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Future Proofing Architecture: Intelligent design processes of an AI-Innovation center in Newtown

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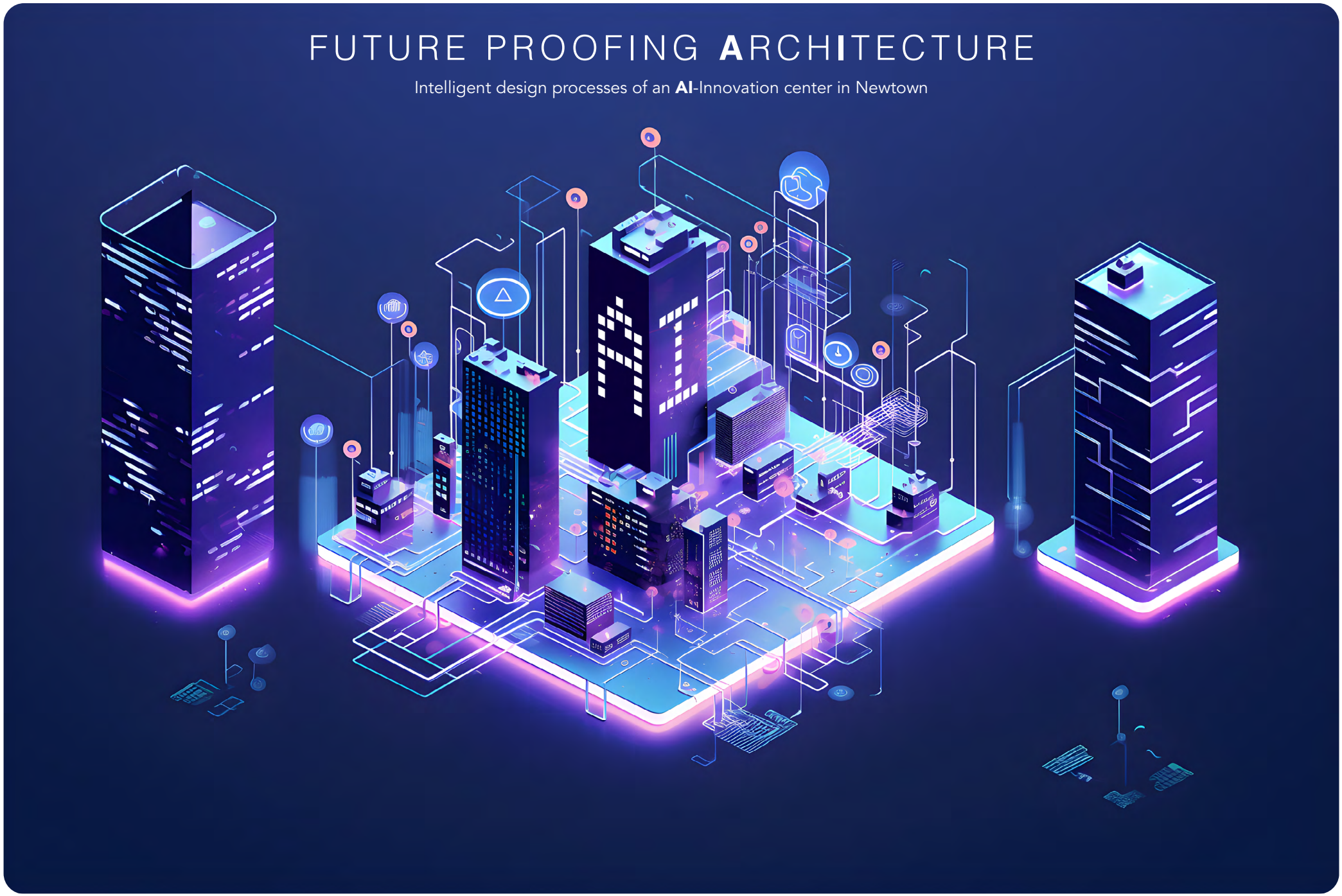
FUTURE PROOFING ARCHITECTURE

Intelligent design processes of an **AI**-Innovation center in Newtown



Liam Wilson - 1711485
M.Arch Prof 2023



A research report submitted to the Faculty of Engineering and the Built Environment, University of the Witwatersrand, in partial fulfilment of the requirements for the degree of Masters in Architecture (Professional).

Liam Wilson, Johannesburg, 2023

Declaration

I, Liam Wilson (1711485) am a student registered for the course ARPL7003 in the year 2023. I hereby declare the following:

I am aware that plagiarism (i.e. the use of someone else's work without permission and/or without acknowledging the original sources) is wrong. I confirm that the work submitted for assessment for the above course is my own unaided work except where I have stated explicitly otherwise. I have followed the required conventions in referencing thoughts, ideas, and visual materials of others. I understand that the University of the Witwatersrand may take disciplinary action against me if there is a belief that this is not my own unaided work or that I have failed to acknowledge the source of the ideas or words in my own work.



Liam Wilson, September 2023

Abstract

In the ever-evolving realm of architecture, tools used by architects and related professionals have transitioned from rudimentary sketches to sophisticated digital simulations. Today, the integration of Artificial Intelligence (AI) stands to redefine this lineage of tools, offering both challenges and opportunities. This thesis delves into AI's transformative potential in architectural design processes specifically within a South African context, exploring its influence from conceptualization to the final design stages. Through a systematic methodology, the research herein investigates and compares the conventional architectural design stages, the current state of AI and its practical applications in architecture.

I have carefully selected a handful of AI-driven software tools that have been instrumental in forging a generative design process. Central to this exploration, is the design of an AI Innovation Centre for Witwatersrand University in Newtown, Johannesburg. This Centre is not just a building but a manifestation of my core argument: that AI, when understood as a tool in the architect's evolving toolkit, can profoundly influence design outcomes in a manner that far outreaches human capabilities.

This study further importantly addresses the ethical implications of AI in architecture, advocating for a collaborative approach that not only complements human expertise, but that illustrates the pitfalls and certain biases inherent to AI. Through this comprehensive exploration, this thesis underscores the need for architectural spaces to evolve in response to AI-driven operational changes, while ensuring designs remain rooted in human-centric principles.



Fig 1.1: *AI image generated, prompt "a world where architects use Artificial Intelligence" from Author, (Midjourney, 2023)*

List of terms

1. **Augmented Age** means a new chapter in human history wherein what humans are naturally capable of are augmented by computational systems and the integration of advanced augmented reality, virtual reality, into various aspects of daily life. These computational systems will help humans think and to create a digital nervous system that connect humans to the world far beyond our natural senses (Conti, 2016).

2. **Artificial Intelligence** means the simulation or collection of human intelligence in machines that are programmed to mimic cognitive functions such as learning, problem-solving, reasoning, and decision-making. AI encompasses, inter alia, machine learning, natural language processing, computer vision, and robotics (Norvig, 2016).

3. **Augmented Reality** means a technology is the integration of digital information with the user's environment in real time (Gillis, 2022).

4. **Computer-aided Design (CAD)** means a technology that utilizes computer systems to assist in the creation, modification, analysis, or optimization of designs, typically in the fields of engineering, architecture, and product design. CAD software allows designers and engineers to create precise and detailed representations of objects or systems in a digital format (Chua, 2014).

5. **Digital Age** means the period in human history characterized by the widespread use and integration of digital technologies, particularly computers and the internet, in various aspects of daily life, communication, and industry. It is an era marked by the digitization of information, the prevalence of digital devices, and the interconnectedness of global communication networks (Tapscott, 1997).

6. **Disruption** means the alteration or disturbance of normal practices.

7. **Disruptive Technology** means product that displaces existing technology and alters old practices, for future needs.

8. **Generative Design** means iterative design process, that uses algorithms and data input to explore permutations of a solution, quickly generating design alternatives (Wikipedia, 2024).

9. **Singularity means** the point in time in which ordinary human intelligence is extended or even taken over by AI (Wikipedia, 2023).

10. **Technological Innovations** means a new invention or the enhancement of a product derived from research developments, technical advancements and knowledge (Fayomi, 2019).

11. **Parametricsm** means a design approach in architecture characterized by the use of parametric modeling techniques. It involves the application of parameters and algorithms to generate and manipulate complex, variable forms in architectural design.

12. **ChatGPT** means a language model developed by OpenAI, based on the GPT (Generative Pre-trained Transformer) architecture. It is designed for natural language understanding and generation, allowing it to engage in conversation, answer questions, and generate human-like text based on the input it receives. ChatGPT has been trained on diverse internet text and is capable of understanding and producing coherent and contextually relevant responses in a conversational setting.

13. **Text to image machine learning** means a field in artificial intelligence where models are trained to generate visual content, such as images, based on textual descriptions. This involves converting natural language descriptions into corresponding visual representations. One notable example is the DALL-E model developed by OpenAI.

14. **Turing Test** means a test for intelligence in a computer, requiring that a human being should be unable to distinguish the machine from another human being by using the replies to questions put to both.

