SAPIENZA
UNIVERSITÀ DI ROMA

Master of Science in
PRODUCT AND SERVICE DESIGN
a.y. 2021-2022

Final Work

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Roberta Psimenos - MAYA, the shadow of reality a.y. 2021-2022

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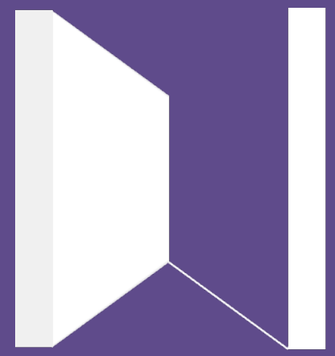
MAYA, mixed-reality window

Mixed Reality Windows for Space Station Habitable Modules



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Faculty of Architecture

Title:
MAYA
Mixed Reality Windows for Space Station Habitable Modules

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PART ONE
RESEARCH

01
INTRODUCTION

Have you ever seen a house without windows?
The most immediate answer is probably no. It is so important to have the opportunity to observe the world that it often becomes a necessity that is impossible to give up.
This architectural element has always been essential in our daily lives because it allows us to benefit from a position that makes us not only spectators. In a certain way makes us be participants of a world and a reality that moves just outside of that glass.

Large windows, bright houses, and panoramic views can create a real fusion with the surrounding environment. Closed spaces are the fulcrum of our material needs as well as our emotional instances and psychological needs. They make us feel at home or more generally have the task of protecting us and shielding us from the snares of the outside.
The window thus becomes a bridge, a union between what is inside and what is outside.
This element is not only an observation point but a real stage, a way to dialogue with the outside. It is a free dialogue that allows a coexistence and fusion with what surrounds us.

In suggestive and fascinating environments the need for contact grows by becoming a need for discovery. Think about a house built over the sea without facing it, or a plane without windows. It would become very vague. Sensations, sounds, movements. Our bodies and our minds would not perceive beauty and would not be able to fit in. The result would be a feeling of discomfort and suffocation.

What if all this happened in front of even more evocative and fantastic landscapes and scenarios, such as space? For centuries and centuries, man has been with his head up, looking for answers to existential questions that we always carry with us.

Aztecs, Chinese, Arabs, and Greeks are just some of the great civilizations that, driven by curiosity, have scrutinized and studied the sky.
Before the advent of Galileo Galilei and the firsts studies with the telescope in the early 1600s, this type of observation was made almost exclusively with the naked eye and for centuries, until just under 100 years ago, the idea of being able to make expeditions into space was just a welcome topic for writing science fiction stories.

We should have waited for the 1950s to see the first living being entering orbit[1] and the mid-1960s to witness the first *spacewalks*.

Nowadays, space missions and explorations, with or without human presence, have made giant steps forward, so much to allow a select few people to make small space journeys for pure pleasure[2].

Would space tourism be science fiction? Absolutely not.

Increasingly large space agencies rely on wealthy companies able to finance initiatives of this kind, even if the idea is to expand the panorama to a large-scale and more varied number of customers.

However, there are many problems with this type of objective.

Converting places that are normally used for study and research into small tourist compartments implies a radical change in the internal structure. Even the most common and everyday objects must be redesigned and recreated to meet the needs of this new environment. The real difficulty in spatial design, currently an avant-garde and still a little-defined concept, is due to the fact that the realization of any element to be sent into space, such as spacecraft, space stations, and housing modules, is linked to structural and physical essential constraints. Shapes, materials, components, and structures must necessarily be subject to precise rules to avoid damage to the object in question and maintain safety in case of the presence of humans or those on board.

Moreover, it is fundamental to specify that everything has a cost and in space, the cost increases even more and becomes very high. Shipping out of the atmosphere requires oodles of propellants.

The more you want to transport, the more you need propellant to do it; with the increase of the weight, you should also increase the amount of propellant required for the transport and the costs will, consequently, rise.

1 The dog Laika, was launched into space on the second orbital Earth flight on 3 November 1957. He became the first living being to enter orbit.

2 The first space flight able to bring passengers to a different station from the starting one happened the 9 April 2022. Onboard SpaceX, four private passengers reached the International Space Station.

What is not essential is therefore paid dearly. We no longer limit ourselves to space travel with a purely scientific purpose, however, we must work to meet the demands of new and old users.

Since this category of users is currently insistent, those who need and make the most of space services are astronauts whose demands are very simple and understandable.

Thanks to interviews indirectly conducted through Thales Alenia Space company, based in Turin, it is clear that the most common request from this catchment area is to have at least one window inside the passenger compartment. They desire a link that allows them to see what is happening outside. For the reasons listed above, however, it isn't possible to fully cover the space station with windows that allow a view of the outside.

Therefore the research is focused on the study and design of a Mixed-Reality Window for Space Station Habitable Modules, starting from the physical structure of the "Axiom Cylinder". The window will be based on a virtual and mixed reality technology, capable of immersing the observer in the surrounding environment without limiting it to an exclusively spatial experience but integrating this journey with everyday scenarios. The user will have the opportunity to spend their days embraced by the surrounding universe but with the opportunity to review and relive home, affections, dear places, and/ or with an alternative to the walls of his new home.

01.1 PRELIMINARY RESEARCH

Articles, publications

Besides the specific case studies, I have analysed different articles related both to the construction of space modules, to the psychology behind the window in space and nautical fields, and also to the technologies used for mixed and augmented reality.

Some of the papers trace a few alternative configurations considered through the Space Station's formulation and early development periods and provide an overview of some of the trade studies, design and modeling activities, and alternative configurations which led to the configuration as it is being flown today.

We need to understand the complexity behind the International Space Station, the basis of this study. The configuration of the habitats inside is not simple and around there is very little about the origin and evolution of their design.

The development of the architecture and configuration of the internal and suitable modules to accommodate the crew of the International Space Station was based on a very comprehensive set of requirements and analyses that have been worked on for a long time. The architectures studied and proposed for the realisation of this type of habitat have been many. Eventually, the architecture adopted was based on a compromise between launch capabilities, system requirements, past experiences, human factors, and political considerations. Over time, the architecture of the housing modules inside the space station has remained unchanged. The International Space Station module design can be used for habitats that go to the Moon or planets. Some more recent designs have focused on the use of an inflatable module to achieve a greater useful volume for life and work without incurring additional mass costs.

Among the various articles analyzed there are some reports that the company Thales Alenia Space, based in Turin, has provided in support during the development of this elaborate.

The multiple reports were describing the design of the Window Assembly for a Cylinder pressurised module designed to be used in LEO[1] applications and provides the justification for the selected solution from mechanical, thermal and radiation points of view. The files are confidential and contain the structural and technical specifications of the product development.

After this analysis, it was chosen to work on the structure of the window inside the Axiom cylinder, better known as the Axiom Orbital Segment. We are talking about a space station project planned for 2024, by the American company Axiom Space, for space tourism at about 400 km of Earth orbit.

The cylinder, but the space station of Axiom specifically, is properly designed for tourism, it, therefore, sets structural objectives that can meet the actual needs and the needs of the future users. The cylinder considered is about six meters long with a diameter of three meters..

The controversy related to windows inside the housing modules is a point that designers and engineers have always struggled to dissolve. The astronauts demand a real window to avoid the sense of alienation and to enjoy the surrounding beauty, and this request will be even stronger from the tourists. It is unthinkable to make a space journey without having a view of the outside.

But what can be the most similar to physical and atmospheric problems, that occur in space? The other critical scenario for glass, plastics, and any material that allows the view of the outside are the boats.

Nowadays the number of windows in ships and their size has increased, moreover, the surrounding structure should be light-weight and as invisible as possible to enable an immersion of passengers into the marine environment but this brings difficulties from a technical point of view, considering that the minimum thickness of the window panes is determined on the lateral design pressure. The tests have shown that bonded window panes significantly increase the shear stiffness of window strips, this could be a positive effect but at the same time, the stresses at the mullion ends are significantly increased by the bonded window panes, which is a negative effect. The stress in the window can be solved opening corners by increasing the radii or inserting plates. This last option is very effective but at the mullion is not always positive. It is fundamental to include the window panes in the stress calculation and focus on the contribution of the window panes to the structural stress.

1 Low Earth Orbit (LEO), is an orbit around Earth with a period of 128 minutes or less and an eccentricity less than 0.25.

Thinking about how to overcome the structural problem of windows, the most immediate solution is to limit the use of fragile materials. This would remedy the problem of breaking and maintaining the object.

For certain types of space, windows are already used a very refined type of plastic able to recreate the glass effect but being lighter and less subject to breakage. Another problem that is so obvious is that of weight: glass, in addition to being very fragile, is heavier than plastic material.

What could be the solution? Certainly not papering the International Space Station or the Axiom Station of plastic to have a higher number of windows.

The structure of these modules must respect the characteristics to stay in space without encountering problems. You would think that the solution could be to use windows made of a material that is not subject to deterioration and damage but with a texture that allows you to see outside the structure. That is not possible.

Meteor showers, pressure variations between the inside and the outside, the absence of gravity, heat, and other external issues, bring the window's design to keep highly detailed characteristics. The portholes inside the living modules in the space have a structure built on three or four levels, using just three or four panels. The most advanced windows have only three panels but tend to have four of them because increases safety at the expense of weight. The outer plastic panel has the task of saving the central glass from the weather that could hit it (meteor showers, heat, etc). The central panels have to maintain the correct pressure levels. The last one, the internal one, is an additional glass place for safety, and it is also the only one that can and must be replaced in orbit in a matter of seconds.

What else allows you to see something without using a material that is transparent or able to show what is outside of the latter? Video-cameras. Especially at a time when digitalisation is omnipresent, this response appears to our eyes even clearer and more feasible.

During the recent pandemic, we have had the opportunity to discover or rediscover the use of technology. The main objective was to project ourselves in places and with people different from those within our homes.

Video calls and meetings were the most used tool to reach someone or something at that time away from us. Just think that after this historical period has been cleared through customs the smart-working. Employees can be in their offices while not physically inside it.

During COVID-19 people have started to demand more digital devices, consoles, and visors. The quality of objects with virtual reality technology has grown, bringing a huge and ever-greater catchment area. These tools allow you to live in fantastic settings far from us light years. At a time when all we could do was stay still, escape was indispensable.

Psychological support was necessary. Deceiving our brain was necessary.

This solution has no long-term benefits since human interaction is as crucial as contact with the outside world. Having this experience for limited periods and with strict constraints, however, has proved to be successful. So is there a similar type of technology for environments where direct contact with the outside world, albeit visual, is difficult?

This kind of high and elaborated technology is still not used for common uses, probably because there were no needs before. Men used to stay in hard environmental situations for research, not for their pleasure. The ocean was a place for fishing, travel, and trade, not a holiday destination. Let alone the space. One of the few existing projects in this field that uses mixed reality is Hyperloop.

The document is open source and this draft led to the realisation of this element, Hyperloop, a high-speed train whose design and improvement depend on the contribution of individuals since there are still points to be developed within the project. Due to the incredible speed of the train - we talk about the sound velocity of 1223/km - it would be impossible to see outside the window, this is why some projects base the portholes on augmented reality technology.

At present, however, the role of technology is taken into account, not as augmented reality but as a fundamental element to ensure security.
Studies have been carried out on the applications of IoT technologies within "mobile" entities, such as cars and trucks, but using "static" infrastructures in which they are immersed and on which they depend, such as highways, parking lots, and urban structures. This type of application is generally referred to as "vehicle-infrastructure" communication. Several projects have taken care of the implementation of this technology in the communication vessel-infrastructure.

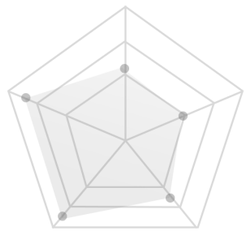
This type of communication has been realised to exploit the IoT technologies for the benefit of pleasure boats and yachts and to ensure greater safety.
Therefore, having contact with "earth" increases safety when you are at long distances

It is evident the necessity to have an IoT Platform which supports Vessel-to-Infrastructure communication and interaction, providing a seamless way to connect boats to the many dedicated service providers, for safety and security while at sea but also for delivering tourist and other important services to the boat owners.

After preliminary research, the analysed case studies have been dividing them by three main necessary categories.

01.2
ANALYSED FIELDS
Space, Nautical, Digital

The images represent the criteria and evaluation points used throughout the study analysis.



The research phase started by analysing the fields in which the window could play a similar role to the one that it has in space. The examined macro areas are three: space, naval and digital. The space field has been analised by researching case studies that could show where and how physical windows have been used for space modules or spacecraft up to the present day.

As far as the naval field is concerned, it has been of considerable interest and inspiration because in this type of environment windows are designed to perform both a psychological and decorative function but respect very stringent physical and design constraints.
Finally, has been analysed the digital field because since the digitalisation of the window has been considered a valide path. Technologies' usage would reduce maintenance, structural, and material problems that in the space are fundamental and limiting elements.

For each type of scenario, are defined criteria and characteristics, the latter same for all, that allowed to evaluate the case study according to the interest of this work.

01.2.1
SPACE FIELD –
criteria and evaluation points

The case studies considered for the space field concern some real projects and other design projects not yet realised. The criteria chosen for the evaluation are optimisation, practicality, and profit. The evaluations are mainly related to the window element, not to the whole product.

The **optimisation** is a key element during the realization of the technical part of a sophisticated structure, even more, if we are talking about rockets, shuttles, or elements that should be sent into space. It is strictly necessary that each component gives the best result using the least amount of resources and costs. Especially considering the weight, it is fundamental to avoid it: a lot of weight means a lot of fuel, high costs, and poor handling.

Even if **practicality** looks similar to optimization, the real meaning is quite different. Talking about practicality the intention is to underline the facility that the user has by managing a component, a product, or a service. In the space field, you do not have the same support and facilities that usually are on Earth, and the dangers increase in all circumstances. This is the reason why each element should be easy to manage and maintain. It is a strong necessity that cannot be underestimated during the design process.

Profit is a common word, used to understand the gain that comes from an action, a work, or an element. Even in this situation, it is important to see how the window element could add positive results from a practical point of view and a psychological one as well. It is not possible, indeed, to underestimate the role that our minds play in these situations. The astronaut receives training that is not just physical but also a deep process to train the mind.

During the realisation of elements designed for space, it is fundamental to take into account the request from the user, which could be an astronaut or in the future a tourist. Nowadays, unfortunately, the focus is only on the structural part of the space design, but these environments should become places pleasant for the mind, the body, and science.

The common evaluation points are target and quality. The first, target, indicates the sector to which the specific product is addressed, whether business to business o business to consumer. The second one, quality, evaluates the quality of materials used. A small graph will be used to understand at a glance which peculiarity is more accentuated than another. The three levels indicate the intensity while the five points analyse the themes: how good and efficient the window is, how much the project takes human needs into account, how much the impact of the window is sustainable, the weight of the material used, and finally the window size compared to the environment.

The images represent the criteria and evaluation points used for the space field.

01.2.1.1
CUPOLA
Thales Alenia Space
2010

The Cupola is an ESA-built observatory module of the International Space Station (ISS). The structure has six windows mounted laterally and a larger window of 80 cm on the upper part, offering all-out visibility in a single direction, the seven windows are mostly used to conduct experiments, dockings , nd observations of Earth.

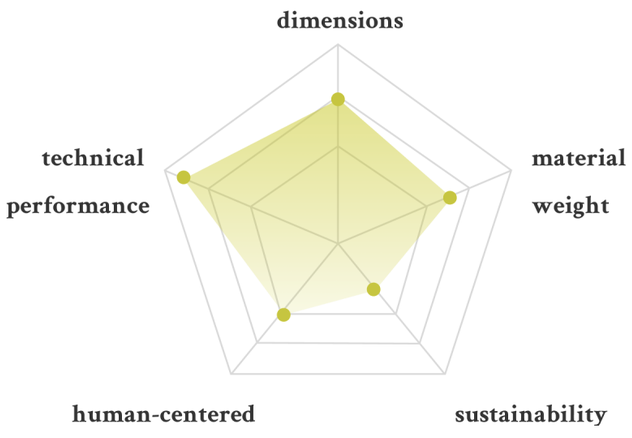
Cupola is 1.50 m high, has a maximum diameter of 2.95 meters, and at the beginning had a mass of 1.805 kg. The windows can be sealed with special shutters for protection from micrometeorites and space debris. Its success is also due to the comfort it gives to the astronauts from a psychological point of view.

The Cupola on the International Space Station is a real control center that allows astronauts to work while enjoying a spectacular view outside. Thanks to the seven portholes it gives a 360° view. It is also used for experiments to take high-definition photos of the universe and Earth.

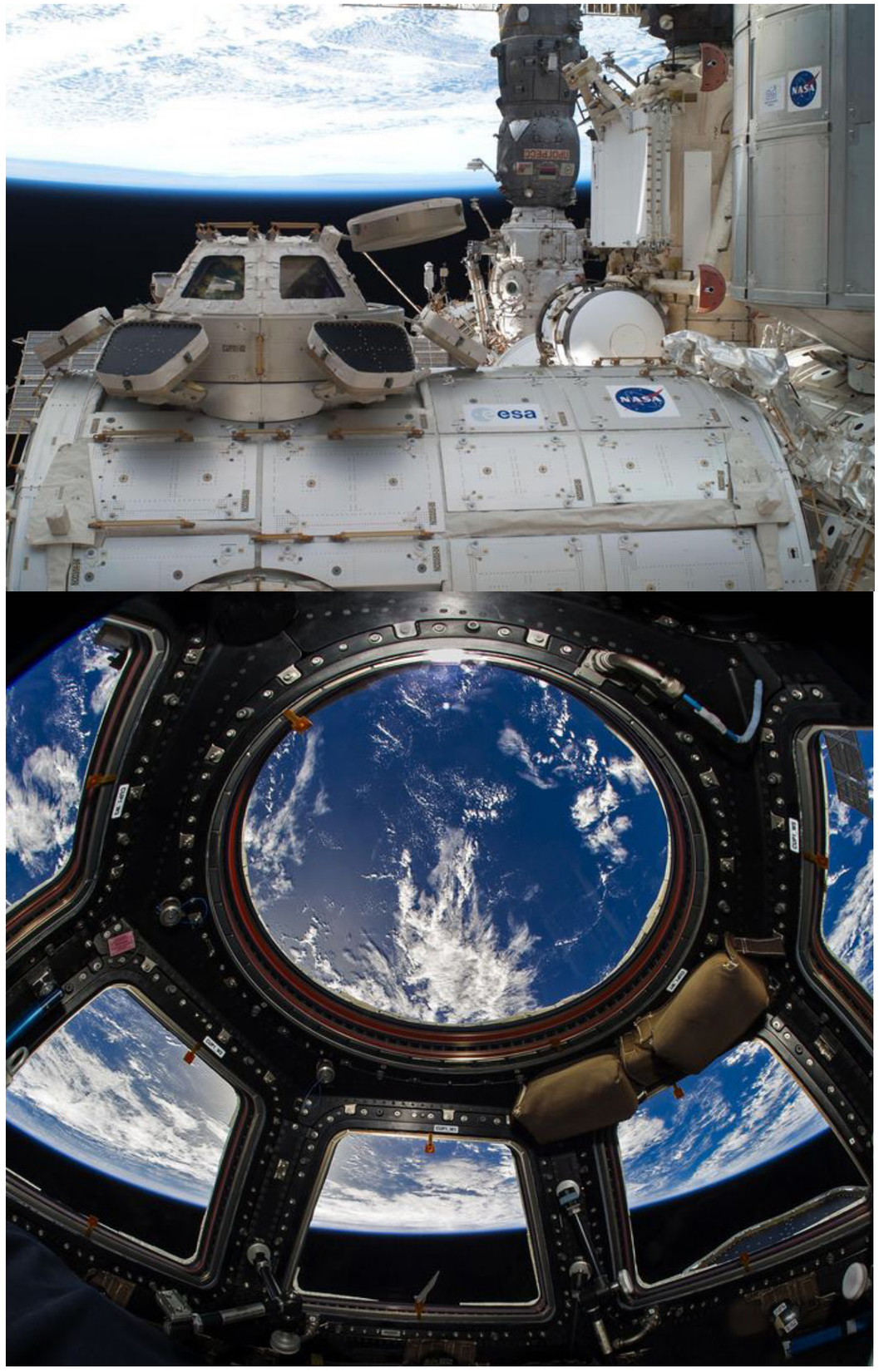
Luca Parmitano, in Blog.esa.it, November, 6 2013

« This window on the world has fascinated and charmed all astronauts and cosmonauts who have had the privilege of looking at our planet from up here. Its seven windows allow a 360 degree view of the horizon and offer a spectacle of unparalleled beauty » thanks to these words it is clear the role that Cupola has inside the ISS - it is a way to study and work as well as a way to refresh the minds with the beauty that surrounds who is so lucky to be there.

One of the strongest points of Cupola is that it meets the psychological needs of the user together with the structural needs. It does not have particular disadvantages. It almost fully meets all the evaluation criteria, with great optimisation, excellent practicality, and very good profit. The target of the case study is Business to Business (B2B) and the quality of the project is high. From the graph, it is easy to see how strong could be Cupola. It perfectly respects all the physical and technical requests, focusing also on the centrality of man.



1. Photo from Asi.it
2. Photo from Nasa.gov, Image Credit: NASA



01.2.1.2
AXIOM EGG
Axiom Space | Philippe Starck
2020

Philippe Starck, for Collatera.al, article of Chiara Fuggetti, 2018.

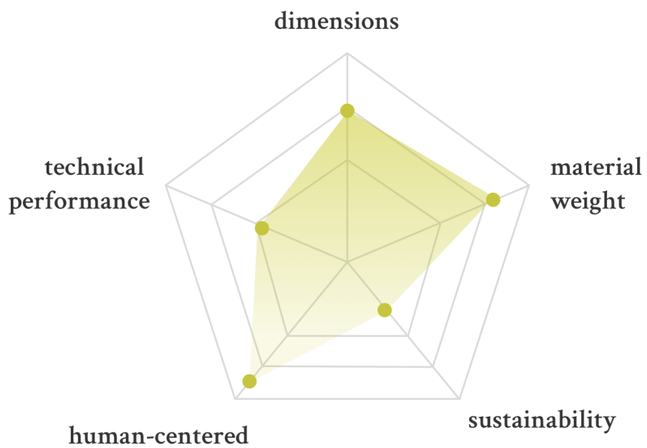
"A space station is ruled by a fundamental law: zero gravity, unlike terrestrial life constraints, life in space is a multi-directional freedom. My vision is to create a comfortable egg, friendly, where walls are so soft and in harmony with the values of movements of the human body in zero gravity."

These are Philippe Starck's words about the creation of the module for Axiom Space. The windows are in the middle of the nest, the focal point around which the entire structure of the passenger compartment is developed.
The shape is very basic, the boldness is in the rest of the cabin.

