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ARQUITECTURA

The Metaverse and the World of the 21st Century: How can Architects and Artists adapt to a fast-changing digital World?

Evgeny M. Sukhov

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Evgeny M. Sukhov. The Metaverse and the World of the 21st Century: How can Architects and Artists adapt to a fast-changing digital World?

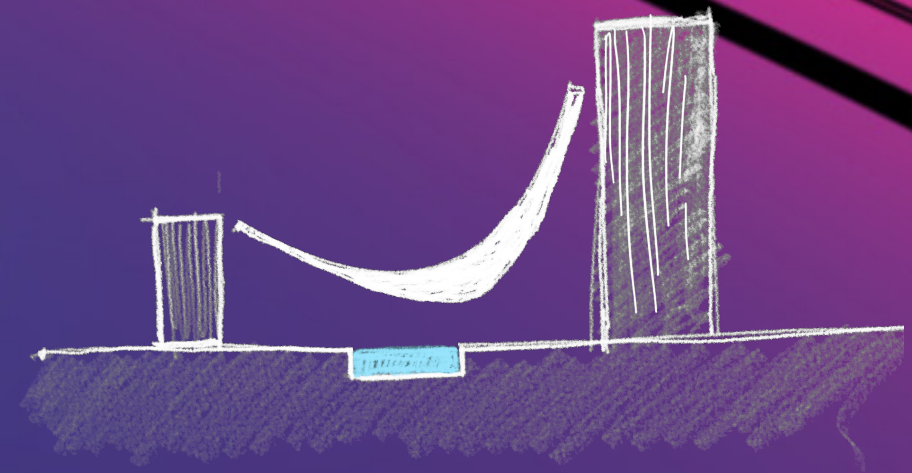


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Editing Note

By author’s decision this dissertation was written in English, apart from the thank you notes and the Portuguese abstract, where the old pre-1990 Orthographic Agreement was used. Throughout this dissertation, standard British English orthography is used, with the author correcting to British orthography any citations and quotations using the standard American orthography.

The digital version of this dissertation shall be presented and read as spreads for better understanding and cohesion between the body text, the images, and the legends which together are intertwined with each other to create a cohesive storytelling, with legends and images oftentimes adding additional information not present in the main body text.

The limit of 90 pages for body text was followed, with a total of 54 pages in font size 11. However, for better legibility and dissertation’s storytelling, leading between characters and text boxes are given ample spacing throughout this dissertation.

To avoid ambiguity, for any enumerating lists of separating items, Oxford Comma is always used.

All currency denominations, fiat or crypto, are stated by the ISO 4217 norm, where the currency ISO code comes before the monetary amount with a hard space, as defined by the European Publication Office in “[Rules for expressing monetary units](#)”.

Моей маме за поддержку на протяжении всех лет университета; даже когда времена были трудные и даже когда, иногда, я был не самый лучший сын.

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Thank you.

RESUMO

O Metaverso como conceito não é uma ideia nova. O termo foi primeiramente cunhado por Neal Stephenson em 1992 no romance de ficção científica ‘Samurai: Nome de Código’; mas a Humanidade tem sonhado com outros mundos e realidades fantásticas há milénios. Com o advento dos computadores, a Internet, tais realidades virtuais estão-se a tornar cada vez mais possíveis através de programação e modelação 3D.

Esta dissertação embarca numa viagem prática, explorando e entendendo os conceitos ligados à indústria do Metaverso, para que arquitectos e artistas sejam capazes de ajudar a construir e imaginar este novo mundo do século XXI.

Desde a sua criação e provas de conceitos iniciais, aos Metaversos de hoje, que são diferentes daquilo que ainda está para vir nos Metaversos de amanhã; enquanto se explora outros tópicos adjacentes como criptomoedas ou a criação de arquitectura que seria fisicamente impossível de existir através de espacialidades não-euclidianas.

Num mundo que está cada vez mais dominado pelos processos de gamificação e difusão do uso de Inteligência Artificial nas nossas vidas sociais e profissionais, esta dissertação reflecte sobre uma revolução inevitável que está para vir nos próximos anos.

Palavras-Chave:

Metaverso; Arquitectura Virtual; Design de Videojogos; Web3; Não-Euclidiana; archi.META

ABSTRACT

The Metaverse as a concept is not a new idea. The term was first coined by Neal Stephenson in 1992 science fiction novel ‘Snow Crash’; but Humankind has been wondering about other worlds and fantastical realities for millennia. With the advent of computers, the Internet, such virtual realities are becoming increasingly more possible through programming and 3D modelling.

This dissertation embarks on a practical journey exploring and understanding the concepts tied to the Metaverse industry, so that architects and artists are able to help build, design, and envision this new world of the 21st century.

From its inception and early proof-of-concepts, to the Metaverses of today, that are different from the yet to come Metaverses of tomorrow; whilst exploring other adjacent topics such as cryptocurrencies or the creation of architecture that would be physically impossible to exist through non-euclidean spatialities.

In a world that is becoming more dominated by gamification processes and widespread use of Artificial Intelligence in our social and professional lives, this dissertation reflects upon an unavoidable revolution to come in the upcoming years.

Keywords:

Metaverse; Virtual Architecture; Game Design; Web3; Non-Euclidean; archi.META

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6 PERSONAL MOTIVATION

I have always been an extremely multidisciplinary person who has always been interested in multiple topics and issues at once. This dissertation is an example of my wide array of interests ranging from architecture, game design, technology, economics, financial markets, entrepreneurship, to politics.

Building, creating, and imagining are my passions since I can remember from my childhood, which significant part was spent drawing and designing cities, houses, stadiums, either with Legos, or colouring in Excel spreadsheets, as I was oblivious to 3D software. As I grew older, I proceeded to create virtual worlds in my computer, either by designing in Lego software, or creating in-game environments such as cities in games like Cities Skylines.

At university, I have discovered a deeper passion for 3D design, especially the one related to building design, and I am thankful for having my work and skills recognised. Since the beginning of the COVID-19 pandemic, I have been investing my time and resources discovering the world of the Metaverse and creating virtual architecture.

It is also important to mention that for six years, throughout my late teens until my early adulthood, I have been an active member of the European Youth Parliament (EYP), which is an organisation that shaped and influenced the individual I ended up becoming today. During those six years, I have travelled to conferences and debates in more than ten countries, been to more than 30 events, and went from discussing the topics up for debate, to presiding and overseeing the entire academic conference proceedings. The most important event I attended has been Tbilisi 2017 - 86th International Session of EYP, where I had the privilege to chair a topic on the rise of cryptocurrencies, which involved hundreds of hours of research resulting in facilitating the writing of a motion for a resolution about cryptocurrencies' complexity and legislation.

The emerging Metaverse industry has been highly linked to the rise of cryptocurrencies, and the reader will eventually understand how those two things can be closely linked. Nevertheless, combining my passion for cryptocurrencies and architecture, whilst taking into account the work I have been developing for the past two years, is the natural choice of a topic for my graduation.

The Metaverse will be something that neither of us can predict in ten years time, as it blends reality with virtuality. This dissertation seeks to understand the necessary conditions for Architects and Artists to shift a part of their work and creations to the virtual environment of the Metaverse.

Despite being a rather theoretical dissertation, it is based upon practical issues that developed over time; and so, the author believes it is first essential to give an introductory chapter about the Metaverse where a brief analysis of its history, the current technology, and the existing virtual worlds settles the common ground for this conversation.

It is not known yet, how big of a role Web3 technologies and infrastructure will play in the creation of a future Metaverse, but it is an entire chapter impossible when discussing potential virtual worlds, as the current Internet is moving towards a semantic, AI-based, decentralised, and interoperable state. And so, from this point onwards, the reader will find specific and complex terminology and concepts that this dissertation assumes the reader is already familiarised with.

From the third chapter onwards, architecture and its design processes are brought into this dissertation, where first, there is an analysis about 3D modelling processes and, then explores the different typologies of architecture in the virtual realm, and dives into the world of unreal spatialities that are only possible in game design.

From this chapter onwards, the author starts talking on a more personal approach, slowly switching the discourse to the first person, as more personal projects start to get mentioned throughout this dissertation, culminating in the last chapter, where all the author's works developed for a Metaverse setting are showcased.



Chapter One:

THE METAVERSE IN A NUTSHELL

Jeremy Paxman:

“You don’t think that some of the claims being made for it [the Internet] are hugely exaggerated? I mean when the telephone was invented people made amazing claims...”

David Bowie:

“The president at the time when it was first invented (...) said he foresaw the day, in the future, when every town in America would have a telephone. (...) I think we haven’t seen the tip of the iceberg. I think the potential of what the Internet is going to do to society, both good and bad, is unimaginable. I think we are actually on the cusp of something exhilarating and terrifying.”

Jeremy Paxon:

“It’s just a tool, isn’t it?”

David Bowie:

“No. It’s not. It’s an alien life form.”

It seems fitting to kick off this dissertation by providing an excerpt from the 1999 interview conducted by Jeremy Paxon with David Bowie about how the Internet would change the world.¹ Companies like Google and Amazon were mere months old and other big players like Meta didn’t even exist yet.

¹ BBC Newsnight. (2016). David Bowie speaks to Jeremy Paxman on BBC Newsnight (1999). YouTube.

14 It is probably human nature to underestimate an upcoming technological revolution because with time and age we tend to settle down for the world we grew comfortable in. Tom Scott² said in early 2023 that he lived through the mass adoption of the Internet, being on the cutting edge of technology; but now, Artificial Intelligence (AI), text transformers, and diffusion models made him feel like there is a chance that we might be in the beginning of a new sigmoid curve in the technological revolution.³

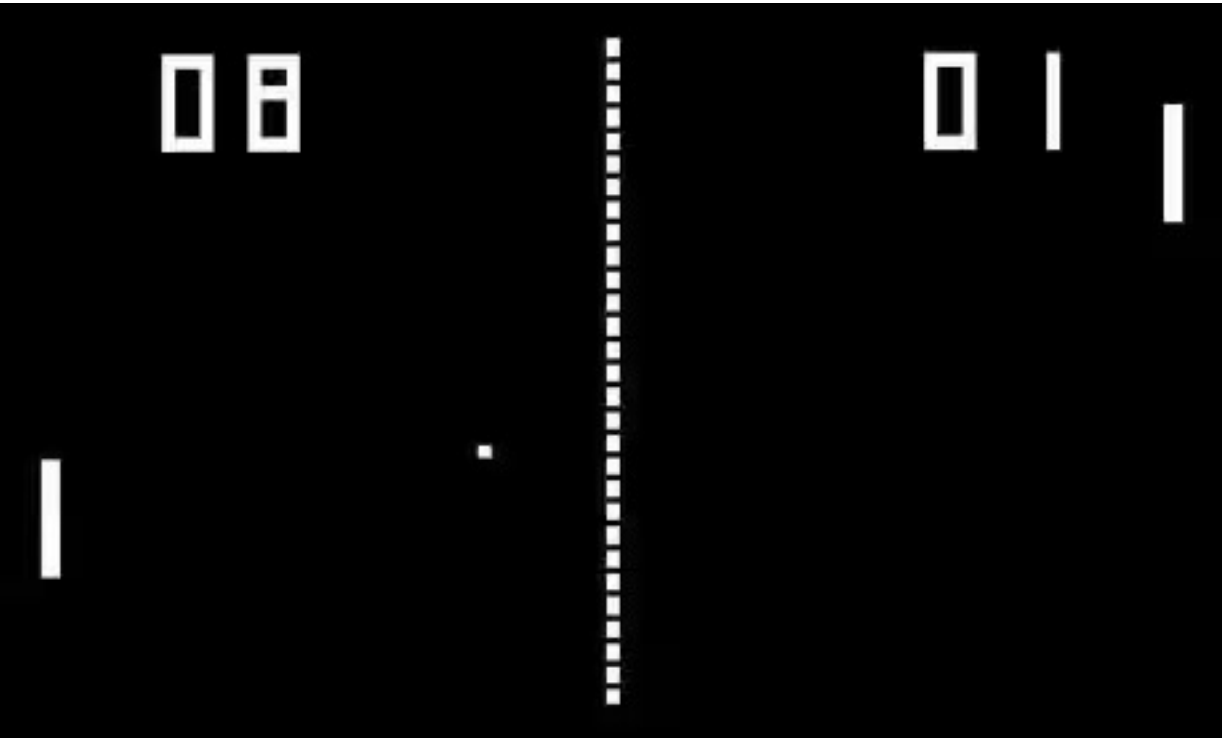
There are several goals for this dissertation. The first one is to explore the Metaverse and how our lives and ways of living might change in the upcoming decades; secondly, is to understand what kind of new spaces, physical and virtual, might be created as a result of digitalisation of our lives; and lastly, understanding how we as architects and artists can adapt to a world dominated by AI and software engineers who can create tools, that we, as architects, cannot even dream to compete with.

There is no denial that the 21st century is the age of the digital revolution, with our lives undergoing a fast and profound change regarding the ways we socialise, stay connected, work, and live our lives in general. This century is a world of fast-changing environments, where we are being consumed by an excess of information that is hard to filter. This fast pace has been accelerating more and more by the advent of the Internet, since the 1990s and the smartphones in the 2010s.

It is very likely that the main advances in the creation of the Metaverse and virtual-worlds industry will be coming from the gaming industry. NVIDIA has been pushing the limits of their graphic cards, investing in AI computing and processes, and their stock went from USD 11 to USD 450 by the time of writing in 2023. Meanwhile, Epic Games has developed Unreal Engine 5, which is the closest we have been to photorealism in game and virtual world development.

Therefore, there is no doubt that the last two decades have seen an exponentially huge development in the gaming industry, becoming a multi-billion dollar revenue industry. We went from basic and simple ping-pong gaming in the 1970s, to almost photo-realistic simulations of entire cities and countries in games like Grand Theft Auto (GTA), The Crew, Test Drive Unlimited series, or Cities Skylines [Figure 2 & 3].

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[Figure 1]
Pong (1972) is considered to be the first video game, designed by Allan Alcorn for the then unknown video company Atari.

2 Tom Scott is an English web developer and video creator, offering educational videos in fields such as science and technology and having won the Streamy Award for Learning and Education in 2022.
3 Tom Scott. (2023, February 13). I tried using AI. It scared me. YouTube.

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[Figure 2]
Map of the island of Ibiza in Test Drive Unlimited 2 (2011), portraying the entire island to a 1:1 scale.



[Figure 3]
GTA V (2013) Gameplay

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It is fair to say that video games became a natural extension of our lives, as for many of us, it is where we socialise and live part of our lives together with our friends. The Metaverse aims to bring our daily lives one step closer by bringing Augmented and Virtual Realities (AR/VR) into that experience, which already exists in some games, giving freedom and power to create whatever kind of worlds one wishes.

Although similar in development, the main aspects that separates the Metaverse and a video game is that, the latter is solely an entertainment and social experience object, whilst the Metaverse combines entertainment, social, work, education, shopping, as well as other industries such as advertising.

The Metaverse is a tri-dimensioning of our flat 2D computer and smartphone's screens - the virtual world we live in today, is mostly comprised of two dimensional screens in our computers and smartphones, with little to no physical interaction and motivation. The Metaverse aims to create and establish that physical interaction, even though there might not be actual physical touch.

So far, one could argue that the main issue in the video-gaming industry is that it has its limitations to what the processing power of present day computers can achieve. From a world-detailing perspective, currently, open world video games can mostly be divided into two different categories: open-environment and closed building-environment.

Open-environment worlds can be freely explored but will generally have very little options and opportunities to explore the interior of the buildings, with most of the scenes happening on the exterior. Game developers, when in need of adding scenes inside buildings, create the building independently, and simply render out the environment as seen from inside the building. In practice, this means that there are two independent spaces that do not influence each other. For instance, if we were to play GTA Online with one of our friends, and we were inside a building, and our friend were outside, the gaming engine would not render our friend

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because they would be in a different world from ours. Currently, this is the most common approach to buildings in open-environment worlds in order to save processing power in our machines.

Building-environments will focus on creating a smaller-world, where the building or complex of buildings itself is the main focus, with little sandbox or exterior scenes. These types of games and world-building might focus on very complex building interiors and designs. One example is the project Titanic: Honor and Glory recreating the Titanic in Unreal Engine 5, exactly as its original plans [Figures 4-9].

Games that combine both open-environment and building-environment are rare, small in world-size, or have very little building-environments inside the open-environment as it becomes increasingly demanding for our current computers.

There is little doubt though, that the Metaverse industry will surge from the basis of the gaming industry, where one is required to be knowledgeable about space design and programming. The spaces to be designed in our Metaverses will either be designed by us or by AI, and those spaces will be designed either for exploring and socialising with friends, working and interacting with clients, having digital twins for things that will eventually get built and approved in real life.

Like the Internet, the Metaverse of the present-day can be divided into two main currents. A centralised Metaverse and a decentralised one. Their differences will be explained by the end of the second chapter, as first it is necessary to look into the conceptual foundations of the Metaverse itself.

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[Figure 4] - Left
Titanic: Honor and
Glory - Dining
Saloon



[Figure 5] - Right
Titanic: Honor and
Glory - First Class
Corridor



[Figure 6] - Left
Titanic: Honor and
Glory - First Class
Promenades



[Figure 7] - Right
Titanic: Honor and
Glory - Second
Class Hall



[Figure 8] - Left
Titanic: Honor and
Glory - Second
Class Promenades



[Figure 9] - Right
Titanic: Honor and
Glory - Officers
and Crew Living
Quarters



20 **Charting the Metaverse**

‘Meta’ from the Greek prefix *‘μετά’*, meaning “after” or “beyond”

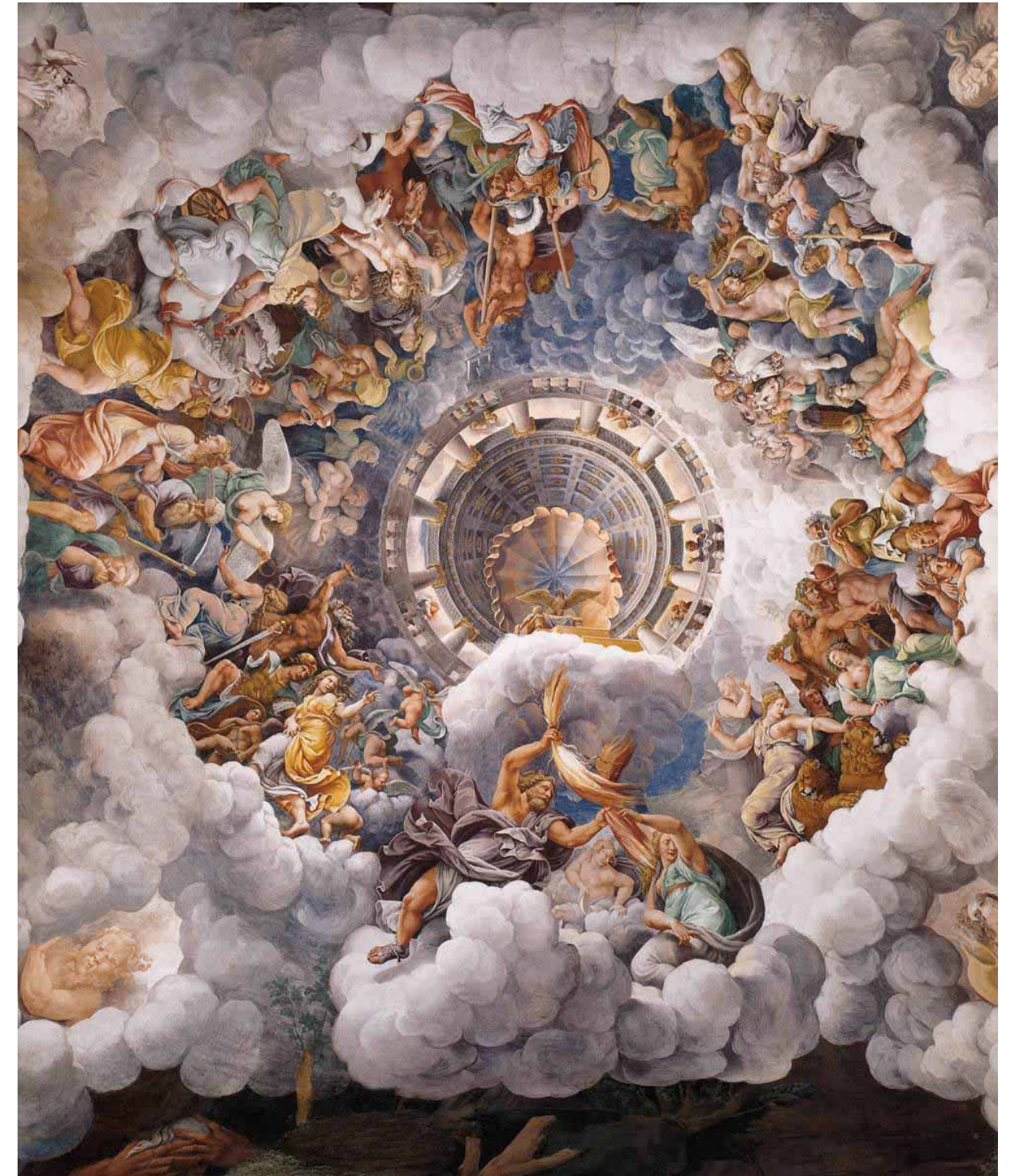
‘Verse’ from the English “universe” coming from the Latin *‘universus’* / *‘universum’*, meaning “combined into one”, “whole”, or “all together”

The goal of this second sub-chapter is to provide a brief history of the Metaverse, and build working foundations by charting and defining some of the limits of what we understand the Metaverse to be.

Humankind in one way or another has been dreaming of alternate worlds and universes for millennia. Mythology and religion where divine and mythical creatures were believed to be inhabited, often feature stories of gods, spirits, and realms beyond the physical world; with humans trying to bring those inaccessible worlds closer to them through literature, paintings, sculpture, and of course, architecture [Figure 10].

Many sorts of literature have provided the Humankind with stories of alternate worlds - Dante Alighieri’s fantastical “Divine Comedy” (1321) with its depiction of various afterlife realms; or utopian and dystopian fiction portraying ideal or nightmarish societies such as Thomas More’s “Utopia” (1516), or George Orwell’s “Nineteen Eighty-Four” (1949) are works commenting about alternate realities and their social and political issues; or the rise of science fiction in the last couple of centuries bringing new features such as space and time travel, parallel universes and alternate timelines, and extraterrestrial species, in books such as “The War of the Worlds” (1898) by H.G. Wells, or Philip K. Dick’s “The Man in the High Castle” (1962), are notable examples.

[Figure 10]
“Fall of the Giants”
(1532-1534) fresco
by Giulio Romano
located at Palazzo
del Te in Mantua,
Italy, portraying
the Gods from the
summit of Mount
Olympus, where
Zeus/Jupiter defeats
the Giants with his
lightning.



Moreover, the advent of the cyberspace, the Internet, and videogames in the last 50 years introduced the notion of digital spaces transcending physical limitations or just our imagination.
22 With the advent of video games, it has been possible to create virtual realities and bring the concept of alternate worlds closer to reality. Video games of today can provide immersive experiences with users being able to explore and interact with not only digital environments but also with other people also present in those same virtual environments, simultaneously or not.

The actual term ‘Metaverse’ was not coined until Neal Stephenson’s 1992 cyberpunk fiction thriller novel entitled “Snow Crash”, set in a dystopian future where nations have been replaced by corporate franchises, and the real and virtual realities coexist in the Metaverse. The novel’s main character is Hiro Protagonist, a computer hacker and a pizza delivery driver for the Mafia, who is investigating a new drug called Snow Crash, which can infect people’s minds in both the physical and virtual worlds, leaving them vulnerable to manipulation.

Hiro unveils that Snow Crash is not a mere drug, but a virus exploiting the brain’s language-processing capacities. Our hero embarks on a journey to unveil the origins of this virus, leading him to a conspiracy involving the ancient Sumerian language and culture, religious fanaticism, corporate control, and a plot of reprogramming humanity’s consciousness.

Hiro’s path crosses with Y.T. (Yours Truly), a courier and skateboarder, whose intelligence gathering begins to coincide with Hiro’s investigations. Together, they unveil a conspiracy to spread Snow Crash creating chaos in society. The two end up exploring a dangerous world of hackers, mafia, and religious zealots, to prevent the spread of the Snow Crash and the collapse of society.⁴

All in all, this novel explores the blending of elements of technology, linguistics, philosophy, ethics, action, information manipulation, and the impact of language, and its consequences, on human behaviour in a fast-paced information world.

4 Neal Stephenson. (1992). Snow Crash. Bantam Spectra.

Many aspects in “Snow Crash” have parallelisms tracing to our current world, such as the way people socialise, work, and conduct business, foreshadows the emergence of VR and AR technologies as we know them today. And technologically speaking, Stephenson’s Metaverse 23 can be described as a metaphor for the real-world, defined by three geometric dimensions, in which users can access it using goggles, similar to current-day VR headsets, experiencing the Metaverse from a first-person perspective under virtual customisable avatars.

The metaverse-timeline.com divides the timeline of the Metaverse into four different eras: Imagination, Foundation, Experimentation, and Adoption Eras.⁵

The Imagination Era (1935-1978):

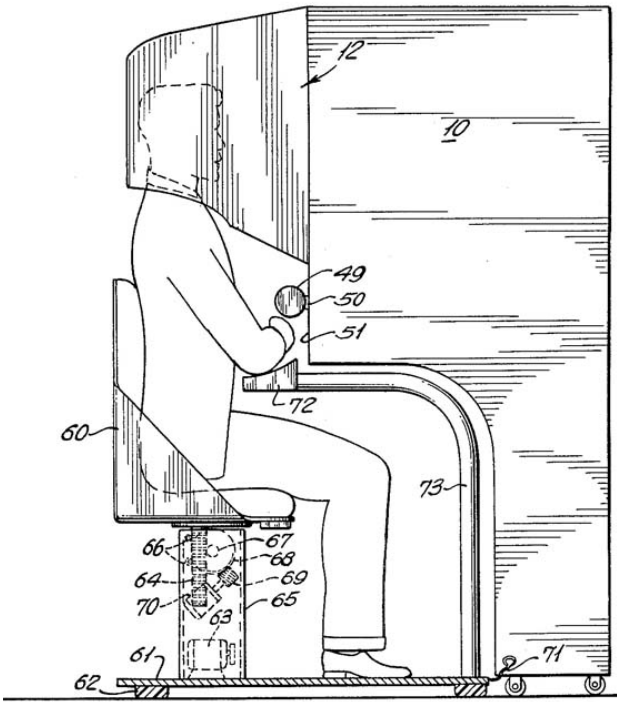
As we have seen in previous paragraphs, Humankind has always had the desire to envision and bring to life alternate realities. Before this era, any kind of virtual world remained confined to the realm of one’s imagination. This first era allowed the migration of ideas to the real with the creation and development of the first technological advances that would later allow the creation of virtual worlds.

The first glimpse of a virtual frontier was Stanley G. Weinbaum’s science fiction book “Pygmalion’s Spectacles”, being the first one to describe the VR model where a pair of goggles would let the user experience a fictional universe through holographics, smell, taste, and touch, thus, creating a multi-sensory experience that extended beyond traditional literature.

The first sensory escapes and virtual exploration came in 1962, the invention of Sensorama simulated a real city environment, in which one could ‘ride’ through on a virtual motorcycle [Figure 11 & 12]. This invention allowed multisensory engagement, giving its users the power to observe the road, hear the engine, feel the vibrations, and smell the engine’s exhaust in the designed environment.

5 Jack Morton. (n.d.). The Metaverse Timeline. Jack Morton.

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[Figure 11] - Left
The Sensorama
Machine (1962)

[Figure 12] - Right
The Sensorama
Machine, Patent
(1962)

Thomas Furness’ pioneering work led to the foundations of an interactive virtual reality in 1966 when the first VR flight simulator was inceptioned, generating interest from the American Air Force due to its potential use for training purposes. Two years later, Ivan Sutherland invented the first VR headset called “Sword of Damocles”, which consisted in a heavy structure suspended from the ceiling that was able to project primitive wireframed virtual content into a real environment, and thus, laying the groundwork for immersive digital experiences.

A pivotal moment is the dawn of the personal computer, which came in 1971 with the launch of Kenbak-1, credited as the world’s first personal computer by the Computer History Museum. It was designed and invented by John Blakenbaker before microprocessors had been invented, and therefore, used small-scale integrated circuits, instead.

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It became possible to explore digital landscapes by 1979 when the Massachusetts Institute of Technology (MIT) introduced the Aspen Movie Map, a first-person interactive city view of Aspen, Colorado, akin to a prototype of today’s Google Street View, allowing users a surrogate travel experience within a digital realm [Figure 13].

Lastly, this first Imagination era reached its culmination, Multi-User Dungeon (MUD1), was created and released in 1978, and became the first video game introducing players to a virtual world. MUD1 laid the foundation for interactive digital universes, where players could explore and interact with the surrounding environment, opening up the possibilities for future sandbox games.⁶



[Figure 13]
Aspen Movie Map
(1979)

6 Jack Morton. (n.d.). The Metaverse Timeline. Jack Morton.

The Foundation Era (1979-2009):

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Integrating our inventions depends on the connection of fundamental parts, because in order to create a fully immersive virtual experiences, it was first necessary to lay the groundwork for a functioning digital world, where the society as a whole was interested in digitising its own behaviours.

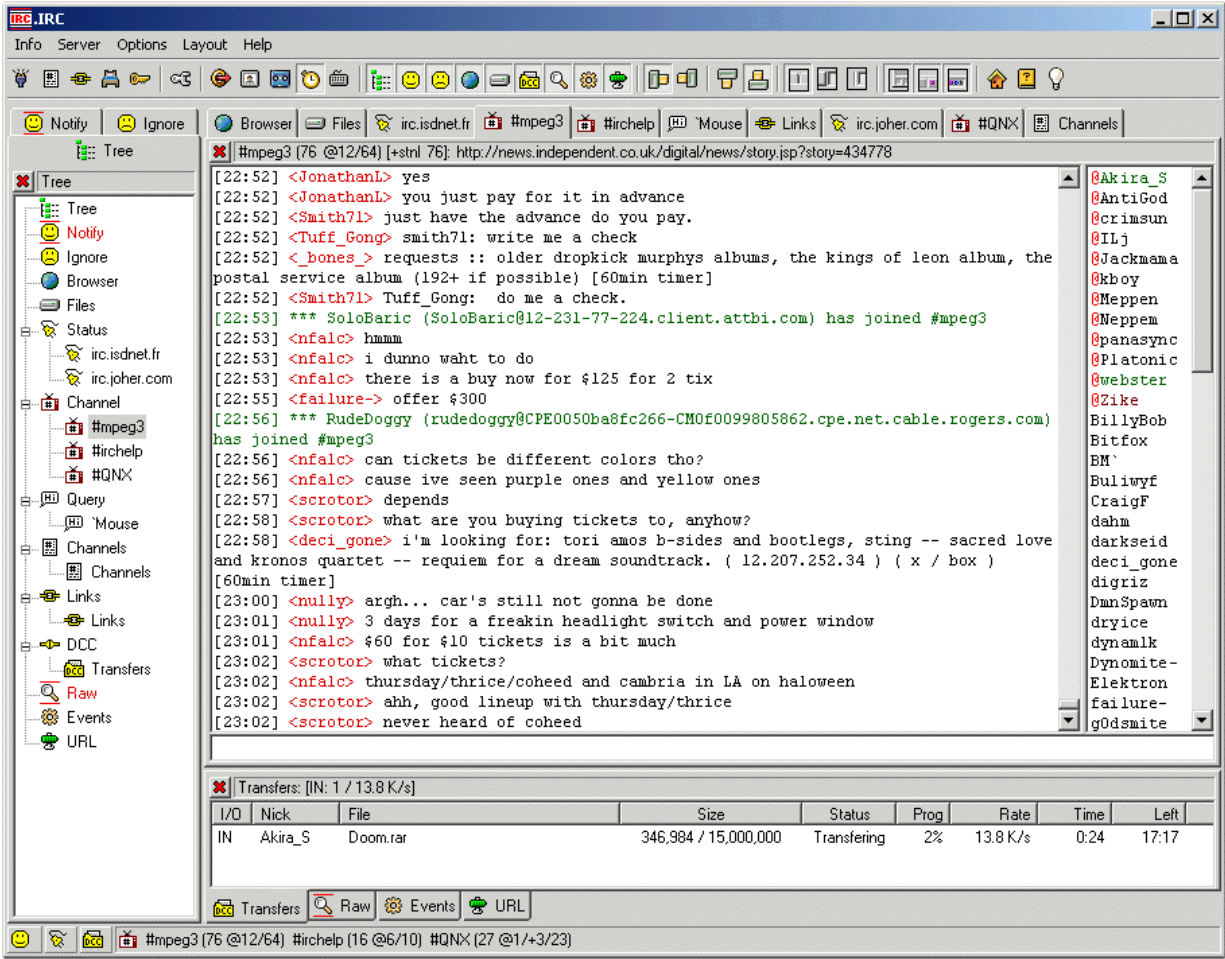
The heralding of the digital frontier came with “Hole in Space” was a performance art piece connecting Los Angeles and New York City via live video in 1980, created and developed by Kit Galloway and Sherrie Rabinowitz, where people could see, hear, and speak like they were around each other in real time [Figure 14]. Furthermore, the 1982 film “Tron” became one of the earliest films to extensively use and bring computer-generated imagery (CGI) to the forefront, and thus, showcasing the potential of visualising digital environments. Later in 1987, computer scientist Jaron Lanier coined the term “Virtual Reality”, foreshadowing the immersive experiences yet to come.



[Figure 14]
Hole In Space
(1980)

Meaningful stepping stones to virtuality, came with the creation of the Internet Relay Chat (IRC) by Jarkko Oikarinen in 1988, facilitating real-time online text communication, later seen by the launch of the first-ever web page on the World Wide Web in 1991 [Figure 15]. Later that year, the Virtuality Group released a series of games and arcade machines in which players would wear a pair of VR goggles, playing immersive games in real-time for the first time. By the end of the decade, Six Degrees became the first social networking site in 1997, where it combined features such as profiles, friends, lists, and school affiliations all in one place; and by 1999, Napster popularised peer-to-peer (P2P) file sharing, being primarily used for sharing audio files, thus anticipating the creation of the streaming industry years later.

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[Figure 15]
An example of
Internet Relay Chat
(1988)

In the late 1990s, many futuristic possibilities started to get unveiled and popularised. The Matrix film from 1999, played an important role in popularising virtual reality for the masses. Wei Dai proposed B-money, which was the first decentralised cryptocurrency system, which although never fully developed, ended up influencing the development of Bitcoin years later. And games like “SissyFight2000” and “Habbo Hotel” were among the first ones to introduce live chat functionality, with Habbo Hotel being one of the first attempts at creating a Metaverse, with the game establishing virtual communities for players where they could design, build, play games, and trade in for different assets.



[Figure 16]
Second Life (2003)
Gameplay

The early 2000s, was marked by pioneering digital frontiers, with Electronic Arts (EA) introducing in 2002 an online multiplayer version of “The Sims”, while Linden Labs launched the first iteration of “Second Life” in 2003, a massive web-based, online community taking place in a 3D space with player avatars and currency [Figure 16]. Later in 2006, Roblox 3D was launched, allowing players to program games and play games created by other users. The advent of social media came with the launch of Facebook in 2004 starting a revolution in how we live and communicate in the digital world; and by 2007, Google’s Street View replicated real-world spaces virtually accessible to anyone.

This second era comes to an end with the emergence of Blockchain with the invention of Bitcoin in 2009 by Satoshi Nakamoto revolutionising digital currencies and setting the stage for decentralised technologies; and the establishment of online cultural phenomenon like Minecraft, which is a blocky online sandbox game focused on building and exploring, and later named as “the most important game in a decade” by Forbes, Polygone, and The Guardian.⁷

The Experimentation Era (2011-2019):

Amidst the fundamentals laid out in previous eras, this new era emerged as a time where innovation came fueled by curiosity and the need to explore and play. With the building blocks for virtual realities in place, the fast pacing development of digital behaviours and literacy became the defining aspect of this era.

New dimensions fusing reality and virtual environments started to get forged when in 2011, Matterport enabled 3D space to be captured, and turned into an accurate and immersive digital twin. The landscape of virtual interaction was transformed with the launch of VR in 2014, providing a platform for virtual world engagement through avatars and voice chat. The same year, the first desktop holographic 3D display was launched by Looking Glass Factory, bridging the gap between digital and tangible realms. In March 2016, the first Oculus VR headset was released for consumers, featuring per-eye display, 360-degree positional tracking, integrated audio, with a heavy focus on consumer ergonomics and aesthetics.

⁷ Jack Morton. (n.d.). The Metaverse Timeline. Jack Morton.

30

The emergence of AR leaped into the mainstream as Snapchat introduced AR spectacles in 2016, which allowed users to see the world in augmented reality, snap videos and photos that could be transferred to their phones. Pokémon Go’s launch that same year, widely popularised and demonstrated the potential of AR gaming, as it used mobile devices with GPS to locate, capture, train, and battle virtual creatures that would appear in player’s real-world locations [Figure 17]. Later in 2019, Google introduced AR functionality for maps, showing walking directions on top of real-world images, showcasing the practicality of AR and practical utility.

Blockchain and Cryptocurrencies’ true potentials started to get unveiled when Coloured Coins, an early precursor to Non-Fugible Tokens (NFTs), were first introduced in 2012, hence introducing the concept of unique digital assets on the Blockchain. Later in 2015, Vitalik Buterin and Gavin Wood launched the Ethereum Blockchain, completely revolutionising Blockchain technologies by introducing smart-contracts and thus, expanding the technology’s capabilities beyond traditional cryptocurrencies. Finally in 2017, NFTs were first introduced via ERC-721 tokens with Axe Infinity, the first play-to-earn Blockchain game, being released in March 2018,

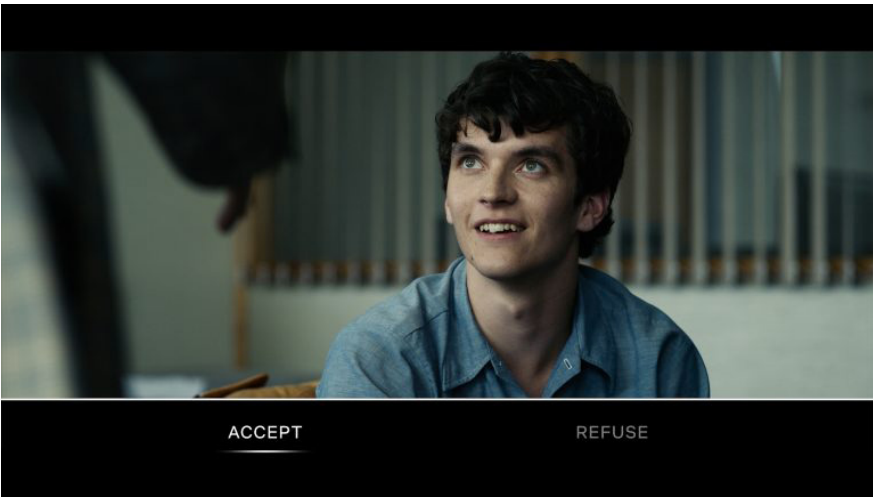
Decentraland was one of the first platforms embarking on the development of digital real estate in 2015, and ultimately becoming publicly accessible in 2020, being a central actor in generating interest in digital ownership of property.

Virtual entertainment broke new ground when Netflix’s Black Mirror: Bandersnatch was released, empowering viewers to shape the storyline’s course by allowing them to create different endings depending on each individual choices [Figure 18]. Assertion of virtual entertainment happened when Fortnite’s first ever virtual concert by Marshmello in 2019 was attended by 10.7 million people, opening the door for similar events on other platforms.⁸

8 Jack Morton. (n.d.). The Metaverse Timeline. Jack Morton.



[Figure 17] - Left
Pokémon Go
(2016) Gameplay



[Figure 18] - Right
Netflix’s Black
Mirror: Bandersnatch
(2018)

The Adoption Era (2019-Present):

As the trajectory of technological progress unfolds and new inventions are practically solving existing problems, the path to adoption is slowly getting unveiled. The current era is characterised by the embracement of all these technologies into our private, social, and professional daily lives.

The COVID-19 global pandemic was a catalyst in virtualising our daily lives, as the global population was obliged to embrace remote routines and virtual social and professional interactions, where adoption of applications like Zoom were adopted at light-speed in an unprecedented way. Unlike in other eras, it is becoming impossible to list all the relevant things being developed in present-day, but a few different directions of development are exposed below.⁹

Amidst the COVID-19 pandemic difficulties in May 2020, Thomas Sulikowski, a 20 year-old founded “Varuna”, a Minecraft design studio charging up to USD 90 000 for custom work, setting path for other people creating their own digital design studios, such as Luca Arrigo founding Metaverse Architects in 2021 or myself founding archi.META in 2022.

9 Patrik Schumacher. (2022, August 17). The Metaverse as Opportunity for Architecture and Society: Design Drivers and Core Competencies. Architectural Intelligence, Tonji University, Springer.

31

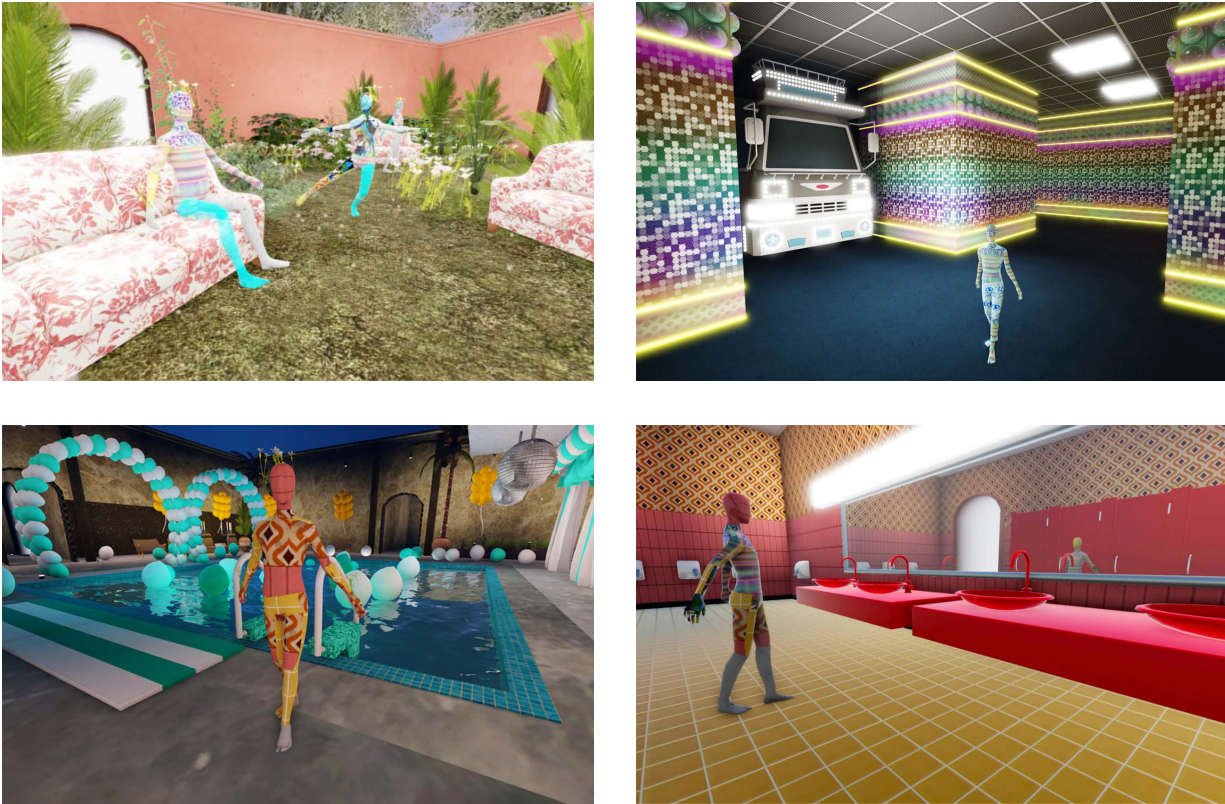
The rise in popularity of NFTs allowed for a new wave of sports fandom and synthetic realities, which can be exemplified when the National Basketball Association (NBA) pioneered a new era of fan engagement by launching their own official NFTs. At the time of writing, many are sports organisations and clubs who have partnerships with crypto platforms, like socios.com to promote fan engagement.

Fashion and interactive immersion in branding has also seen its development in the virtual worlds, as Gucci inaugurated the Gucci Garden in Roblox in May 2021¹⁰ [Figure 19], and many other brands, such as Samsung, are releasing virtual fan experiences, fostering interactive and immersive experiences with the user base.¹¹

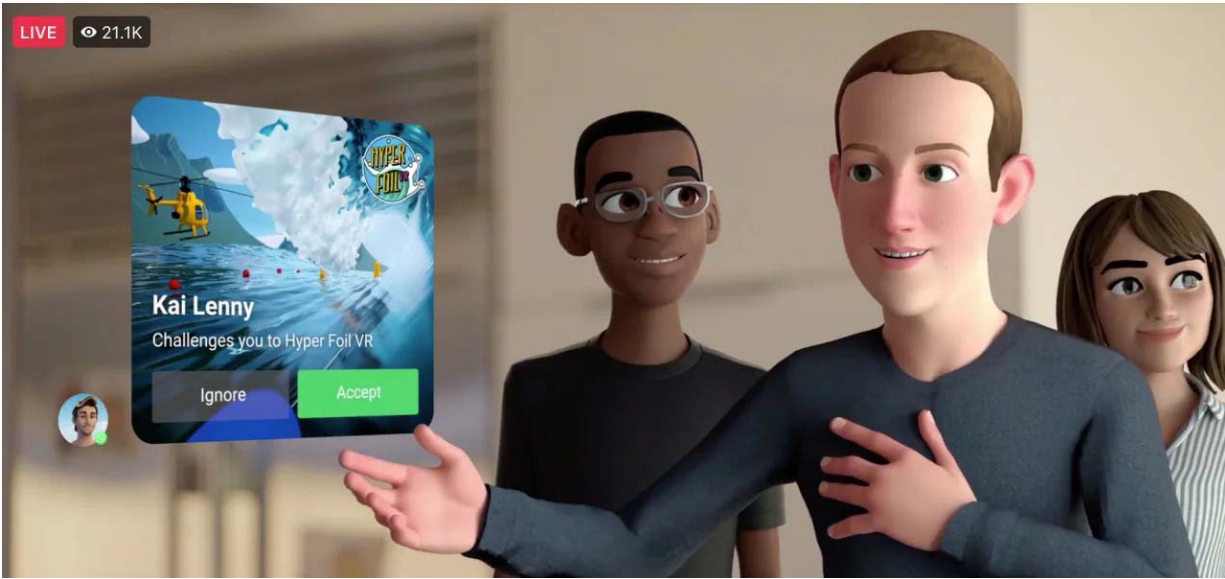
This new era has also seen the rise of AI being used in development of things like Meta Humans Curator, which is a free cloud-based app to generate synthetic humans developed and launched by Epic Games in April 2021.

Boundaries between physical and virtual realities continue to blur, with the creation of visionary insights and real-time analysis, such as with Unity’s Metacast, a real-time (RT3D) technology aimed at capturing and analysing sports in real-time, launched in October 2021; thus, offering a glimpse into how the Metaverse could revolutionise content consumption and engagement.

And overall, we are seeing more and more companies and organisations investing their time in virtual technologies that could be adopted in a Metaverse setting. In May 2021, Google announced Project Starline, allowing users to see 3D video object without headset/goggles’ lenses; and later that year in October, Mark Zuckerberg announced Facebook’s transformation into Meta, shifting the vision from social media as we know them today, to aiming to be a participant in shaping the virtual landscape of tomorrow¹² [Figure 20].



[Figure 19]
Gucci Garden



[Figure 20]
Mark Zuckerberg
and Facebook’s
rebranding to Meta
in October 2021

10 Maghan McDowell. (2021, May 17). Inside Gucci and Roblox’s new virtual world. Vogue Business.
11 Sarah Block. (2023, January 9). Samsung 837x is a Model Metaverse Experience. Influencie.
12 Jack Morton. (n.d.). The Metaverse Timeline. Jack Morton.

34 **Virtual Concepts of Space**

Architecture as a practice can be described as the definition, organising, and construction of physical space, and we as architects are familiar with how different building typologies have evolved not only to address the different environments where those spaces are located, but also how those buildings can address and evoke our spatial senses. However, navigating the cyberworld and webpages at first glance seems to have nothing to do with architecture; but it is the opportunity to transcend from the bidimensional space that dominates the Internet by creating immersive three dimensional environments that bridges these two very different spatial concepts.¹³ With the digitalisation of our lives, a virtual spatial dimension to our lives has been created, and this subchapter seeks to understand and explore different concepts of space that exist in the virtual world where our lives are also located.

The development of the cyberspace ended up to the virtualisation of many of our daily actions and concepts of space; for instance, while in the pre-Internet days, to send a letter, one was required to physically write the content on a piece of paper, put it in an envelope, go to a post office, where the letter would physically be transported to its recipient - the same process nowadays can be replaced by a few clicks on our smartphone screens. Our virtual space is divided into different applications with different functions ranging for instance Slack for work, Instagram for our private and social lives, Twitter/X for news, or Reddit for anonymity. We understand that there are specific online places where we can do and say certain things and divide and distribute our lives accordingly; however, the current User Experience (UX) and User Interface (UI), only offer a flat and non-immersive visual experience, where there is little to no engagement besides the windowed two-dimensional format.

Consequently, it is not unreasonable to believe and expect that many of the aforementioned bidimensional tasks and places on our computer and smartphone screens, might also become

13 John Marx. (2023, September 6). Placemaking in the AI Era. ArchDaily.

available in three dimensional environments in our future Personal Metaverse Immersion Devices (PMIDs) through the means of VR and AR, as we start moving onwards that kind of virtual spacialisation of our lives.

35

Although both AR and VR have already been mentioned several times throughout this dissertation, both of these concepts have not yet been fully explored and explained. Augmented Reality is a term coined in 1990 by Boeing Computer Services Research employee Thomas Caudell, who compared this technology to the head-mounted displays that electricians use when assembling complicated wiring harnesses.¹⁴ In simpler terms, AR can be described as the integration and overlay of digital information with the user’s environment in real time. This technology is primarily used to either visually change natural environments in some way or to provide additional information to its users, altering the user’s perception of the real world.¹⁵

The capturing of AR can be performed in a variety of different ways and formats; the most common nowadays are smartphones, tablets, and glasses, with AR delivered through contact lenses is also being developed. To deliver an augmented environment, hardware components like sensors, accelerometers, global positioning system (GPS), solid-state compasses, or light detection and ranging (LiDAR) lasers might be required, components which, currently any flagship smartphone already possesses.¹⁶

AR has already a wide array of small real world and commercial applications. It first appeared on 27th September 1998, when ESPN introduced a virtual yellow line during a televised American Football match.¹⁷ It has since developed, being present in Google Glass, smartphone games like Pokémon Go, or heads-up displays (HUD) in car windscreens. However, AR technology is also used in industries ranging from healthcare, tourism, or marketing. In architecture, construction, and interior design, AR is so far mostly used to help professionals visualise their final products during the creative process, as it serves as a three-dimensional substitute to traditional methods, like paper or two dimensional screens¹⁸ [Figure 21 & 22].

14 Alexander S. Gillis. (2022, November). Augmented Reality (AR). TechTarget.

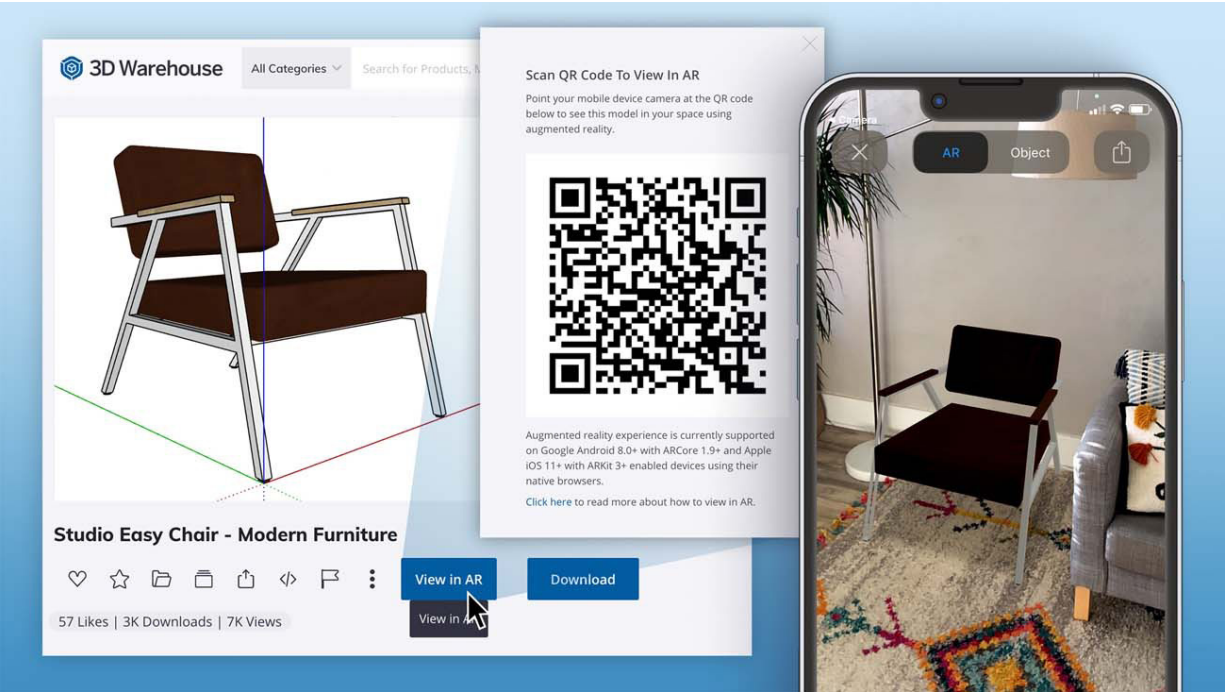
15 Ibidem.

16 Ibidem.

17 Thomas Didier. (2021, January 15). 1998 - Augmented Reality & Football. Atomic Digital Design.

18 James Paine. (2018, May 30). 10 Real Use Cases for Augmented Reality. Inc. Magazine.

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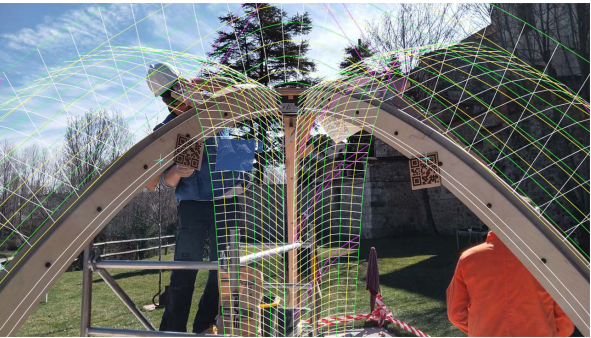


[Figure 21]
Trimble's SketchUp Viewer offering Augmented Reality features for mobile applications.

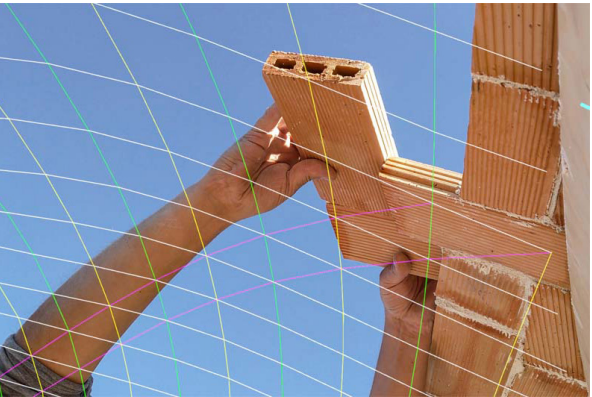
37

On the other hand, and as previously mentioned, VR's inception came to existence in 1966 with Thomas Furness' flight simulator, and the term was first coined in the mid-1980s when Jaron Lanier, founder of VPL Research, began developing gear such as goggles and gloves required to experience VR as we know it today.¹⁹ The actual definition of VR can mainly be attributed to computer generated imagery and hardware which is specifically designed to bring vision and sounds in an immersive way.²⁰ However, there are several different definitions that may also classify VR as non-interactive types of media, such as 3D films, 360 video, and other similar non-interactive "look but do not touch" type of content; and although media like 360 video might not be much different in its functionality to a pre-planned generated VR imagery²¹, for the purposes of this dissertation, it will only be considered interactive and immersive content as actual VR experience.

VR uses headsets as pieces of hardware which require a console, computer, or a smartphone to be slotted in. Depending on the headset, immersion can either use two LCD displays (one per eye) or two different feeds sent to one display, whilst creating a stereoscopic 3D image by angling the two 2D images, mimicking how each of our two eyes sees the world. To create a moving picture in the eyes, the headsets are capable to caption the user's head movement through a system called Six Degrees of Freedom (6DoF), which looks to the head's position in terms of X, Y, and Z axis to measure head movements, through tools like gyroscope, accelerometer, and a magnetometer. And the use of sound coming from behind, next, in front, or in the distance from the user is also used to create a greater sense of immersion. Lastly, some VR headsets have controllers which are used to make the user feel in control and more immersed in their environment, with different input methods that can include voice control, smart gloves, or even treadmills, with buttons or sensors detecting hand gestures such as pointing and waving.²²

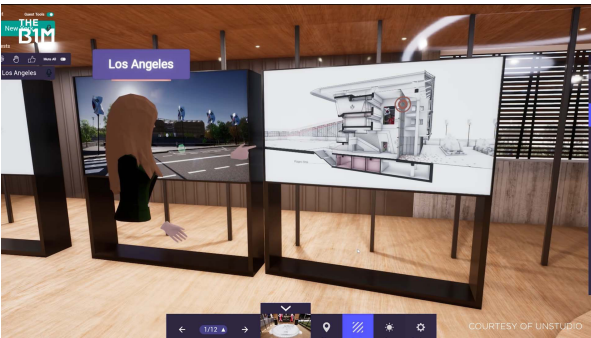
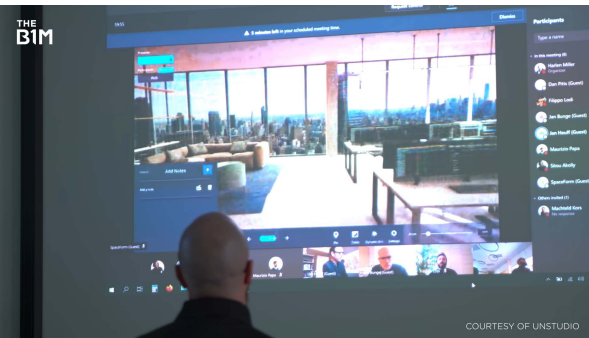


[Figure 22]
"innixAR" is an unreinforced masonry structure in Segovia, Spain, built by researches from IE University, Princeton University, and the University of Bergamo which incorporates vernacular and traditional constructions techniques with Augmented Reality, enhancing craftsmanship without the need for physical guides and temporary molds.



19 History of Virtual Reality. (n.d.). The Franklin Institute.
20 History Of Virtual Reality. (n.d.). Virtual Reality Society.
21 Ibidem.
22 Zaynah Bhanji. (2018, October 2). A New Reality: How VR Actually Works. Medium.

38



[Figure 23]
Use of VR technology and SpaceForm during the design of the Korean National Football Centre, by UNStudio, portraying the project throughout its several design stages, and in different physical and virtual environments.

39

Whilst AR is a feature to improve and facilitate certain aspects of our daily lives, at the end, it is unlikely it will be able to replace our current and traditional ways of living, working, and socialising. On the other hand, VR has got the potential of doing everything AR does, with the addition of challenging the current roles performed by our computer and smartphones' bidimensional screens.

A practical architectural example of a great use case of VR technology is the UNStudio's workflow used to design the Korean National Football Centre. The complex located 85 km south of Seoul will feature two new stadiums, a health and resort facility, museum, training pitches, a youth hostel, and some retail space, spanning a total of 450 000 square metres. UNStudio has used a software called SpaceForm which allows to import the three dimensional model of the architecture project, so that architects and designers can work and view their concepts in VR [Figure 23]. Ben van Berkel, UNStudio's founder and principal architect states that:

*"the most interesting is that you can work with physical build models in architecture because you do that a lot. But then, you cannot really go into the model. The advantage of SpaceForm platform is that you can really go into the model, you can look around, you can step down, you can walk on the field, you can look around, you can see other people moving."*²³

This practical example summarises this subchapter, because at it end, it is not about explaining how the virtual space is organised in our computers and smartphones, neither it is about explaining what AR and VR are; but it is about showing that these things are tools for effective communication and collaboration, getting people from across the world together to either work or socialise together. More and more, there is the need of international teams collaborating in professional projects, remote work is slowly becoming more accepted and demanded by younger generations, and it is a way of staying connected with far away friends and family; and so, even though sometimes it might seem otherwise, but these tools are the human centric approach to a fast-changing and increasingly more digital and virtual world.

²³ Jaden Urbi. (2022, January 26). South Korea's Quest to Build the Future of Football. The B1M.

40 Existing Metaverse Platforms

So far throughout this dissertation the word “Metaverse” is being used as a capitalised proper noun; however, there will probably be no such thing as a single Metaverse, like sometimes it may look like, but many different metaverses (with lower case) developed by several different people and organisations that may or may not be interoperable with each other. Listing and describing all the existing Metaverse platforms, would not only be impossible for this dissertation, but also a pointless exercise, especially because it is likely that tomorrow something new will appear, discontinuing the current platforms, driving them to irrelevance. Therefore, it makes more sense to analyse some intrinsic values of the existing platforms as those aspects will always be carried over, independently of the platform.