15. **Deep learning** means a subfield of machine learning that involves the use of artificial neural networks with multiple layers (deep neural networks) to model and analyze complex patterns in data. These networks, often referred to as deep neural networks or simply deep networks, are

capable of automatically learning hierarchical representations of data through the composition of multiple layers. Deep learning has shown remarkable success in various applications, including image and speech recognition, natural language processing, and decision-making tasks.

16. **Machine learning** means a subfield of artificial intelligence (AI) that focuses on the development of algorithms and models that enable computer systems to learn from and make predictions or decisions based on data. Rather than being explicitly programmed, machine learning systems use statistical techniques to improve their performance on a specific task over time as they are exposed to more data. ML encompasses a variety of approaches, including supervised learning, unsupervised learning, and reinforcement learning.

17. **Modularity** - the use of individually distinct functional units, as in assembling an electronic or mechanical system. (https://www.dictionary.com/browse/modularity#:~:text=noun,an%20electronic%20or%20mechanical%20system.)

18. **GANs (Generative Adversarial Networks)** means a type of artificial intelligence model where two neural networks, the generator and the discriminator, compete against each other. The generator creates data, and the discriminator evaluates it. This dynamic helps the model improve over time, generating realistic content such as images or text.

19. **Control Net** means a neural network that regulates or manages certain aspects within a larger system. It's like the supervisor, overseeing and influencing the behavior of other networks or components.

20. **Discriminator** means In the context of a GAN, the discriminator is like an art critic. It evaluates images produced by the generator, distinguishing between real and fake images. Its job is to guide the generator in creating more realistic content.

21. **Training Set** means a collection of examples (images in this case) used to teach an AI model, like a GAN, to recognize patterns. It's like a teacher showing a student various images to help them learn and improve their ability to generate realistic content.

22. **Fake Image** means a picture created by an AI model, like a GAN, rather than captured by a camera. The generator produces these images, aiming to make them indistinguishable from real ones.

23. **Random Noise** means unpredictable, chaotic data. In the context of GANs, adding random noise to the input can make generated content more diverse and less predictable.

24. **Prompt** means a specific instruction or input given to an AI model to generate desired output, such as text or images.

25. **Parameters (in the context of generative AI)** means the internal settings or configurations within a generative AI model that influence how it generates output. Adjusting these parameters can alter the characteristics of the generated content.

26. **Computational Algorithm** means a step-by-step procedure or set of rules designed to be executed by a computer to solve a specific problem or perform a task.

27. **Fusion 360** means a cloud-based 3D computer-aided design (CAD) tool developed by Autodesk.

28. **Feedback Loop** means a process where the output of a system is fed back into the system, influencing future outputs. It's a way for a system to learn and adapt based on its own performance.

29. **Bot** means a computer program that performs automated tasks. Bots can be designed for various purposes, from simple repetitive actions to more complex interactions.

30. **DALL-E** means an AI model developed by OpenAI that can generate creative and diverse images from textual descriptions.

31. **Preprocessor** means a program or tool that prepares data for further processing by cleaning, transforming, or organizing it in a specific way before it's fed into a larger system.

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Fig 1.1: *AI image generated, prompt "a world where architects use Artificial Intelligence" from Author, (Midjourney, 2023)*

01

INTRODUCTION

SETTING THE STAGE FOR AI IN ARCHITECTURE

"Understanding how art can become a part of technology, while technology becomes art." - *Roman Kuchukov*

In the modern era, where technological advancements are reshaping industries and redefining boundaries, Artificial Intelligence (AI) stands out as a beacon of transformative potential. From healthcare to finance, AI's influence is pervasive, promising unprecedented efficiencies and novel solutions to age-old challenges. Among the many sectors experiencing this wave of AI-driven transformation, architecture holds a unique position. The confluence of design, creativity, and technology in architecture offers a fertile ground for AI to sow its seeds of innovation.

Historically, the tools of the architect have evolved, mirroring the technological advancements of their times. From the rudimentary sketches on rocks to intricate blueprints, from physical scale models to sophisticated 3D digital renderings, each tool has expanded the architect's ability to visualize, innovate, and create. These tools, while diverse in nature, have always been extensions of the architect's vision, aiding in translating imagination into tangible structures. Today, as we stand on the cusp of an AI revolution, it's imperative for architects to recognize AI not as a replacement but as the next powerful tool in their arsenal. A tool that, when understood and wielded effectively, can lead to unprecedented design outcomes.

The intricate dance between aesthetics and functionality, between form and purpose, has been the cornerstone of architectural endeavours. However, as the world around us becomes increasingly complex, so do the challenges faced by architects. Urban spaces are growing denser, environmental concerns are becoming more pressing, and the expectations of communities are evolving rapidly. In this dynamic landscape, the traditional tools and methodologies of architecture often fall short. Reflecting and analysing what tools architects have at their disposal should become common practice.

Enter AI, with its promise of data-driven insights, automation, and optimization. The potential of AI to revolutionize architectural design processes, from the initial generation of concepts to the final optimization of designs, is profound. It offers tools that can analyse vast datasets, simulate countless design variations, and even predict the future needs of urban spaces. Yet, despite its evident potential, the full impact of AI in architecture remains underexplored and often misinterpreted. This exploration is grounded in the design and conceptualization of the AI Innovation Centre, a space envisioned to not only promote AI's advancements but also to serve as a testament to the symbiotic relationship between AI and architectural design. This thesis seeks to bridge this knowledge gap, delving deep into the intersection of AI and architecture. It aims to reveal AI's role in contemporary design methods, shedding light on both its transformative potential and the challenges it presents.

1.1 Personal Reflection on the Research Journey

Embarking on this thesis was similar to setting sail on uncharted waters. The vast expanse of AI, with its ever-evolving landscape, presented both exhilaration and anxiety. Every day, I was introduced to new tools, software, and concepts, each promising to revolutionize the architectural domain. The sheer volume of information was overwhelming, and discerning which avenues to pursue became a challenge in itself.

The scarcity of existing research on my chosen topic was both a benefit and a pain. On one hand, it offered the thrill of discovery, of treading paths few had ventured before. On the other, the absence of established guidelines or references often left me feeling adrift, relying solely on my intuition and the insights I gathered along the way and from those around me.

This initial phase of my journey was marked by trial and error. I dabbled in various AI experiments, each teaching me something new. While not all these explorations had meaningful outcomes, they were instrumental in shaping my perspective and refining my research direction. As I wrap up this phase and gear up for the next, I'm filled with a sense of anticipation, eager to delve deeper into the symbiotic relationship between AI and architecture.

1.2 Understanding Artificial Intelligence in Architectural Design

As we venture into the realm of integrating Artificial Intelligence with architectural design, it's paramount to grasp the foundational principles of how AI operates. My conclusions on this topic have been shaped by extensive explorations and research conducted up to this point, details of which will be elaborated upon later in this research.

AI's outcomes are heavily reliant on the quality and relevance of the input data provided. To visualize this, consider the following scenarios:

1. Basic Input, Basic Output:

- Description: When AI is provided with minimal input data without clear objectives and goals, the result is elementary. It may not address specific architectural needs or nuances.
- Implication: For architectural designs, this could mean generic structures that lack innovation or specificity to the project's requirements.

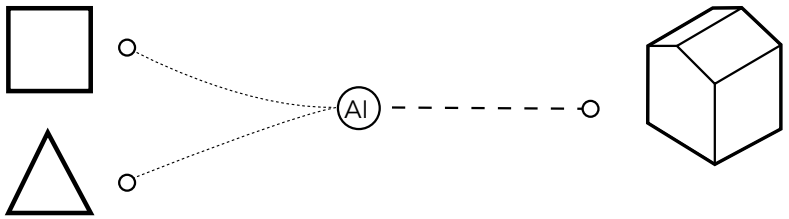

Fig 1.2: *AI Basic Input, Basic Output (Author, 2023)*

2. Random Input, Random Output:

- Description: If the input data is random, lacking coherence or relevance, the AI's outcome will mirror this randomness. Such results are often weak and may not serve any meaningful architectural purpose.

- Implication: This underscores the importance of providing AI with meaningful data. Random or irrelevant inputs can lead to wasted resources and designs that are neither functional nor aesthetically pleasing.

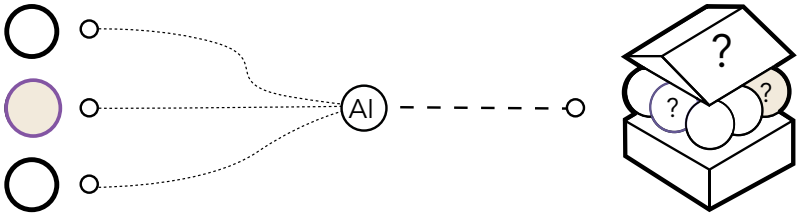

Fig 1.3: *AI Random Input, Random Output (Author, 2023)*

3. Informed Input, Optimal Output:

- Description: With a comprehensive understanding of AI systems and clear objectives in mind, architects can manipulate AI to yield the best possible results. The outcome is a direct reflection of the AI's capabilities and the quality of information provided.
- Implication: This approach leads to designs that are not only innovative but also aligned with the project's goals, ensuring both functionality and aesthetics.