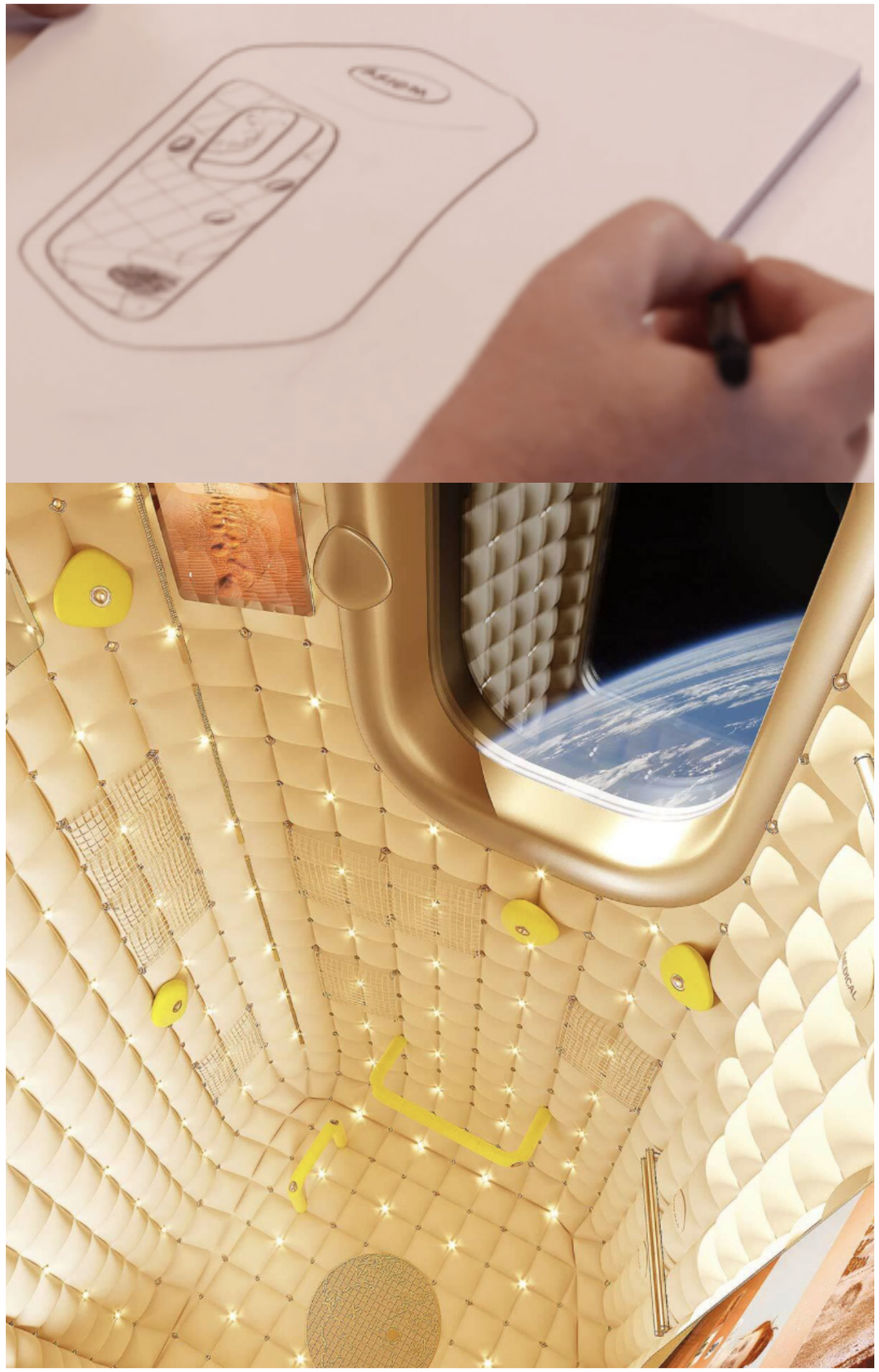
The idea he wanted to realised is based on the concept of space-nest: the walls of the housing module are dotted with hundreds of nano-LEDs that change color depending on the mood and the biorhythm of its inhabitant. The environment was designed to be a comfortable place of freedom, but at the same time of protection, so much so that it was defined by the same Starck as a kind of "fetus" space.

The product meets perfectly the psychological needs of the user, on the other hand, it presents an ambitious structure not fully compliant with the criteria and physical constraints to be respected. It is not fully optimised but it shows great practicality and profit.

The target is Business to Business (B2B) and the quality of the product should be high. From the graph, it is clear that the project is fully human-centered, and less attention has been put on the structural field.



1.-2 Philippe Stark per Axiom Space



01.2.1.3
SPACESHIP 2

Virgin Galactic
2020

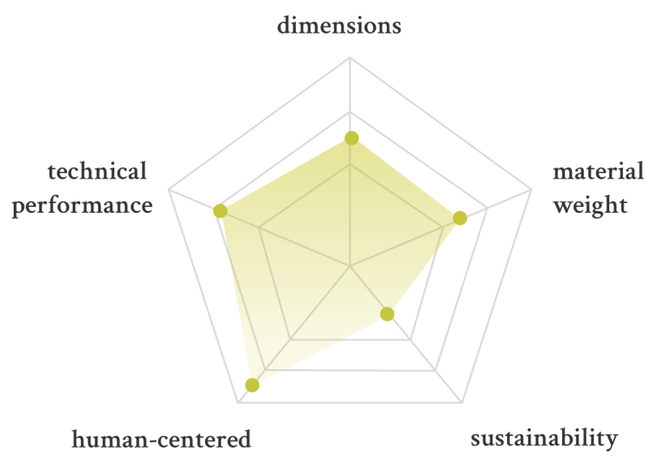
The aircraft, designed to carry out commercial flights under the banner of Virgin Galactic, was the protagonist of a long and complex development phase, in which the first built model - the Vss Enterprise - was even destroyed in 2014 during a test with the death of one of the pilots.

The Space Ship 2, which is still under development and testing, is a family of commercial suborbital and orbital spacecraft that will be owned and operated by the Virgin Galactic spaceline company. It was used in 2020 for the first tourist space travel by Richard Branson and others billionaires. SpaceShipTwo has been designed to avoid complexity, with minimum moving parts.

The inside of Virgin Galactic's space plane is like a space-age executive jet; there are twelve windows – two for each of the six passengers that provide an impressive view of Earth and the darkness of space. Modern technology provided an imaginative solution.

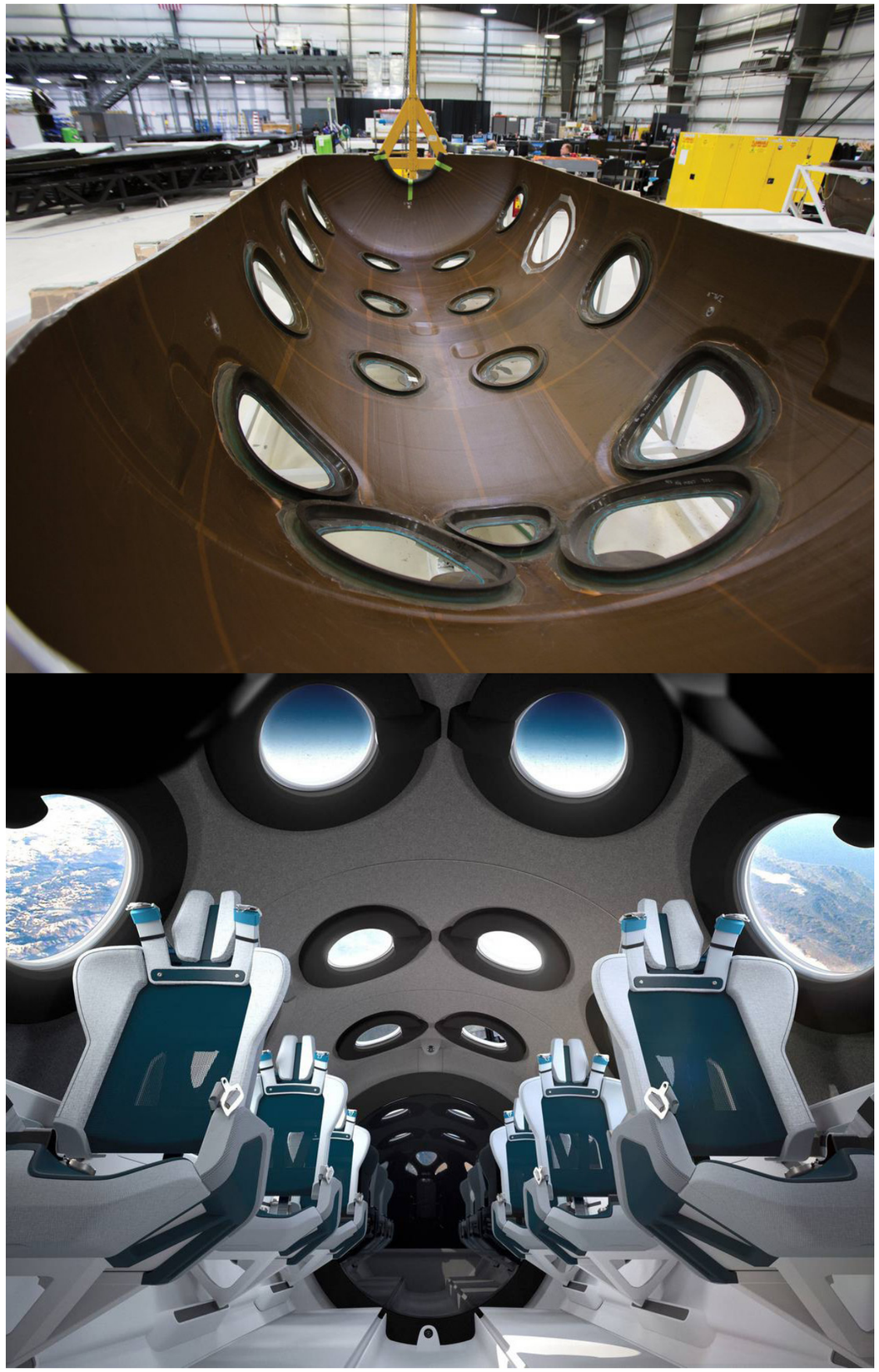
Virgin Galactic loaned Oculus virtual-reality headsets to journalists so they could chat with the designers of the cabin while walking through a computer-generated version of the cabin. The Space Ship 2 is abundantly in line with the selected criteria.

It gets almost the maximum for optimisation and practicality and it keeps a high level also for profit. Of great interest the implementation of technology.From the graph, it is clear that we are faced with a product that tries to completely meet the needs of the user while maintaining the technical constraints.



1. Photo from the article " Leveraging composites for space tourism", Donna Dawson in Composites World.

2.Photo credits: Virgin Glactic



01.2.2
NAUTICAL FIELD
criteria and evaluation points

The choice to work on case studies from a nautical field comes from the similarities that these means of transport have with the space world. Vessels operating in the open sea, whether they are cargo vessels or luxury vessels, need to overcome problems due to variations in temperature, pressure, and atmospheric agents, which are not similar but at least comparable, to what windows in space could suffer.
The choice to analyze only luxury ships is given by the fact that the materials and the technologies are much more sophisticated than those used for other kinds of boats and the design of the yacht is a lot more developed and is based on meticulous research of the users' necessities.

Comfort ca not be considered within this section as those who have the opportunity to use this kind of boat are people who mainly look for comfort and well-being. Analysed from the point of view of the windows the intention is to underline how the structure created can put the consumer at ease without neglecting the involvement with the surrounding environment.

Since these elements play a fundamental role in user psychology it is interesting to see how the product brings substantial changes in design, this is why the criteria that analyses **influence** is included. Often finding ourselves in front of innovative design, either for the current period or for that of production, it is interesting to see how they have changed or how they could change developments, designs, and our behaviour.

As a consequence of the influence, there is undoubtedly **growth**. The discovery of new technologies and new designs that positively affect the environment in which the product has life, leads inevitably to growth, and awareness, demonstrating the best outcome to meet the needs of the market, the user and the environment.

The common evaluation points are target and quality. The first, target, indicates the sector to which the specific product is addressed, whether business to business o business to consumer. The second one, quality, evaluates the quality of materials used.

A small graph will be used to understand at a glance which peculiarity is more accentuated than another. The three levels indicate the intensity while the five points analyse the themes: how good and efficient the window is, how much the project takes human needs into account, how much the impact of the window is sustainable, the weight of the material used, and finally, the window size compared to the environment.

The images represent the criteria and evaluation points used for the nautical field.

01.2.2.1
ARCADIA YACHTS

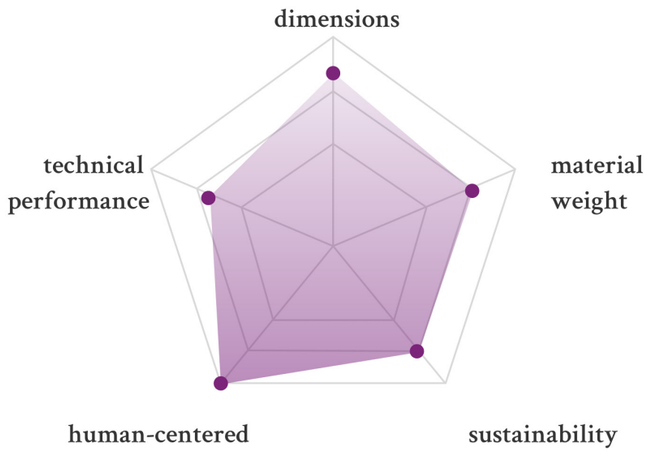
Ugo Pellegrino
2009 - ongoing

Navigation revolves around the man who discovers a real relationship with the sea and the environment around him. The designers have focused on the study and creation of spaces and familiar areas, surrounded by glass that will lead to the exaltation of the environment thanks to the use of technology. Arcadia Yachts sees its birth in places rich in love for hospitality and culture. First of all, Pompeii, where the ancient Roman nobles owned the summer residences and the Emperors sailed to their villas. The aesthetic in search of the joy of conviviality is evident from the large spaces recreated inside the boats and not to limit the relationship with the sea these boats consist of huge windows that allow the passenger to benefit from the views surrounding.

The ceilings are made with glass containing solar panels, which allows you to use the solar energy accumulated in the batteries on board to power the main devices, without the use of generators. On the sides, the large windows are made of multilayer glass that contains Krypton noble gas to ensure a thermal differential of about 18 °C: the same effect as a 20 cm thick brick wall.

It is evident how the window - as a means of connection and fusion with the outside - is the basis of the design of this type of boat. Man and his psychological and physical needs are placed at the center of the design process. It uses sophisticated and cutting-edge technology that allows both the realisation of specific functionalities for the ship and promotes the maintenance of the boat with clean energy consumption, thus winking to the protection of the environment.

The case study presents agreat attention to comfort that will necessarily also affect the behavior and needs of the user, leading to a change in the design according to them. Concerning growth, the use of clean energy is certainly a plus for the project. The quality of materials is very high to maintain the standard of users. The product is part of a Business to Consumer market field.



1. Photo credit: Arcadia Yacht

01.2.2.2
ARTEFACT YACHTS

Gregory C. Marshall

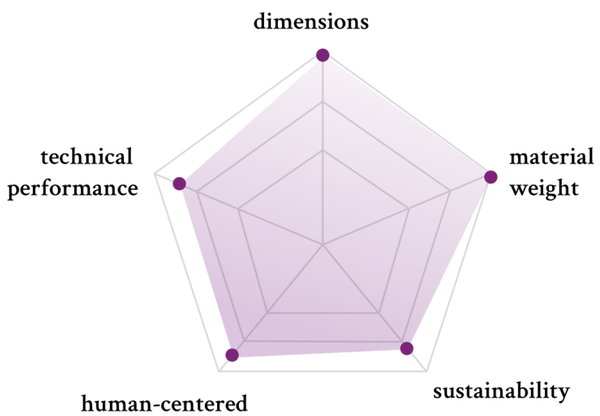
2020

This yacht was created to try to blend as much as possible man, nature, and comfort. The goal was to prove that beautiful man-made objects can complement and celebrate the natural environment with minimal impact. The exterior of the Artefact megayacht was designed by Gregory C. Marshall and features organic shapes inspired by nature. The glass portion in the middle of the ship, which connects all the bridges vertically, is interesting: it is an unprecedented solution for the yachting industry

The vessel uses solar panels and a large battery storage system that allows the vessel to operate for a limited time with no use of internal combustion engines. It was created a floor-to-ceiling glass central section complimenting 740 square meters of curved and expressive glasswork weighing almost 60 tons. They have tried to merge new engineering avant-garde for the reduction of emissions and environmental protection, together with very accurate design research.

At a first glance, even if inexperienced, what immediately catches the eye is the peculiarity of the windows. In this type of product, the window is presented both as an almost completely decorative and aesthetic element and with the functionality of overlooking and at the same time immersing man in the surrounding environment, if we take as reference the large glass structures that are in the center of the boat. What normally are portholes are redesigned with a shape very different from the usual to shoot natural elements.

This type of design certainly has advantages by placing the user at the center of the creative process, but at the same time to be able to create a similar structure, the use of sophisticated materials and the highest quality leads to great money expenditure. Considering also the immensity of the vessel will be necessary a great expenditure of energy in order to allow the development of all its functions.



1. Artefact's details.
Credits: Artefact Yacht

01.2.2.3
WALLYPOWER58
Wally | Allseas
2020

Luca Bassani Antivari, Wally's owner-

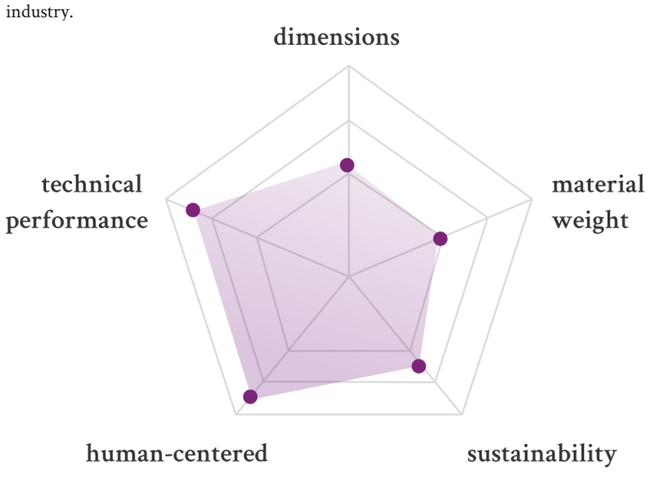
«There was no visual separation, the look embraced a whole environment and it was magnificent; so I thought to propose this effect on my boats» so says Wally's owner after the realisation of Wallypower58. One of the main objectives of the designers of Wallypower58 is not to create interruptions between the various elements that make up this boat. The will is to make this element seem the result of a continuous line, and without interruptions.

This problem is inevitable when elements are inserted into the main body of the yacht. They wanted to remedy the problem by changing the part of the hull: there will be no windows to interrupt the continuity of the shape but instead is installed what is called "magic porthole". This is the real news: instead of having a glass-made window they used a camera with 4K resolution and stabilisation installed on each side, which projects what happens outside on two screens, mounted on both sides of the living room. This installation adds another point of view that fully immerses the passenger into the environment that surrounds him by maintaining a higher grade of security, safety, and privacy.

Stefano De Vivo, Wally's managing director, 10 June 2022 - Interviewed by Alessandro Bacci for "Barche a motore".

Stefano De Vivo, managing director of Wally, comments on the porthole saying - we have created a wide view outside even in the absence of portholes. «We are very proud of this innovative and effective solution because it requires less maintenance of the portholes, no risk of damaging the glass during a mooring "English" and, above all, guarantees maximum privacy, both at anchor and in port».

Using a screen that replicates the surrounding environment is a very functional choice. This saves material, but above all, it promotes greater passenger and object safety. The glass in fact, especially in the part of the hull is subject to sudden changes in temperature, pressure, etc. Due to weathering, windows are subject to material and structure problems. You can not go too far with a creative design based mainly on aesthetics. The result of Wallypower58 is to provide a very comfortable environment, capable of influencing consumer habits, and of great impact in terms of technological growth in the shipping industry.



1. WallyPower58 details.
Credits: Gilles Martin-Raget

01.2.3
DIGITAL FIELD -
criteria and evaluation points

Working on the development of elements that can be innovative, nowadays we must also take into account the technological aspect that in the great majority of cases constitutes a fundamental part of the product or service, since it comes first of all from a user's request and secondly a practical design needs.

Studying the window element the first thing to take into consideration is the digitisation of the latter.
The case studies in this section are examples of augmented reality or products that "deceive" the user allowing people to see things not present in that environment with the realism they would have if they were.

In this section, we will not only analyse products that contain windows but elements that are very sophisticated from the point of view of technology and virtual reality.

Mixed reality, not just augmented reality, played an important role in the design and study of this project. Being able to merge what are concrete and tangible objects with fictitious and not real objects but shown in such a way that they look like, it was the keystone of this work. These days is a necessity for the digital element to be **user-friendly**, this criterion servea to assess how easily the user can interact with the product/service and how well it adapts to the needs of the latter.

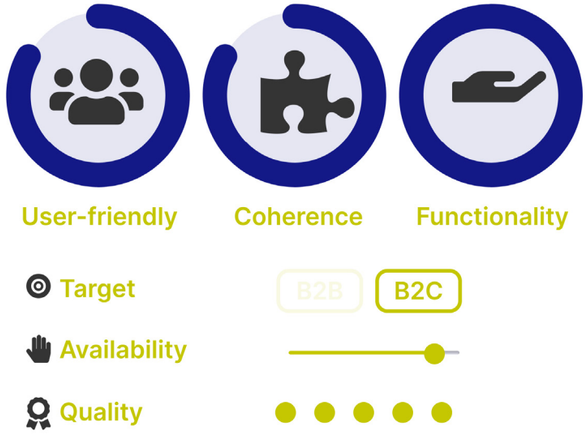
Coherence is important at the digital level because it is crucial that the product meets user expectations and leads to optimal results. If you are promised a reproduction of reality that will not allow you to figure out whether the image is real or not, this promise must be respected.

Often it is much debated the role that technology has in our lives, for this reason, it has been included among the criteria **functionality**. Is important to understand if the product is really useful, what kind of benefit can it bring to the user, and if it does respect the proposals that are being made.

Digitalisation must lead to enrichment and not to brutalisation and alienation. The common evaluation points are target and quality. The first, target, indicates the sector to which the specific product is addressed, whether business to business o business to consumer The second one, quality, evaluates the quality of materials used.

The images represent the criteria and evaluation points used for the digital field.

01.2.3.1
MIRROR LAKE
Meta
not declared



It has been a while since Meta is working on the realisation of virtual reality viewers able to replicate and reproduce reality mpst faithfully. Mirror Lake is the latest project they are carrying out which aims to achieve detail in the reproduction of reality so faithfully that it does not allow the user to distinguish what is fiction and what is not. Mirror Lake hasn't yet been built into a functional device – it's still just a concept being actively worked on.

