



INTRODUCTION

Inspiration & Research

"Since, in the long run, every planetary civilization will be endangered by impacts from space, every surviving civilization is obliged to become space-faring; not because of exploratory or romantic zeal, but for the most practical reason imaginable: staying alive... If our long-term survival is at stake, we have a basic responsibility to our species to venture to other worlds."

Sagan (1994, p. 371)

Sparked into being by NASA's 2017 discovery of the star system: 'TRAPPIST-1', the project dares to question what it would take to travel to distant worlds; utilising the fields of architecture, physics, film and science fiction to speculate upon the type of space architecture required to transport a branch of mankind to three habitable worlds of TRAPPIST-1.



▲ TRAPPIST-1 POSTER released by NASA shortly after the discovery

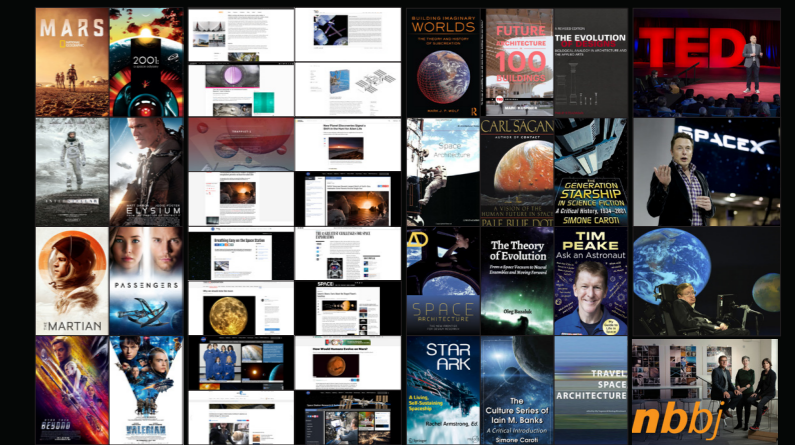
Along with the above poster and an informative animation, NASA announced the spectacular claim that TRAPPIST-1 contained three Earth-sized planets within the 'Goldilocks Zone': a stretch of space in which it's not too hot, nor too cold to support liquid water. In addition to releasing a flurry of details and statistics on these worlds, NASA themselves labeled it the "largest batch of Earth-size, habitable-zone planets around a single star" NASA (2017).

During an interview regarding the discovery, lead scientist of the upcoming James Webb Space Telescope giddily proclaimed: "I would have never predicted this, it's beyond anything I could have ever dreamt of" (2017). The James Webb Telescope will be utilised to determine whether the planets do indeed have atmospheres, defining their composition if so. Further study into the system will continue, with the details of the planets likely to be revised with more concrete findings. While it remains to be seen if TRAPPIST-1 is indeed the 'Holy Grail' astronomers have been searching for, the time has come to contemplate what the discovery of habitable worlds could mean not only for the species, but for architecture.

Situated 39 light-years from Earth, TRAPPIST-1 is well within our cosmic neighborhood, in the context of the unfathomable radius of the Milky Way (27,000 light-years). How long it would take to get to the distant worlds is very much up for debate, but even with significant advances in engineering and technology, any mission to TRAPPIST-1 or any other foreign star-system would require an interstellar voyage spanning millennia. Therefore, the invention of colossal, world-encasing space architecture is required.

The challenge was to take a very speculative concept and inject validity and architectural ideas, while maintaining the creative mindset that sparked the project into being. I achieved this by reaching proven science, factual precedents, and speculative futures; taking from the fields of physics, science-fiction and architecture.

Historical projects such as the 'Biosphere 2' experiment of the late 20th century aided the plausibility of such a mission, while warning against the idea of small-scale space architecture. It soon became clear that any interstellar architecture must take inspiration from the Earth to create a sustainable, large-scale biosphere in which a branch of humanity can adapt and evolve over the vast spans of time.



▲ Research a small example of the range of research carried out during the project

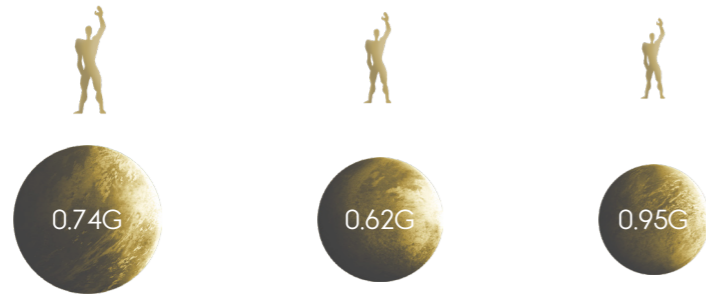
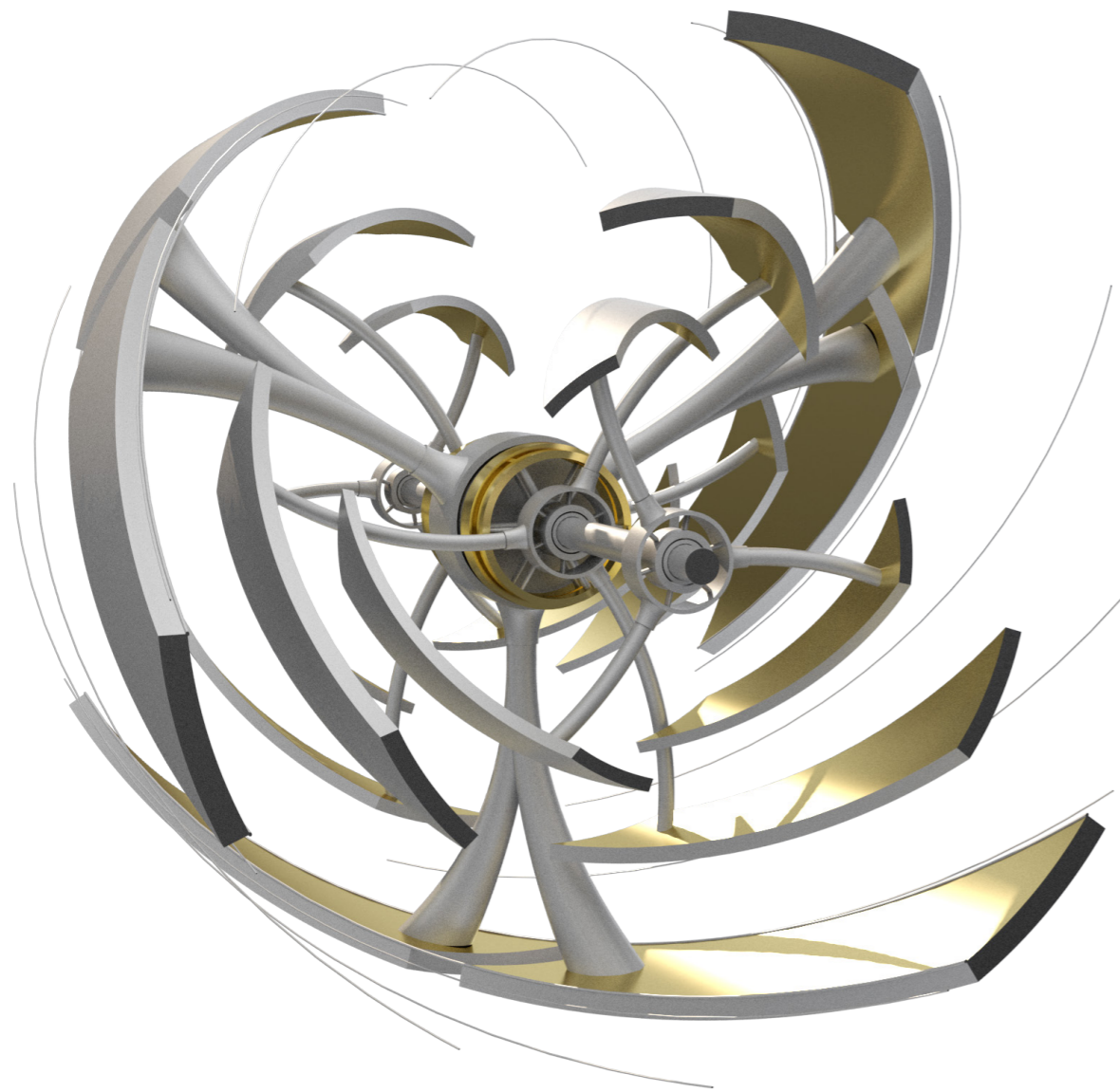
FORM CREATION

Gravitational Ribbons

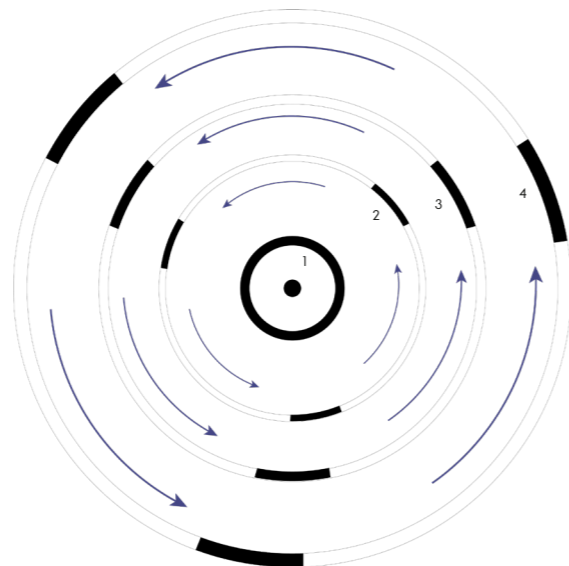
The plethora of research carried out suggested that not only should the concept be designed on a huge scale, but that it would require weather, artificial daylight, a sustainable source of oxygen and diverse levels of artificial gravity. *A project with three target worlds provides the unique opportunity to match what we know about the three planets, adapting the passengers to the gravitational loads of TRAPPIST-1e, f and g, over thousands of years.* This would allow the future generations of explorers the advantage of being somewhat acclimatised to the target worlds on arrival.

Starting with layers of rotating rings to generate gravity via centrifugal force, I soon started to play and twist the planes in one axis, to create a series of sectional shell-worlds, represented by rotating gravitational ribbons. This proposed form is in stark contrast to existing space architecture of the 21st century.

