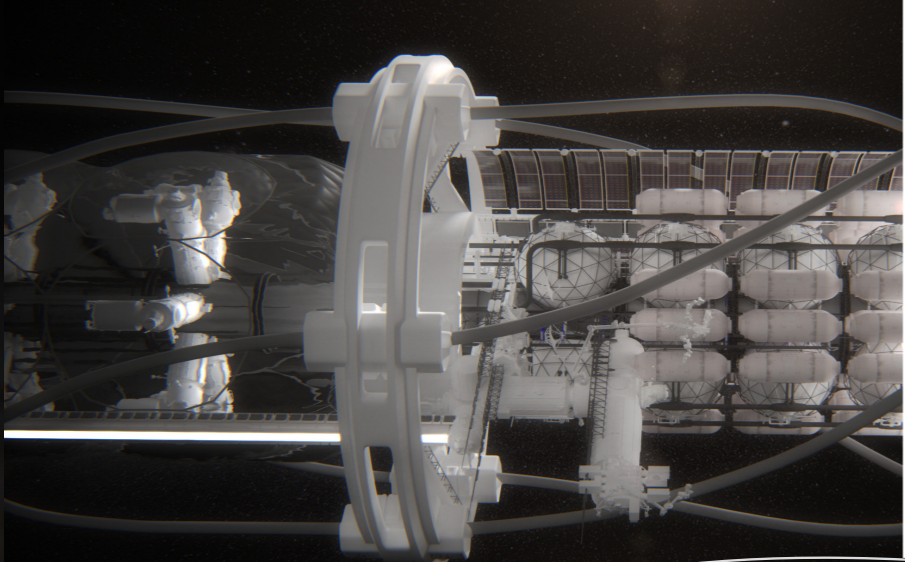
chemical drones
 Isp [s] H2 cold gas 250
 SI [-] 0,85
 Ø [m] 0,5
 ρLH2 [kg/m³] 70
 usable volume for propellant [%] 45
 mp [kg] 2,1
 m0 [kg] 13,7
 Δv_total [m/s] 398,6
 x-check dry mass
 ρAlu [kg/m³] 2,7
 wall thickness if only Alu [mm] 6481
 Δv1 [%] 40
 Δv2 [%] 60