Meta would like to mix and improve all of the advanced visual technologies they have been incubating over the past seven years in a compact form.

All current VR headsets use technology with fixed-focus lenses. Each eye gets a separate image, but the images are focused at a fixed distance. The eyes will point (converge or diverge) towards the virtual object you are looking at, but can not properly focus (accommodate) to this distance. This is called the vergence-accommodation conflict. It causes eye strain and can make virtual objects look blurry close-up.

A key point could be that our eye needs this resolution for the focus view, while for the peripheral view is sufficient a lower resolution, but the problem is that our attention is constantly moving and for this reason, it is essential to follow the observation of the viewer. The improved eye tracking can also improve the accuracy of variable focus, distortion correction, and pass-through mode. Meta's Mirro Lake is the first object based on machine learning to solve this matching with ayes' position.

Even if theoretically the project and the technology makessense there are a lot of challenges with the realisation of these displays. They must cover the entire visual field with a very high resolution, 60 pixels per degree, which means screens with a definition higher than 8K. and all this in the space of a viewer, therefore using a very elaborate technology in a very small space.

Abrash, Meta's Chief Research, at Mirror's Lake presentation

"We'll need to do a lot of engineering to achieve a consumer viable laser that meets our specs — that's safe, low-cost, and efficient and that can fit in a slim virtual reality headset. As of today, the jury is still out on finding a suitable laser source," said chief researcher Abrash at Mirror Lake's presentation.

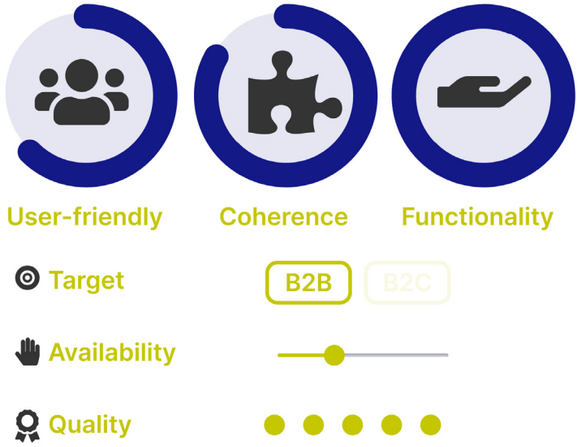
His study is certainly avant-garde. Nobody would have imagined the realisation of platforms such as Facebook, Whatsapp, and Instagram before seeing them in their own hands, and in the same way, no one currently manages to concretely visualise the possibility of getting to reproduce reality so faithfully that they do not know what is real and what is not.

The product aims to be widely user-friendly, concerning the consistency between expectations and reality but unfortunately, we can not yet assess as the object was not produced, however, indeed, the technologies proposed by Meta for augmented reality headsets have always lived up to expectations. Could the product be useful? Surely from a psychological point of view yes, you must always be careful to avoid the user's brutalisation.

1. Mata's prototype.
Credits: Meta
2. Some of the prototype Meta has built on its journey into VR thus far.
Credits: Meta

01.2.3.2
ASTRONAUTS' TRAINING

ESA
ongoing



Since the training that astronauts do on Earth to prepare themselves for missions or permanence in space are sometimes developed through technology, this kind of case study is included in this section.

To qualify for any type of action in space, an astronaut must have very thorough technical knowledge. The tasks he will perform, whether they are research or physical, such as extravehicular activities, are complex tasks carried out in the hardest and most difficult-to-reproduce environment, space. For this reason, both from a technical-scientific point of view and from a purely physical point of view, these people undergo very rigid and rigorous training.

The technologies to be used to replicate the situations and environments in which astronauts will operate are very sophisticated and expensive, so much so that they can only allow some places in the world to use them. Practice is the most disparate. To prepare for a space flight, astronauts must face tests ranging from centrifuge to Zero-G aircraft.

Consequently not only the realisation of these elements but also the maintenance of neither simple nor economic.

And it is here that Virtual Reality comes into play, presenting to astronauts the possibility of conducting different types of comprehensive training but having manageable costs, high accessibility, and multiple other benefits. Surely the cost of a very elaborate and detailed viewer will not be underestimated but will remain the cost of realisation and maintenance of some scenarios.

In practice, VR[1] also allows practical sessions for specific activities of space flight, such as VAT[2] and EVA[3] , and even planetary EVA (also called lunar walk or mars walk).

Today, the use of augmented reality for these purposes is increasingly common. The NASA[4] Space Center in Houston, for example, as well as EAC Coloni's European Astronaut Centre (EAC), have been using virtual reality for space training and simulations for several years.

Virtual reality allows astronauts to perform these training sessions in faithfully digital replicas of the International Space Station (ISS) but you can also simulate a landing site and the expected lighting conditions with high precision.

It is a very advantageous technology from the economic point of view that allows you to achieve a satisfactory result and is very close to reality.

This kind of use of VR is human-centered, the interaction between men and training should be strong. It also maintains a good consistency with the expectations around this kind of technology. If the result were mild the training would not be functional and you would not get preparations suitable for the situations in space. In terms of functionality then, the product is useful in many ways.

1 Virtual Reality.

2 Intra-vehicular Activities.

3 Exra-vehicular Activities.

4 National Aeronautics and Space Administration.

1. Astronaut during his training.
Credits: ESA
2. Luca Parmitano during VR training.
Credits: ESA

01.2.3.3
ASTRONAUTS' TRAINING

ESA
ongoing

Finta Finestra is a window-shaped digital screen, the product was created for the need to give light and depth to very small rooms, and without external openings.

Fake Window uses a type of LED lighting. Once the window is installed it will project the image you selected to form a gallery. The image from the gallery should look like you are looking out the window. The feeling will be to look out over the selected landscape. The product is presented as modular, facilitating installation and ductility.

The size can be adjusted by simply joining more than one unit to create a larger screen. Another peculiarity is that this type of window can be combined with the real ones so as not to create a detachment.

The main objective of this product is to give those who use it a way to interact, albeit fake, with the outside. The led monitor with high-resolution images allows you to bring light in rooms or areas particularly small and dark, illuminating and giving depth.

This product, called fake window or artificial window, has a thin structure of only 2.5 centimeters that can be affixed on any surface.

This type of technology presents a limit when the projected image is nothing more than a photo placed on a larger and brighter screen. But it would be as if we had a big computer screen that tries to replicate reality. The surrender will be limited.

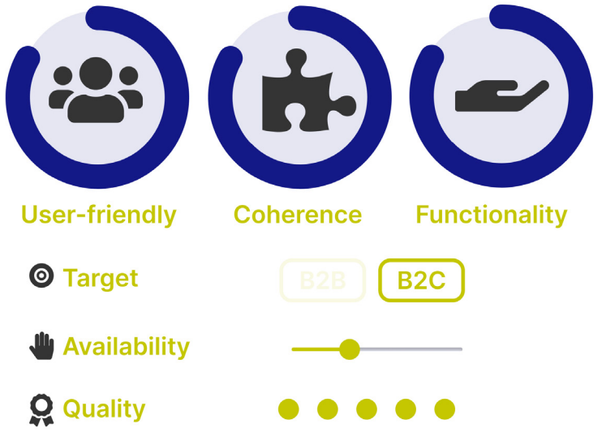
The case study in question has been particularly interesting to me, not so much for the success of the product because the quality is lower than what was previously analysed, but for the idea behind it. Paradoxically, although the yield is not optimal, the user and his needs are at the center of the design process. Has been taken into consideration the need for man to have contact with the outside, and that increases when the environment does not allow it. Think about small houses with no windows, jails, or enclosed spaces.

This case study led to a practical idea for this study because it underlines the importance given to the psychological aspect, and the need to include it as a basis to build on a design suited to the users' needs.

The window is very user-friendly, even if the consistency between the expectations and the result is not so close to reality because the LED technology does not allow an image rendering faithful to reality.

1, 2. Example of FintaFinestra products.
Credits: Finta Finestra

01.2.3.4
HYPERLOOP
HyperloopTT
2013



Hyperloop is a hypothesis of futuristic technology for the high-speed transport of goods and passengers inside low-pressure pipes in which the capsules are pushed by linear induction motors and air compressors. The infrastructure linked to the Hyperloop system should consist of a double overhead tube in which transport capsules can flow.

Born from an idea by Elon Musk made open source in 2013, Hyperloop provides for the realisation of a supersonic train that should run in a few minutes thousands of kilometers.

Although the idea of itself being linked to Hyperloop is interesting, the focus of this research is not so much focused on the analysis of the technology of the project as a high-speed train, but the way they used to overcome the visual and physical problems that would be derived from the installation of real windows inside it.

A bit to distract from the trip and a bit to not feel a sense of claustrophobia, the capsule will be equipped with windows like on a plane.

We are faced with an open-source project and this means that the usable versions are multiple. The interest has gone toward one of the last studied models whose prototypes have been realised.

In the model taken into consideration, the big windows that are on the walls of the train are not real. They talk about "augmented windows". The idea was to create porthole-shaped screens, inserted inside the body of the train that, thanks to the use of very advanced technology, can project a chosen scenario.

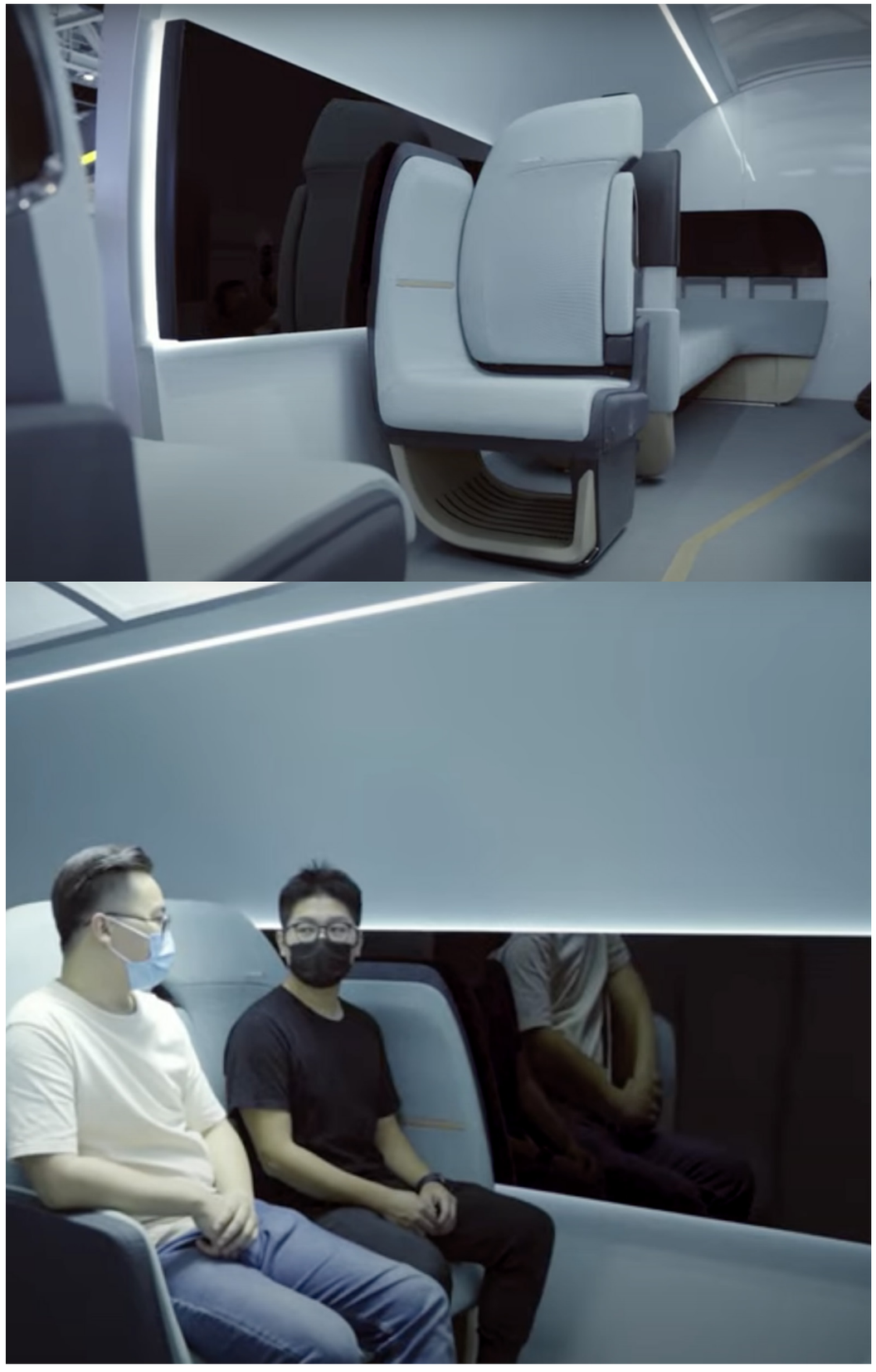
The increased windows allow you to choose in advance the view you want to exploit in augmented reality. It is possible to choose between fantastic or thematic worlds such as the period of the dinosaurs or a spatial scenario or even the landscape that would be seen at that time in that particular geographical stretch as if they were real windows.

To make this kind of view more realistic and truthful, however, Hyperloop uses a type of technology called "face tracking" based on motion capture systems that can track the look and follow our movements to adjust the perspective.

Augmented windows can deceive the eye. The image we see outside the window will give us the impression of being completely real. This type of screen not only allows viewing panoramas but also is the user who chooses the content to see. The user can then select to watch a movie, or web pages or view data such as temperature, route, speed, and more.

The window in this project looks very interesting and easy to a useful consumer, putting it once again at the center of the design. Excellent also the consistency of the proposals made with the - possible - realisation. It could revolutionise the industry as it would lead to a much safer and more ductile object.

1, 2. Prototype of the interior of Hyperloop. Credits: Hyperloop TT



01.3
CASE STUDIES ANALYSIS

Following the analysis of specific case studies, this conceptual map has been created. It visually represents the relationship of each case study to its macro-area.

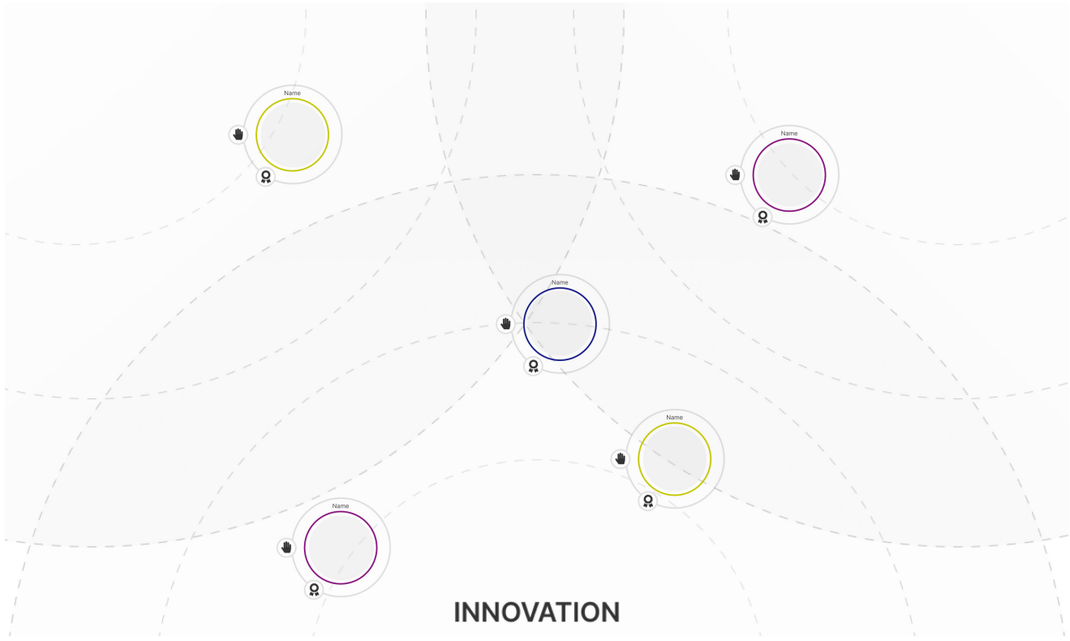
Specifically, the extremes of the map are composed of three elements: digitalisation, innovation, and interaction. Each element has been placed on the map depending on the membership of each of the three criteria.

The digitalisation parameter Indicates how much the considered case study exploits the digital aspect and is enriched by the latter.

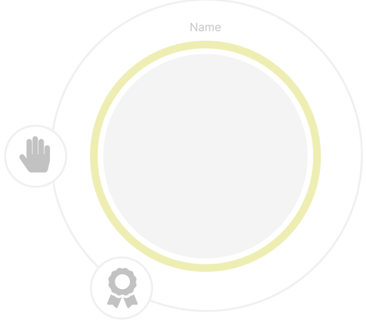
The **Innovation** parameter wants to identify the level of novelty that leads the product to be efficient on the market and turning point. Finally, the **Interaction** parameter indicates the correlation between man and the object and how these two come into contact with each other.

Graphically the case study is presented on three levels: the inner one is formed by a photo of the element. The second layer has the color of the category to which it belongs with the product name. The third and final section presents the criteria that all the case studies have in common; the circle indicates the most advantageous criteria for the product.

01.3.1
LEGENDA
Visual Analysis of Case Studies

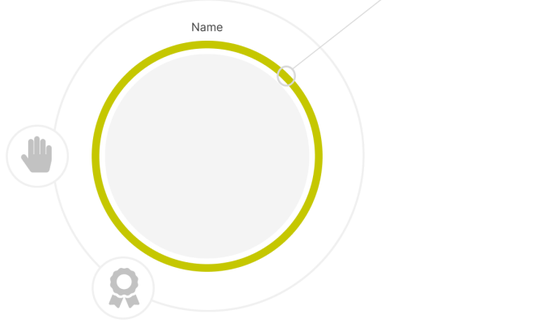


Level 1



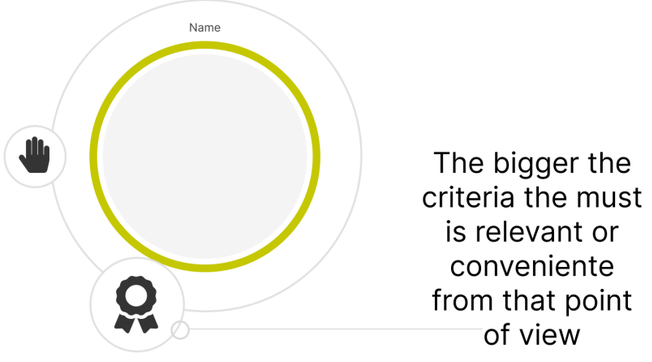
Photos of the case study

Level 2



Name of the product/service

Level 3

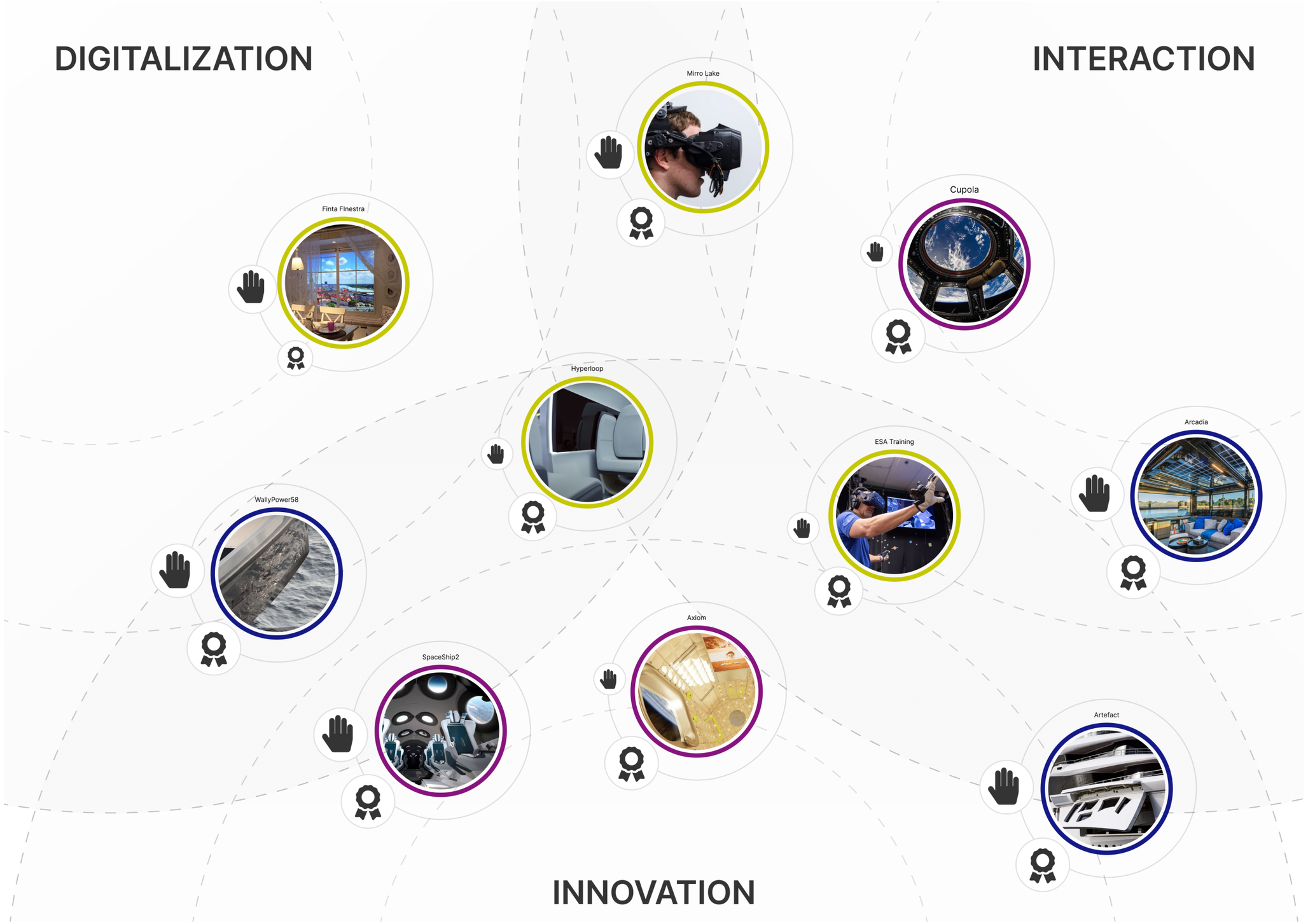


Common criteria

01.3.2
CONCEPTUAL MAP
Visual Analysis of Case Studies

DIGITALIZATION

INTERACTION



INNOVATION

01.3.3 CONCLUSIONS & HIGHLIGHTS

The most relevant case studies were highlighted for each category. Specifically, those that would have been useful for the purposes of the research were listed table that explained the points in favor and the criteria in which the case study has a greater development.