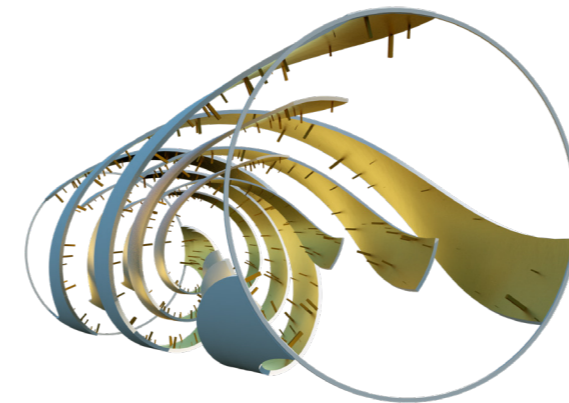
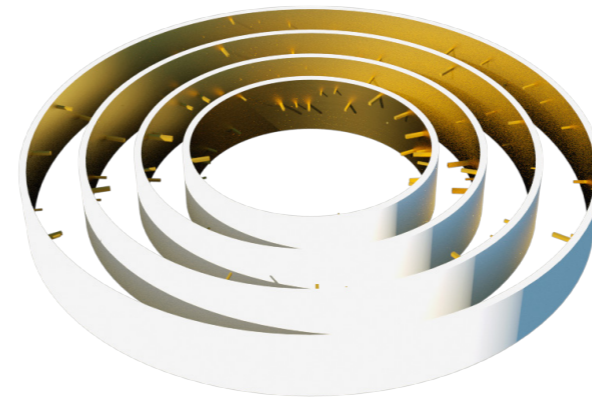
My research has instructed that for the wellbeing of the passengers, the encased world must have a sense of openness to create a stimulating environment. The ribbons allow not only for a sense of openness, but should allow for spectacular and connecting views of the neighboring districts. The artifact will produce constantly changing views, separated by a great void in which an atmosphere is able to keep the biosphere fresh and alive. This space within the centre of the ribbons will also allow areas, free of gravity, in which designers and artists can create free of the worries of gravity.



1-	Central rings	-	0-1 G
	Radius	-	0.92 km
	Angular Velocity (rotations per minute)	-	0.981 r/m
2-	Ribbon 'E'	-	.74 G
	Radius	-	0.2.90 km
	Angular Velocity	-	0.477 r/m
3-	Ribbon 'F'	-	.62 G
	Radius	-	4.14 km
	Angular Velocity	-	0.374 r/m
3-	Ribbon 'G'	-	.95 G
	Radius	-	5.94 km
	Angular Velocity	-	0.378 r/m



► **Diagrammatic sections** the above diagrams show the four layered approach, spinning at different rates to match the target worlds

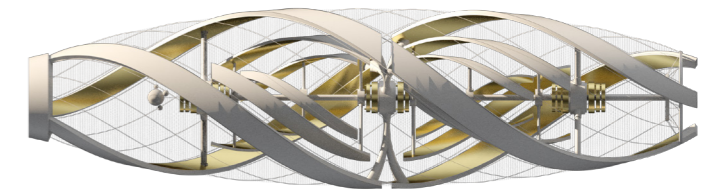


▲ **Ribbon form** created by manipulating the form in a single axis

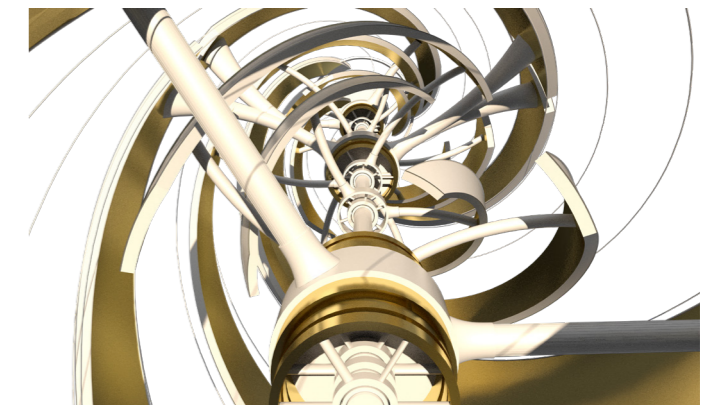


▲ **Concept art** Early and developed renders that experimented with the kind of environment that could be produced by this artefactual form.

In addition to the ribbons and supporting structure, an engine, structural spine, magnetic shield and encasing mesh are required to produce a sealed and moving design, in which inhabitants can sculpt their unique worlds.



▲ **Developed form** essential elements such as the encasing mesh added to the form



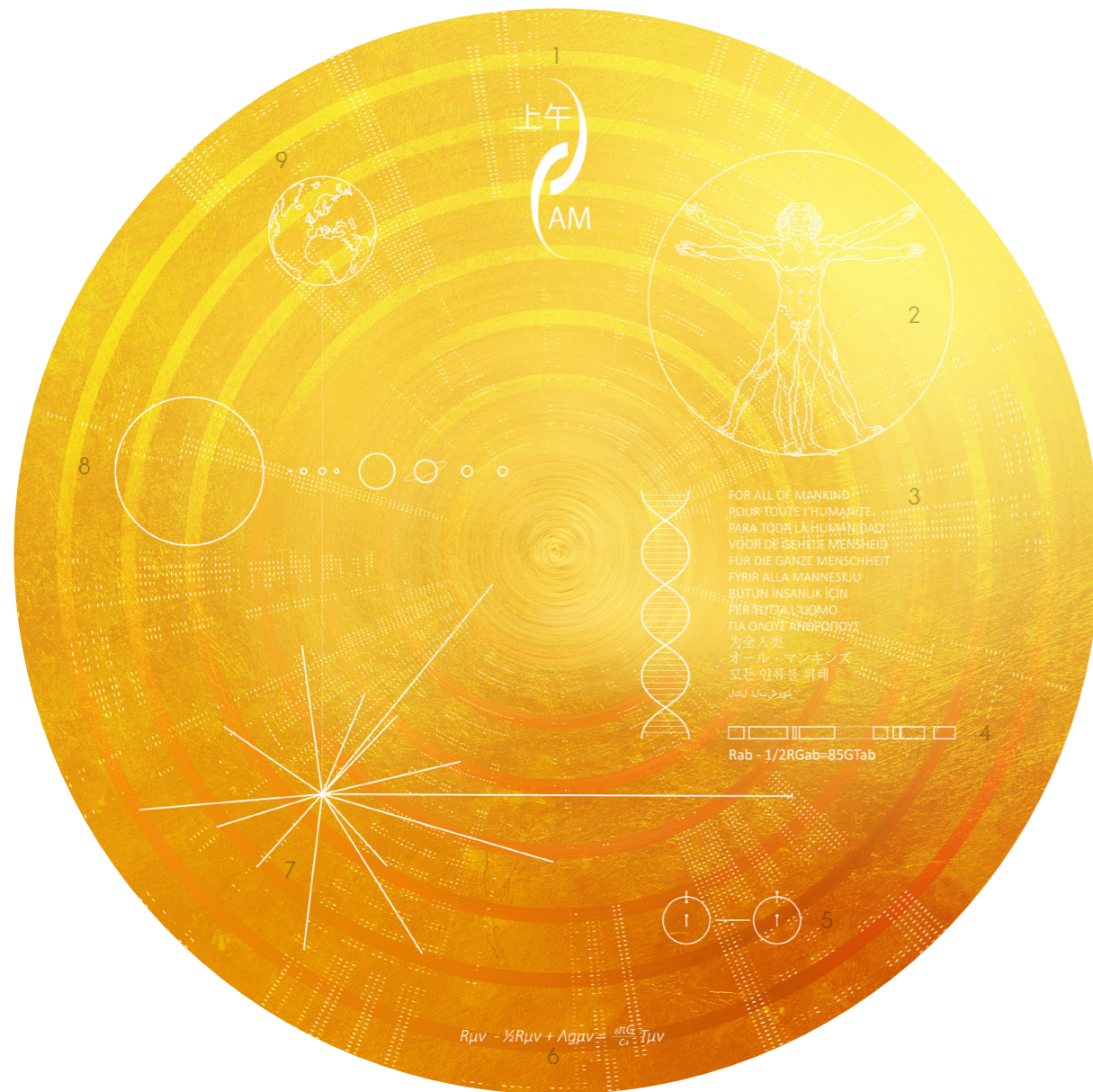
SYMBOLISM

Inspiration & Research

The project takes inspiration from existing space architecture, as well as imagined; one of those inspirations is *Voyager* spacecrafts of the 1970's, which dreamed of a populated universe, sending out explorative machines into the depths of the galaxy.

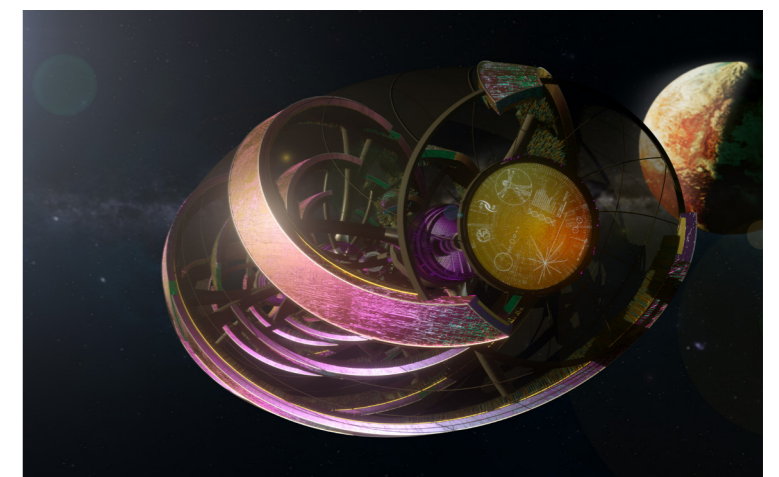
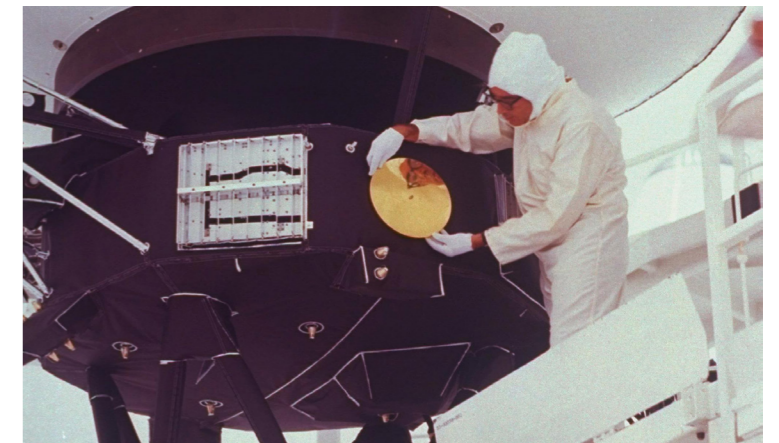
Attached to the *Voyager* spacecraft was a 'golden disk', containing the sounds of Earth. Etched onto the casing of the artifact were symbols of mankind, as well as instructions on how to play the disk.