2. Drone Layout 1: orbit mechanics

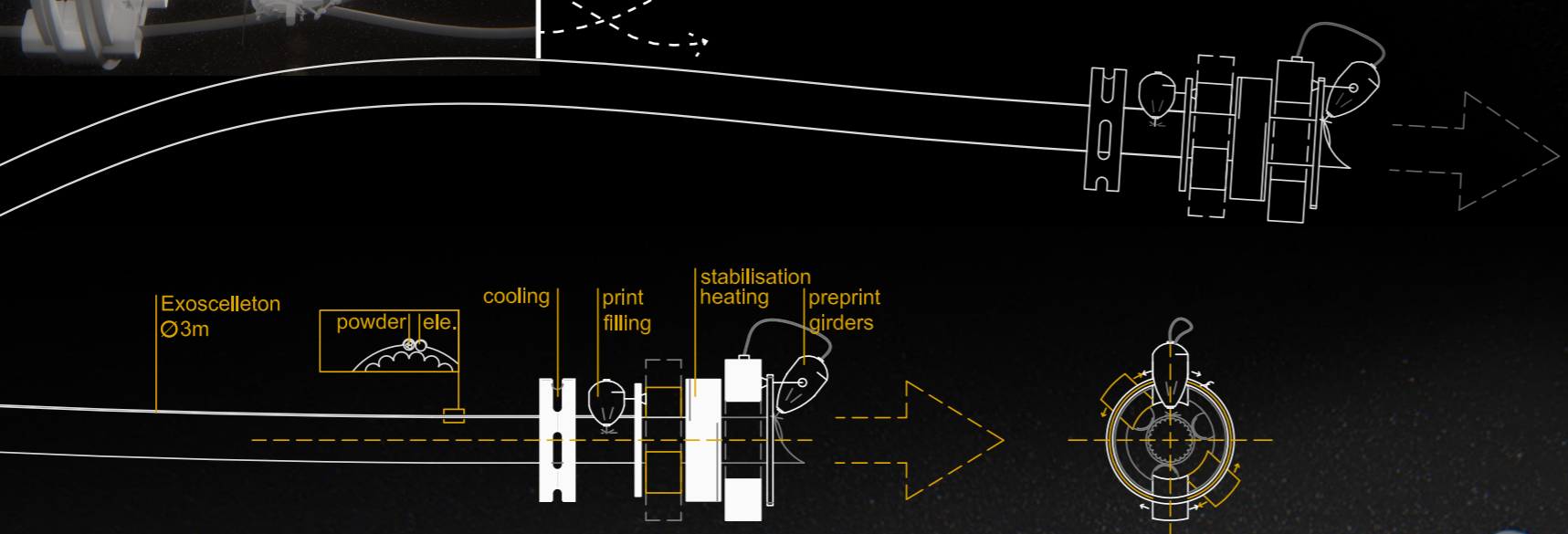
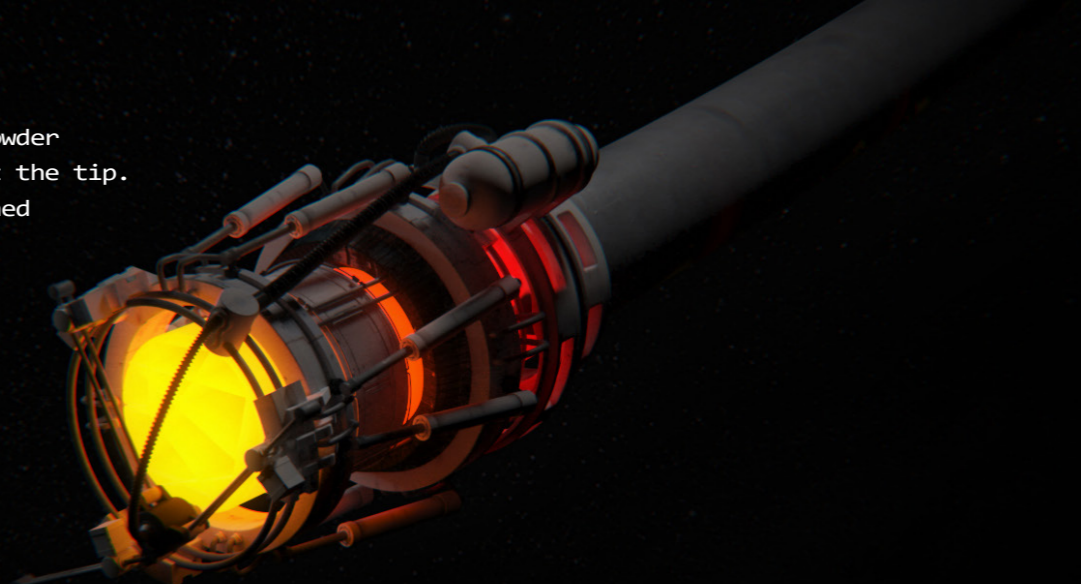
- In space different locations feature different velocities. In order to reach different positions the velocity has to be changed accordingly → Δv
- A circular orbit is defined by its
 - Orbitheight h_{orbit}
 - Inclination α (= angle measured from the earth equator)
- Simplifying the Vis-Viva Equation for small masses and circular orbits leads to $v_{orbit} = \sqrt{\frac{G \cdot M_{earth}}{r_{earth} + h_{orbit}}}$
- With this formula a relation between change in orbit height and velocity need can be established:

$$\Delta h = \frac{G \cdot M_{earth}}{\left[\sqrt{\frac{G \cdot M_{earth}}{r_{earth} + h_1}} - \Delta v \right]^2} - r_{earth}$$
- As well as for inclination change vs. velocity need: $\Delta \alpha = \arccos \left(1 - \frac{\Delta v^2}{2 \cdot v^2} \right)$





After processing the space Debris to powder this is transported to the 3D printer at the tip. For this purpose the Exoskeleton is designed with an additional strand to transport the powder via argon gas. Here the 3D-PRINTERS heat, mold and cool the material, growing further and shaping the Spaceship.