First things first, it is unlikely that in the foreseeable future people will be able to possess their own private Metaverses, as such a feat would require extensive programming, maintenance, and energy costs; and so, just like with social media platforms, the Metaverse is being developed by medium to large enterprises who can expect a return on their investment. As a result, it is essential to understand that besides the platforms’ intrinsic characteristics, they can essentially fall under two different umbrellas - a traditional centralised Metaverse, where most traditional video games fall under, and a decentralised Blockchain Metaverse platform that is run on cryptocurrency smart-contracts where virtual economies exist²⁴; aspects which are explained throughout the next chapter: Web3 and Cryptocurrencies.

As explored in the previous subchapter, the Metaverse’s space starts in the bidimensional cyberspace we are already used to. So, it is fair to consider that after the COVID-19 pandemic, conferencing applications like Zoom or Microsoft Teams have become part of our daily lives [Figure 24], either to connect with friends, or for educational and professional environments, with these applications allowing to write and sketch over someone’s screen for better collaboration.

24 Danial Ibrahim. (2023, March 27). Exploring Metaverses: 10 Leading Metaverse Platforms [2023]. The Metaverse Insider.



[Figure 24]
Two dimensional
conference meeting
in Zoom.



[Figure 25]
Immersive three
dimensional VR
conference meeting
in Meta's Horizon
Workrooms.

42

In the last couple of years, fully immersive 3D conferencing platforms like Meta’s Horizon Workroom or Microsoft’s Mesh allow collaboration on a variety of devices, creating fully immersed or mixed-reality environments [Figure 25]; with these types of platforms aiming to deliver their virtual working environments to resemble and feel as close as possible to a real working room. Alex Kipman²⁵ said that - “you can actually feel like you’re in the same place with someone sharing content or you can teleport from different mixed reality devices and be present with people even when you’re not physically together.”²⁶ - something I can personally attest having used Horizon Workroom in the past.

Activity-based immersion, although similar to 3D conferencing platforms, allows full physical immersion for entertainment, education, or professional purposes, where a platform like SpaceForm lets users upload their designs from a 3D modelling software and build real-time, immersive 3D presentations [Figure 23].

Real-time rendering platforms like Spatial or even Twinmotion²⁷ allow the visualisation and exploration of physical spaces and environments through their cloud services where multiple people can be present at once; with or without social interaction between the participants [Figure 26].

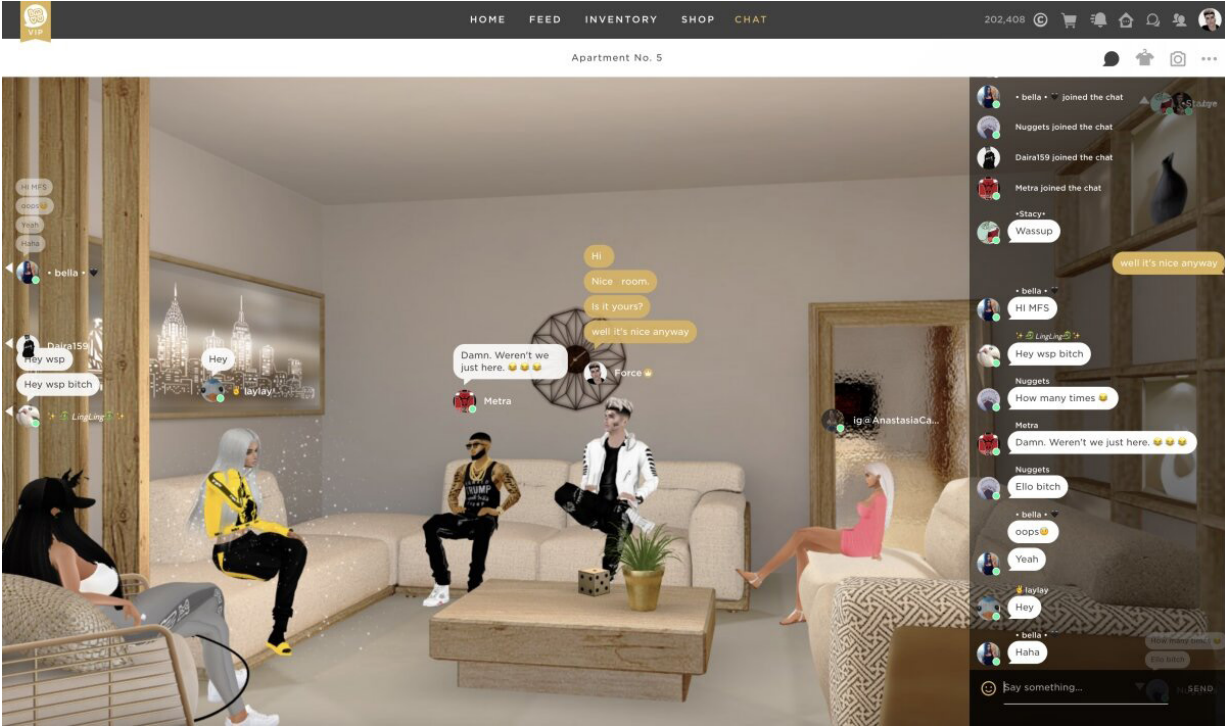
Chat-centred Metaverses like Habbo or IMVU where there is a detachment from the real world to virtual. Even though these platforms may have 3D environments, rooms, shops, and assets created by its users, their essence still revolves around the chat with not much meaning to walk and explore the environment [Figure 27].

25 Alex Kipman worked in the development of Xbox Kinect and was Microsoft’s HoloLens smart glasses lead developer.
26 Tom Warren. (2021, March 2). Microsoft Mesh feels like the virtual future of Microsoft Teams meetings. The Verge.
27 Through Epic Games cloud, it is possible that a maximum of 100 people attend a virtual space exported from Twinmotion, however, as of the day of writing the people are unable to see and interact with each other when entering the environment.



[Figure 26]
Spatial.io

43



[Figure 27]
IMVU

44

Traditional video games and open worlds like Grand Theft Auto can fall under the category of closed development as the entire environment and game goals are defined by their developers and publishers [Figure 3], even if game modding²⁸ is allowed within the environment, as they do not change the game’s fundamentals.

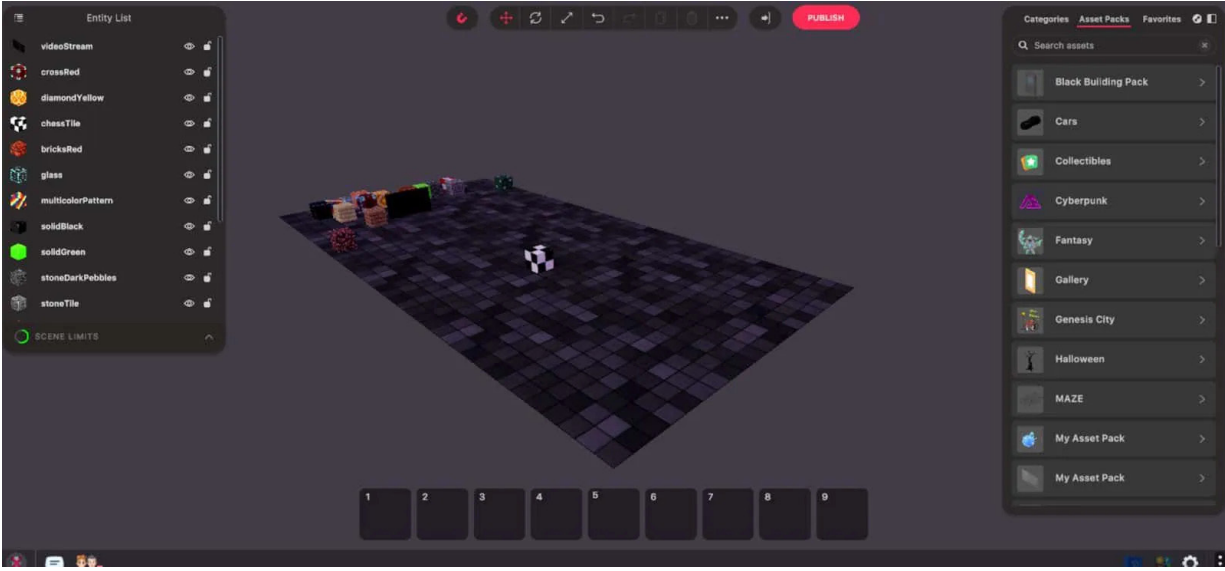
Open Sandbox platforms like Second Life, Mincecraft, Decentraland, The Sandbox, Cryptovoxels, or Roblox, where one can freely build and edit the environment depending on characteristics such as land availability or ownership; but where participants can virtually express themselves to their fullest [Figure 28 & 29].

These are the main identified groups of existing platforms of the Metaverse, and one important aspect to keep in mind is that although these groups categorise and differentiate the existing platform; these platforms may borrow and share characteristics with each other. SpaceForm and Microsoft Mesh can be both used for a professional environment and three dimensional collaboration, but that does not mean that their potential and use cases are equivalent between each other. It is possible that with time new categories will be created, and platforms will shift in their purpose, because neither their nor Metaverse’s development is static. In an utopian world, a truly immersive Metaverse like the one in Snow Crash would encompass all of the above mentioned categories into a single platform - but such reality is still far from existence.

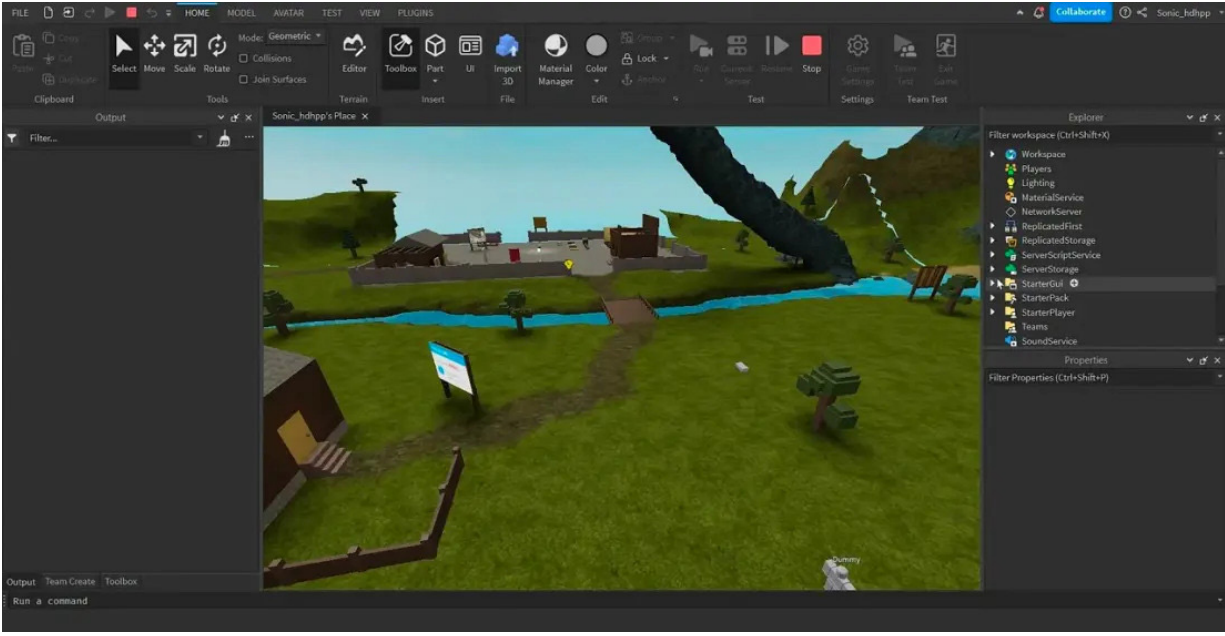
28 Video game modding is the process of altering or enhancing a video game’s content and functionality, oftentimes using custom-made or third-party software tools and assets. The “mods” can create new content and customise existing one; can enhance the graphics of the game; can change the gameplay; fix existing bugs; and can create communities around mod creation and modded content creation in-games, sometimes contributing to a game’s longevity and active user base.

45

[Figure 28]
Decentraland Builder, the game’s built-in 3D editor, which allows to build wearables, scenes, and land, as well as scripting using TypeScript, physics and animations to objects, and UI Design for environments.



[Figure 29]
Roblox Studio allows the creation of games and experiences within Roblox, and it provides a range of tools and features for both beginner and experienced developers and programmers. It is possible to create 3D worlds and environments; scripting in Lua programming language to control the behaviour of objects, characters, and mechanics; asset creation; physics and animations of characters and objects; and UI Design for creating menus, inventory screens, and other in-game displays.



46 Ethical Considerations

Before diving deep about ethical considerations in the Metaverse, it is important to understand that some of these concerns already exist in the regular web of nowadays. Currently, online privacy and big data are the main ethical questions on the Internet, and it is possible that the existence of the Metaverse will raise many more ethical concerns than the ones we are experiencing today.

Online privacy includes several issues concerning what we, as users, expose about ourselves on the web. It ranges from issues like personal data protection involving safeguarding of our private information from unauthorised access, use, or disclosure, things like, names, addresses, or financial data; to the ownership of the data generated by the users and their interaction with online platforms such as social media or e-commerce websites; to encryption of data to prevent eavesdropping and data interception by malicious actors; to transparency and consent about the data being collected by the websites about their users; or about users' data retention policies establishing what can be retained and what are the users' rights to be forgotten.

On addition to our online privacy, the collection of big data also poses risks to our private information, as social media or corporations collect and analyse large and complex datasets from various sources, to provide valuable insights and patterns; and thus, leveraging complex algorithms and machine learning to extract meaningful information which can be used for things like business intelligence, healthcare research, or marketing and user experience personalisation, recommending and promoting products and services based on users' online behaviour and preferences. The collecting and handling of such pieces of information can pose risks when sensitive or personally identifiable information is mishandled or leaked, and therefore, existing a very thin line between deriving insights from data and infringing on an individual's privacy.

47

All the above mentioned issues will also exist in the Metaverse, if not even enhanced as our lives will become even more digital than they are now; and therefore the first ethical concern about the Metaverse is understanding what kind of virtual worlds we will be interacting with. The difference between centralised, decentralised, or mixed-centralisation Metaverses will be explored in next chapter, but from an ethical standpoint it is important to note that there will not be a perfect solution and both of these options have different advantages, disadvantages, and implications and questions regarding power dynamics, governance models, data protection and privacy, all of which are way too complex to analyse in such a short dissertation.

There are many other issues including aspects like the digital divide of the global population, which will not be able to access these kinds of technologies and features, especially where there is lack of digitalisation and digital literacy due to low living standards. Furthermore, content moderation and safety in virtual spaces will play a key role in the Metaverse public spaces as the hate speech, misinformation, harassment, child protection, and cyberbullying we can already observe in many social platforms will only be exacerbated in the future, posing a threat to the mental wellbeing of those visiting these virtual spaces. On this note, it is important to note that the immersion in virtual environments might lead to addiction and mental stress on higher notes than those experienced by video games and regular screen time caused by mobile phones and computers.

Another major issue is being aware, understanding, and adapting to how our personal lives will change from their current state. New forms of interaction and social media will arise, and new economies and jobs which do not exist yet will arise, in a world probably dominated by AI in many aspects.

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Ethical issues in the Metaverse from an architecture and design point of view may revolve around how we live and experience the digital space surrounding us, because it is likely people will spend as much time in VR and AR as today looking at our mobile phone screens. Negative impact as those experienced in the Disney and Pixar’s 2008 film WALL-E, where people suffer from physical and mental issues related to not being able to leave the comfort of a digital environment [Figure 30 & 31]. Therefore, as artists, designers, and architects, we end up playing a role in how people will be living and experiencing many of these virtual spaces, even if we do not know yet which direction we are moving towards. And finally, it is also important to keep in mind that a new array of intellectual property and ownership will be brought into question for artists and everyone developing virtual twins of real life assets, spaces, and buildings.²⁹

All in all, when studying at the school of architecture, everytime I would bring the issue of the Metaverse to my friends and colleagues, the biggest discussions coming out from it would be the ethical implications of the Metaverse, and not all the buildings and AR/VR gadgets I would show my friends; it is because of those discussions that a small sub-chapter about these ethical implications is important. We have spent hours discussing tradition and the future, where technology is heading, and how we have little to no control where we are heading. It is probably silly to reject the notions and ideas of an upcoming Metaverse, as it is probably silly to believe the day the scenarios described in this dissertation will not be coming to life and become reality and the norm for our private, social, and professional lives. And therefore, being aware, prepared, and identifying and understanding how these developments will impact our lives is fundamental so that, we, as potential creators for this future universe, can create projects and platforms where meaningful interactions can be developed; because at the end of the day, if we do not think and work with ethical considerations in mind, someone always will in our place for us.

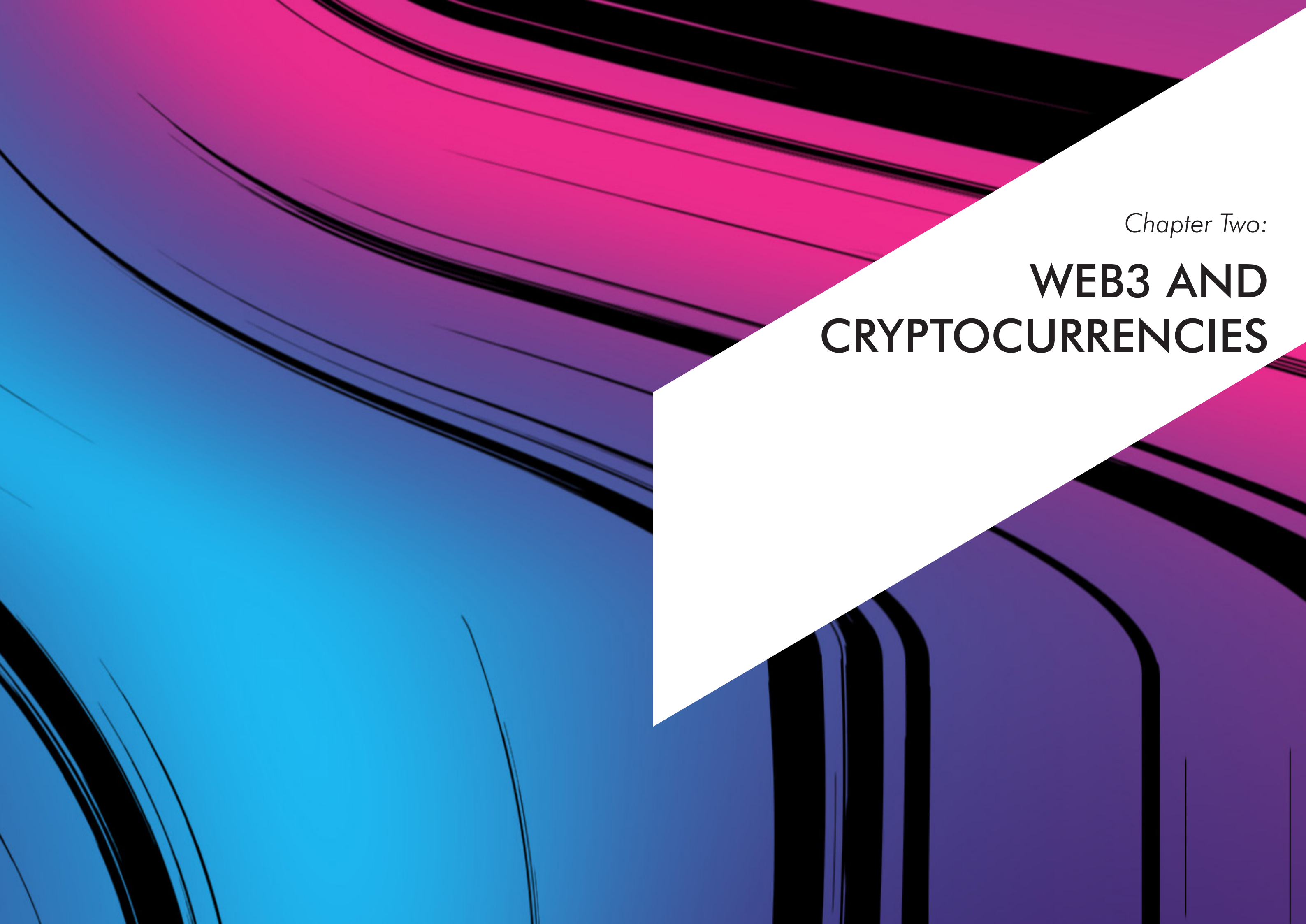
²⁹ Merav Ozair. (2022, September 6). The Value Implications of Ethics in The Metaverse. Nasdaq.



49



[Figure 30 & 31]
Scenes from Walt
Disney and Pixar’s
film: WALL-E (2008)



Chapter Two:

WEB3 AND CRYPTOCURRENCIES

The invention of the modern computer and the Internet have entirely revolutionised our world in the last decades. In the 21st century we live in a world where all the information is accessible in our pockets and we are connected to people wherever they may be in the world.

Some might think that the Web has always been the same. However, it has not; and the World Wide Web (WWW) has had several different transformations since its conception in the early 1990s. There is no rigid line where one can see the changes between the different kinds of webs throughout the years, but it is impossible to observe that the dynamics of the Web are shifting and the way we use the Internet in our daily lives keeps on changing with the passing years.

It is possible to break the Web’s history into these loose periods - Web 1.0 and Web 2.0, as well as a new period which we are entering now - the Web3.³⁰

Created in 1989, Web 1.0 was a read-only Web without any kind of social interaction between its users, very few content creators who generally also owned their content due to its unilateral and inflexible websiting structure.³¹ The whole Web was divided into linked directories and websites and content in the first Web were all about static HTML pages, with features like GIF buttons in websites.³²

30 Ethereum Foundation. (2023, March 3). Introduction to Web3.
31 Ganesh Viswanathan, Punit Dutt Mathur, & Pradeep Yammiyavar. (2010). From Web 1.0 to Web 2.0 and beyond: Reviewing usability heuristic criteria taking music sites as case studies. Page 1
32 Ibidem. Page 2

54 Social Media platforms arising from 2004 onwards have transitioned the Web into its second stage. Web 2.0 encourages social interactions through content creation and engagement³³, which was allowed by the rise of Flash applications, where users are presented with an altogether different web experience, immersing themselves into the content they are consuming. This transformed the role of passive recipients into active contributors and producers of information, changing the overall behaviours and demands from the Web.³⁴

The second generation of the Web is also characterised by the rise of the smartphone and mobile applications that heavily changed how we, as society, live, interact, and portray our daily lives; as social media platforms encourage their users to generate content, interact with other users, and advertise their media.

A final important distinguishing aspect between Web 1.0 and 2.0 websites, is that, whilst websites like Ebay or Amazon were created during the Web 1.0 era; these websites later developed into multi-billion dollar companies with complex management structures and strategies. Moreover, Web 2.0 also allowed individuals who do not have the need of creating their websites with complex managing structures and strategies (which are expensive to create and maintain) to profit from their own content creation using inexpensive tools and software.

The invention of the Web ultimately changed how we connect and interact with the world around us. However, Web 2.0 applications and companies creating those applications also made it easier to create an environment where government surveillance and user data selling was made easier than ever before.

Web3 is thus created upon the notion that the Web needs privacy and anonymity, hence using protocols that can work autonomously without the need of an application overseeing and monitoring users’ activity. This privacy and anonymity can be achieved through cryptocurren-
cies and smart-contracts, which are explained more in detail a little bit down the road.

The Difference between Web 3.0 and Web3 55

Before moving onwards, it is necessary to distinguish Web 3.0 and Web3 because despite these terms being oftentimes used interchangeably, they do not mean the exact same thing; and Web 3.0 is rather irrelevant for this dissertation besides explaining this terminology difference.

Web 3.0 is the term referring to the vision of the Semantic Web, which is an important piece of infrastructure that allows the development of a Web where web data is more structured and machine-readable, thus allowing for more intelligent automation and personalised user experiences.

A small example of what the Semantic Web will bring to everyday life is the increasing number of websites automatically adding semantic data to their pages to boost search engine results, contract intelligence, building digital twins, or the use of Artificial Intelligence (AI) to assist human work.³⁵ With this dissertation being written between 2022 and 2023, we are already witnessing that happening with the rise in popularity of software like ChatGPT.³⁶

The term Web3 is however, referred to the third generation of the Web, being characterised by the emergence of decentralised technology, like the blockchain - which make cryptocur-
rencies and decentralised applications (dApps) possible. It encompasses a wide range of concepts and technologies, some briefly explained in the upcoming pages; but Web3’s main goal is to create a more decentralised, anonymous, and secure Internet.

33 Ganesh Viswanathan, Punit Dutt Mathur, & Pradeep Yammiyavar. (2010). From Web 1.0 to Web 2.0 and beyond: Reviewing usability heuristic criteria taking music sites as case studies. Page 1
34 Ibidem. Page 3

35 George Lawton. (2023, January). Semantic Web.
36 Krystal Hu. (2023, February 2). ChatGPT sets record for fastest-growing user base - analyst note. Reuters.

Whilst Web 1.0 and Web 2.0 were the Webs where one could read-only and read-write the content, respectively; Web3 is the Web that allows one to read, write, and own their content [Figure 32]. The current Web heavily “relies on trusting a handful of private companies to act in the public’s best interests.”³⁷

Surfing the second generation Web requires trusting big companies like Meta/Facebook, Amazon, or Google with your data, which can be selling one’s data either to advertisers or to governmental agencies for surveillance.³⁸ Nowadays, all kinds of content that are being produced rely on these companies’ platforms (Facebook, Instagram, Youtube, Twitter/X, etc.) to be published and getting monetised by its creators. Generally speaking, a company or an individual will not meet much monetisation success if they decide to produce content on a platform where there is not a large audience to begin with.

As of the time of writing, it is challenging to set a clear definition of everything that encompasses Web3, but there are some core principles and concepts guiding its development:

- Decentralisation from big entities that control large swathes of the Internet, allowing that content gets created and distributed through creators and users, without the need of a hosting platform;
- Permissionless environment where every individual has equal and/or equitable access to participate in decision-making processes according to their share;
- Native payment system, using cryptocurrency relying on smart-contracts, instead of relying on traditional hosting banking platforms and payment processors;
- Trustlessness by operating smart-contracts not only for payments, but also for other types of agreements and mechanisms where there is a need to rely on third-parties nowadays.³⁹

37 Ethereum Foundation. (2023, March 3). Introduction to Web3.
38 Shira Ovide. (2021, June 14). Government Surveillance by Data: We should be able to use a dating app without fear of winding up in a military database. The New York Times.
39 Ethereum Foundation. (2023, March 3). Introduction to Web3.

[Figure 32]
Key visual differences
between user
authentication in
the different webs.



Other concepts that could help guide and build in the Web3 can also include machine-readable data; intelligent automation (personalised recommendations, chatbots, and intelligent search engines); personalisation of content and experiences; or interoperability of different platforms through open standards like APIs, or interoperable protocols and bridges.

As Tom Scott doesn’t know where on the Sigmoid Curve we are regarding AI⁴⁰, there is also no way of knowing where on that Curve we are regarding Web3 adoption and all the technologies it encompasses. Any answer at this point is, no more than a guess, and the best one could do is to make as educated of a guess as possible.

While still in its early stages, Web3 has the potential to transform many aspects of the digital landscape and create new opportunities for innovation and growth, by aiming to create a more open, decentralised and intelligent Web. It already represents a significant shift from the current Web paradigm, which is dominated by centralised platforms and data silos.

40 Tom Scott. (2023, February 13). I tried using AI. It scared me. YouTube.

58 **Digital Currencies, Virtual Currencies, and Cryptocurrencies**

In the present day, most of the existing money in circulation is digital, with banks and financial institutions holding little money compared to their list of transactions. With the rise of the Internet, it is no surprise, financial markets and instruments also became digital.

Furthermore, we live in a world where fiat currencies are the standard of our economy. Unlike previous times in history where money was backed by a commodity like gold or silver, fiat money is solely a government-issued currency that is not backed by a physical commodity. Therefore, the value of the currency is derived from trusting the money has got value, the relationship between supply and demand, and the stability of the issuing government, rather than a physical commodity backing its price.⁴¹

It is important to distinguish digital currencies and virtual currencies. Virtual money is in most cases a result of gamification. It can be seen in games like Monopoly (which currency is the most printed in the world), where there is no value outside the game. With the rise of gaming, virtual worlds, and digital collectibles, it is becoming harder to understand where the separation lines draw, as many virtual goods have enough supply and demand to keep their price rising.

There are three types of different virtual currency schemes: closed, unidirectional, and 59 directional:

- Closed virtual currencies have existed for ages, and we can imagine them as any in-game currency that can be earned and traded within the game or platform. It generally has no implication to the outside world in any regard. One generally cannot exchange this currency with other people, and its earning is generally created by the player’s own progression within the game.
- Unidirectional flow is when the in-game currency can be bought with real world tangible money, but it cannot be transacted back into real cash, and generally cannot be transacted between different persons. It creates a recurrent cashflow to the game developers/publisher, being a source of income. Microtransactions within a game giving bonus or benefits to a player are generally a great example of such unidirectionality.
- Directional flow is when the money can freely roam to a game/platform, transacted between individuals, and converted back to real world tangible cash, without any kind of restrictions. Currently, this kind of directionality and interoperability is usually only possible to achieve through the use of cryptocurrencies and all the structures surrounding them.

⁴¹ James Chen. (2023, July 5). Fiat Money: What It Is, How It Works, Example, Pros & Cons. Investopedia.

Cryptocurrencies are digital or virtual currencies based on cryptographic hash that allows two parties to send and exchange value from one end to another. Cryptocurrencies fall under the European Banking Authority’s definition of a virtual currency as “a digital representation of value that is neither issued by a central bank or a public authority, nor necessarily attached to a fiat currency, but it accepted by natural or legal persons as a means of payment and can be transferred, stored or traded electronically. The main actors are users, exchanges, trade platforms, inventors, and e-wallet providers.”⁴²

Originally conceived as a replacement for the fiat currencies issued by central banks, nowadays, many existing cryptocurrencies do not fit most accepted definitions of currencies or money in the formal economy - at least in most countries, with few exceptions like El Salvador⁴³ - being too volatile to function as a store of value. Instead, many governments and institutions categorise them as financial assets or securities, hence sometimes being described as “crypto assets” - a definition rejected by the author of this dissertation to any form of fungible cryptocurrency.⁴⁴

There are several kinds of different cryptocurrencies. Most people think of Bitcoin (BTC) when talking about cryptocurrencies as it was the first to appear and it is probably the simplest in its functioning to understand. In a nutshell, these currencies use a cryptographic hash to ensure it is possible to make a secure transaction from one person to another, without the need of a financial institution as a middleman to process that said transaction⁴⁵, hence being decentralised.

42 European Banking Authority. (2014, July 4). EBA Opinion on ‘virtual currencies’.

43 Henri Arslanian, Robert Donovan, Matthew Blumenfeld, Anthony Zamore, Davide Di Stefano, Emanuele Coscia, & Gabriel Simion. (2021, October). El Salvador’s law: a meaningful test for Bitcoin. pwc.com.

44 Sam Gilbert. (2022, March). Crypto, web3, and the Metaverse. Bennett Institute for Public Policy. Page 1 & 2.

45 Grant Sanderson (3Blue1Brown). (2017, July 7). But how does bitcoin actually work? YouTube.

Since the invention of the Web, there have been many attempts to create digital and virtual coins and currencies, such as Flooz, Beenz, or DigiCash, but all of them failed⁴⁶, especially because they were centralised, were not secure and encrypted enough, and had very little use cases.

The decentralisation and the removal of middlemen is possible via Blockchain. In simple terms, the Blockchain, is a bunch of blocks containing data, namely a list of transactions, thus creating a collection of records. Blocks have limited capacity and when they are full, they are added to the network containing all the other past transactions.

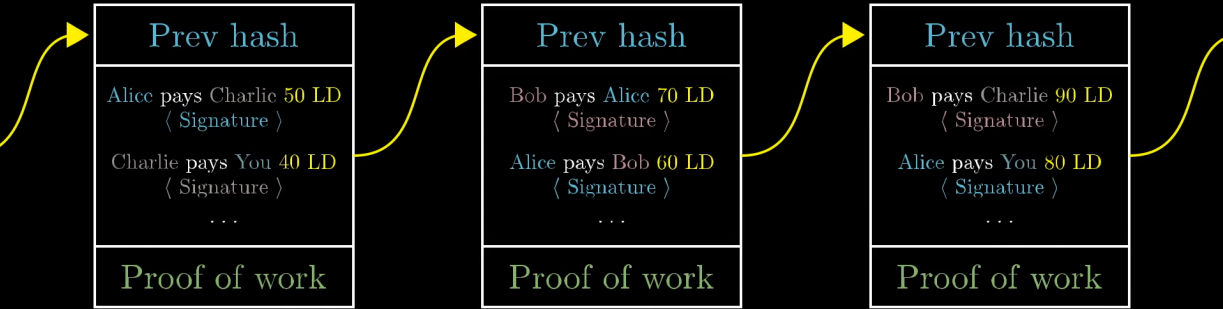
The process of moving into the next block is called ‘mining’ and it is a process done by ‘miners’ who are responsible for solving a function hash which completes the present block. The mechanism of proving miners have done their work by mining a block through a hashing function, makes the coin proof-of-work (PoW).

Whoever solves the hashing function of a block, completing all the block’s transactions gets a monetary reward to start the next block in the network, with a new hash tying to the previous block, hence making all the blocks connected to each other in a chain - the Blockchain [Figure 33].

This cryptographic mechanism makes it so no transactions can ever be undone and where it becomes practically impossible to hijack a network as it would require at least 50% plus one of processing power of the network; therefore, making the Blockchain an extremely secure mechanism for any kind of decentralised transactions⁴⁷ [Figure 34].

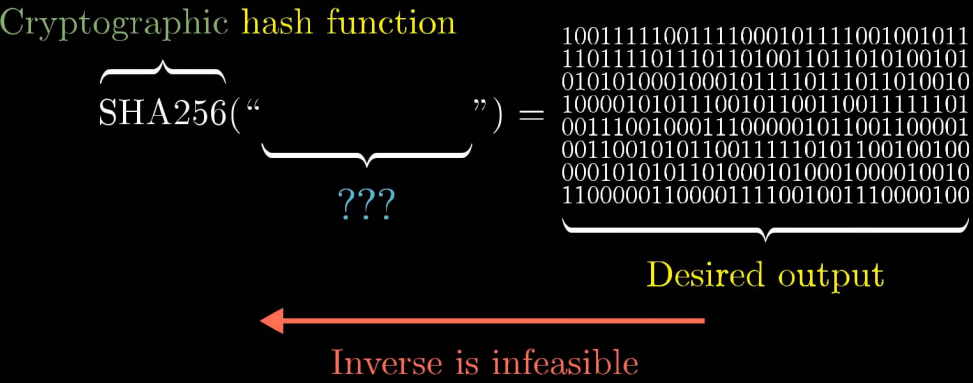
46 Stan Higgins. (2014, November 30). 3 Pre-Bitcoin Virtual Currencies That Bit the Dust. CoinDesk.

47 Whiteboard Crypto. (2021, April 26). What is a Blockchain? (Animated + Examples). YouTube.



SHA256(“Guess #2”) =

11101101011010100111110011011010
00010001111010000001011100100001
0101111010111000111110110111100
11111001001011001111011001000011
10111011111011001010111010111001
01001101000110000011000101001111
01010110010101000000011101001100
100111010011101010110000000101



Although not the most relevant aspect to this dissertation, it deserves a paragraph acknowledging that there are other cryptocurrencies that do not use a PoW mechanism nor a Blockchain in their transaction records and processing, which in turn, means there is no need for miners whatsoever. In 2020, Ethereum (ETH) went from PoW to Proof-of-Stake (PoS) consensus, where block creators are called ‘validators’. A validator checks transactions, verifies activity, votes on outcomes, and maintains records; and to become a validator, one needs to own enough equity of a said currency - owning a small stake.⁴⁸ There are other currencies, such as IOTA that do not use Blockchain at all, instead, use a mechanism called Directed Acyclic Graphs (DAGs) that consist of vertices and edges, and therefore, triangulating the transactions of the network by referencing to previous transactions so that they get accepted into the network.⁴⁹

[Figure 33] Graphical explanation of how a PoW Blockchain, like Bitcoin works.

Lastly, it is important to bear in mind that several governments around the world have been studying the implementation of digital forms of fiat currency, also known as Central Bank Digital Currencies (CBDCs), which may be based on a Blockchain, but will likely be centralised. The CBDC debate and its eventual implementation has been a heated debate between economists, law makers, politicians, and privacy advocates, as CBDCs might pose a threat in the future if the money we own is directly susceptible to the control of central banks and governments.⁵⁰⁵¹

[Figure 34] In order to confirm its digital signatures and verify blocks on the Blockchain, Bitcoin uses the SHA-256 cryptographic hash function. Therefore, if one wanted to break a given piece of security, they would need to guess a specific string of 256 bits, which translates to 2²⁵⁶ guesses. This number is so far from removed from reality that makes it virtuality impossible for any kind of existing computer randomly guessing that number.

48 Jake Frankenfield. (2023, May 31). What Does Proof-of-Stake (PoS) Mean in Crypto? Investopedia.
49 CoinMarketCap. (n.d.). Directed Acyclic Graph (DAG). CoinMarketCap.
50 Shobhit Seth. (2023, April 18). What Is a Central Bank Digital Currency (CBDC)? Investopedia.
51 Stefano Leucci. (n.d.). Central Bank Digital Currency. European Data Protection Supervisor.

The term “smart contract” was first introduced by computer scientist and cryptographer Nick Szabo defining it as a new way to formalise relationships in the digital revolution, because these are contracts that are more functional than their inanimate paper-based ancestors. Therefore, a smart-contract being a set of premises, specified in digital form, including protocols within which the parties perform on these promises.⁵² Szabo’s example is a vending machine, where a purchaser satisfying the conditions of the “contract” (i.e., inserting money into the machine) the machine automatically honours the terms of the unwritten agreement and delivers the snack.⁵³

Simplifying, smart-contracts are self-executing pieces of code with pre-agreed terms and conditions, which are visible and accessible to everyone on the Blockchain. Once a smart-contract is deployed on the chain, it runs autonomously and cannot be altered by any party.

Moreover, smart-contracts besides allowing monetary transactions, also allow the construction of infrastructure carrying information on top of its chain, with many different purposes, and therefore enabling the creation of things like - Decentralised Applications (dApps); Decentralised Finance (DeFi) and Decentralised Exchanges (DEXs); Decentralised Autonomous Organisations (DAOs); Decentralised Oracles; Governance; Storage; Supply Chain Management; Identity and Authentication; as well as tokenisation of assets and powering gaming and virtual worlds; as well as Non-Fungible Tokens (NFTs).

⁵² Nick Szabo. (1996). Smart Contracts: Building Blocks for Digital Markets.
⁵³ Stuart D. Levi, & Alex B. Lipton. (2018, May 26). An Introduction to Smart Contracts and Their Potential and Inherent Limitations. Harvard Law School Forum on Corporate Governance.

Nevertheless, smart-contracts do not come with its downsides and difficulties in adoption, such as the lack of standardisation across different networks and chains resulting in many infrastructure not being interoperable with each other. Furthermore, to establish and to execute a smart-contract on a blockchain, one incurs fees that are also known as ‘gas’, which are paid in order to process the said contract into the Blockchain. High gas fees lead to scalability issues as it congestions the network with too many transactions. These issues can be solved by creating a second layer, or Layer 2 (L2), to the main Blockchain network, Layer 1 (L1); where it is possible to have faster processing times and lower gas fees or transferring assets between L1 and L2⁵⁴ - an example of a L2 solution is the Polygon network.

⁵⁴ Oskar Hurme. (2023, January 19). A Starter Guide to Understanding Layer 2 Blockchains. BlockSpaces.

66 **Non-Fungible Tokens (NFTs)**

According to the Merriam Webster online dictionary, ‘fungible’ can be defined as “something (such as money or a commodity) of such a nature that one part or quantity may be replaced by another equal part or quantity in paying a debt or settling an account”

Therefore, we can define ‘fungibility’ in cryptocurrency as any piece of a coin that is equal to another; for instance, ETH 1 will always be worth and look exactly like any other piece of ETH 1. Thus, NFTs can be defined as any pieces of information on the Blockchain that are unique in their characteristics and metadata from any other pieces of information in the same Blockchain.

NFTs were massively hyped in late 2021 and early 2022, and it is possible to find countless articles and videos questioning and justifying why people were spending ludicrous amounts of money on JPEG files, just like the one footnoted below.⁵⁵ However, these articles and many critics treat NFTs like a bunch of pixels on your device’s screen, completely disregarding their intrinsic technology behind it. In consequence, one needs to mention smart-contract’s token standards to better understand what NFTs truly are.

Ethereum Request for Comments (ERC) standards are a set of technical standards that are a crucial component of the Ethereum Blockchain ecosystem as they provide a set of guidelines and specifications for creating, implementing, and managing smart-contracts, tokens, and other blockchain-based applications on the Ethereum network.⁵⁶

55 Daniel Van Boom. (2022, January 13). NFTs explained: Why people spend millions of dollars on JPEGs. CNET.
56 The Ultimate List of all ERC Token Standards in 2023. (n.d.). Web3 Jobs.
57 Ibidem.
58 Ibidem.

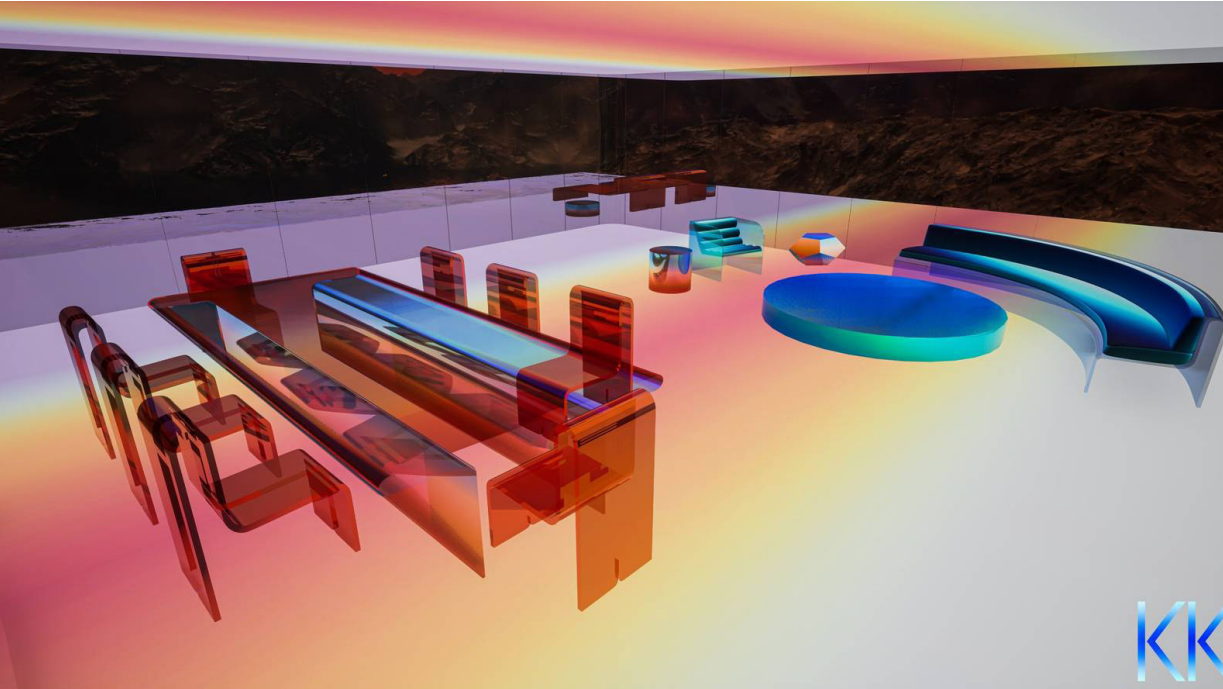
There are several types of ERC standards. ERC-20 is the most widely used and popular standard and it is used to create fungible cryptocurrency tokens such as ETH, Chainlink (LINK), or Uniswap (UNI). Its rules allow the smart-contracts to check a token balance, sending tokens from one address to another, or approve or authorise a third party to spend tokens on behalf of an address.⁵⁷

Moreover, there are dozens of different ERC standards, but besides the aforementioned standard, ERC-721 is the token standard establishing non-fungible token contracts, making it unique and non-interchangeable. Therefore, each NFT is represented by a set of metadata identifying it which can have associated things like a name, description, or an image; making the NFTs pieces of code that can be owned, easily verifiable, and transferred between individuals.⁵⁸

Other types of ERC standards are constantly being developed and improved. For instance ERC-4907 is an extension of the EIP-721 protocol⁵⁹, which in practice allows the renting of NFTs through the creation of time-limited permissions of the token.⁶⁰

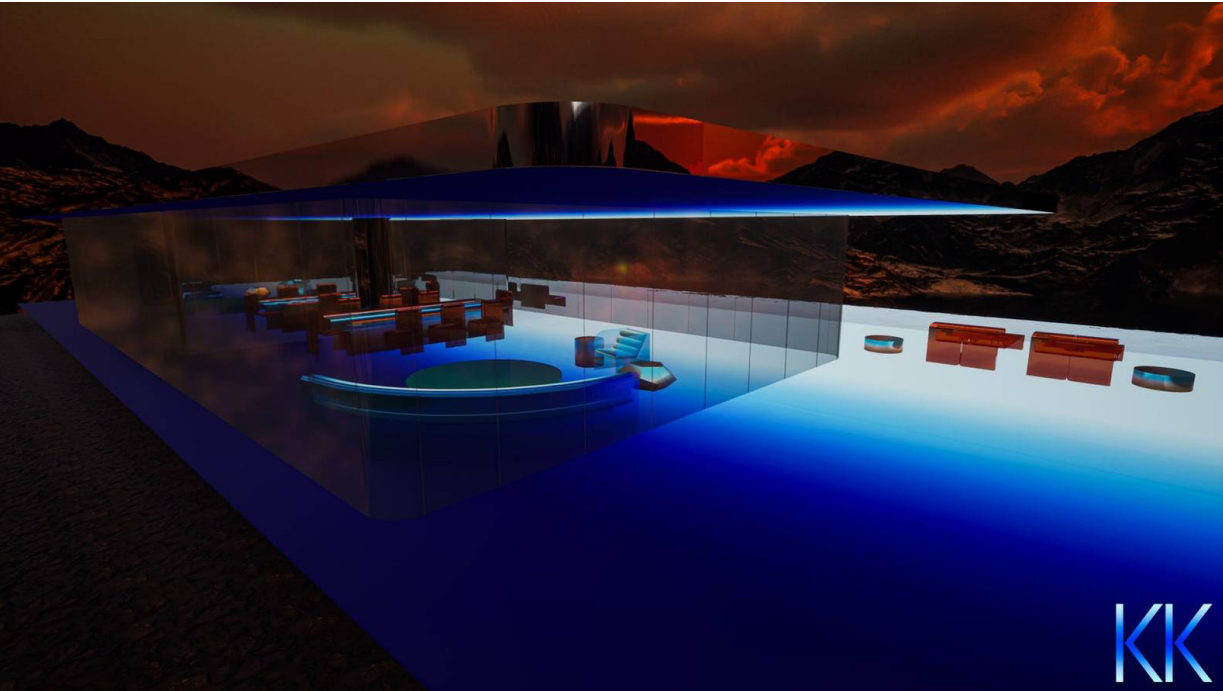
Nowadays, the use cases for NFTs range from things like royalties, event ticketing and invoices, supply chain management, art and collectibles, Web3 identification and authentication, or tying real-world items to the blockchain such as real estate, cars, or legal documents.⁶¹ Enumerating all the use cases for NFTs would be almost an endless list and certainly just a small fraction of possibilities was mentioned.

59 EIP stands for Ethereum Improvement Protocol. Whilst ERC standards define a set of rules and guidelines for implementing a specific type of functionality or feature on the Ethereum blockchain; EIPs are proposals suggesting changes, enhancement, or improvements to the Ethereum protocol itself, and they can cover a wide range of issues going from technical specifications, network upgrades, or governance changes. EIPs are used to discuss and document proposed changes to the Ethereum blockchain, allowing developers, key actors and stakeholders, and the community itself to provide feedback, collaborate, and review on these proposals before they get implemented.



[Figure 35 & 36]
Mars House by artist Krista Kim, designed in May 2020, and sold for ETH 288 on 17th March 2021, was the first digital NFT home to be sold in the world. The 3D digital file can be experienced both in VR and AR.

The house's structure is a light structure, with LED substrate extending to the pool, throughout the entire perimeter of the house, with all the furniture pieces designed with tempered glass and fabrics, thus creating a healing atmosphere accompanied by the musicality of Jeff Schroeder of The Smashing Pumpkins.



"Conceptually, MARS HOUSE is NFT 2.0 for our future AR and Metaverse lifestyle. This is where we are headed, curating our AR environments with digital 3D NFTs that we love. I want to sit in MH with friends in AR and drink Champagne. I want to have my zoom meetings in Mars House. I will eventually be able to transpose MH over my physical environment whenever I fancy. I created Mars House because it is my dream house. I hope the new owner will love it like I do. This is the future of ART"

– Krista Kim

How does all this matter for the Metaverse? 69

As previously stated, Metaverse is a term coined long before the existence of any cryptocurrencies and Web3 technology, and both the Metaverse and the new age of the Internet are not intrinsically tied to each other. However, there are currently many examples of companies and start-ups of the likes of Sandbox, Decentraland, Spatial, or Metamundo using Web3 technology - cryptocurrencies; NFTs; decentralised governance, etc - in their Metaverse projects.

These companies are doing so, because the Metaverse is currently in the same state as the Internet in the mid-1990s. Today, there is not a Metaverse, but a whole set of promometaverses, with the aforementioned companies aspiring to develop the Metaverse. However, so far they are building non-interoperable proprietary platforms, making it impossible to exchange virtual assets or even to communicate between different platforms. It is argued that with no interoperability there will be no Metaverse; instead video games as the ones we have today with more complex social and economic dynamics.⁶²

There is little doubt that interoperability is one of the factors that will impact how the Metaverse is developed in the upcoming decade. Currently, there is tension between vendors and users - on one hand, vendors expect a return on investment and therefore the companies developing the Metaverse platforms are pushing for non-interoperable platforms. On the other hand, users, and brands will be the ones benefiting the most from having an interoperable Metaverse from a user and advertising perspective.⁶³

60 @0xanders (GitHub Profile), @LanceSnow (GitHub Profile), & shrug@emojidao.org. (2022, March 11). ERC-4907: Rental NFT, an Extension of EIP-721," Ethereum Improvement Proposals, no. 4907.
61 Ellen Glover. (2022, December 19). 10 Popular NFT Use Cases. Built In.

62 Albert Meige, Juan Abascal, Rick Eagar, & Michael Papadopoulos. (2022, September). The Metaverse: beyond fantasy. Blue Shift by Arthur D. Little. Page 33.
63 Ibidem. Page 33

As mentioned in “Charting the Metaverse”, the Metaverse is arguably the fusion of the Internet, social media, our digital lives, and gaming, into one single and interoperable space. Currently, the development of Web3 decentralised technologies and applications like NFTs, bring that dream of a future interoperable digital world a little closer to reality.

So far, NFTs have played a role in consumer awareness of Web3 through the selling of digital artworks and collectibles⁶⁴ [Figure 35 & 36]; however, the front-end of the entire Web3 (ranging from wallets to DeFi) is still clunky and very little user friendly, being hard to navigate for non-tech savvy people, and therefore, adoption in this realm is slower than some investors and project shillers seem to project.

Despite its difficulties and slow general adoption, the advance of Web3 applications and technologies in a Metaverse based Internet will also enable the creator economy. This new economy presents a transformative shift in how creators, artists, influencers, and content producers can monetise their work, engage with their audiences, and build online businesses, by adopting the use of cryptocurrencies, NFTs, and DeFi mechanisms, without Web 2.0 intermediaries like Youtube or Twitch taking a significant cut out from the creators.

A further analysis regarding creator economy can be found in the Fourth Chapter of this dissertation. As architects and artists, most of us will never learn any programming, and therefore, the creator economy will probably be our main source of revenue in the Metaverse and in the Internet dominated by AI, where literally anyone will be able to design buildings and cities as good as any qualified architect with only a few clicks.

⁶⁴ Sam Gilbert. (2022, March). Crypto, web3, and the Metaverse. Bennett Institute for Public Policy. Page 7.

All in all, to summarise this second chapter, we are starting to gain the notion that there are two (or three) possible kinds of Metaverses - a centralised and a decentralised one, and an additional hybrid metaverse with features from both approaches.

In a centralised Metaverse, the place is owned and controlled by a central entity, company, developer, or publisher, having the authority over the rules, governance, content, monetisation, data storage, and updates to this virtual world, where interoperability with other platforms may be limited or non-existent.

A decentralised Metaverse takes the opposite approach regarding its rules, governance, content, monetisation, data storage, and updates.

Lastly, an hybrid Metaverse approach could blend and integrate elements from both centralised and decentralised worlds, by combining the benefits of both models, and thus, enabling characteristics of collective governance whilst keeping aspects of centralised control. And ultimately, the decision between a centralised and a decentralised Metaverse shall depend on the goals, values, and priorities of the creators, users, and investors.



Chapter Three:

CONSIDERATIONS ABOUT ARCHITECTURE IN THE METAVERSE

For most of the architecture’s history, drafting and planning the construction of buildings has been a two-dimensional process using plans, cross-sections, and elevations, with more or less detail depending on the project’s stage. Even with the invention of the computer, these processes remained almost untouched for decades with the use of two-dimensional software like Autodesk’s AutoCAD, due to the fact that three-dimensional design is too hardware demanding with specialised software not always being able to draw exactly what we are envisioning. Although we as architects, together with our collaborators are slowly moving towards three-dimensional design and Building Information Model (BIM) techniques, we are still far from creating authentic digital twins of reality due to the fact it is almost impossible to handle and process all the information.

Building in the real world is different from designing and building in a software, and designing a space for a virtual environment is different from designing a building meant to be built in the real world. Therefore, this subchapter seeks to explore some of the differences between all these design and building processes of spaces.

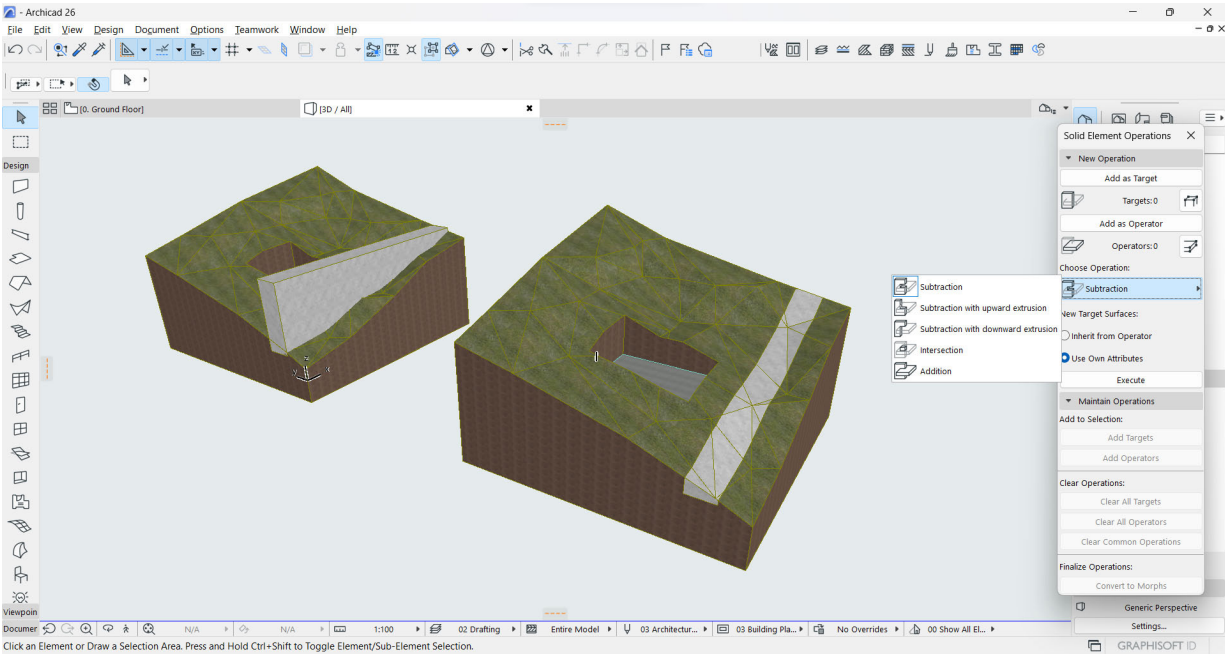
The main consideration one must start by having is the software, because it will influence the way a building is designed, either due to its own limitations or due to our own capabilities handling that software. In the present day many still envision their creations with pens and paper, but transforming buildings from ideas in the head to actual physical objects is becoming more resource demanding, more often than not making pen and paper, and repetitive design processes simply unprofitable to make the ideas come to life.

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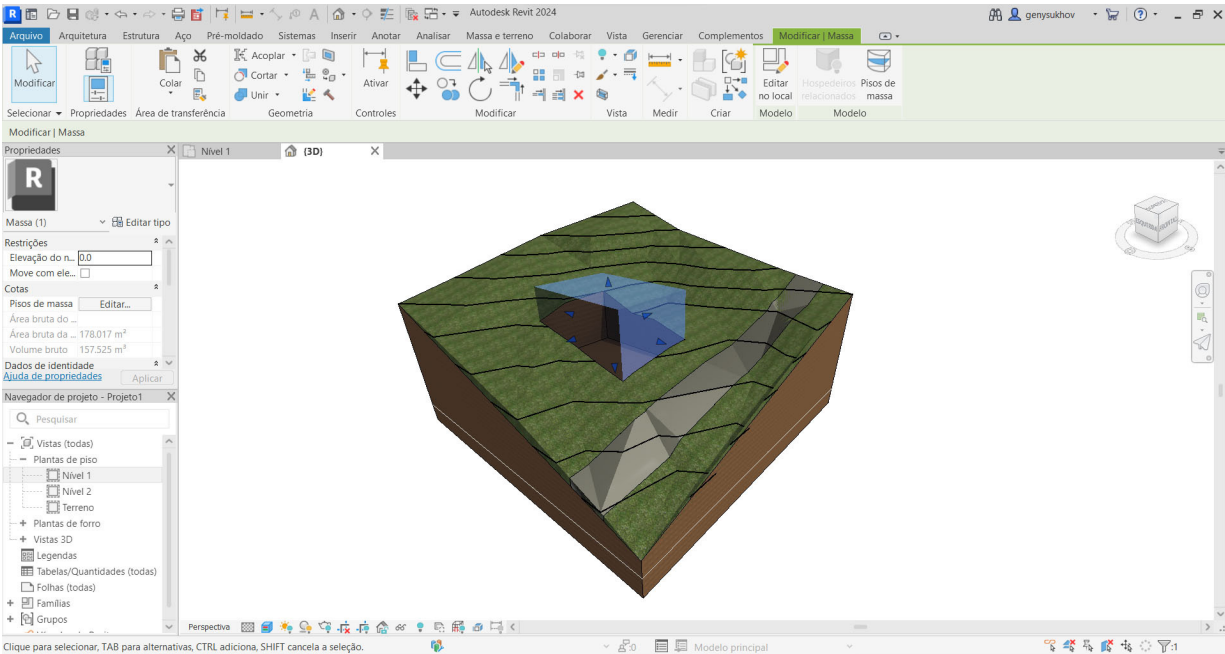
Some people might argue that we, as architects, design buildings in architectural software, like Revit or ArchiCAD, the same way and logic we would build them in real life. Such an argument is probably an overstatement when taking into account all the processes that really happen between physically building and designing a building that is supposed to be built in real life. It is impossible to explore all the differences in workflow between the two aforementioned BIM softwares, but it is worthwhile to point out some of the key differences to illustrate the point why there are not only differences between softwares, but also how real life processes actually occur.

There are many instances where these two softwares handle the modelling and construction of the building in distinct procedures. For instance, to place a building in the site so that it adjusts to the terrain, in ArchiCAD the commonly used tool is Solid Elements Operations (SEO), which is a boolean set of tools where two different geometries (target and operator) can subtract, subtract with upward extrusion, subtract with downward extrusion, intersect, or add with each other in their virtual environment. Therefore, in practice it means that if we want to place our building onto a sloped terrain, we will be performing a boolean action to remove the excess terrain from inside the building [Figure 37]. On the other hand, Revit does not possess this kind of boolean operations, and to position the building in the same manner as above, it would be required to either create a void space cutting the terrain, or use the Building Pad tool creating a base slab. Furthermore, other issues can arise if the complexity of our construction increases, in ArchiCAD’s case if the building is buried with terrain on top of its ceiling slab; as the software’s boolean actions do not manage well such geometry; being the solution, literally creating a small piece of terrain to be placed on top, with no connection to the main terrain.

[Figure 37]
ArchiCAD’s workflow creating a flat building platform inside the terrain and an adjacent road. Both were created using SEO, where the former used “subtraction with upward extrusion” and the road was created with two SEO functions: the first where the road is the ‘Target’ and the terrain the ‘Operator’ “intersecting” with each other, and the second where the road is the ‘Operator’ and the terrain the ‘Target’ using “subtraction”.



[Figure 38]
In Revit, the blue cube represented on the image, is a solid in place acting as a void space which removes a piece of the terrain where it intersects; whilst the road is built as a subdivision of the toposolid geometry from which the terrain was built, and therefore it automatically adapts to whatever pre-existing topography.