Specifically for the space field, the case of SpaceShip2 by Virgin Galaxy has been considered coherent and interesting for the final analysis. First of all, the project is not designed to make space flights for scientific research only but is also the result of a request for tourism. Currently, the social class that can afford these walks in space is very rich but this does not take away that in the future the request for space tourism could be open to anyone.

The number of windows created and installed on SpaceShip2 is of great interest. Maintenance of the elements can happen on the ground since the permanence in space is limited to a limited period. Consequently, it will be easier to install items that need specific care. The use of virtual reality for ground connections is another focal point as the desire to include distant elements and people grows.

For the naval sector, despite all the cases examined having a very elaborate and refined window design, the one that has moved further away from the others and proved more interest is WallyPower58.

The interest comes from the ability to create "fake" giant windows. On the outside what you see is a fully glazed hull but, as mentioned earlier, this would be very risky for maintenance and safety. Overcoming the problem by installing completely artificial interior windows brings this element to be very innovative.

The digital element fits into this product giving it greater security.

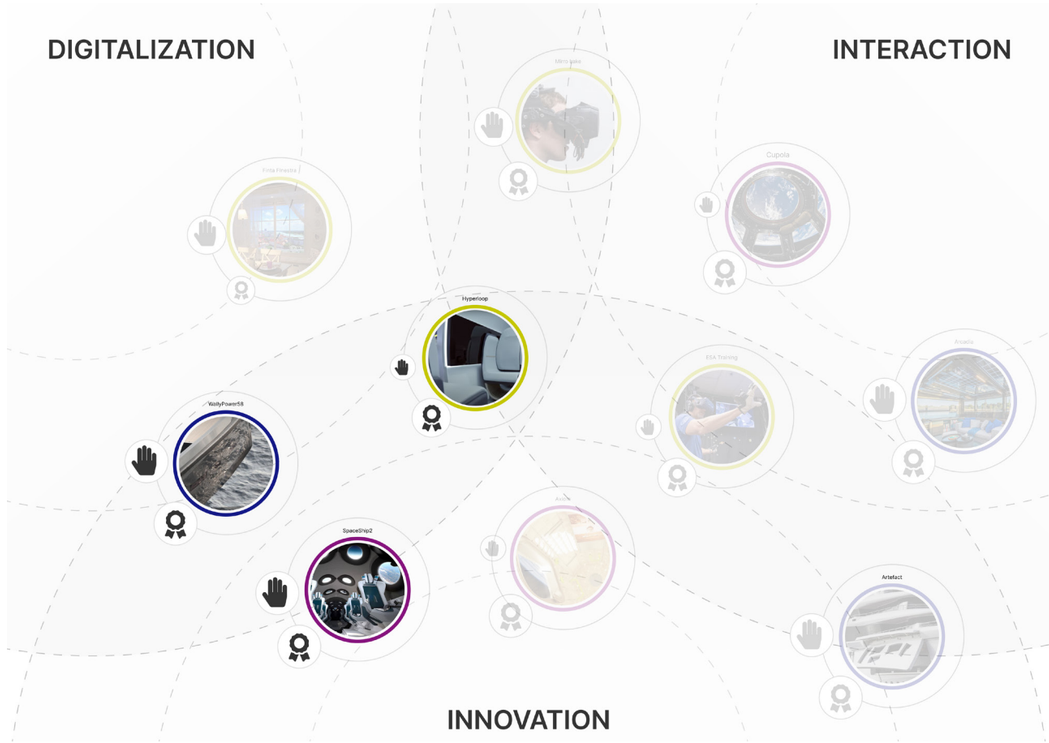
In the digital field, all the cases examined are based entirely on virtual, augmented, and mixed reality. Some are presented as overly ambitious projects and created to be installed on very small viewers.

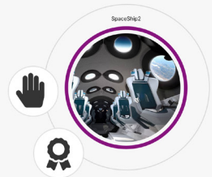
The case study more inherent to the project turned out to be Hyperloop. First, being an open-source document, implies that many versions and ideas can be consulted. Of particular interest is the one that provides for the use of very large fake windows.

Traveling at a speed of 1223 km/h makes it not possible to allow the passenger to view the panorama outside. Since the capsules of the trains will be inserted inside cylinders, completely sealed, and subjected to high vibrations due to the dizzying speed, even the idea of having real views of the outside is slowly waning. Kind of like what happens when structures go into orbit. The external agents to which these glasses - or plastics - must be subjected lead engineers and designers to opt for the creation of a few easily maintainable portholes.

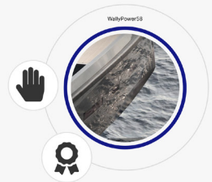
Hyperloop TT decides not to deprive the passenger of the external view but to allow him to choose what to see. The screens augmented reality through very sophisticated and advanced technology follow the eye of the passenger and project either a fantastic scenario or what you would see at that moment outside or a movie, etc.

Great is innovation and digitalisation, it would be nice if the user also had a greater interaction with the object.

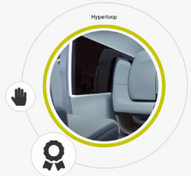




High number of windows — DIGITALIZATION ↑
Tourists' request — INNOVATION ↑
Use of virtual reality — INTERACTION ↑



Large fake windows — DIGITALIZATION ↑
Virtual reality screens — INNOVATION ↑
Higer safety — INTERACTION ↑



Large fake windows — DIGITALIZATION ↑
Virtual reality screens — INNOVATION ↑
Higer safety — INTERACTION ↑
Hard environment contitions

01.4
USER NEEDS' ANALYSIS
Personas and Map

The first step to fully define the features of a product is to study and define the user who will use it. This is a project based on space tourism or a reality that begins to take its first steps in our days, it was quite difficult to study the needs of the user. Currently, those who can use the services provided by this sector is the astronaut, the main user of space travel.

Thanks to the support provided by the engineers S. Conti and F. Vagnone, respectively Project Design Authority and System Engineer at Thales Alenia Space Torino, it was possible to enlighten the user's needs. With the help of the company's Human Factor Manager, it was possible to conduct indirect interviews to analyse the greatest needs.

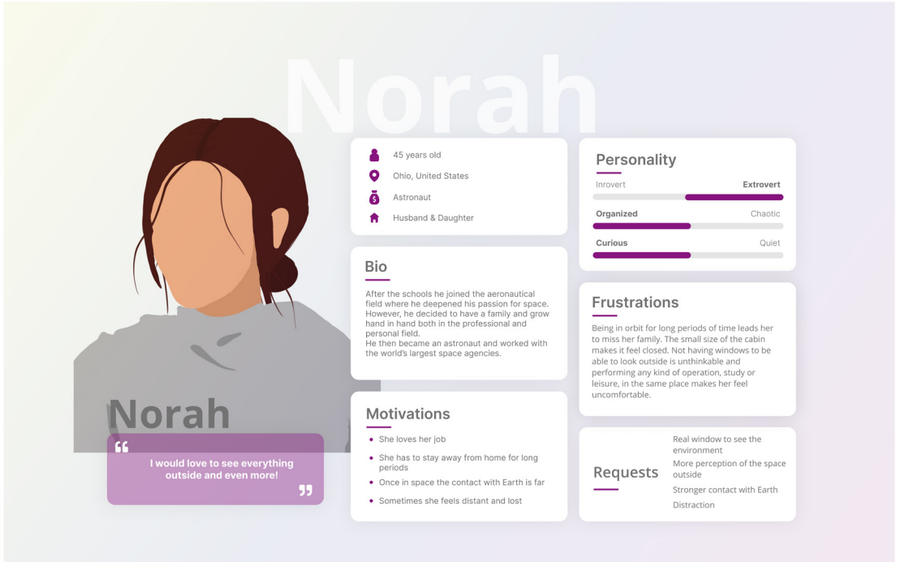
The main need of the astronaut at this time is the presence of a real window. Although the real windows are small, they now have an outlet valve allowing them to see what is happening outside. It is not by chance that Cupola, of the International Space Station (ISS), is the place they prefer. In Cupola is possible to carry out tasks purely related to research and study (photo, observation, etc.) but also is possible to spend leisure moments in a very comfortable area for them.

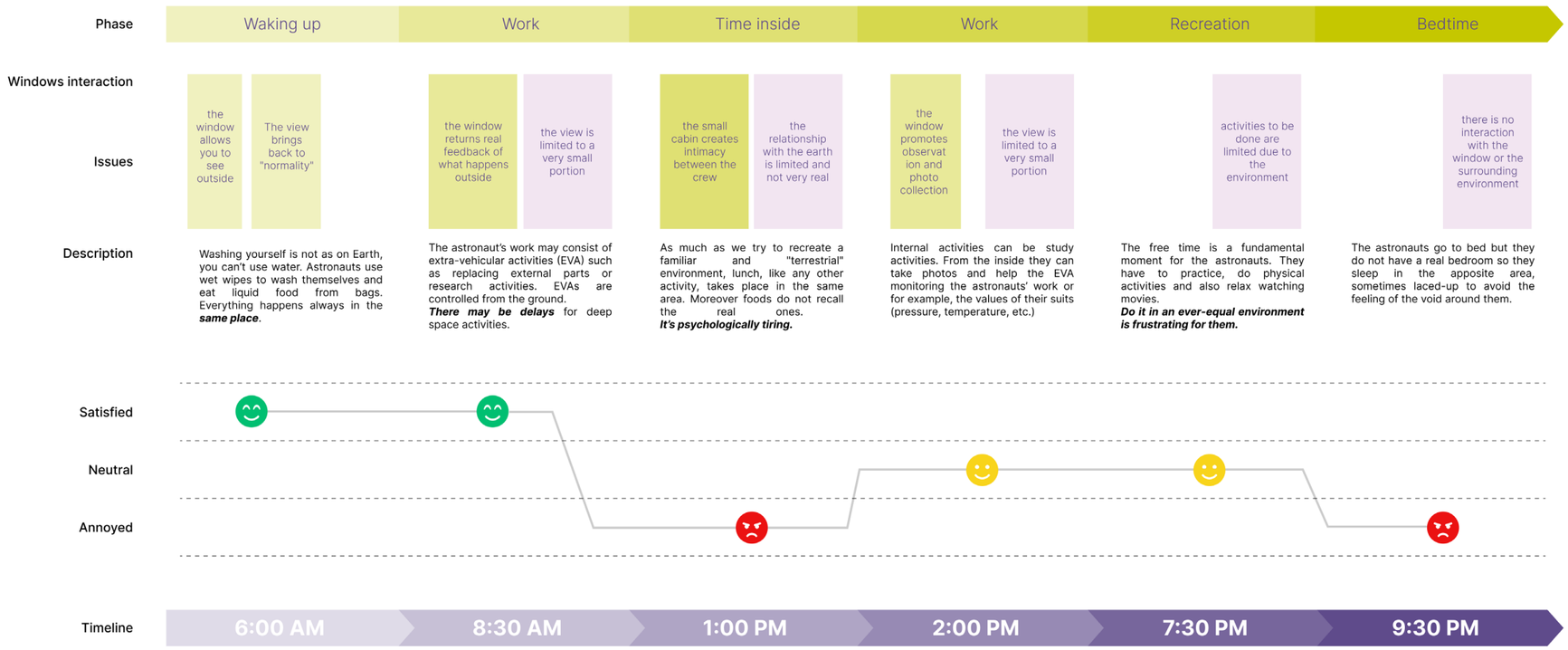
The window can therefore be of help both for technical functions and for recreational functions. In the image below it is possible to view the customer journey of the astronaut. I analyzed six main moments of his day in which the aid of a real window, virtual or mixed, could be significant.

01.4.1
MOTIVATIONS

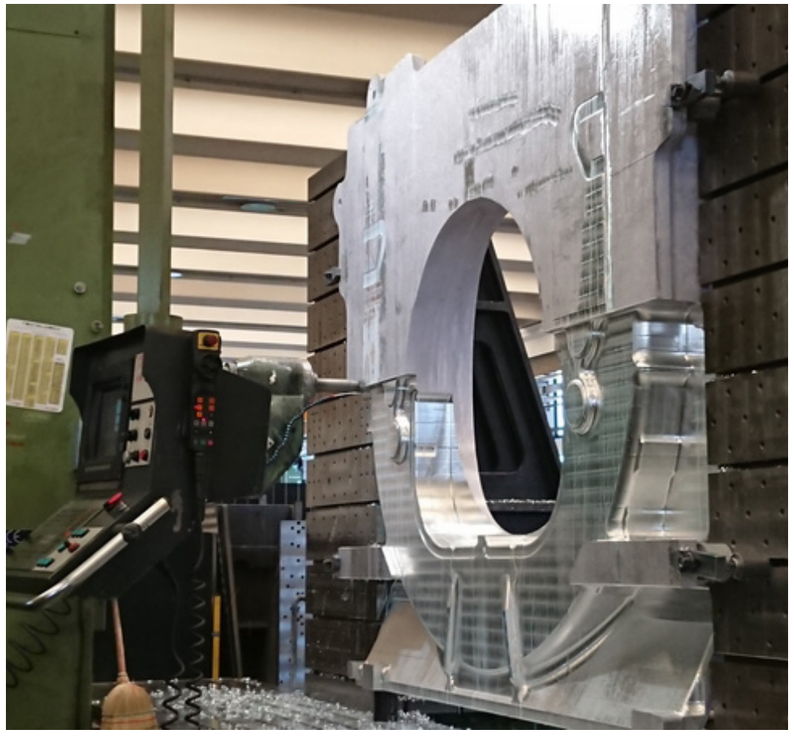
Carrying out this type of interview, albeit indirect, proved to be the most thoughtful choice in the process of drafting the user's needs. Since there were no real users other than astronauts, for example, a questionnaire would not have been useful because the needs analysed would have been generic and based on assumptions.

The support of Thales Alenia Space, based in Turin, was fundamental. The company is currently collaborating in the design and construction of the Axiom Space Station, whose goal is precisely the construction of a station orbiting not only for commercial purposes, where it will not only be the experience of the journey but also the destination.





1. Personas template.
2. Customer Journey Map



1.Thales Alenia Space production for Axiom.
2. Thales Alenia Space for axiom render.
Credits: Thales Alenia Space

PART TWO
CONCEPT DESIGN

State of the art and design process

02
OBJECTIVES

02.1
GENERAL OBJECTIVES & SPECIFIC OBJECTIVES

1. The storyboards were made taking the circumference of the Axiom cylinder but the window shape and dimensions were agreed upon later.

Following the analysis of the basic stages of the astronaut's day with a focus on the interaction between the latter and the window - or windows - it was possible to define the general objectives and consequently the specific ones. It is not possible to realise a project that provides only windows and digital screens because for their psychological comfort they need to be able to see what is happening outside their housing module. This choice would have obviated a whole series of problems related to maintenance and safety.

The main idea then is to merge the two elements of the physical and virtual windows. By doing so, the real window will allow the vision of the surrounding environment while the virtual one will serve to create environments and connections that are detached from reality but that are helpful for the psychology of the user. Moreover, the use of a virtual window integrated into the real one can be of great help in the technical field.

Specifically speaking of technical support, the project aims to facilitate the collection of photos and videos of the surrounding environment. It provides, through the help of very elaborate technologies Baste on virtual reality, to support the astronaut during the extra-vehicular activities, allowing you to see in real-time what is happening and supporting the activity step-by-step. It will also be possible to control directly from the inside the state of the spacecraft suits that are located outside the housing module.

As for psychological support, the mixed window will allow the astronaut to view not only the complete scenario of the surrounding environment but also different scenarios chosen by him/her.vThis type of interaction can be helpful during the astronaut's physical activities, to give him the feeling of varying because the tools are few and anchored at specific points.

The mixed window will also help during the free time since it will be possible for the astronaut to see movies or read the news directly on the screens around him. It can help in the contact with home, playing a true video on the screen, and finally in the game, creating games based on the interaction between the user and the windows around him.

To analyse each scenario in more detail, the next chapter will present storyboards that retraced the interactions between the astronaut and the window. Specifically, eight scenarios have been developed: *view mode, photo mode, leisure time mode, news mode, physical session, EVA mode, game session, and video call-conference mode.*

The idea was to integrate real windows with screens that act like virtual windows. Through a light activity selector, the user can choose which activity to perform and how to use the window.

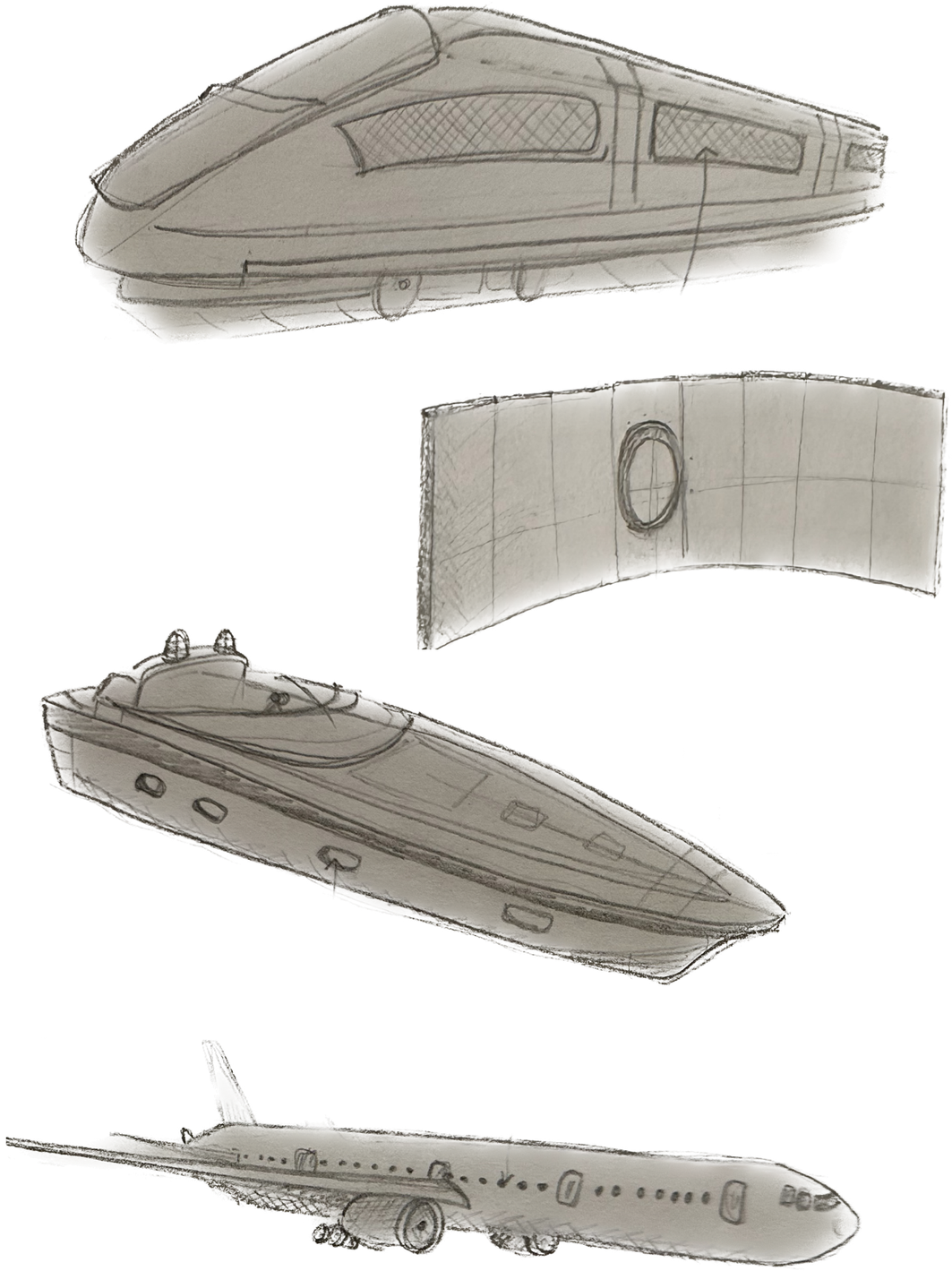
02.2
WINDOW FEATURES

After the study made on the case studies presented in the previous chapters, we will examine the general objective of this project.

First has been analysed the windows that are subjected to very difficult environmental conditions. All types of portholes, be they of ships, aircraft, or trains, tend to have an oval shape because it guarantees greater security of the window. Analysing the different possibilities of living modules, in collaboration with the company *Thales Alenia Space Italy*, based in Turin, we have chosen to work on a habitable cylinder with oval windows. The choice of the window shape was dictated by essential structural and design needs.

The oval shape is also used by luxury boats to better impact climate change and temperature. The great idea belonging to the hull lies in the fact that outside the portholes are presented as a single large window, to deceive the observer. The same kind of "trick" used by boats, has been borrowed but this time from the inside out. The observer must have few real windows, to keep the costs reduced and increase safety, but the possibility to expand its view at any time and according to their needs.

To define more precise general objectives and specific objectives, the first phase was to research what the user's needs were.



02.3
STATE OF THE ART

This section aims to analyse the the 'state of the art', so the point at which the research has arrived regarding the monitors that must be inserted inside the housing module, summarizing and explaining the reason for my choices. Being in front of a project that involves the use of a very sophisticated technology it was necessary to understand which currently living projects could get as close as possible to the primary idea.

Starting from the beginning, the first need is to have screens that exploit virtual reality to make it seem to the passenger, which is inside the housing module, that the projected objects are real and tangible. This would give comfort from the psychological point of view, and support from the technical one and would help in the recreational moment.

The first case analysed is "Deep Frame". They produce a mixed-reality display that merges real and virtual elements, making it possible to blend physical and digital elements in real time. You should look through the display lens, and see lifelike animations of any size and at any distance, without the use of traditional VR eyewear. The result is very similar to a hologram. The digital image looks three-dimensional and keeps the background on the back. The object consists of transparent glass and a frame to support it.

The second case analysed is 'Re-Flect' Company. The platform allows workers to take advantage of augmented reality videos to better learn the steps of processes to be carried out. Avoiding paper learning in favor of the practical and visual one for manual work is useful. The problem with 'Re-Flect' is that the screen comes with a common monitor which projects high-quality 3D videos. The inspiration is definitely valid for technical support during extra-vehicular activities.

Moving forward the analysis was conducted on INDE. INDE deploys augmented reality activations and mixed reality solutions to create interactive and immersive experiences in sports, advertising, retail, and entertainment. The quality of the screens of INDE is very high, so much so that the projected objects seem real. The figure in front of the monitor is identified and immersed in the augmented reality environment. The main problem is that the user can see the "imaginary" scenario on the screen but not around him/her. For example, looking at the monitor you can see a cat and interact with it. The image you see will consist of you and the virtual cat, but in reality, you will be interacting with the void and this mixed reality will return to be real.

Another great point of interest in the research was the three-dimensional billboards. The idea comes mainly from the scenario that concerns sports activity.

The purpose linked to physical activity was to make it interactive and fun by only using three tools that always anchored at the same point.