The '*Quintessence*' pays homage to the *golden disk*, adding artistic design to the structural shield that adorns the front of the starship. Updating and adjusting the symbols of the precedent, the disk will represent mankind, showing our place of origin, DNA and advanced mathematics. While the etchings of the *golden disk* send sounds of mankind into deep outer space, the *Quintessence* will cradle a branch of Mankind beyond our star and towards distant worlds. **It should be clear that this is not a project for any individual or country, but for the entire species, containing a diverse range of nationalities and cultures; guiding the best of our civilizational towards a bold future amongst the stars.**

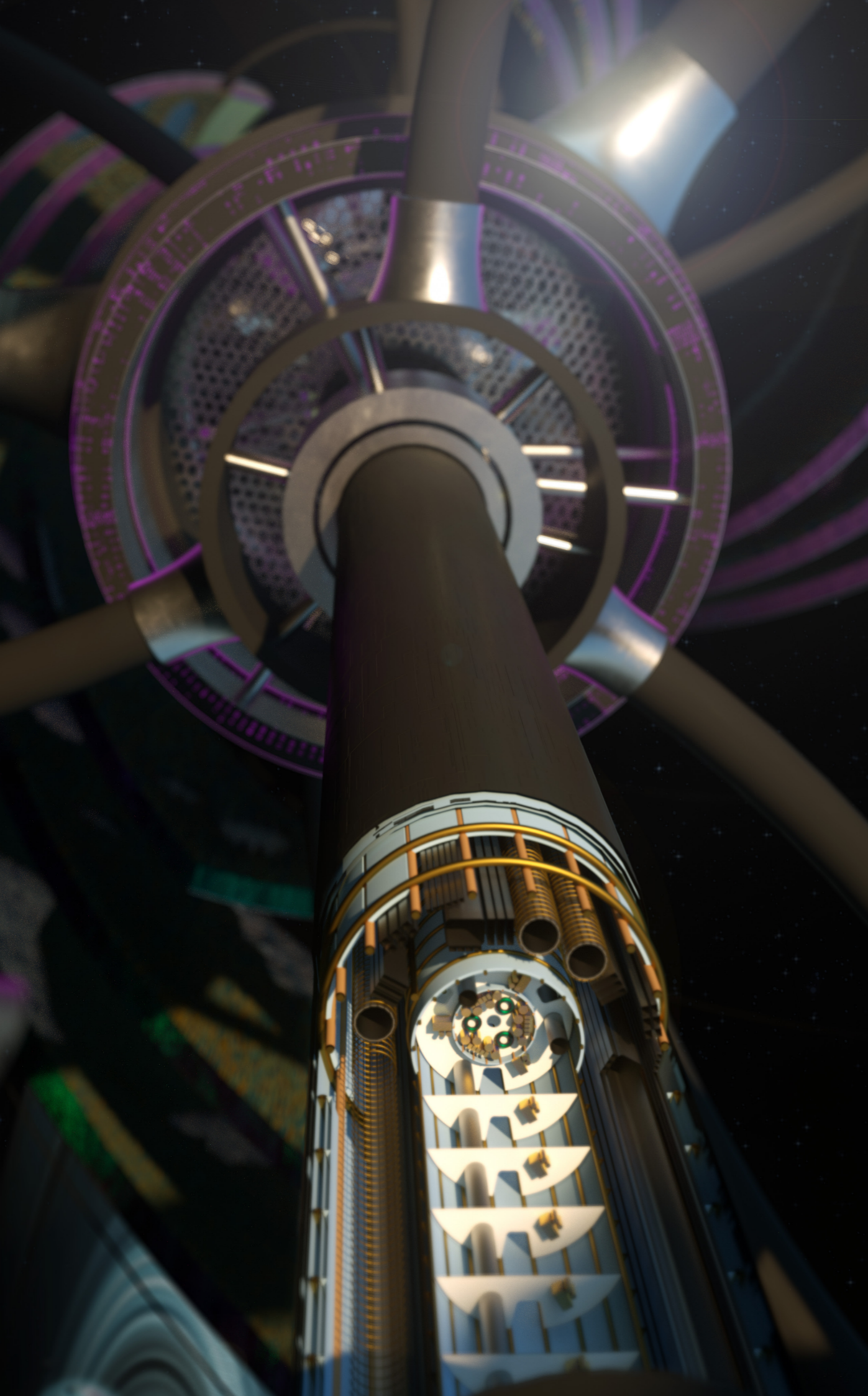


- 1 - Fictional logo of the company helping fund the project
- 2 - Da Vinci's 'Vitruvian man', showcasing the human form
- 3 - A message of goodwill for the mission, showcasing the numerous languages of the diverse occupants
- 4 - The sequence of human DNA
- 5 - Diagram illustrating the two lowest states of a hydrogen atom
- 6 - Einstein's 'field equation', showcasing the general relativity theories that describe the fundamental interaction of gravitational space-time
- 7 - Earth in context of the Milky Way Galaxy
- 8 - Earth in context of the Solar System
- 9 - Mankind's home planet

▼ *Voyager and the golden record*



▲ *The Quintessence adorned with a golden disk*



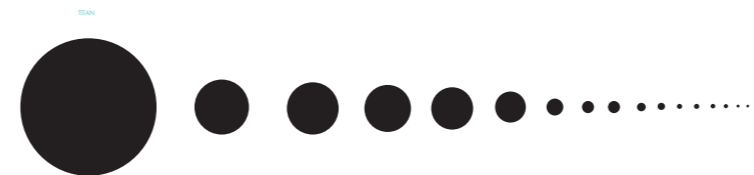
CONSTRUCTION

Mining resources & zero-g construction

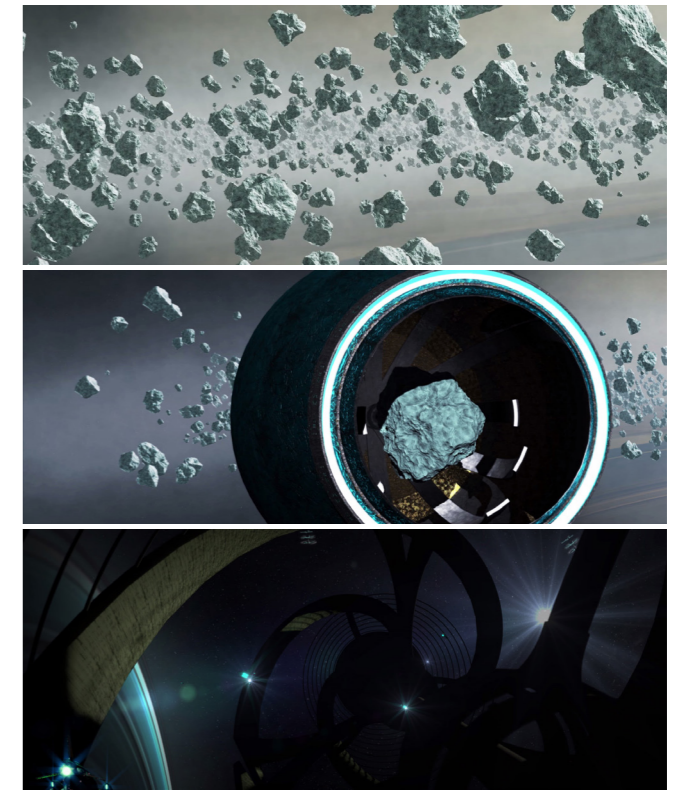
As we venture out beyond the confines of our gravitationally heavy planet, we will find a solar system brimming with usable material, able to mine and build in space. We need not look too far to find usable materials outside the confines of our home world; the moon for example is "rich in potentially useful but heavy (and thus expensive to launch from Earth) raw materials such as magnesium, aluminum, silicon, iron and titanium", as declared by Professor of Planetary Science Ian Crawford (2014).

Looking further into the system, we see planets, moons, asteroid belts and debris fields with materials ripe for the picking. If we could build the starship using materials sources beyond the Earth, then the potentially unprecedented cost of the project will fall, not sending large volumes of Earth's precious re-sources on a one way trip out of the solar system. Beyond the material benefits of doing this, the ability to construct in zero-G will surely have benefits, with robotic construction units able to position and construct huge building elements not possible on a gravitationally heavy planet surface.

In addition to the specialist materials per-fabricated around the Earth, a huge amount of material will be readily available around the rings and moons of Saturn and the nearby asteroid belt. Setting up base there, a army of small spacecraft will collect the usable material, taking it to a re-purposing plant on one of the many nearby moons.