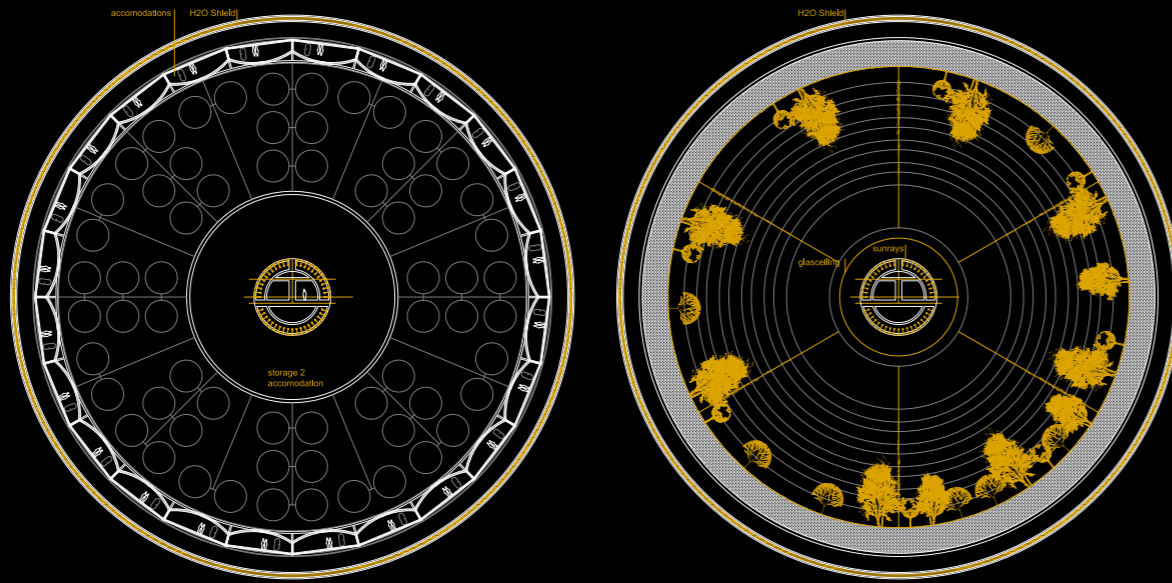


reused as construction Material

A coordinated ecosystem of orbiting drones will follow and collect the debris; they will return it to the main structure for the recycling process where it will be screened, sorted and ground in to powder. This recycled material will be used to expand the spaceship by fabricating a 3m diameter EXOSKELETON, necessary for stability, infrastructure and for protection.