The first thing studied, was the technology used by Meta in making visors. Meta Quest 2, in particular, is one of the most advanced viewers of the company controlled by Meta. The viewer merges fitness and video games. The idea is not new because since modern consoles have been implemented with sensors able to read our movements, many are passionate about physical exercises resulting from the game. The difference with virtual reality is that the stimuli the brain is subjected to, are so many because you are completely immersed in another environment and this distracts the rest of the body from the actual fatigue faced.

Deepening this topic some academic articles have been analysed and they have corroborated the initial idea, giving more food for thought. Some research has shown that exercise among people of university age has fallen in recent years. The causes could be many: large workloads, the need to work during school, or perhaps the use of technology. Although technology can distract from the physical activities made in the real world, the use of virtual reality systems in this kind of operation shows that technology can bring benefits. It has been studied that performing physical activity in a gaming situation leads to an increase in physical activity and brings also in the burn of more calories during a workout. In addition, immersion in this new environment can remove the player from his body sensations allowing him to train longer.

This kind of research helped in confirming the idea of supporting the physical activities of astronauts. Allowing them to immerse themselves in a different environment and interact with it is helpful to divert attention from the real environment. But how to do it without the use of a viewer? What is particularly interesting about 3D billboards, is their ability

to make objects appear as if they were coming out of the screen. The technology behind these screen 3D billboards works on the principle of “forced perspective.” Forced perspective is a technique that uses an object's scale and the spectator's vantage point to create an illusion of the thing appearing larger, smaller, nearer, or distant. These technologies combine two images taken from different angles and put them into a single one. As a result, our left and right eyes see the visuals from different points and our brain recognises the objects in three-dimensional depth. To achieve this illusion, 3D billboards usually use curved displays with two faces.

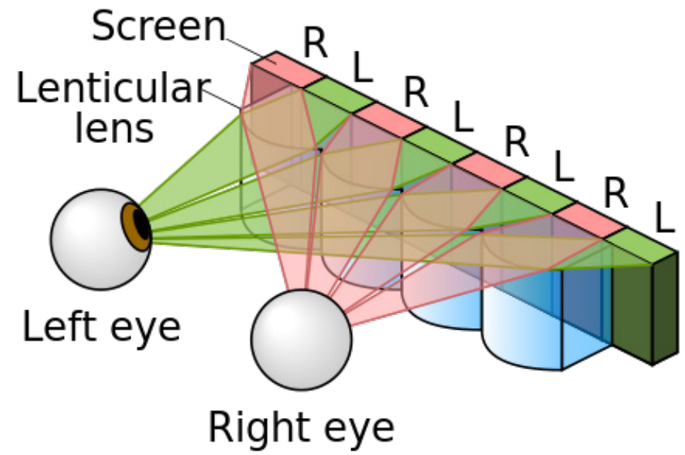
Particularly interesting was also the project 'MiRa'. MiRa is a project for the Mixed Reality Environmental funded by the Lazio region and MIUR. It aims to achieve strong interaction and engagement within exhibition spaces. The idea is to develop a software platform to create interactive exhibition spaces. The principle of Augmented Reality, or Mixed Reality, would be used to create an immersive environment for the user who would be able to visualise scenarios and digital objects as if they were real. The infrared sensors and cameras detect the position of the visitor and analyse the distance, after that the image to be displayed on the screen is projected and can be visualised as if is real.

Another project that turned out to be very useful was Project Starline by Google. Project Starline is a video-calling booth that uses 3D imagery, high-resolution cameras, custom depth sensor sensors, and a breakthrough light field display to create a lifelike experience for callers on both sides of the screen. The most interesting part of Starline’s technology is that this project uses a different type of "virtual" reality. People are not represented with game-like avatars, but rather as real ones themselves. Instead of developing a technology that uses cameras to track eye and facial movements to make avatars more realistic, such as Meta’s viewers, for example, Google is working to display people as they are and without the help of viewers. The cameras and sensors capture the person from multiple angles and figure out their exact shape, creating a live 3D model of them. This model and all the color and lighting information are sent to the other person’s setup, which shows it in 3D. It also tracks their heads and bodies to adjust the image to their perspective.

02.3.1 CONSIDERATIONS

For the type of study conducted and for the cases analysed, the final choice involves monitors that can reflect the outside - or any scenario chosen by the user - as if he looked out of the window. The realisation of this type of structure will take into account the best and most advanced technologies. Everything will be integrated by high-definition cameras present both inside and outside the housing module. Six will be sufficient internally and six externally, distributed equidistantly.

The window, better-called mixed-window, will have the real portholes integrated into the panels of the screen. When the "view" function is selected all the screens will turn on, and the external cameras will capture the surrounding environment and project it inside. If the user chooses to view any other environment, due to the activity selected, then the 3D technology will allow you to be immersed in something different from the external space, and this new environment will appear to the user as real.

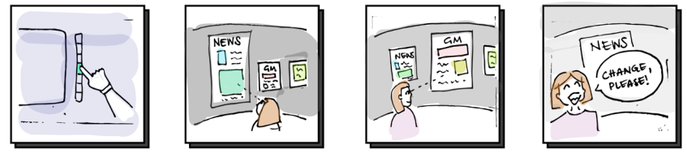


1. Lenticular autostereoscopic displays.
Credits: Wikipedia.
2. Time Sqaure 3D Billboard.
Credits: Blunt Action
3. MiRA Project.
Credits: DTC Lazio
4. Starline by Google Project.
Credits: Google.

02.4
STORYBOARD

The astronaut feels swamped in his/her routine scheduled by ground control. During meals or when the astronaut does not have to perform his/her duties, the environment around him/her is always the same and the only contact with the outside is the real window. Also for physical activity, given the reduced space of the housing module and the possibility of using only 3 objects: an exercise bike, treadmill, and ARED (Advanced Resistive Exercise Device), the environment remains identical and uncomfortable. When there is the possibility to have contact with loved ones it happens via small laptops and similar devices.

The distance, is however, obvious. In the housing module the life of the astronaut is entirely unfolded; from scientific research to recreational moments, from morning until evening, from alarm clock to bedtime.

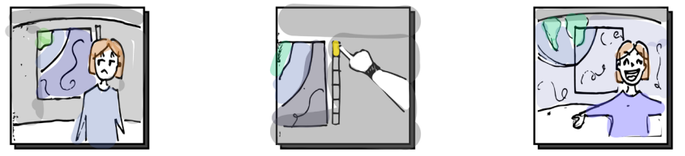


1. The cartoons are read from left to right. the descriptions in the text follow the same

02.4.1
VIEW MODE

The view mode is the first and the most requested. The astronaut needs to know and discover the surrounding environment as much as possible.

The greatest need for astronauts is to see outside the housing module. Due to the high weight and fragility of the windows, a mixed one could be the solution. The astronaut feels sad and spatially disoriented due to the small physical window. The astronaut selects the “Enhanced View” featured on the Activity Selector. The astronaut feels more comfortable and visually stimulated once the view is enlarged thanks to the mixed-reality window.

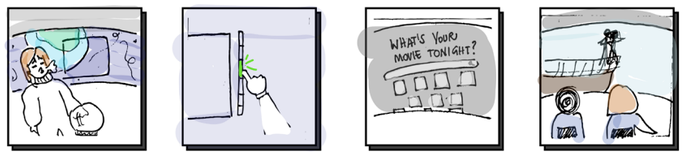


02.4.2
PHOTO MODE

One of the activities in the International Space Station (ISS) involves collecting photographs. What if collecting these photos becomes easier? The astronaut selects the “Photo Mode” feature on the Activity Selector The astronaut with a simple and intuitive gesture is able to select an area, zoom-in, zoom-out, and take a picture. The picture is taken, saved, and sent to Earth.

02.4.3
LEISURE TIME MODE

The solution for leisure time could be to exploit the surrounding space and enlarge it to become a big 360° cinema. The astronaut comes back from EVA, he/her still has to perform de-briefings and discussions with crew members and ground control. The astronaut is tired after a long day of work and wants to spend his/her spare time in a fun and pleasant way. He/she selects the "Leisure time Mode" feature. A screen with all the movies appears and the astronaut and the members choose the movie and the atmosphere to enjoy their leisure time.



02.4.4
NEWS MODE

Despite the distance, all the astronauts need to stay updated on what happens on earth. Thanks to the cameras that locate the astronaut's position, it is possible to quickly change an article or newspaper , or focus page. The astronaut selects News mode thanks to the "Activity Selector". The news of the day are shown directly on the mixed-reality window, enlarged to facilitate reading. Thanks to the placement of 6 cameras inside the housing module the mixed-window can to track where the astronaut is looking, in this way the article or news in question will be highlighted.

02.4.5
PHYSICAL SESSION MODE

The session of physical activity is fundamental for the astronaut. The possibility of using only three tools is limited. Through mixed-reality window ,the astronaut could experiment with new ways of train and having fun. After the selection from the "Activity Selector" starts the physical training. The astronaut is free to choose a new environment to train, from the most classic ones to the strangest. Once he/she selected the scenario the training starts. All the activities are supported by 3D technology to get the training more interactive and fun. The mixed-window will suggest personalised training to the astronaut, following him/her step by step. The session will be pleasant and the astronaut will forget to use just three different training supports, he/she has an entire world around him/her.

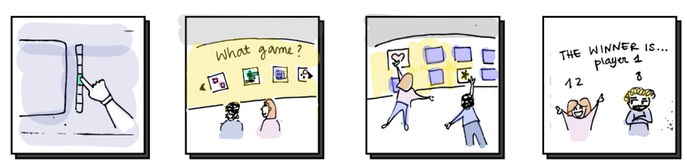
After the workout, the mixed-window gives the astronaut the feedback and he/she had a complete and fun workout.

02.4.6
EVA MODE

The support of the EVA operations provides a step-by-step guide from the ground and monitoring always at a distance. The presence of the mixed window eliminates this problem by bringing everything into orbit. One of the astronauts is ready to perform EVA (Extra Vehicular Activities). The other member of the crew will support him/her through the mixed window from the inside of the ISS. He/she selects the "EVA Support" feature on the Activity Selector. The astronaut is guided step-by-step without time delay and with direct interaction with his/her colleague. Through the mixed window are shown the parameters related to the health monitoring of the suit. The support crew member has a complete and visually simple view.

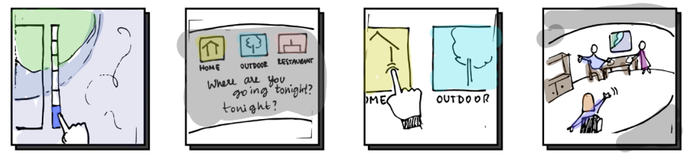
02.4.7
GAME SESSION MODE

The mixed window offers interactive games that astronauts can play together in their free time. Astronaut selects Games mode thanks to the "Activity Selector". The screen shows a series of games that the astronauts can do together or on their own. Thanks to the interaction and the possibility to float around the astronauts can play simple games together, interacting directly with the screen. It could be a good way for them to spend their free time inside the station by living the environment differently.



02.4.8
VIDEO-CALL/ CONFERENCE MODE

Spending long periods away from home leads to psychological discomfort, the mixed window also allows you to feel loved ones thanks to 3D technology. The astronaut selects the video-call/conference scenario on the Activity Selector. Different options will appear as home, outdoor, restaurant, and conference. He/She will feel the atmosphere selected through the 3D technology that the screen provides.



PART THREE
DETAILED DESIGN

03
THE IDEA

The main idea is to have an interactive window, which is not limited to projecting the outside, but with features that amplify the perception of space and allow the astronaut to go beyond the "space" in which it is located. Moreover should be able to support technical interventions.

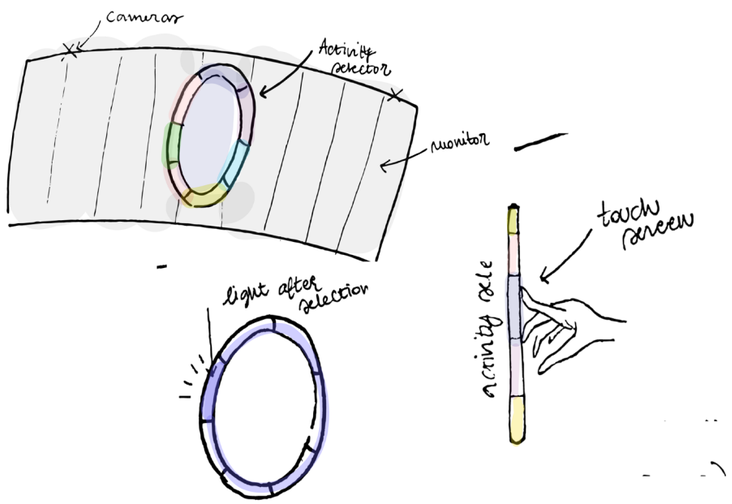
With the use of external high-quality cameras, we could have an interactive screen. On one side there is the possibility to see the environment around you, on the other side you can receive information from the monitor or receive feedbackfrom the interaction with it. The mixed-window should have also different cameras inside the habitable space modules to detect the position and movement of the astronauts that are floating inside. The technology should be very high.

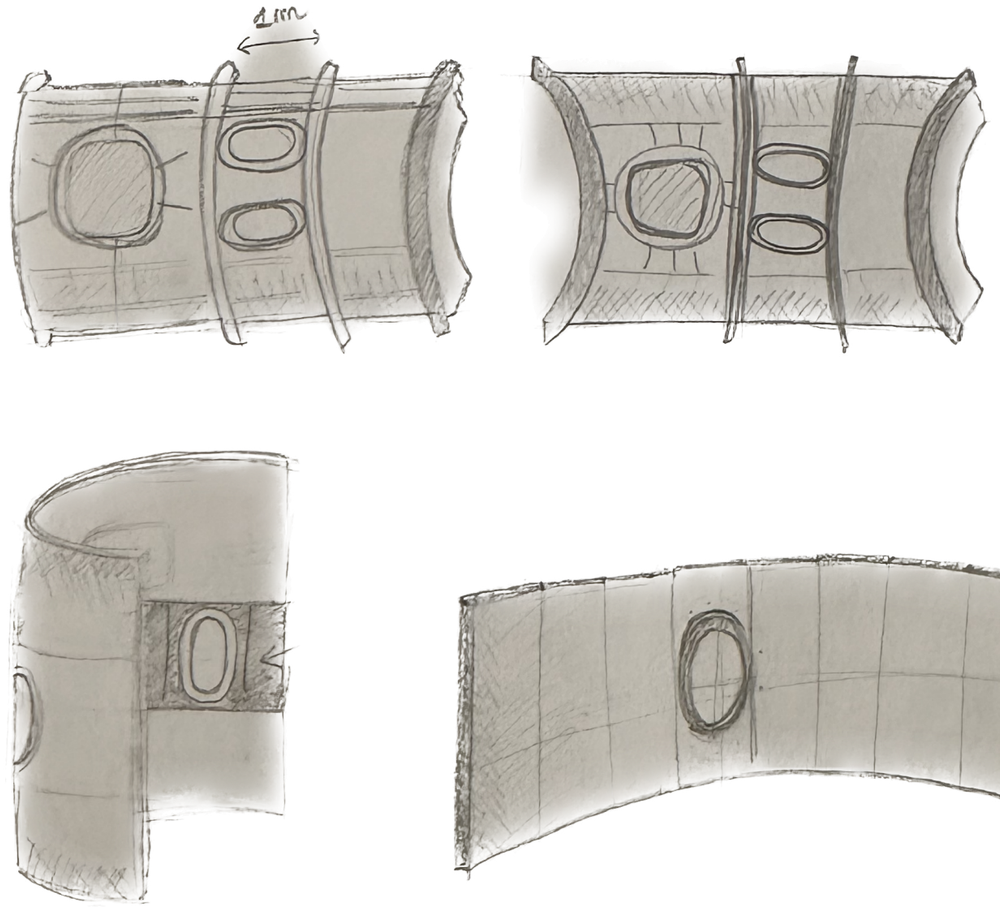
Through the use of a mixed-window, we will avoid the issues related to weight: the reduction of weight brings a gain from a security point of view and reduces the cost. The product brings a gain from a psychological point of view because the user is free to choose the environment that allows him/her to feel more free and comfortable. In that way, the window gets a life because the interaction with it and the benefit it brings makes it indispensable. Having this kind of interactive screen can bring facilitation from the point of view of research and can also meet the needs of the user most simply.

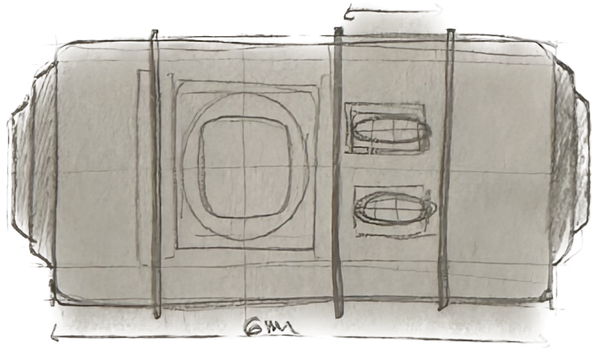
03.1
THE STRUCTURE

The window will be inserted inside a cylindric space habitable module of 9 meters in diameter, that will go into orbit. The band taken from the screens will be about one meter long and is located in the middle of the cylinder. The physical windows will be maintained, as they are embedded between the screens. To use augmented reality technology at its best, it has been decided to use flat screens to approximate the cylinder circumference at its best. About 25 flat screens 1 meter high and 37.3 centimeters wide. Around the real window, a bright LED strip will light up when someone will have an interaction with it. Just approach the window and tap the screen near it to start the Activity Selector.

The highest-quality cameras will be placed outside the cabin to project internally the outside environment and many high-quality cameras will be placed inside to identify the astronaut's position and allow more real and detailed interaction with the product. Thanks to the use of sensors, the cameras track the position of who is viewing allowing you to see beyond the screen a 3D projection as if you really look out of a window.

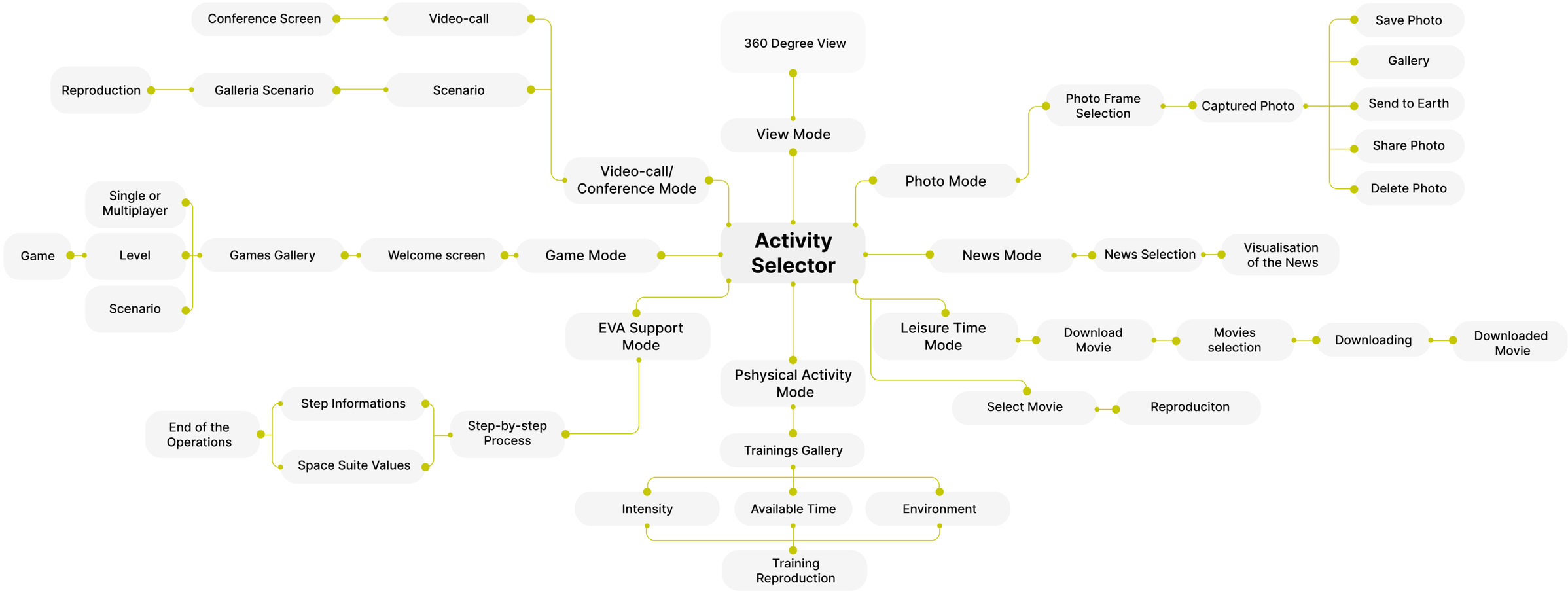






03.2 GENERAL ARCHITECTURE

This section presents the general architecture of the mixed-window before analyzing the interface in detail thanks to the use of wireframes. It is essential to have a general idea of how it works entirely to understand the type and number of possible interactions. From the central activity selector, the first interaction with the mixed-window, the eight main functions branch off, and each of them is then developed into its own components.



03.3
WIREFRAMES

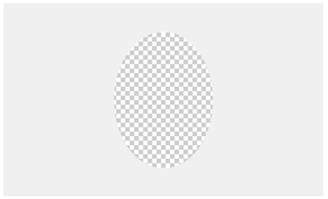
After the 'state of the art', a sequence of wireframes are developed for each type of scenario to see what is the type of interaction between the user and the interface. Each drawing is empty, it is a first draft of the interface, without any design element, which represents the skeleton and indicates the elements present within the page.

What appears as a square oval is the physical window, around which the elements present on the monitor develop. Side captions explain the interactions that can occur during the selected mode. Yellow links allow you to see the ratio between each screen.

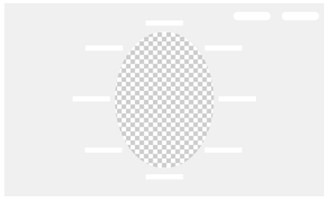
03.3.1
VIEW MODE
Wireframe

The "view mode" is the most important because is the one that meets the user's first need. It was requested by the astronauts to have a real window. In doing so, not only do you have the real view, but you also can expand this view, getting to have an entire circular crown capable of showing the external environment at 360 º. First, the screen is turned off, but when the user approaches the window and touches the monitor the activity selector appears. Selecting the "view mode" turns the entire circular crown into a large window. The external environment appears and disappears in fading.

The first image represents the mixed-window where the oval with squares is the real one, and all around the screens are switched off.

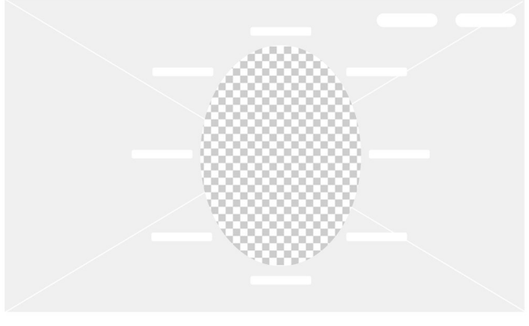


Once you get closer and touch the screen it shows the "Activity Selector".