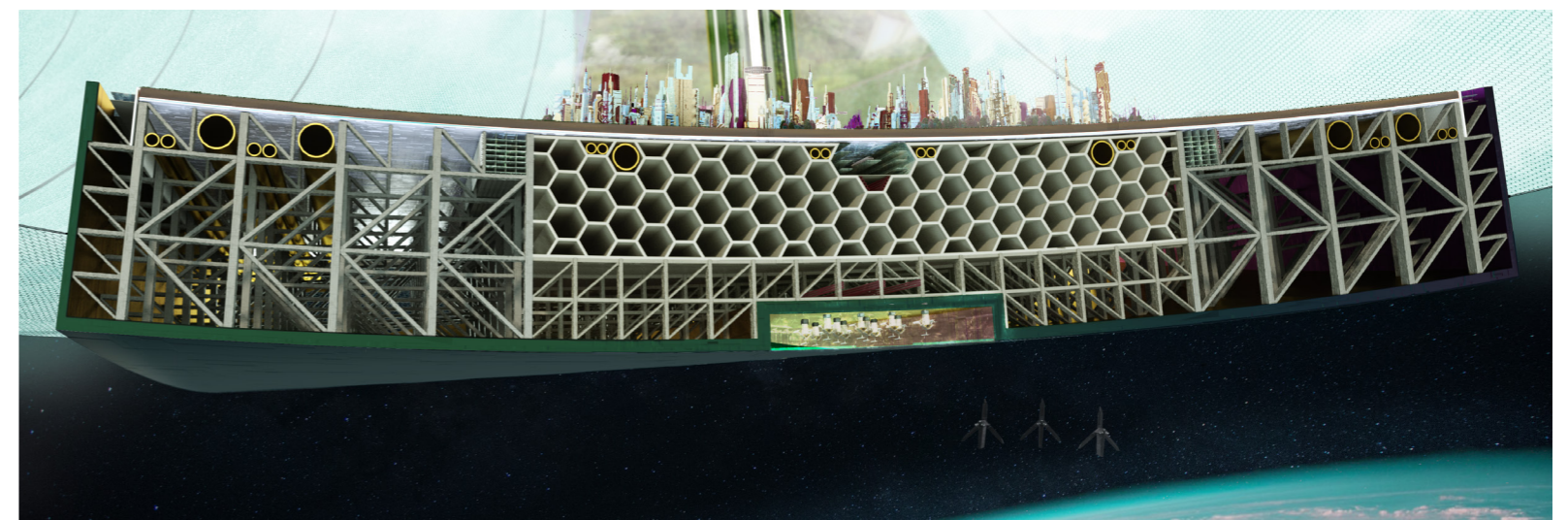


▲ **Moons of Saturn** A plethora of material is available around the planet

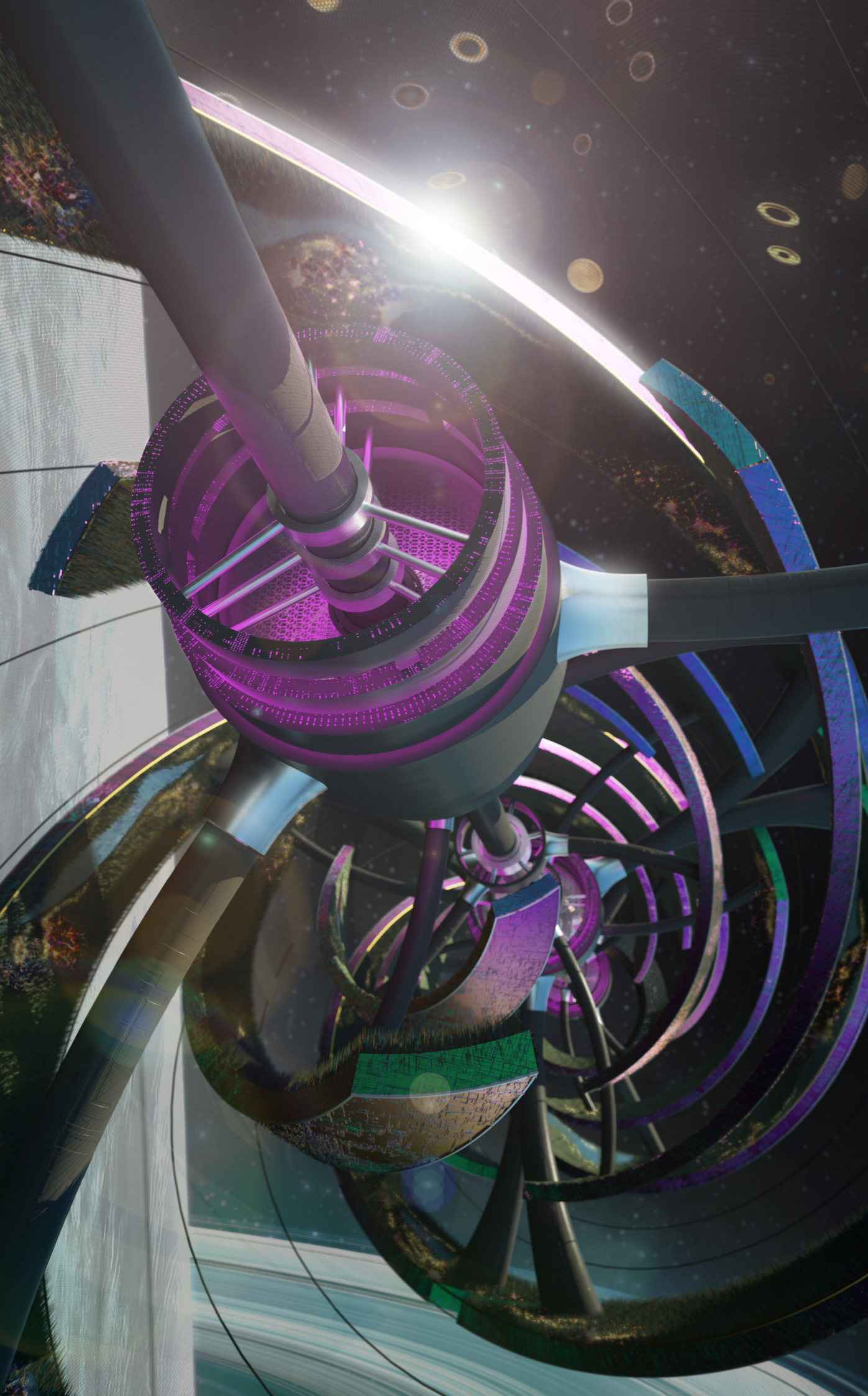


The structure of the *Quintessence* will then start to take shape around the rings of Saturn, capitalising on the advantages of a zero-G construction. Only when the structure of the ribbons is completed, will the spinning commonsense.

The structural spine of the ship will host a plethora of fusion reactors, plant, transport links and services, hidden within the surface. The inner carbon-fiber structure of the ribbons will play a similar role, also allowing for embedded architecture within.



▲ **Ribbon internal structure** Hidden below the surface we find a plethora of transport links, services, airlocks, structural support and power stations



VOYAGE STRATEGY

Millennial time-line

The starship will be designed with room to grow and develop; with large portions of the ship left unpopulated for centuries. As the years go by, the passengers will be allowed access to these locked areas, utilising the vast spaces available. This strategy will allow for a gently controlled population growth over the years, setting of light on passengers but brimming with materials.

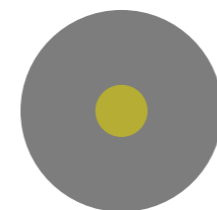
While the time required to a foreign star system is very much up for debate, famed physicist professor Kip Thorne has wrote of the possibility of amazingly fast space travel, speculating: *“And what will fusion power plants in 2050 mean for spacecraft propulsion by fusion? The most practical designs may achieve 1000 kilometers per second, and conceivably 3000 kilometers per second by the end of this century”* Thorne (2014). At this speed, it would take a brisk century to reach its destination. Of course, Thorne is applying the optimistic thinking he is known for and even with significant advances in propulsion and engineering, in addition to an abundance of substantial gravity assists, the trip will likely take well beyond the life-span of any single generation (it would take hundreds of thousands of years with propulsion of the early 21st century). For the sake of this voyage strategy, a very ambitious 1,000 journey will be presumed.

With the potential future growth of the population set to expand hugely over the voyage, there need to be plenty of room to grow within the *Quintessence*. If the population grows even faster than forecast, the design has room within the ribbons and structural component where more usable area can be assigned. Despite this, it is desired to keep the population to a comfortable ratio, allowing large areas of the ship for oxygen forest and protected nature zone. Compared to say Paris, the *Quintessence* will allow the average inhabitant far more m2 per person, providing a comfortable living arrangement. If the initial generation are to confine their families to a starship for multiple generations, then there is a responsibility to supply an environment equal or exceeding that which may be expected on Earth.

PARIS

QUINTESSENCE

SINGAPORE



▶ A newly born Quintessence

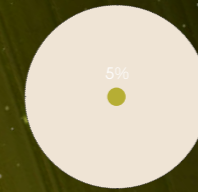
In the first days of the Quintessence, the inhabitants will settle within the central rings, spinning at 1G; ribbons populated by vegetation and building materials.

▶ Growth of the Quintessence

The starship will begin the journey unfinished and rather empty, growing internally and filling-up over the millennial voyage.

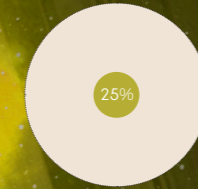
-30YEARS CONSTRUCTION

The construction will utilise plentiful resources from earth, Saturn rings and moons, completed in a variety of zero-g and lower gravity environments. While the final stages of construction take place, the occupants will begin to arrive, first populating only the central rings that hug the central spine.



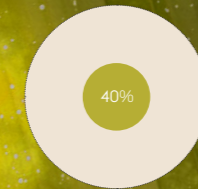
250 BUILDING THE CITIES

The first generations of the Quintessence have now come and gone, with the proceeding generations acclimatised to their unique world. A third of the ribbons will now have been 'unlocked', occupants able to craft their desired worlds upon them.



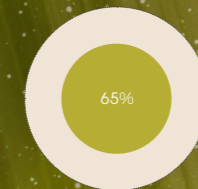
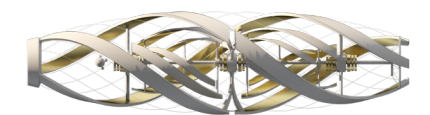
500 INTO DEEP SPACE

Now residing within deep space, the ship and its inhabitants will have transformed into a very different kind of 'world' than the one that left our solar system half a millennium earlier. It is important that they do not cling onto the rules and ideals of 2st century Earth, but instead develop their own cultures and ideals.

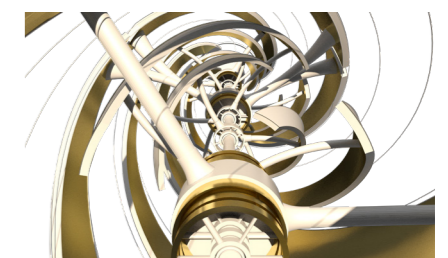


750 3 RIBBONS

750 years in, all the layers of ribbons are gently populated, each with their own cities and spaces that will have been designed and redesigned.