77

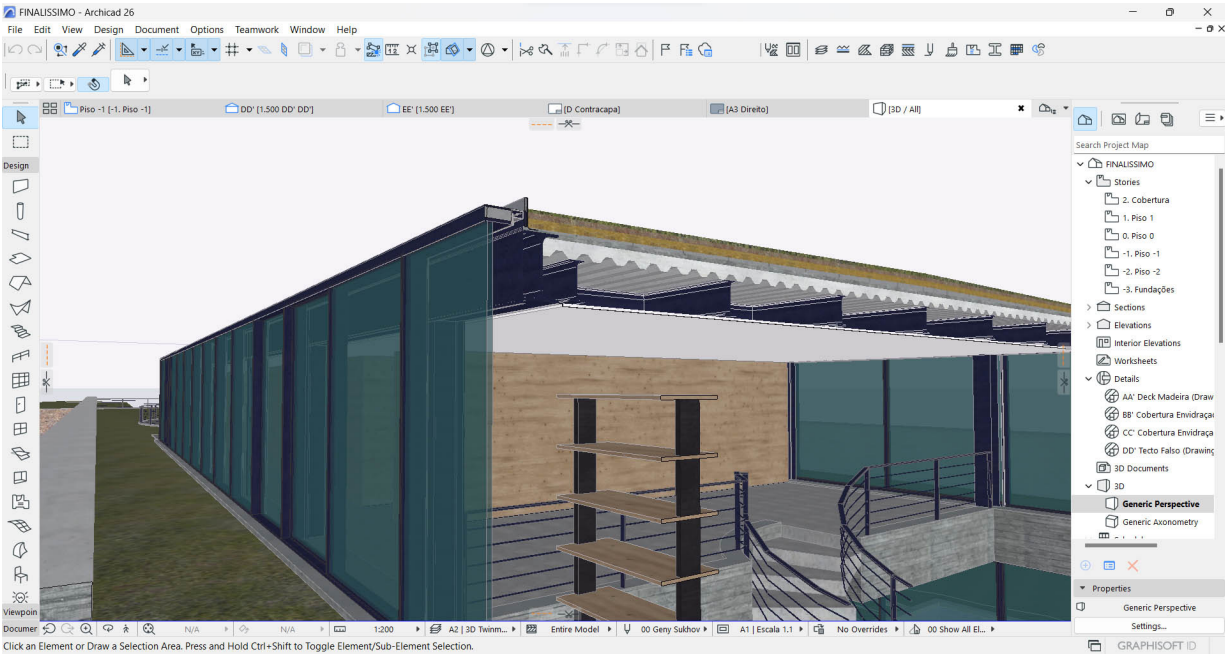
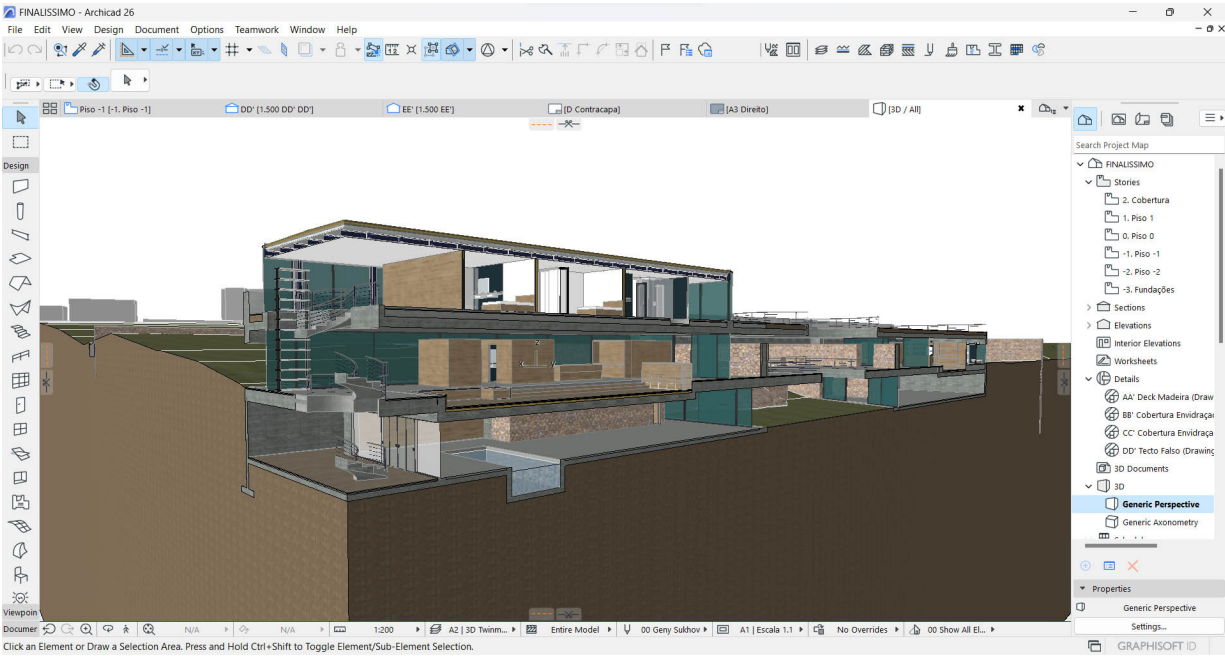
78

On the contrary with new tools in Revit 2024, such as Toposolid, it became much easier to manipulate our building site, as for example, it allows to create roads following the topographic features by drawing simple shapes in plan view [Figure 38]; a process which does not happen in Archicad, where it is necessary to create an independent and separate mesh from our terrain and use SEO procedures.

Nevertheless, neither of those three dimensional modelling processes resemble real life on-site construction methods. Another example would be the detailing of walls and its complex elements. To add simple yet complex elements such as skirting boards to a wall, in ArchiCAD it is possible to design complex profiles and have them act as walls; while in Revit it would be necessary in addition to the existing wall to add any complex elements, such as skirting boards, as extra geometry individually; meaning the changing the type of wall would play no influence in the skirting type that was chosen.

Moreover, due to the complexity of some buildings, it is not always recommended to design its entire structure and details, especially because in very large buildings there would be an unnecessary load on the software and computers. Therefore, many architectural detailing is often only done and represented in 2D because it is either labour or time costly to design all the elements in a large scale virtual environment. However, during my years studying at FAUP, I always took the notion of designing everything in three dimensions to almost an unhealthy extreme. The first example, and seen above is the Duas Casas in Monção, designed by João Paulo Loureiro and replicated in ArchiCAD for the 4th year curricular unit “Projecto BIM”; where many metallic profiles and complex shape of the roof slabs could not be designed with a simple single movement [Figure 39 & 40].

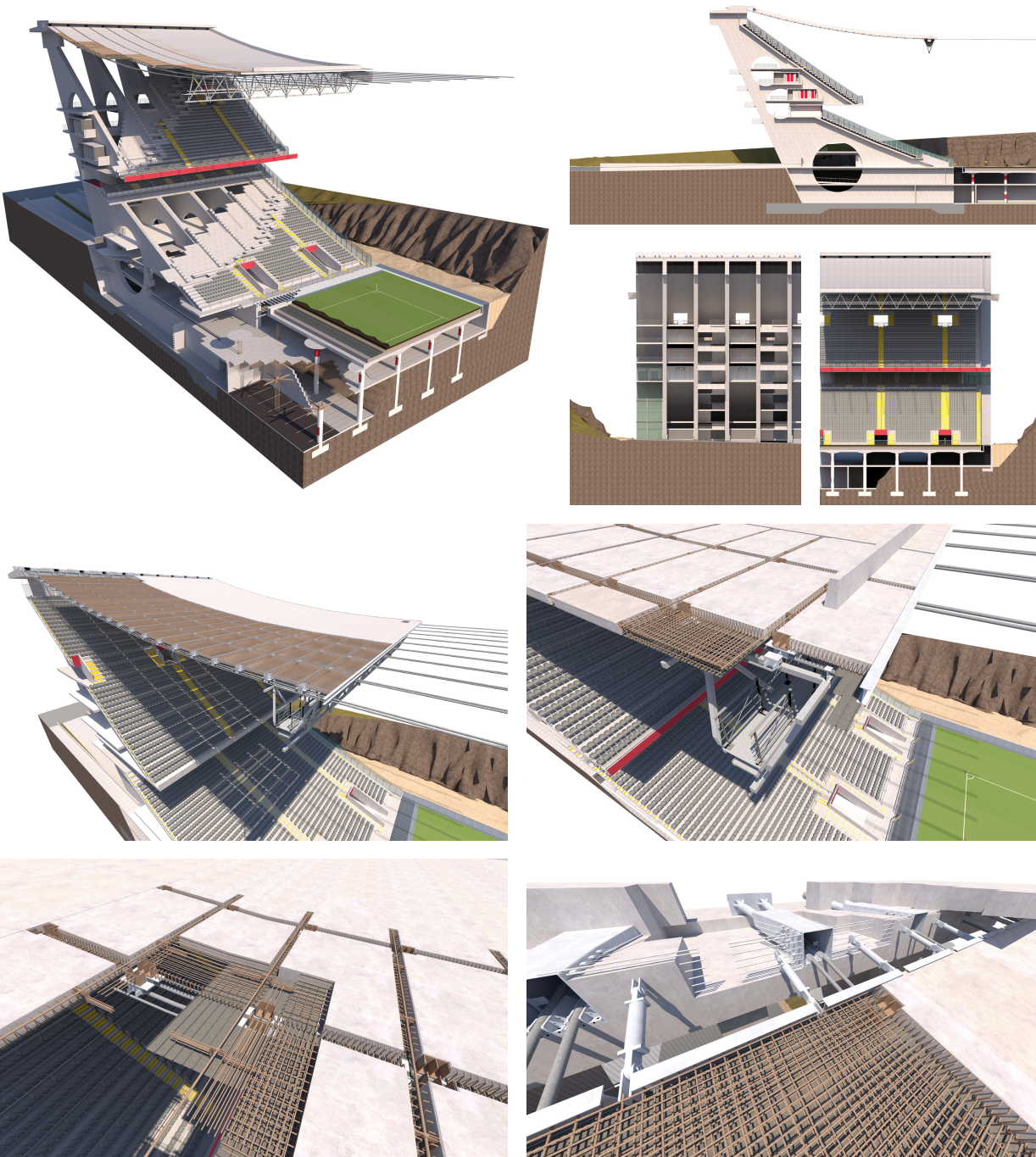
[Figure 39 & 40]
3D modelling
detailing of
Duas Casas in
Monção by João
Paulo Loureiro
fully recreated in
ArchiCAD, where
complex profiling
and SEO were
extensively used.



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Other software like SketchUp or Blender use completely different modelling techniques from the above-mentioned BIM softwares, since they move from the realm of designing physical architecture, being solely 3D modellers treating geometry as plasticine. The 3D model of the Estádio Municipal de Braga, presented in “Construção 2” and now published in the numbers 41 to 44 of “Frente & Verso”, was designed in SketchUp [Figure 41], using totally different set of tools and designing principles from those of BIM software mentioned a few paragraphs back. As stated at the beginning of this subchapter, understanding the software is essential to designing anything we want, and Braga’s architectural and engineering complexity is probably beyond the scope of a 3rd year student of architecture. Therefore, in such situations, the focus shifts from understanding the physical and mathematical principles that allowed the piece to get built, to understanding how the different geometries of the building entangle and live with each other; and this is exactly what the software allows to get replicated. Whilst designing it, I sought to understand the shape of the formwork marks and metallic frames inside the concrete, how the sustaining cables attached the roof to the core of the building, or how the different geometric features, such as ramps, intertwined with each other.

This reverse process not only allowed me to design the building in a flexible software like SketchUp, but also to gain insight about deeper engineering and architecture aspects that otherwise I would not have gained. This exercise goes against “building as it will get built in real life”, but instead, follows the principle of “doing what we can observe in space” and that obliges us to mentally build the object as it is in real life; whilst software like Revit or ArchiCAD intend to provide architects and engineers the documentation to ensure there is the necessary weight and amount of metallic elements to sustain the construction, and not how it entangles with the rest of the building’s geometry.



[Figure 41]
3D SketchUp
model of a section
of the Estádio
Municipal de Braga
by Eduardo Souto
de Moura; where
plug-ins were used
to massively edit
certain repetitive
tasks and detailing.

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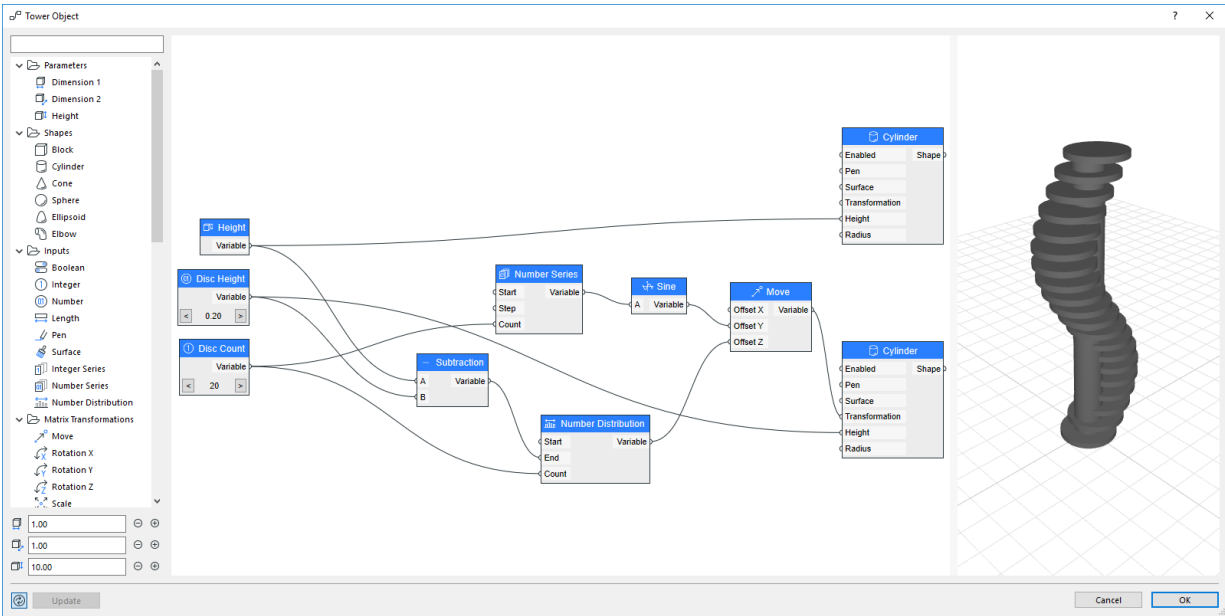
Furthermore, a software like Blender, or parametric add-ons and plug-ins like ArchiCAD’s PARAM-O and Revit’s Dynamo, allow the programming of three dimensional elements in whichever way we like and need [Figure 42]. With these kinds of tools it becomes extremely easy to build complex shapes, while it is almost impossible to design, build, and manufacture them without that initial parametric design process due to its twisted and curved angles and geometry.

In addition, gaming engines like Unreal Engine 5, or Unity might feel like Blender or SketchUp on steroids, as besides the 3D modelling they also allow programming of different actions and environments, hence creating interactive scenes [Figure 43]. This detail is what allows to change the focus from a solely static picture of a building on a computer, to creating a scenario where the virtual buildings start to interact with us in many different ways.

These are the main differences between softwares and how we interact with them for building in the physical and virtual environments. However, buildings in the real world also have other constraints, as they must undergo several stages from an initial site and architecture study to construction plans; whilst designing buildings in a virtual environment requires other, more flexible stages, more connected to design processes and designer’s workflow.

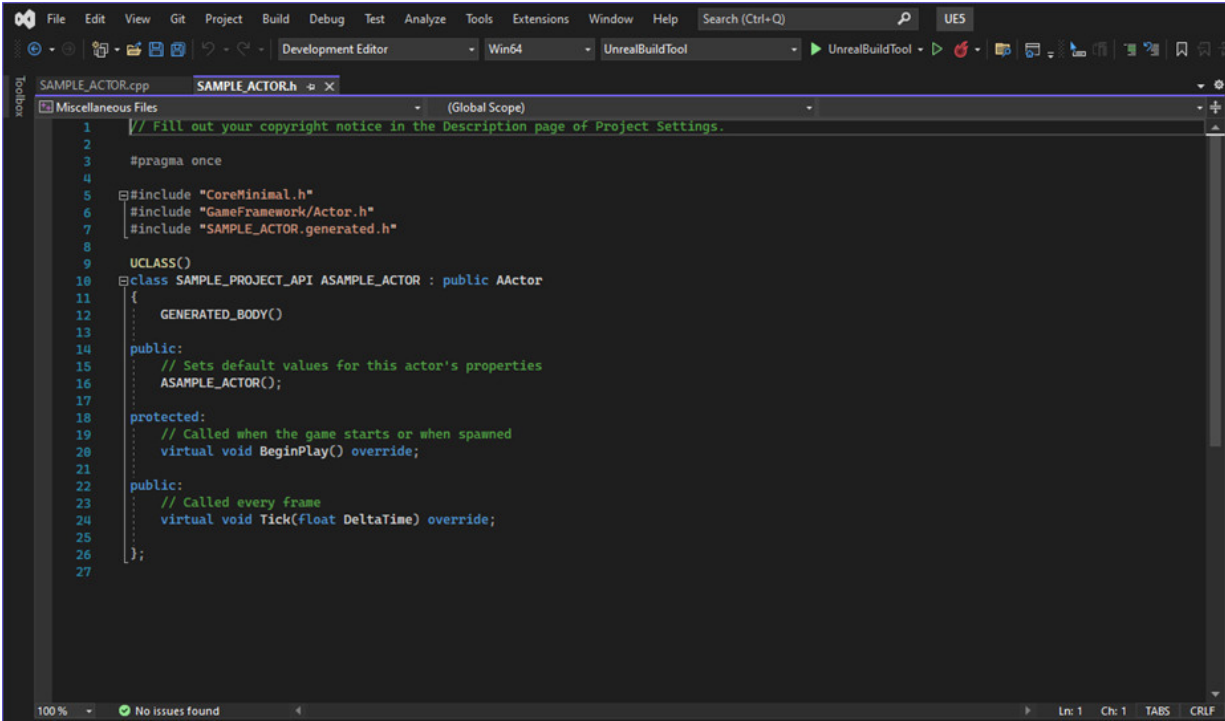
Therefore, there is no doubt that building architecture in the real world and designing virtual spaces, or virtual architecture, can incur in two very different processes depending on our final objective, with other also relevant distinctions to keep in mind, besides the already mentioned ones.

[Figure 42]
PARAM-O’s visual scripting that allows the creation of custom parametric library objects ad building elements, without writing a line of code or script.



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[Figure 43]
It is possible to open Unreal Engine’s code in Visual studio for further environment editing.



Real world architecture and presence and creation of physical buildings must abide to physical laws of nature such as gravity, structural integrity, and the science between the relation of the building's different materials, as these issues occupy physical space and interact with their surrounding environment; whilst building in the virtual realm, spaces can exist in purely digital form with no need of having bearing elements, such as columns and beams, or mechanical, electrical, and plumbing (MEP) infrastructure and physiological spaces such as toilets.

The purpose, dynamics, and motivation for its existence are entirely different in both physical and virtual architecture, as the former explores factors like building's durability and materiality, climate resistance, and aesthetics, with construction involving physical labour, resource management, and a very extended project management; the latter shifts its focus to other aspects such as the existence of digital and collectible items, textures of its environment, community engagement, and spatial storytelling, which in physical architecture can for instance be achieved through elements like light entering the building.

Physical constraints like land availability, zoning regulations, and building codes, or historic pre-conditions are some of the conditioning factors that allow physical architecture to be unique as it adapts itself to the place where it is located. Although in some platforms, like Decentraland land availability is also a factor for virtual architecture, in practice the land can be infinite and therefore, virtual architecture's virtue is an extra layer of freedom where it is possible to create a bigger artistic expression where virtual spaces can be abstract, whimsical, surreal, or be non-euclidean, like later explored in this dissertation, making the software and hardware's processing power the only true limitations in building in the digital world.

Real world buildings serve a meaningful functional purpose, such as housing, offices and workspaces, and public facilities, being often required extended maintenance to keep its regular use. It is unlikely that digital forms of space will replace all the existing physical spaces, because we all need a place to live and not all jobs can be performed from the comfort of our homes. However, as seen during the COVID-19 pandemic, such transition, at least in part, is possible, and probably inevitable with the advent of globalisation and remote-work. Therefore, when up until this point virtual spaces were mainly designed solely for gameplay experiences with its main purposes being exploration, navigation, and interactions with virtual characters, it seems more likely that with the development of the Metaverse, our workplaces, and public facilities, such as the tax office, or virtual public agoras, such as Twitter/X or Instagram move towards virtual architecture spaces.

With each passing day and the development of Metaverse industries, it will become more common seeing architects switching from building physical architecture to building virtual spaces, and so, the aforementioned paragraphs serve as a reflexion to different aspects and differences so that, we as architects, can better adapt to the environment where we want to work. There are clear and massive differences between building in the real world and in the digital one, many of which are not even explored in this dissertation, such as how to design and build profitable projects in both of those environments. Building in one and not in another, is not necessarily better or worse, just different; and as professionals understanding the core differences between addressing confort, function, and sustainability of physical architecture, and a fast-paced world where immersive experiences and spatial narratives are prioritised, is crucial, because neither of those things are going away from our daily lives.

86 Different Types of Spaces in the Metaverse

“I had lunch on the moon, took a swim in a shadowy lake on Mars, played croquet with the clouds, and chased rainbows under the sea, all in one glorious afternoon.”⁶⁵

– John Marx

Most of the buildings ever designed by architects, actually never left their blueprints. In fact, most buildings are not even remotely close to their first sketch on that napkin. This subchapter dives into the architectural theory and debate of building virtual spaces for the Metaverse. For us architects, the debate about architecture in the Metaverse is the debate about how to create compelling spaces that will gather people in them, and keep returning to them once the novelty of that space has worn off. Architecture is not only a discipline studying and organising the space where we live in, but also the discipline studying, organising, and gathering people and human interactions in different types of spatialities.

The making of what constitutes a place or a space, is not, however, solely in the hands of architects and designers. This is true in all built environments, whether they are urban, rural, or virtual. The sense of a place or *genius loci* is also made up of non-spatial qualities, as it revolves around the people and the activities that bring it to life. John Marx, gives the example of wine-making regions and their villages where the production of wine, also include rituals and festivities associated with viniculture, and how those activities transform and emotionally engage with the local community, turning those villages into attractive, distinct, and memorable places. Even though cyberspace will not offer opportunities of wine tasting or shared meal, it is already a place where social networks come together with many different online communities that work, socialise, and collaborate with each other.⁶⁶ Physical behavioural patterns, as the ones mentioned above, are organised around spatial elements of the physical world, and

⁶⁵ John Marx. (2023, August 16). Experiencing Reality in the Metaverse from Life-Like to Surreal. ArchDaily.

⁶⁶ John Marx. (2023, September 6). Placemaking in the AI Era. ArchDaily.

these behavioural patterns can be carried over to virtual environments by designing them to have the same affordances for action and interaction than the ones existing in the physical world.⁶⁷

The building of spaces in the Metaverse is an entirely new field of virtual architecture, and Sevince Bayrak argues that when architects think within the limits of real-life architecture, their initial response to this new universe is to celebrate the “unlimited possibilities” this new space has to offer.⁶⁸ These unlimited possibilities can be a vast array of different features, conditions, and in the words of Fernando Távora, “project circumstances” that are not equivalent to those of physical architecture.

Leon Rost, director of Bjarke Ingels Group (BIG) argues that in the Metaverse “structure, materiality, and cost go out the window”, which is true, because as explored in the previous subchapter, there is no necessity of abiding to the laws of nature. There is no need of designing kitchens or toilets in the houses and offices of the Metaverse, just like there is no need of building a structure for Earth’s gravity. But just because the circumstances of building in the Metaverse can be very different from the circumstances of building in the real-world, it does not mean that building architecture in the Metaverse has no project circumstances. John Marx argues that in the Metaverse, the quality of experiencing the space is something more important than the space itself⁶⁹; adding a complexity layer to build in the Metaverse because in physical architecture the quality of the space already determines the quality of experience, which in virtual architecture is not always the case.

⁶⁷ John Marx. (2023, August 16). Experiencing Reality in the Metaverse from Life-Like to Surreal. ArchDaily.

⁶⁸ Sevince Bayrak. (2022, July 11). Is Metaverse Really the End of Barriers for Architects? ArchDaily.

⁶⁹ John Marx. (2023, August 16). Experiencing Reality in the Metaverse from Life-Like to Surreal. ArchDaily.



[Figure 44]
Winter House
(2022) by Andrés
Reisinger and Alba
de la Fuente.

The Winter House seeks to merge both the interior and exterior, with the surrounding nature becoming part of the house, searching for a balance revolving around intimacy and seclusion that can create the perfect winter hideaway.

The pink hues predominate the interior spaces with texturing of light natural materials such as concrete, glass, steel, and beige tones; with these colours and textures offering different degrees of warmth in each of the spaces. The materials chosen seek to represent the duality characteristic of such project, and contribute to transmitting a sense of tranquillity, where we as observers “*imagine what the winter season might look like in the metaverse, bringing together all the feelings of tranquillity, stillness and comfort we associate with winter and translating them into a residential form.*”

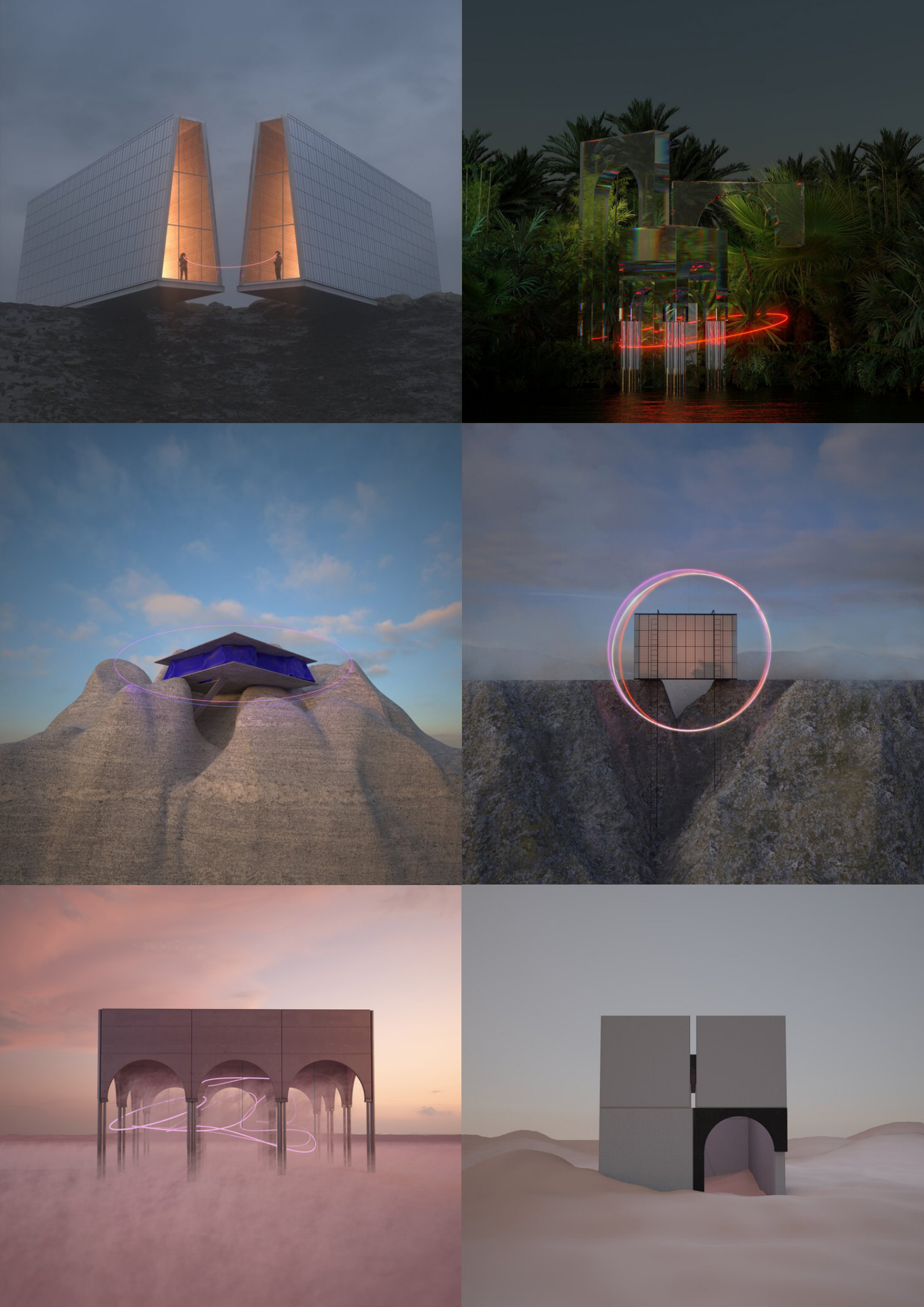
– Andrés Reisinger

In place of materiality, colours and textures are an important aspect of experiencing the space in virtual architecture. These two components will determine how we perceive the space where we are located. For instance, when designing the “Winter House” [Figure 44], Andrés Reisinger and Alba de la Fuente, have chosen their white and pink-ish colours and textures to offer different degrees of warmth, as well as the feelings of tranquillity, stillness, and comfort, imagining what the winter season could look like in the Metaverse.⁷⁰

In spite of getting rid of contractors, project management teams, and potential traditional grumpy clients by building virtual architecture in the Metaverse, architects could still face those exact same real-life problems in the virtual realm. Yet, this time, architects will have to team-up with UI-UX designers, software developers, and coders, all of which might become a significant financial constraint, especially if the Metaverse becomes more interactive and customised; as it makes more sense to use new technologies such as big data, AI, AR/VR in the construction of virtual architecture.⁷¹ Grand Theft Auto V cost USD 140 million to develop⁷², and it is not unlikely that as virtual architecture in the Metaverse gets more of the above mentioned features implemented into it, its development costs get to values of physical architecture, and proving Leon Rast that costs going out of the window are only gone in architects’ imagination.

As we dive deeper into the limitations and liberties of designing architecture in the Metaverse, we also start questioning what is its real intrinsic purpose? Why not create architecture that is absolutely limitless and free from all rules of nature such as gravity? The answers for these questions may be laying down in the way our brain works and processes information, as neuroscientific research shows that our brain perceives new images whilst relating them to past experiences. Therefore, even though there is no need of using physical architecture’s

⁷⁰ Agustina Iñiguez. (2022, May 3). Towards a Virtual Architecture: The Winter House by Andrés Reisinger and Alba de la Fuente. ArchDaily.
⁷¹ Sevince Bayrak. (2022, July 11). Is Metaverse Really the End of Barriers for Architects? ArchDaily.
⁷² Jake Selway. (2023, June 6). How Much Did GTA 5 Cost to Make? Game Rant.



[Figure 45]
“NoChurch” is a series by Oderspace that was born in relation to the theme of travel in a historical moment where travel was banned: 2020.

“If it’s true that ‘travels are the travelers’ and ‘what we see is not what we see, but what we are’ (The book of Disquiet by Fernando Pessoa) we believe that a journey can be led virtually in places that are not bound to a physical reality.

This is why each NoChurch lies on the edge of the possible/impossible, real/virtual: the boundary between reality and fantasy is dissolved like the barrier that divides art and architecture.

By pushing Architecture to the limit of Art and vice versa, we don’t want to criticize a current aspect of life, we don’t want to create a new image for the world, we just want to add a new possible experience. We want to augment the limited reality we’ve found ourselves in.

NoChurch is a realistic abstraction where architecture’s functional problem and question of scale are eliminated, the only thing that matters is to nourish the imagination, the soul.

The name comes from the notion of church as a link between physical life and extra-physical, a place where you hope there is something more than what you can experience everyday.”

– Oderspace

elements such as doors, windows, beams, and pillars, their use might be useful in convincing our brain about the spatiality we are located in. Nevertheless, taking into account that the Metaverse does stand on the traditions of architecture, bringing its own rules to the game; and so it is possible that as virtual architecture gets explored and developed, Metaverse architects and designers will also start questioning the existence of physical elements like doors, windows, or pillars.⁷³

And whilst getting rid of gravity for construction purposes might be a dream for architects as it will allow to create structures impossible to build in physical architecture, gravity is still one of the most important senses to us, as humans; because is another tool like architectural elements to trick our brains into thinking that the virtual environment is real. People with fear of heights have experienced difficulties of walking and jumping down from an elevated plank in VR, as those who jump down experience a real sense of falling.⁷⁴ Therefore, the virtual environments of the Metaverse might experience some sort of mixed gravities, where some elements are built mimicking real environments to provide a sense of comfort to the user, whilst simultaneously exploring its limits [Figure 45]. Environments and buildings can have their structure and architectural elements ignoring physical principles, and people may have the freedom to choose if they want to fly in those environments, or if they want to stick to the ground, where elements such as railings will prevent them from falling from heights. Such mixed gravity conditions already exist in real-time rendering software like Twinmotion, where it is possible to turn on and off gravity and collision with elements.

73 Sevince Bayrak. (2022, July 11). Is Metaverse Really the End of Barriers for Architects? ArchDaily.

74 Ibidem.



[Figure 46]
Ethereum House
(2022) designed
by Atelier Monolit,
is a conceptual
mansion inspired
by Ethereum. It is a
rotating house with
Ethereum's logo as
its volume, and thus
imposing a striking
silhouette across the
entire landscape.

*"Similar to the
technology behind
it, linking two
dimensions – known
and unknown,
past and future,
classic trade and
technology - the
Ethereum House
rests on the edge of
the rocky and
stable shore, and
in the meantime, it
rises high, facing
the seemingly-end-
less and somehow
unpredictable
horizon.*

*Accessible by
both car and
boat, the house is
portrayed sitting
on the seashore of
an Icelandic-like
location. The
mansion is
composed of three
registers. The lower
and the upper
pyramid-shaped
volumes are
enclosed and are
destined for the
living areas. The
middle area is
opened towards the
spectacular scenery,
complementing
and connecting to
it through a terrace
and an infinity pool
with glass walls."*

*– in Amazing
Architecture*



With or without gravity, virtual architecture still needs to follow some principles of form and function like physical architecture does. However, it is possible that our bodies and unique avatars will play a role in influencing some of the spaces created in the virtual environments. The avatars can be represented using all the existing flexibility and variety with features like “fancy wings or a giant monster head”⁷⁵. Although not 3D models yet, these sort of avatars have already been popularised and widespread as Reddit Collectible Avatars available on the Blockchain as NFTs.⁷⁶

This to say that we are still at a very early stage of Metaverse, where the current demands for realistic environments do not reflect the virtual and fantastical trends around the world, where the concept of place and space might be something else entirely; for example Alper Özyurtlu, the co-founder of Timelooper, a company that builds virtual environments, stated that whilst their clients from the Americas expected more grounded ideas of realistic virtual habitats, the expectations of their Japanese or South Korean clients radically changed where they chase novelty, innovation, and unprecedented digital atmospheres, instead of replicas of the real world⁷⁷ [Figure 46].

When looking at different spatial dynamics and atmospheres between realistic and virtual builds and environments, it is possible to identify four categories of environment ‘shells’ for developing place-like atmospheres in the Cyberspace, worth keeping in mind, and each with their own set of characteristics:

- hyper-reality;
- abstracted reality;
- hybrid;
- hyper-virtuality.

⁷⁵ Sevince Bayrak. (2022, July 11). Is Metaverse Really the End of Barriers for Architects? ArchDaily.
⁷⁶ Shilpa Lama. (2023, January 11). Reddit Collectible Avatars: A Deep Dive Into Reddit's NFTs. BeInCrypto.
⁷⁷ Sevince Bayrak. (2022, July 11). Is Metaverse Really the End of Barriers for Architects? ArchDaily.

Hyper-reality is the best attempt to mimic the physical world in its greatest detail. It can be defined as much by the completeness of the imagery as by its attention to solving processing constraints revolving around the laws of nature - gravity, wind, weather, dirt, etc. To achieve this kind of quality and truthfulness to the real world is already technologically possible using Radiosity and other algorithms used in computer-intensive animation seen in film’s special effects; these kinds of processes and computation are not easily achievable for regular hardware of today. Hyper-reality has the advantage in terms of place building as it provides the user with familiarity and comfort of the real world. It is an easy environment for people to understand and relate as buildings and places in such environments will contain walls, ceiling, stairs, lights, doors, and simulated materials - from their textures, roughness, and sounds.⁷⁸

[Figure 47 & 48]
Duas Casas (2013)
in Monção, Portugal
was originally
commissioned as
two houses on the
same plot, one
for the father and
the other for the
son. Therefore,
the architect João
Paulo Loureiro
combined the two
houses into a single
construction, where
a single prestressed
slab with 84 x 16m
would combine the
two buildings into
one.

The building is
made of glass,
pained wrought
iron, and pine
wood, supported by
new yet traditional
granite walls. In
between the two
houses, there is a
circle, an ellipse
and a space that
can accommodate
a tree, a sculpture,
or a space that
simply remains,
claiming its place.

The 3D model
(2020), designed
by Evgeny Sukhov
seeks to be as
accurate as
possible to reality,
in its materiality,
colours, or even the
place’s environment
seeking tall trees
and a morning fog
that is characteristic
of the river Minho’s
left bank.



⁷⁸ John Marx. (2023, August 16). Experiencing Reality in the Metaverse from Life-Like to Surreal. ArchDaily.

Abstracted reality is described by John Marx as an environment which obeys enough laws of nature without necessarily creating a ‘true-to-life’ reality, where objects and textures can be abstracted, not perfectly rendered, but yet attempting to avoid disorientation and unfamiliarity. In these kinds of spaces, one might not be able to walk through walls, and might still need to ride a lift and ascend a flight of stairs between floors. Gaming and cartoonish platforms such as Second Life, Minecraft, or Horizons Worlds are examples of such realities where the avatars can also deviate from reality by not arms or legs, for instance. Abstracted realities allow more artistic freedom than hyper-realistic environments and they offer simpler texture mapping and lighting as photorealism is not its main purpose.⁷⁹

[Figure 49, 50, 51, & 52]

Antireality is a collection of conceptual architecture proposal series on Instagram. It proposes abstract visions and alternative worlds questioning the relationship between people, architecture, and nature.

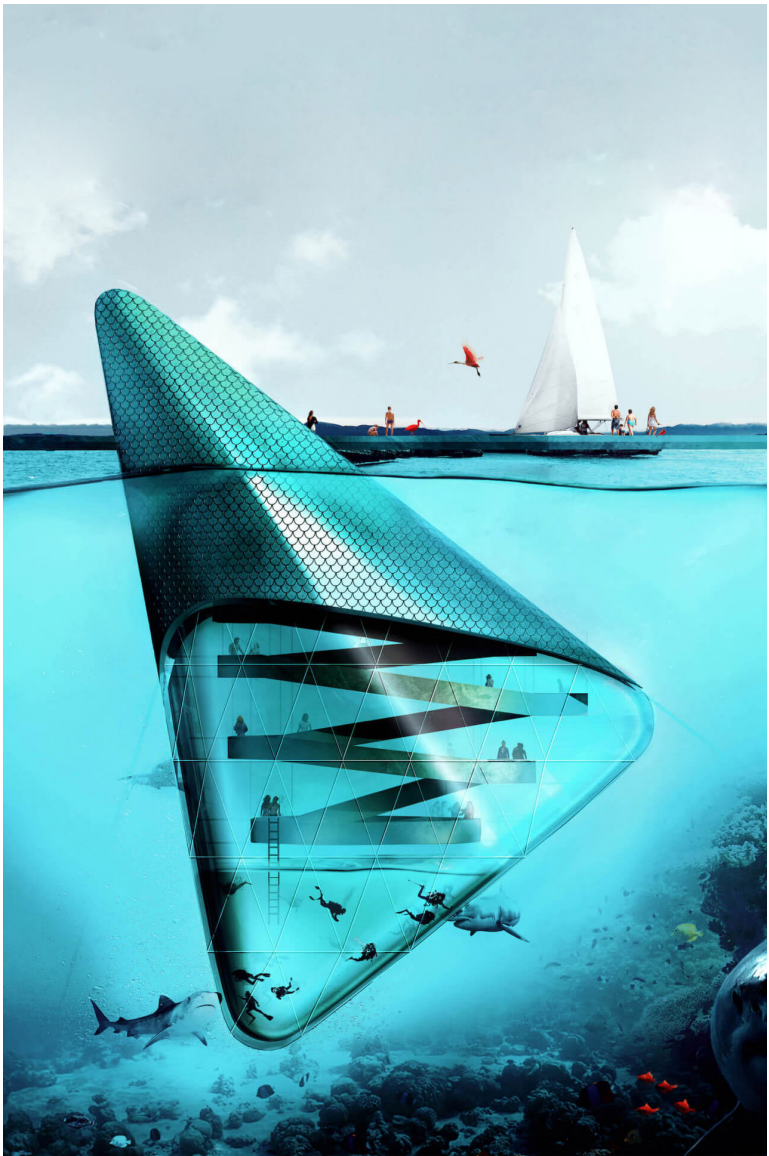
“Antireality is a conceptual world built on the basis of abstract ideas about reality. It is a space that escapes realism and pragmatism and is dedicated to exploring ideas that oftentimes can be neither adapted to the existing reality nor implemented. The reality I have created is founded on seeking unconventional architectural-spatial situations, that often oscillate between reality and dream.”

For me, Antireality is a kind of a get-away from daily life, a space that shows an alternative image of the world that tells a story about fairy-tale-like utopias. It is a diary of my architectural imaginations and non-materialized ideas aiming to stimulate recipients’ imagination.

Architecture objects in Antireality are almost like illusions of buildings, at first glance they may seem possible to construct but laws of physics allow them to exist only in this parallel reality.”

– Antireality

79 John Marx. (2023, August 16). Experiencing Reality in the Metaverse from Life-Like to Surreal. ArchDaily.



In the **hybrid cyberspace**, the senses of virtuality and unfamiliarity start to kick in as this kind of atmosphere starts to freely mix the real and virtual experiences, where the laws of nature can be completely discarded or changed beyond our physical recognition. It is the environment where artistic expression starts to become limitless and can easily become surreal as participants’ avatars can easily take an unrealistic form, objects could start behaving in unusual ways by changing size, texture, and form over time, and there can be significant mismatches of form and material observed in the real world.⁸⁰

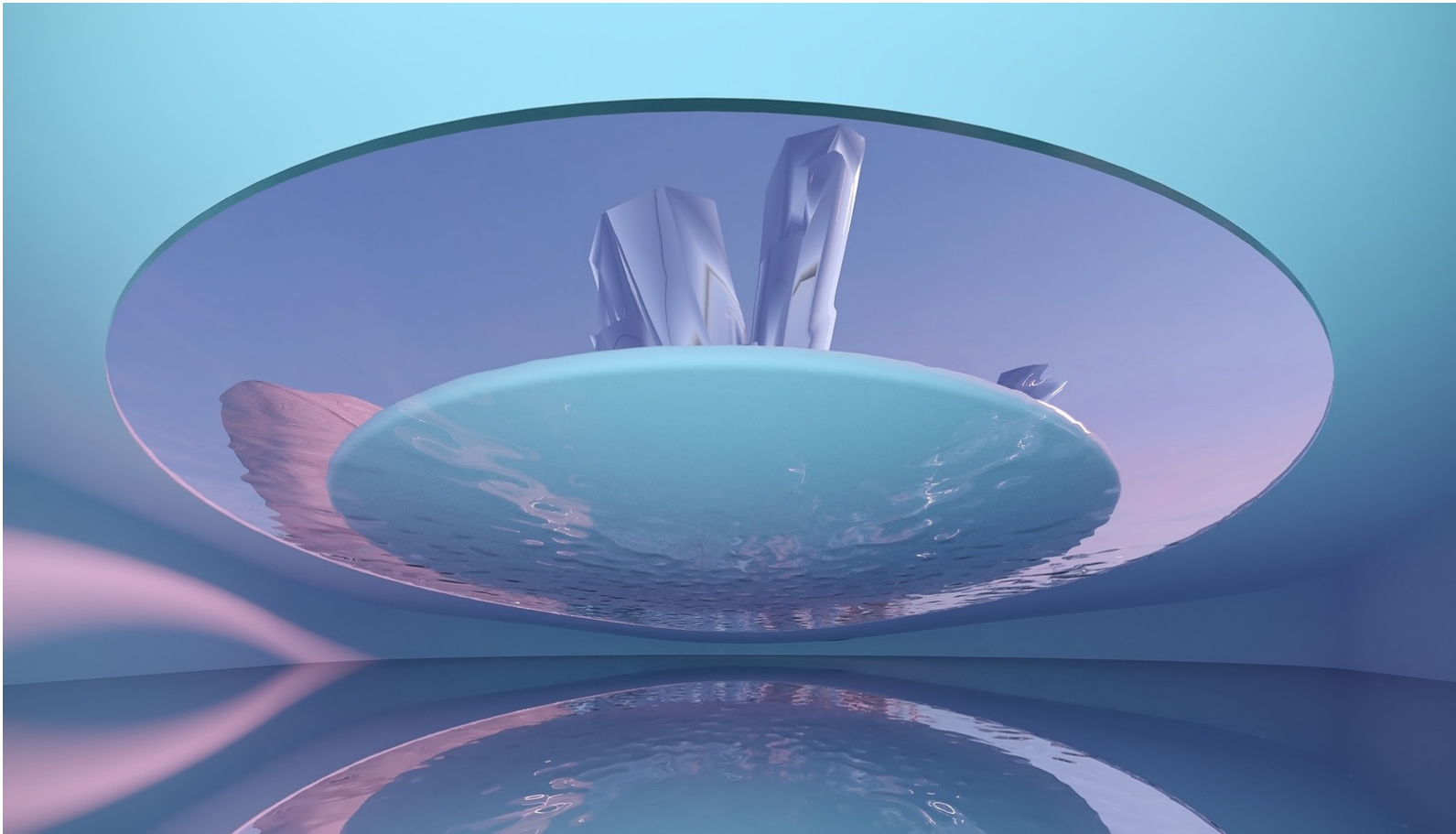
[Figure 53 & 54]
Crystal City (2022)
designed by Felipe
Escudero, is a
Decentraland’s
tallest multi-purpose
tower, high-rise
observation deck,
an ice-covered
marketplace, and
a packed snow
gallery.

It aims to break
with the limitations
of physical
architecture by
defying gravity and
material properties,
and offering a
transcendental
and immersive
experience that
could not exist
anywhere, but in the
Cyberspace.

*“I am inspired by
nature to create
pieces that feel
animated, as if they
have a soul.”*

– Felipe Escudero

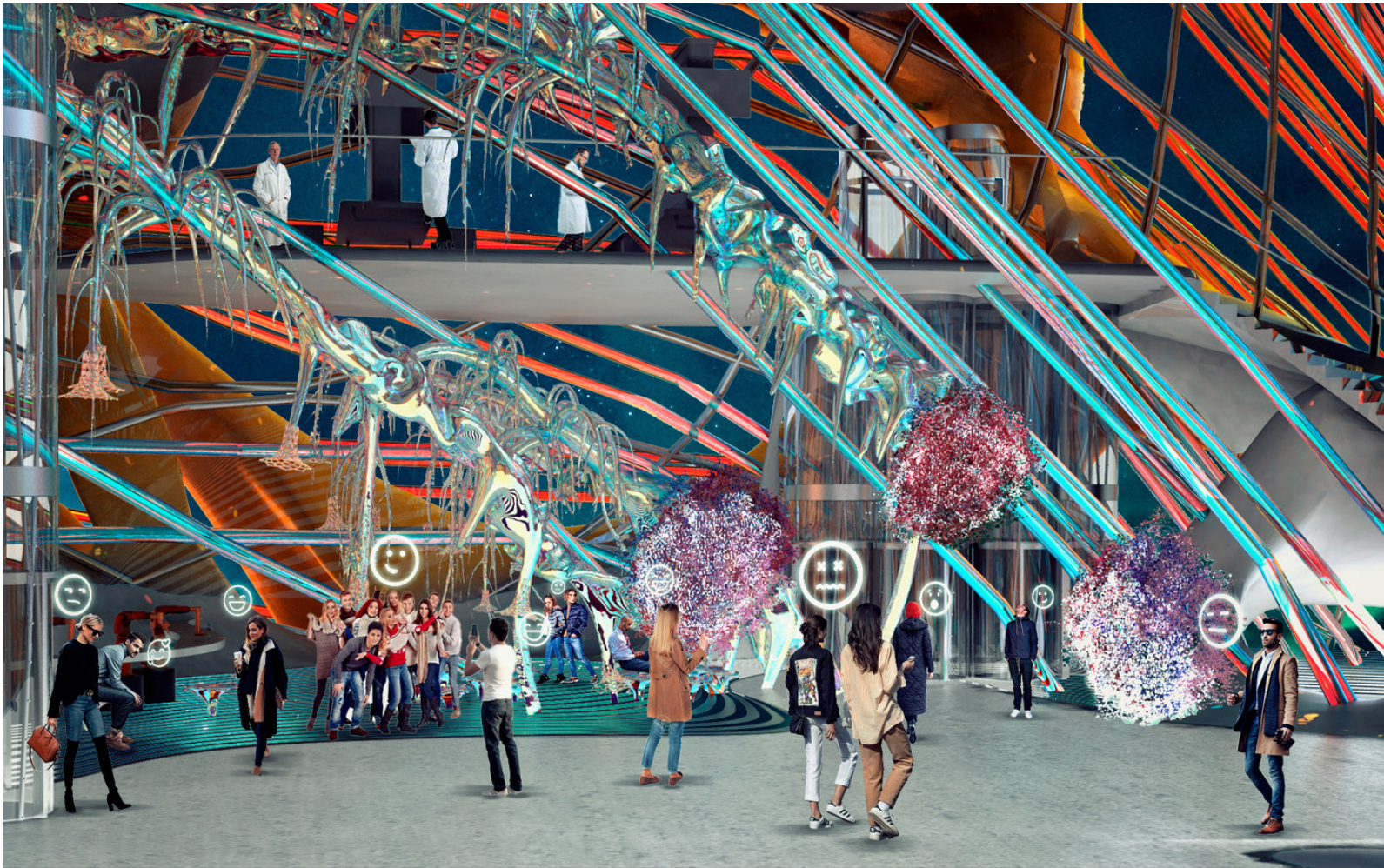
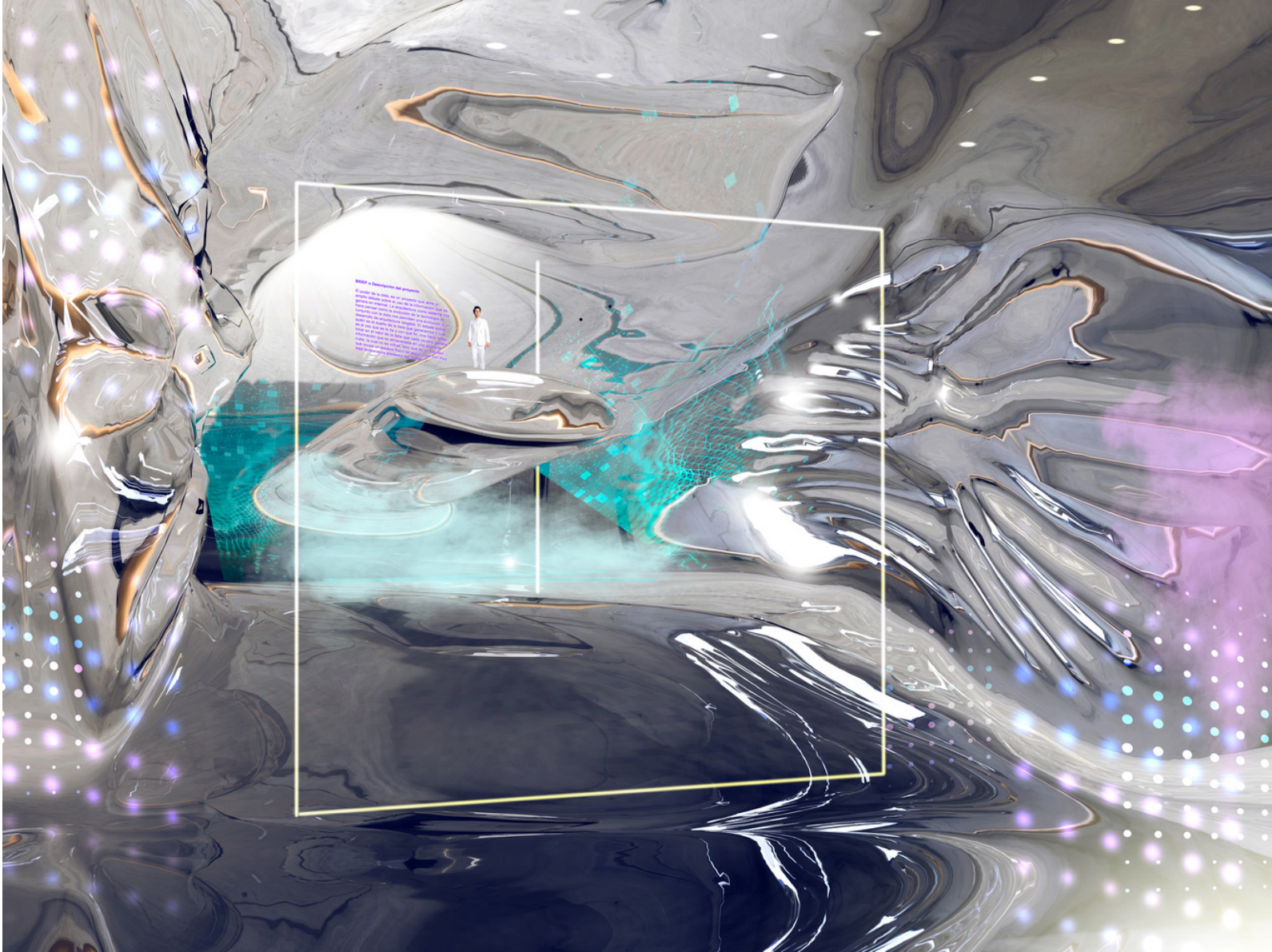
80 John Marx. (2023, August 16). Experiencing Reality in the Metaverse from Life-Like to Surreal. ArchDaily.



Every relationship and connection to the physical world and the laws of nature are dropped in **hyper-virtuality**, exploring the uniqueness and innovativeness of the experience, with the intentional exclusion of familiarity, being its primary importance. Each site can have its own set of virtual rules, challenging the sense of reality, materiality, time, and enclosure of space, where physical elements such as walls, doors, windows, or floors not only have no meaning, but also feel out of place. An example of such surreal hyper-virtuality could be non-euclidean environments explored in the upcoming subchapter. Hyper-virtuality takes advantage of the computer’s abilities to organise time, data, and space, to provide the participant with a sensory experience that is completely unbounded from the laws of nature. Naturally, by completely discarding the physical spatial metaphor, hyper-virtuality loses any sense of social cues that come along with the sense of familiarity of our physical world.⁸¹

[Figure 55 & 56]
Building visualisations that hosted “The Power of Data” exhibition designed and curated by Online Lab of Architecture (OLA). The building is conceived by three-dimensional geometries based on various AI algorithms.

The project itself is based on an analysis of the invisibility of data and social networks, and so, the project’s methodology consisted in transforming the data by using machine learning techniques and software that enables the coding, processing, and use of information from real social networks, with the aim of transforming the information from an intangible data state to a generated virtual architecture.



81 John Marx. (2023, August 16). Experiencing Reality in the Metaverse from Life-Like to Surreal. ArchDaily.

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John Marx argues that places are shallow things defined by their surface, as it is the human behaviour in a determined place that determines its true value.⁸² We see this sort of evolution in our culture and how our cities and buildings evolve around it, but we can also see it in the aforementioned cyber environments where different cultures, or communities in the cyberworld, can attribute different meanings and functions to these spaces.

Before rushing to build a house, a gallery, or any other type of mainstream space in the Metaverse, we as architects, first need to comprehend the storytelling motivations of visiting and coming back to the spaces we have designed; as Yehuda E. Kalay and John Marx enumerate in their paper “Architecture and the Internet: Designing Places in Cyberspace”:

1. Places are settings for complex and rich events: they provide a reason and a purpose for being there. In digital games, the purpose may be to slay the enemy, to concur territory, or to ascend to ‘higher’ levels of the game. In physical space, the ‘event’ may be to shop, to be educated or entertained, to conduct business, or simply to meet other people.
2. Places involve some kind of engagement with objects or with people. Thus they require presence. Presence can be participatory, as in a game or in a MUD, or remote, as in voyeurism. Either way, it exposes the actor to social norms, cultural customs, and scrutiny.
3. Places provide relative location: they let you know where you are, where you came from, and where you might be going in the future, spatially, temporally, and socially. This provides places with a sense of uniqueness and a character of their own that helps to differentiate one place from another.
4. Presence and location promote a sense of authenticity: it allows the actor to know s/he participates in a ‘real’ event, rather than viewing a previously

82 John Marx. (2023, September 6). Placemaking in the AI Era. ArchDaily.

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recorded one. It is the sense one gets by actually being at a ball game or a concert, rather than viewing them on TV. The tell-tale signs of an authentic place are change and serendipity.

5. A place must be adaptable, so as to allow appropriation to the specific needs of the user, and to foster an ability to make a place personal. Well-designed places foster a sense of ownership and a sense of control and at the same time a shared responsibility and access.
6. Digital places, unlike their physical counterparts, afford a variety of experiences: they can provide multiple different points of view, different scales, different levels of abstraction, and even different temporal perspectives.
7. The choice and control over transitions in Cyberspace from place to place offer much greater richness than physical space affords: one can hyper-jump, or use the journey as an event in and of itself.
8. Finally, well-designed places are inherently memorable: they are places you want to be in, stay at, and come back to. This could be based partially on a degree of enclosure and definition of the space, as well as on a textural and environmental richness.⁸³

Spaces in the Metaverse can range from things like entire cities and towns, islands, individual or small sets of buildings, to abstract pieces of geometry. It is important to be aware of the aforementioned principles, as whichever iteration of virtual architecture that is getting built, buildings’ functions in the Metaverse can rapidly lose their sense of meaning and existence. There is no point in contributing with buildings that only add dead virtual space, and so, it is fair to admit that the most valuable types of spaces in the Metaverse will always be the ones which promote social interaction, gatherings, discussion, and collaboration between individuals.

83 Yehuda E. Kalay, & John Marx. (2001, October 14). Architecture and the Internet: Designing Places in Cyberspace. Reinventing the Discourse - How Digital Tools Help Bridge and Transform Research, Education and Practice in Architecture. Page 238. [Proceedings of the Twenty First Annual Conference of the Association for Computer-Aided Design in Architecture].

Although architecture (houses, stadiums, museums, public space, etc.) can come to mind as different types of spaces in the Metaverse, they might all fall under different categories. Therefore, it makes more sense to distinguish the architecture in the Metaverse by its practical use cases by the community:

- Entertainment spaces, like sports and gaming events or concerts⁸⁴;
- Commercial spaces, such as virtual marketplaces and virtual online stores, where people can not only purchase goods from their usual big retailers, but also buy, sell, and trade virtual goods and services;
- Educational and Professional spaces, such as virtual classroom, libraries, offices, and digital twins, where the environment is focused on collaborative work;
- Artistic spaces, to serve as a platform not only to artistic trends but also as a place where work can be exhibit;
- Personal and Private spaces such as home environments and virtual residencies where users can personalise their living spaces;
- Virtual Vehicles that can include cars, planes, boats, and other modes of transportation to move within the environment;
- Transportation Hubs which unlike vehicles can be used for instant travel between different parts of the environment;
- Natural Exploration including, planetary, underwater, or outer space exploration set in unique environments;
- Fantasy and Surreal spaces defying the logic of the world we are familiar with.

84 Jack Tien-Dana. (2023, June 5). 12 Major Artists Who Have Performed in the Metaverse. ONE37pm.

In the end, it never rains in the Metaverse; and there is no gravity, hence no weight in the Cyberspace, and therefore no need for columns and beams. Windows and doors are nothing more than portals looking to another space, and distances can be elastic with hyper jumps to the extreme, hence making roads, walkways, ramps, and long promenades irrelevant, especially when it is not plausible walking long distances with a headset, in a closed space.^{85 86} All these features of physical architecture suddenly become superficial constructs unless they assume their alternative meaning as transitional places that afford serendipitous encounters, views, mid-journey changes of destination, and stories between social creatures.⁸⁷

85 Sevince Bayrak. (2022, July 11). Is Metaverse Really the End of Barriers for Architects? ArchDaily.

86 John Marx. (2023, August 16). Experiencing Reality in the Metaverse from Life-Like to Surreal. ArchDaily.

87 Ibidem.

This subchapter came to life after watching “How do non-euclidean games work” on Youtube by DigiDigger who is a professional programmer who works on games, web, and VR/AR applications.⁸⁸ Therefore, this sub-chapter seeks to understand with DigiDigger’s help what is basic non-euclidean geometry, how that correlates to game design and virtual worlds, and how we can extrapolate that to create architecture in the Metaverse.