Once in the “View mode” the black screen fades and everything is sourrounded by the universe.

By clicking any part of the screen the user goes back to the “Activity Selector”.



03.3.2
PHOTO MODE
Wireframe

Through the "Activity Selector" you can select the photo mode. The user will have the opportunity to interact directly with the screen that provides a touchscreen technology and take the photo anywhere. With the movement of the hands, you can enlarge and shrink the framed section. Once the photo is taken there is the possibility to save it, delete it, view it in the gallery, send it to Earth or share it on social networks. "Back Button" always brings to the previous page, "Exit Button" always brings the “Photo mode” landing page.

The first page of the “Photo mode” shows a frame that the astronaut can move freerly on the screen to choose the right spot.

By clicking the circular button the user takes the photo and by clicking the squared button the user goes directly to the gallery.

Once the photo is taken the user can save it, see all the gallery, send it to Earth, share it on social media, or delete it.

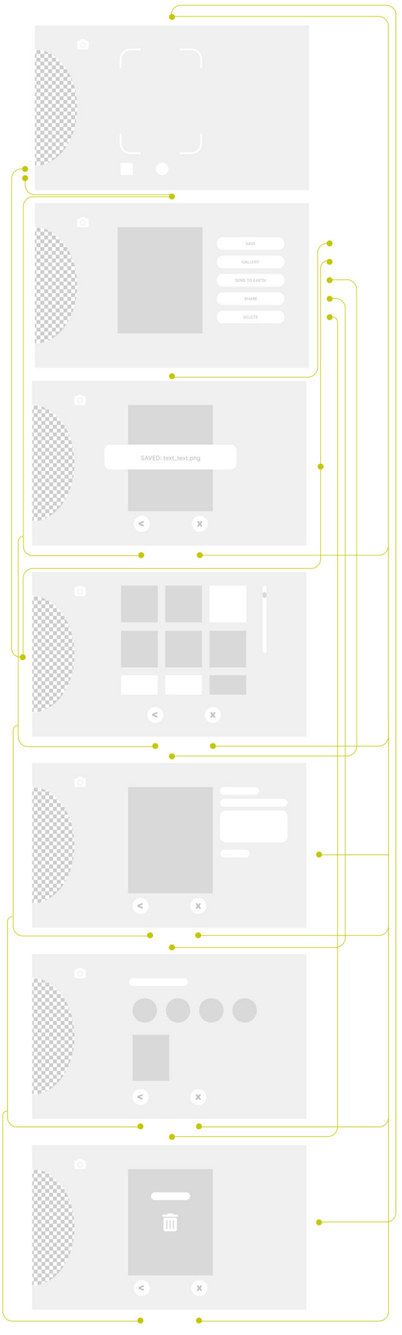
By clicking on the saved photo the user goes to the gallery.

The user can scroll the gallery to see all the photos.

The user can fill the spaces to send the photo and then the page goes directly back to the “Photo Mode” landing page.

The user can choose the social media on which he/she wants to share the photos, after that the page goes directly back to the “Photo Mode” landing page.

By clicking on the “Trash” icon the user can delete the image.



03.3.3
LEISURE TIME
Wireframe

The astronauts have free time in the evening, after having done their work: Intra and Extra-vehicular activity, study, research, and physical activity One of the most popular and easiest activities to do is to watch a movie. From the indirect interviews conducted with the astronauts, reported later by the head of Human Factors of the company Thales Alenia Space, based in Turin, the possibility of using this circular crown as a large cinema was optimal. Movies are usually viewed via laptop, so it could become a time to spend time and do it together. Because in space it will not be convenient to download movies, the interface works as a streaming platform but without taking advantage of the convenience of the movie in real-time. Users will be able to draw from a bucket of films if they request new ones.

This scenario will be dealt with exclusively in this paragraph because, although useful, the reproduction of films appears as a side feature compared to other more interactive and innovative. However, the development remains as it can be used.

The "Back Arrows" always brings to the previous page, the "Play Buttons" reproduces the movie, and the "Exit Button" brings to the landing page of "Leisure Time".

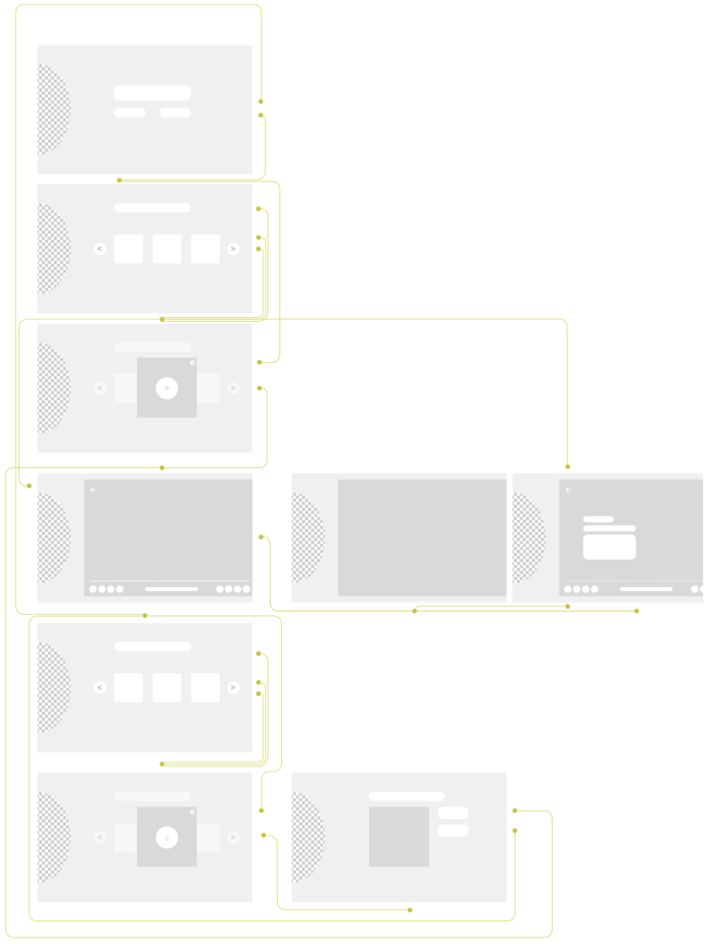
The user can select to download new movies or see it.

He/She can search the title.
By clicking on the image the platform reproduces the movie.

During the reproduction the user can select paly/ pause and language/subtitles/info.

If the uses decide to downolad the movie he/she can request it by selecting it.

Once the movie appears in "Download" is ready to be reproduced.



03.3.4
NEWS MODE
Wireframe

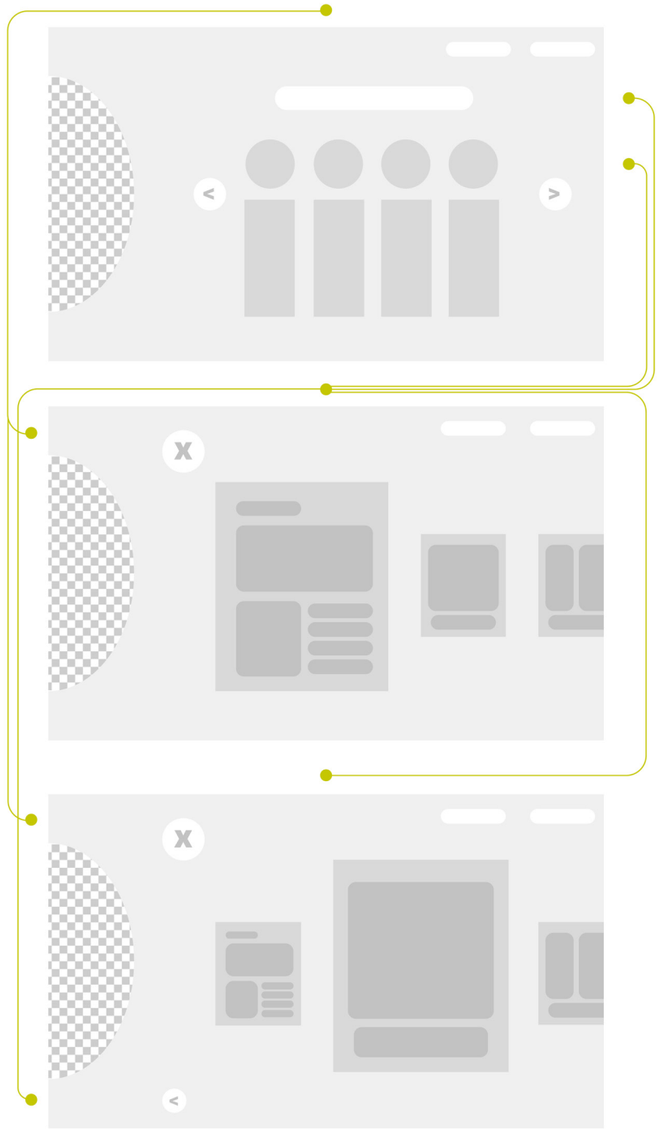
The news section remains an important feature for the mixed-window as it allows the astronaut to view real-time news directly on the screens around him/her. It is not part of the main features but the interface is still analysed. By selecting from the "Activity Selector" the News Mode, the window will display the latest articles and news. By clicking directly on the screen the user will choose what he prefers to read. Thanks to the high-definition cameras inside the housing module will be analyzed the position of those who are reading and the page in question will enlarge its view. To change the page, simply rotate in the direction of the new page to read.

Through the "Back Button," you will return to the home page of the News Mode. With the back and forth button - or vocally - you can select the new page to display.

The astronaut can directly search the article or the newspapers' names; can also selcet the article or switch or browse thanks to the arrows.

After the selection the entire newspaper in pages appears on the window.

Thanks to the internal cameras that detect the position of the astronaut and his/her point of view, the pages switch automatically.



03.3.5
PHYSICAL SESSION MODE
Wireframe

The mode prepared to support physical activity is one of the most interesting. It will be deeply analysed later. This section shows only how the screen will show in front of the user. During the selection of the physical activity the user, in addition to selecting the type of activity he/she would like to perform, can set the intensity of the training, the time available to train, and the surrounding environment. Once the settings are done, you can start the training interactively thanks to the three-dimensional reproduction of the environments on the circular crown. At the end of your workout, you will receive a summary of your physical activity data.

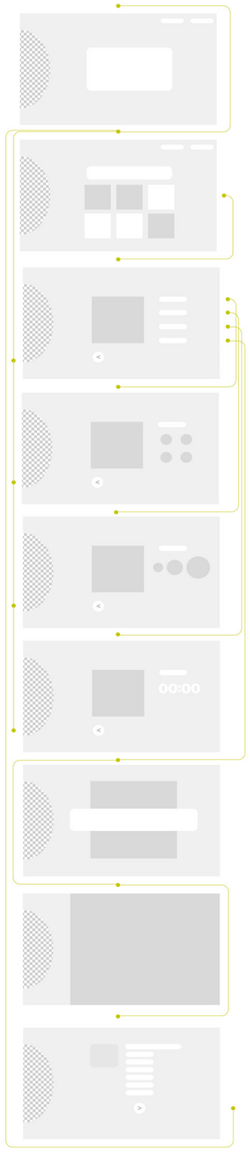
The selections happen automatically, the platform will change on its own and goes directly to the next selection. The "Back Arrow" allows the user to return to the previous screen. The training can be interrupted at any time by simply clicking on the screen and going back.

The platform welcomes the user, after that he/she can look for the scenario in which wants to train and select it.

After the scenario selection the user can choos the intesity of the training, and the available time.

After the last section to be selected, the platform goes directly to the training.

Automatically the page switched on the training modality, fully in 3D and real dimentions.
At the end of the training the platform shows your results.



03.3.6
EVA MODE
Wireframe

The support of extravehicular operations is another interesting scenario. The interactivity with the mixed-window will be further explained in the next paragraph. Once in orbit, the astronauts will have to carry out both research and practical operations. During the activities that happen outside the habitable module, the astronaut must exit to perform tasks such as maintaining or replacing station structural components. In this scenario the protocol to be followed implies a step-by-step procedure driven from Earth. Thanks to the interface support for EVA (extra-vehicular activities) will take place directly in orbit. Also on the screen, you can view the specifications of the suit to make sure there are no problems.

The user will follow the protocol and will execute a procedure simply by clicking on the command in question. By clicking on it you can also read additional information about that step. Selecting the figure of the astronaut will display the values of the spacesuit.

The screens follow automatically once the task is marked as completed. The "Back Button" always returns to the previous page compared to the current one.

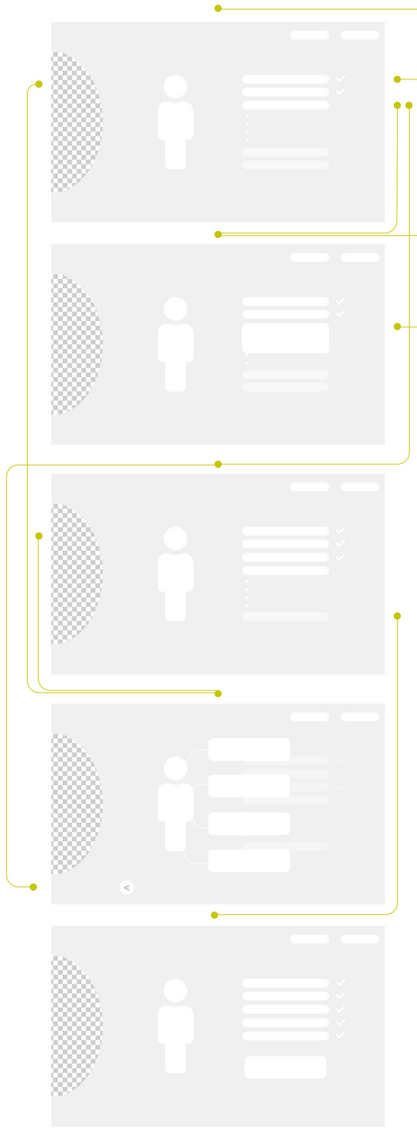
After EVA mode selection the astronaut follows step-by step the procedure.

You can check the instruction as “complete” and you can directly move to the next one. or you can click on the instruction to see the details.

After seeing the details click back on the box to return to the instructions.

The astronaut is able to control the suit-status by clicking on the collegue’s immage, detected by the external cameras.

Once the procedure is completed the Window goes automatically back to the “View Mode”.



03.3.7
GAME MODE
Wireframe

The game mode is very interesting from the point of view of the interaction between the user and the mixed-window. First, as has happened for other modes such as Leisure Time or Physical Activity, the astronaut can select the game to play within the housing module. In the next paragraph will be presented a specific game to explain the type of interaction between the user and the surrounding environment. Also in this case the player can choose the level and the scenario/ type of game to play and in addition, can select whether to play alone or with other people. Once the game starts the circular crown will transform projecting the selected setting and allowing the user to move, or rather in this case float, inside the cockpit to interact by touching the screen directly. At the end of the game, the platform will present either the ranking of your current score compared to the usual or the ranking of players who participated at that time.

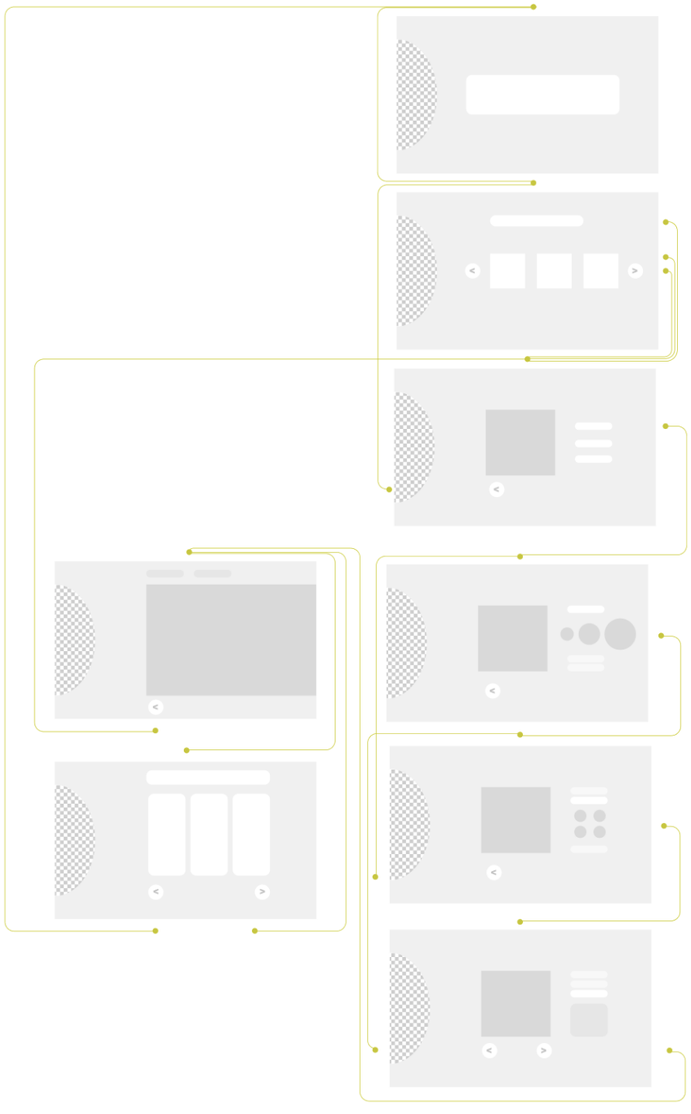
The "Back Button" allows you to return to the previous screen compared to the current one, and the "Next Button" allows you to start or restart the game.

The platform welcomes the user and he/she can serarch or directly select the game to play.

The player can select the scenario, difficulty of the game and if is one player or multiplayer.

After the selectione the games start in a 3D mode around the circular crown.

At the end of the game the platform shows a personal or general score . The player(s) can choose to play again or quite the *game modality*.



03.3.8
VIDEO-CALL CONFERENCE MODE
Wireframe

The latest scenario available on the "Activity Selector" is video-call/conference mode. Once in orbit, astronauts have many conversations with Earth, both professionally and personally. The innovation of the mixed-window in this scenario will be analysed later. The interface initially offers the user the choice of what type of scenario he/she will want to have. If you select the video-call mode you can connect directly with the person on the other side of the camera and, by using 3D technology, this interaction will appear much more real than it would be behind a laptop. Otherwise, the user can just select a scenario to be viewed, perhaps during meals, that will allow him/her to carry out the activity in question as if he were somewhere else.

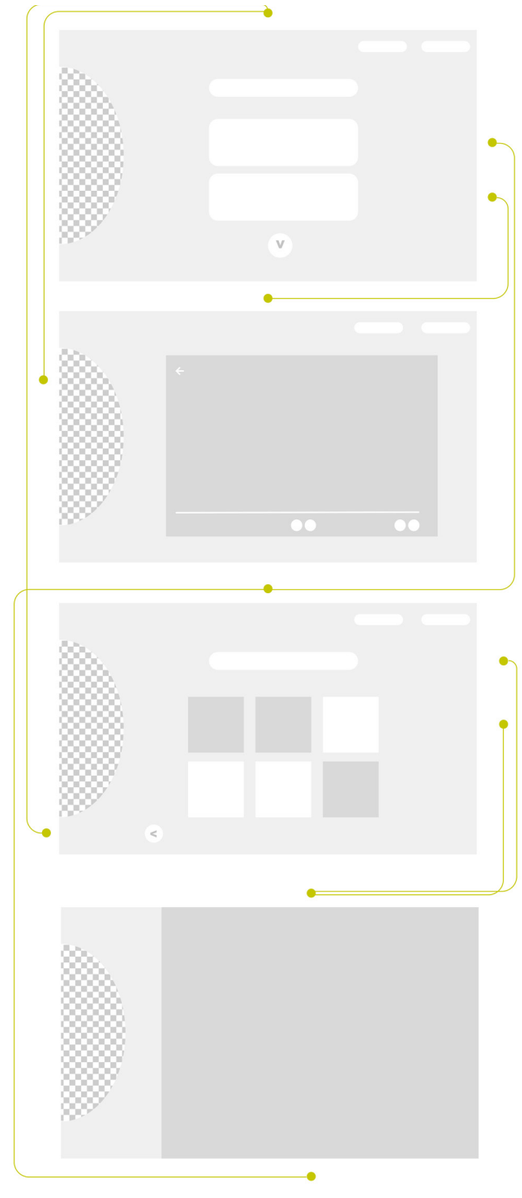
The "Next Button" leads directly to the next screen compared to the current one while the "Back Button" takes the user to the previous screen compared to the current one.

The platform welcomes the user and he/she can coose between scenario and video-call.

After "video-call" selection the interface with the meeting is opened.

After "Scenario" selection the "Scenario Gallery appears.

The selected scenario is reproduced.