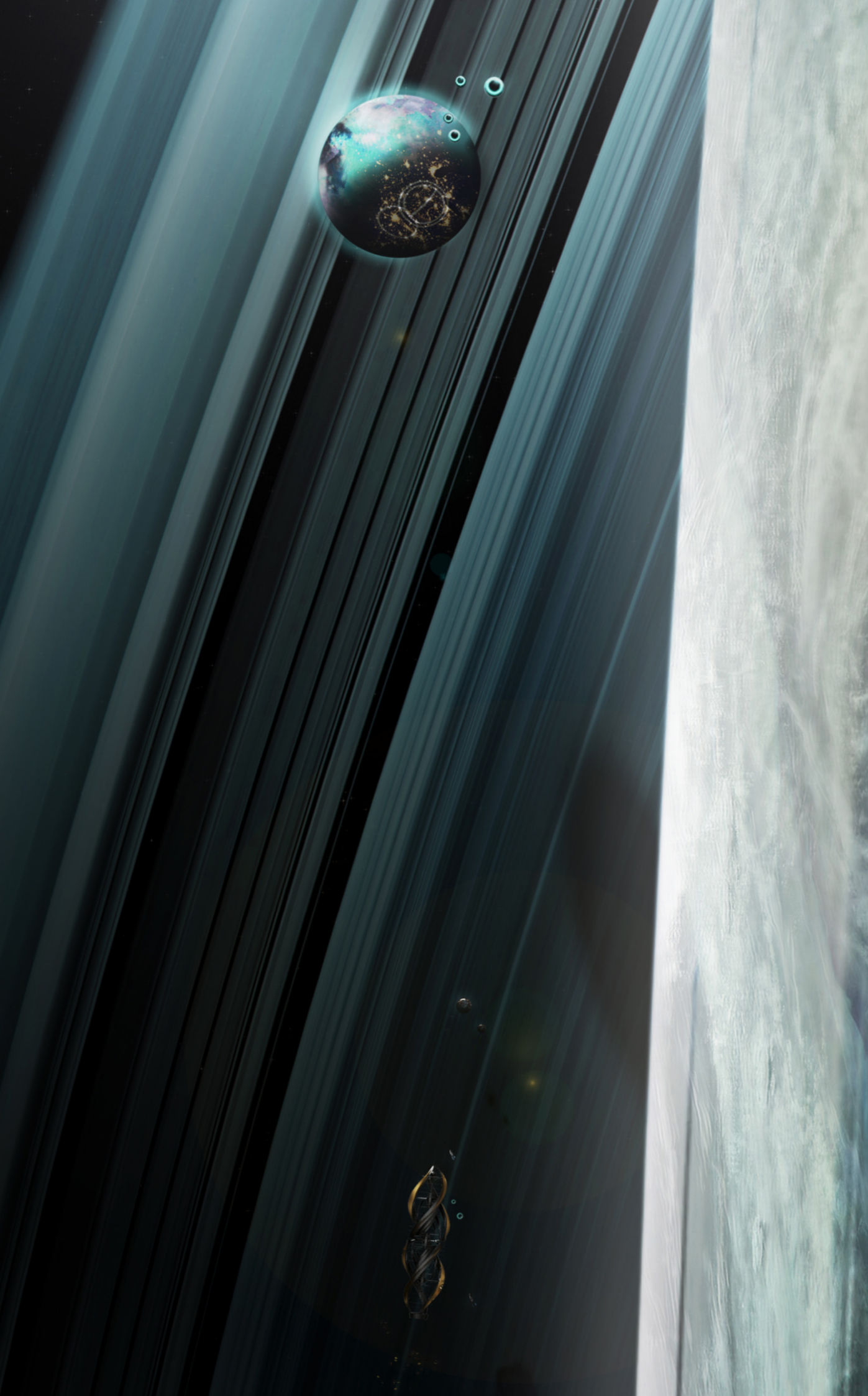


1,000 AL ARRIVAL



The ship will arrive in the Trappist-1 system, with post-humans beginning humanoid will disembark onto the three habitable worlds of foreign star system, elements of the internal world extracted onto the planets below. The remainder of the ship will enter a stationary orbit around the central planet, acting as a artificial moon, and outpost.





POWER OF THE SUN

Energy source

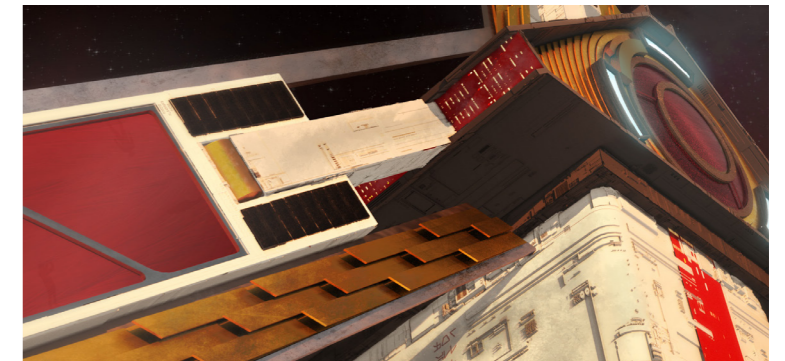
The power of the sun, other en route stars and a series of artificial fusion reactors will power the *Quintessence* beyond our solar system and towards habitable worlds.

During the construction of the *Quintessence*, large solar sails will be attached to the rotating ribbons of the structural skeleton, bathing in solar energy. In conjunction with a series of smaller 'solar collectors', the solar power will be used to fire up the initial fusion reactors that will be required for interstellar travel.

The voyage towards TRAPPIST-1 will begin with a gravitational slingshot around the sun, gaining in velocity and soring up on solar energy before being flung towards the target star system. During this stage, and during gravitational assists via en route stars, a series of independent 'Solar Collectors' will be deployed. These vessels will be specifically built to withstand and store the intense solar energy that the *Quintessence* simply can not. They will then re-dock with the *Quintessence* and replenish the energy store of the starship. These vessels will also have the unique opportunity to see a foreign star close-up, allowing for spectacular views.

Not directly power of a star, but instead taking inspiration from it, fusion energy will be the primary power source during the years void of starlight. Once confined to the realms of science-fiction, fusion power is becoming a reality, with the first fusion reactor (*ST40 Fusion Reactor*) viably tested in the United Kingdom in 2017. Despite theoretically creating a core 7 times hotter than the sun, and producing sustainable and seemingly endless energy, the reactors require only salt and water as the key ingredients to run.

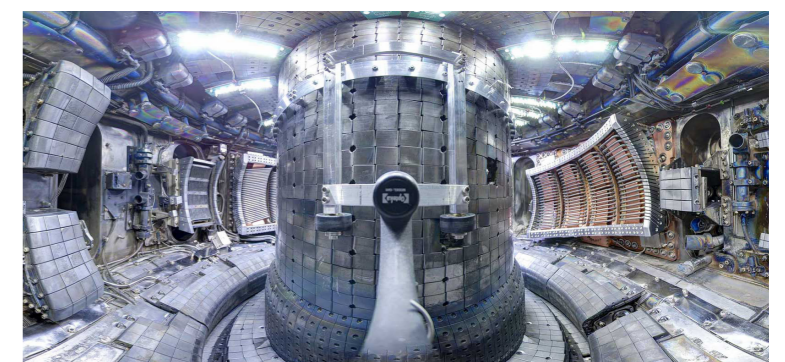
◀ **Saturn Birth** *The Quintessence in close orbit around Saturn, using Titan and other space stations as a base from which to construct nearby a large source of material*



▲ **Solar Collector Concept Image** *What the solar collectors may look like at the beginning of the voyage, with protected viewing areas and large power storage units*



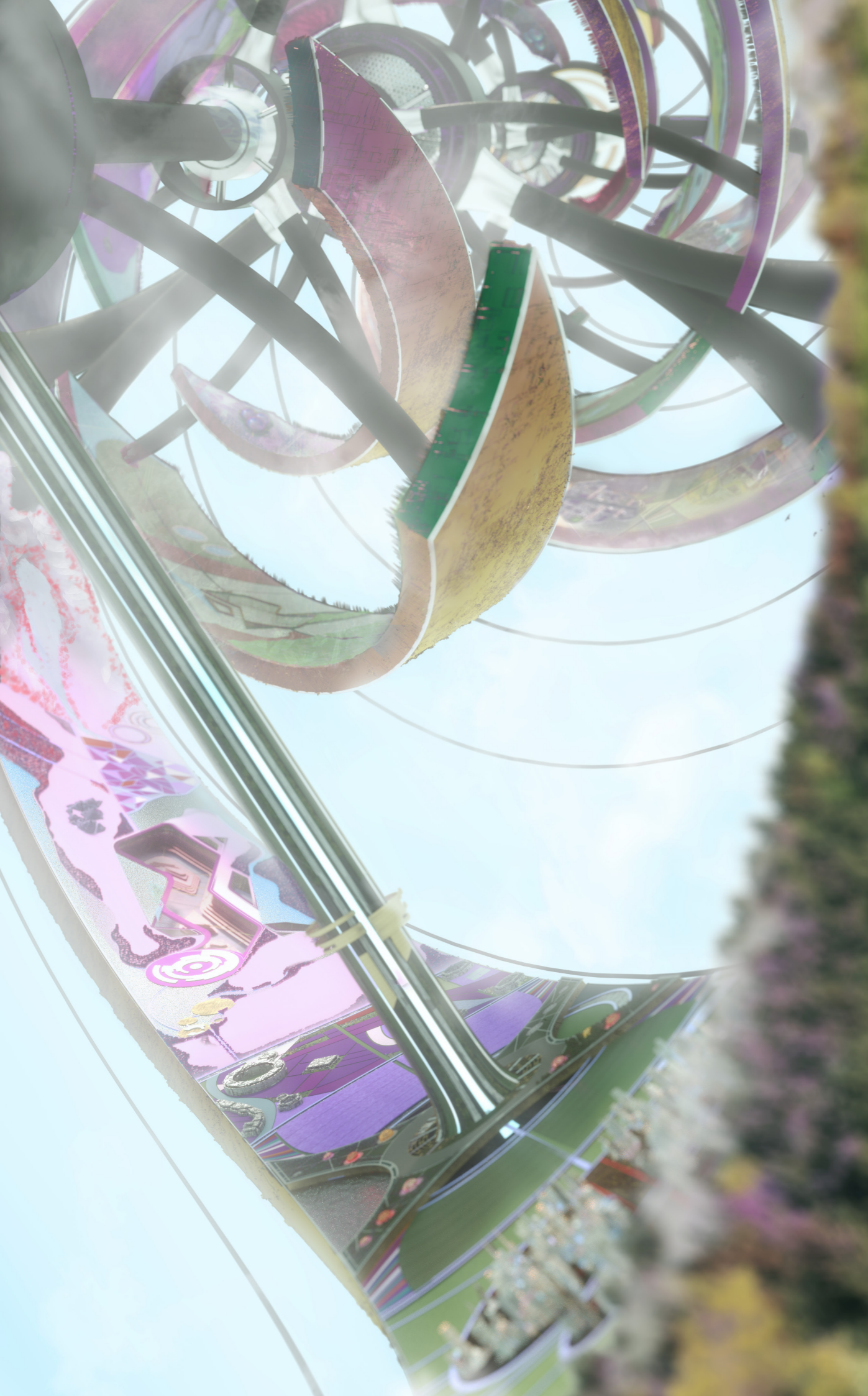
▲ **Solar Collectors V2.0** *Over the centuries, the technology, design and engineering of the inhabitants will advance, likely leading to a varying array of design styles*



▲ **Fusion Precedent** *One of the world's first fusion reactors, capable of producing staggering volumes of clean energy*



▲ **Solar Collectors V2.0 sequence** *The ringed spacecraft close to present more solar sails when in position for solar collection, the iris dilating to improve control when transporting into to and from the Quintessence*