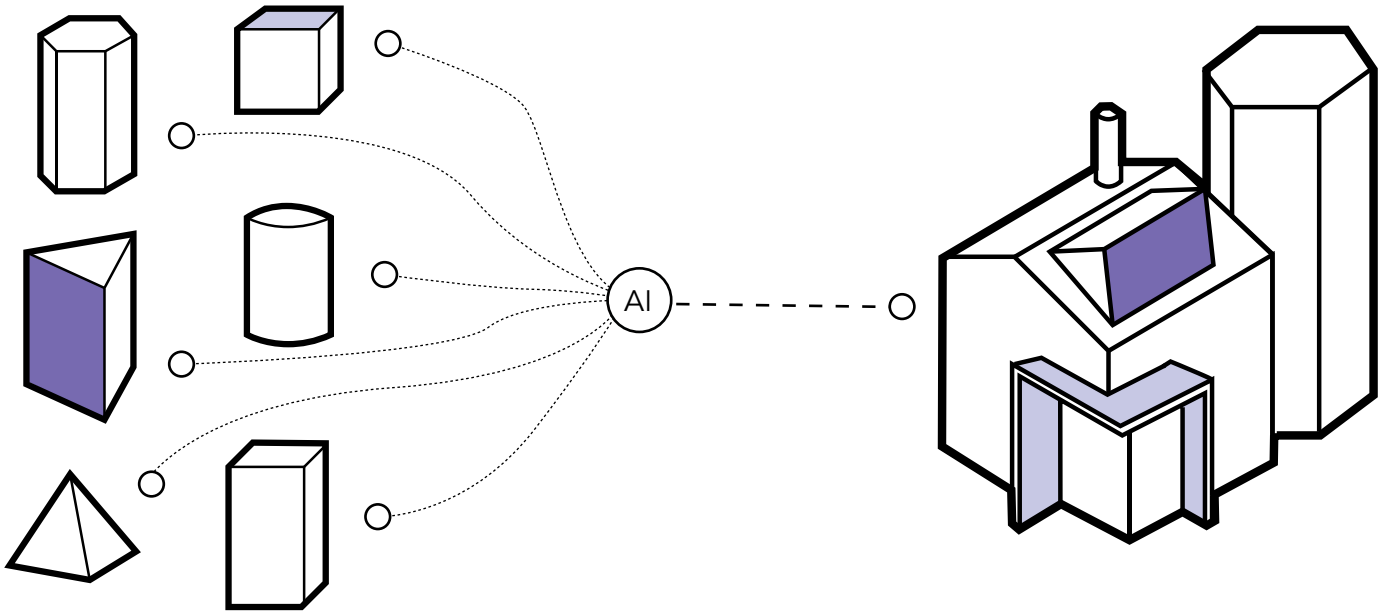

Fig 1.4: *AI Informed Input, Optimal Output (Author, 2023)*

1.3 Research Journey and the Significance of the AI Innovation Centre:

The architectural realm stands at the threshold of a transformative era, with Artificial Intelligence (AI) poised to redefine its trajectory. This research, structured as a journey, delves deep into the intricate relationship between AI and architecture, aiming to bridge the existing knowledge gap. The focus is on understanding the advancements in AI and how they can complement the traditional architectural processes, especially addressing the skill set gap among professionals.

Significance of the AI Innovation Centre:
The AI Innovation Centre in Newtown serves as the connection of this exploration. Beyond its physical structure, the Centre embodies the thesis's central proposition: that as architectural tools have evolved over time, AI represents the latest, and perhaps most transformative, addition to this lineage. The Centre is envisioned as a beacon of technological integration in design, a space where the potential of AI as a tool in architectural design is both showcased and realized.

Throughout the research journey, the Centre has been more than a case study; it has been the definite manifestation of the research's findings. As cities like Johannesburg evolve, there's an urgent need to address the many challenges they face, from housing shortages to environmental concerns. AI, with its ability to analyse complex systems and generate innovative solutions, could be a game-changer in this context. However, for this potential to be realized, a comprehensive understanding of AI's capabilities and limitations is essential. The AI Innovation Centre stands as a testament to this understanding, a space where the symbiotic relationship between AI and architecture is brought to life.

By intertwining the AI Innovation Centre into the research journey and clearly defining the structured stages, this study provides theoretical insights along with a practical blueprint showcasing seamless integration of AI in architectural designs. By creating structures that are both aesthetically pleasing and technologically advanced, this approach embodies the future of architecture.

The Journey:
Foundational Exploration (February to April):

- Introduction to the research's objectives and hypothesis.
- Comprehensive exploration of available AI technologies and their relevance to architecture.
- Identification and access to AI software aligning with architectural needs.
- This stage laid the groundwork, ensuring a robust understanding of AI's role and potential in architecture.

AI Tool Mastery (May to June):

- In-depth exploration of selected AI tools, grasping their intricacies and functionalities.
- Mastery of the basics of generative design and principles of GANs.
- Comparative analysis of AI tools and traditional architectural processes to discern synergies.
- This phase was pivotal in equipping me with the technical expertise required for the subsequent design phase.

Design Exploration (July to date):

- Application of AI tools to the conceptualization of the AI Innovation Centre in Newtown, a central piece in this research journey.
- Exploration and iteration of various design options using AI, culminating in the selection of an optimal design structure.
- Refinement of the chosen design, leveraging AI-generated data to align with research objectives.

Finalization and Reflection:

- Synthesis of the research findings into the final design proposal.
- Critical analysis of the feasibility and practicality of the AI-informed design.
- A reflective look back at the journey, emphasizing the symbiotic relationship between theoretical exploration and practical application.

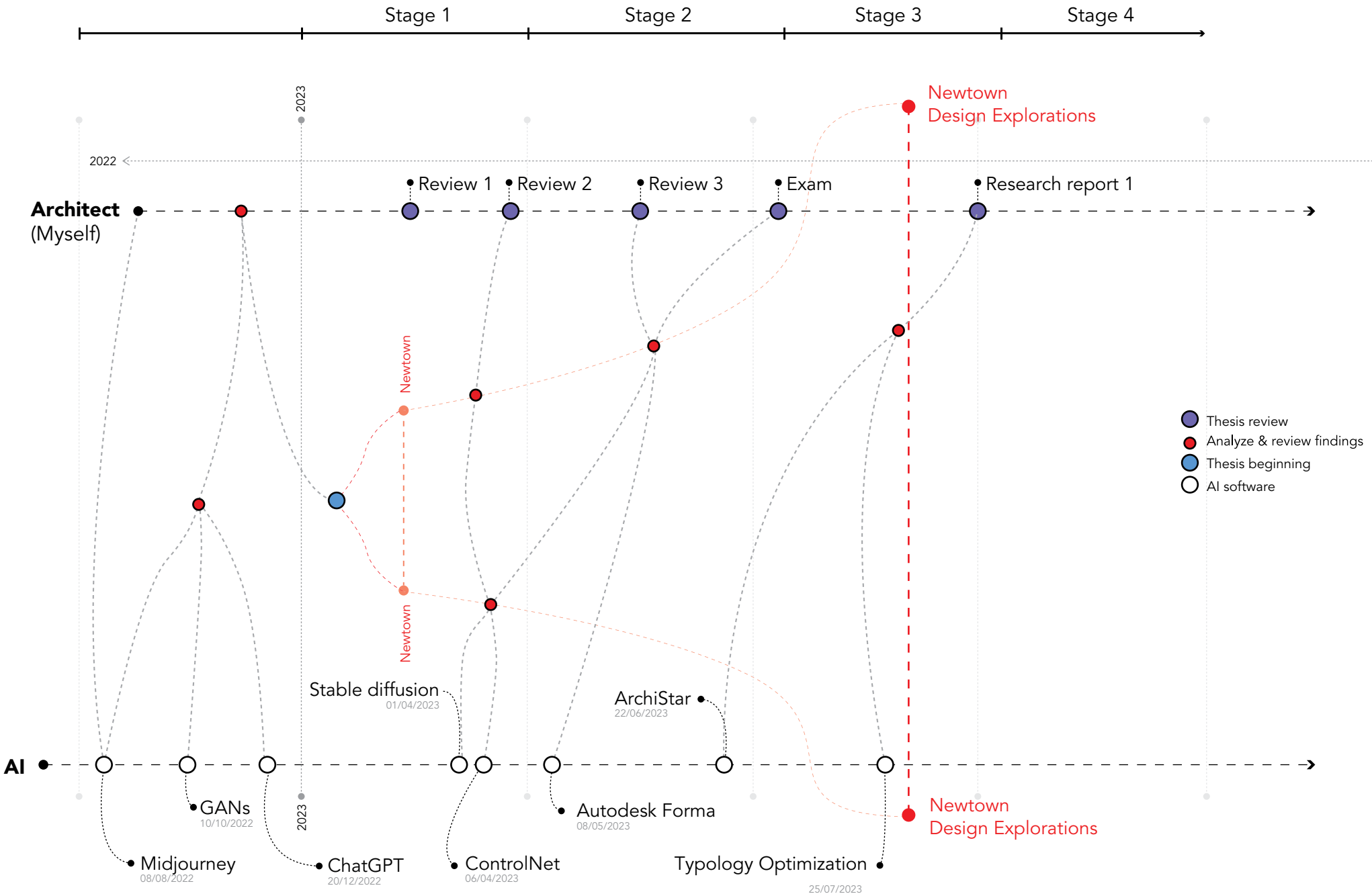

Fig 1.5: *Timeline of thesis structure and research (Author, 2023)*



Fig 2.1: *AI image generated, prompt "AI & ARCHITECTURE An Evolving Symbiosis" from Author, (Midjourney, 2023)*

02

AI & ARCHITECTURE

AN EVOLVING SYMBIOSIS

"Today, the scale of the largest AI computations is doubling every six months, far outpacing ***Moore's law****. At the same time, advanced generative AI and large language models are capturing the imaginations of people around the world"- Google CEO Sundar Pichai*

2.1 Moores Law and Singularity

A principle that was observed by Gordon Moore in the 60s noticed that the speed of change in technology was exponential. This law states that the speed of computers, as measured by the number of transistors that can be placed on a single chip, will double every year or two (Mollick, 2006). The exponential increase in computing power predicted by Moore's Law has been a key driver in the development and advancement of AI technologies. As computing power has increased, so has the complexity and capabilities of AI systems.