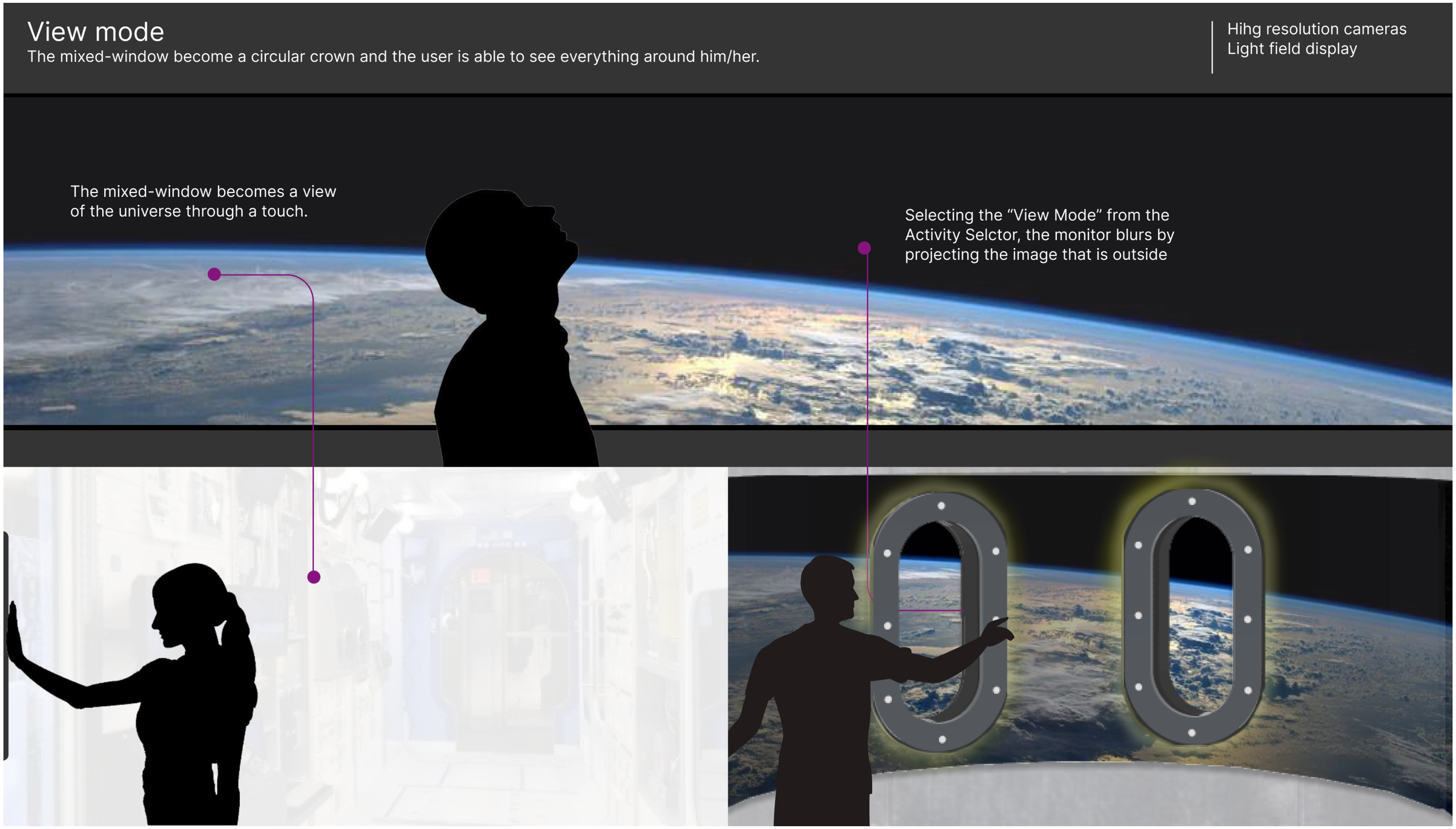


03.4
SCENARIOS

In this section are collected mockups that showcase the product in action. The representations appear two-dimensional and show the interaction between the user and the mixed-window. The scenarios analysed are view mode, physical session mode, EVA mode, Game mode, and Video-call/Conference mode. The choice fell on them as they bid well for innovation from the mixed-window. The other features analyzed mostly remain additional.

03.4.1
VIEW MODE
Wireframe

As we have already seen the view mode is active by simply selecting it in the Activity Selector. With a touch, the mixed-window will integrate the view - already available through the real window - with the one from the external cameras. The cameras will project the surrounding environment onto the circular crown using mixed-reality 3D technology. In this way, the astronaut will feel like he is looking out of a huge real window. The user request has been satisfied and the window stands as a great psychological support.



03.4.2
PHYSICAL SESSION MODE
Scenario

The physical session involves a great innovation compared to the sports activities that the astronaut does in orbit. Physical training is a fundamental aspect for the astronaut and is more important than on Earth because living in microgravity conditions for long periods can cause several disturbances to the body. In the International Space Station, there are only three different machines: a stationary bike, a treadmill, and ARED (Advanced Resistive Exercise Device) a multipurpose machine. ARED allows astronauts to train by simulating the weight of barbells that would work in microgravity. This tool consists of a mechanical arm free to move on three axes, a platform, and a saddle. The further problem is that this type of equipment is fixed - out of necessity and like everything in the space station - to specific spots. The mixed-window comes into support to allow the astronaut to vary and live sport session at its best. Through mixed reality, the window can show a new environment next to those who train, by simulating a run or a ride in the park. Thanks to 3D technology it will be possible to carry out workouts free body dodging for example objects or moving to escape from them. Their 3D rendering will be so faithful to reality as to create a real interaction with them. Finally, with the help of cameras on Earth, it will be possible to perform physical activity in connection with loved ones and take walks together or accompany their children to school.

Physical session mode
During the sports session it is possible to choose the scenario in which to practice the physical activity

Hihg resolution cameras
Depth sensors
Light field display

Thanks to the augmented reality for the astronaut it will be possible to choose the scenario to be visualized, so as to use the few tools at its disposal in a more varied way. You can choose whether to exercise outdoors or in an imaginary scenario.

Thanks to the mixed window it will be possible to see objects on the other side as real, as a result, physical activity will have a playful component: avoid objects, run away from enemies, and view a personal trainer.

With the help of a third person able to frame the environment, the astronaut can carry out daily activities, such as accompanying children to school or carrying out activities together.

03.4.3
EVA MODE
Scenario

The EVA - Extra Vehicular Activity - support is a very important activity that the mixed-window needs to support. Extravehicular activity is the work done by an astronaut in space and outside of his spacecraft. The astronaut can be attached to the spacecraft with an oxygen tube, for example, or it can be free.

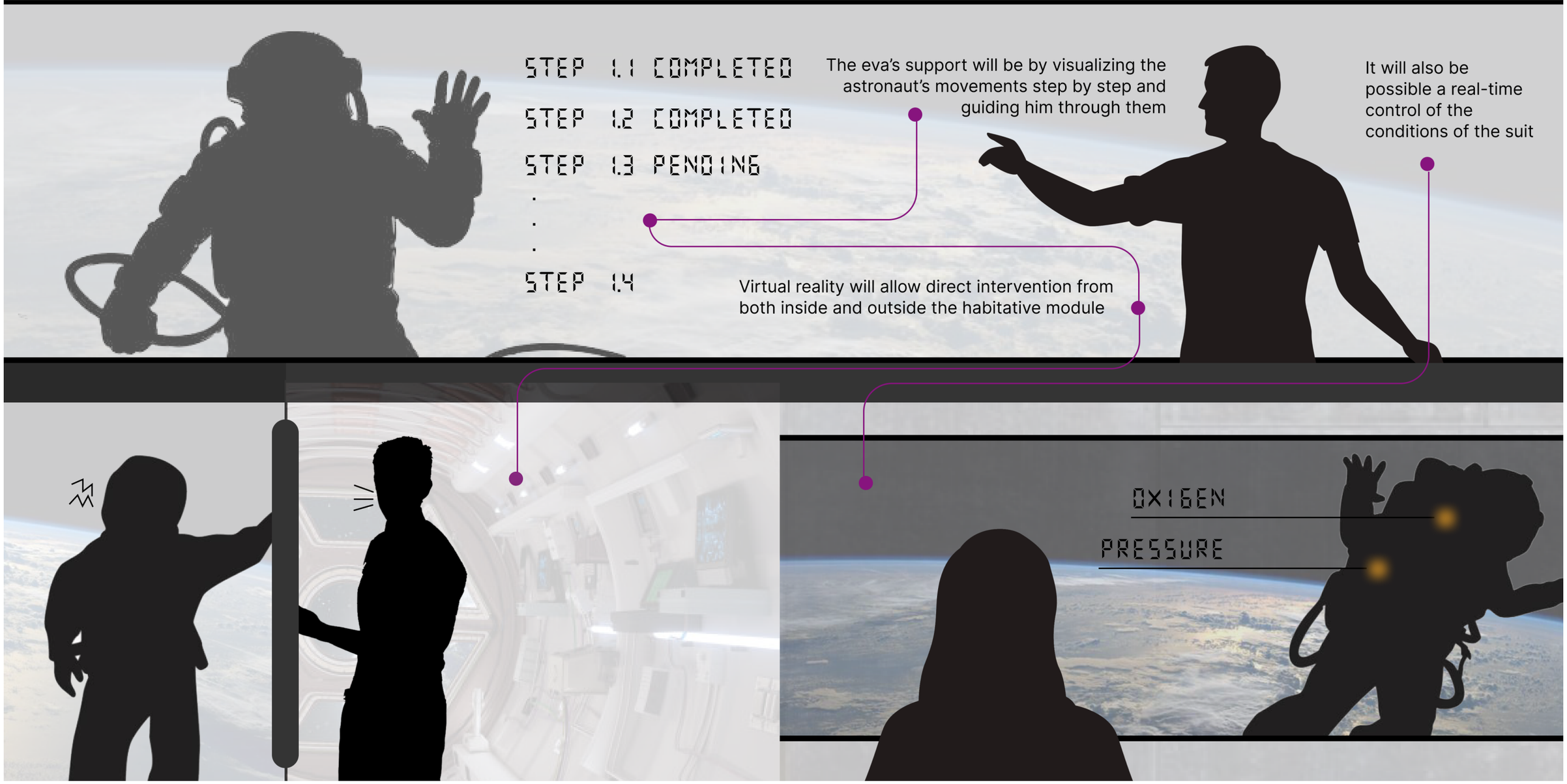
Usually, the main activities that take place during an EVA include the maintenance or replacement of elements belonging to the station. The procedure is normally guided by Earth and follows specific steps that the astronaut studies before but that are guided step by step by who controls the operations.

The novelty of the mixed-window is first of all to be able to drive the EVA directly on board, this will be particularly useful for future missions in deep space where the time delays will be much wider. Moreover, through the real-time visualisation of what happens outside, supported by 3D technology, it will involve the ability to support the performance of the work. It will also be possible to control the conditions of the suit directly on board and act faster in front of the needs.

Extravehicular Activities Support

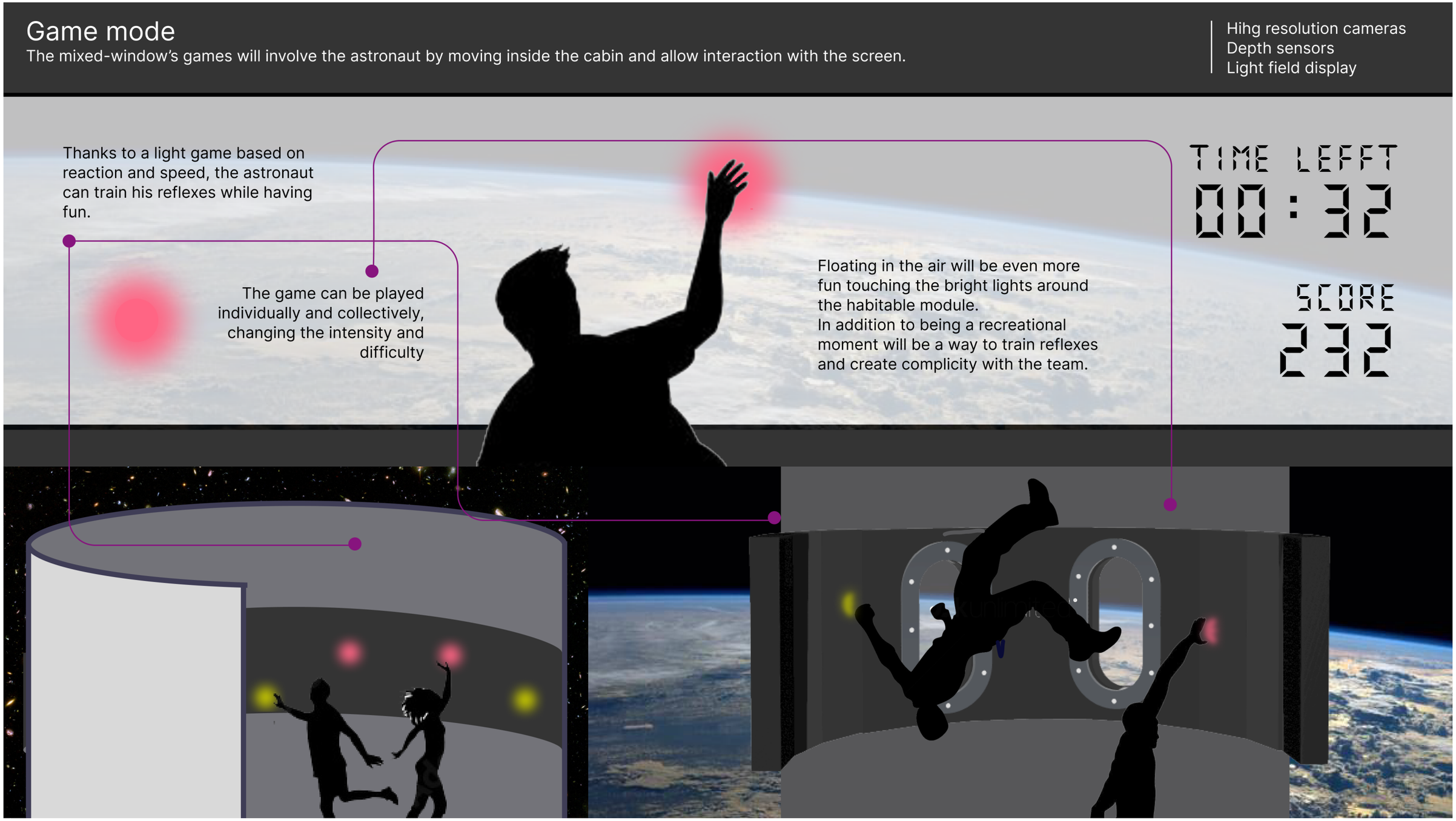
Thanks to the use of augmented reality, EVA support on board becomes simpler and more functional.

Hihg resolution cameras
Light field display
Suits' sensors



03.4.4
GAME MODE
Scenario

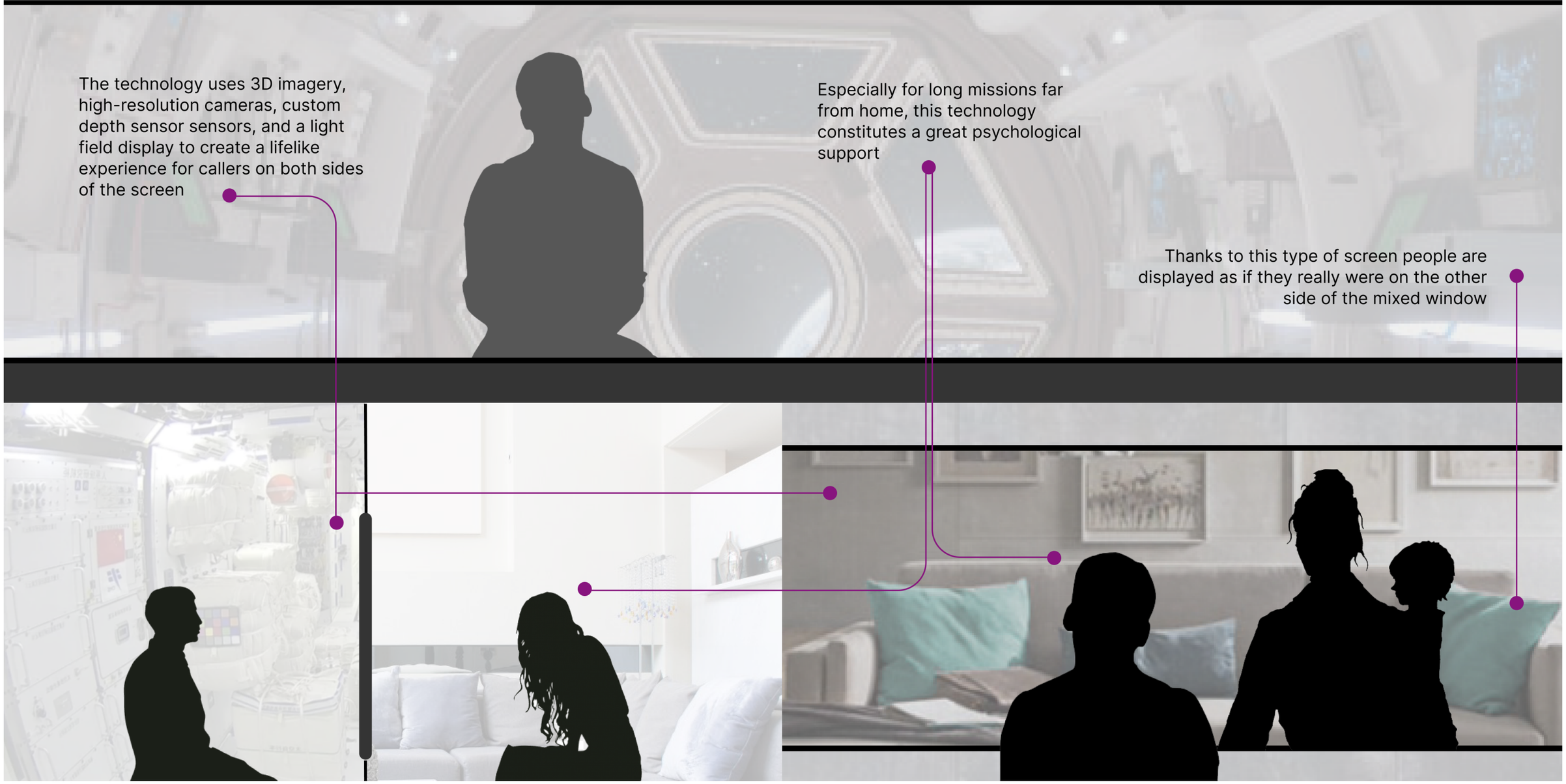
During their free time, astronauts tend to read a book or watch a movie. It is easy to say that the simple tasks to do in a small cabin in microgravity are quite reduced. The mixed-window aims to give the astronaut a new way of recreation. Recreating scenarios, even imaginary ones, on the mixed-window will be possible to have numerous ways to interact by playing with the window. In this case, is presented as a game that is able both to entertain the crew, to create team spirit, and also train the reflections of the astronaut. From a physical point of view, the game will not impact because fluctuating does not help to increase the effort of the body. This does not mean that the reflexes cannot be trained. Specifically on the walls of the mixed-window will appear colored lights - in the case of multiplayer each player will have its color - and the user's goal is to click on all the colored lights that will be scattered inside the cabin in the shortest time possible. The condition of microgravity in this case is no longer an element against the astronaut but becomes a fundamental component of the game. The player can float in search of his/her light trying to beat himself or the opponent.



03.4.5
VIDEO- CALL/ CONFERENCE MODE
Scenario

The last scenario that is analysed is the call or video conference. Surely, it presents an innovation because the mixed-window works as a bridge and a direct way to be connected with loved ones or with the professional world. First, the 3D technology, the highest quality cameras, and the depth and light sensors installed in the housing module and in the place that is connected, will allow the viewing of the interlocutor as if it were real. The machine will reproduce a 3D mesh of the person we are talking to. The great convenience of this system is that the people in front of us will be displayed on a 1:1 scale as if we were talking to each other for real. Maybe out of the window.

From a psychological point of view, it is a great support because we talk about missions and a job that leads people to live outside their homes for many months. Allowing visions of familiar environments, such as home, a workplace, or a public place creates great comfort for the astronaut. The video call display mode can also be used, for example, during meals if you want to escape from what are the four walls, or rather the cylinder, in which the astronaut has to live. Thanks to the mixed-window you can have your family dinner or simply have a coffee in the cafeteria.

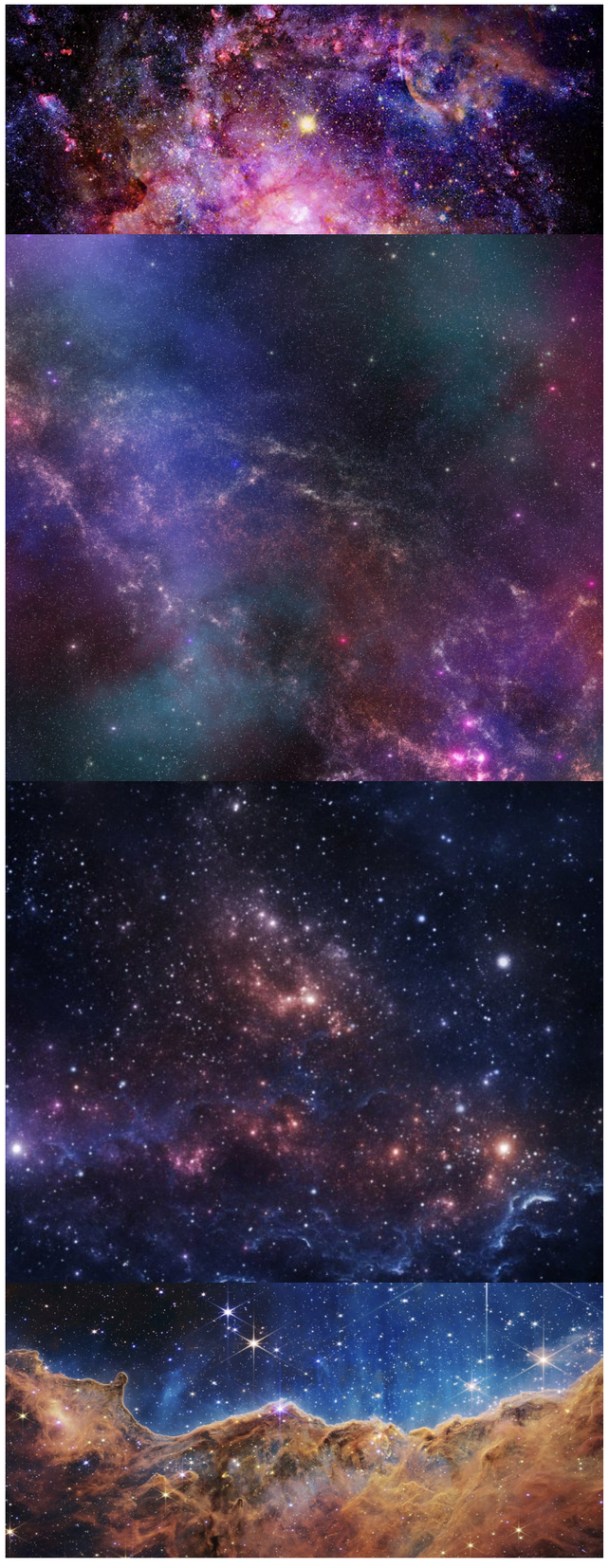


03.5
VISUAL IDENTITY
Name, Inspiration, Palette, Logo

03.5.1 NAME

The name chosen for the mixed-window is MAYA. It has to be immediately understood that the mixed-window allowed us to visualize things as real, despite at that moment and in that circumstance they are not.
What you see beyond the virtual window seems true. Actually it is true but not orbit. The idea was inspired by the German philosopher Arthur Schopenhauer. He coined the expression "veil of Maya". According to him, the veil of Maya was the illusion that prevented the human being from experiencing the Truth, the absolute principle of reality. Maya represented the power to shape. In our lives, we can live countless forms of life since the illusion lies only in the gaze of the observer unaware of his nature and that of the world in which he lives.