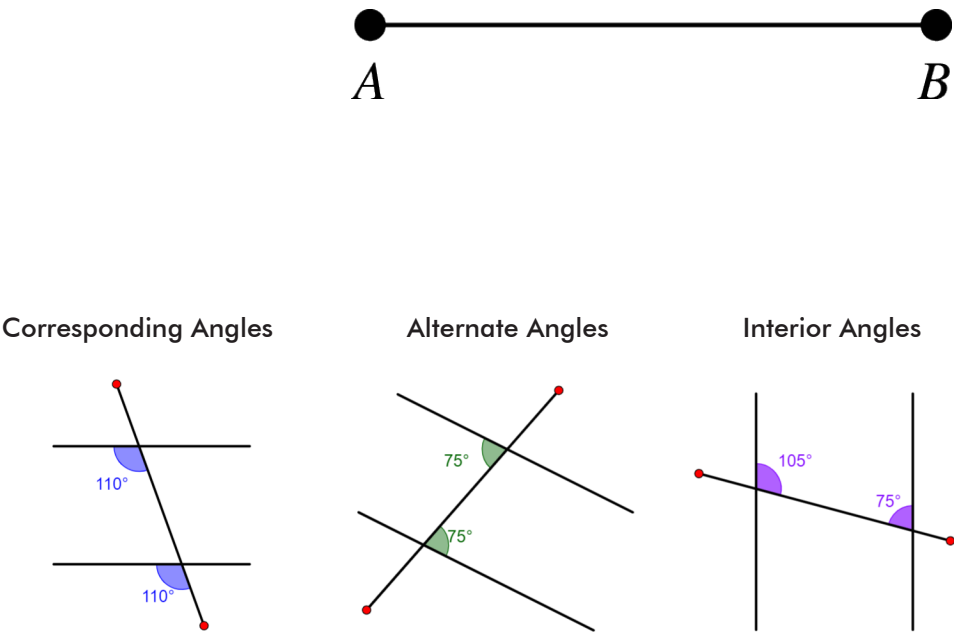
Games sometimes feel like magic because they allow us to experience things that might seem impossible in the real world. Games like Antichamber, Superliminal, Hyberbolica, or Portal can often be described as “non-euclidean” because at first glance it looks like they bend reality and the rules of nature.

However, before discussing how these games work, it is necessary to clear out some simple mathematical and geometric concepts we have learned at school regarding angles, triangles, and the pythagorean theorem, which seem completely logical and clear when dealing in a two-dimensional world. Therefore, going through Euclid’s Postulates⁸⁹ one can take the following conclusions about euclidean geometry, as also seen in [Figure 57]:

- 1. the straight line between two points is always the shortest possible path between those two points;
- 2. parallel lines are always at a constant distance from each other;
- 3. the angles of a triangle always add up to 180 degrees.

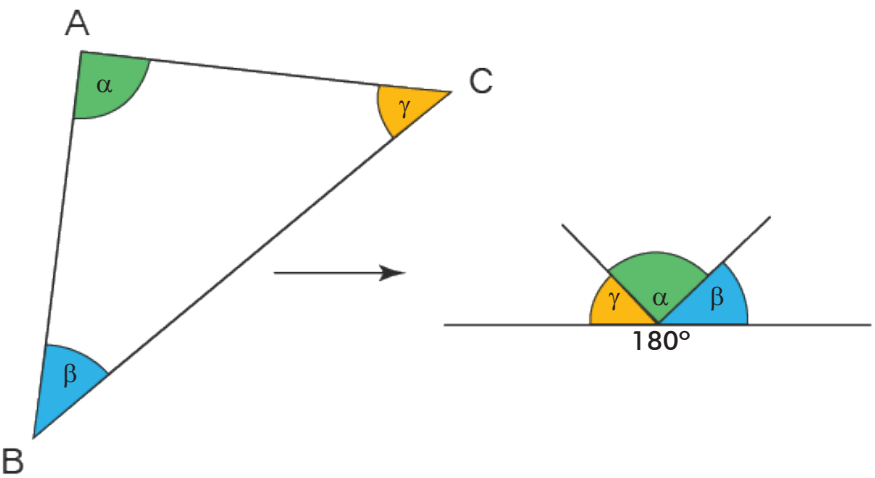
88 DigiDigger. (2020, August 24). How do non-euclidean games work? | Bitwise. YouTube.

89 1. A straight line segment can be drawn joining any two points;
2. Any straight line segment can be extended indefinitely in a straight line;
3. Given any straight lines segment, a circle can be drawn having the segment as radius and one endpoint as centre;
4. All Right Angles are congruent;
5. If two lines are drawn which intersect a third in such a way that the sum of the inner angles on one side is less than two Right Angles, then the two lines inevitably must intersect each other on that side if extended far enough. (This postulate is debatable and equivalent to what is known as the Parallel Postulate.)



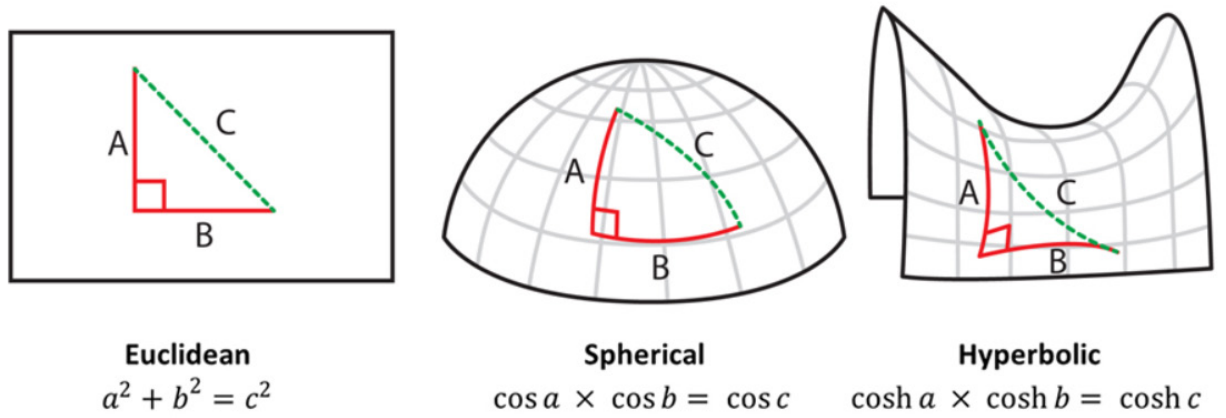
[Figure 57]
Three main rules for the construction of euclidean geometry:

- 1. Shortest path between two points;
- 2. Definition of Parallel Lines through different kinds of angles;
- 3. The sum of internal angles of a Triangle.

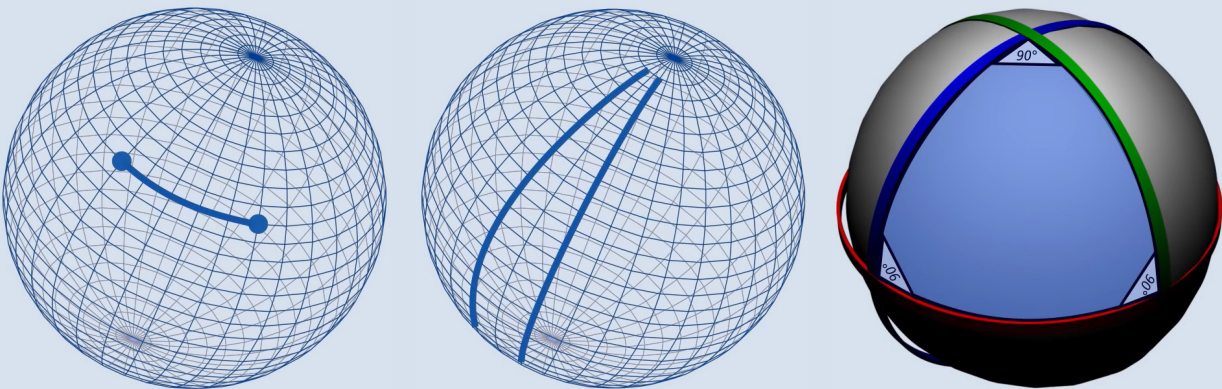


To consider we are experiencing a non-euclidean environment, one must recognise if one of the aforementioned rules is getting broken. As soon as we bend a sheet of paper, these rules can be broken and we stop experiencing a two-dimensional environment. The shortest route between two points on a sphere is no longer a straight line; two parallel lines on a meridian converge and diverge from each other; and the angles of a triangle are three 90 degree angles, totalling 270 and not 180 degrees [Figure 59]. Therefore, when talking about non-euclidean geometry and space, one is mainly referring to curved types of spaces in which we can include hyperbolic and spherical spaces [Figure 58]. For instance, in hyperbolic spaces, parallel lines diverge from each other and in spherical spaces those parallel lines converge with each other.

A visual example of the above mentioned concepts can be seen at [Figure 60] - Looking at these snowballs in hyperbolic space, it is possible to notice how all the parallax existing in euclidean space is gone. Everything seems to be coming at the observer at the same speed, regardless of distance. And in spherical space, things might seem even weirder where snowballs that are behind the observer look like they are in front of our point of view, and everything seems to be moving back and forth.



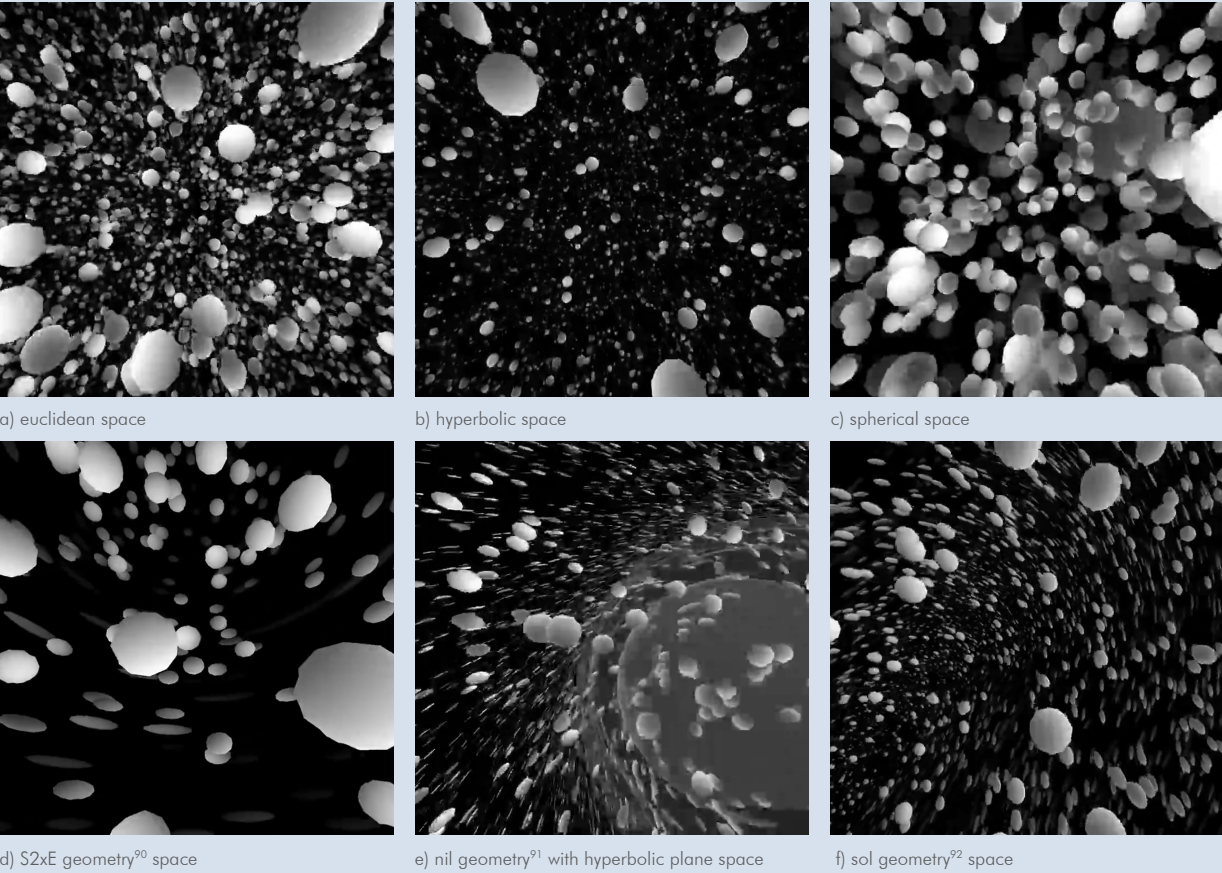
[Figure 58]
90 degrees angles on different types of euclidean and non-euclidean surfaces and their mathematical equations.



[Figure 59]
Demonstration of the three previously demonstrated euclidean rules on a non-euclidean spherical space.

[Figure 60]
Snowballs animations created by @ZenoRogue (Twitter/X username), portraying its visualisation from different kind of non-euclidean spaces.

- a) euclidean space.
- b) parallax expands everything, everywhere and snowballs close to us behave similarly to euclidean ones.
- c) snowballs behind us, look like they were in front of us.
- d) snowballs directly below or above us will look like rings.
- e) making a loop in the plane moves the observer in this third dimension.
- f) hyperbolic in horizontal and vertical directions where curvatures work in opposite ways.



90 The Product Geometry $S^2 \times \mathbb{E}$, is the cartesian product of the two-sphere and the real line. It can be also seen as the universal cover of the product $M = S^2 \times S^1$ where S^2 is the two-sphere and S^1 the unit circle.

91 Nil is a 3-dimensional nilpotent Lie group. It can also be seen as the universal cover of the suspension of a 2-torus by a Dehn twist.

92 Sol is a 3-dimensional solvable Lie group. It can also be seen as the universal cover of the suspension of a 2-torus by an Anosov matrix.



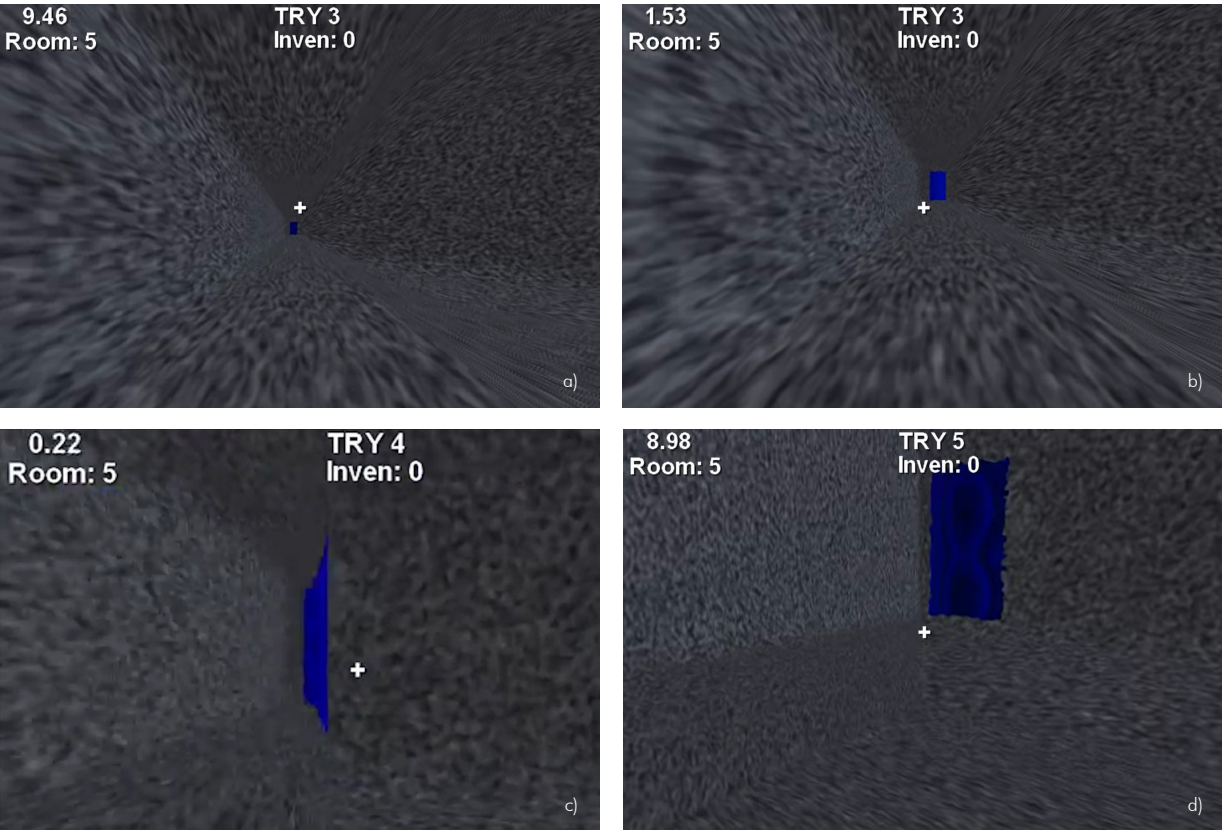
[Figure 61]
Hyperbolica (2022)
Gameplay



[Figure 62]
Superliminal (2020)
Gameplay

Hyberbolica is a game which showcases exactly what walking around a world defined by non-euclidean geometry could look like [Figure 61]; but most games using non-euclidean behaviour achieve these effects mostly relying on clever tricks to deceive our perception of space completely, and thus creating impossible worlds, not only in real life but also in traditional game engines [Figure 63].

Antichamber is a game which completely changes the notion of non-euclidean environments due the above mentioned tricks. The entire game is built around mind-bending and counterintuitive puzzles, some of which defy the logic of space itself. There are two main examples relevant for our dissertation: a stair's illusion and a cube in a museum.



[Figure 63]
CNLoehr's
non-euclidean
GPU Tracer.

Entering the corridor (a), the observer must reach the blue portal within a few short seconds.

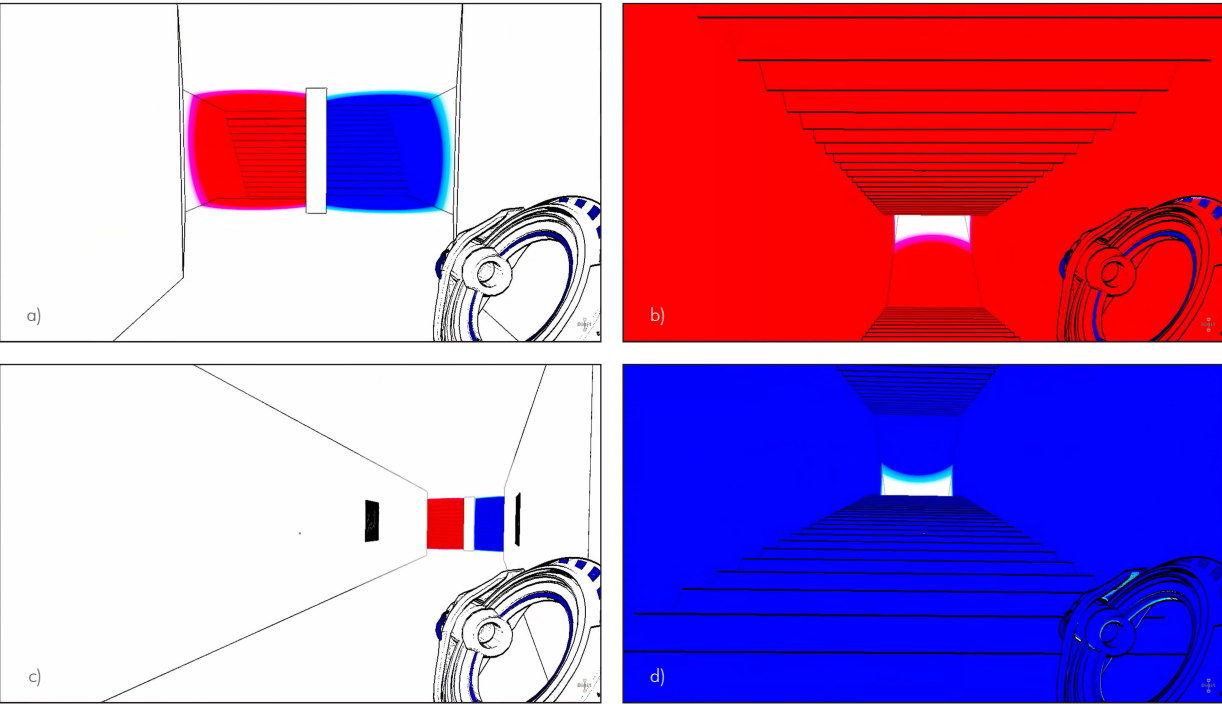
If the observer decides to go as fast as possible in a straight line towards the blue portal, they will eventually run out of time before they reach it (b).

However, if the observer moves to the right the space becomes warped (c) and the blue portal becomes well within one's reach (d).

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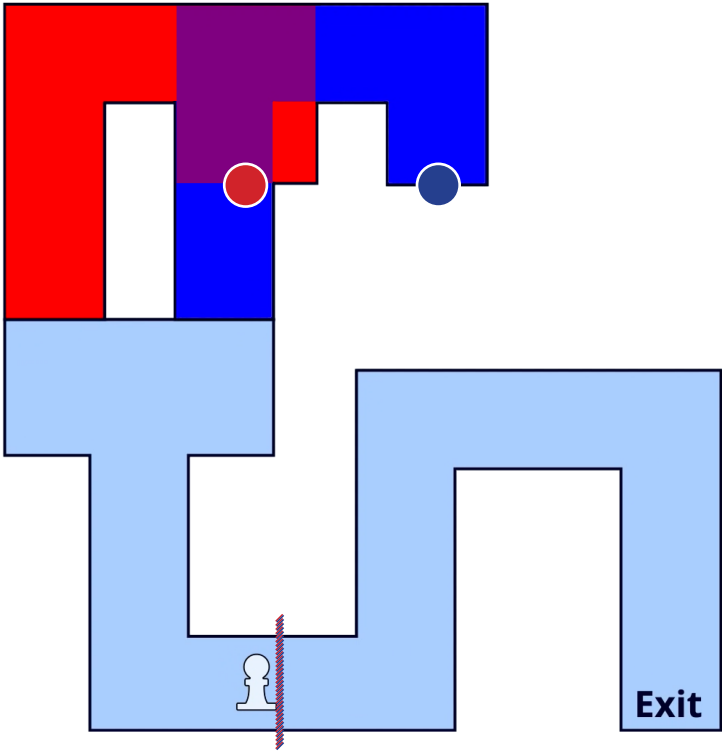
As it is possible to see in [Figure 64] there are two sets of stairs, red and blue [64a], and the player must pick one of them. The player walks down [64b], turns the corner, and sees the same set of red and blue stairs [64c]. Then, the player chooses the other side this time; walks up [64d], turns the corner, and comes to the exact same initial place [64a] and [64c]. The solution to this problem is choosing neither of the staircases, and instead, turning around and going back where we came from, and the puzzle is solved.

This problem uses a computational trick that would be impossible to create in either two or three-dimensional environments, because the way the hallways are designed is the key to understanding how does this illusion works. As seen in the [Figure 65], there are two sets of stairs together with the hallway leading up to the stairs the player is supposed to go back into. What actually happens in reality is that when we turn the corner and walk far enough to a certain pre-determined and programmed point, the player is simply teleported to the beginning of the hallway without even realising such action due to Antichamber’s flat lighting. However, it is possible to trick the game into giving a little bit of its secrets, if for instance, the player puts an object at the beginning of the hallway, it suddenly becomes possible to see the exact frame where that teleportation happens.



[Figure 64]
Antichamber's
double staircase
puzzle as viewed
solving the problem.

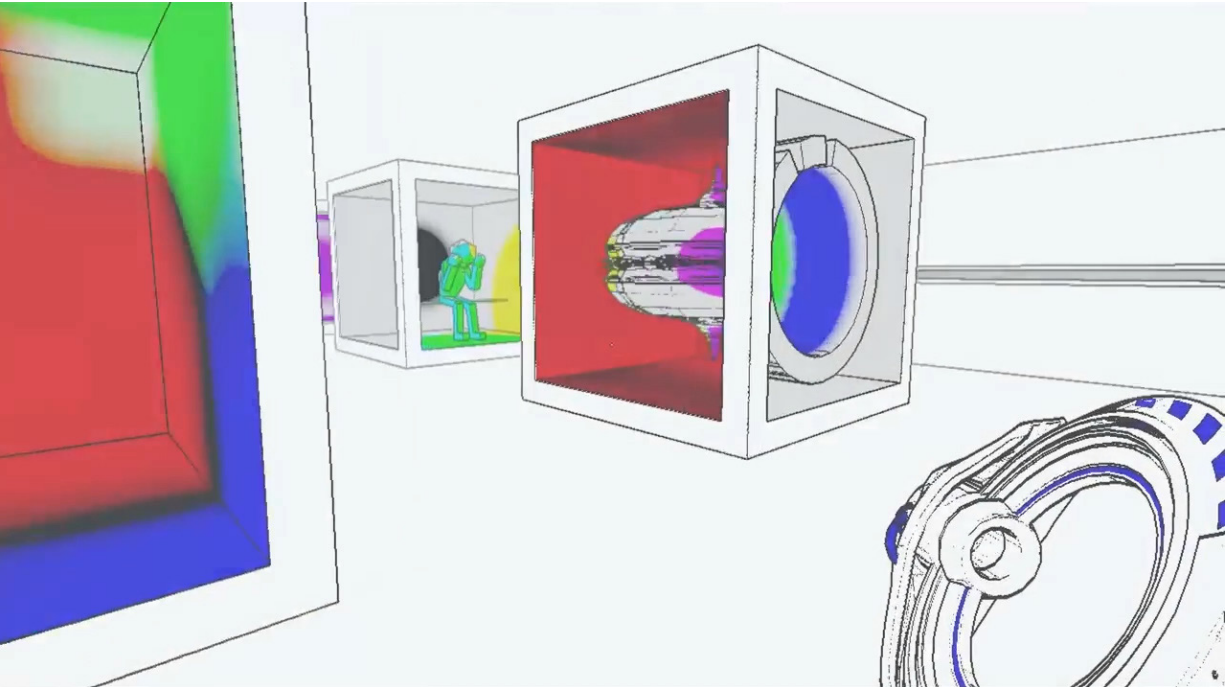
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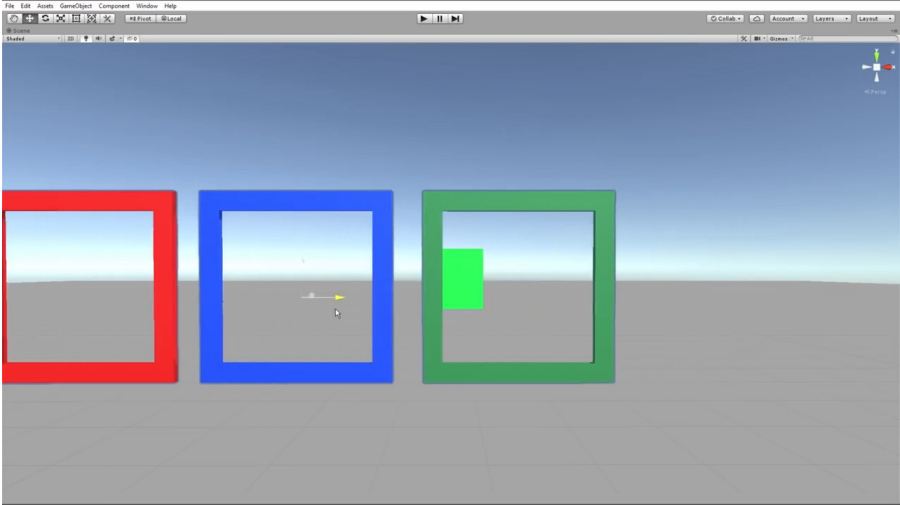
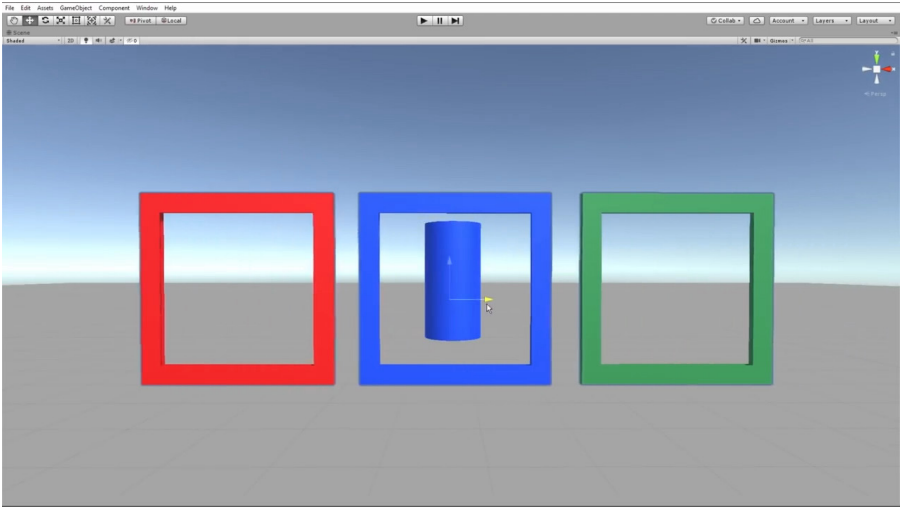
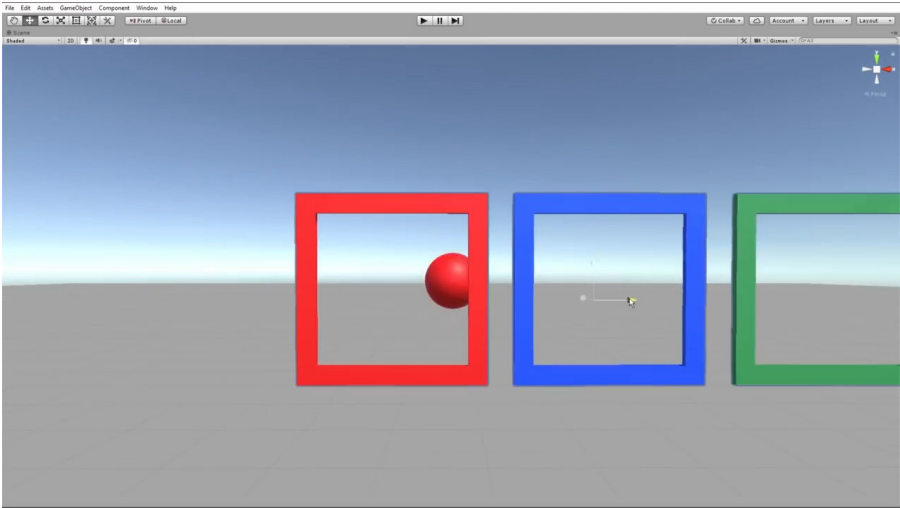
[Figure 65]
Antichamber's
double staircase
puzzle: solution
and how it is
programmed.

 starting point  red teleporting moment  blue teleporting moment  teleporting destination from  or 

Such teleporting tricks are riddled throughout the entire game, and sometimes. Another trick that seems impossible is a cube in the museum, showcased in the [Figure 66]. On every cube's face it is possible to see a completely different scene inside it, creating a visual effect where it seems multiple different scenes exist in the exact same physical space. To understand how this trick works, it is first required to understand how the graphics card in our computer gives us a little buffer which can mask and discard pixels on the screen. Usually, this buffer is used to mask out parts of the screen using stencils, and therefore, this buffer is called the stencil buffer. A practical example of such a trick could be the rendering of a rear view mirror of a car in a game, where there is no need of drawing the entire rear view of the car on top of the frontal view one is experiencing - we just want that tiny rectangular mirror. Therefore, a stencil is defined where only the rear view will be rendered in parts that overlap with the said stencil; and thus, stencil buffers can have multiple channels, let's say red, blue, and green [Figures 67-69], where a stencil assigned to the red channel will only render objects assigned to the same red channel. When this process is repeated and the buffer stencils are put into the shape of a cube, it suddenly becomes possible to create a cube like the one we see in the museum above, and the entire illusion unfolds [Figures 70-75].

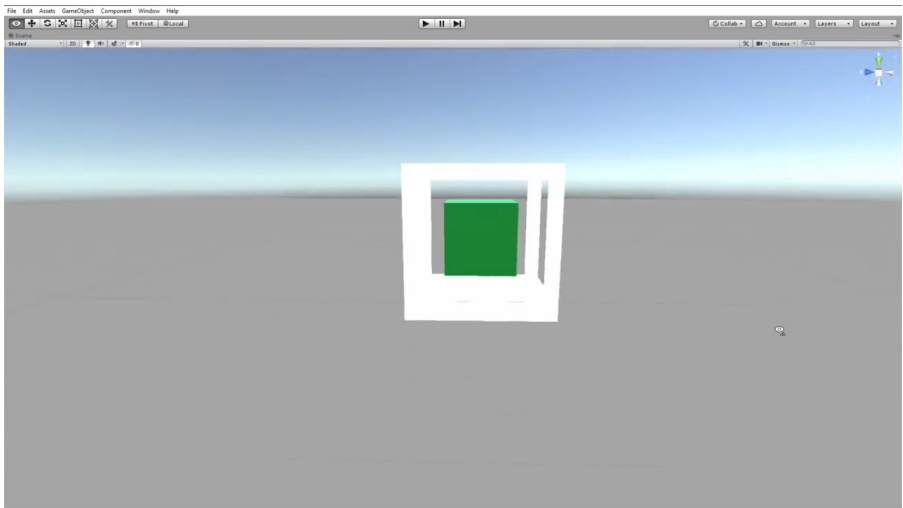
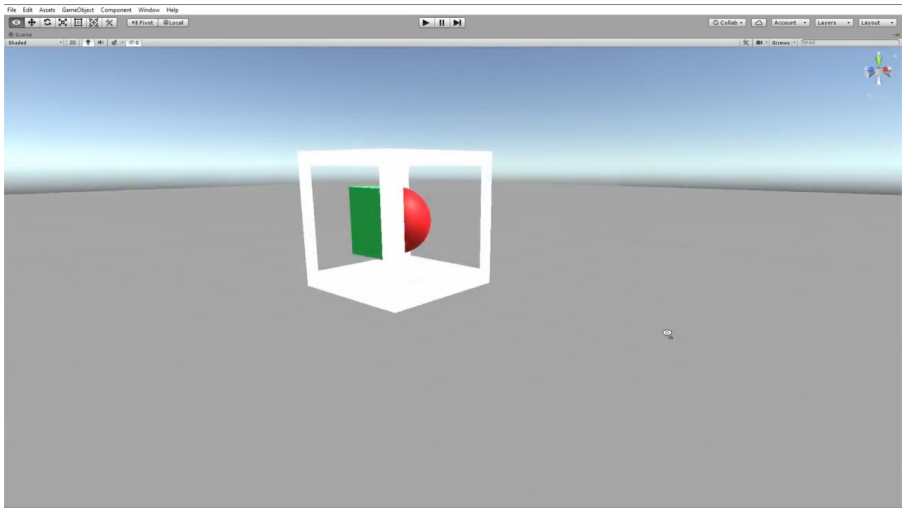
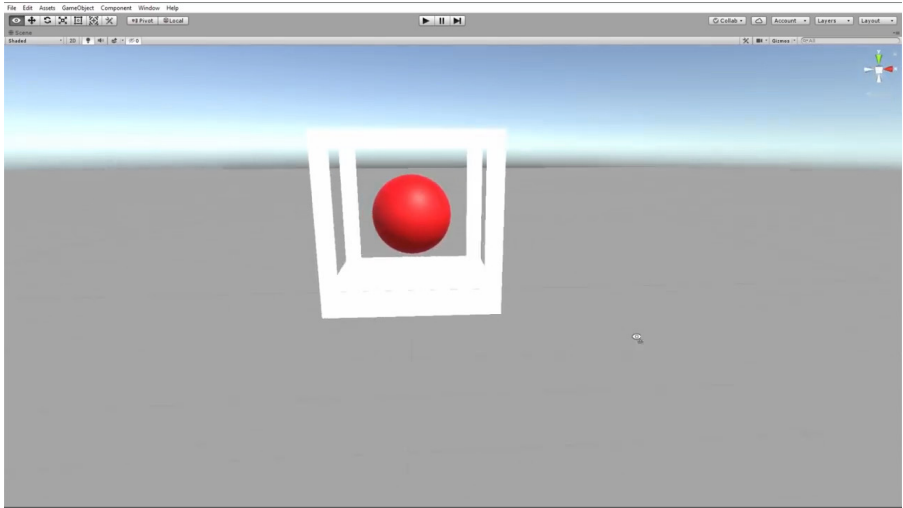


[Figure 66]
Antichamber's
Museum Cubes.



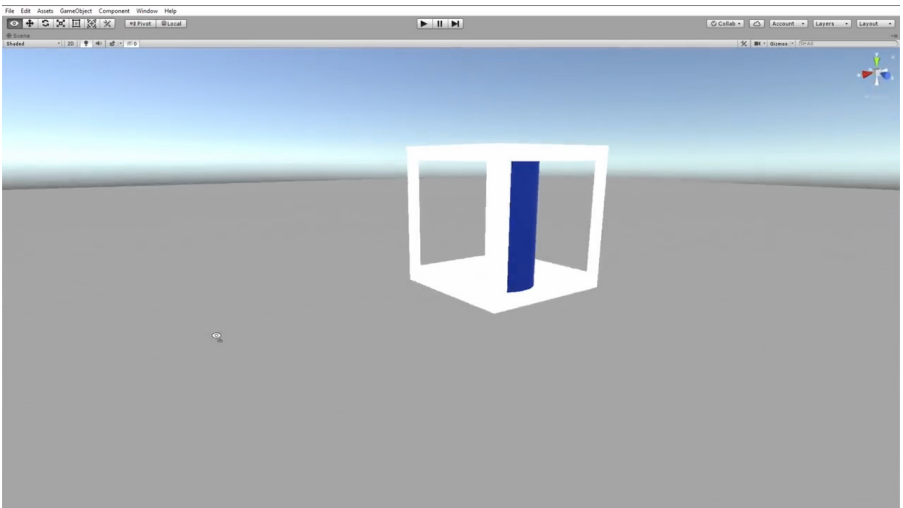
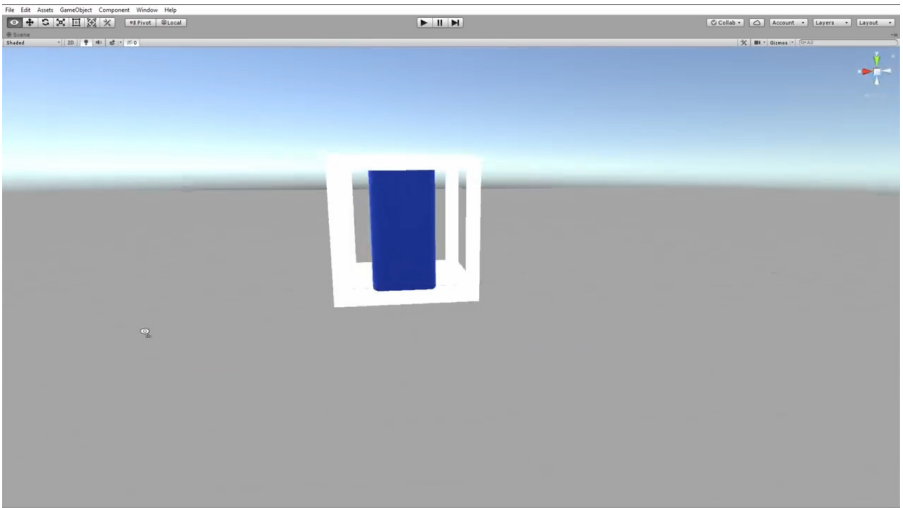
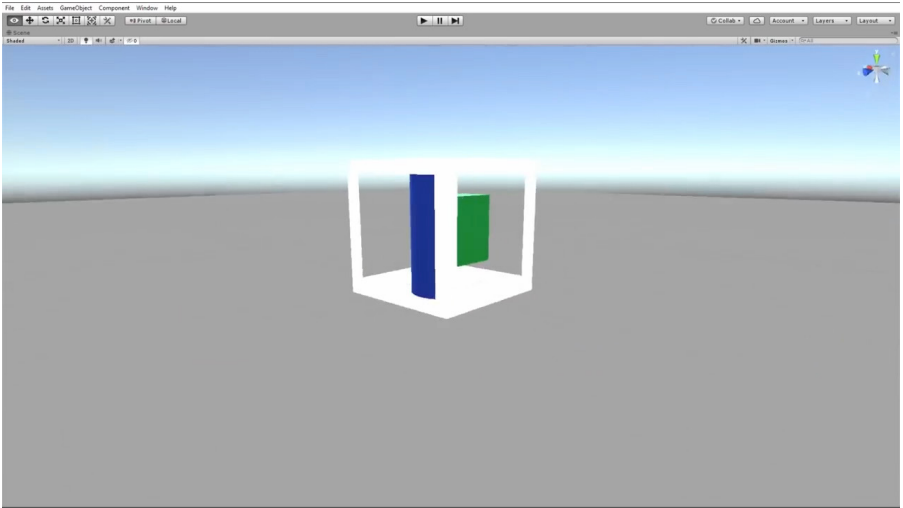
[Figure 67]
[Figure 68]
[Figure 69]
Demonstration of
stencil buffers in a
game engine.

116



[Figure 70]
[Figure 71]
[Figure 72]
Buffer stencils put
into the shape of a
cube.

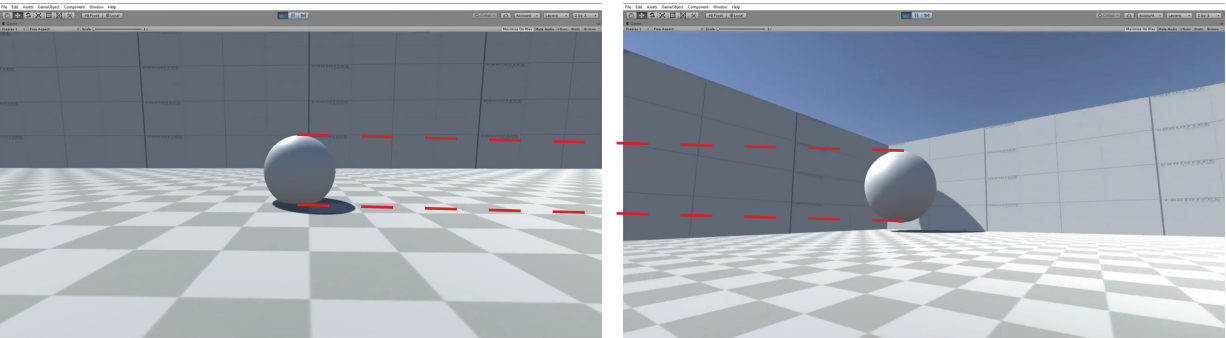
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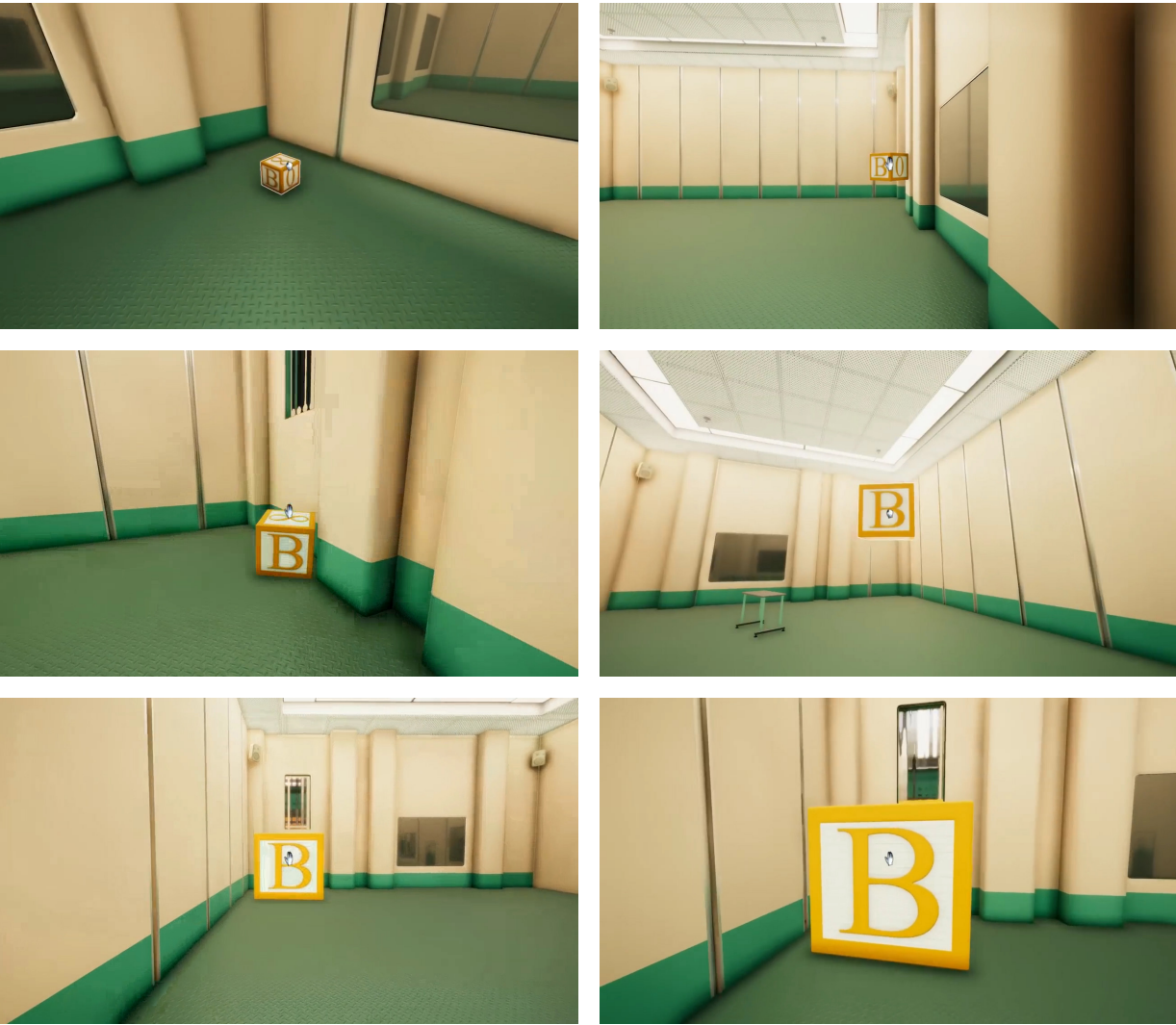
[Figure 73]
[Figure 74]
[Figure 75]
Buffer stencils put
into the shape of a
cube.

Superliminal is a game that uses a different form of perspective deception as it forces the player’s surrounding environment to change according to their position [Figure 62 & 78]. The game’s idea is to pick up objects and while their perspective size remains the same, their real size changes dramatically depending on the point where we put the said object; and therefore, objects that appear really big, are always that big in the game’s world. This is possible because of the angular diameter of the player’s point of view, or in other words, the apparent size of an object in our view; and so, the trick is to keep the angular diameter always the same, regardless of the distance to the object.

The angular diameter is determined by two variables - diameter and distance, and the way to enforce this trick is to change the scale of an object, simultaneously with the distance it is to us; so if the distance is twice as far, the game engines forces the scale to be twice as big, or vice-versa when scaling down. By doing these actions, our object will always stay the same size in the player’s field of view [Figure 76 & 77].



[Figure 76 & 77]
Exemplification of point of view’s angular diameter, changing the scale of the object, whilst remaining the same on screen.



[Figure 78]
Gameplay of Superliminal (2020), portraying a practical example where angular diameter of the subject is used.

The two previous examples do not really mess up with the geometry of a two-dimensional plane world works, and therefore, in practice they do not even break any of Euclid's Postulates rules, instead they use computational processes only possible in a virtual world not defined by physical laws. This is why DigiDigger's conclusion to the question if these games are really non-euclidean is "yes and no". Nevertheless, one could argue that the most important aspect is that these games and these types of spatial experience provide the player a non-euclidean experience, by providing a sense of amazement and confusion, even if the games themselves do not break any of the euclidean rules.

From the analysis in the last paragraphs, we can define that non-euclidean games distort the spatial notion, with distorted or unconventional spatial geometry; use gameplay mechanics in their layouts and puzzles; and create a surreal atmosphere evoking a dreamlike atmosphere, disorienting spatial design, where physical rules are bent.

Breaking these types of rules is not possible in real world architecture, although it is possible to make an effort and search for close characteristics. So far, the closest we can get to non-euclidean architecture are illusions of built environment and spaces, such as impossible staircases, also known as Penrose Stairs, created by Oscar Reutersvärd in 1937; or Escherian Stairwells such as the ones portrayed in 1953's *Relativity* by Maurits Cornelis Escher [Figure 79].

[Figure 79]
M.C. Escher:
Relativity (1953)

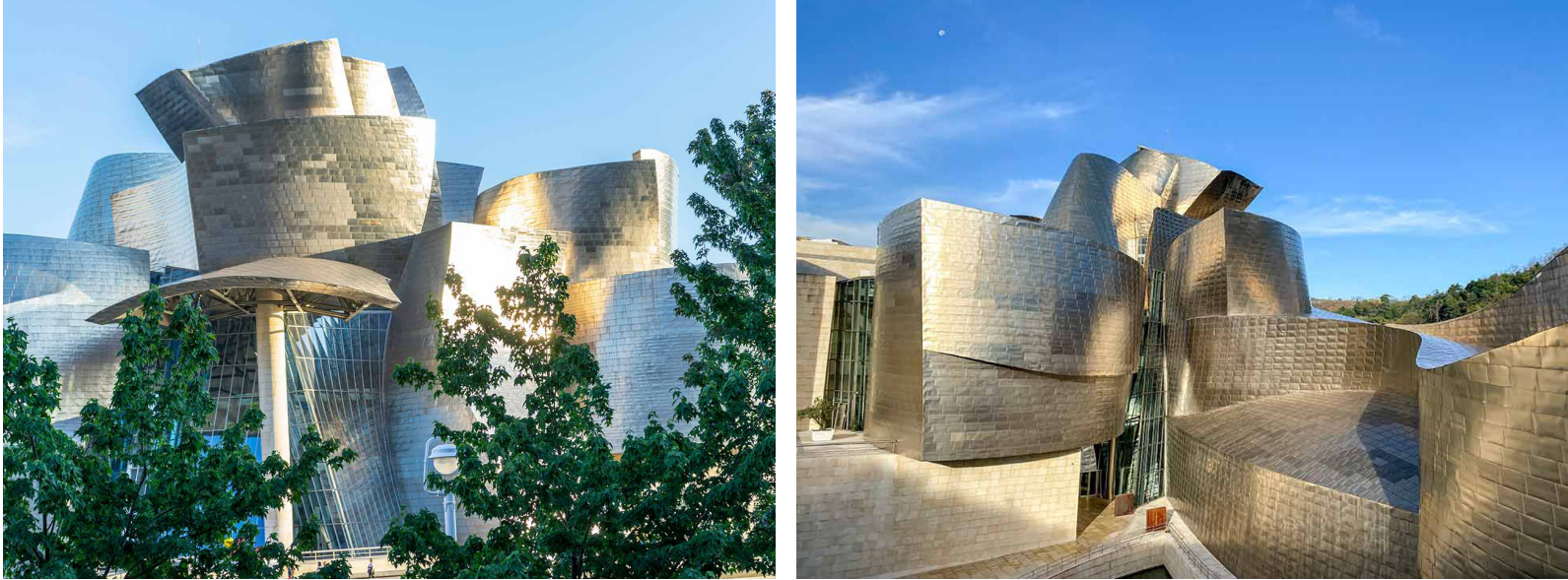


Therefore, transponding the characteristics of the virtual spatial design into real world architecture presents a massive challenge. Probably the closest we could get to non-euclidean architecture in the real world are spaces with elements that defy conventional geometry - buildings or space that may feature curved surfaces, irregular angles, or unconventional shapes deviating from the norm. Examples of such buildings could be the Guggenheim Museum in Bilbao by Frank Gehry or Zaha Hadid’s Heydar Aliyev Center in Baku, Azerbaijan [Figure 80 & 81].

Before continuing, it is important to understand that non-euclidean type of spaces and architecture is not something mandatory to have in the Metaverse. However, non-euclidean spaces are something unique to virtual worlds, hence why it makes sense the theoretical questioning about their design in this dissertation.

With this being said, the first step to creating non-euclidean architecture could be establishing a non-euclidean building site. In practice, some of the longest buildings in our planet already obey to a spherical geometry - for instance, suspension bridges are built with such discrepancies in mind with their tops being at a different distance than their bases - however, things change radically when the space is entirely non-euclidean at a scale of a city or a building, and especially where light obeys to non-euclidean geometry.⁹³ Consequently, the use of hyperbolic and spherical spaces is the easiest starting point where the rules can be bent and broken.

[Figure 80]
Guggenheim Museum Bilbao (1997) designed by Frank Gehry, in Bilbao, Spain.



[Figure 81]
Heydar Aliyev Center (2012) designed by Zaha Hadid Architects, in Baku, Azerbaijan.



⁹³ In practical terms for this dissertation, light travels mostly in a straight light through our mostly two dimensional euclidean space. Although the spacetime continuum can bend light across objects, its effect is negligible to naked eyes. Ray and path tracing in game engines follows the Principles of Geometric Optics rather than the General Theory of Relativity; hence in practical terms for this dissertation, light following non-euclidean trajectory through a spherical or hyperbolic space would mean the light would follow and bend alongside the curvature of the plane-ground.

Video games and computer simulations could use the above mentioned principles of physical geometry to bend and break rules to create non-euclidean spaces and environments, but understanding how our computers work and process the images they portray us could also be used to go even further creating worlds that defy any kind of logic, by using computer tricks such as ray tracing. Used in rendering softwares like Twinmotion, Lumion, or Autodesk’s 3ds Max, and any type of 3D video games, ray tracing is a rendering technique used in computer graphics to simulate light’s path and behaviour as it bounces and interacts with the environment where it is located, thus, creating different shadows, reflections, and refractions, from the observer’s point of view. Since the rays bouncing to the observer’s lens alters with every position the observer is in, it is essentially possible to use ray tracing as a visual trick, creating an environment where the space is compressed and expanded based on the observer’s position everytime they move is possible, like portrayed in [Figure 63].

The creation of non-linear narratives of space where the space itself divides in different options and scenarios depending on our actions on the surrounding environment is also a possibility to create an illusion of a non-euclidean world. Similarly to what already happens in Antichamber with its staircases or museum cubes, one could create an environment where the player would be seamlessly teleported through portals or buffer stencils depending on their movement and interactions with their surroundings. A spatial narrative combining features from both Antichamber and Superliminal where the player is the one changing size and scale as it enters different spaces through buffer stencils, therefore creating an infinite loop of smaller and smaller environments, like demonstrated in CodeParade’s example about non-euclidean game engines in the [Figures 82-86].⁹⁴

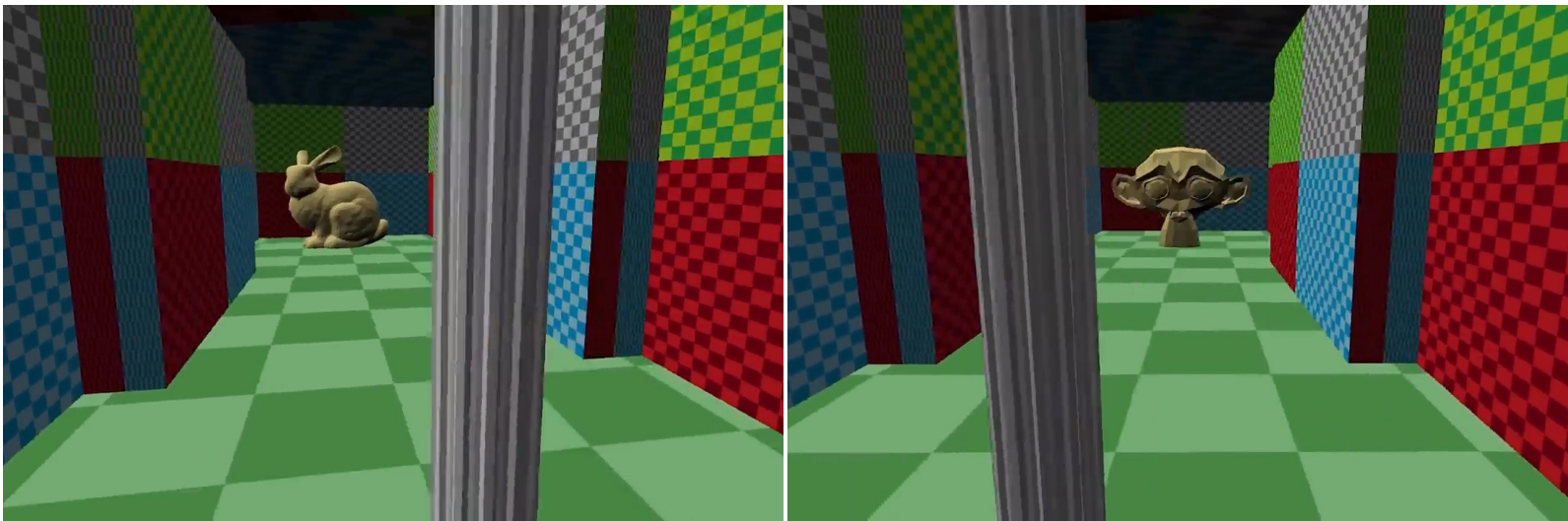
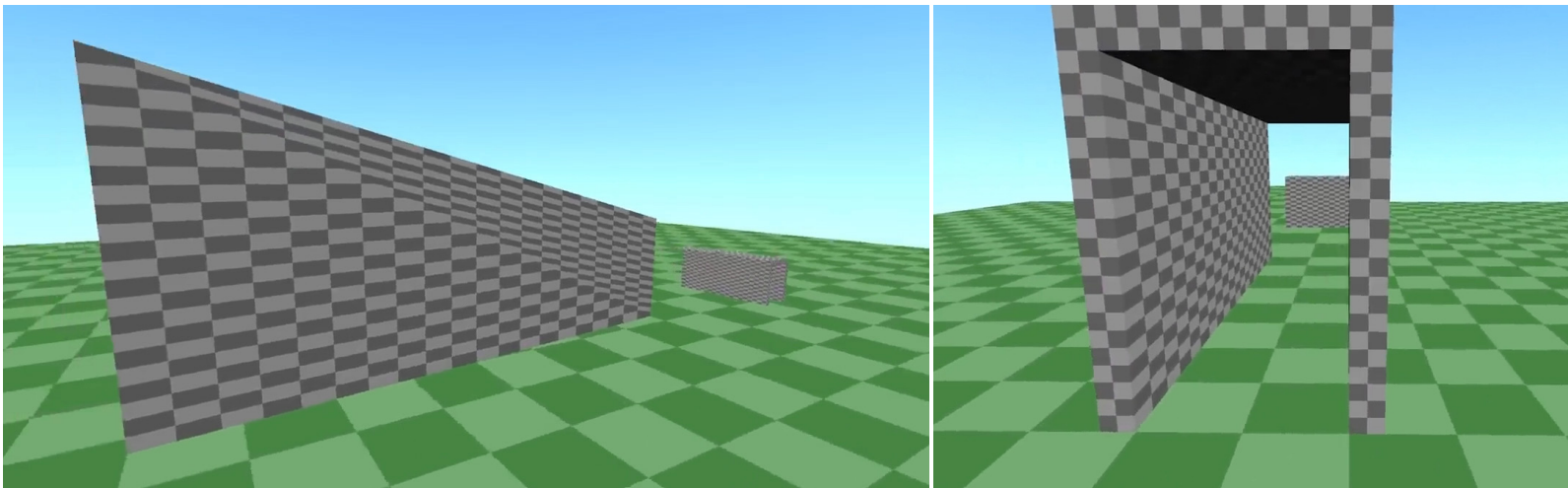
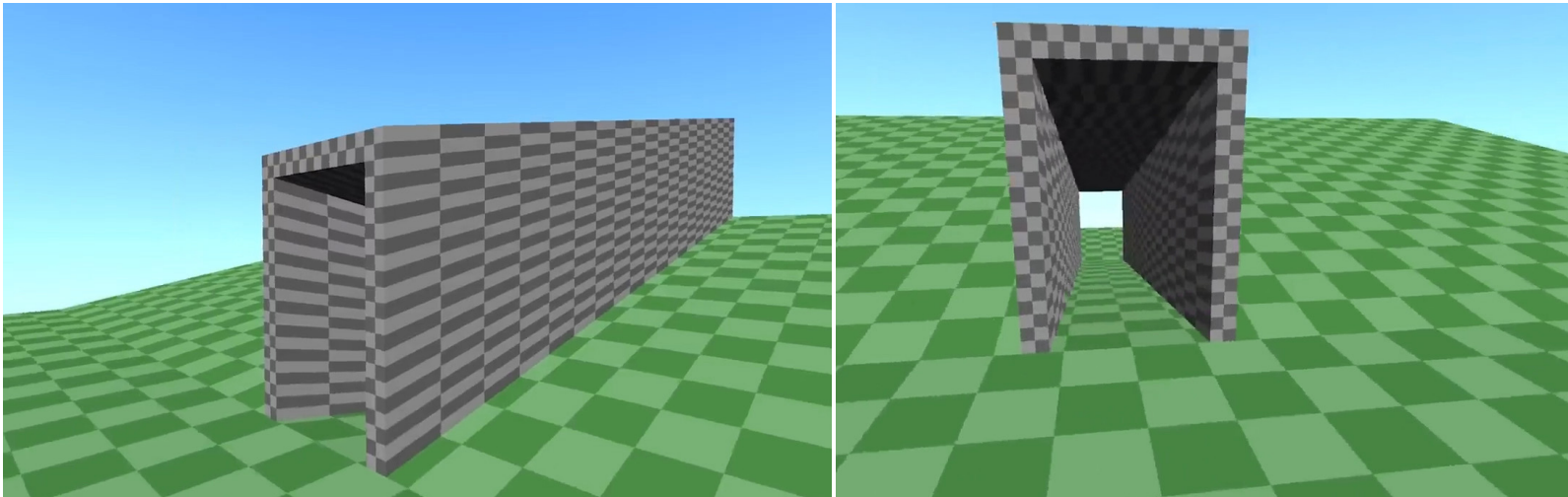
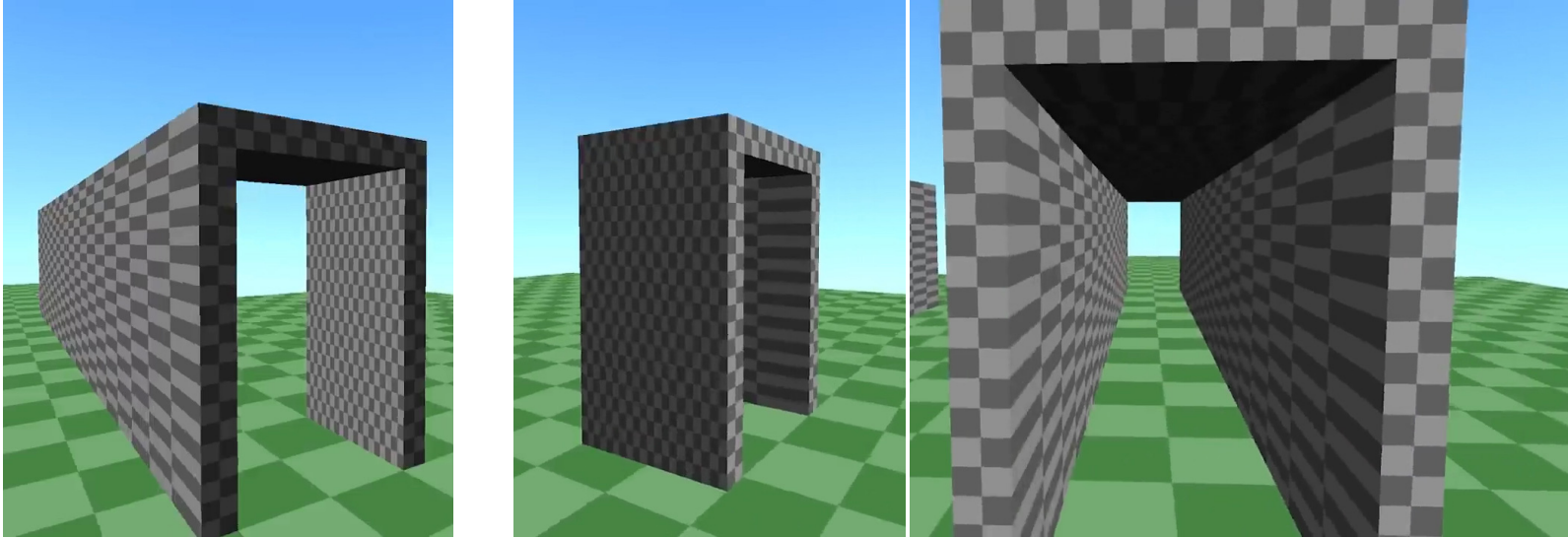
[Figure 82] - Left
A non-euclidean tunnel which from its outside appears long, whilst its interior is short. It is possible to observe the deformation on the checkered pattern on both inside and outside walls.