The concept of singularity in AI refers to a hypothetical future point in time when artificial intelligence will surpass human intelligence, leading to an unprecedented and unpredictable technological growth. The continuous doubling of computing power as per Moore's Law is often cited as a factor that could lead to this singularity.

Ray Kurzweil, in his book "The Singularity Is Near", argues that due to Moore's Law, the rapid advancement of technology will lead to a point of singularity within the 21st century. He suggests that as technology progresses, it will lead to machines that are smarter than human beings, resulting in a merger of human and machine intelligence. (Kurzweil, 2005)

Ray Kurzweil, the renowned futurist and Director of Engineering at Google, is known for his accurate predictions. Out of his 147 predictions since the 1990s, Kurzweil claims an impressive 86 percent accuracy rate. (Reedy, 2017)

In a statement to Futurism in 2017, Kurzweil elaborated on his prediction. He mentioned that he consistently foresees 2029 as the year when artificial intelligence (AI) will surpass the Turing test and attain intelligence equivalent to that of humans. Furthermore, he has set the year 2045 as the estimated time for the Singularity (Reedy, 2017). The Singularity represents a phase where our intelligence will expand exponentially, multiplying our capabilities a billion-fold by merging with the intelligence we have created.

Yet in another article, according to Darren Orf's titled "Humanity May Reach Singularity Within Just 7 Years, Trend Shows," it is suggested that the singularity, as predicted by Ray Kurzweil, might be even closer than initially anticipated.(Orf, 2023)

We could be approaching singularity sooner than we thought or imagined. This can be seen in recent events over the last couple of months in AI. Looking at some examples such as Stable diffusion, ChatGPT, Googles Bard and many more.

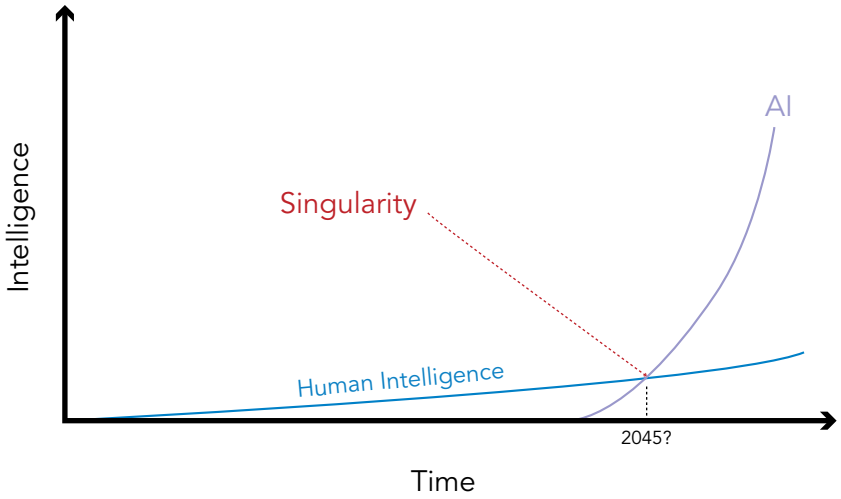

Fig 2.2: *Graph showing where and when singularity will occur (Author, 2023)*

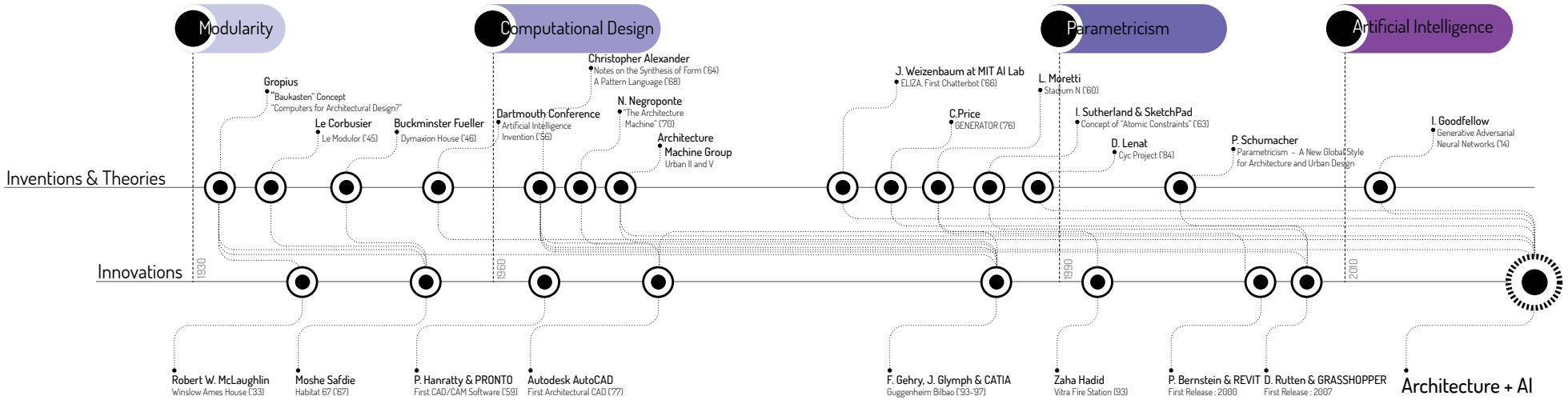

Fig 2.3: *Timeline showing the advent of AI in architecture (Chaillou,2019)*

2.2 The Evolution of AI in Architecture

In the ever-evolving world of architecture, every significant advancement has been marked by architects re-evaluating and adapting to their tools. From the earliest days of drafting on parchment to the digital age of today, the tools of the trade have always been integral to the architectural process. As we delve into the transformative journey of AI's integration into architecture, it's crucial to remember that each stage we explore represents a pivotal moment when architects had to reconsider their toolkit. This chapter traces the historical progression of tools and methodologies, emphasizing the symbiotic relationship between architects and their instruments. By understanding this relationship, we can better appreciate the current juncture where AI stands poised to redefine architectural paradigms. As we navigate through the stages of 'Modularity', 'Computational Design', 'Parametricism', and 'Artificial Intelligence', we'll witness the continuous dance of adaptation and innovation, underscoring the architect's timeless quest for mastery over their tools.

Modularity

'Modularity' can be likened to the earliest tools of architecture – the foundational building blocks. A classic example of this concept in architectural history is Le Corbusier's Modulor. Devised as a system of proportions based on the human figure and the golden ratio, the Modulor aimed to provide a standardized system for design, ensuring harmony and human-scale in buildings.

Just as architects once relied on simple tools like the compass and straightedge to create designs, modularity uses basic modules to construct diverse structures. The concept of modular design, akin to using a piece of Lego, is reminiscent of these foundational tools, emphasizing repetition and standardization. The piece of Lego represents what is called a 'module' in modular design which is used over and over again to create the whole structure. Practical examples of modules could be rooms which are designed to consistently fit together in a precise manner.

This concept of modular design was utilised famously by Walter Gropius who formed a part of Bauhaus school of design in Germany. "Baukasten" is what Gropius coined the term for the notion that a standard module (i.e. Lego) was capable of being used to create many different structures and buildings. The result of using Modularity is simplification of the design and construction phase. The benefits thereof include cost-effectiveness and efficiency that also allows for flexibility and the ability to customize the design.

In modern times, similarities can be drawn between Modularity and what is now known as generative design. I have explored this concept at length herein and find it impossible to ignore that generative design is simply a more technically advanced mechanism and tool to achieve modular design through AI. It is therefore clear that AI is simply a tool to advance techniques that architects have been exposed to for almost a century. My thought is that by highlighting parallels such as this between AI and common architectural principals, it will start to dispel the fear or intimidation which may be associated with AI tools.