03.5.2 DEVELOPMENT



1. Universe.
Credits: Irina Dmitrienko/Alamy
2. Nebula
Credits: Getty Image
3. Universe.
Credits: NASA
4. Nebula Carina.
Credits: NASA, ESA, CSA, STScI

Palette

#07050a #362A50 #5F4B8B #8674AE #BDAED0

Analog Colors

#8E4B99 #8150A3 #5F4B8B #5450A3 #4B5C99

Monochromatic Colors

#9575D9 #88E869F #5F4B8B #C1B6D9 #3D3059

Triad Colors

#271C40 #8C735A #5F4B8B #3E8C49 #1F4024

Complementary Colors

#271C40 #A38BD9 #5F4B8B #403D16 #8C884C

Split Complementary Colors

#D9C48B #A38BD9 #5F4B8B #9FD95F #6A8C45

Squared Colors

#573E8C #8C655A #5F4B8B #8C873E #458C77

Composite Colors

#B054BF #D622F2 #5F4B8B #999479 #BFA354

Principal Color

#5F4B8B

Color Shades

#07050A #362A50 #5F4B8B #8674AE #CFC7E0
#0A080F #403559 #675491 #A697C7 #D3CCE3
#0E0B15 #4A3F62 #6F5D97 #AB9CCA #D8D1E6
#120E1A #544A6A #77669C #AFA2CC #DCD7E9
#15111F #5E5573 #7F6FA2 #B4A7CF #E1DCEC
#191425 #685F7C #8778A8 #B8ACD2 #E6E1EF
#1C162A #726A85 #8F81AE #BDB2D5 #EAE7F2
#20192F #7C758D #978AB4 #C1B7D8 #EFECF4
#241C35 #867F96 #9F93B9 #C6BCDB #F3F1F7
#271F32 #908A9F #A79CBF #CAC2DE #F8F7FA

03.5.3 PALETTE

03.4.5
LOGO

Inspirational sketches

Construction

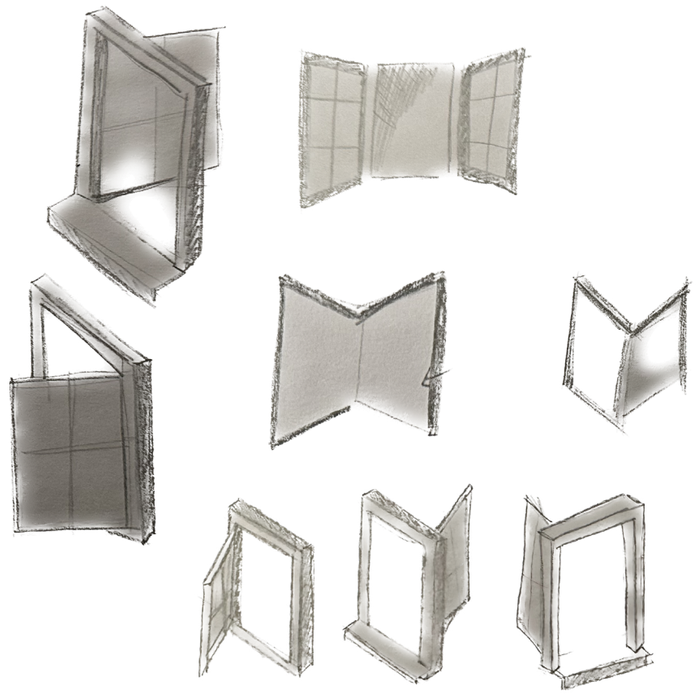
Final Logo

Original logo and logo in grayscale, black and white

Logotype structure

Typography

Logo Variants

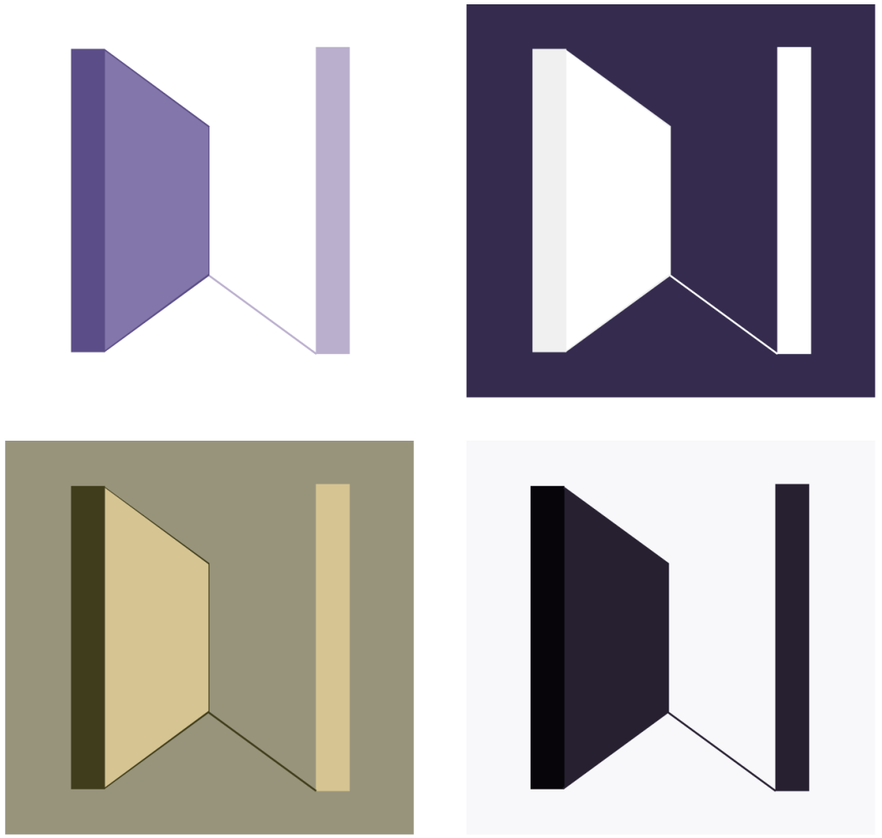


MAYA

maya

POPPINS font

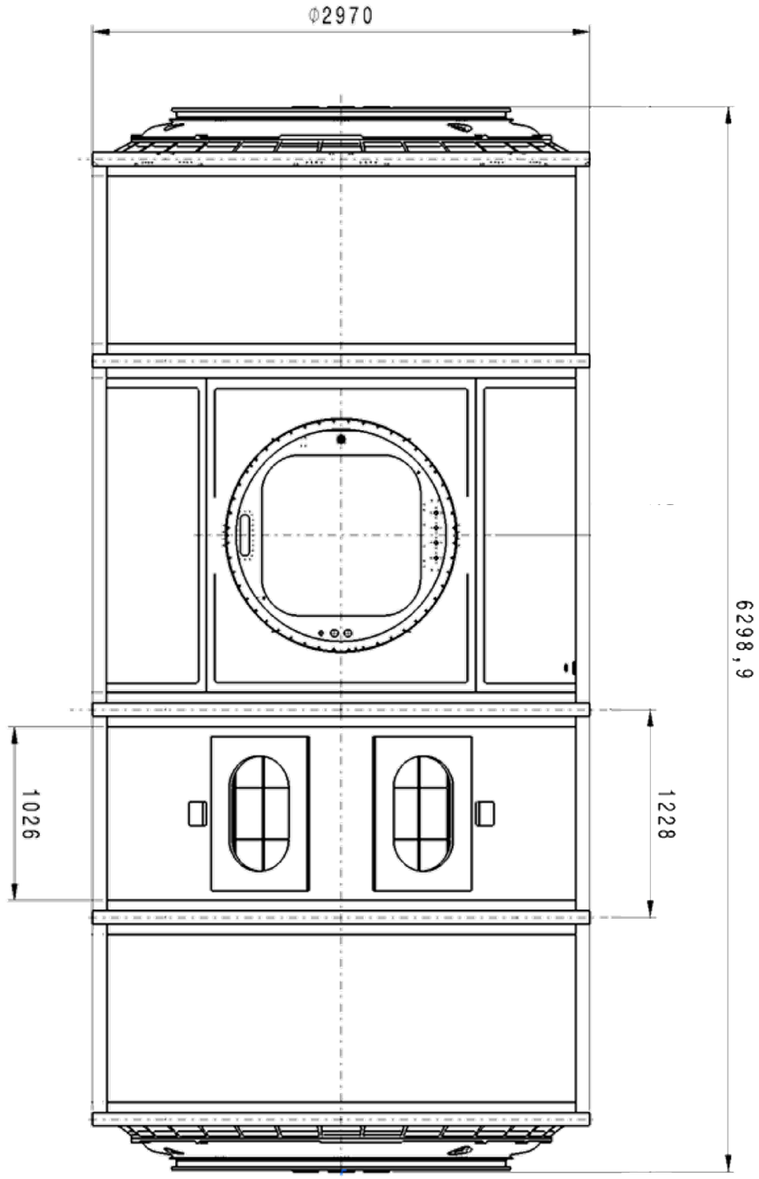
Thin
Light
Regular
Medium
Semibold
Bold
Black



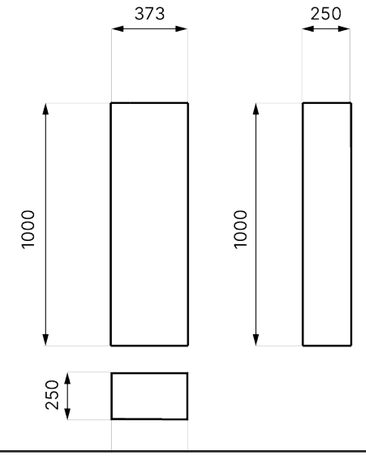
SIMULATION OF TECHNICAL DRAWING

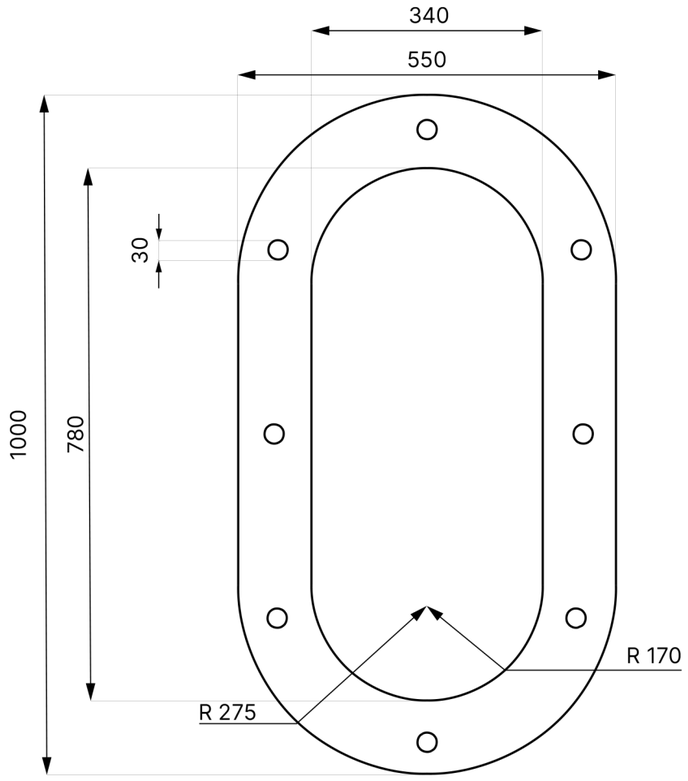
Approssimative dimensions of the structure

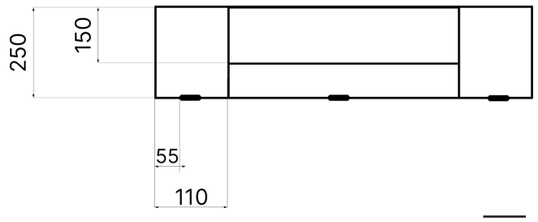
The size was given as an indication because of production rights.

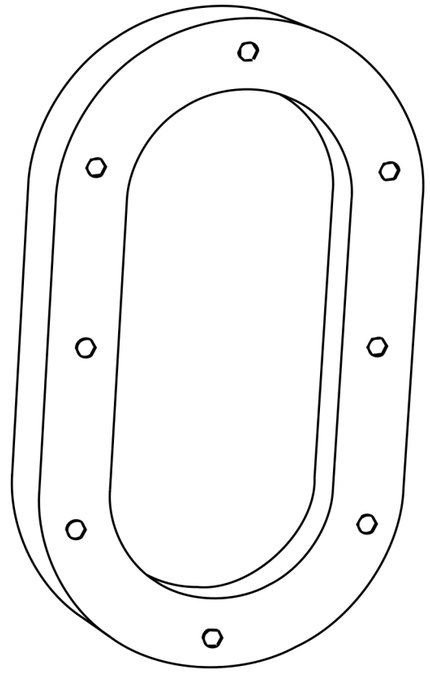


These are the dimensions of the panels to be used for the realization of the component of the screens to realise the mixed-window.









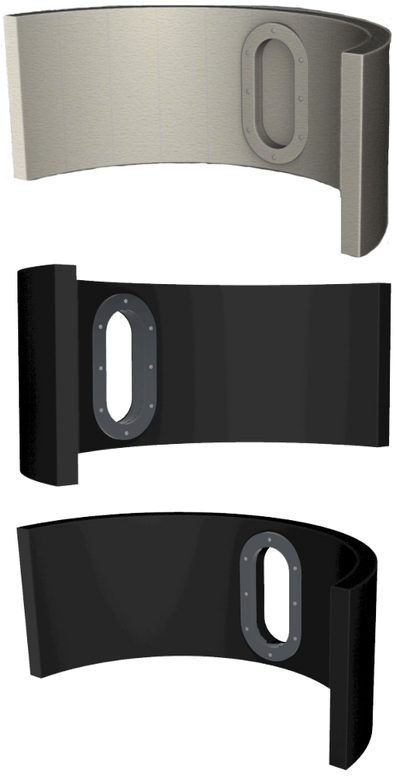
EXPLANATIONS

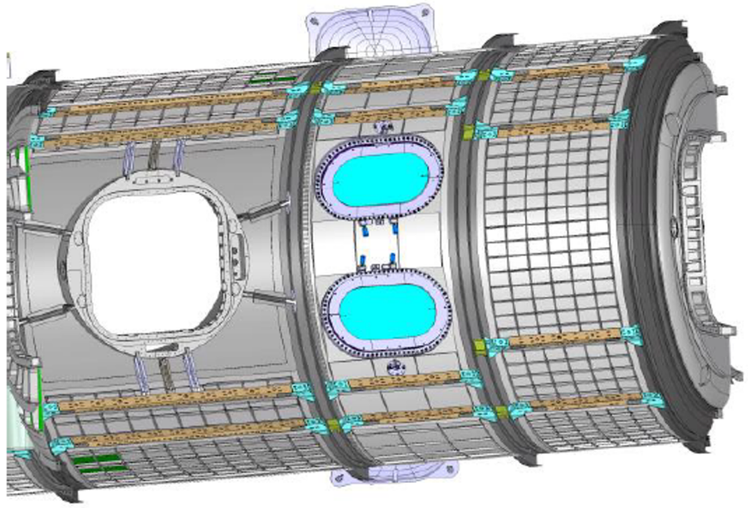
The cylinder on the left is owned by Thales Alenia Space, only the main dimensions have been left as for reasons related to future production it is not possible to quote the exact design.

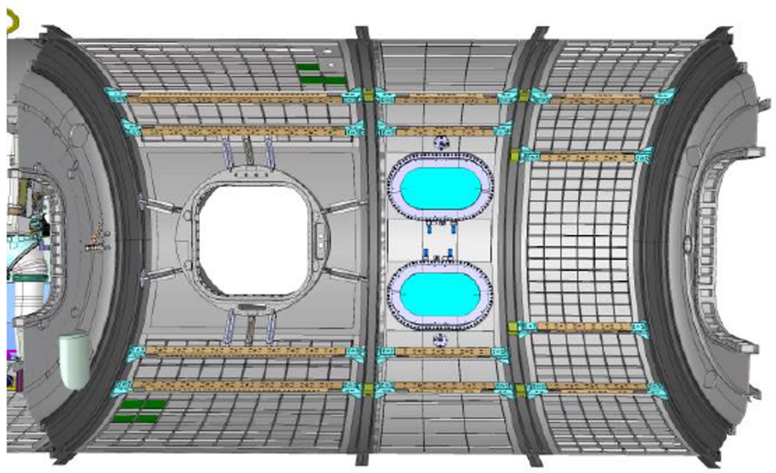
The same applies to the window, a simple window has been created with dimensions and shapes similar to those of the real window that cannot be reported for what has been said before.

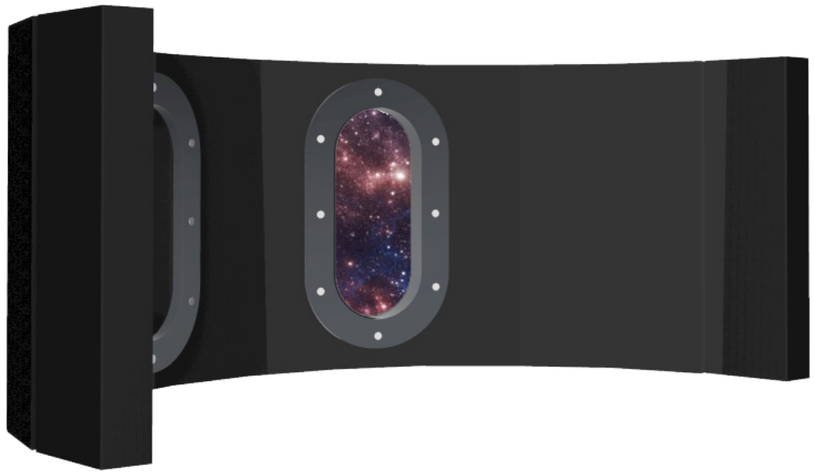
THE MODEL

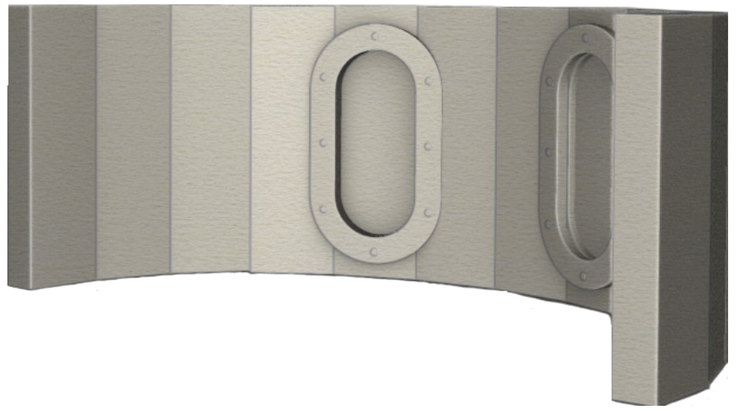
The model shows how MAYA is formed by the union of different flat panels and the implementation of two windows. The models are illustrative to understand the size of the mixed-window and to contextualise the dimensions of the structure in which it will be inserted.
Below instead, there is an alternative, where the model is made with curved panels and the implementation of a single window.
In both cases, the window and panel sizes remained constant.











PART FOUR
CONCLUSIONS

04.1
FEEDBACK

After the realisation of the project, the feedback phase is fundamental. Receiving a reply from the user to the given offer is a starting point that allows you to work better whether the feedback is positive or negative. In the case of negative feedback, there is a new starting point from which to build by modifying the weakest tiles of the project presented. If, instead, the feedback is positive it is confirmed that the study carried out so far has pursued its purposes.

The work done with the experts of Thales Alenia Space, who have placed themselves as a direct link with the astronauts, has been a continuous and rhythmic work that has produced useful feedback, throughout the time of its realisation. It has been a work of giving and receiving where proposals have always been accepted and analysed by themselves and by specialised teams, always providing a technical opinion of the highest validity. From the outset, the experts stressed the importance of the real window, which cannot be excluded in any way from the project as a primary and fundamental request by the astronauts.

The focus on the five scenarios presented in detail - view mode, game session mode, physical session mode, EVA mode, and video-call/conference mode - took place thanks to a comparison to understand what the user needs to feel more satisfied. Following the completion of the project, they confirmed its validity, underlining the interest in the interaction that takes place between the astronaut, the mixed-window, and Earth. Positive feedback found is that the experts considered this project and its scenarios feasible, especially in view of deep space missions and space tourism.

04.2
FINAL REMARKS

The work carried out has been of particular interest since it was set up to find solutions to problems that have not yet been fully defined and that the majority do not frequently encounter. Space tourism is going to be defined as an important area of development for the space economy in which many private companies are investing together with potential first tourists. We have already witnessed in real time the first travelers who have had the opportunity to take short walks outside the atmosphere. When this - and hopefully more than this - will be available to everyone, you may not know. There are many difficulties and obstacles between the idea of space tourism and the realisation of something that has to be useful in this area. The difficulty lies in the fact that it is still a completely unexplored environment to the crowds so it is much more difficult to discover and meet people's needs. Moreover, errors and inaccuracies in a calculation become much more serious because during the tests we are not talking about fragments of material but about people's lives.

The greatest difficulty encountered during this thesis work is reflected in the fact that the desire to solve problems not yet defined involves much more extensive research and a list of major solutions. First, the research began with a direct request to experts in the field of the greatest needs found in space by the only users: astronauts. After a general skimming on what are the actual and possible needs of the user, the choice fell on the development of a visual area - a window - for the passenger. The new window had to respect all project constraints and be psychological supporting. It is also not possible to contemplate the idea of going into space as a tourist without being able to enjoy the wonder of the universe that is outside the small housing module that houses the passenger.

Another problem arises when you are in orbit. The distance, the absence of contact with home and affection, the problem of the tiny living space that you have to share for so long with other people, and the limited number of activities you can do. This is part of the role of the astronaut, but the role of the designer is to help and facilitate others' lives.

The ambition of the project is reflected in the desire to create a window that could match the psychological comfort and the technical demands. Having no real case studies concerning the windows inside the housing modules, apart from the few testimonies concerning missions and real permanences in the space that do not, however, deepen the theme in question, made the process even more complicated. The initial phase of research has seen its focus on all environments similar to atmospheric conditions in space. The main inspiration was to carry out research in the naval field.

The key, however, was given by the idea of uniting the real world to the digital world, thus creating something that would meet the needs of the astronaut and future space tourists The continuous discussion with the experts was fundamental in the realisation of the project as they were the true witnesses of what were the needs currently present in the space field.

The realisation of the general idea, to unite the real window to the virtual one, has been a rather primordial thing in the phase of the plan, decided in the first times. The difficulties arose when the role of the mixed-window changed: it now should meet even deeper needs. How to use virtual reality? How to create an interaction between the user and the product? How to meet user needs? And how to meet the needs not yet revealed? These were just some of the questions that accompanied the entire process of carrying out this work.

Creating a mixed-window that uses the technology at our disposal to heal the psychological problems of the user and at the same time respects, the preliminary structural limits, has proved to be a winning solution.

The installation of panels inside the housing modules would require a greater improvement in the order and distribution of the elements inside the cabin. The screen also does not involve risky maintenance operations. Merging the virtual window with the existing one fully meets the user's needs.

The work carried out was detailed and intense. The continuous exchange of experiences, feedback, opinions, and ideas was the key to the realisation of a project that, despite everything, met the needs of the user. The research phase has been carried out for a long time and in detail to evaluate every hypothesis and scenario similar to the one under consideration. During the design process, the confrontation was fundamental to bring value to the proposal and to underline the fundamental aspect of the users' requests and put them in the development process.

The project is presented as a first solution, prepared for improvements and implementations, for problems related to a field that will be probably available to everyone soon.

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