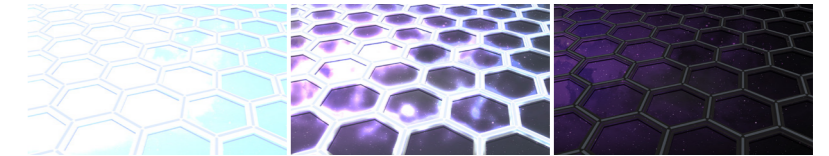


BIOSPHERE

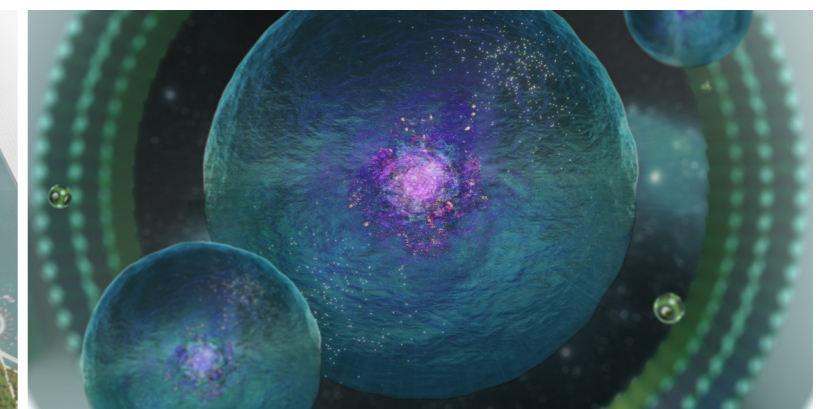
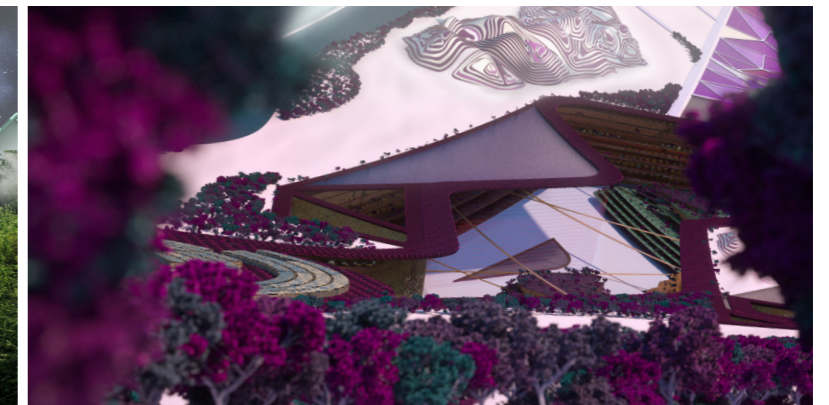
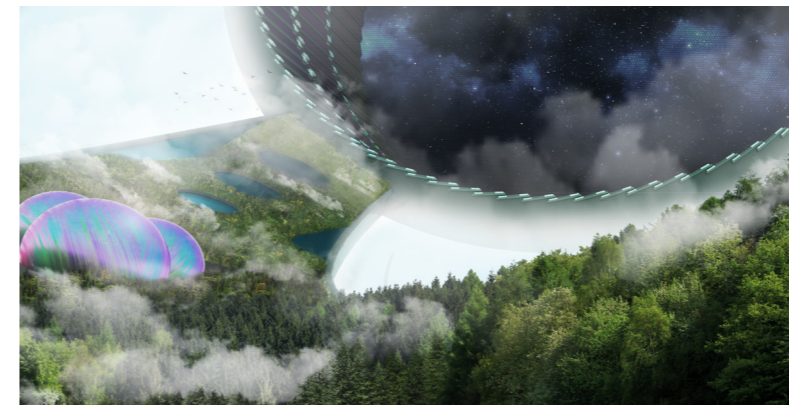
Environmental engineering

Research into the subject matter has strongly suggested that any large-scale space architecture has to be less like the space architecture of today, and more of a self-contained biosphere, encapsulating vegetation, trees, algae and so on, to generate a passive life support system within the ship interior.

▼ **Day/Night** During the 'day', the encasing mesh will emit glowing light, illuminating the ribbons of the Quintessence. This will aid productivity, as well as allowing for photosynthesis to drive the living system. 'Night' will allow for starlight to penetrate the encasing facade.

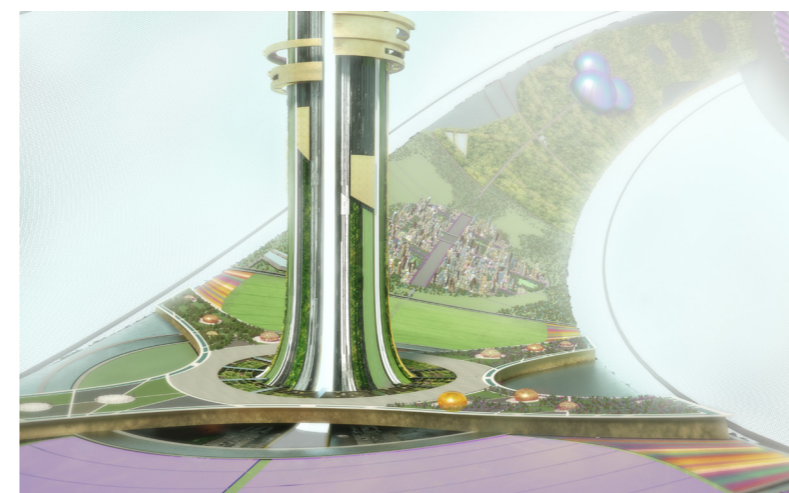


The very planet we call home generates its oxygen via photosynthesis, a process in which light energy is transformed into chemical energy. The Quintessence will produce a sustainable and breathable atmosphere via dense oxygen forest, engineered nature, algae-clad architecture and spectacular spherical oceans.

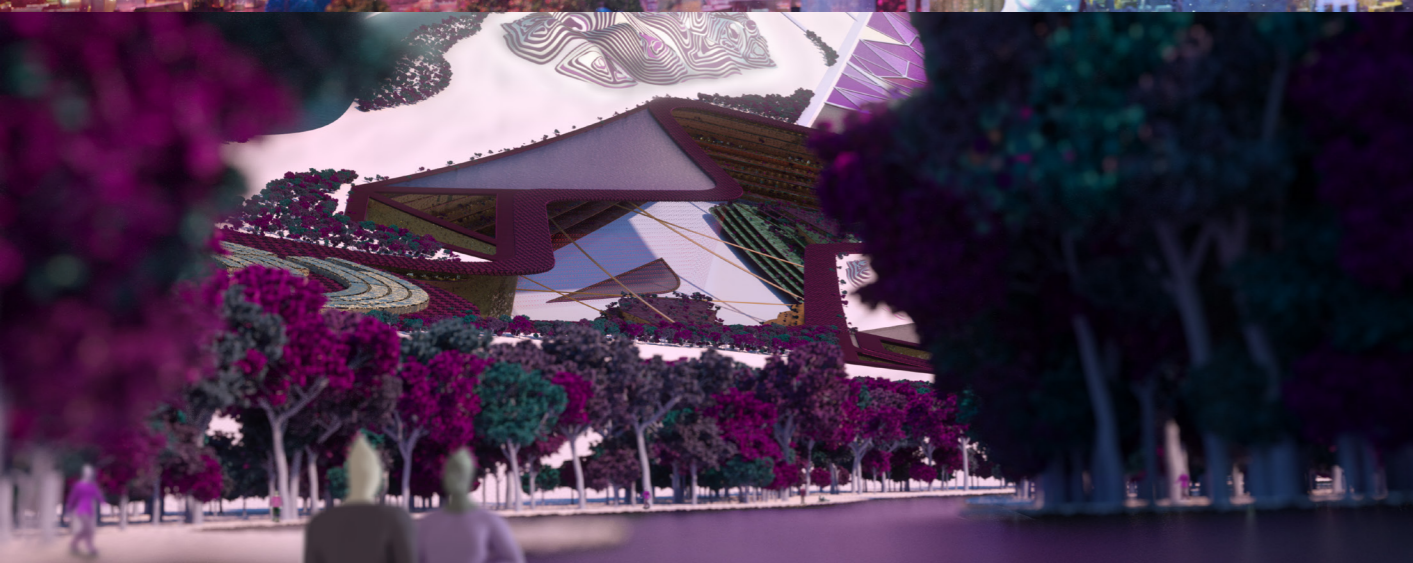
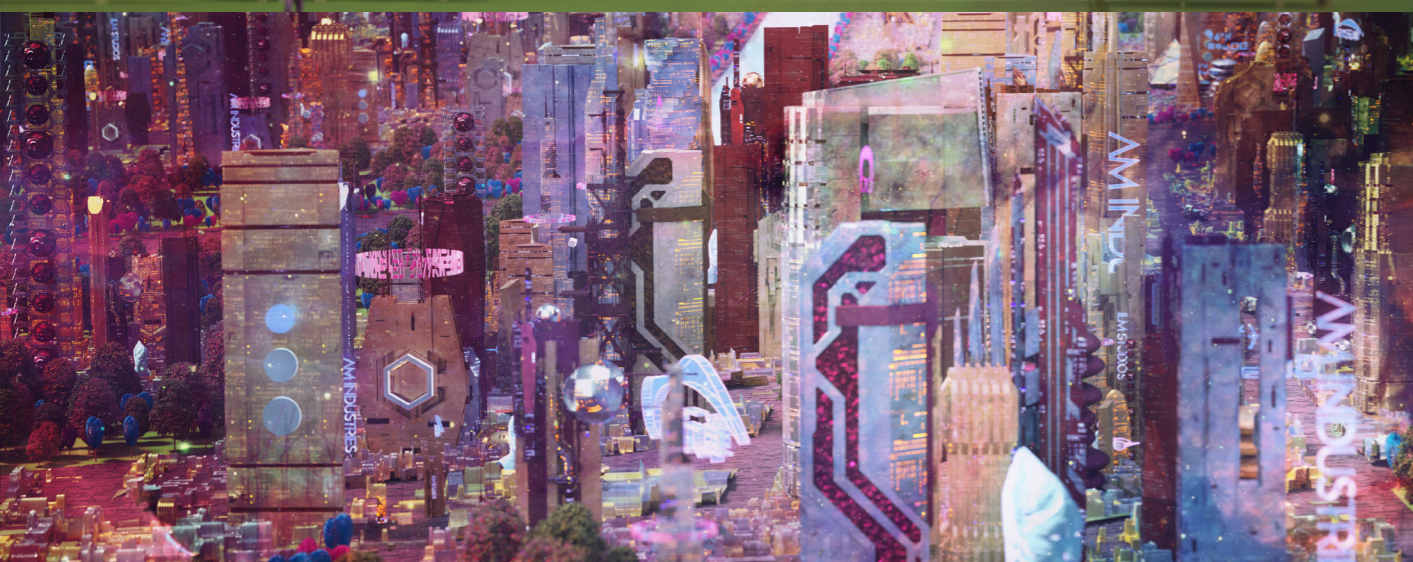
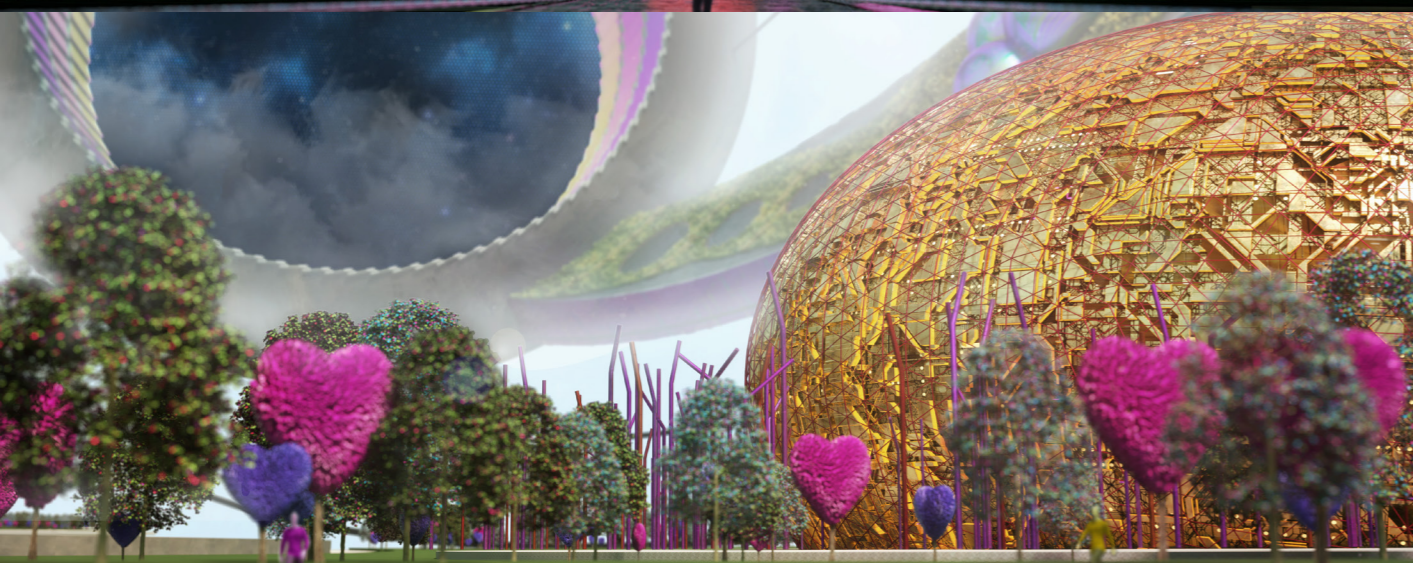