[Figure 83] - Right
The opposite kind of tunnel is presented, with a short outside, and long inside.

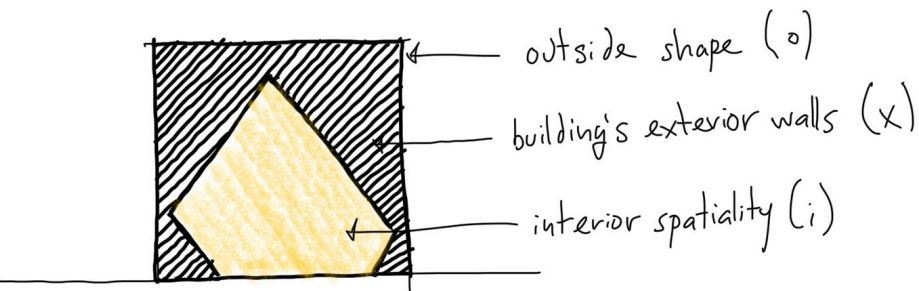
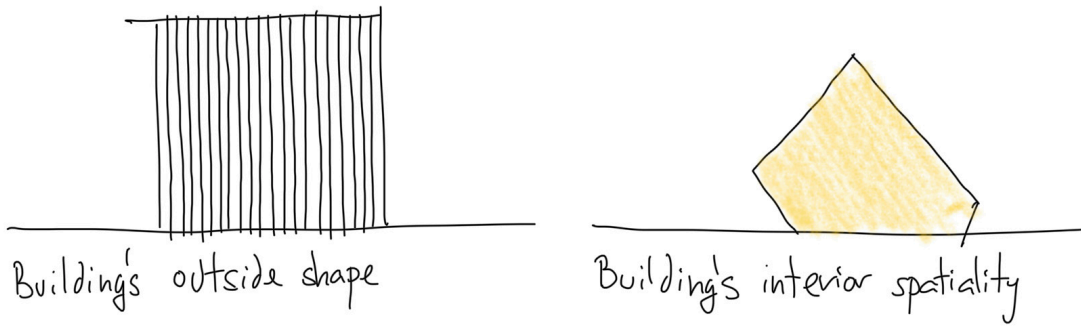
[Figure 84]
Another tunnel which from its outside appears to be going up the terrain, but upon entering it, it is revealed it actually goes down. The opposite effect would be achieved from the other end of the tunnel.

[Figure 85]
In this example there are two tunnels – a large and a small one, through which the observer cannot pass – passing through the large tunnel, changes the observer’s scale when they come out – A fact that can be observed at the end of the large tunnel.

[Figure 86]
It is also possible to place different objects in the same place, making them visible depending on observer’s point of view.

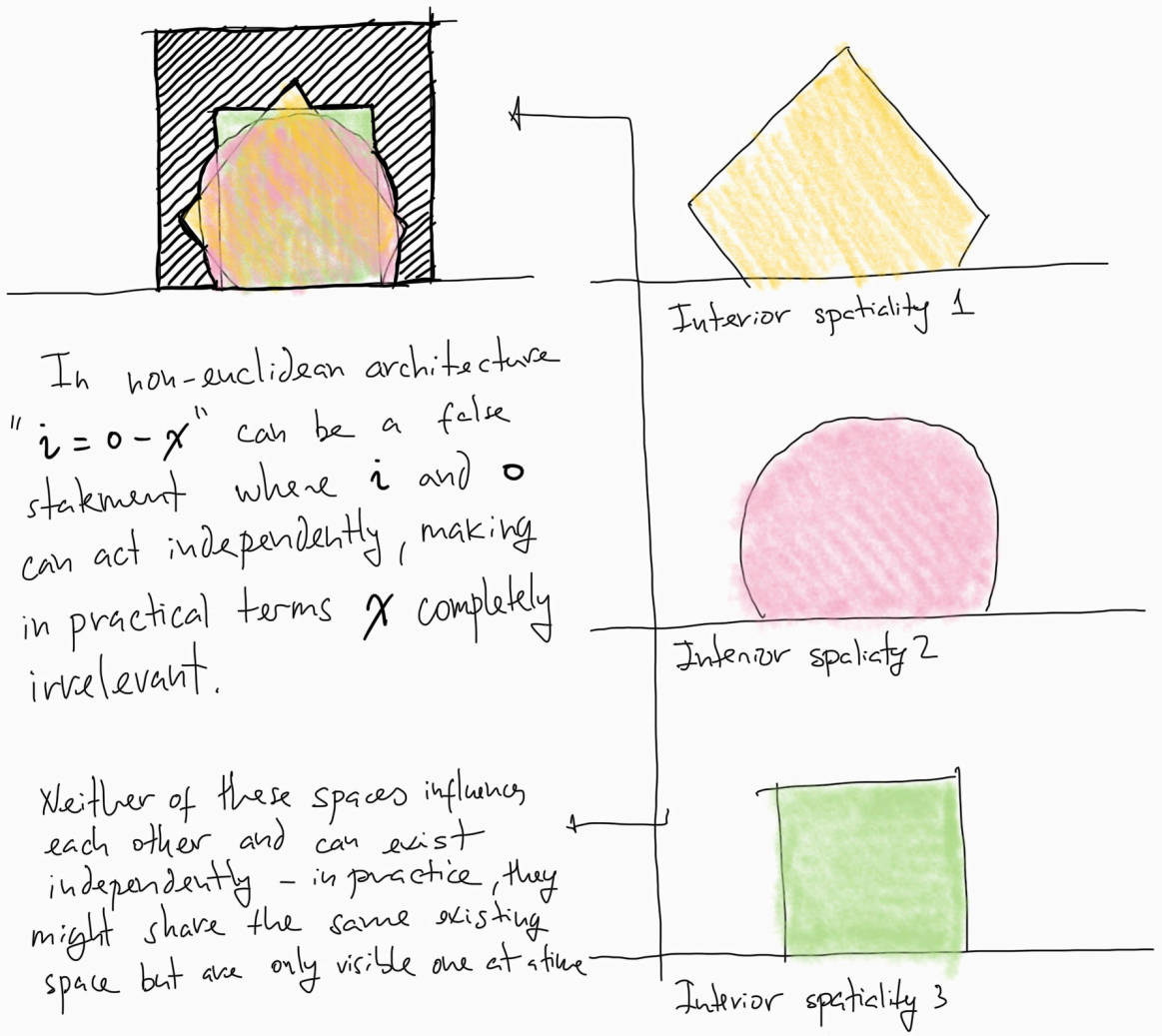


⁹⁴ CodeParade. (2018, August 14). Non-Euclidean Worlds Engine. YouTube.



In physical architecture the space one experiences inside a building is the result of the following equation: $i = o - x$

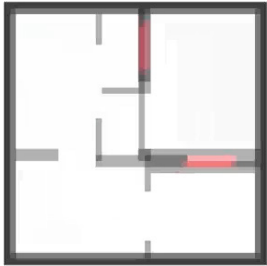
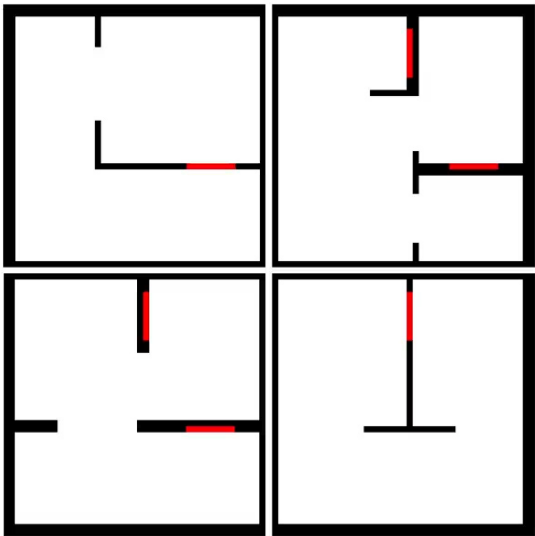
[Figure 87]
Sketch about the fundamental logic of a building's shape and interior spatiality in euclidean space.

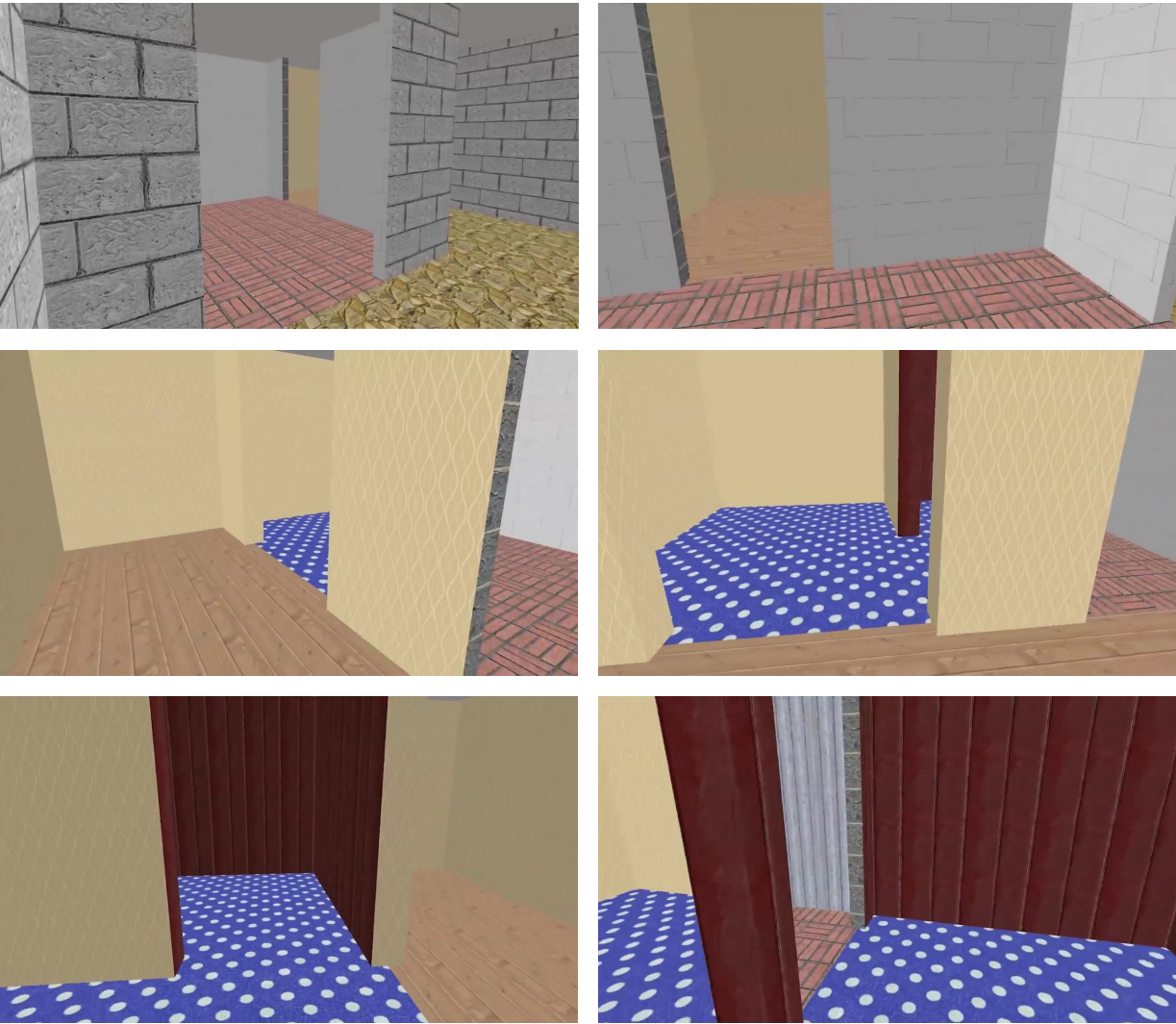


[Figure 88]
Sketch about the a building's spatiality and exterior shape in a non-euclidean space.

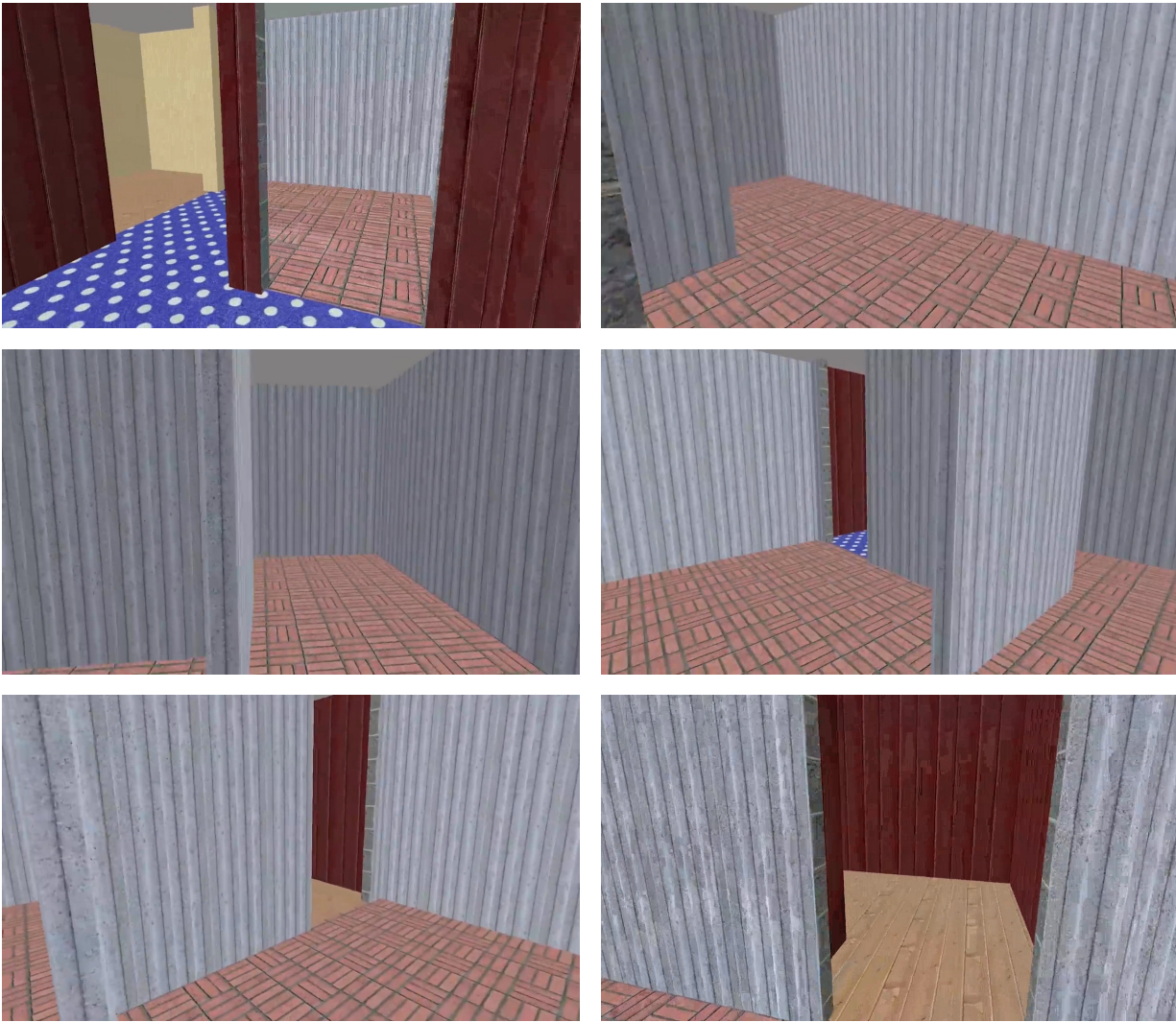
[Figure 89]
CodeParade's example of how non-euclidean spaces can all share the same physical space, whilst remaining independent from each other.

In this particular example, the portals to different spaces are represented in red, and the four spaces are overlayed in the plan shown on the right.





[Figure 90]
CodeParade’s 3D
walkthrough the
space represented
by the plans in the
[Figure 89].

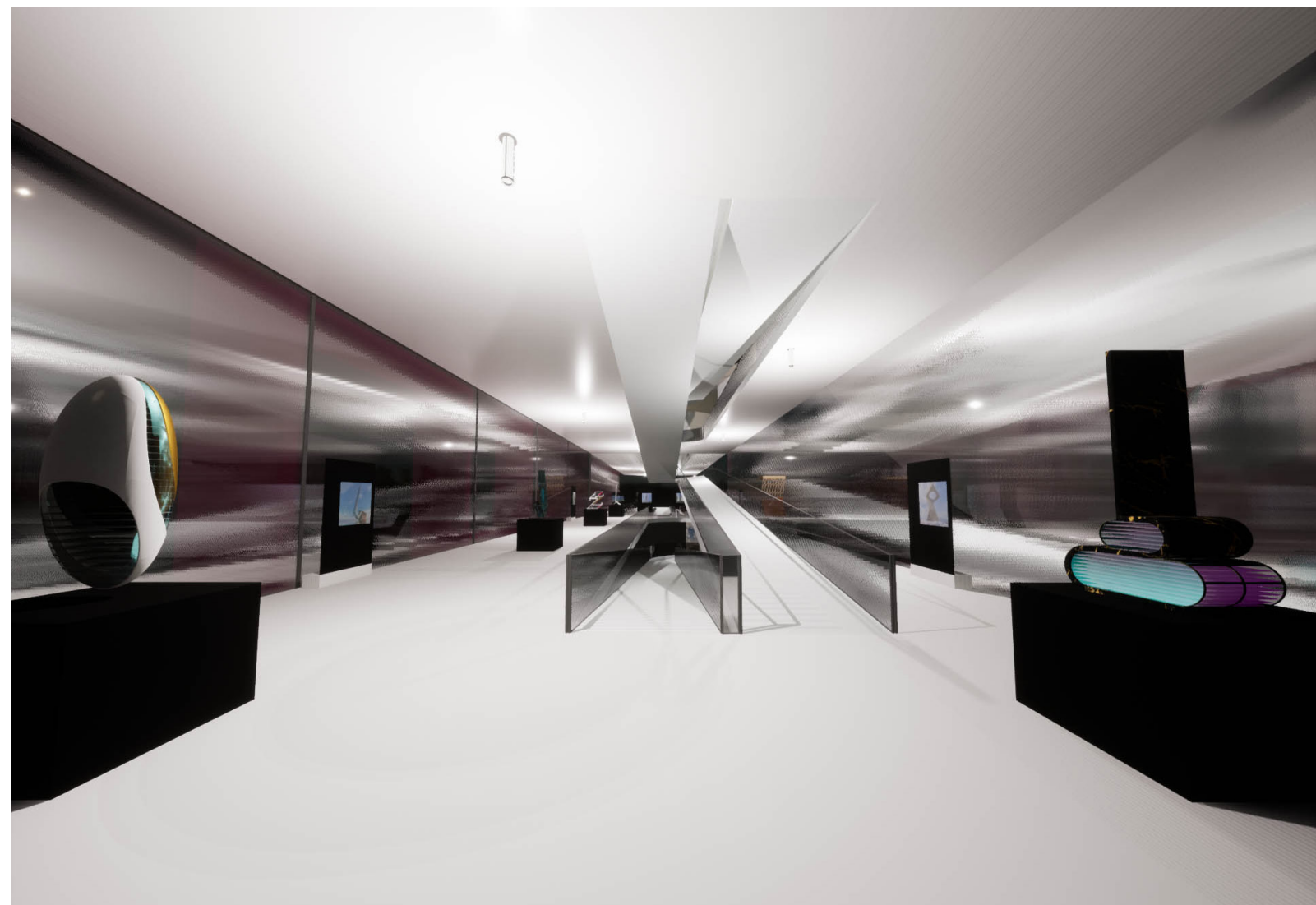


[Figure 91]
CodeParade’s 3D
walkthrough the
space represented
by the plans in the
[Figure 89].

In physical architecture, the only way to configure a different space on the inside from what the building's shape is on the outside, is by having its exterior walls to act as a negative shape - or what we call it in FAUP's first year of school: sculpting the cube on the inside [Figure 87]. Non-euclidean buildings could have environments where the interior, exterior, and the building's different rooms seamlessly overlap with each other [Figure 88 & 89]. As an analogy, one could picture conventional architecture as bits in a computer where their state is either zero or one (exterior or interior); whilst imagining non-euclidean buildings as qubits (bits of a quantum computer) where their state can be simultaneously zero or one, in a state of superposition, depending on our observation point. This approach creates a game changing situation where it becomes possible to design rooms that overlap each other in space, where each room can have its own rules, not influenced by another. In practice, this means that exterior and interior environments can suddenly overlap with each other in cross-sections and plans, as seen in the practical examples in the [Figures 89-91].

As a conclusion for this subchapter, it is arguable that non-euclidean architecture is all the design of space that includes some sort of impossible geometric characteristics, which might be achieved by altering the building site to a three dimensional plane, by using computer tricks and spatial narratives to give an illusion of what is really happening behind the observer's point of view, or simply by creating a building that would not be possible in the real world. The idea about non-euclidean architecture came to life when developing #003 - Metaverse Pavillion by archi.META as one of the exhibition floors in the building was entirely transparent to the outside with glassed walls on the inside, whilst it kept its opaque surfaces seen from the outside, and thus, creating a building not possible to build in real life [Figure 92 & 93].

[Figure 92 & 93]
_umexh's (Instagram username) exhibition floor at the #1 MetaverseExpo – by archi.META inside the #003 - Metaverse Pavillion by archi.META, with glassed walls on the inside and opaque walls from the outside the building.



132 Bridging Architecture to Game Design

Throughout this chapter, many differences and characteristics between the two distinct disciplines of physical and virtual architecture have been explored. One could argue that spatial architecture of the Metaverse will be located somewhere between classical physical architecture and regular game design as we know it today; and for now, we as classical architects, are extremely ill-prepared to go into designing meaningful objects in the virtual worlds.

Designing and building in the Metaverse will require a new set of skills but most importantly, a shift in perspective from physical architects, as to design in the virtual environment it will be necessary to include other aspects such as content, character, and game design.⁹⁵ It is likely that the professionals of the future, independently of their professional field, will increasingly require programming knowledge to bridge their fields with the technological potential. This subchapter delves into the bridge between the design of architecture and gaming design, exploring a little bit the difficulty that us, as classical architects, will encounter on our ways, if we want to develop projects for the Metaverse.

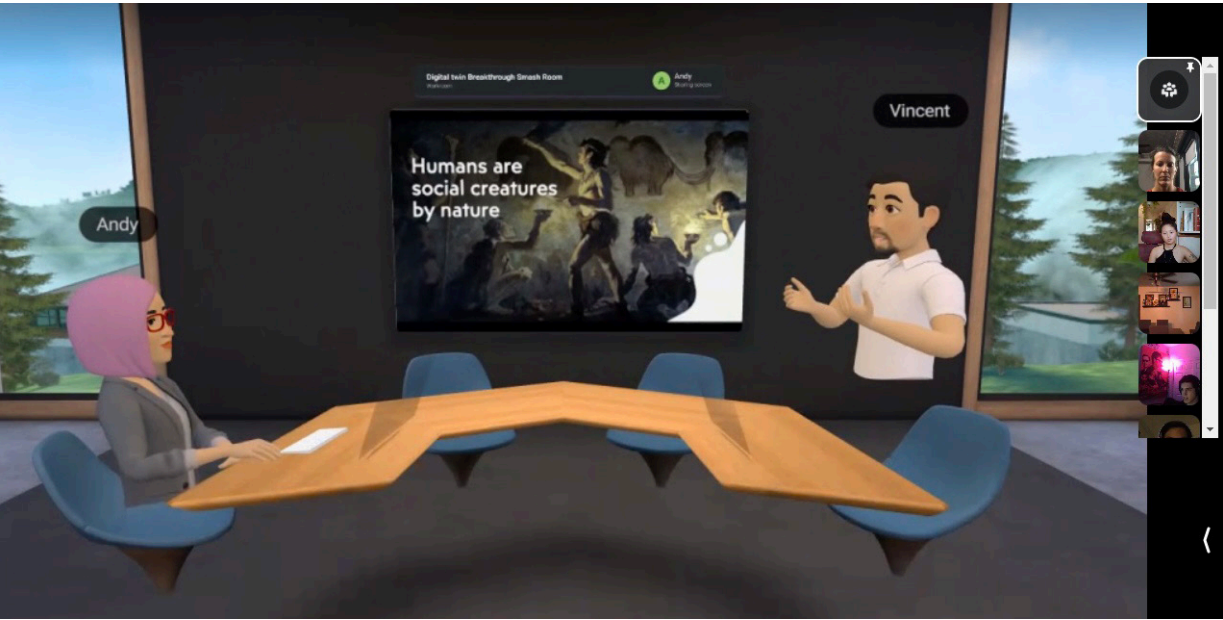
The first time I was put into a position outside my comfort box, was when in September 2022, I met Vincent Serpico, who is an app developer, AI data scientist, and founder and CEO of Founders Workshop™, a software development company, which creates mobile apps and web apps for start-ups and non-tech founders. Vincent had launched Metaverse Workshop, a sub-division of Founders Workshop™, and he wanted to create a digital smash room, just like the one he owns in real life, and I was one of the potential candidates to design the virtual architecture and assets for that project.

The project of creating the digital smash room was supposed to undergo three different complexity stages, and although I had at the time seven years experience in 3D modelling, I clearly was underprepared for what Vincent's vision was. The first stage of development was creating a digital twin in Roblox, using the Roblox Studio as a 3D modelling software; the second stage was to use and model in VR using the Oculus Quest 2 for the Facebook's Horizon Worlds; whilst the last stage of development was moving onwards to an actual gaming engine like Unity.

My biggest concern throughout the entire process was the fact that despite being able to create any necessary 3D modelling, I had no knowledge about either programming or object physics, which was essential being it a smash room, where assets would need to be broken; and simply 3D modelling an object is a very different process from modelling that same object with the intent of having it react like it would in real world when broken, as it becomes necessary to simulate all its components.

After several meetings in the Metaverse through Facebook's Horizon Workrooms, extending for almost one month, Vincent and I ended up not going ahead with our partnership to create the Breakthrough Smash Room together, although the project on Facebook's Horizon Worlds ended up getting released at some point in 2023.

⁹⁵ Camilla Ghisleni. (2022, December 3). The Metaverse in Practice: How to Build in the Digital Space. ArchDaily.



[Figure 94]
Meeting with the Founders Workshop™ team regarding the creation of the digital smash room on 29th September 2022 via Meta's Horizon Workrooms.

Therefore, this subchapter came to life as a practical example which allowed myself room for reflection about the existing knowledge gap between the required skills to design something in 3D and creating a functional digital twin of a building with a running business inside it. There are four fundamental challenges to overcome when it comes to designing virtual worlds and digital twins.

Learning game design fundamentals and principles, which includes everything going from game mechanics, player engagement, level design, to narrative and spatial storytelling, which on itself can come in many different forms, shapes, and styles; and which is equally important in both game design and virtual architecture, as spatial storytelling is the motivation of someone visiting and spending time in spaces we create is the main purpose for the space's existence.

The learning curve of game engines like Unity or Unreal Engine might be steeper than in any complex architectural BIM software like Revit, but learning and being familiar with those engines is fundamental as they provide the essential framework for creating virtual environments. And even when those engines are not getting used for actual building and asset design, they are still the final software recipient of our projects, as better explained in the upcoming chapter.

Consequently, without much doubt it is clear that the most challenging task will always be with scripting and coding syntax, as level design and interaction of the user with the world requires the understanding of languages such as C# for Unity, or C++ for Unreal Engine; and therefore it might be more recommended to start with more beginner-friendly programming languages like Python or JavaScript to build a foundation in coding logic.



[Figure 95]
Metaverse Workshop's Breakthrough Smash Room with Oculus Quest on Meta's Horizon Worlds.

Lastly, as explained in the personal example above throughout this subchapter, 3D modelling and asset creation are probably the areas where architects will feel the most comfortable in; as it allows the use of software where architects are already proficient like SketchUp, 3ds Max, or Blender. However, although it is the area where, at least I, felt more confident, that does not mean it is challenge free, as further explored throughout the next chapter.

Overcoming the limits of traditional and physical architecture, means first and foremost exploring the unknown where a dialogue with other disciplines is essential.⁹⁶ This bridge between architecture and game design is exactly what these last paragraphs sought to explore and understand; and in sum, this entire chapter as a whole tried to understand the relationship between physical and virtual architecture, and how we, as architects, can leverage the tools ranging from BIM to scripting and coding, collaborating with other professionals to build immersive environments and landscapes in the Metaverse.

⁹⁶ Camilla Ghisleni. (2022, December 3). The Metaverse in Practice: How to Build in the Digital Space. ArchDaily.



Chapter Four:

RESEARCH, ADAPT, AND DEVELOP

“My thesis is that the design of the Metaverse falls within the remit of the discipline of architecture and the wider design disciplines”⁹⁷

– Patrik Schumacher

So far, this dissertation has been more academic and theoretical more than anything else. However, this dissertation is the culmination of practice that results in my passion for building virtual environments. Therefore, this last chapter does not aim to be a conclusion for the theory in the previous chapters, but instead, it is meant to be a very personal chapter, with my own architectural introspections, as it dives into the work I have produced over the past two years for the Metaverse. This last chapter is my starting point for bigger and better projects for the Metaverse in the future; and so, this first subchapter entitled “Research” explores the path I went through to launch my architecture design studio for the Metaverse, where some projects, for one reason or another, just did not work.

My first Non-Fungible Token (NFT) project came along in the Summer of 2021, when this dissertation was still about the design of football stadiums and I was spending a good portion of my time investing and trading cryptocurrencies futures on a daily basis. Although I have known about cryptocurrencies since 2015, chaired a topic on them at an International Conference in 2017, and investing into the technology since then, I was only introduced to NFTs in late 2020.

⁹⁷ Sara Kolata. (2022, April 14). The Metaverse as Opportunity for Architects: An Interview with Patrik Schumacher. ArchDaily.

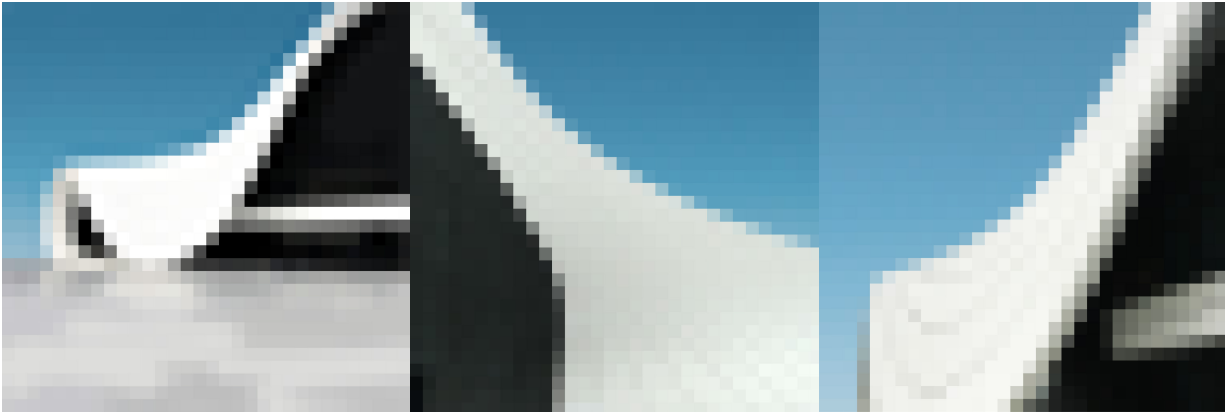
And so, in that Summer of 2021, I created my first NFT project called NFT_ARTchitecture on Opensea together with an Instagram profile where pictures of the NFTs were posted. The project had a very simple concept, where I would edit pictures in Adobe Photoshop of architectural landmarks visited by me throughout the years, and turn them into pixelated photographs, in hope someone would buy them as NFTs. All in all, I consider that there was no goal, no vision, and no objective in the NFT_ARTchitecture project, and at the end, it was just me playing with Photoshop just for the fun of it.

PIXEL Architecture was a collection of images where those landmarks I had visited would be transformed from their original pictures to pixelated representations of the said landmark. In total 12 images were created, three from each architectural landmark. The first to be released was the Heydar Aliyev Center by Zaha Hadid Architects, in Baku, Azerbaijan [Figure 96]; the second was Eduardo Souto de Moura’s Casa das Histórias Paula Rego, in Cascais [Figure 97]; the third was the Parthenon in Athens pictured in a freezing December day [Figure 98]; and the last set of pictures getting published was the Camp Nou stadium in Barcelona [Figure 99].

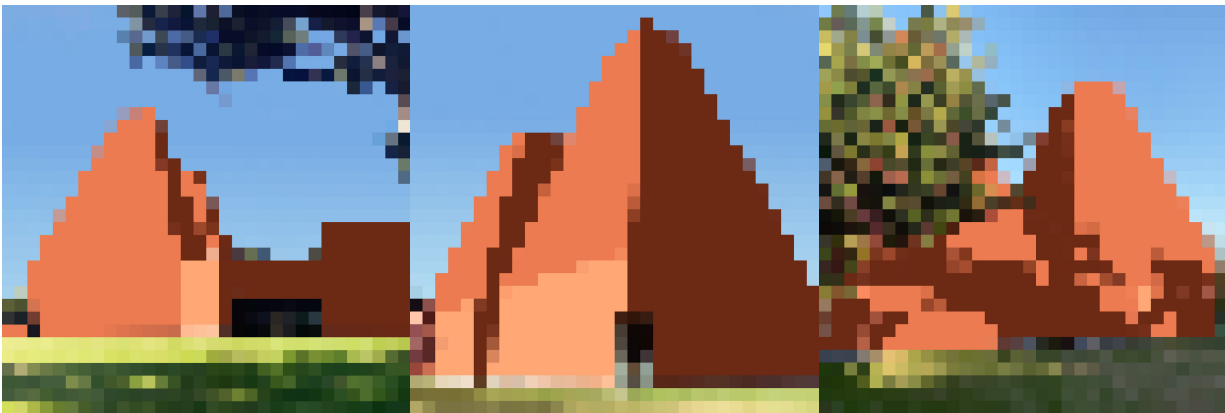
In the following pages, [Figures 100-105] exemplify the process of turning the raw picture of the Heydar Aliyev Center into the final version that turned into a NFT.⁹⁸

⁹⁸ Since NFTs cannot be deleted from the Blockchain, it is still possible to see and make an offer to buy these NFTs on Opensea.

[Figure 96]
Heydar Aliyev
Center (2012)
designed by Zaha
Hadid Architects in
Baku, Azerbaijan,
photographed in
March 2019.



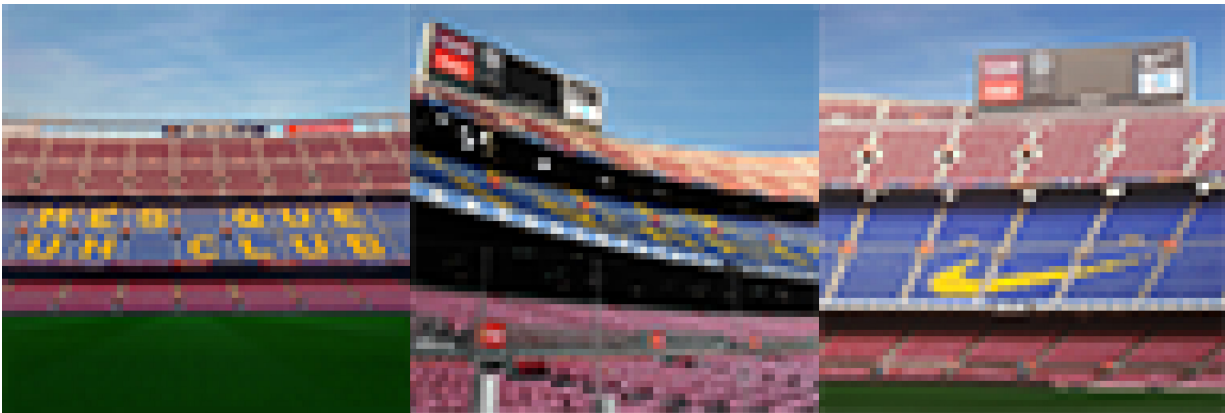
[Figure 97]
Casa das Histórias
Paulo Rego (2009)
designed by
Eduardo Souto
de Moura in
Cascais, Portugal,
photographed in
September 2020.



[Figure 98]
Parthenon, on the
top of the Athenian
Acropolis, built in
the fifth century BC,
after the Hellenic
victory during the
Greco-Persian wars,
being one of the
main symbols of
Western civilization
and architecture;
photographed in
December 2016.



[Figure 99]
W





[Figure 100]
Original picture as it was taken with the first generation iPhone SE.



[Figure 101]
Removal of the sky to alter the original atmosphere, creating a more minimalistic environment for the scene.



[Figure 102]
Addition of almost an unrealistic sky to enhance the building's existence and presence in the space.



[Figure 103]
Whitening of the building's shell from white-yellowish tones to pure white #FFFFFF Hex-tones.



[Figure 104]
Removing non-black reflections from the building's glass to increase contrast between the façade's materials.

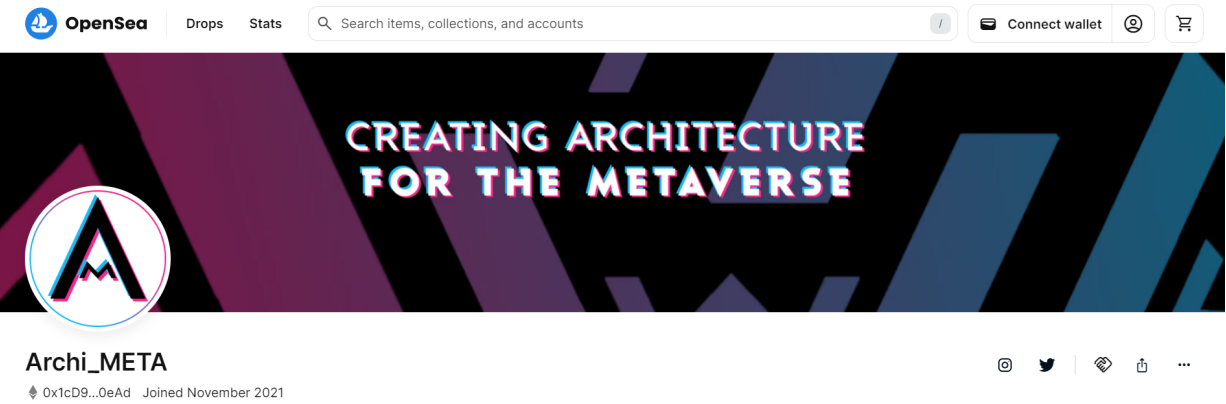


[Figure 105]
Final result before getting pixelated as observed in [Figure 96], where the background building was removed and the contrast between the façade's materials were increased to its maximum, so that the building's gesture was solely defined by two gestures.

Nevertheless, after a month or so, this project was quickly discontinued as I realised it was work leading me nowhere, with no real future use case, that was dependent on my own photography archive.

As Facebook rebranded to Meta, as the hype of the Metaverse hit the trends in Autumn 2021, and as I started to study the relationship between cryptocurrencies and pieces of virtual land that were being sold for ludicrous amounts of money, the idea of developing for the Metaverse became extremely attractive, since I have always had a passion for 3D design building my own virtual worlds either in SketchUp, ArchiCAD, Cities Skylines, or on paper since my childhood.

Consequently, it surged the idea of building architecture for the Metaverse in a way that people could access the 3D files so that they could import them wherever they wished. The projects ought to be simple enough and proofs of concept that such projects were viable in their execution. archi.META, a Metaverse Architecture initiative that aimed to be transformed into a business venture came to light with the rebranding of the old NFT_ARTchitecture Instagram page, and with the release of the three initial posts on 1st January 2022 at 00h00 GMT.



[Figure 106]
archi.META's profile
on Opensea.

Unlike founding a physical architecture studio where good contacts in the intervention area and a client base are probably fundamental aspects to have work (and eventually success); I soon came to realise that the formula in the Metaverse was probably a little bit different, as my goal is to find people to whom these pieces of 3D modelling were necessary. Therefore, the marketing strategy focused more on social media channels - Instagram, Twitter/X, Youtube, Reddit, and Discord - to advertise the existence of the project. During this stage, the amount of research and work put into this project went beyond all the scopes of architecture, as a single person working for the project I had not only to design the architecture and landscape of my builds, but also render and edit the pictures, create and edit videos and animations for various social media platforms, manage and engage on social media to gain visibility on my profiles, and build a cohesive marketing and branding strategy not only for individual projects but for the entire archi.META project [Figure 106].

Patrik Schumacher argues in his Metaverse thesis that design process is intertwined with the following four domains: spatiology (organisation delivering complex configurations); phenomenology (articulation delivering perceptual tractability); semiology (signification delivering information-richness); and dramaturgy (interaction delivering interaction-richness)⁹⁹ - these four competences are what give the projects in the Metaverse their real meaning and will allow the creation of that storytelling mentioned in the previous chapters. The world of cryptocurrencies and the Metaverse is full of scams and get rich quick scheme, promising this world and another, and it becomes very easy to deviate from the principles mentioned by Schumacher, especially when Metaverse content creators and artists are surrounded by projects not obeying these rules.

⁹⁹ Patrik Schumacher. (2022, August 17). The Metaverse as Opportunity for Architecture and Society: Design Drivers and Core Competencies. Architectural Intelligence, Tonji University, Springer.

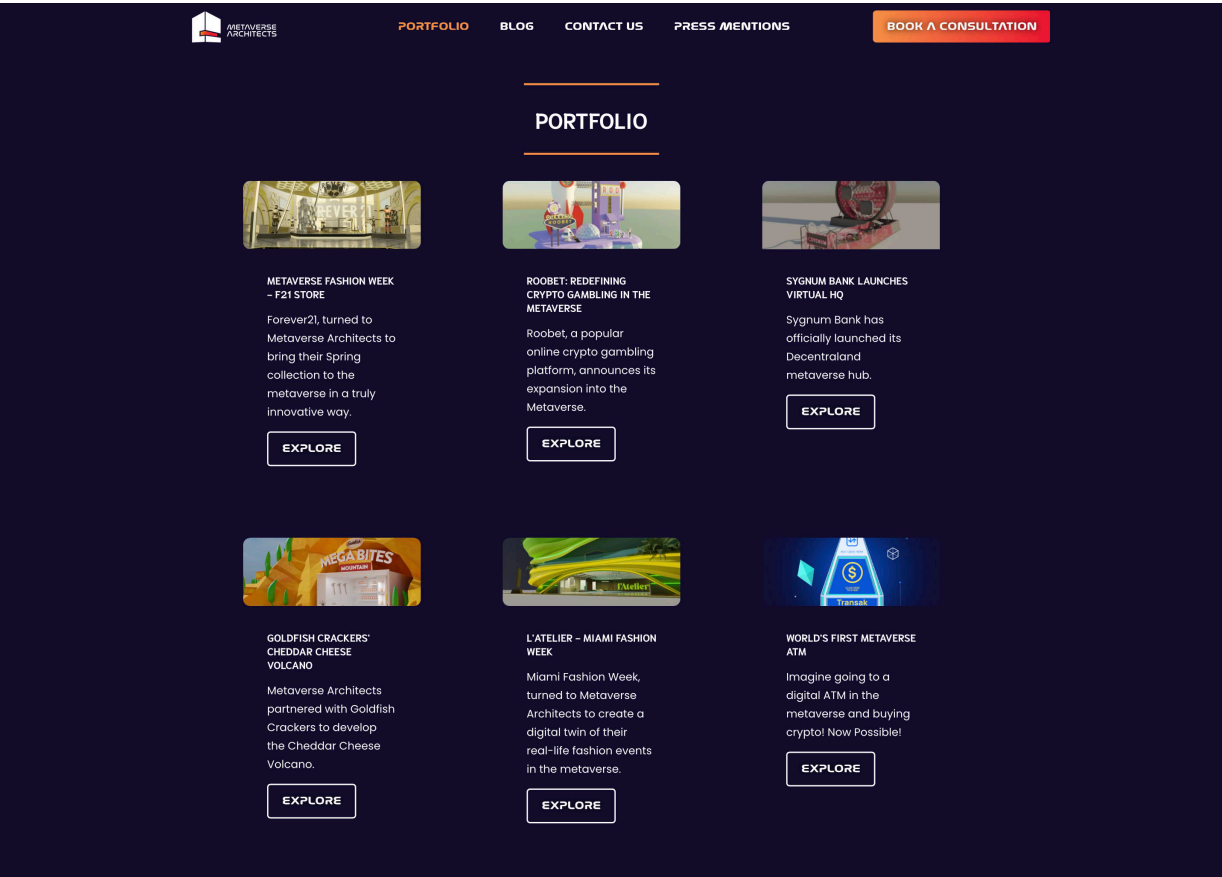
In one way or another, adapting to our surrounding environment is a survival skill, especially in a field where we are competing against everyone in the world. The flow of this subchapter is divided into two different branches that come under the same umbrella of adapting ourselves to the environment we are in; as it is about some key actors in the field that end up influencing our work and all the difficulties we encounter whilst developing our work, which ultimately require us to adapt and improve.

Although there is no clear path for the Metaverse industry yet, paving a path that has been yet unexplored without any references is at best counter-productive, and at worst wasting time by creating irrelevant work that no one is interested to purchase or give it future use. As a result, there are four worth-mentioning people that have produced relevant work in the Metaverse and realm of virtual architecture that have influenced my own journey in how I create my own designs.

Metaverse Architects and its division of Decentraland Architects created by Luca Arrigo were my first point of contact of architecture for the Metaverse sometime in Autumn 2021. If one checks their websites¹⁰⁰ or even Instagram (meta_archs) as of September 2023, they do not resemble a typical architecture website nor office, as it is difficult to find any references to their projects and the ones existing do not portray the architecture and spatial design in an architectural meaningful way with plans, elevations, and sections [Figure 107]. It is not a company created by architects, and on their team they have got a full-stack developer, an architect who is also a junior developer, and a junior architect, besides many other positions outside the field of architecture; and they describe themselves on their website as “Metaverse pioneers. We service all builds, no matter how big. If you can think it, we can build it.” - where they mainly create virtual world design and development; generative AI applications; Web3

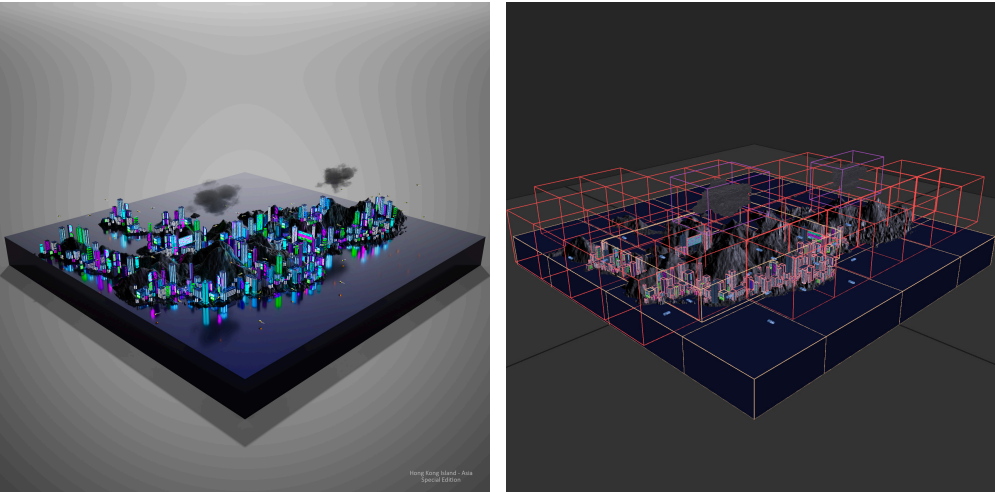
services; as well as custom 3D virtual architecture, wearables and skins, and non-player characters (NPCs). When archi.META did not have a name yet and its projects were a mere idea in my mind, they were the first Metaverse project that I came across that was profitable and running as a proper business. They were the ones responsible for the first realisation that pursuing architecture in the Metaverse was going to be a task that would require going outside of the boundaries set by ArchiCAD and SketchUp, as an interdisciplinary team would be necessary in the medium to long run to create the projects I envisioned; and ultimately, they were the first step to writing this dissertation in the form it is written.

[Figure 107]
Metaverse Architects' Portfolio on their website, where one can see the following list of projects showed in the image to the right, but upon clicking on a project to “EXPLORE” more, it is forwarded to a page with a list about the project's key takeaways and with no possibility of actually exploring the project's 3D model.

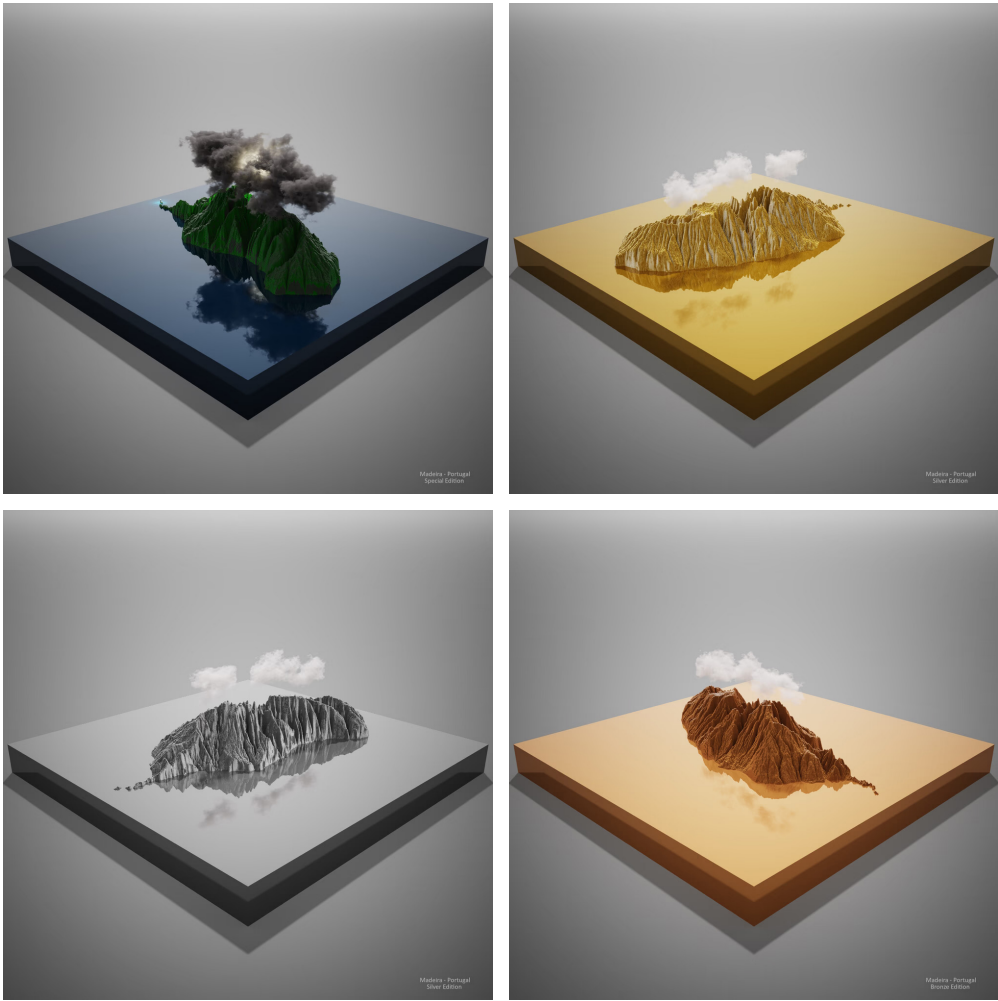
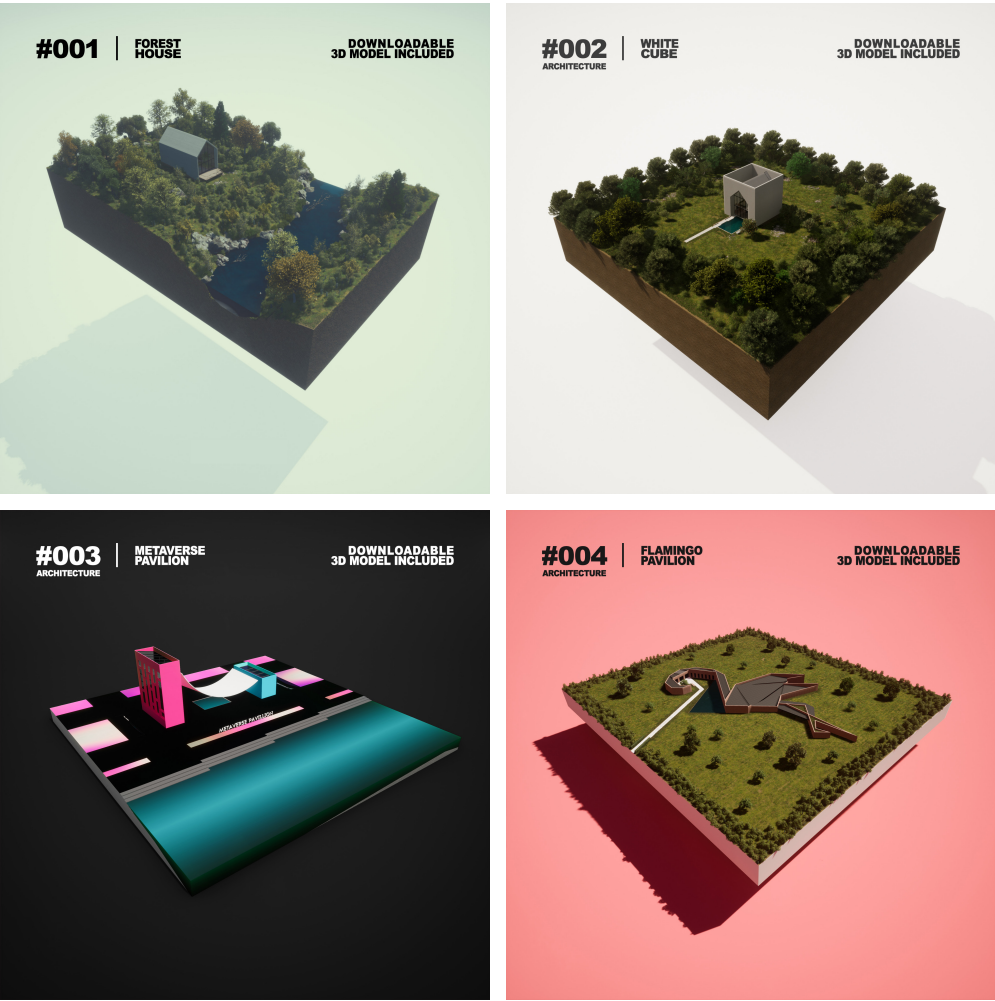


100Metaverse Architects' Website: (<https://metaverse-architects.com/>).
Decentraland Architects' Website: (<https://decentralandarchitects.com/>).

Instagram’s name ‘Cryptallic’¹⁰¹ was one of the first people I came across when launching archi.META as he designed and developed voxel¹⁰² islands of real locations that would be sold as NFTs, which were rapidly selling out with every single launch [Figure 108]. His influence on my work ended up being from a graphic nature (as in terms of content, there was no intention in creating voxel architecture from my part). The way archi.META’s buildings ended up being portrayed was also very similar to Cryptallic’s islands, maybe because from a subconscious point of view, I had always seen my buildings for the Metaverse as their own islands - isolated buildings surrounded by a sea of land, so that the buildings could be plotted by their owners [Figure 110].



[Figure 109]
Cryptallic’s Hong Kong Island which included a city using cyperpunk colours. On the right the island is showcased in its raw state with all components in Magicavoxel. The island’s environment would be replicated at a section of the #1MetaverseExpo by archi.META, as seen if [Figure XX].



[Figure 108]
Cryptallic’s Islands - Special, Gold, Silver, and Bronze versions of the Island of Madeira, Portugal in voxel geometry, created in MagicaVoxel and sold on Opensea as NFTs with unlockable content.

[Figure 110]
archi.META’s four first Metaverse Architecture projects: #001, #002, #003, and #004.

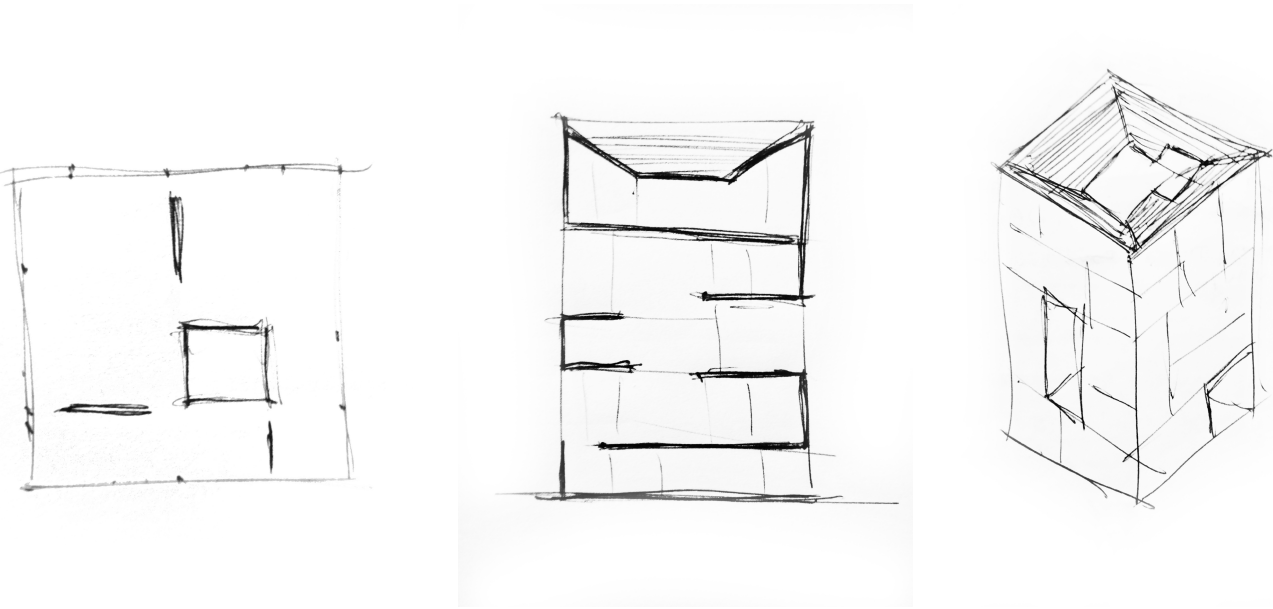
101 Cryptallic’s Instagram: (<https://www.instagram.com/cryptallic/>).

102A voxel (volumetric pixel) could be defined as a three dimensional pixel, and in 3D computer graphics, a voxel represents a value on a regular grid in three-dimensional space. As with pixels in a 2D bitmap, voxels themselves do not typically have their position (i.e. coordinates) explicitly encoded with their values. Instead, rendering systems infer the position of a voxel based upon its position relative to other voxels.