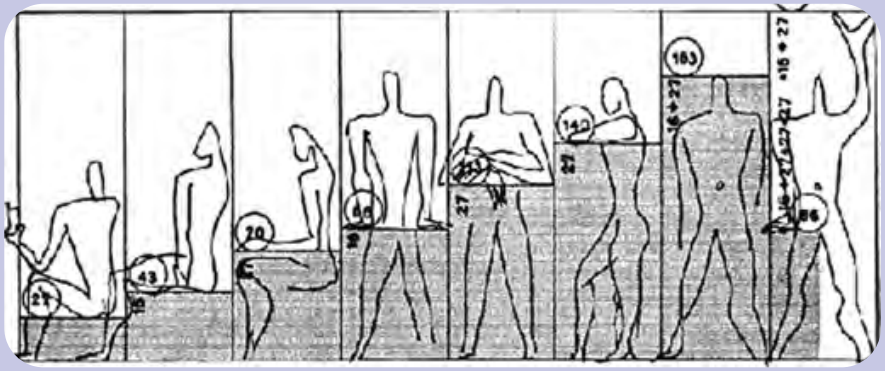

Fig 2.4: *Corbusiers Modular*

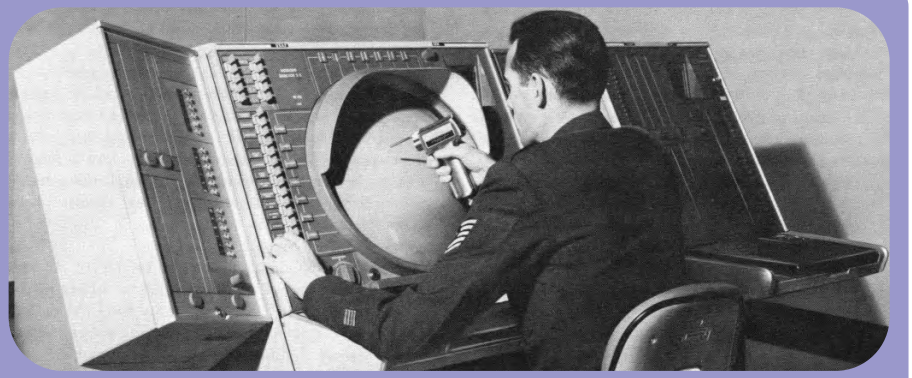

Fig 2.5: *A SAGE operator at a Situation Display Console, holding a light gun (IBM)*

Computational Design

Stanislas Chillou names the second evolution phase 'Computational Design'. This naturally came about due to the advancement in technology and the increased access to machines and computers. The increasing ability to make use of data storage capacities as well as the affordability of machines, which became accessible to most, is what drove this phase. Just as an architect once transitioned from chisel and stone to pen and paper, the move to digital design tools marked a significant shift in the tools architects used. Hand drawn sketches were, and arguably for some still are, the reality for many architects. This was revolutionized by 3D design software. The design process is improved through the use of such software as it facilitates more design iterations. However, Computational Design does not exist without its downfalls, including the requirement for architects to learn and develop specialized skills. This era altered architecture permanently in that computers are now used as an aid to create designs and to manipulate them. Beyond the typical 3D design software, the opportunity presented by computational design allows computers to generate types of a design and to solve complex issues in a design, thereby increasing the quality of design in architecture and improving efficiency.

Parametricism

'Parametricism' can be seen as an evolution in the tools architects use, branching off from Computational Design to address its complexities and shortcomings. Just as architects once transitioned from using rudimentary tools like the compass to more advanced ones like drafting machines, the rise of parametric design represents a similar leap in design capabilities.

Parametricism is an architectural style that harnesses algorithms and mathematical formulas. At its core, it allows architects to adjust certain parameters or variables, changing the design outcome. This is akin to adjusting settings on a smartphone or computer; altering one parameter can change the entire result. However, in architecture, this involves more intricate complexities, requiring both technological and mathematical expertise. For instance, architects can modify parameters like size, angle, orientation, and shape to influence the design. These manipulations are executed through intricate algorithms.

A prime example of the power of these advanced tools is the Beijing National Stadium, commonly known as the "Bird's Nest". Designed by Herzog & de Meuron and artist Ai Weiwei, this iconic structure showcases the capabilities of parametric design. Its façade, a complex interplay of steel beams creating a bird's nest pattern, was optimized using parametric design software. This tool allowed the architects to explore various design options efficiently, ultimately achieving a design that was both innovative and structurally sound. Just as the Bird's Nest stands as a testament to the capabilities of modern design tools, it's a reminder of the continuous evolution of tools in architecture.

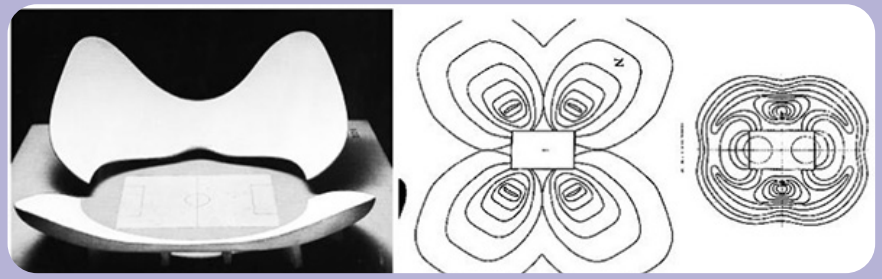

Fig 2.6: *A model of stadium N. Exhibited at the 1960 Parametric Architecture exhibition (Moretti, 1960)*

Artificial Intelligence

Just as architects once embraced the concept of modularity, using foundational building blocks to create diverse structures, the field now stands on the cusp of another transformative tool: Artificial Intelligence (AI). Traditional parametric methods are left behind as AI introduces a statistical approach to architectural design. Machine learning, forming the basis for AI, allows computer systems to develop an "intuition" aimed at solving intricate problems. This method, rooted in the logical processes of the human mind, enables robots to extract intermediate parameters from existing data. Emulating learned information's statistical distribution,

The historical potential of AI in architecture was realized by pioneers like John McCarthy and Nicholas Negroponte. In the case of Negroponte's URBAN V and Cedric Price's GENERATOR, we see early examples of AI integrated into architectural design, albeit limited by the simplicity of their algorithms.

The 1980s saw a resurgence in AI interest, driven by increased computational power and funding. This era birthed inference engines and expert systems, which could reason based on rules or deduce new truths from a knowledge base. The introduction of Generative Adversarial Neural Networks (GANs) by Ian Goodfellow and his colleagues in June 2014 marked a significant breakthrough. Goodfellow's conceptualization of GANs shifted AI from analysis to generation, positioning it as a potent tool for architects. GANs will be explored and explained in depth in chapter 5. Just as architects have historically adapted to new tools and methods, from the compass and straightedge to modularity, the integration of AI into architectural software presents both an opportunity and a challenge. The goal remains the same: to harness these tools reliably and efficiently, ensuring that designs are both innovative and human-centric.

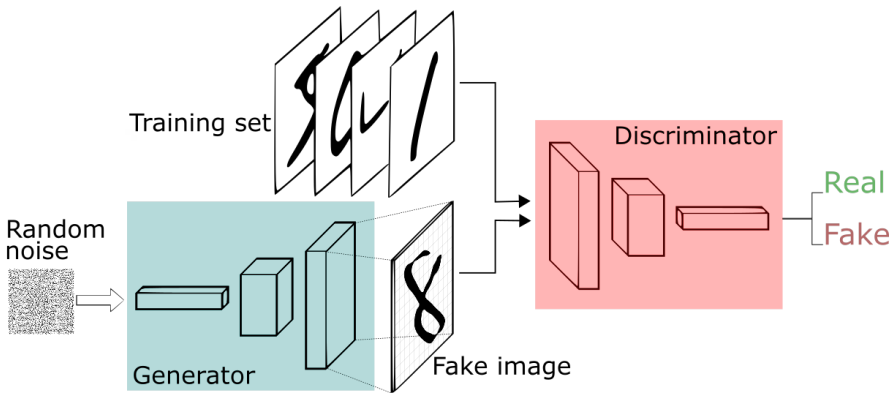

Fig 2.7: *GANs typical model (Silva, 2017)*

Think of GANs as an art forger (generator) trying to create a perfect replica of a famous painting. There's also an art detective (discriminator) trying to spot which one is fake. As the forger keeps improving, the detective gets better at spotting fakes, pushing the forger to get even better. In the end, the forger becomes so skilled that their paintings are almost indistinguishable from the real ones.

Conclusion:

The journey of architecture, as traced through its evolving tools and methodologies, is a testament to the profession's adaptability and resilience. From the simplicity of modularity to the complexities of AI, architects have consistently embraced change, integrating new tools to enhance their craft. The progression from Moore's Law to the advent of singularity underscores the rapid technological advancements that have shaped the architectural landscape. As we reflect on the evolution from modularity to AI, it becomes evident that these tools, while transformative, are merely instruments in the hands of architects. They serve to amplify the architect's vision, creativity, and expertise.