▲ **Sustainable environment** Taking inspiration from the Earth, injecting architectural ideals and a sense of play & fun

The encasing mesh that locks in the atmosphere and shields inhabitants from outer space, will also double as a light source; billions of lights emitting a blue hue during the 'day' and turning off to allow for spectacular views of the cosmos during the 'night'.



▲ **Warped horizons** The curved ribbons will be bathed in artificial daylight during the designated 'day cycle', before during blank to display the stunning environments the Quintessence inhabits during the 'night' cycles; allowing a reminder of where they are and the mission they are on



DIVERSE RIBBONS

Masterplan

The eighteen ribbons of the Quintessence differ in scale, with the largest layer representing the worlds of TRAPPIST-g. Stretching roughly 24km in varying length, these particular ribbons host large oxygen forests.

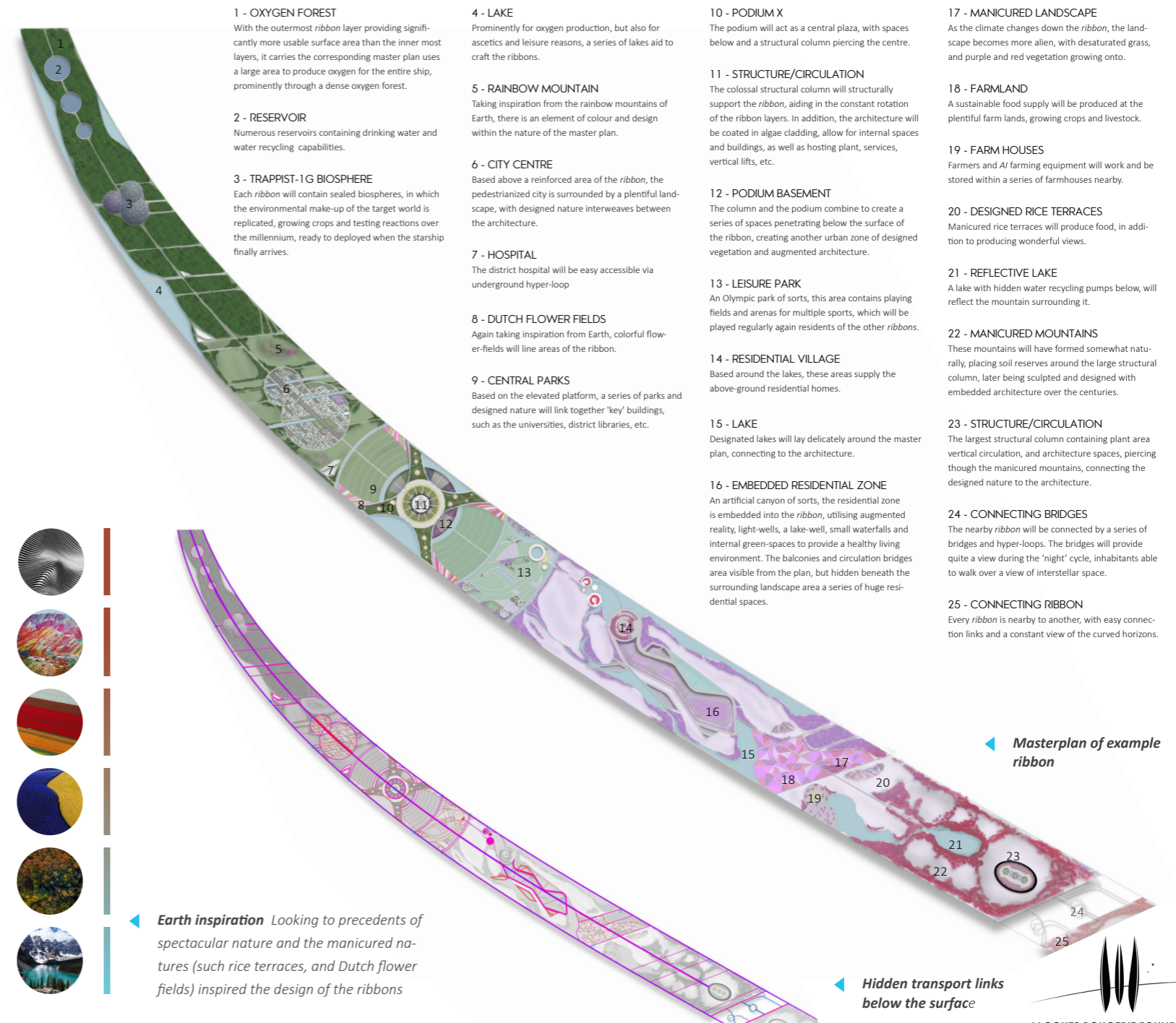
While the initial landscaping of the ribbons will likely be pretty basic and untouched, over the centuries I expect the ribbons to become manicured, sculpted and shaped by the residence. With diverse climates and programs, I have envisaged colorful ribbons, artistically replicating some of the best environments of Earth, advancing them

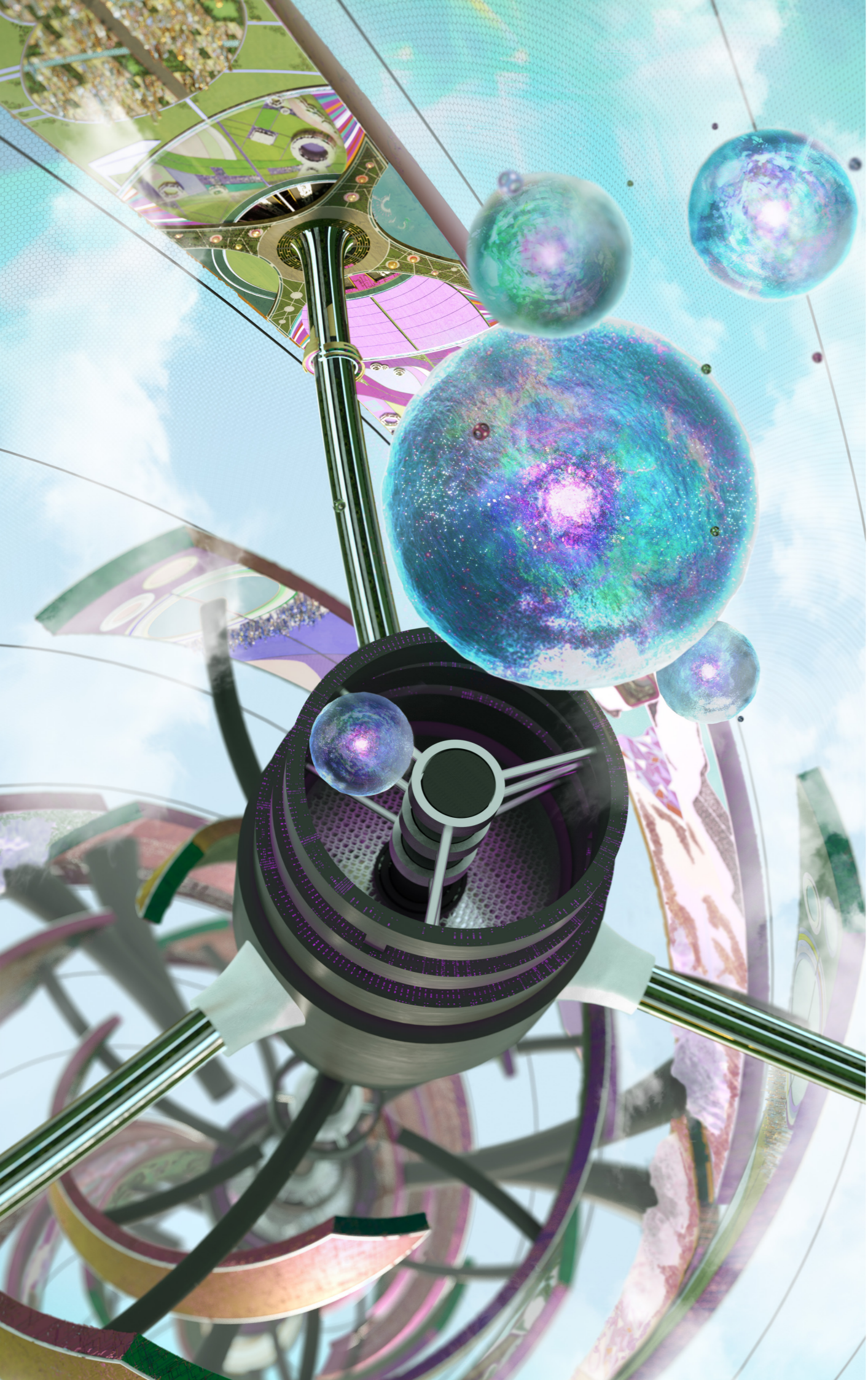
▼ **Scale comparison** 1 of the 18 ribbons placed over a map of London to show the immense scale of the design, stretching 24km in varying length



to a further degree as technology, art and engineering evolve. Despite there being no such thing as 'nature' in its purest meaning, the ribbons will be brimming in engineered nature.