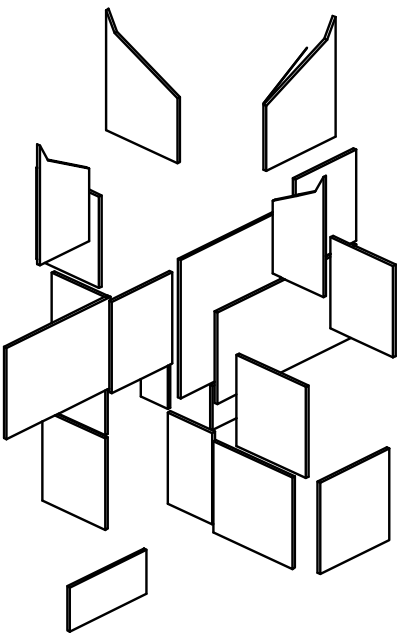
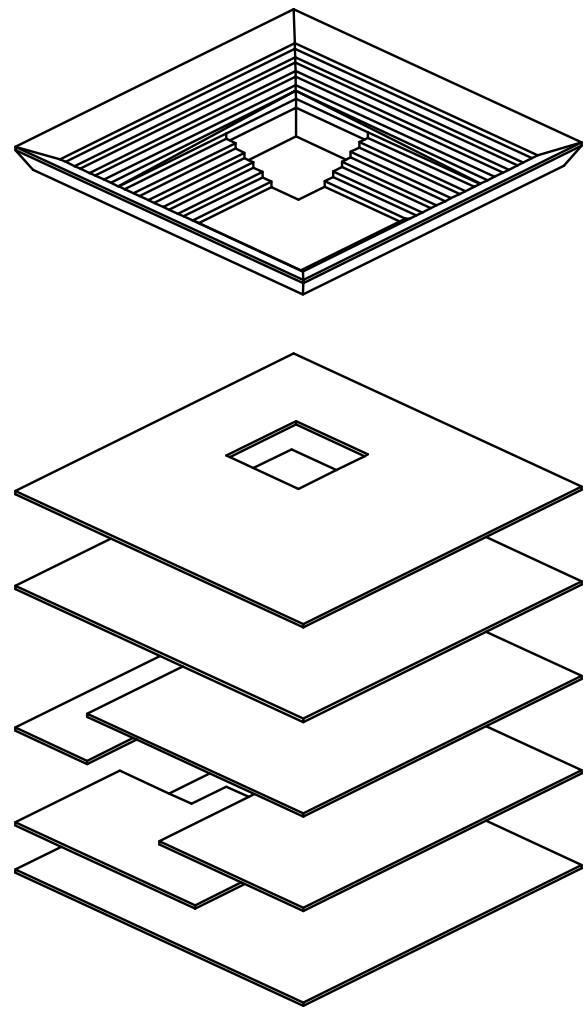
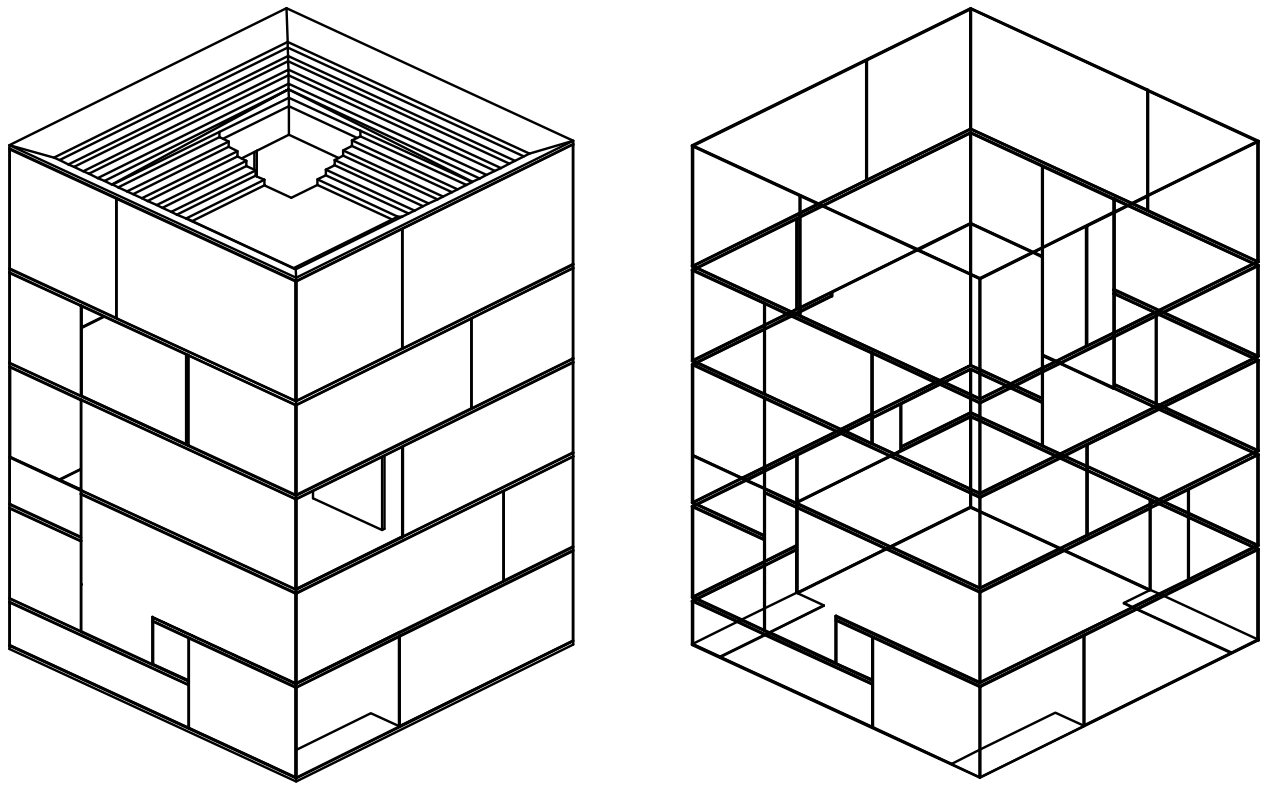
Lastly, there are two examples of more traditional architecture groups developing for the Metaverse and in virtual environments that influenced the way one looks at Metaverse architecture. Decent Architecture¹⁰³, founded by Leonardo Marchesi and Michel Vieira in 2021 and defining themselves as “crypto-brutalists” take a somewhat traditional approach compared with what is possible to create in Cyberspace, as they mix basic architectural elements such as slabs and walls, creating an extremely clean look on their definition of space. It could be compared to physical architecture’s initial project stages when rendering still looks simplistic, but with the added life of buildings and a finished look that would be impossible to achieve with actual physical architecture. In 2023, Decent Architecture’s project Decent Headquarters has won the Interior Design magazine’s MAD competition in the Workplace Extension category, as Decent Stage and Enonautilus Metaverse Centre have respectively collected finalist status in Built Commercial and Metaverse Destinations categories.¹⁰⁴

Decent Architecture describe the Headquarters’ architecture as a balance between human spatial experience and extended limits of the Metaverse, taking advantage of the free flow of creativity allowed by the “parameters of the Metaverse”; in a building where window frames were designed to provide a playful façade, breaking the regularity of the structure, and the areas in-between floors revealing different environments for the many meetings and collaboration simultaneously happening.¹⁰⁵

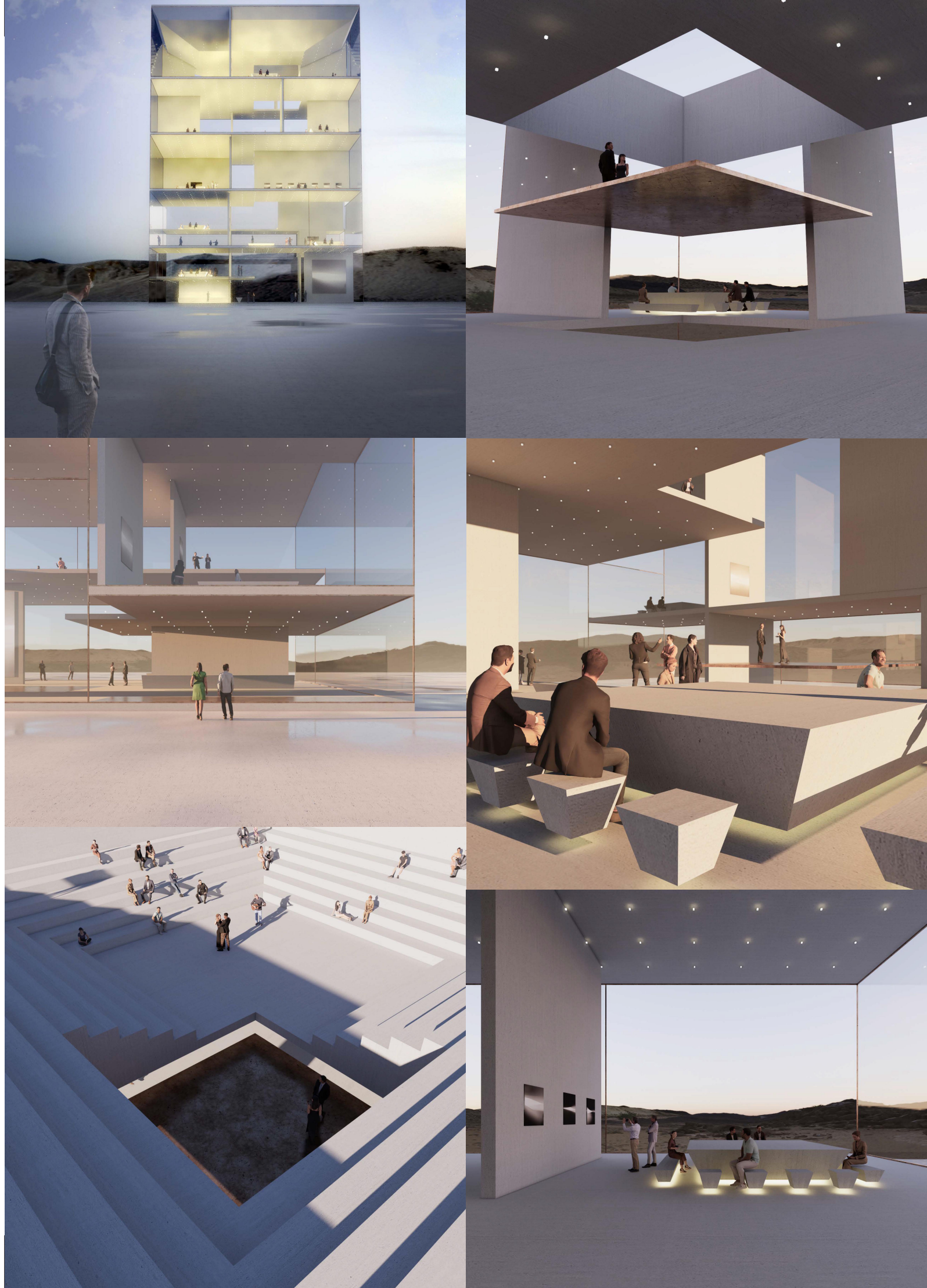
[Figure 111]
Decent Headquarters’
initial hand sketches.



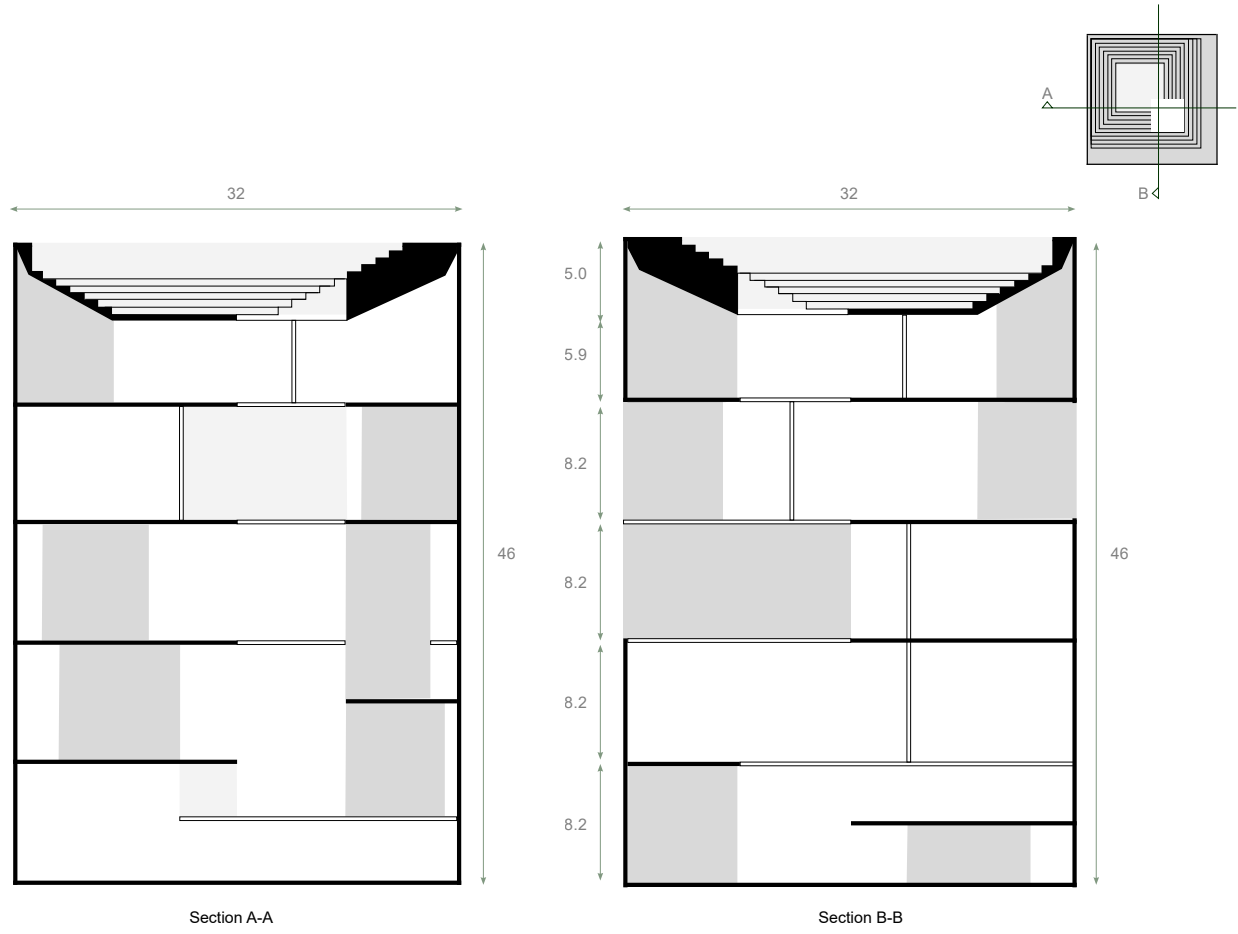
[Figure 112]
Decent Headquarters’
general volumetry
of slabs and walls.



103Decent Architecture’s Website: (<https://www.decent-architecture.com/>).
Decent Architecture’s Instagram: (https://www.instagram.com/decent_architecture/).
104Interior Design Magazine. (2023). Presenting the Metaverse Architecture and Design Awards Winners. Interior Design Magazine.
105Leonardo Marchesi, & Michel Vieira. (2023). Decent Headquarters. (Internal Documents for Interior Design’s MAD competition, courtesy of Decent Architecture).



[Figure 115]
Page 153 - Right
Decent Headquarters'
plan views of each
floor.



[Figure 114]
Page 152 - Left
Decent Headquarters'
cross sections.

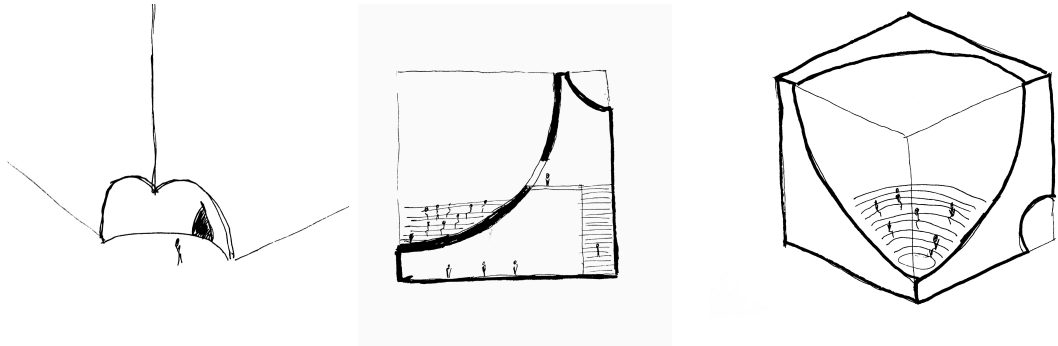
[Figure 113]
Decent Hedquarters'
exterior and interior
rendering.



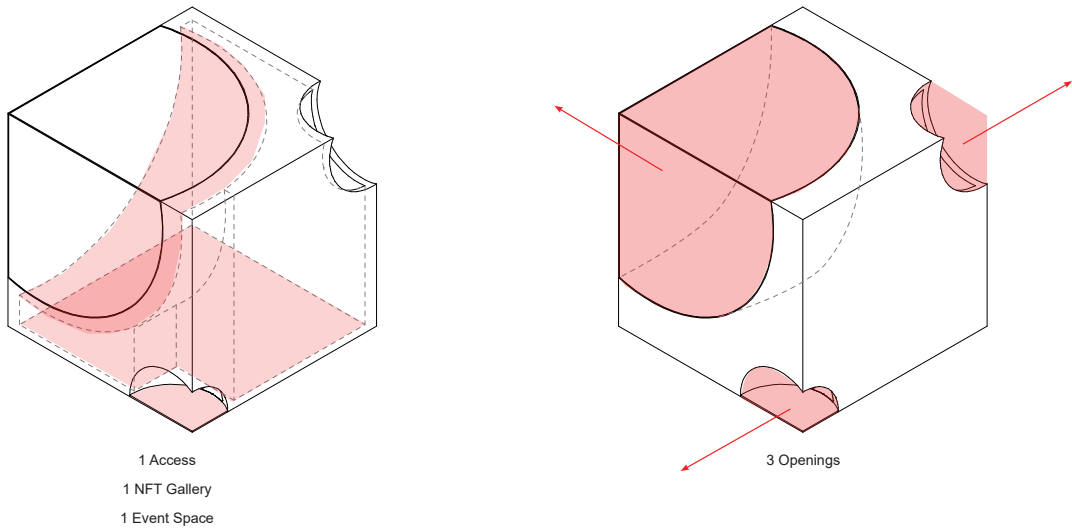
On the other hand, the Decent Stage is described as a space ambitioning to promote gatherings through its shape, where the contrast between the cube and the spherical shape draws attention to the glazed area where the stage is located, clearly revealing the building’s main function. Shape, light, and scale, are the three main principles in Decent Stage as upon entering, visitors are by a grand scale foyer that takes shape as a result of the spherical space, enhancing the dramatic perception of the space, and two large staircases leading to the stage area, where its scale and continuous steps create a dramatic effect ascending towards the light.¹⁰⁶

¹⁰⁶Leonardo Marchesi, & Michel Vieira. (2023). Decent Stage. (Internal Documents for Interior Design’s MAD competition, courtesy of Decent Architecture).

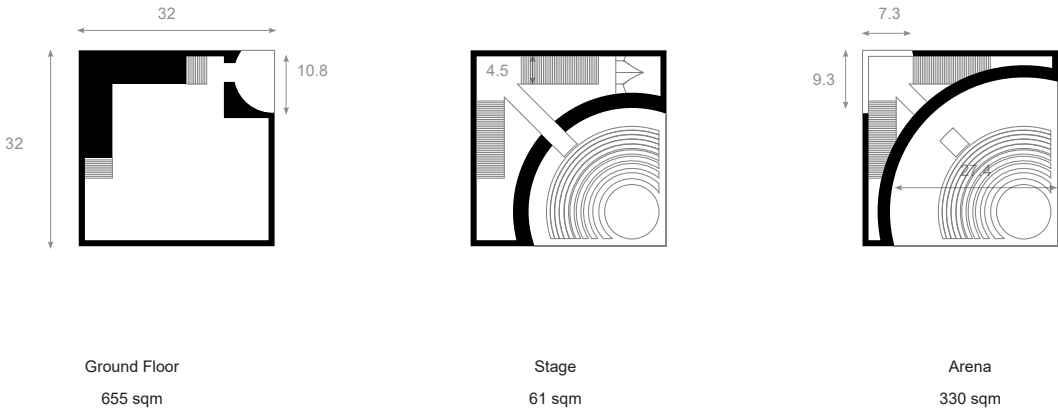
[Figure 116]
Decent Stage’s
initial hand sketches.



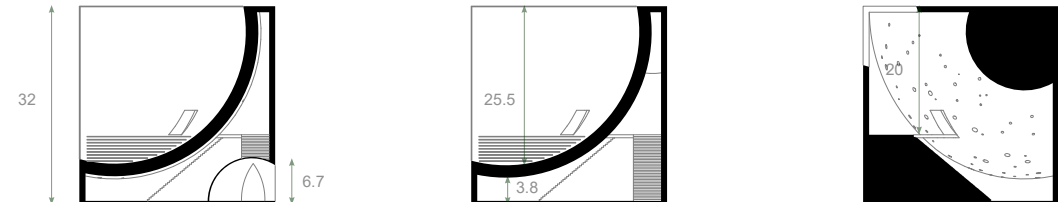
[Figure 117]
Decent Stage’s
general spatiality
and negative spaces.



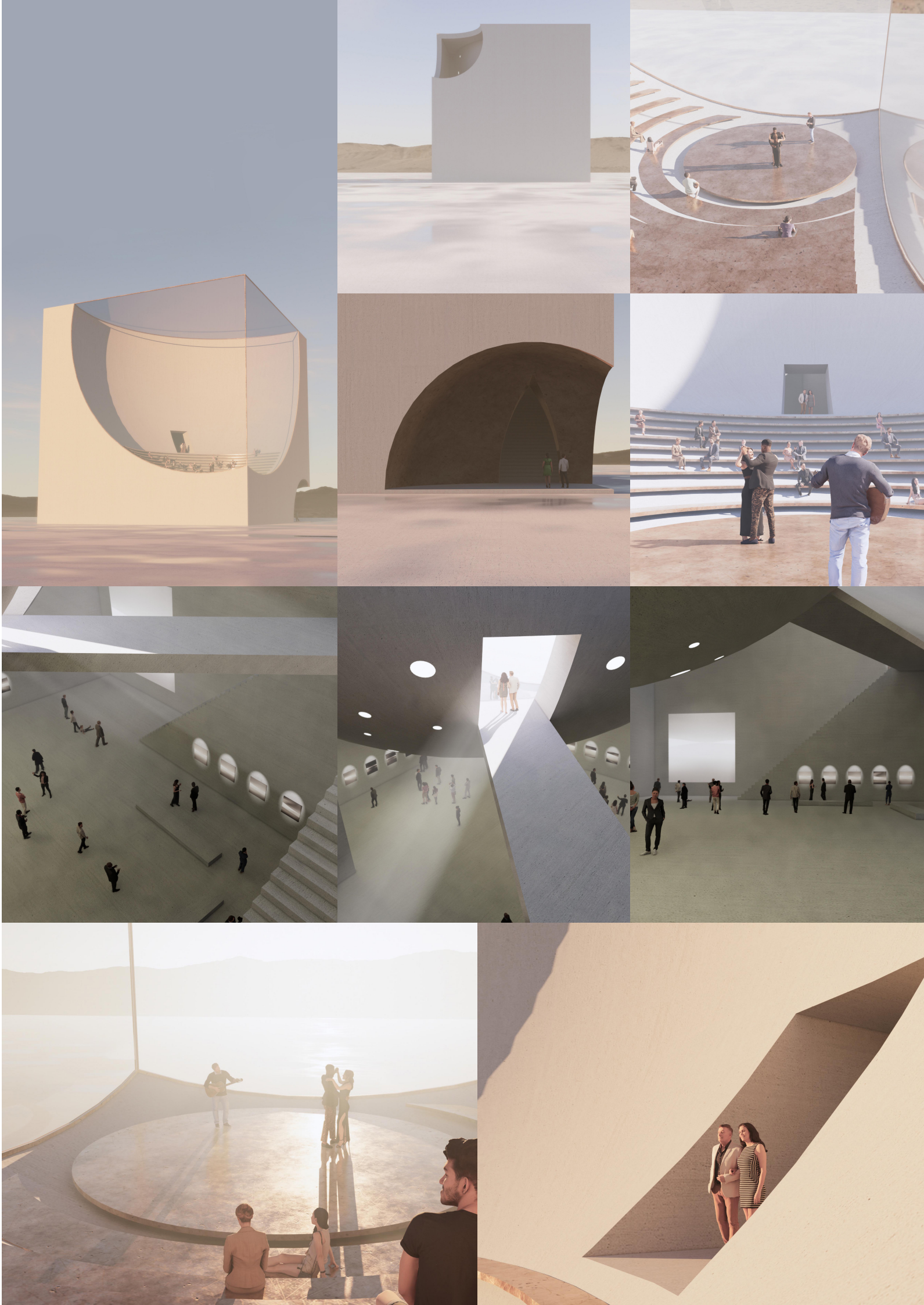
[Figure 118]
Decent Stage’s
plans at its several
different levels.



[Figure 119]
Decent Stage’s
cross sections.



[Figure 120]
Decent Stage's
interior and exterior
rendering.



Oderspace is a studio merging digital art and architecture founded in 2020 by Stephy To and Raffaele Palmieri, who worked for Sir David Adjaye and Kengo Kuma, being driven by a shared desire to imagine alternative realities and discover new ways of making architecture beyond buildings. Their interpretation of architecture masterpieces such as Le Corbusier’s Ville Savoye; Frank Lloyd Wright’s Fallingwater; Aldo Rossi’s San Cataldo Cemetery; or Mies van der Rohe’s Farnsworth House, take a provocative approach creating dreamy artworks that are conceived as real architectural objects that nonetheless defy the laws of space, gravity, and time [Figure 121]. Thus, creating and expressing spatial design through multimedia and visual narrative, pushing the boundaries of the possible, opening a new outlook for exploration and discussion.¹⁰⁷ Although Oderspace does not develop directly for the Metaverse, they are a perfect example of buildings and architectural discussions that could be brought to the Metaverse space as their provocative and surreal environments of the above mentioned buildings helps to bridge the physical and virtual architectures together, eventually even looking to venture themselves into installation, product, and interior design in the physical world from the digital findings.

[Figure 121] All these four pieces are part of the RE-lcon Collection which “questions the capacity of architectures to define ideas and at the same time aims to trigger a critical dialogue about the concepts behind architecture. When we talk about ideas in architecture, we mean the relatively conscious response that the designer gives to instances of four different types: social, intellectual, technical, and aesthetical. The image of a building should be a synthesis of who the users of that space are, what they want to be, what they can do and what they love. This project aims to rediscover some of the ideas of modern architecture and explore the possibilities of their use nowadays in a reality where the physical context is no longer a major priority and it is all about how the space interacts with the mind.”

– Oderspace

- a) Plan Libre
- b) Free Plan
- c) The Blue of the Sky (L’azzurro del cielo)
- d) Weightlessness

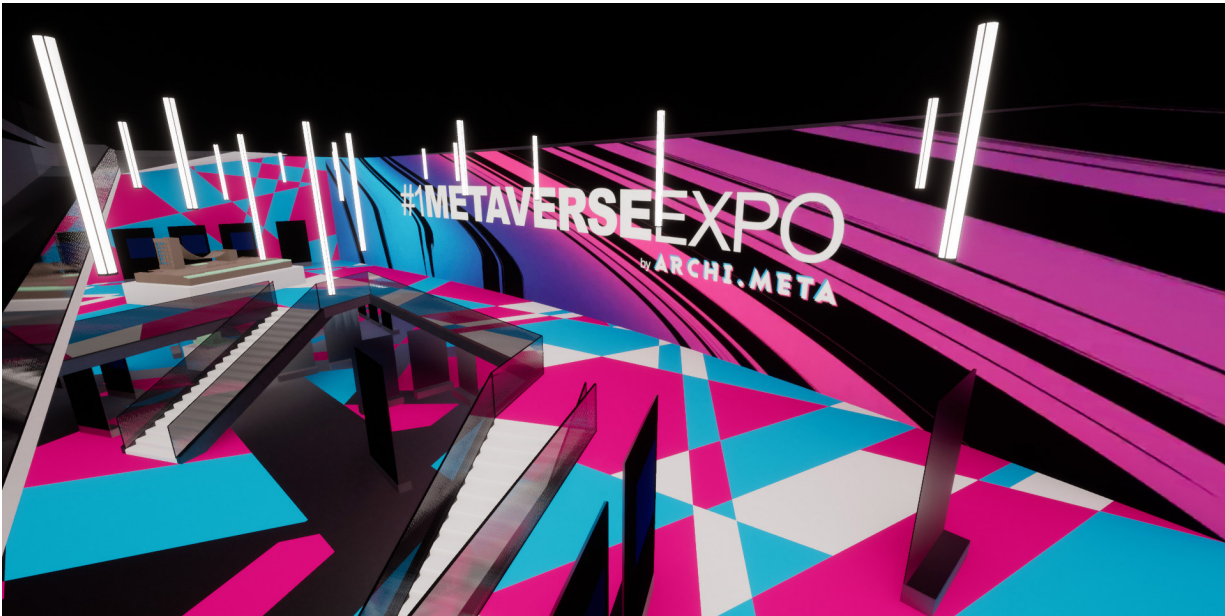
¹⁰⁷Stephy To, & Raffaele Palmieri. (n.d.). Oderspace. Oderspace.com.



My first projects were simple buildings designed relatively quickly on ArchiCAD, however the third project #003 - Metaverse Pavillion by archi.META was supposed to be accompanied by a Metaverse Exhibition that was going to be entitled #1MetaverseExpo – by archi.META curated alongside other Metaverse creators. Taking some of the above mentioned people, Crystallic and Oderspace, together with _umexh, Architect_NFT, l.adriana.pascale, marcfrancisprints93, later joined by De Structura who ended up becoming the 2023 Estonian national winners of the European Charlemagne Youth Prize, I started developing the exhibition to promote each other’s work where each creator’s piece of work could be bought as a NFT. Combined among all the creators at that time, we had an audience of around 40 to 50 thousand followers on social media, which would allow us to sell NFT tickets to the exhibition, sharing a percentage of profits, as all creators would have a percentage of tickets allocated to them.

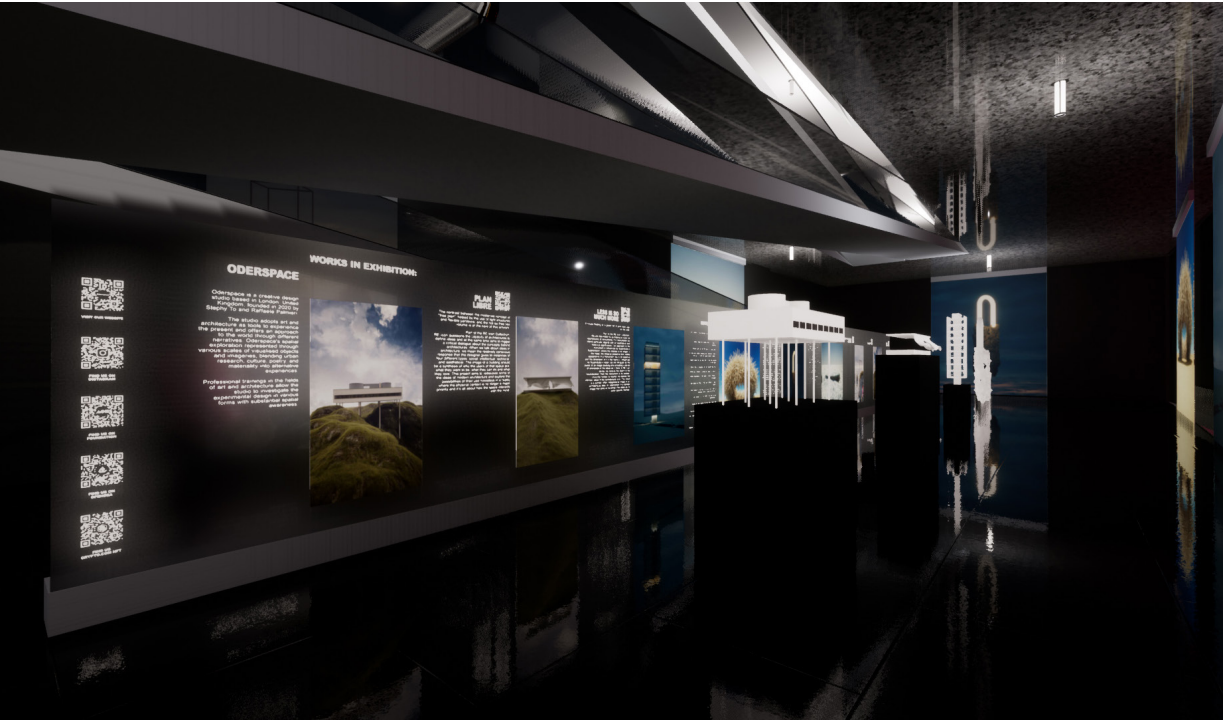
Looking back in time, it is clear that I underestimated the task I had in front of me for such a small time frame, and there were difficulties creating interactive content from the very start. The first issue was understanding how people could access the exhibition, as until that I was creating downloadable 3D files on Opensea for those owning my previous projects, as ERC-721 does not support the large sizes of 3D files. Thus, there was the need of something instantaneous on a web-browser that could be easily accessible - Spatial.io could be a solution, but due to the large size and scale of the project, it was decided to go with Epic Games’ Twinmotion Cloud which would allow easy interoperability between ArchiCAD, realistic rendering, and artwork and asset management, in detriment of not having exhibition interaction between its visitors once launched.

[Figure 122]
General overview of the archi.META’s permanent exhibition floor at the #1MetaverseExpo – by archi.META.



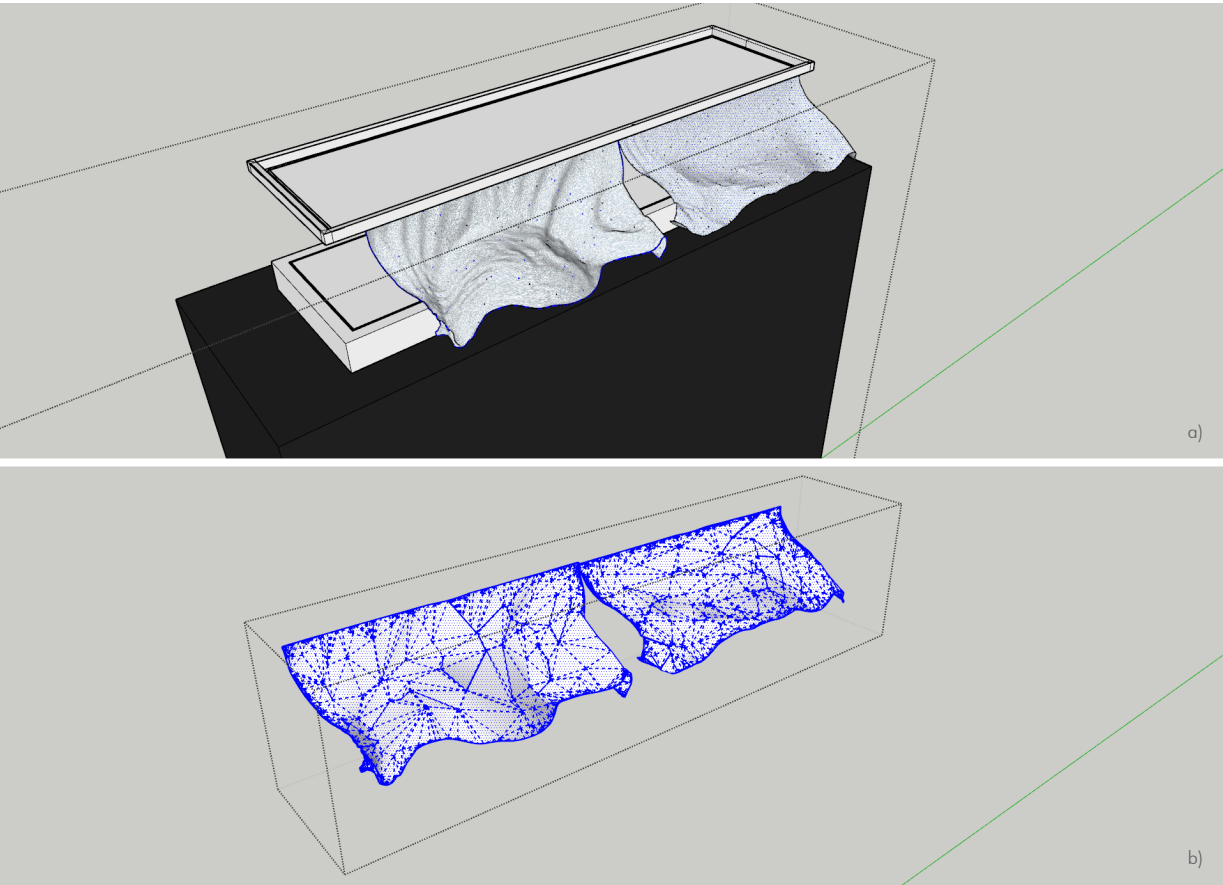
[Figure 123]
Oderspace’s preview of their exhibition floor at the #1MetaverseExpo – by archi.META.





[Figure 124]
Oderspace's
exhibition
floor at the
#1MetaverseExpo –
by archi.META.

Additional struggles can include daily aspects of curating and coordinating seven different people/organisations, the way Twinmotion handles images and textures would make the file's size extremely heavy, creating lag and blur effect browsing through the exhibition, and thus, requiring extra care to optimise every single detail. And lastly, managing the creators 3Ds as everyone used different softwares with different designing techniques, not prone to exhibition's optimisation. For instance, the Oderspace's Less Is So Much More draping was designed using SketchUp, a software that cannot create curved geometry like Blender, resulting in hundreds of thousands of unnecessary vertices for a small 3D model at the exhibition.



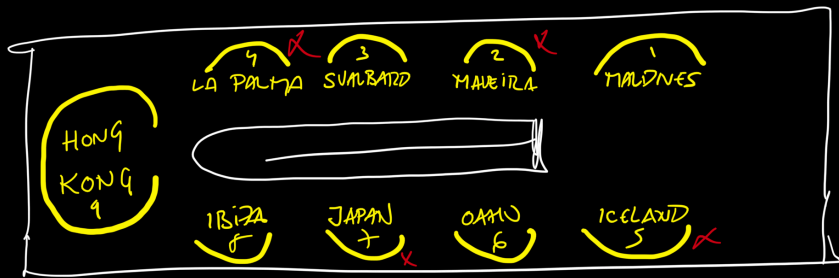
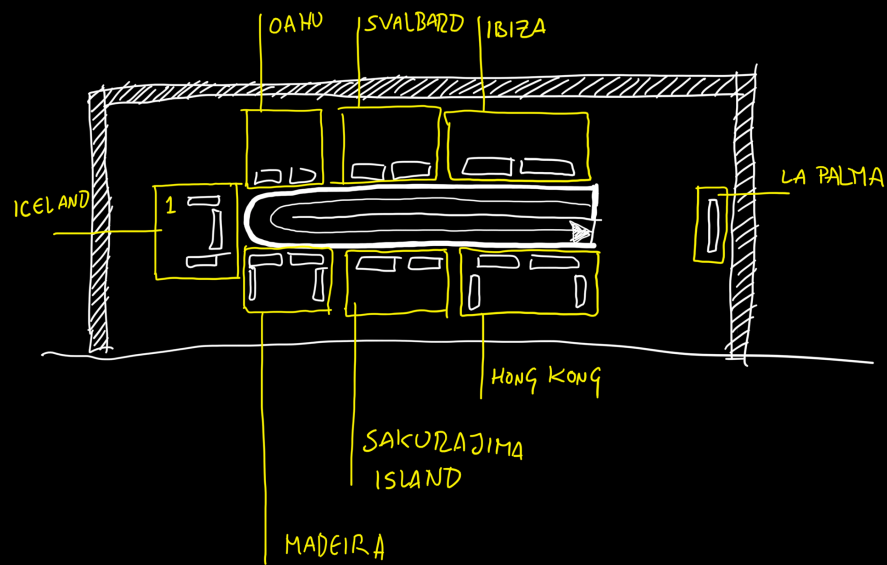
[Figure 125]
Oderspace's "Less
Is So Much More"
original draping (a)
weighted 253MB;
whilst the entire
#1MetaverseExpo
– by archi.META.
exhibition with
the building and
creators' artworks
was aiming at no
more than 150MB
in size, otherwise
its rendering would
be laggy. At the
end, its geometry
was simplified (b)
down to 4,39MB in
order to make the
exhibition.

Ultimately, the #1MetaverseExpo – by archi.META failed as it never launched and I was unable to reach the marketing stage of the project. Although I was extremely eager to make it work, and creating something of this scale with those people was a motivator to push forward, my debilitating mental health did not allow me to push from May 2022 onwards, as the entire management of this project was extremely stressful as I had the initiative of the idea, and I doing the asset and people management, and the entire marketing and content strategies were all being simultaneously developed. All in all, the exhibition was weeks away from being announced and completed, and the idea and desire of finishing it in some form or another in the future is still an idea wandering in my mind.



The general view how it will stay bound
work.

CRYPTALIC FLOOR



[Figure 126]
Page 164 Top Left
Sketch of a
exhibition board
that would serve as
a template for every
artwork.

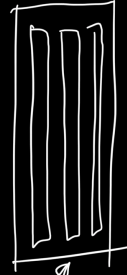
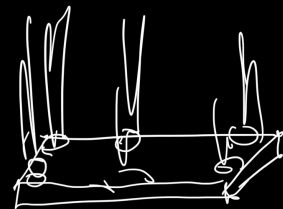
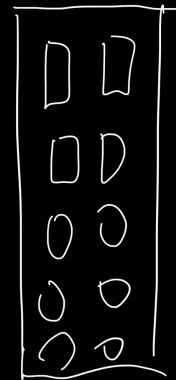
[Figure 127]
Page 164 Top Right
Sketch of the main
exhibition board
(2,25m x 19,75m)
for Oderspace, as
also seen in
[Figure 124].

[Figure 128]
Page 164 Middle
Sketch of the
first version
of Cryptallic's
exhibition floor.

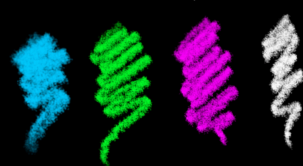
[Figure 129]
Page 164 Bottom
Cryptallic's floor
was later changed
to accomodate
a small enclosed
space where Hong
Kong island would
be showcased with
more detail.

[Figure 130]
Page 165 Top
Hong Kong's
enclosed space
would be portraying
the city's buildings
as seen in
[Figure 109] from
its ceiling to give the
space the ambience
of walking in the
city.

[Figure 131]
Page 165 Bottom
Rendering inside of
the Hong Kong's
space within
the Cryptallic's
exhibition
floor at the
#1 MetaverseExpo
by archi.META.



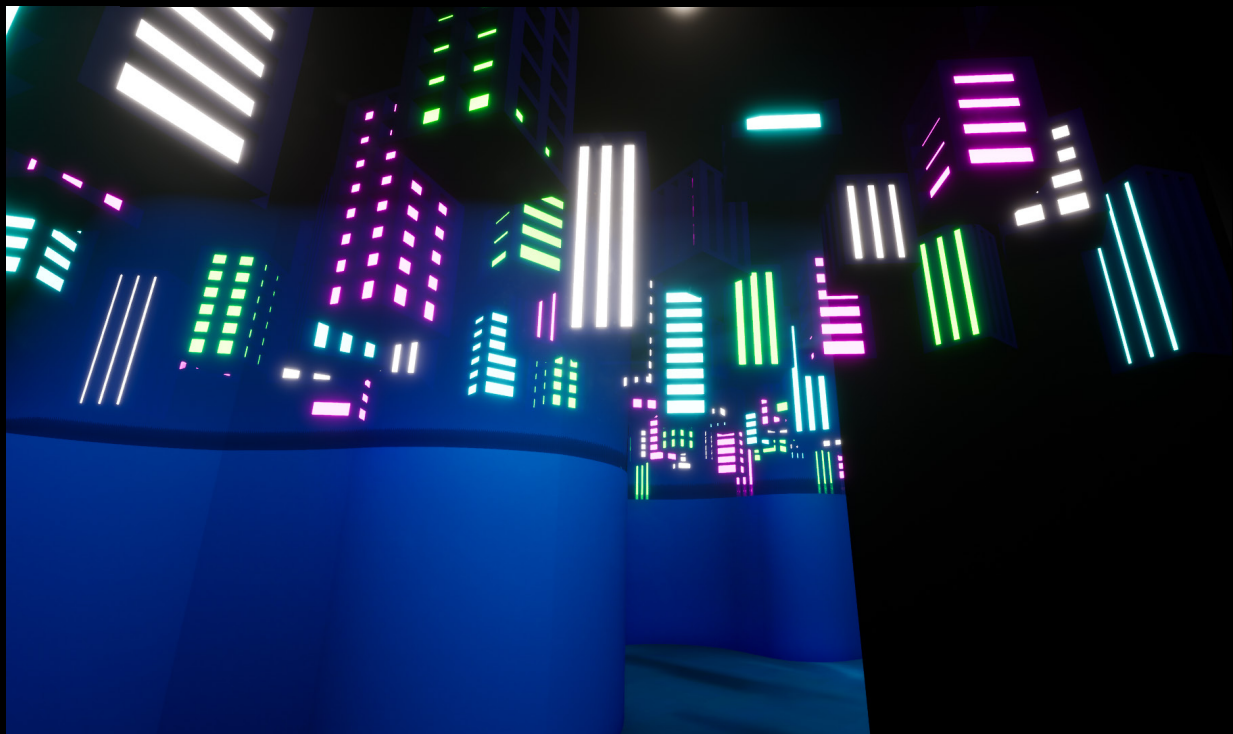
colours



offe.

residant

commercial



Although inactive since May 2022, when not only the exhibition was stopped but the entire archi.META’s projects, the ultimate reward for pushing hard those months came in later that year in November, when MetaMundo, an NFT platform and marketplace selling 3D assets, models, and architecture for the Metaverse reached out to the top 50 creators of the Metaverse as they were launching their platform to have our works exhibit at the 2022 Miami Art Basel, where archi.META was included.¹⁰⁸ Collaborating with MetaMundo meant an exclusivity agreement with them switching away from Opensea, but even then, I was required improvisation and adaption as MetaMundo’s allows interoperability between different 3D files, as my work was uniquely prepared for Twinmotion and Unreal Engine with its unique textures and features such as dynamic doors, that simply did not work under a .fbx file used for other platforms such as Decentraland; and hence requiring me to quickly research about UV mapping and file interoperability between different 3D softwares as Art Basel was a couple weeks away in time.

This subchapter is a showcase about how this entire dissertation would not exist without it, as the people and the struggles experienced in creating archi.META’s projects helped me shape and establish a vision for the kind of Metaverse I want to help building from this point onwards.

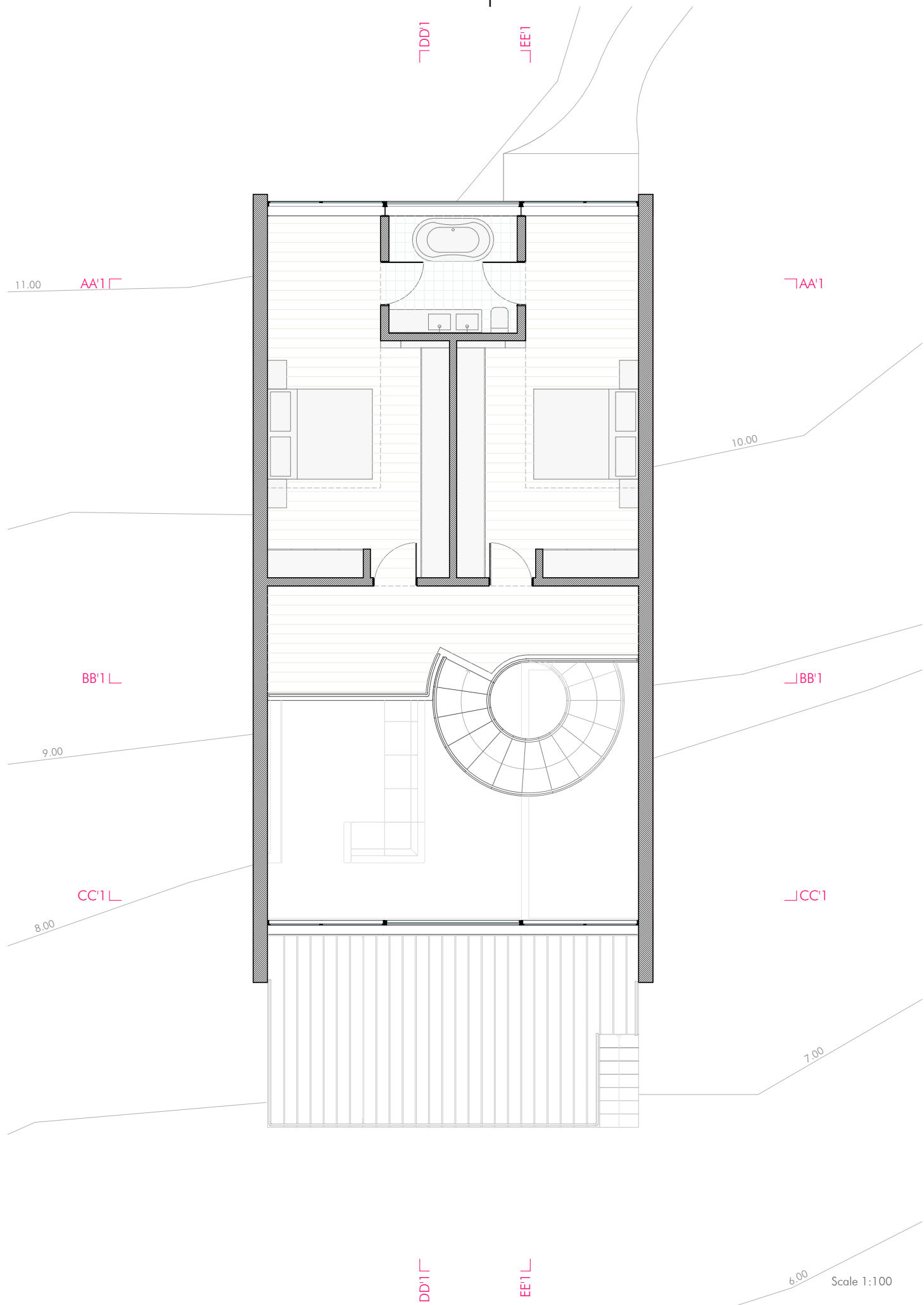
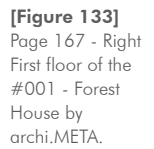
¹⁰⁸Damir Yalalov. (2022, December 5). MetaMundo announces the Top 50 Creators of the Metaverse and revamps their 3D model marketplace. Metaverse Post.

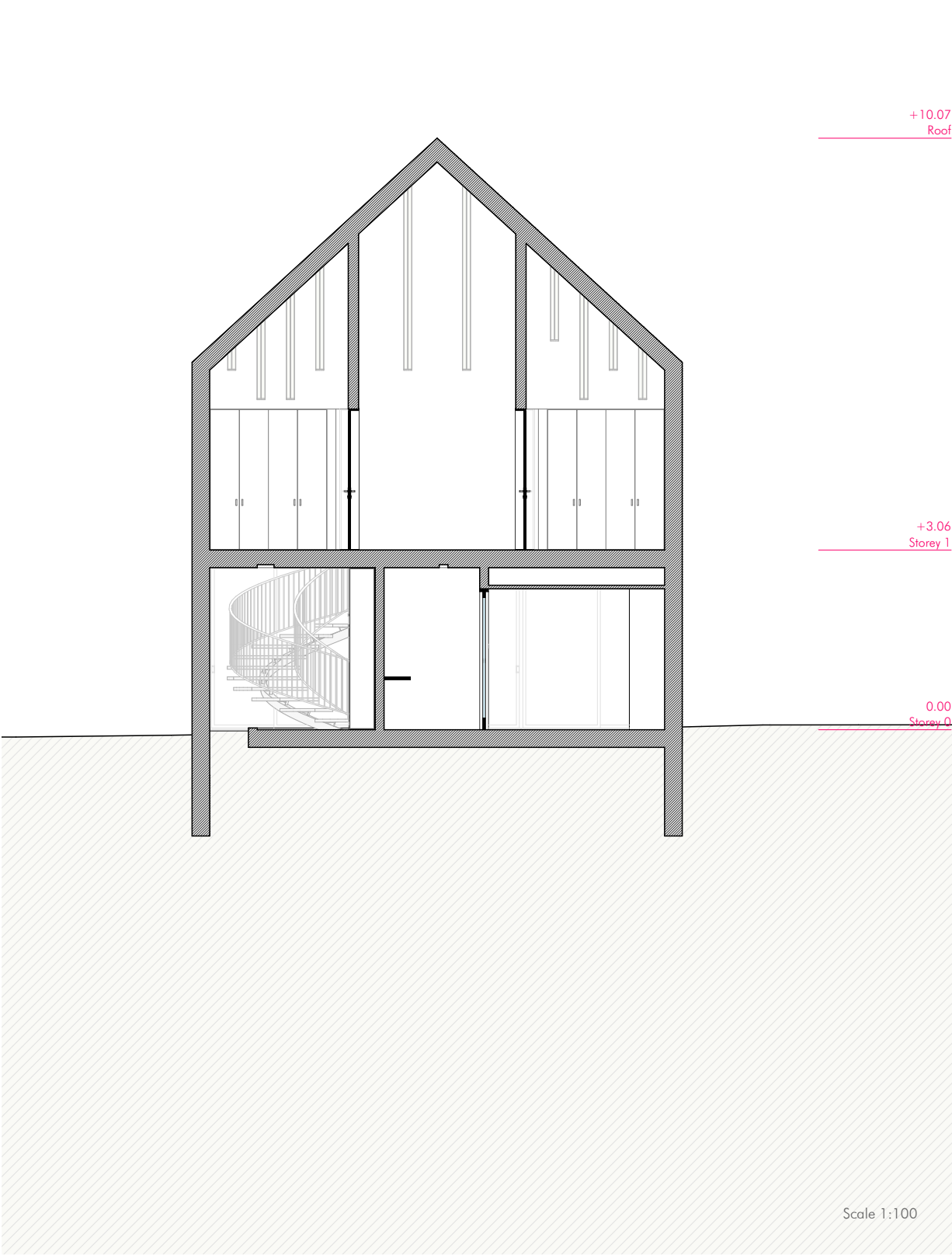
This subchapter is the closure and conclusion to this dissertation. In some cases, the work produced is the actual theme of one’s dissertation, but in this particular case, the work I have developed putting archi.META from paper to reality, is what allowed me to research and question myself about all the topics in the previous chapters in this dissertation.

Despite its relevance from an architectural standpoint, archi.META’s projects are not the focal point of this dissertation, as there is yet so much to discover and develop in the Metaverse industry, and orbiting this dissertation around the work I developed would undermine all the future work yet to be developed.

In the months developing archi.META, there was the opportunity to fully create four buildings ready for the Metaverse, besides many more ideas that never left the drafting board in the first place. This subchapter will be looking in detail into all of those four buildings, which are:

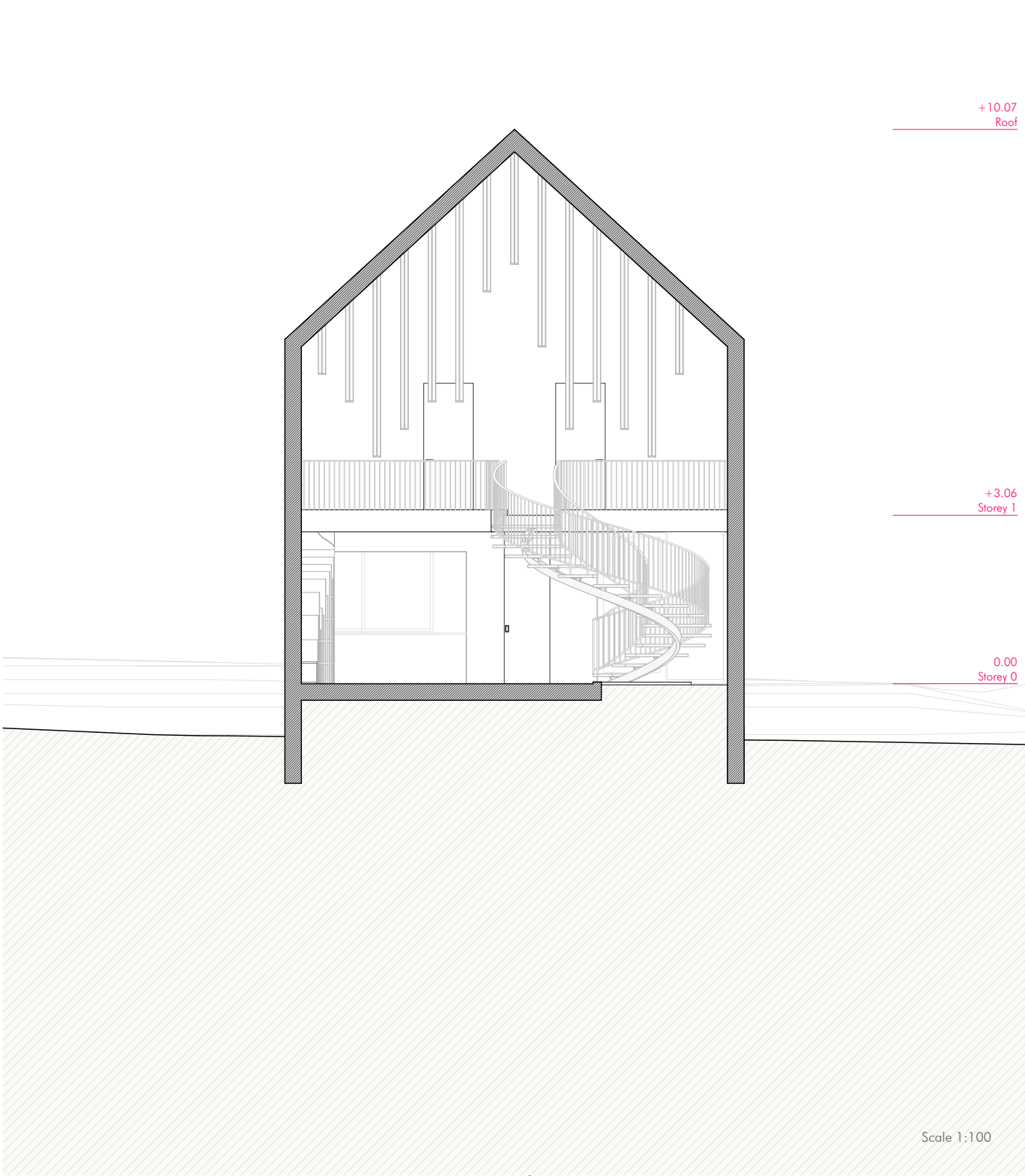
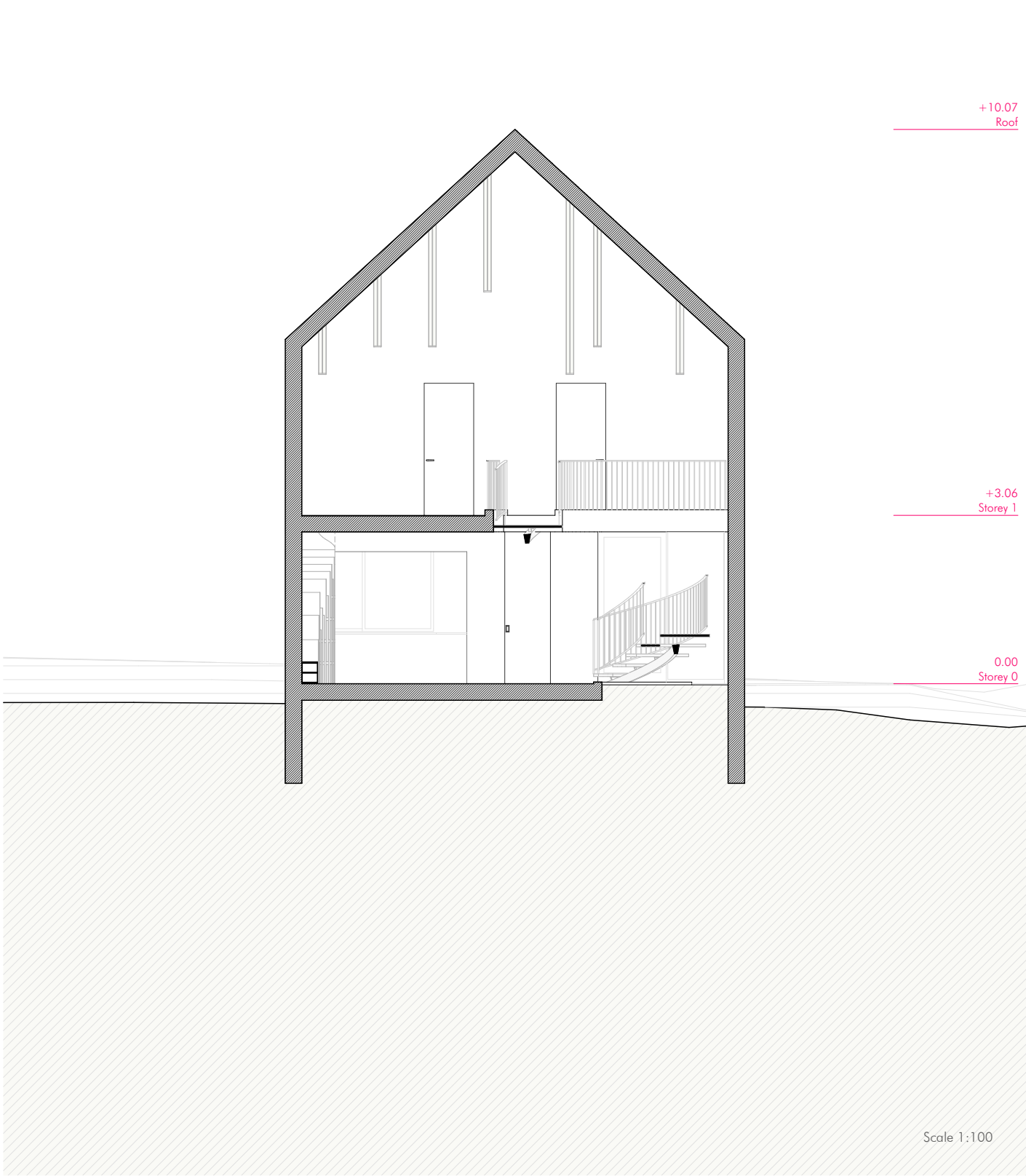
- #001 - Forest House by archi.META
- #002 - White Cube by archi.META
- #003 - Metaverse Pavilion by archi.META
- #004 - Flamingo Pavilion by archi.META



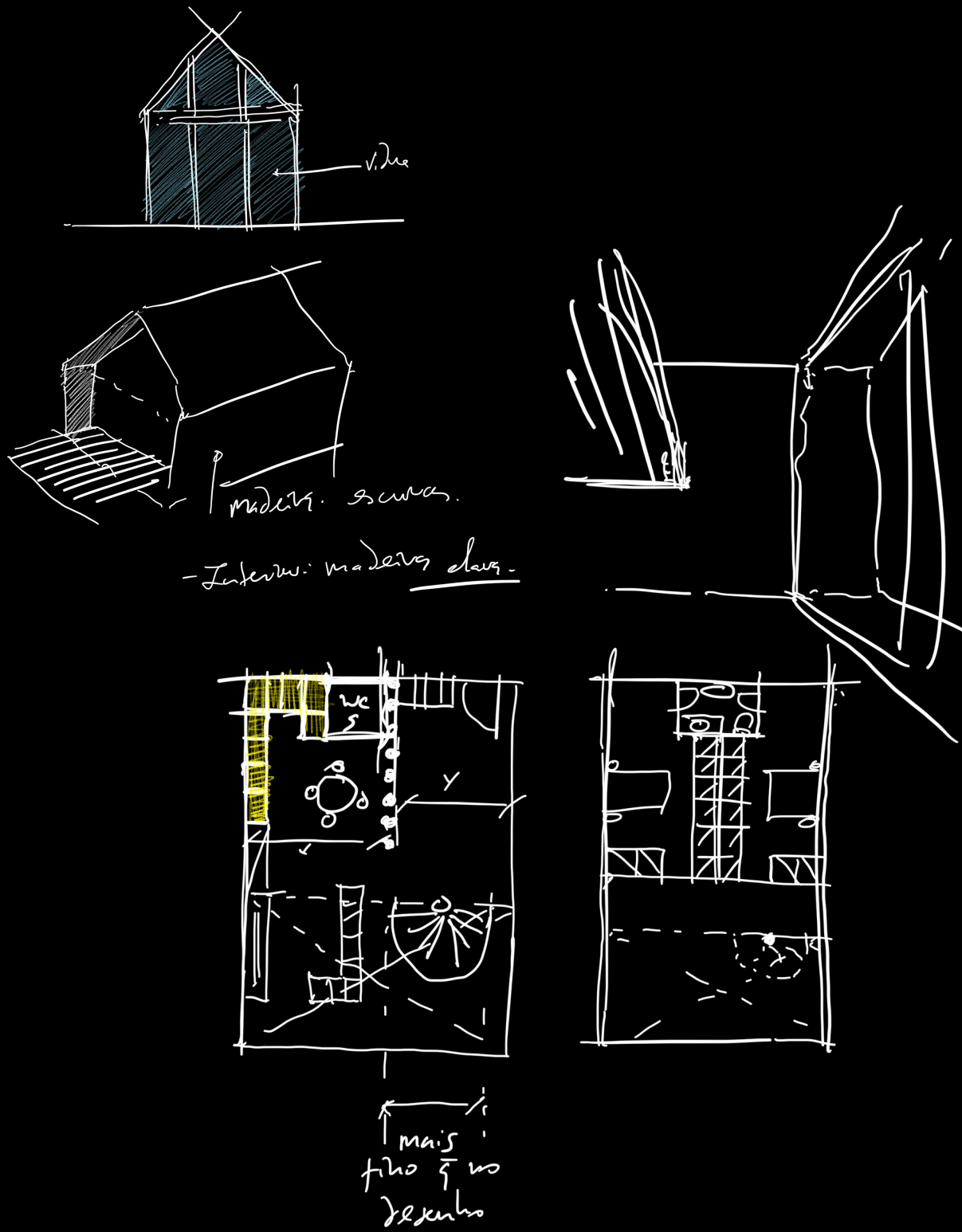


[Figure 135]
Page 169 - Left
Section BB'.