The integration of AI into architecture is not a disruption but a continuation of this age-old tradition of adaptation. Just as modularity, computational design, and parametricism were once novel concepts that became integral to architectural practice, AI too will find its place as an essential tool in the architect's toolkit. The challenge for contemporary architects lies not in mastering this new tool but in understanding its potential and limitations. By doing so, architects can harness AI's capabilities to create designs that are not only innovative but also deeply human-centric, ensuring that the built environment continues to resonate with the people it serves.

As we move forward, it's crucial to remember that while tools and technologies will continue to evolve, the essence of architecture – the creation of spaces that enhance human experience – remains constant. In this ever-changing landscape, architects are not just passive observers but active participants, shaping the future of design through their choices, innovations, and vision.

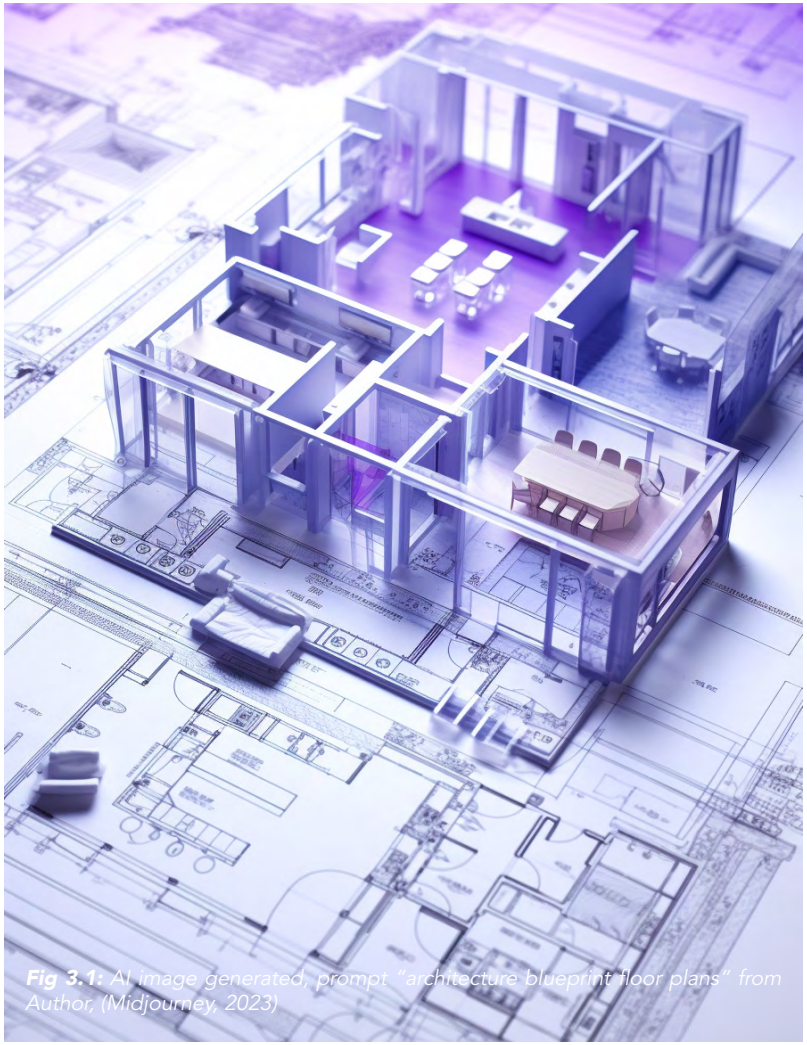

Fig 3.1: *AI image generated, prompt "architecture blueprint floor plans" from Author, (Midjourney, 2023)*

03

RESEARCH METHODOLOGIES

THE BLUEPRINT

Reframing the Research Question:
Building upon the initial research question, "How can AI influence and enhance architectural design processes?", the research has evolved to address more nuanced aspects of AI's integration into architectural design, particularly in the context of Newtown's AI Innovation Centre.

3.1 Framing the research question

Updated Research Questions:
How can AI tools, as explored in the subsequent chapters, be effectively integrated into different stages of the architectural design process?
What are the tangible benefits and potential challenges of AI's integration into architectural design, especially in urban contexts like Newtown?

3.2 Sourcing Information

Given the extensive research conducted, the methodology now focuses on a more in-depth exploration of specific areas:

Architectural Design Stages Revisited:
Building on the foundational understanding of the architectural design process, the research now delves deeper into the nuances of each stage, identifying specific areas where AI can bring transformative enhancements. This is further explored in Chapter 4.

Deep Dive into AI's Evolution:
Beyond a basic understanding, the research now offers a comprehensive view of AI's trajectory, its evolving techniques, and its broader implications for various fields, as detailed in Chapter 2.

AI Tools - An In-depth Analysis:
The research provides a more detailed exploration of the three main AI tools: Stable Diffusion, Autodesk Spacemaker, and Archistar as discussed in Chapter 5. Each tool's potential and challenges in the architectural design process are critically assessed.

3.3 Relevance to the AI Innovation Centre Design - An Evolved Perspective

The AI Innovation Centre's design in Newtown, Johannesburg, serves as a practical application of the research findings. The design process now incorporates a more holistic integration of AI tools, considering Newtown's unique urban context and the potential for urban regeneration.

3.4 Addressing Gaps in Information and Strategies for Data Collection

Given the depth of research conducted, the methodology now focuses on:

- Practical Experimentation: Hands-on testing of AI tools to derive practical insights and understand their real-world implications.
- Expert Insights: Interviews with industry experts have been conducted to gain a deeper understanding of AI's practical applications in architecture.
- Uncharted Territories: The research identifies and explores areas that require further exploration, particularly concerning AI's seamless integration into the architectural design process.

3.5 Data Collection and Analysis

- Hands-on Experimentation: Practical testing of AI tools to derive tangible insights.
- Thematic and Comparative Analysis: A deeper analysis of literature reviews, case studies, and expert interviews to draw meaningful conclusions.

3.6 Ethical Considerations and Strategy



"European Architecture"



"African Architecture"

1. Mitigating Negative Consequences

The potential negative consequences of AI, such as algorithmic bias and lack of transparency, were acknowledged. Strategies to mitigate these included the use of open-source AI tools and promoting transparency in the AI design process. By addressing these concerns, the research aims to promote responsible and inclusive use of AI in architectural design.

2. The Ethical Implications of AI in Architecture

This research recognizes the ethical implications related to the use of AI in architecture, including issues of job displacement and the potential misuse of AI-generated designs. These issues were addressed by advocating for a collaborative approach where AI complements rather than replaces human architects, ensuring that ethical concerns are considered in the design and implementation of AI applications in architecture.



Fig 4.1: *AI image generated, prompt "architect designing with AI" from Author, (Midjourney, 2023)*

04

DECODING THE ARCHITECT'S DESIGN STAGES:

DISCOVERIES IN AI TOOLS & TECHNIQUES

4.1 Architect's Role in the Era of AI: Redefining the Design Process and its Implications

The essence of architectural design is encapsulated in three primary elements: They undertake actions - the architect and the resulting artefact. This trio forms the process's core design according to Bennet (2020). Extends beyond mere design, the architect's role. Smooth communication and project execution are ensured by them serving as a conduit between the client and the construction team. Developing new theories along with researching techniques are their tasks. This process not only expands but also pushes boundaries in architecture designs. Additionally they can increase their architectural knowledge base (Onal, 2018).

Design-based research and precedents inform the architect's creative process in the 'actions' component. This is a dynamic iteration of

trial an error. It isn't linear but it can foster innovation in addition to some unique solutions. (Onal 2018)

The design process gives birth to a physical manifestation known as 'the artefact', it's essentially a visible outcome from an architect's undertaking. It also reflects on an architect's research and his or her whole design journey. Furthermore. by these elements can you judge if their designs were successful often times(Onal , 2018).

We are standing on the cliff of a new era where AI is poised to disrupt conventional processes and it's vital that we comprehend these aspects of design. The architect's role and actions must be emulated by AI systems to create successful designs. The nature of design is redefined by architects through this technological shift that presents an opportunity. Better than humans, AI can do research in some aspects currently. However, when will this be the case for all? Architects must integrate AI into their workflows as a means of adapting to this new landscape. This strategy will enhance their capabilities and reshape the future of architectural design. As Bennet suggests (Bennet, 2020).

From our research into AI tools - yet to be discussed further along - it's becoming evident how they can help streamline processes for architects who are intermediaries between clients and contractors per Onal's concept from 2018. In the sectors where AI can lend its hand to these three entities, a schema is presented.