Each ribbon will act as an independent community, containing cities, towns, mountains, lakes, farms, etc...connected by high-speed hyper-loops, vertical bullet lifts and pedestrian footbridges.





SPHERICAL OCEANS

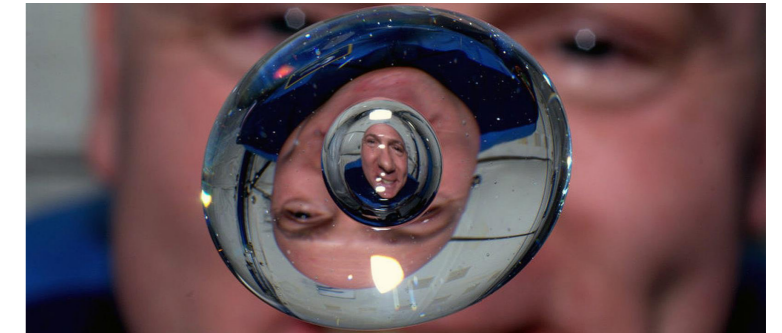
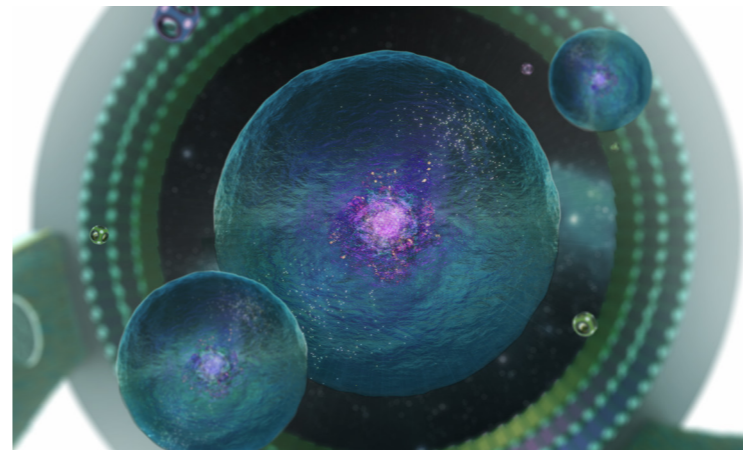
Utilizing zero-G

There is a large void between the ribbons in which gravity is non-existent. This area supplies an exciting opportunity in which all kinds of unprecedented architecture could be design; self-containing spherical oceans is something that I chose to include. This area can be used for multiple-purposes: as a form of effortless water storage, as a living ocean that significantly aids in oxygen production, for recreational activities and as an ascetically artifact that produces a stunning view.

Looking into the deep oceans of Earth, we find an array of incredibly versatile and unusual creates, capable of living in the most extreme environments. A living ecosystem of this type on-board the *Quintessences* will bring a plethora of benefits, not to mention the spectacle of a glistening sphere of water floating above head. The spherical ocean will be salt-water artifact with cores of sculpted art, glowing as it creates a centre of gravity, home to the most beautiful and spectacular of sea-life.

Layers of artificial reef will build the core of the spherical oceans, encouraging sea-life and oxygen production. Within the centre of these cores will be magnetic elements that work in tandem with the magnetic structural spine to keep the floating sphere in place within the zero-G void. Surrounding the large spheres will be a plethora of small, magnetic, algae-clad elements that will maintain stability, freshen the environment and oversee and analyse the health of the oceans.

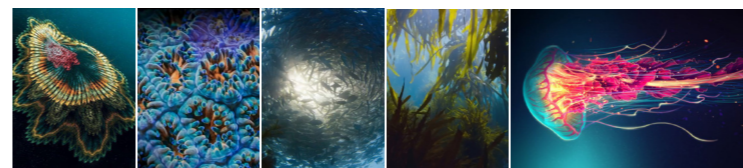
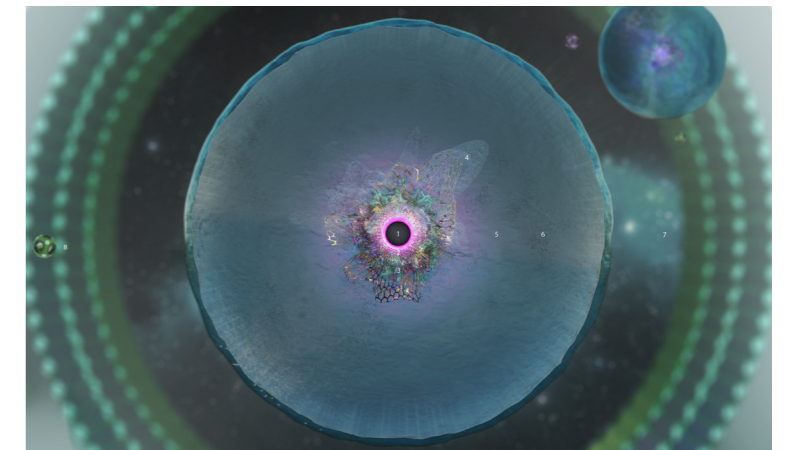
▼ **Floating Spheres** The number of spheres can grow and adapt over the voyage, adding as liquid is harvested by en route space debris



▲ **Liquid in space** The concept was sparked into being after watching on-board footage of the effects of zero-G on liquid in the ISS

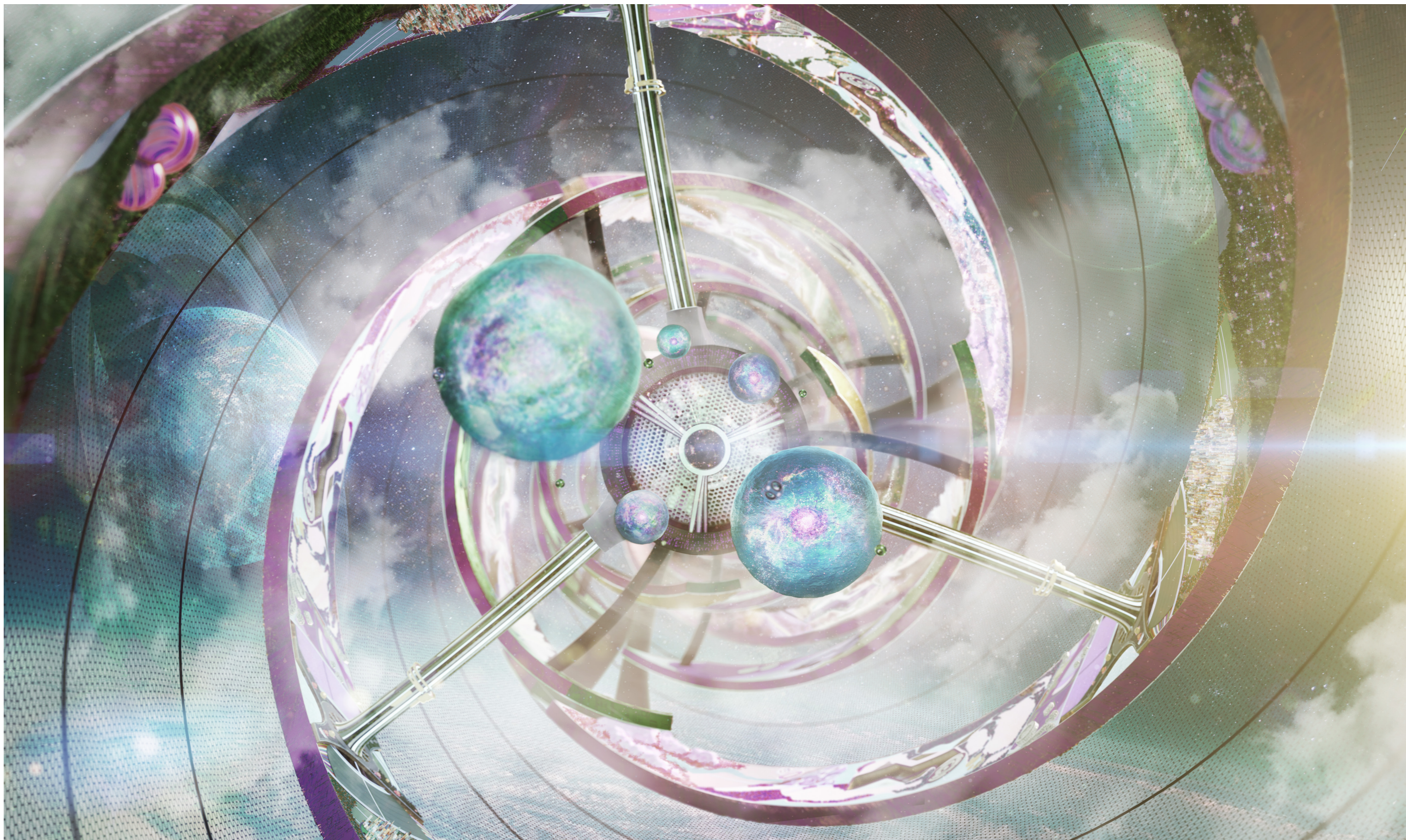
Liquid does amazing things when void of gravity, as seen within the testing of the International Space Station. Within these videos, you can see the breathtaking manor in which water acts when free of gravity, generating it's own gravitational core and dancing in motion. Unlike the small amounts of water tested so far, the huge volume of the oceans will supply a far more stable and manageable sphere, floating and glistening nevertheless.

▼ **Sectional perspective** The build-up of the spheres aims to produce oxygen and rich sea-life that will serve the entire Quintessence



▲ **Inspiration** the rich sea-life of Earth

- | | | | |
|-----|-----------------------------|-----|-----------------------------|
| 1 - | Magnetic Core | 5 - | Sea Water |
| 2 - | Luminous Layer | 6 - | Sea Creatures |
| 3 - | Artificial Reef | 7 - | Zero-g Zone |
| 4 - | Artificial Reef (secondary) | 8 - | Magnetic, Algae Controllers |



QUINTESSENCE

Project Quintessence isn't about abandoning our planet in some dystopian future; it instead dreams of what may be possible as architecture expands into space. While space holds a plethora of complex challenges for architects and engineers, if overcome, we can create spectacular architecture that manipulates gravity, programs time and engineering

nature. Space will bring forth a whole host of exciting new opportunity which designers of today should be encouraged to dream of, utilising emerging technologies, sustainability and wellbeing. We don't need to settle for the norms of today; our future isn't within uninspiring aluminum cans, nor is it confined to our beautiful yet fragile home world, it is within daring, artefactual biospheres that spawn divergent civilisations. Together, we can create the unthinkable, travel to the unconceivable and accomplish something truly special.