[Figure 136]
Page 169 - Right
Section CC'.



174



[Figure 137]
Page 170
#001 - Forest
House by
archi.META initial
concept sketches.

[Figure 138]
Page 171 - Top
Section DD'.

[Figure 139]
Page 171 - Bottom
Section EE'.

+10.07
Roof

+3.06
Storey 1

0.00
Storey 0

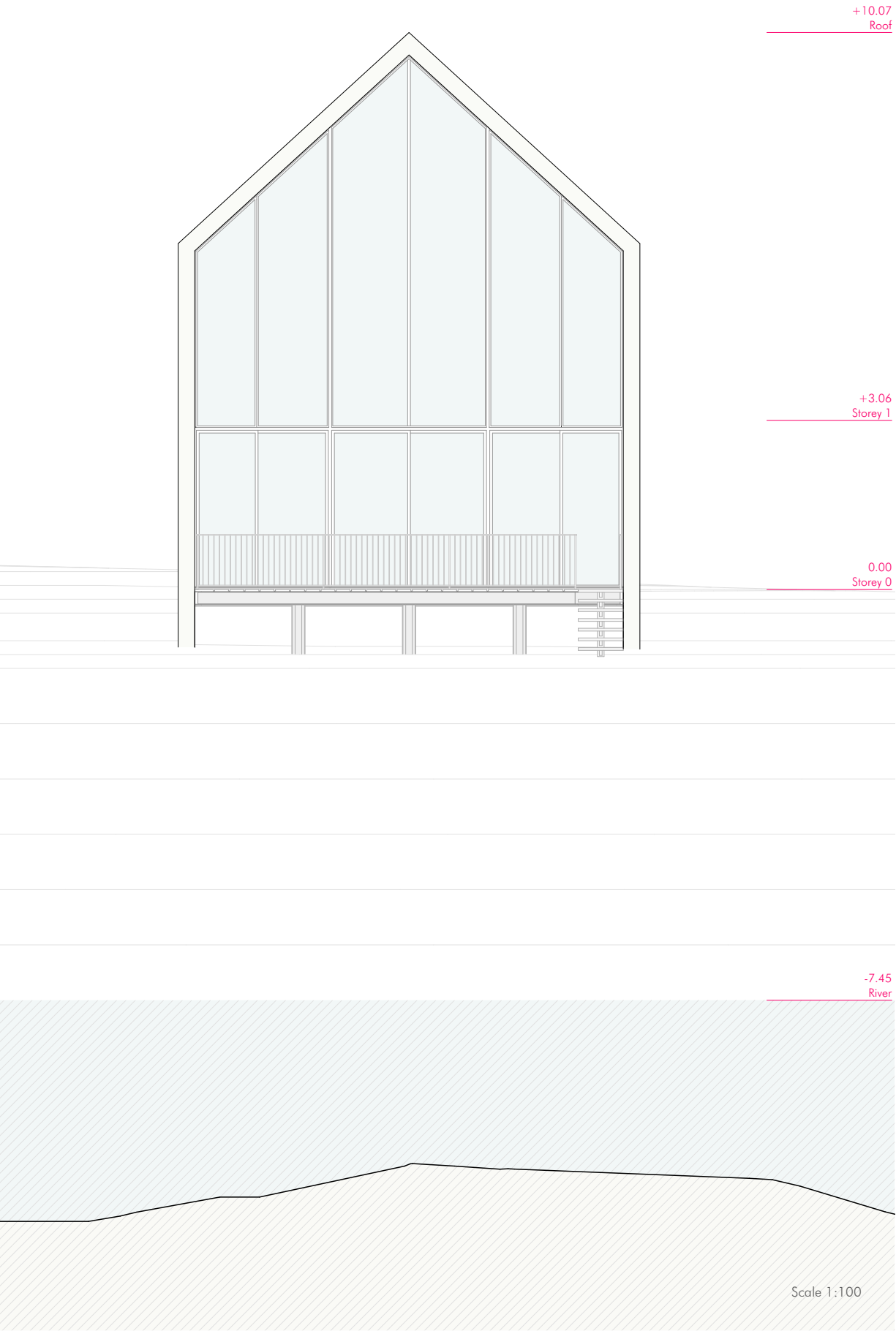
+10.07
Roof

+3.06
Storey 1

0.00
Storey 0

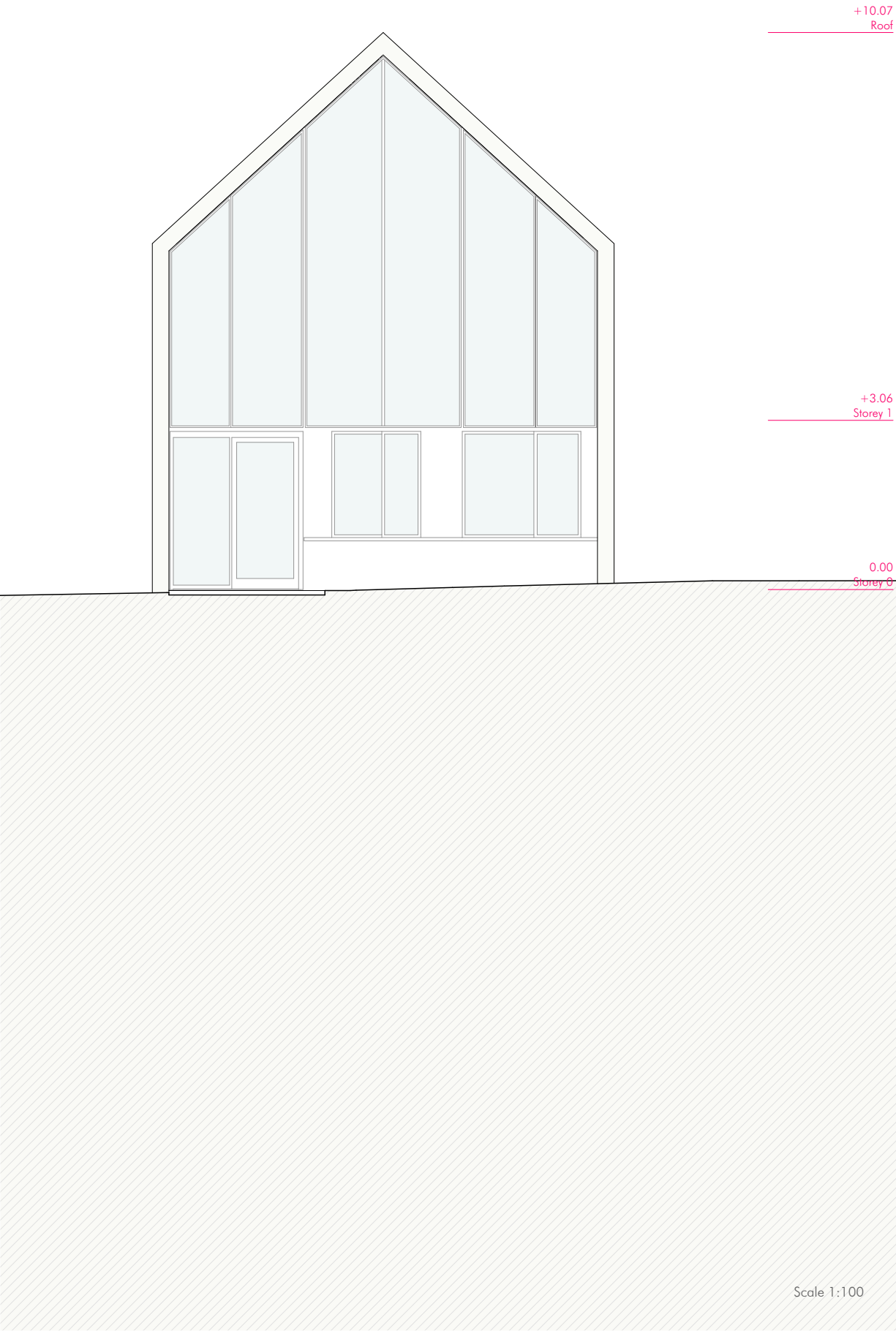
Scale 1:100

Scale 1:100



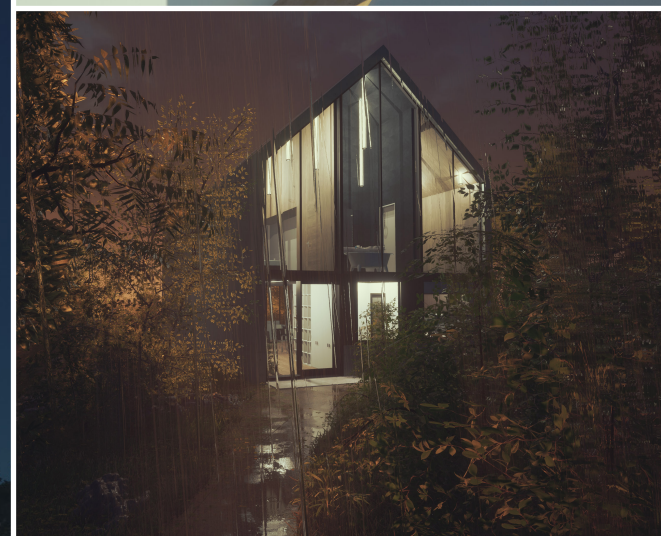
[Figure 140]
South Elevation.

[Figure 142]
Page 174
Exterior and Interior
Renderings.



[Figure 141]
North Elevation.

[Figure 143]
Page 175
Exterior and Interior
Renderings.



#002 - White Cube by archi.META

One could argue that project #001 draws some references from Aires Mateus brothers, but those influences are much more visible in this second project: #002 - White Cube by archi.META, where Leiria House recalls #002 by its triangular shape, front entrance, or light openings in the ceiling [Figure 144]; and the School of Architecture’s white cube in Tournai with its triangular passing evidentiates the main designing principle for this project [Figure 147].

However, both #001 and #002 are each other’s main influences as they were designed practically in simultaneous sketches as the Forest House was initially meant to be a silhouette of the White Cube in the early design stages.

The most difficult component in designing this was its extremely strict and inflexible façade, which conditioned both the ground and upper floors as with three rooms it was not possible to create a symmetrical design on the house’s inside.

[Figure 144]
Similarly to #002 – White Cube by archi.META, Aires Mateus’ Leiria House (2010) programme is vulgar, as it is simple divided between a private zone with bedrooms and a social living area. Leiria House is organised at street level, as well as at a level below ground, unlike #002 – White Cube, with the living spaces arranged around a void that receives light from above.

As seen throughout Aires Mateus’ work, the building’s shape is a recognisable archetype of a house and its interiors mostly combine gypsum white and wood with irregular triangular shapes, just as seen in [Figure 139].



[Figure 145]
As seen in the picture, there is no central courtyard organising the #002 – White Cube, but its skylights are used as small and enclosed courtyards to send indoors small breaches of light to different zones of the house. And despite being a cube, its actual real shape is also the archetype of a house, just like #001 – Forest House by archi.META.





[Figure 146]
Interior views of
the Leiria House
by Aires Mateus on
the left and one of
the rooms in #002
- White Cube by
archi.META on the
right.



[Figure 147]
Architecture Faculty
in Tournai (2017) by
Aires Mateus, also
using the house
archetype in this
cube's entrance.

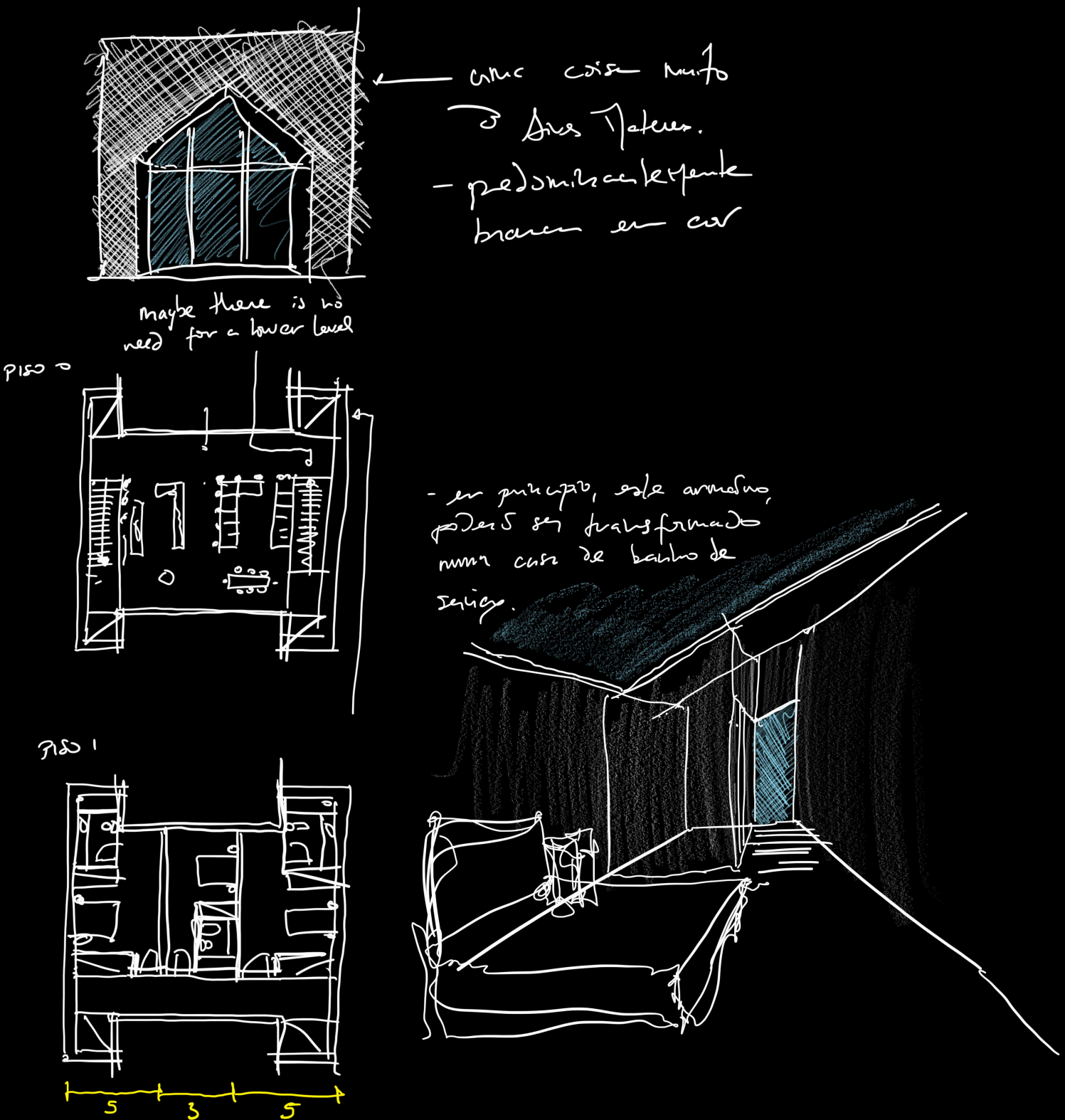
[Figure 148]
Page 179
#002 - White Cube
by archi.META initial
hand sketches.

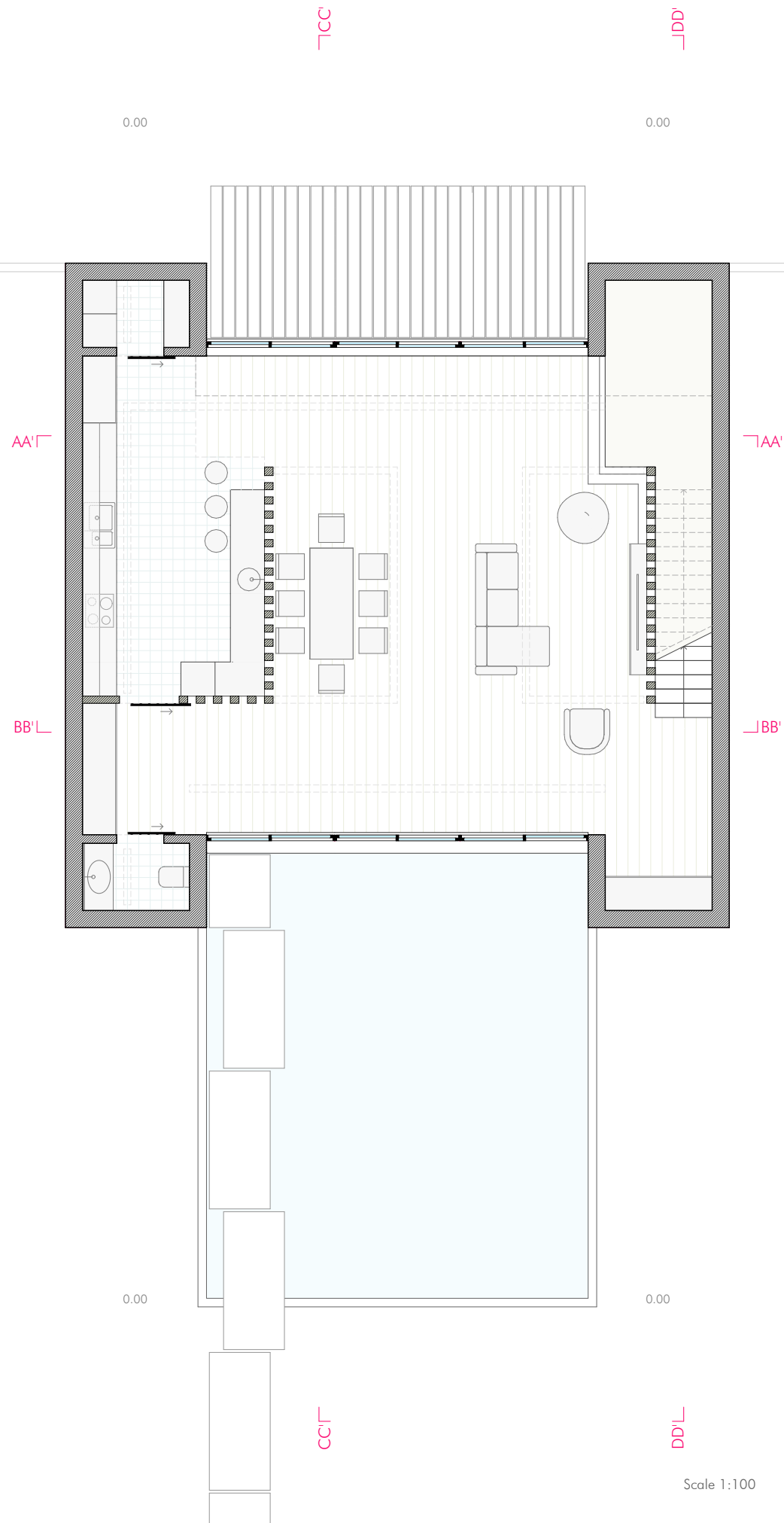
Light is an important theme in the White Cube as it is in the Forest House, but although the house looks like a cube from the outside, in reality its roof is as sloped as it is in its counterpart. This happens so that it is possible to provide ten quality skylights throughout the entire house, where otherwise light would not be able to reach.

Contrasting the Forest House, the White Cube is built on an entirely flat plane as a graphic evidence of the squareness of the building that otherwise would not be achieved.

The house's entrance is marked by a reflection pool with marble suspended over it. The ground floor contains low ceilings to give a more cosy and familiar environment with a 80 square metres living room composed by an eating area, living area, and a small interior garden gaining life from under the stairs, as well as an open-space kitchen closely linked to a service toilet and a laundry.

The upper floor is comprised of three bedrooms, each with their own private bathroom, which are all different from each other, and thus, creating different light effects inside each sleeping space, as neither of the spaces is symmetrical in the building axis.



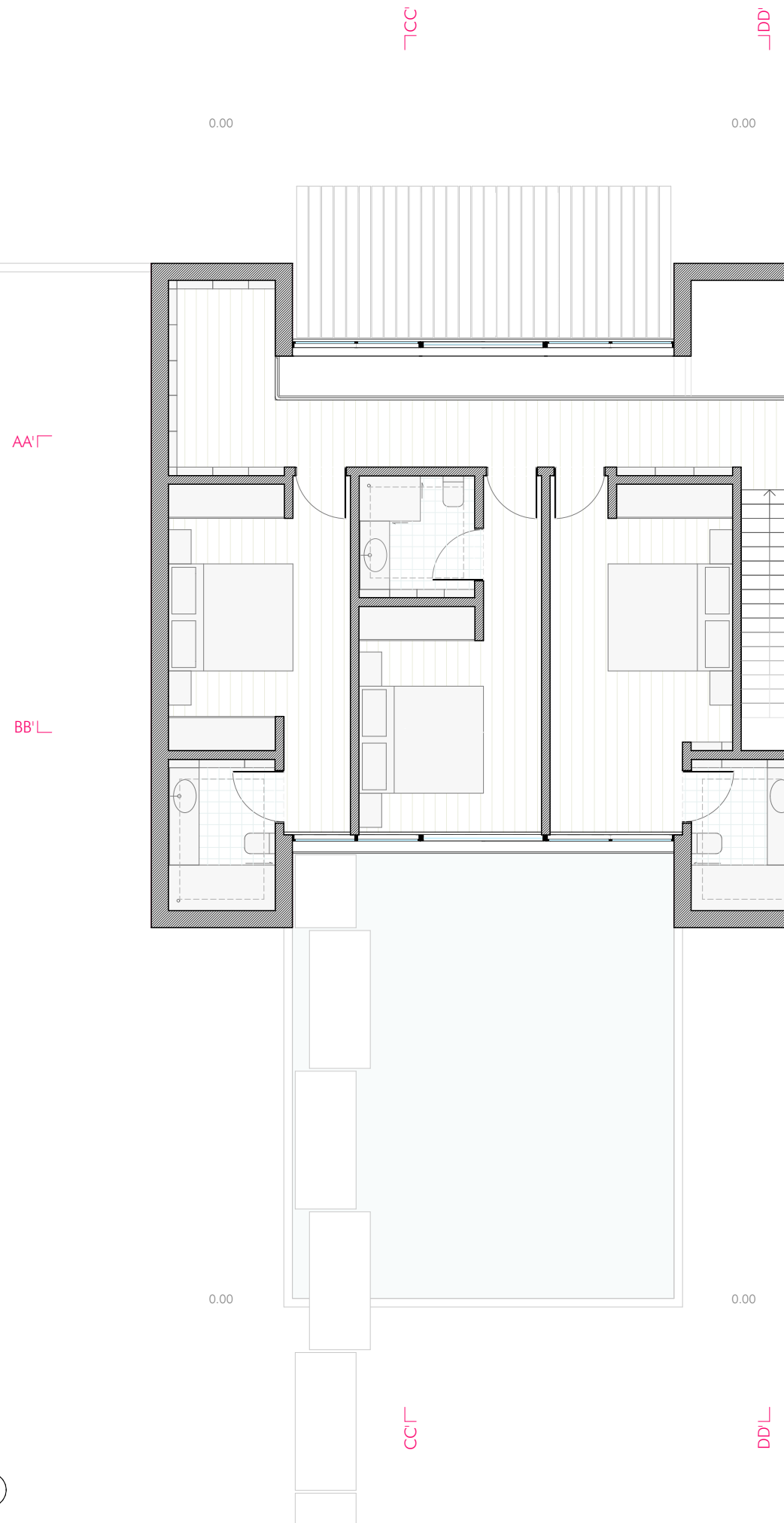


[Figure 149]
Page 180
Ground floor of
the #002 - White
Cube by
archi.META.

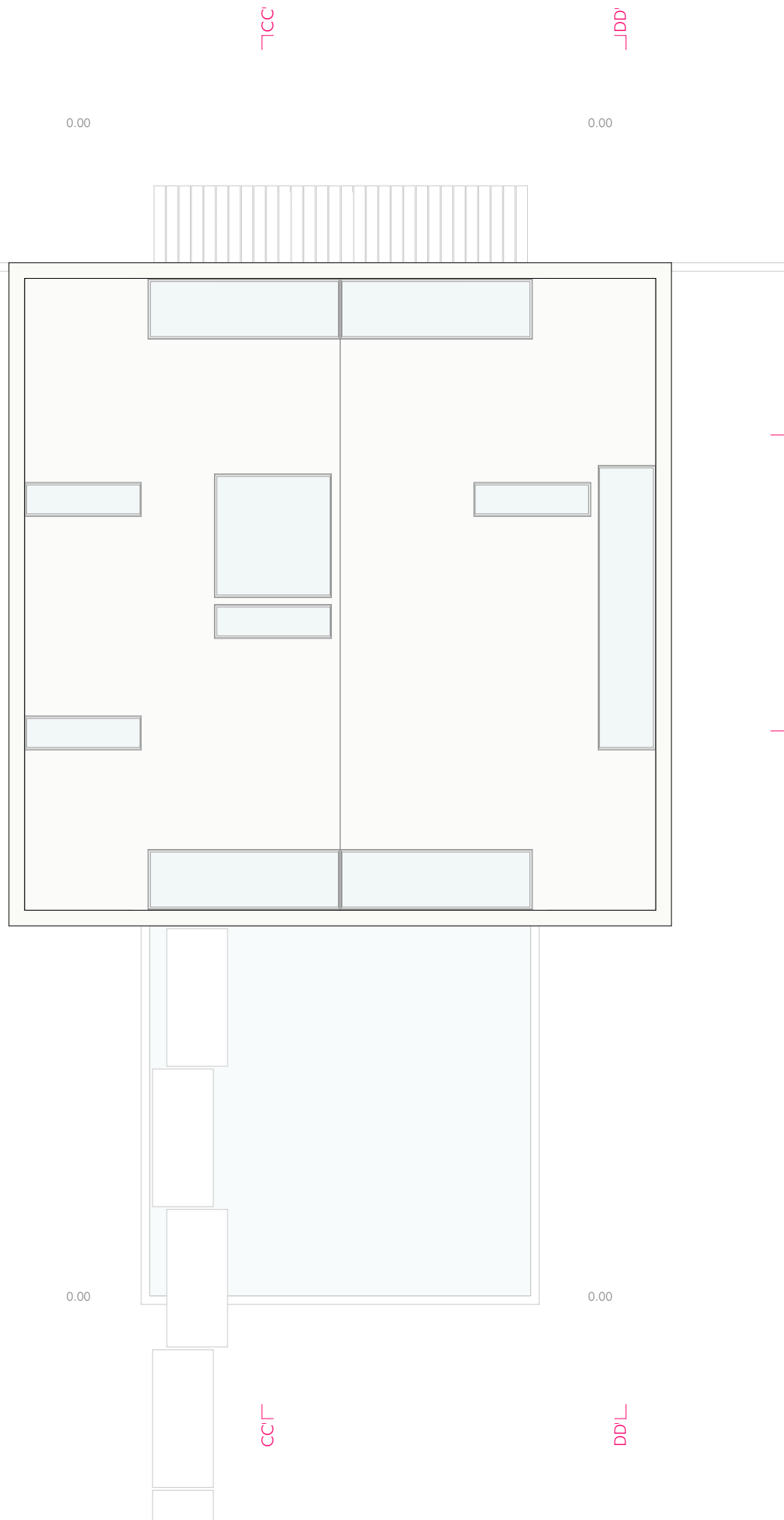
[Figure 150]
Page 181 - Left
First floor of the
#002 - White
Cube by
archi.META.

[Figure 151]
Page 181 - Right
Ceiling plan of
the #002 - White
Cube by
archi.META.

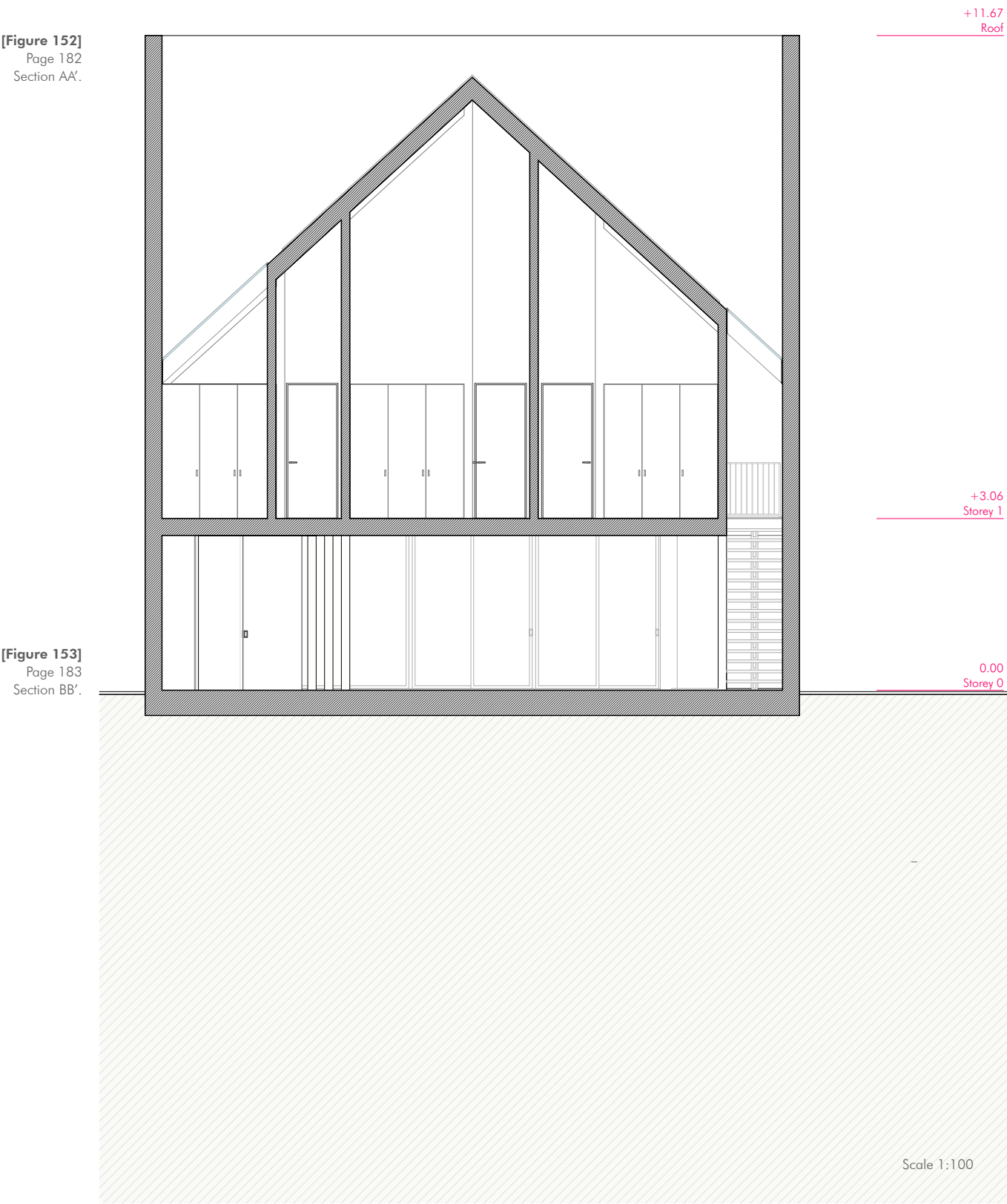
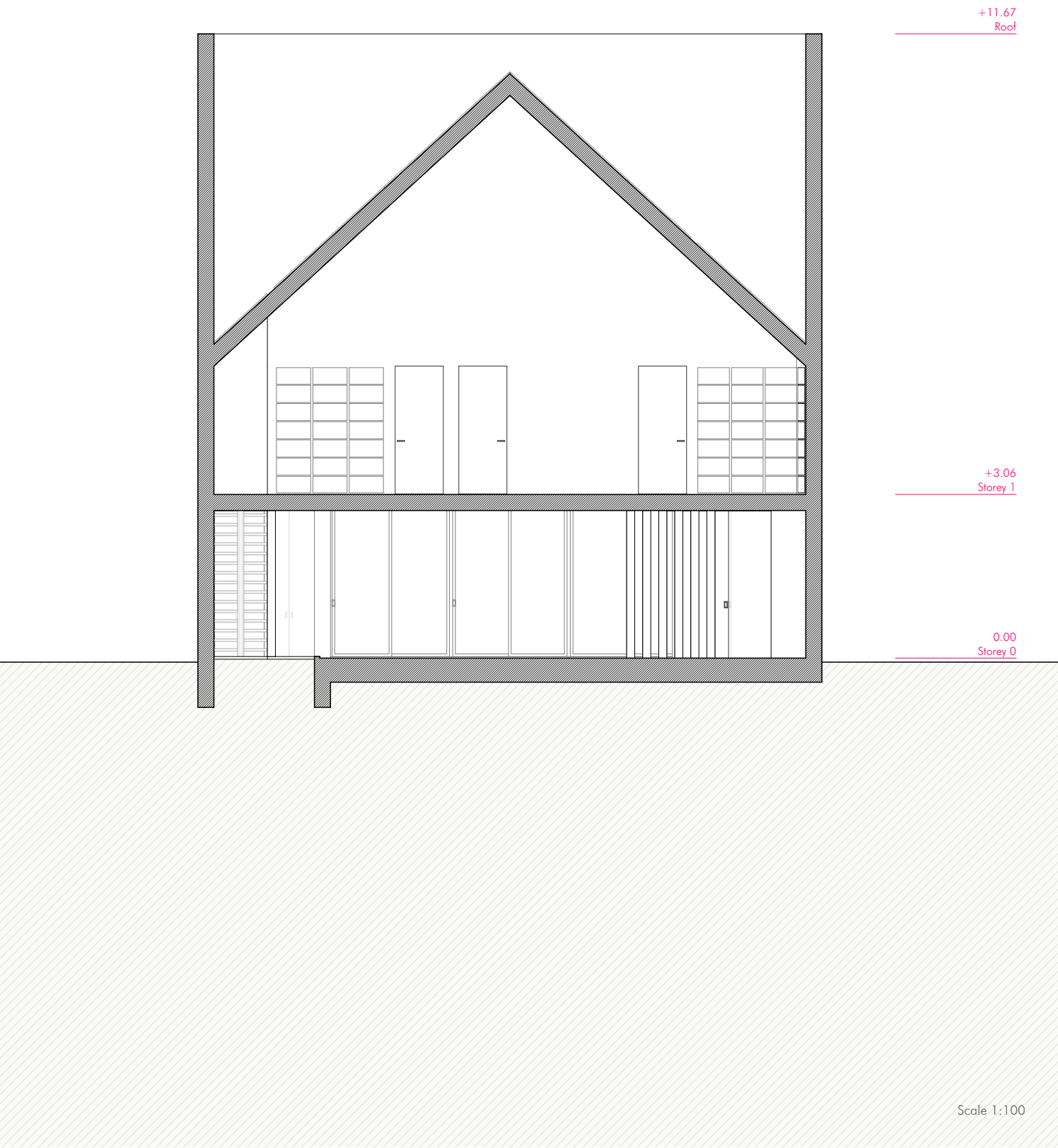
Scale 1:100

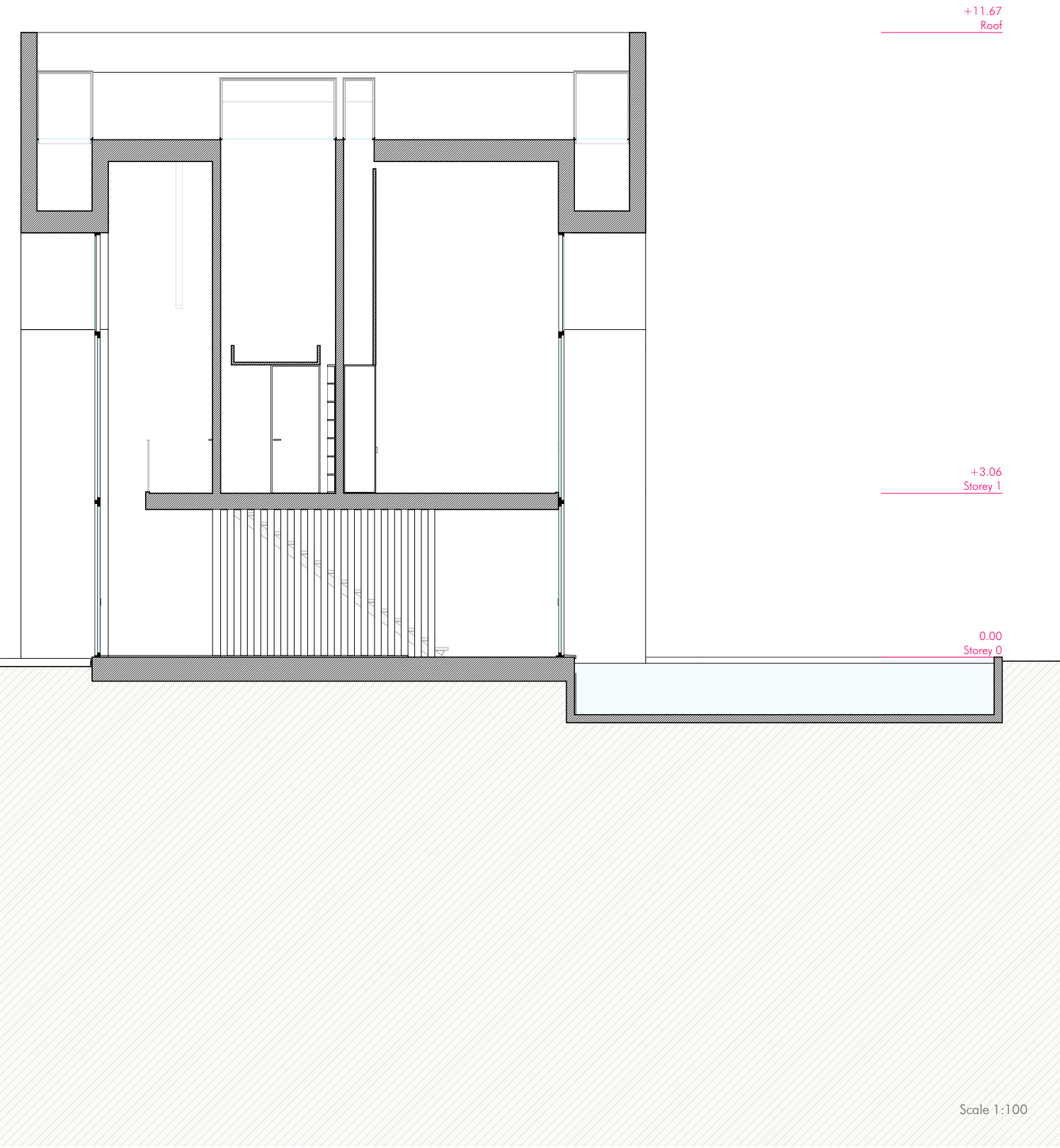


Scale 1:100

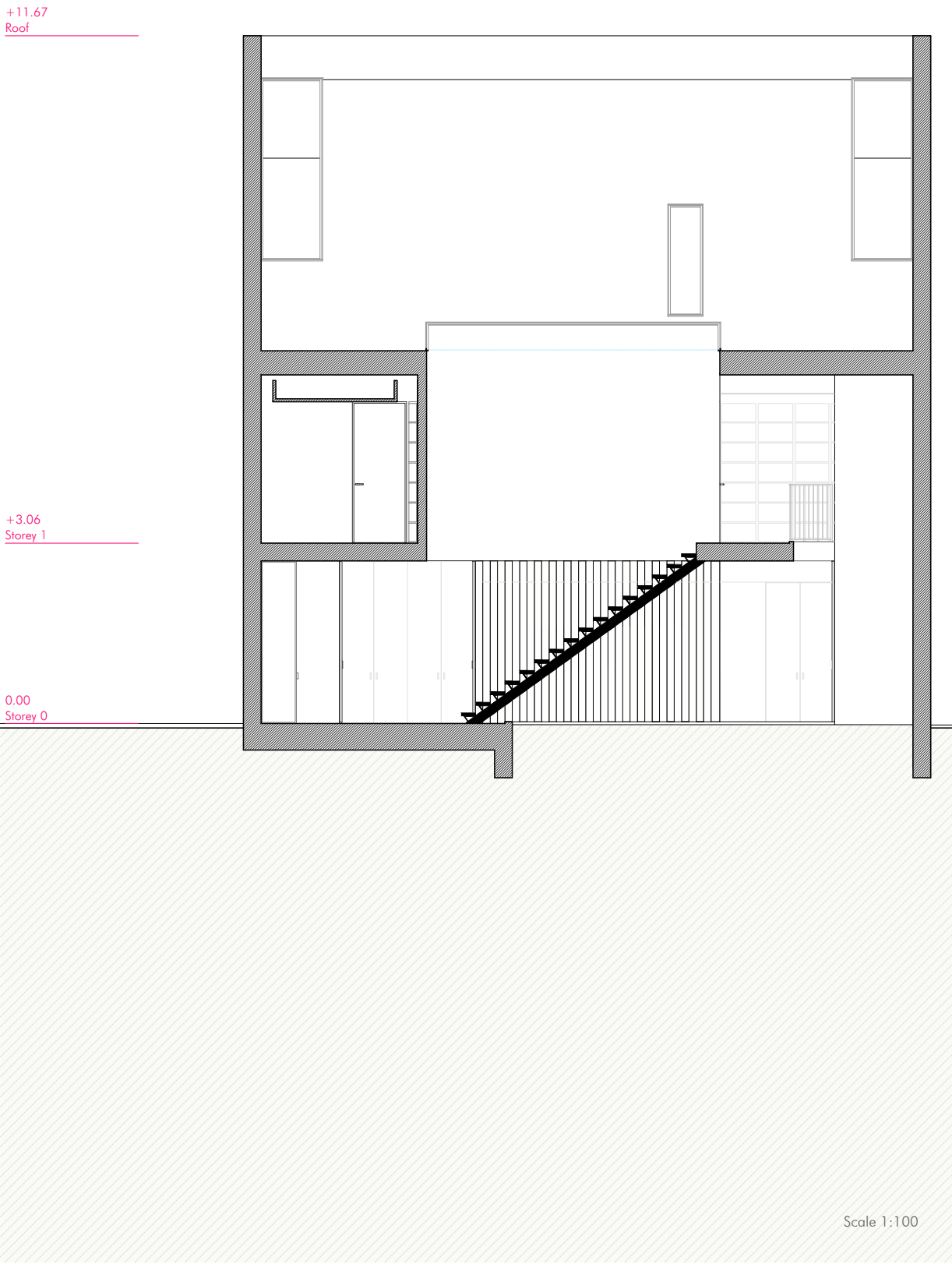


Scale 1:100

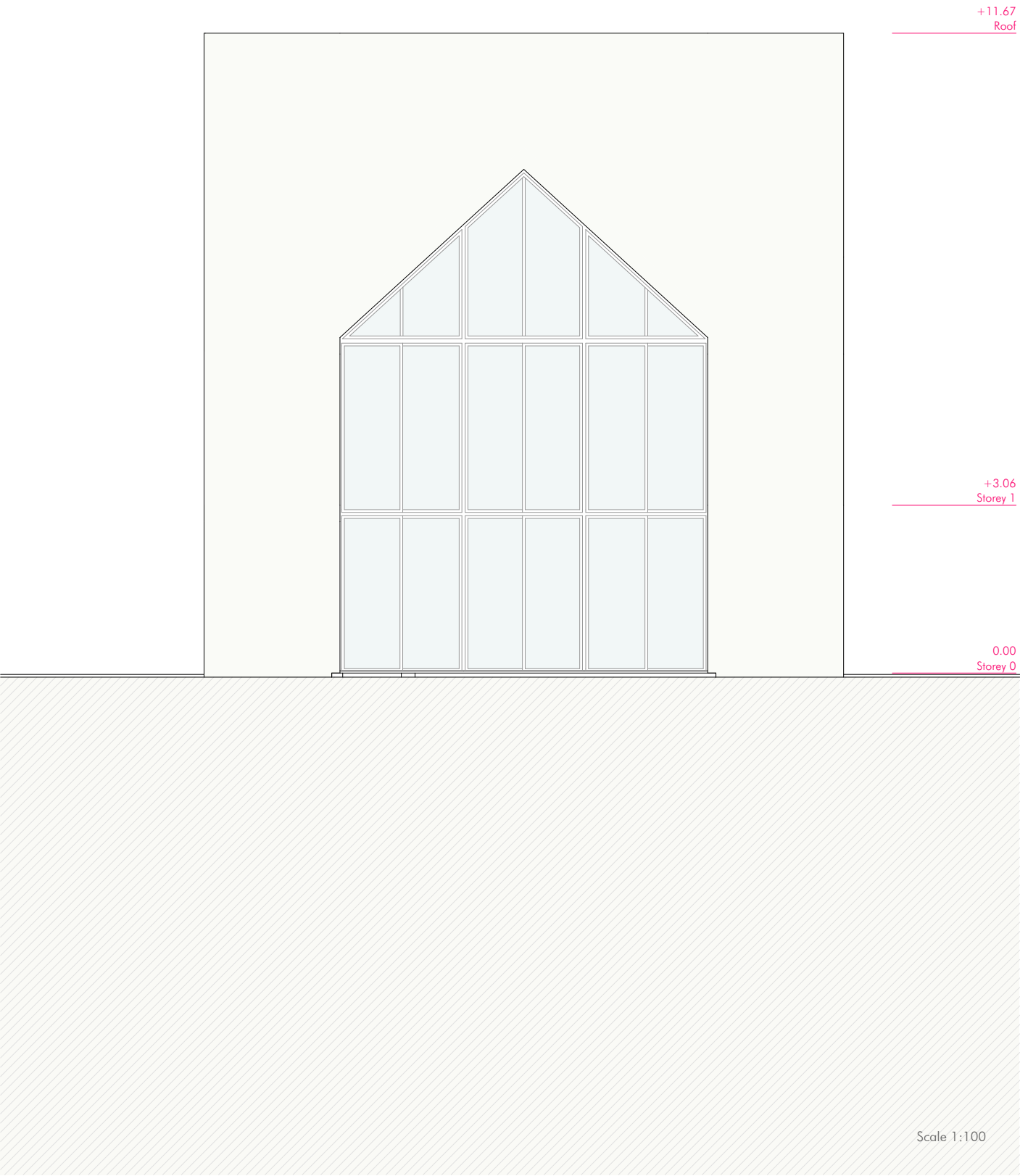




[Figure 154]
Page 184
Section CC'.



[Figure 155]
Page 184
Section DD'.

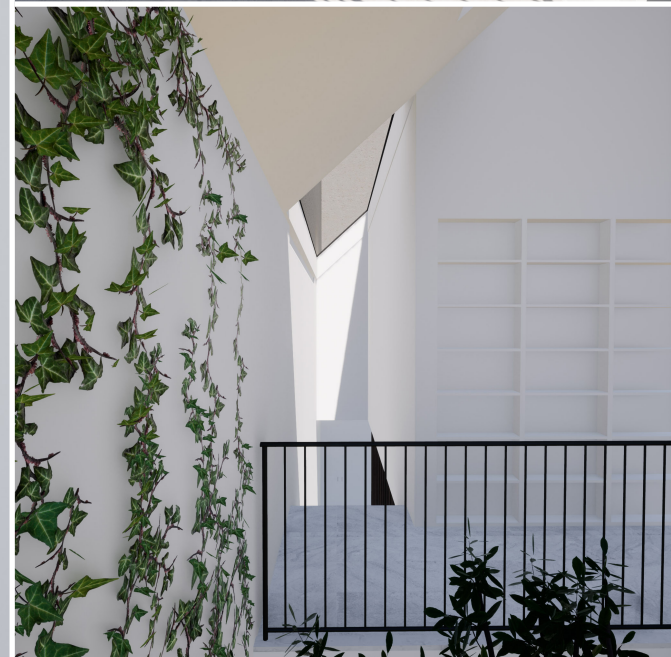


[Figure 156]
South Elevation.

[Figure 157]
Page 188
Exterior and Interior
Renderings.

[Figure 158]
Page 189
Exterior and Interior
Renderings.

Scale 1:100



#003 - Metaverse Pavilion by archi.META

The creation and design of the #003 - Metaverse Pavilion was the first stage where established principles in physical architecture like gravity, materiality, and engineering started to be seriously questioned; as this building wanted to be a place of Cyberspace and Metaverse’s potential.

Needless to say that even in such environments, where gravity and materiality do not exist, this building’s core architecture is taken from Álvaro Siza Pavilion of Portugal in Lisbon, designed for the 1998 World’s Fair [Figure 159].

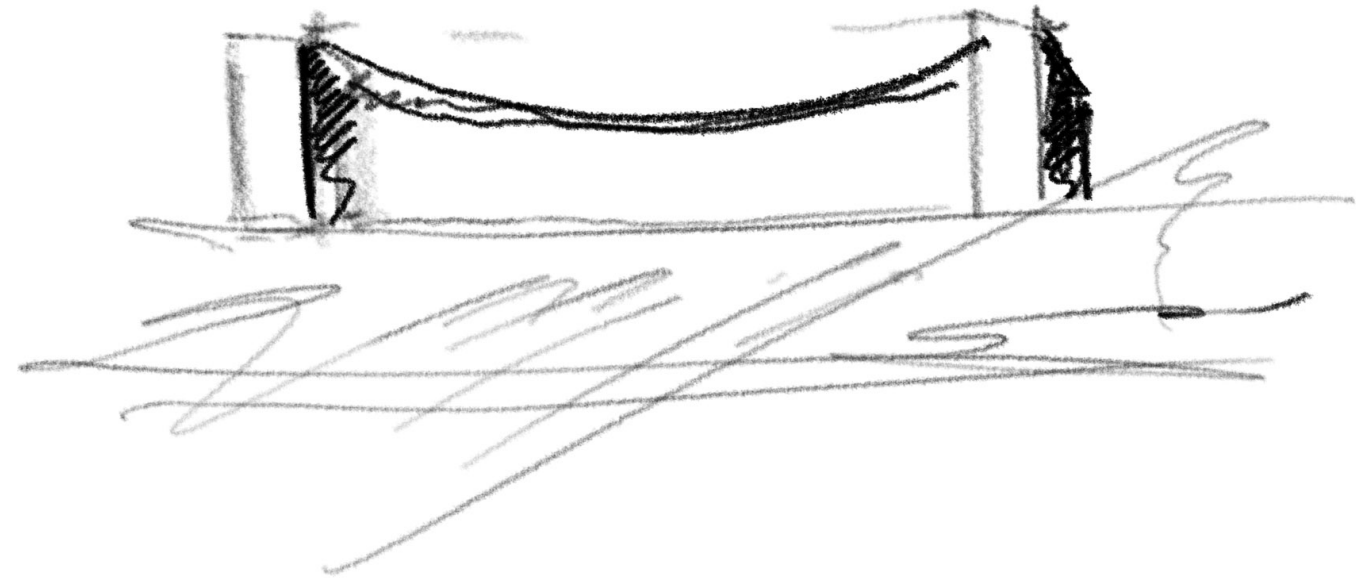
Like Siza’s pavilion, the Metaverse Pavilion is comprised of two rectangular volumes connected by a massive canopy, that in this case is not only stretched but also massively twisted on all its sides. The key difference between buildings is that the rectangular volumes in the Metaverse pavilion are of massively different heights and the canopy is not physically attached to either of the volumes [Figure 160 & 161].

The main difference between the two volumes is that the shorter volume is the pavilion’s enormous auditorium that stretches to the ground [Figure 163 & 164], whilst the taller volume is the art gallery with a skylight throughout the entire last floor, poetically extending the building to the sky.

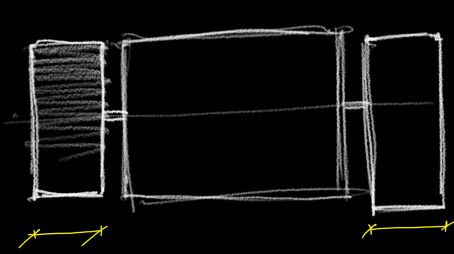
[Figure 159]
Pavilion of Portugal (1998), designed by Álvaro Siza; it features a concrete canopy covering a plaza measuring 60 x 50m.



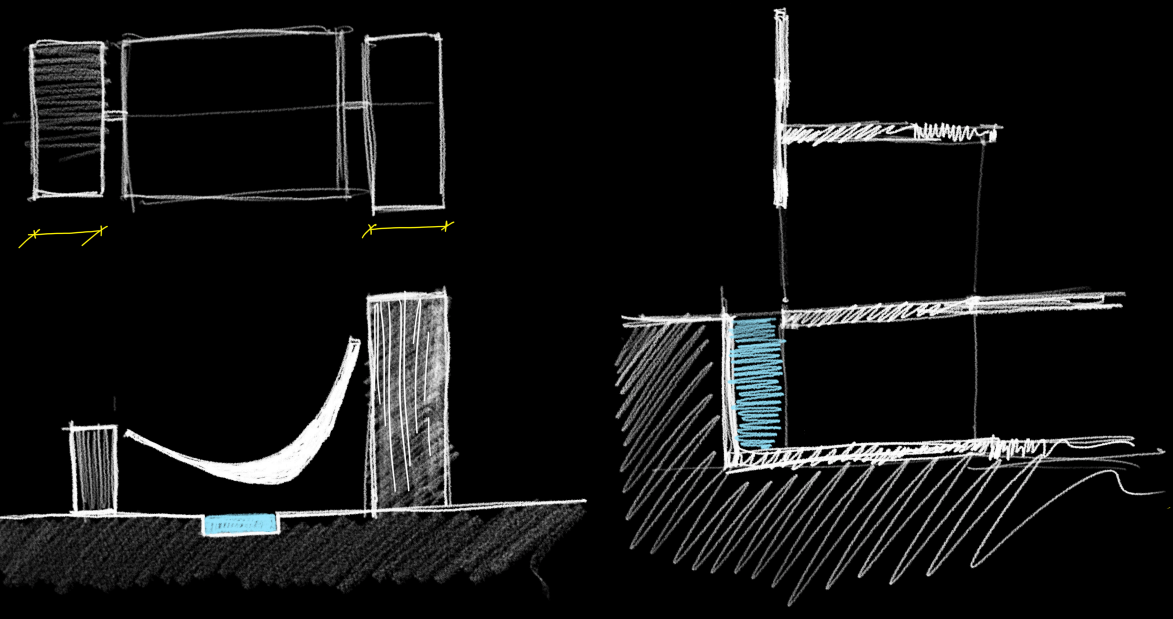
[Figure 160]
#003 - Metaverse Pavilion by archi.META first sketch mimicking the Pavilion of Portugal in all its features.



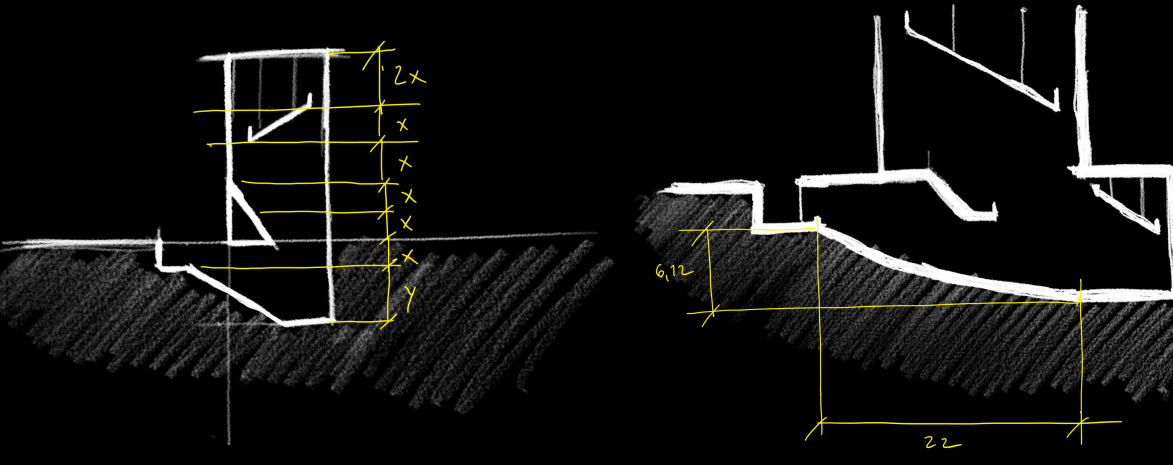
[Figure 161] - Left
Sketching distorting the volumes and the concrete canopy of Pavilion of Portugal, eventually leading to the shape of #003 - Metaverse Pavilion by archi.META.