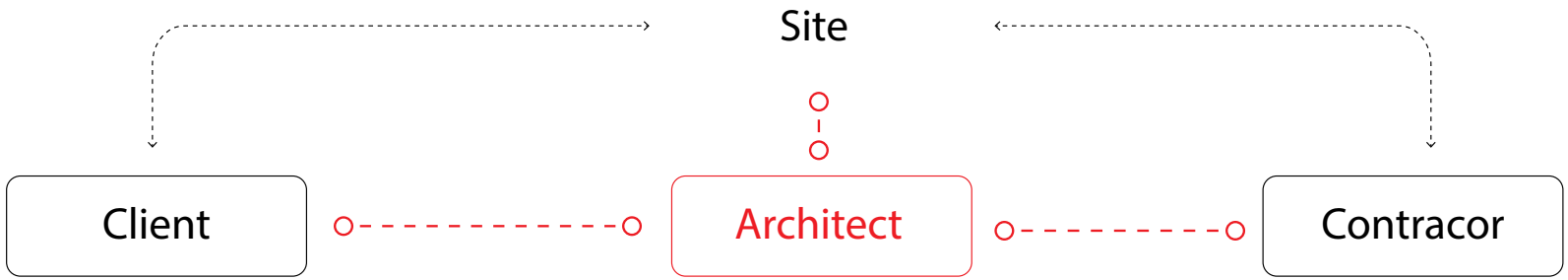

Fig 4.2: *Representation of the position of an architect in the process of the Nature of Design (Author, 2023)*

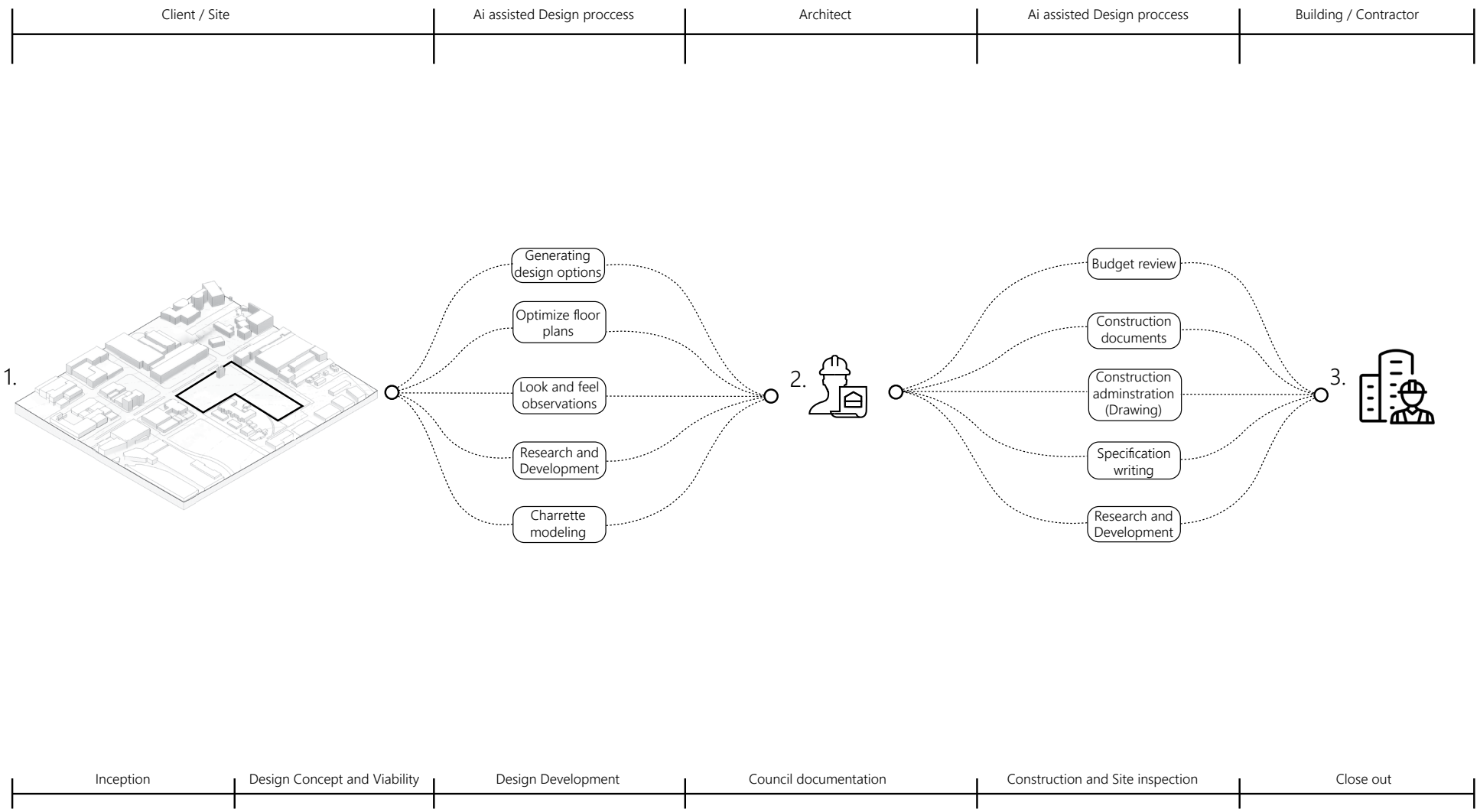

Fig 4.3: *The above diagram illustrates the process in design from client to architect to contractor. This diagram lists some factors based of research, that Ai can assist on the design process. (Author, 2023)*

4.2 Integrating Artificial Intelligence Across SACAP Design Stages: An Overview

Building on the critical architectural design stages as defined by the South African Council for the Architectural Profession (SACAP), this chapter seeks to weave together the potential of AI tools within each stage of the architectural design process. Leveraging the extensive research on AI tools detailed in Chapter 3, we map the potential applications of AI across these stages. In the diagram below, we distil these insights into a comprehensive overview of the seven SACAP-designated stages of design (SACAP, 2022), emphasizing the integration of AI tools and methods at each juncture. This illustrative approach underscores the transformative potential of AI across the architectural design spectrum in South Africa.

Stage 1: Inception

- Simulation and trial: AI can simulate and test many examples of designs and configurations to assist in concluding which scenario is best fitted to the brief and specific construction or legislative requirements.
- Design inspiration: Through the analysis of data and precedents, AI can create applicable examples for the design to serve as an inspiration to architects.
- Data analysis: AI can aid architects in efficiently and speedily analysing vast data available as it pertains to the site, local council regulations, demographics and other relevant factors.

Stage 2: Concept and viability

- Material selection: AI can aid Architects in the selection of proposed building materials in a South African context from a climate and environmental point of view.
- Generative design: An architect can through the insertion of input cause multiple design solutions to be generated by AI.

Stage 3: Design Development

- BIM model: AI can create Building Information Modeling which will make the design process much more time efficient. AI is able to automate the creation of 3D models of a building design, deriving the quantity estimates, creating schedules etc.
- Design optimization: By using prompts and parameters such as a monetary budget, timeline and materials, AI can generate a multitude of iterations and options which the architect can choose from to best compliment the brief at hand.
- Optimizing floor plans: AI can help architects optimize floor plans for natural lighting, circulation, and space utilization. For example, if the brief calls for a building that maximizes usable space within a limited footprint, AI can generate multiple floor plan options that optimize the use of space while also providing natural light and efficient circulation.

Stage 4.1: Council Documentation

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Stage 4.2: Construction Documentation

- Compliance with regulation: AI tools are available to the architect for purposes of analyzing the building design to ensure that it complies with local regulations.
- AutoCAD: This is an AI tool used by architects to automate the creation of 2D and 3D drawings which in turn minimizes the manual drawing time and effort required by the architect.
- Design visualization: AI tools and software systems create digital renders of building designs which are realistic and illustrate the architects design in an advanced way that speaks more to the client.

Stage 5: Construction and Site Inspection

- Quality control: AI can be used to identify errors and oversights which an architect would through human error not likely have picked up such as incorrect or missing details and labeling errors.
- Site monitoring: Using cameras, sensors or drones architects can access the visual of a site on a remote basis through AI. This will provide real-time updates to the architect and also allow an open means of communication with other professionals on site.

Stage 6: Close out

- Site monitoring: Using cameras, sensors or drones architects can access the visual of a site on a remote basis through AI. The architect can then pick up any variations in the project for as-builts

Through the course of this research, the potential of AI in redefining the architecture design process has become abundantly clear. As I move forward in our architectural journey, I plan to leverage these AI tools in creating innovative designs. I will test and apply what I know works—AI for data analysis, generative design, and compliance checks, to name a few—and see first-hand the efficiency and creativity it brings.
This journey is about more than just creating efficient designs; it's about uncovering the true potential of AI in architecture. With each design we create, we'll learn more about what works, what doesn't, and where we can still explore. It's an exciting path ahead, one where each step brings us closer to redefining the architectural landscape through the integration of AI.