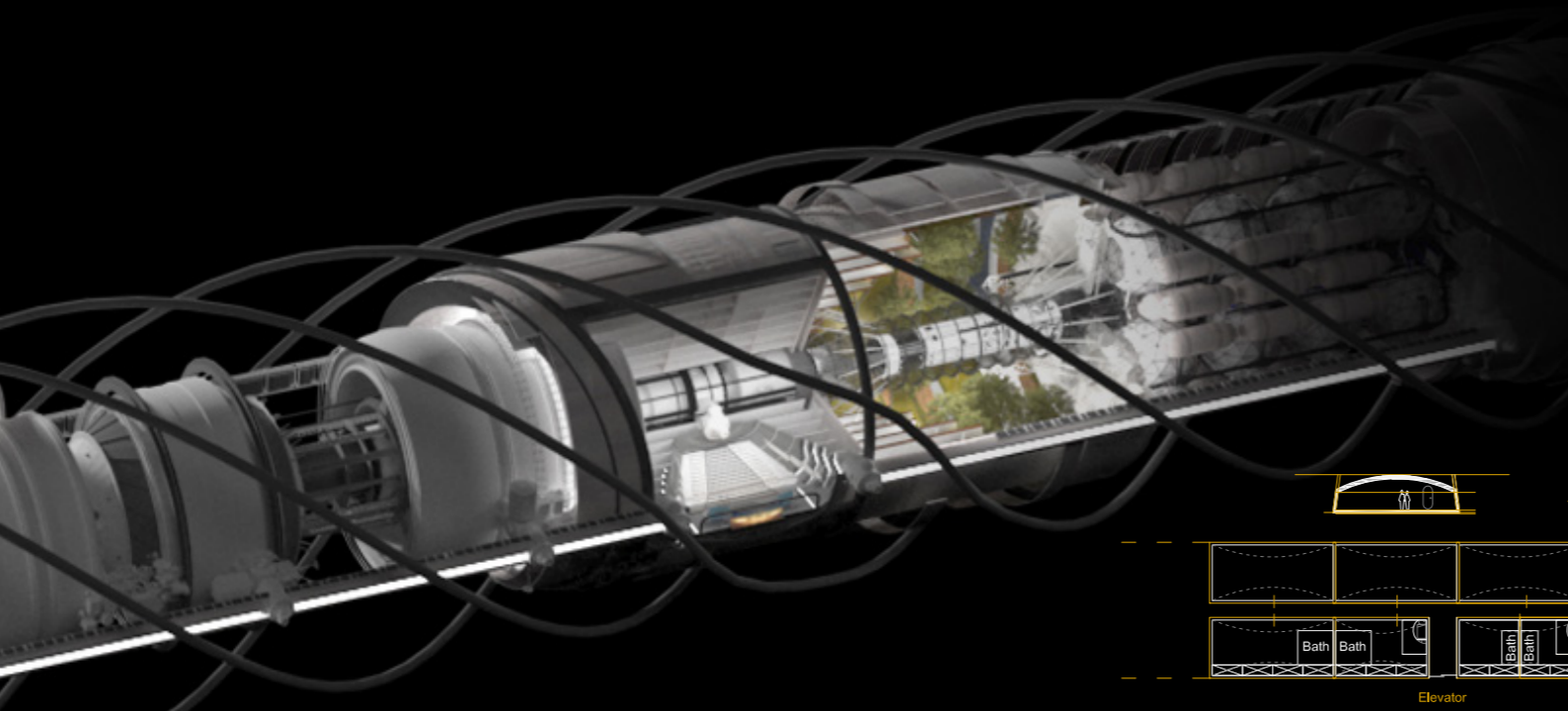
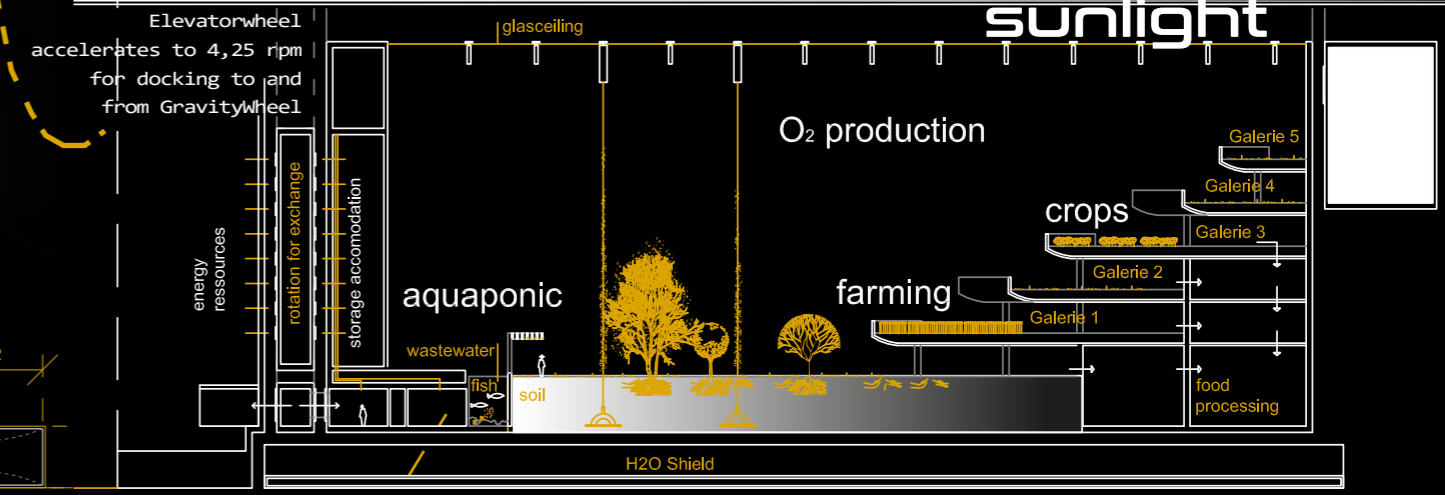
If no gravity exists every person loses muscle tissue and bone mass. At space stations without gravity each astronaut has to do physical exercise for several hours a day. This is not seen suitable for Spacetourists.

The accommodation rooms are positioned at a radius of 40m from the axis, providing Gravity of 1G with 4,25 rpm also considering the coriolis curve. <goto calculation> Enabling earth like conditions the station becomes accessible to everyone.



Gravitywheel

Sunlight is caught by the sunlight absorbers on the outside of the ship and transportet via photonic liquids into the core of the Gravity wheel



creating a Habitat



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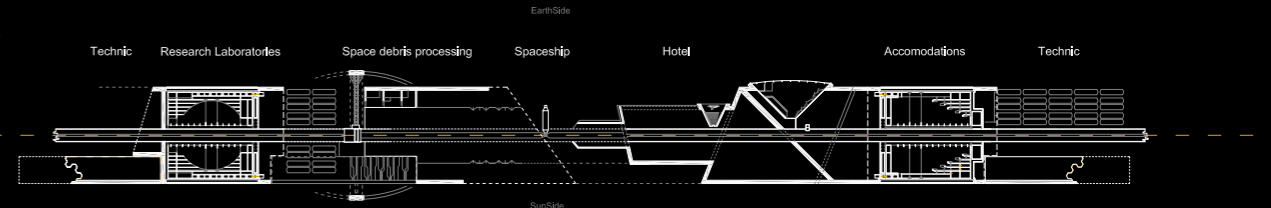
CORALLATION