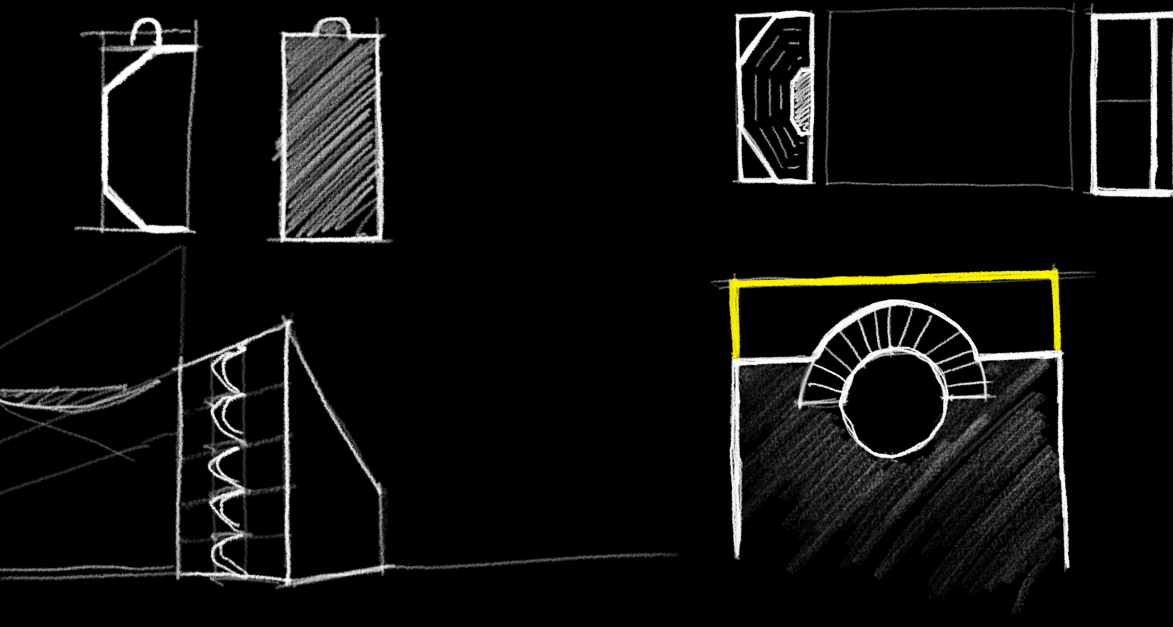
[Figure 162] - Right
First study regarding the underground entrances to the building.



[Figure 163 & 164]
Metrics and volumetric studying the building's auditorium

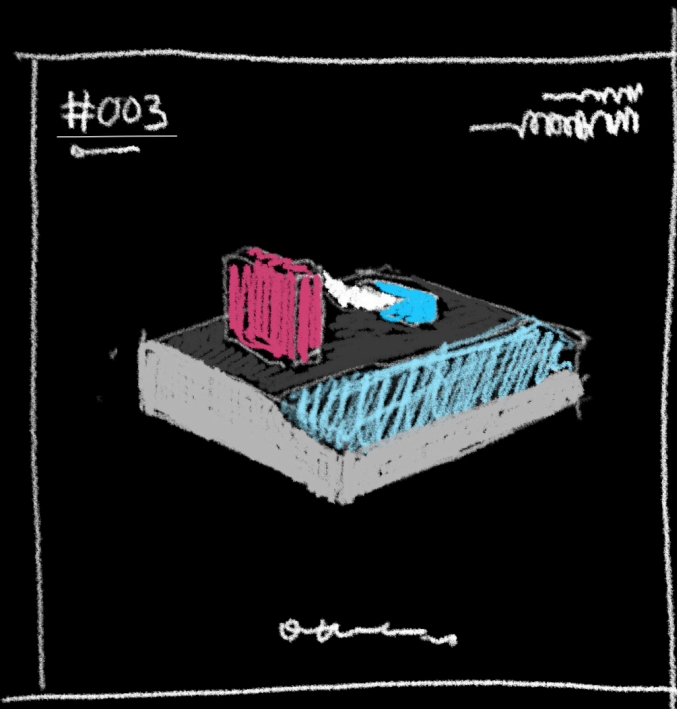


[Figure 165 & 166]
The building's biggest issue was finding a solution for its vertical elevations, where staircases were initially studied like showcased on the right. However, ramps ended up being used to connect the several floors of the exhibition space.



A vertical void, as seen in Decent Headquarters [Figure 115] was not considered as visiting each exhibition floor by its order was part of the storytelling experience of the pavilion.

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[Figure 167]
Page 196 - Top
Sketch of the #003
- Metaverse Pavilion
by archi.META
presentation board
for the different
several social media
platforms.

Physical materiality as we know it in traditional architecture is purposely discarded in this building in turn of creating a cybernetic and virtual environment. The building's chromatic palette is cyan, white, and pink, as those colours are commonly used in cyberpunk environments, besides being archi.META's colours [Figure 167 & 168].

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The building's water side is composed by stairs running in a diagonal pattern alongside the coast - influenced by the Zadar's Sea Organ, in Croatia, where the water enters the stairs to create a sound effect [Figure 169]. The water on the side of the building is neon cyan with a bright flash running alongside it, and in general there is no lighting in this environment, as everything that needs to be illuminated naturally glows by itself.

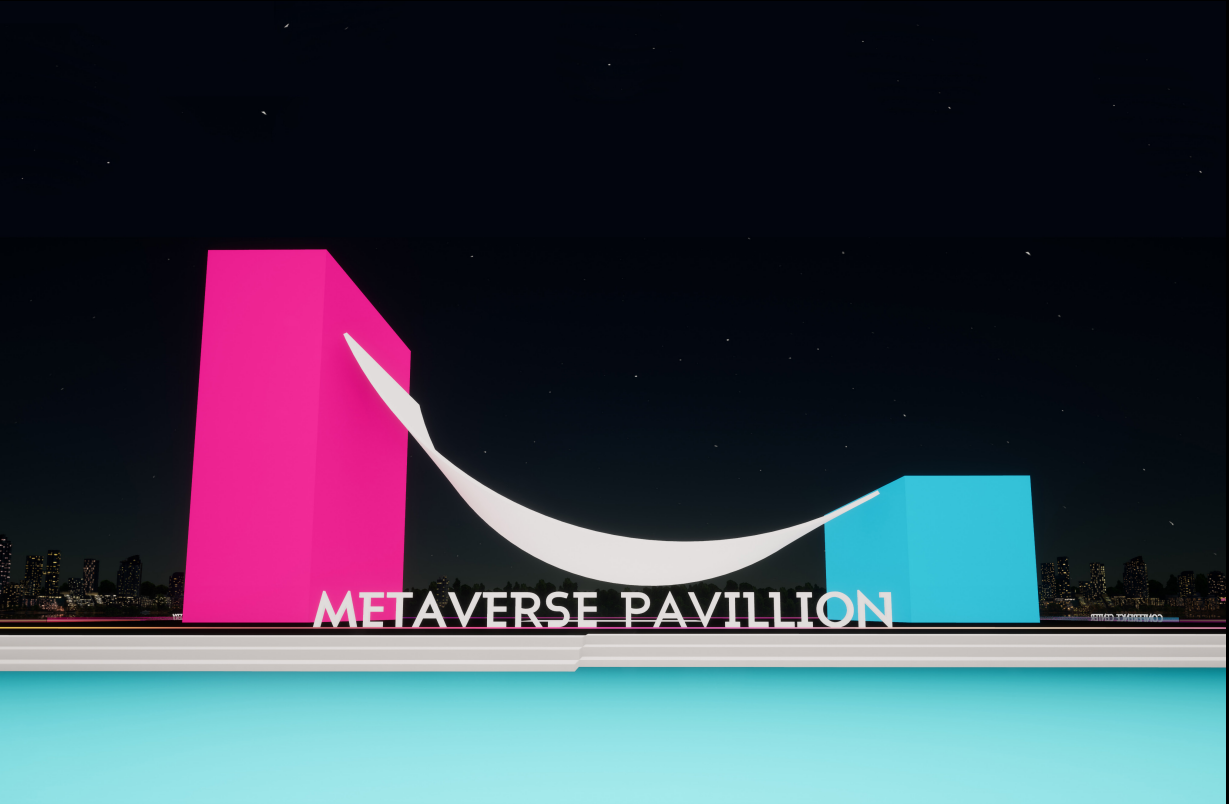
The art gallery's first floor is comprised by the entrance where an index of exhibitions would be located followed by two floors with double height with a permanent archi.META exhibition. The rest of the floors are connected through massively long ramps extending almost the volume's length, with each floor having its own personality according to the artist's personality.

[Figure 168]
Page 196 - Bottom
#003 - Metaverse
Pavilion by
archi.META final
presentation board.

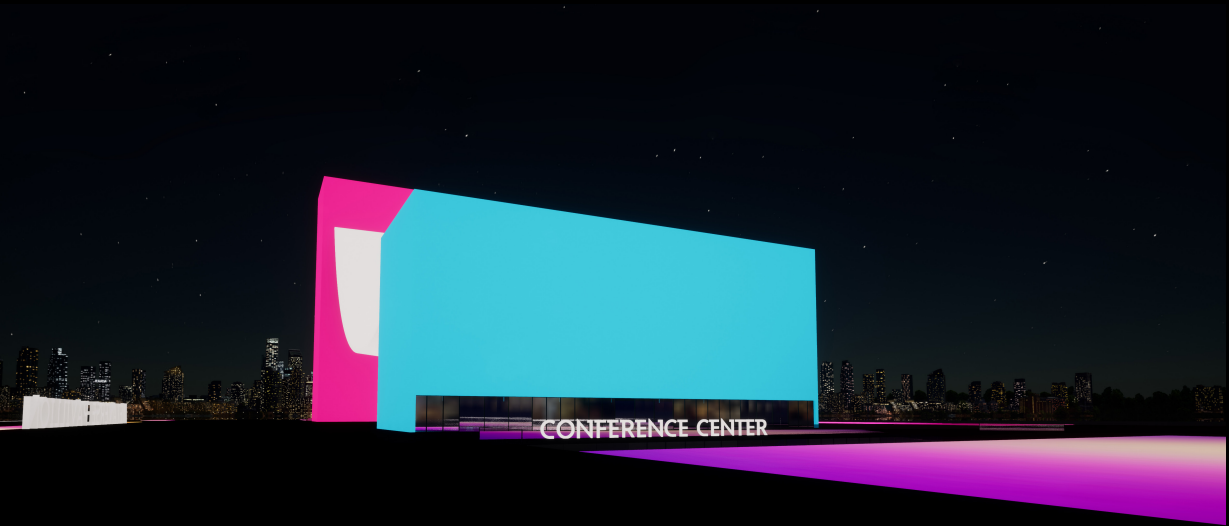
[Figure 169]
The Sea Organ
(2005) located in
Zadar, Croatia,
and designed by
Nikola Bašić; and
the winner of the
2006's European
Prize for Urban
Public Space.

The waves interact with the organ concealed underneath the white marble steps, to create harmonic sounds, through a system of polyethylene tubes and a resonating cavity.

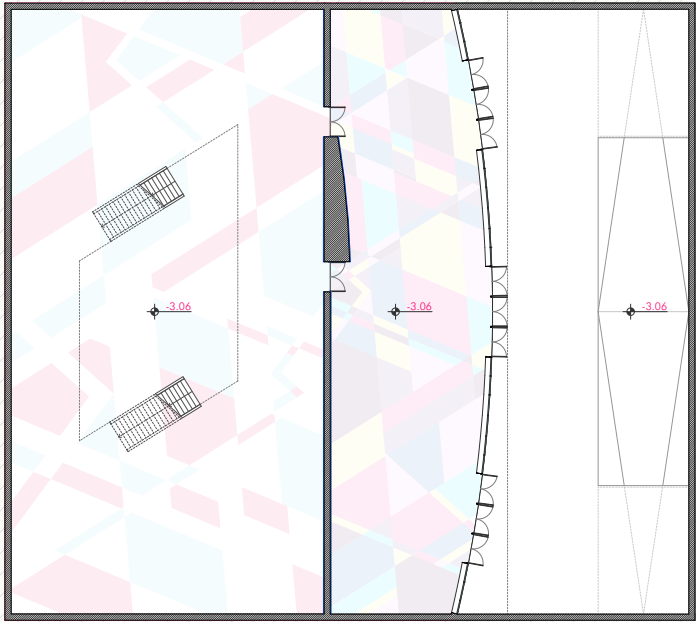
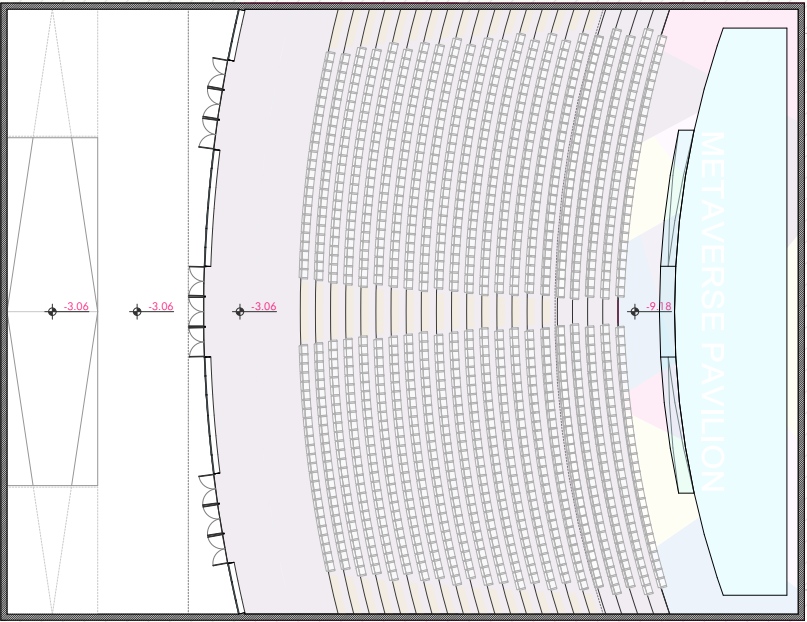


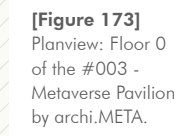


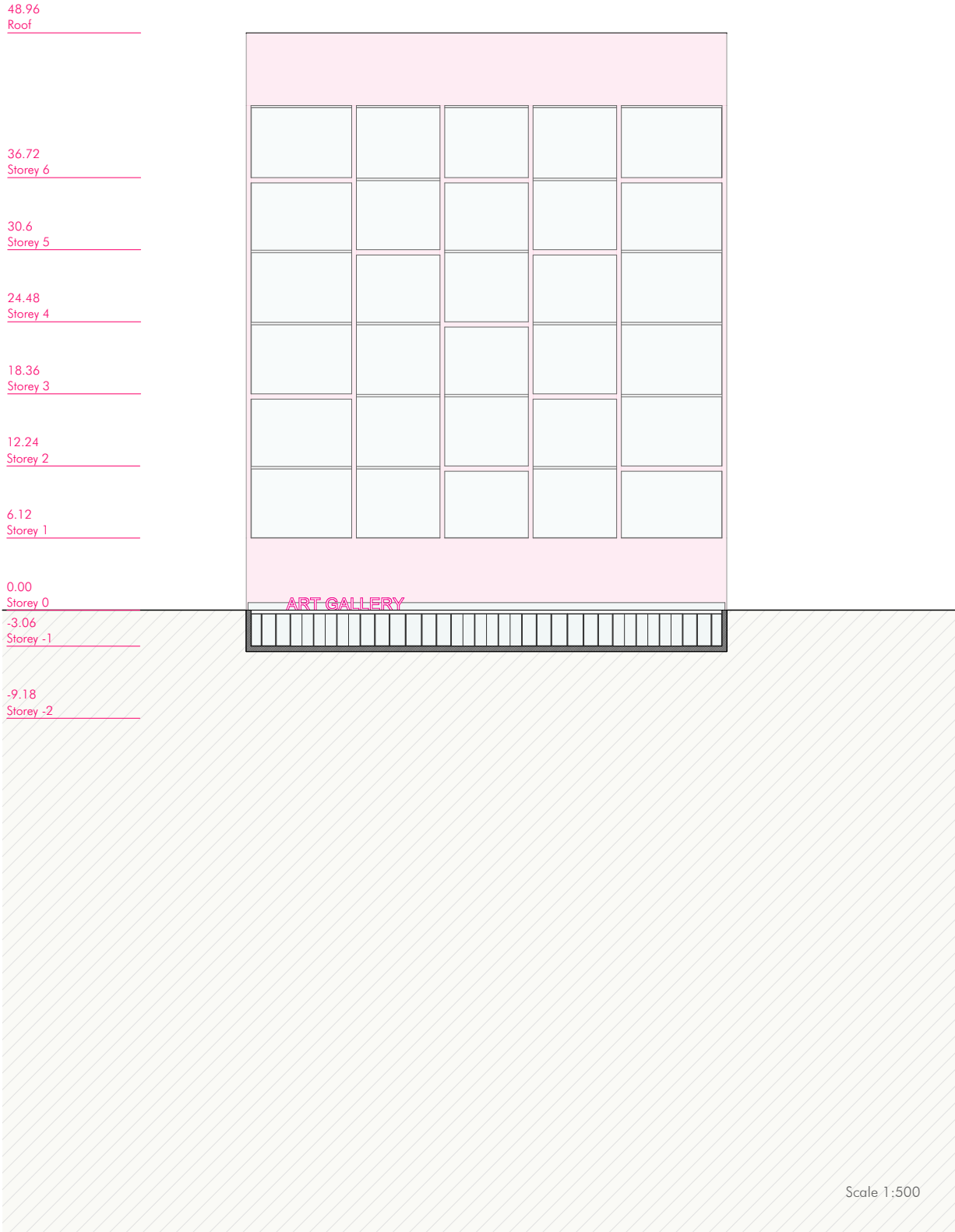
[Figure 170]
#003 - Metaverse
Pavilion by
archi.META exterior
renderings.



[Figure 171]
Planview: Floor -1
of the #003 -
Metaverse Pavilion
by archi.META.

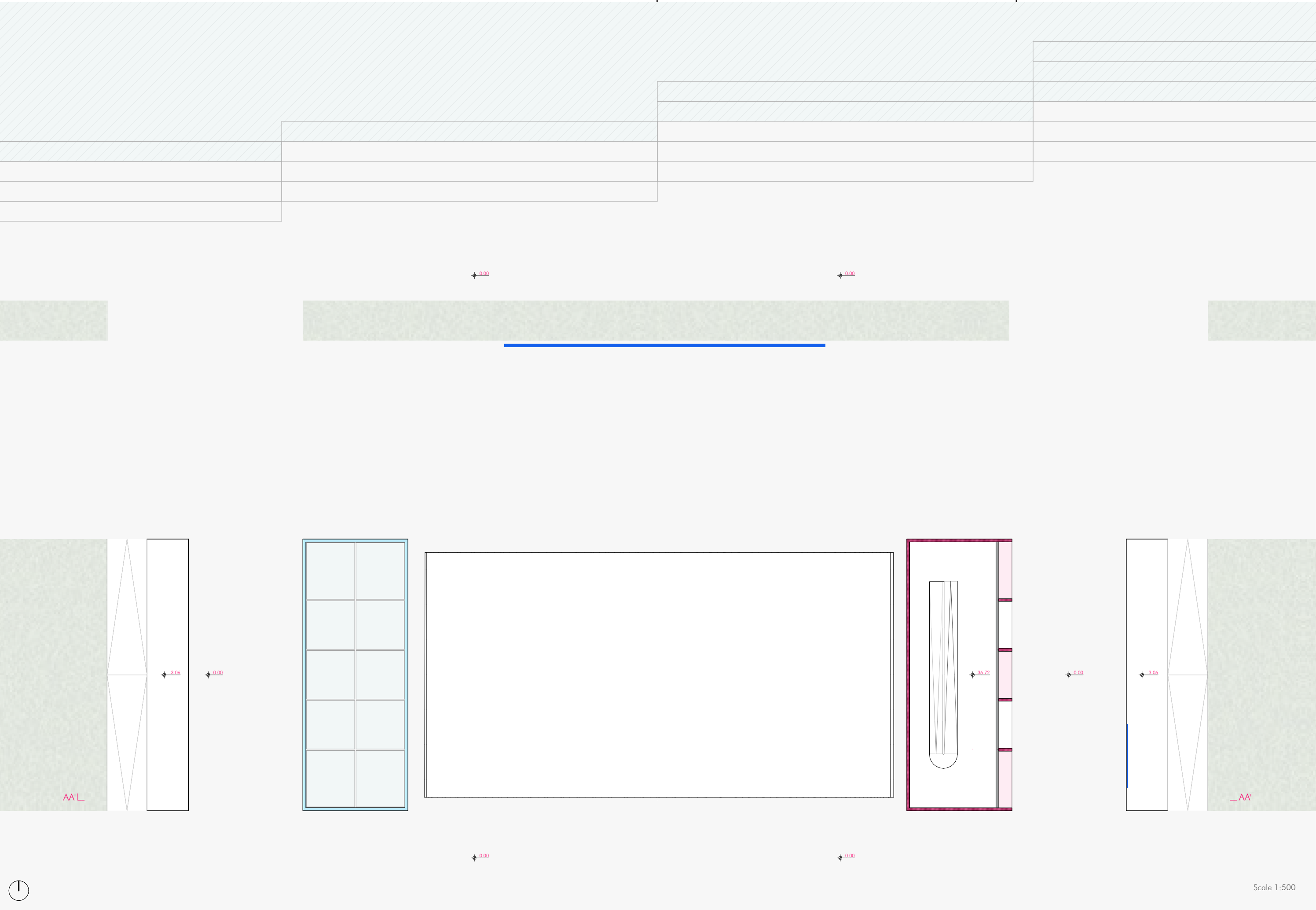




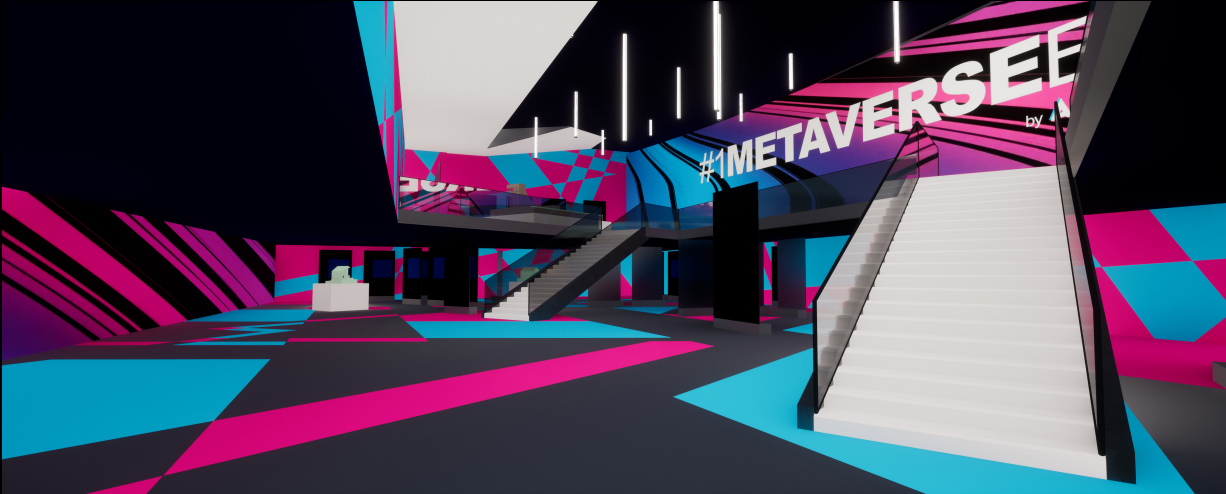


[Figure 174]
East Elevation
of the #003 -
Metaverse Pavilion
by archi.META.

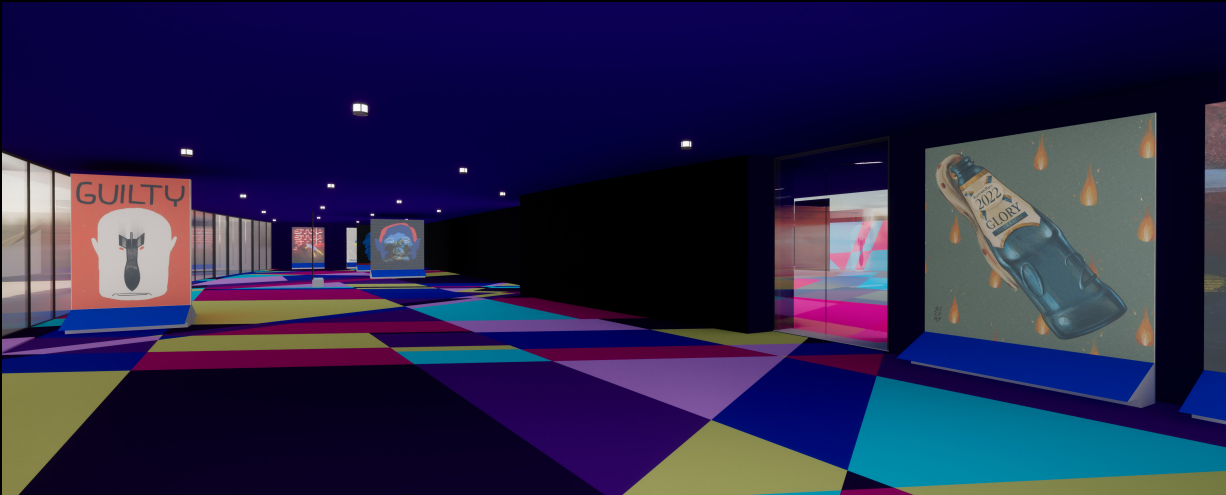
[Figure 175]
Planview: Floor 6
of the #003 -
Metaverse Pavilion
by archi.META.



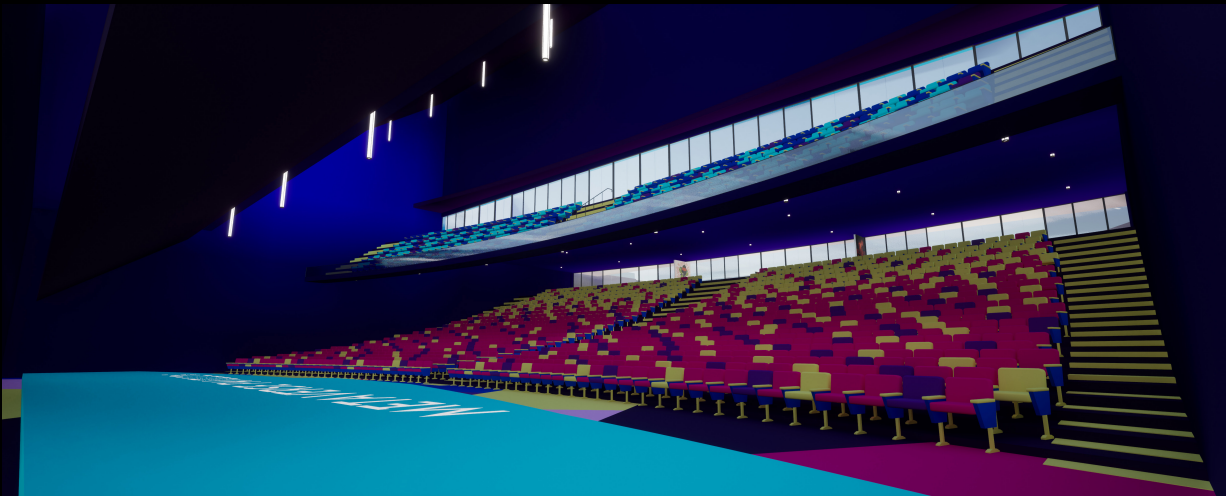
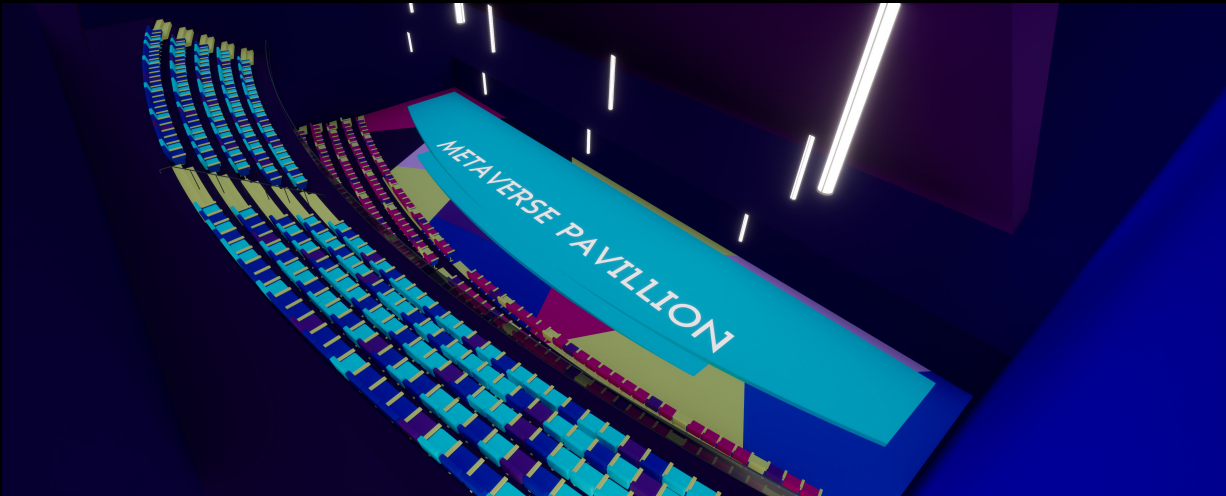
204



[Figure 176]
#003 - Metaverse
Pavilion by
archi.META interior
renderings.

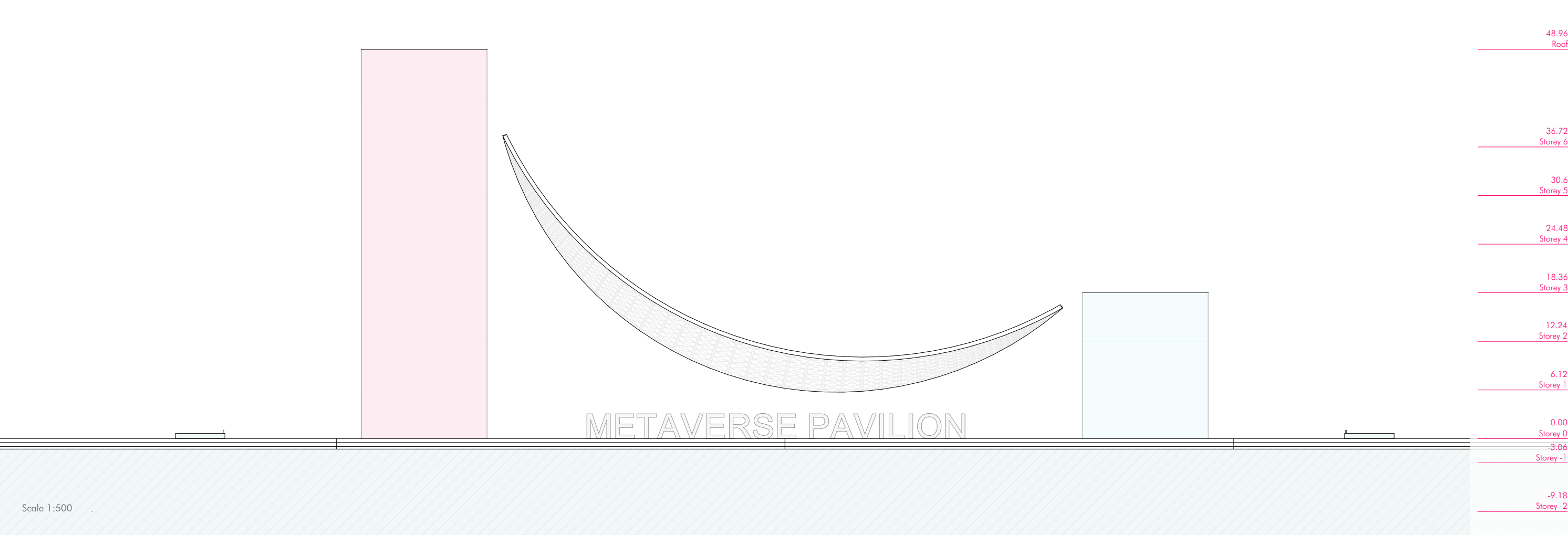
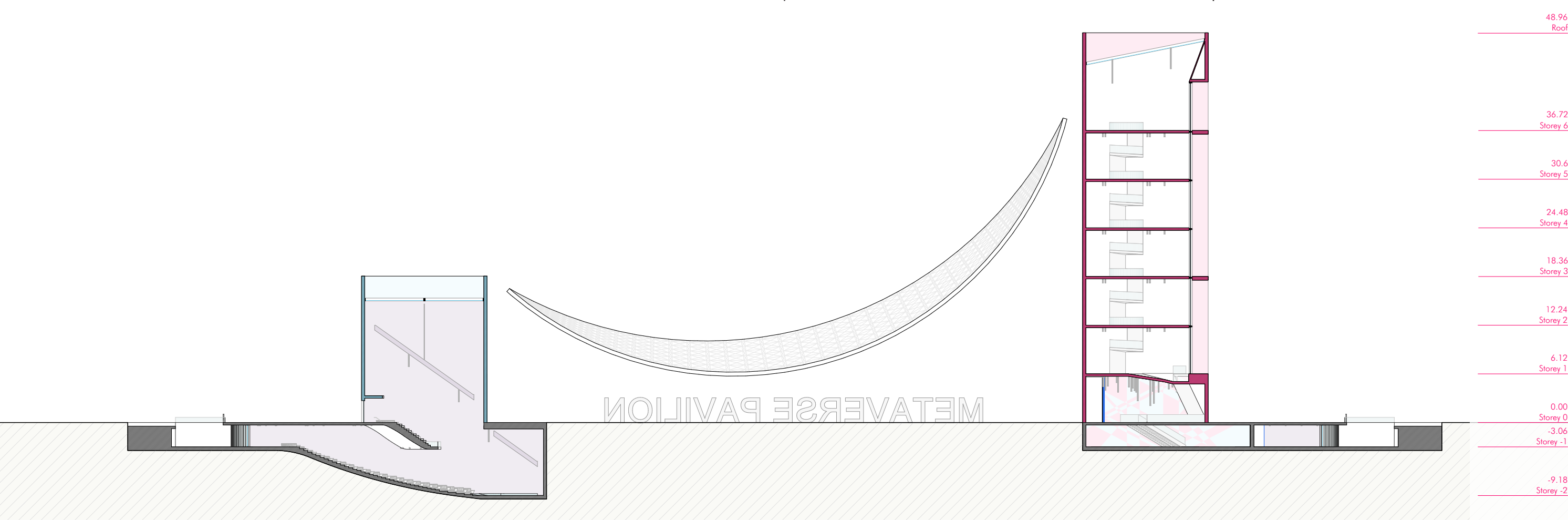


[Figure 177]
Section AA.



[Figure 178]
North Elevation
of the #003
Metaverse Pavilion
by archi.META.

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#004 - Flamingo Pavilion by archi.META

The Metaverse Pavilion can be considered eccentric and exotic, but the #004 - Flamingo Pavilion is the true outlier among the buildings that were designed for archi.META.

It was designed for a competition in Nifty Island, which is an open social gaming platform and a virtual world, part of the Nyftverse: a set of interoperable games, a marketplace, play-to-earn protocol powered by Web3. The competition’s premise was to design a flamingo based building or landmark, and the Flamingo Pavilion was a five hour sprint for the competition submitted by archi.META.

The building is composed by four key elements: the reflection pool, the spatially enclosed entrance, the interior walking gallery, culminating in an auditorium. Although the building was texturised as pink marble due to flamingos, its entrance volumetric geometry was inspired by Aldo Rossi’s San Cataldo Cemetery if it was cut short [Figure 179 & 180]. Its interior is dark, resembling Peter Zumthor’s thermal baths in Vals, with the walking corridor receiving light coming from the ceiling and the water from the exterior reflection pool flowing underneath the wall, illuminating and reflecting the dark walking gallery [Figure 181 & 182]. The auditorium plays with different ceiling heights and angles, so that it creates different beams of lighting reaching its interior.

As for the building’s exterior, to take advantage of the flamingo’s pointy silhouette, this building volumetry distinguishes itself from all the other three buildings as its goal is to create a pointy and uncomfortable angles to the exterior visitor providing optical illusion where walls sharply meet.

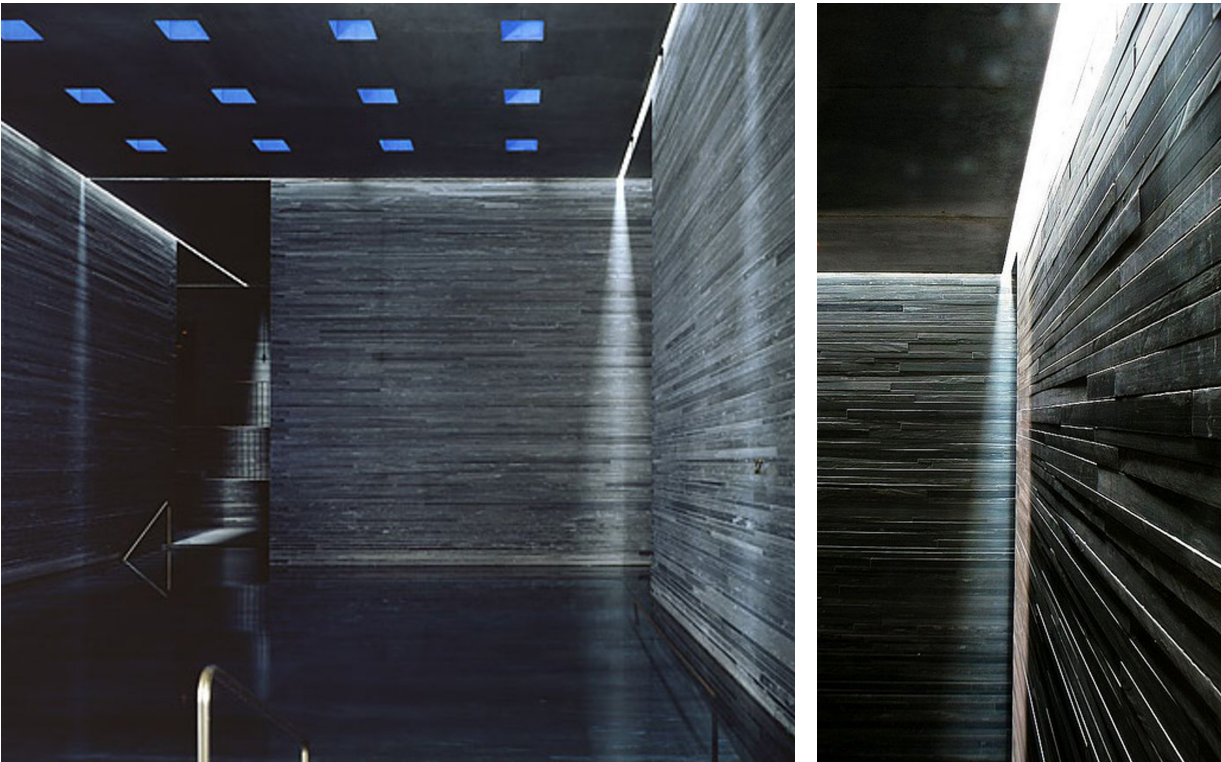
[Figure 179]
Page 205 - Top Left
San Cataldo Cemetery (1971-84) by Aldo Rossi, from where the entrance to #004 - Flamingo Pavilion is derived from.



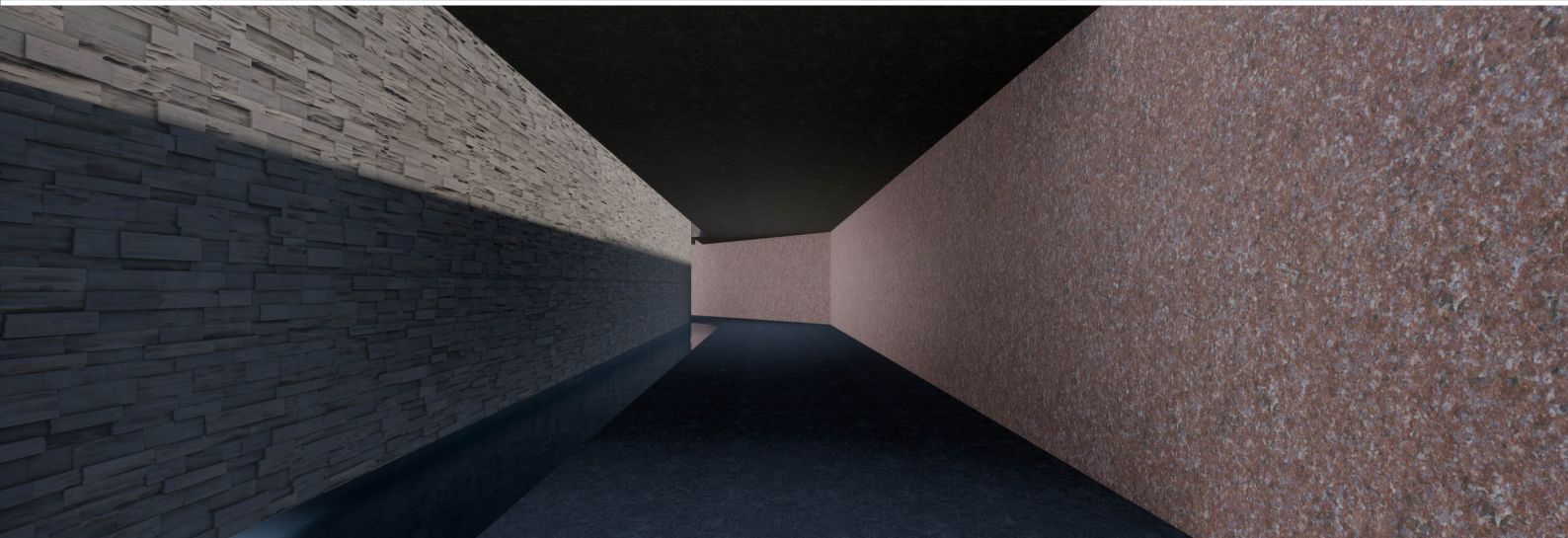
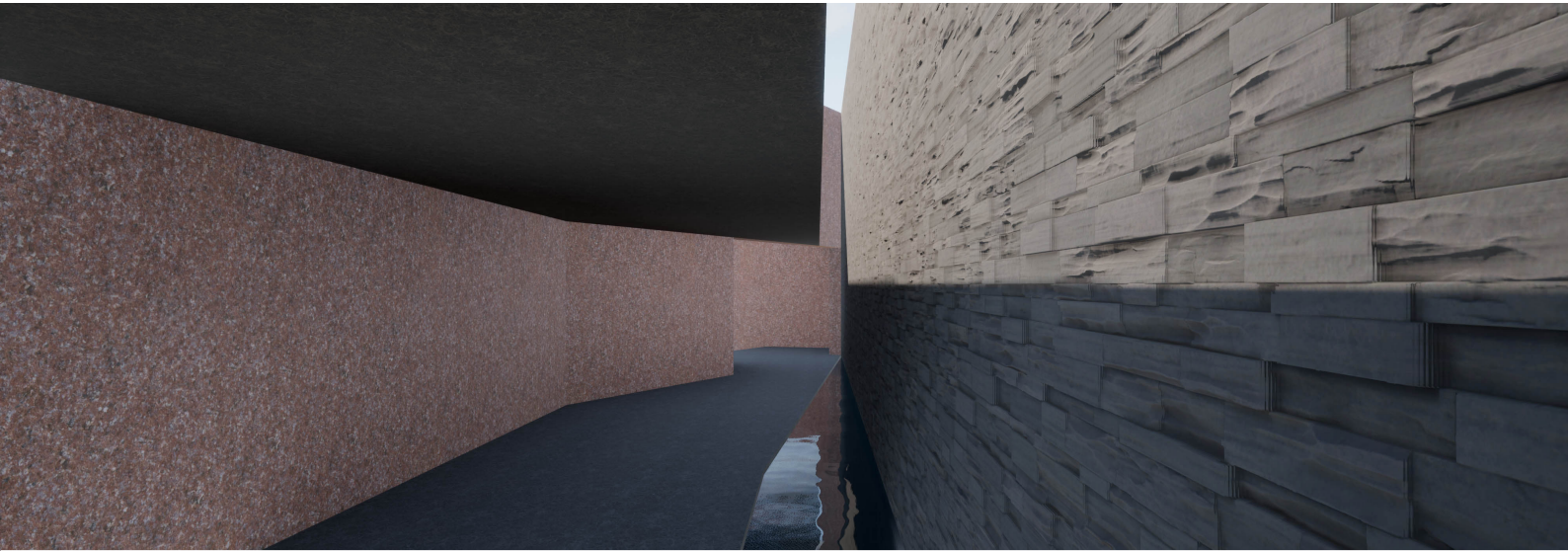
[Figure 180]
Page 205 - Top Right
#004 - Flamingo Pavilion by archi.META exterior renderings.

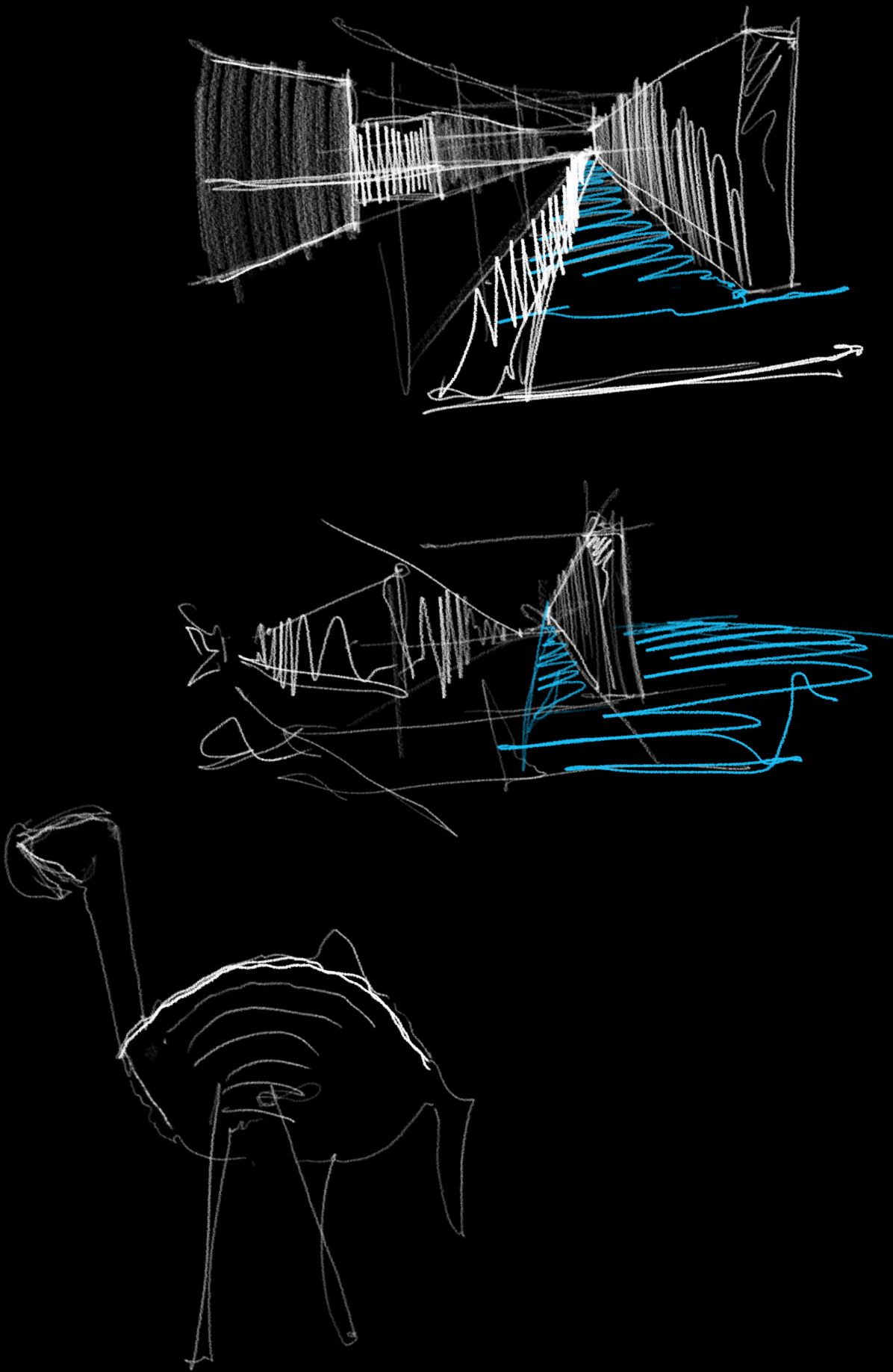


[Figure 181]
Page 205 - Bottom Left
Thermal Baths at 7132, Vals (1996) by Peter Zumthor, materiality and light games influenced the interior dark texturing and slot skylights in its ceilings.



[Figure 182]
Page 205 - Bottom Right
#004 - Flamingo Pavilion by archi.META exterior renderings.

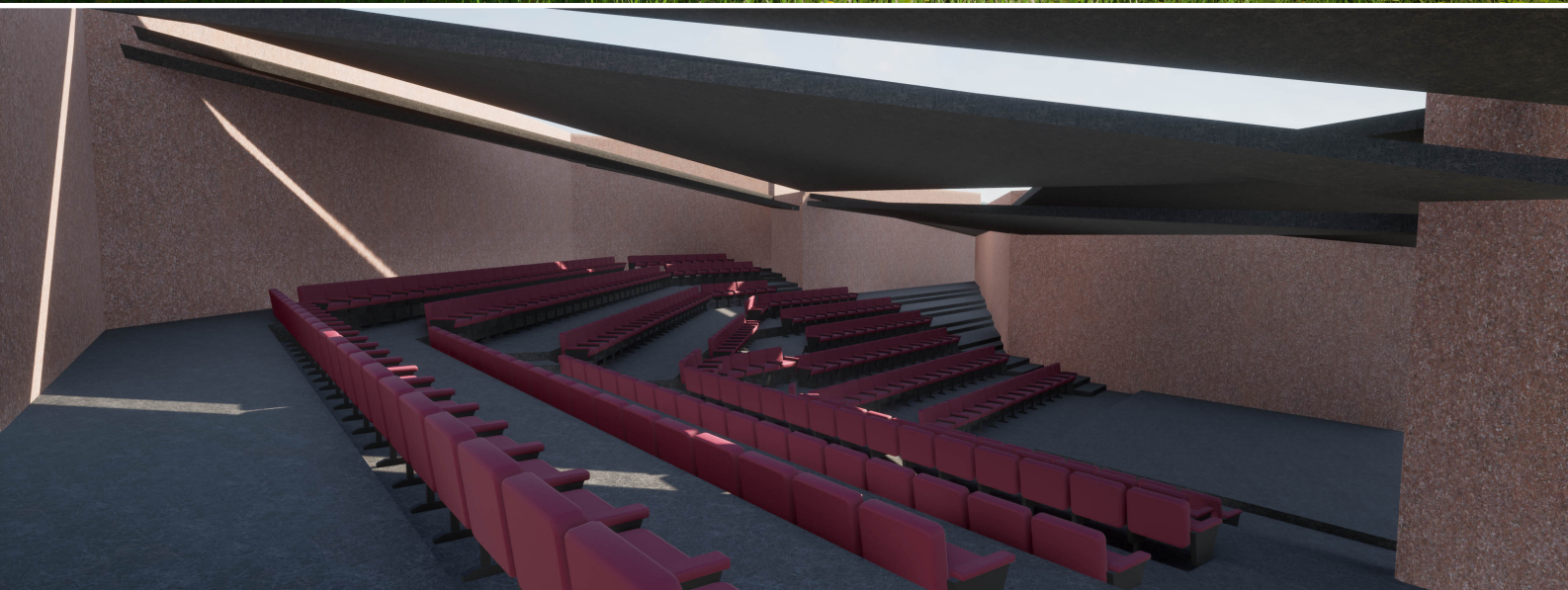




[Figure 183]
#004 - Flamingo
Pavilion by
archi.META initial
hand sketches.

[Figure 184]
Floor Plan of the
#004 - Flamingo
Pavilion by
archi.META.





[Figure 185]
Page 208 - Top
#004 - Flamingo
Pavilion by
archi.META exterior
renderings.

[Figure 186]
Page 208 - Bottom
#004 - Flamingo
Pavilion by
archi.META interior
renderings.

[Figure 187]
Southwest Elevation
of the #004 -
Flamingo Pavilion
by archi.META.

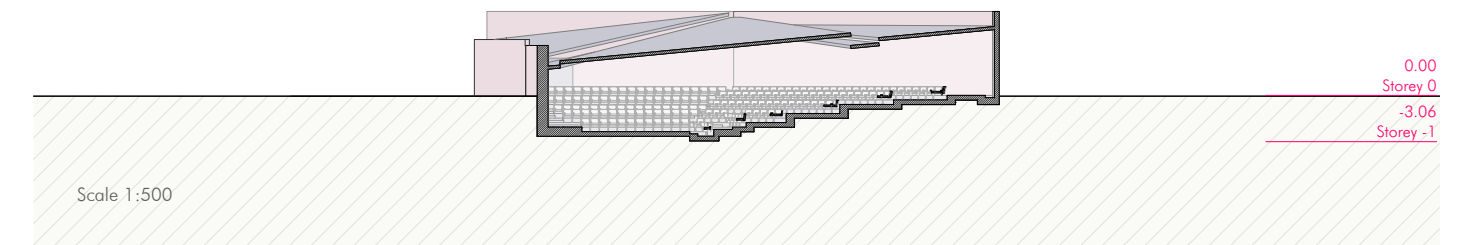
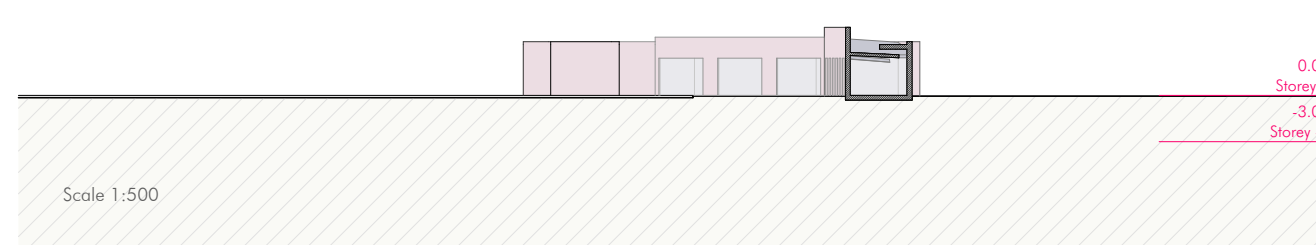
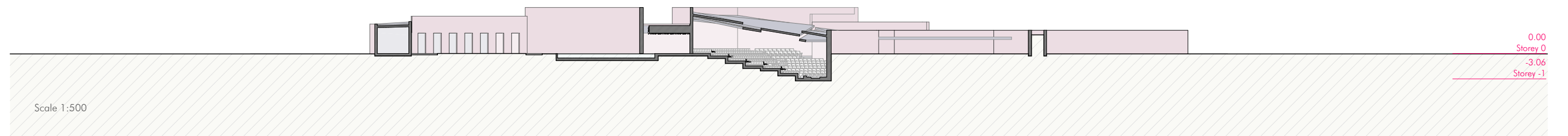
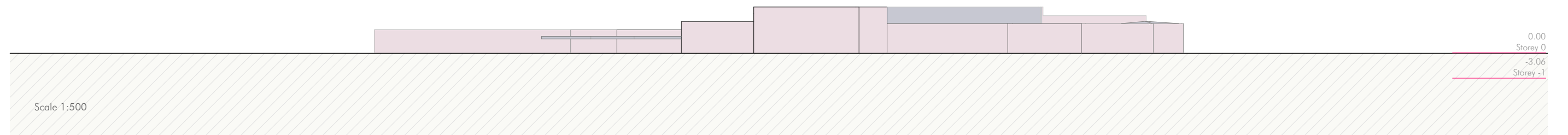
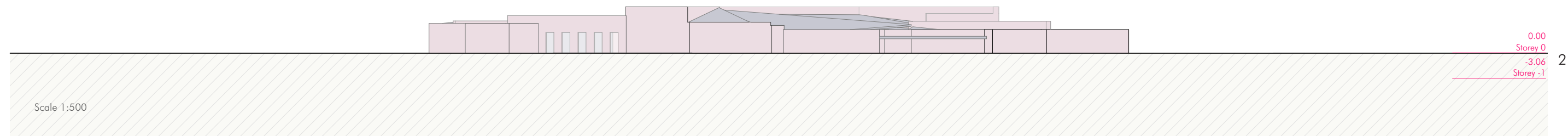
[Figure 188]
East Elevation of the
#004 - Flamingo
Pavilion by
archi.META.

[Figure 189]
Section AA'.

[Figure 190] - Left
Section BB'.

[Figure 191] - Left
Section CC'.

Develop



The writings in this dissertation are a fixed point in time, showcasing everything that is in the past, and pointing towards an unknown future. When the above mentioned projects were being developed, this dissertation’s theme was still about football stadiums. Sometimes it seemed and felt counter-intuitive putting 16 hours of work a day to these projects, whilst dedicating two or three days a week to research and writing a dissertation about a different topic entirely. Eventually it reached a point, with all the learning, projects, contacts and network that I had developed, where it just made sense to switch towards the Metaverse, as working on these projects made me much happier than working in any project class in university.

Superliminal storyline happens in a dream, and the future Metaverses using the technology of tomorrow may feel like a dream in reality; but all the worlds, whether they are real, fictional, fantastical, or virtual are nothing more than a flat projection produced by our brains. No aspect of those worlds has any more “real world depth” than another, and the fake sights are no different from the real ones. A film is nothing more than a collection of photographs played in quick succession to trick our brains into creating an illusion.

Lewis Carroll’s 1865 novel “Alice in Wonderland” tells the story of a girl who falls through a rabbit hole into the land of illogical characters and nonsensical scenarios. It is perhaps foundational to the concept of worlds that break all the rules. Only by embracing irrationality of Wonderland, in accepting that rules are nonsensical and can be broken, that Alice can return home - or more accurately wake up from a dream.

Non-euclidean worlds are a fun gimmick that are possible in virtual environments, but the world of 2023 may seem illogical, breaking all rules and conventions by Lewis Carroll’s standards; and whatever the kind of Internet, and subsequently the Metaverse we end in a few decades time with, it is by embracing its irrationality by exploring its possibilities that, we, as people, will be able to adapt to the world of tomorrow.

[Figure 192]
Scene from the
1910’s silent film
“Alice’s Adventures
in Wonderland”
directed by Edwin S.
Porter.





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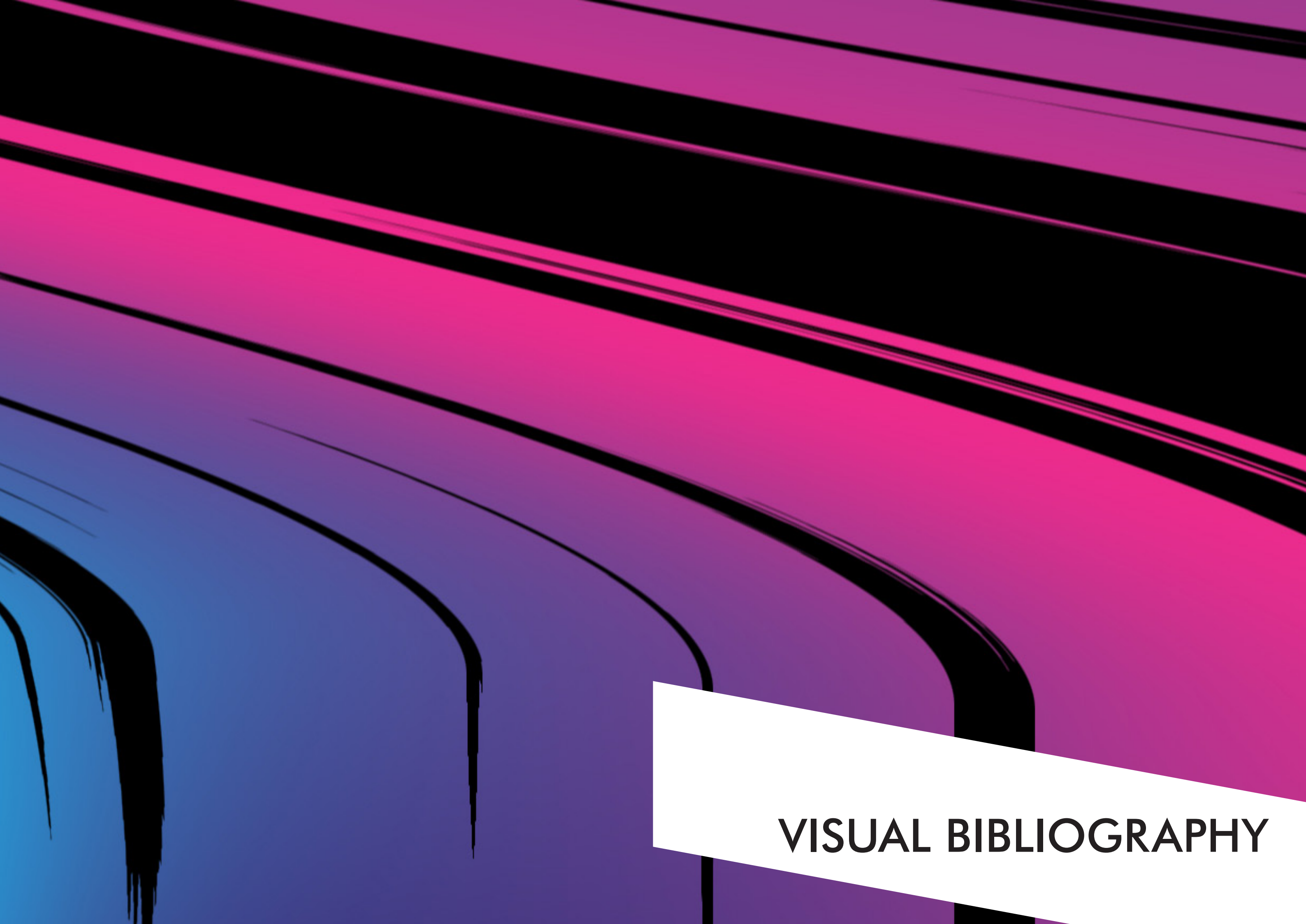
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Upcoming questions and inquiries regarding the work developed in this dissertation or the construction and development of the Metaverse please forward to: genysukhov@gmail.com



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