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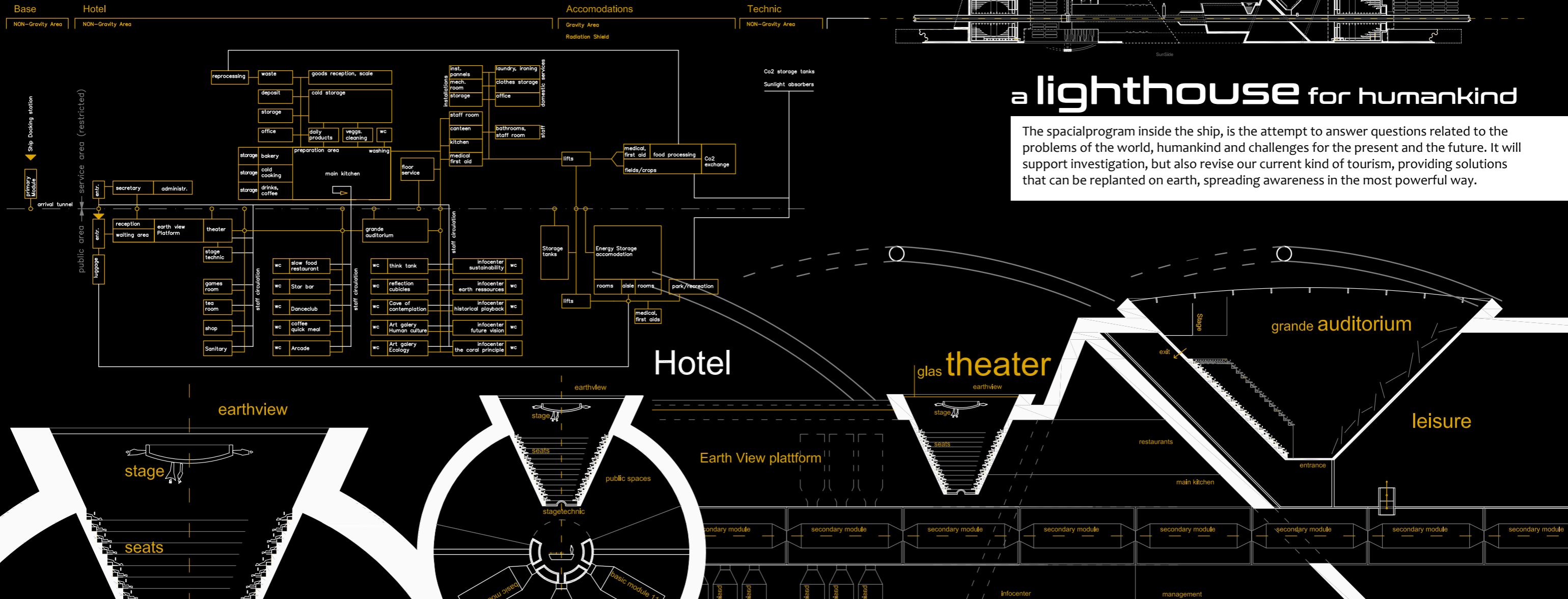
We are concerned about the sustainability of massive tourism, the loss of culture and identity. Is there any sense in thinking about a new way of travelling? Or is it more sensible to think about a reservoir of our natural and cultural heritage ?

Our tourism concept provides the financial support, and follows the Corporate Social Responsibility (CSR). As it grows, the Ship becomes a museum for preservation of human heritage enabling contemplation and awareness.



a lighthouse for humankind

The spacial program inside the ship, is the attempt to answer questions related to the problems of the world, humankind and challenges for the present and the future. It will support investigation, but also revise our current kind of tourism, providing solutions that can be replanted on earth, spreading awareness in the most powerful way.



the grande Auditorium



“The most dangerous worldviews
are the worldviews of those,
who have never viewed the world.”

Alexander von Humboldt

enabling reflection

tourner [Def.:] turn, circumference, go, walk, stroll round, stage (of a competition) Ancient Greek origin **ΤΟΠΝΟΣ** **tórnos**, significates a carpenter's tool for drawing a circle.

TOUR implies a CIRCULAR movement, to go and to come back and will only be completed if we were returning to the starting point. But we return more wisely, and with added value to places, creatures, people, cultures, ressources, concepts...