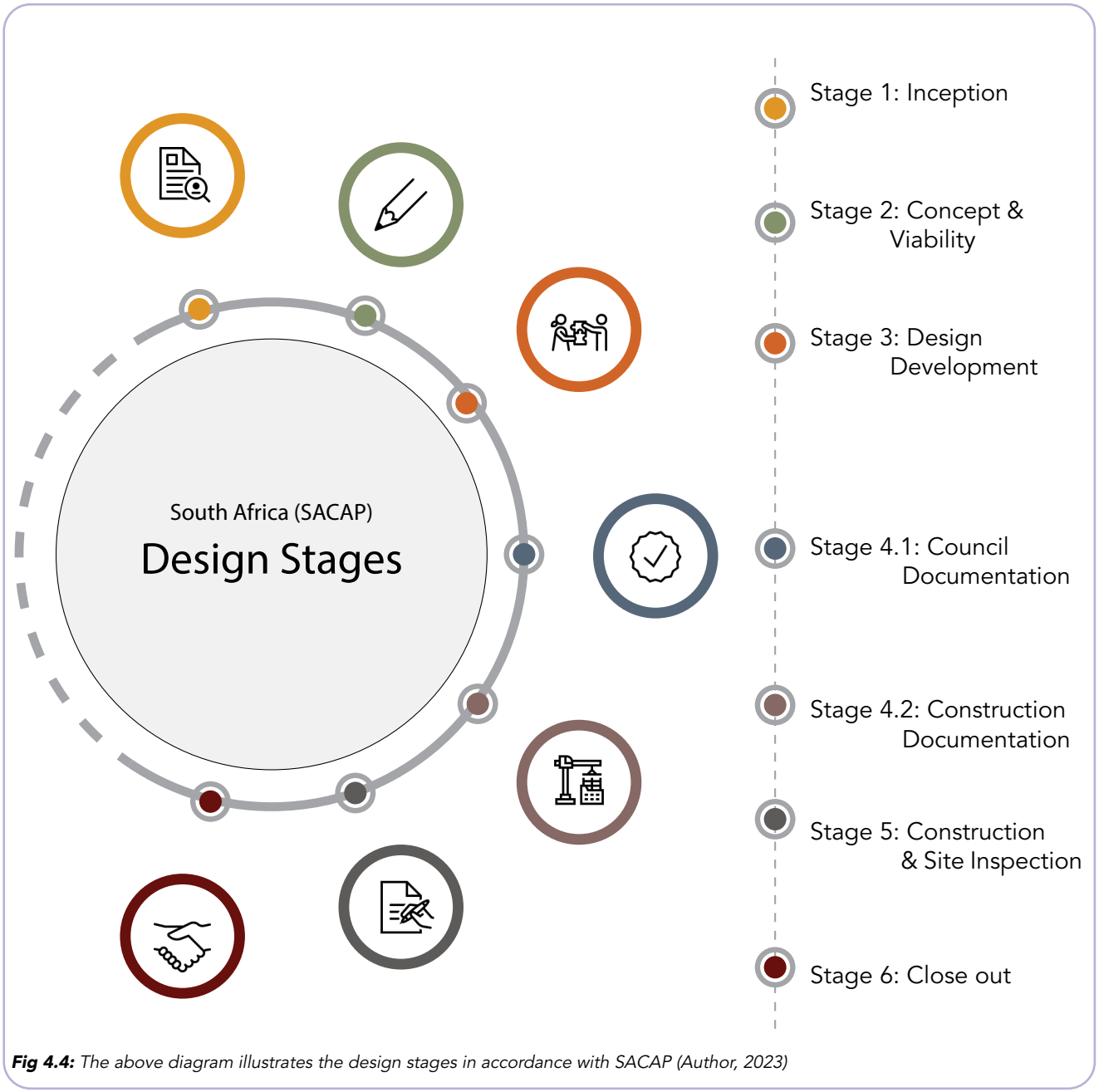


Fig 4.4: *The above diagram illustrates the design stages in accordance with SACAP (Author, 2023)*

4.3 Ethical considerations of AI

The European Union Artificial Intelligence Act ("AI Act") is currently still in draft format and it has not been effected as yet officially by the European Union. On as recently as 24 January 2024, journalists including Luca Bertuzzi, along with European Parliament staff members Dr. Laura Caroli and Dan Nechita, publicly shared the latest draft of the AI Act. Although this Act is still in draft form, it is nevertheless paramount to the discussion of regulation and ethical considerations within the AI sphere globally.

The European Commission introduced the AI Act initially during 2021 as a proposed legislative framework for purposes of regulating AI technologies within the European Union. An important objective of the Act is to ensure and encourage the responsible development and usage of AI systems. This serves to hopefully balance innovation with ethical considerations and to safeguard fundamental rights.

As a brief overview, the AI Act cleverly categorizes AI systems into different risk levels and imposes obligations accordingly, including transparency, human oversight, and compliance with fundamental rights. (European Union Artificial Intelligence Act, 2024)

In the context of South Africa, ethical considerations surrounding AI are crucial as the use and adoption of AI in our country and the African continent is increasing daily. Those who adopt AI technologies have a responsibility to address potential biases in AI algorithms, considering the diversity of cultures, languages, and socio-economic conditions across South Africa. Especially having regard to the historic progression of architecture and design trends or methodologies over decades, it is essential to ensure that inclusivity, fairness, and respecting local values are considered.

One can only hope that these legislative steps taken globally, such as the AI Act discussed above, will contribute to the progression of AI and the use of its technology from a regulatory and ethical point of view. Within the architectural realm and the usage of AI technology, it is vital to take into consideration these global movements and examples of AI regulation and to use this as a guide to inform our own usage. The parameters in respect of AI are often a grey-area and not always finite, therefore extra care must be afforded to conducting research and to remain informed on the developments in AI regulation.

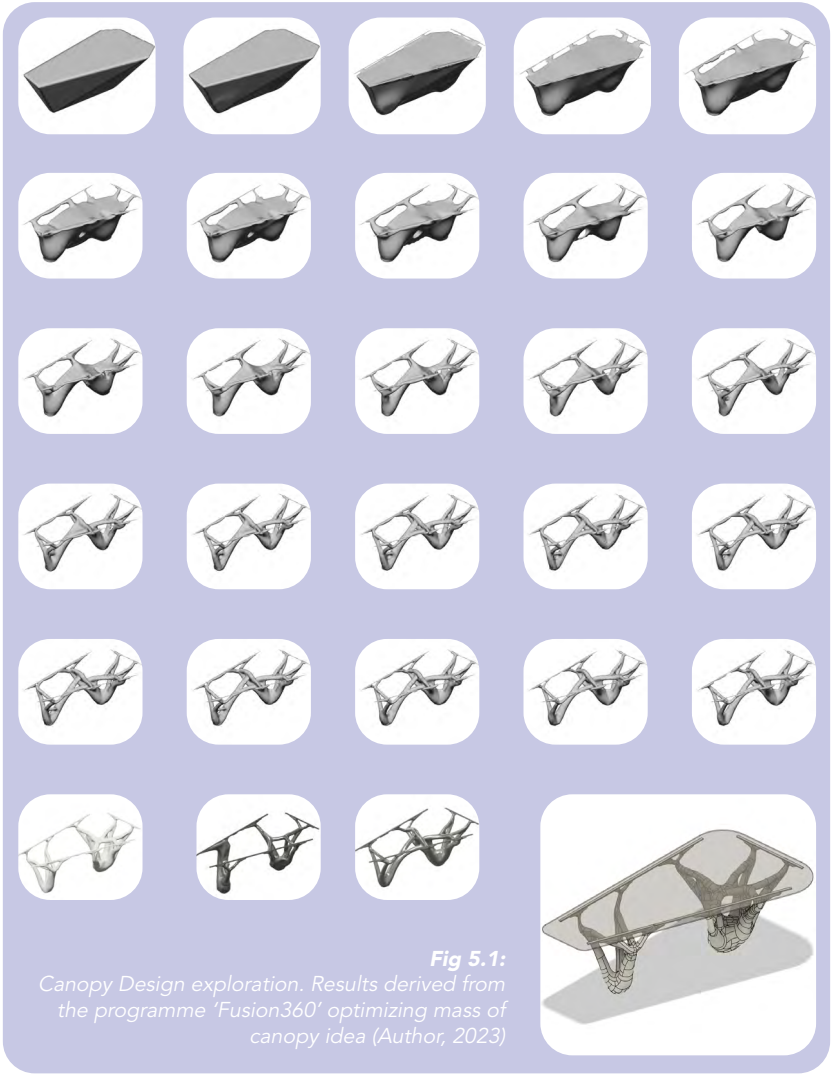


Fig 5.1:
Canopy Design exploration. Results derived from the programme 'Fusion360' optimizing mass of canopy idea (Author, 2023)

05

AI TOOLS AND THEIR ROLE IN ARCHITECTURAL DESIGN:

GENERATIVE DESIGN, GANS, STABLE DIFFUSION AND FORMA

Brief Overview:

Generative design represents a paradigm shift in the architectural design process, utilizing computational algorithms to craft numerous design solutions from predefined criteria. The integration of AI has enhanced this approach, enabling the creation of designs that satisfy functional needs while also showcasing creativity and innovation.

Objective:

This chapter embarks on a comprehensive exploration of current projects and literature that delve into the fusion of AI models within the architectural design realm. Through meticulous analysis, this research has unearthed pivotal insights about AI learning models pivotal for architectural design innovation. Among various machine learning models, Generative Adversarial Networks (GANs) have

emerged prominently in this exploration. Recognized for their ability to produce creative outputs typically associated with human creativity, GANs have captivated the arts and design sectors (Huang, 2021).

5.1 Generative design

Generative design employs AI-powered software to craft multiple design solutions within set constraints (Formlabs, 2020). Unlike traditional methods that begin with a model rooted in a designer's expertise, generative design initiates with design goals, allowing AI to shape the model. By iteratively refining these goals, designers can unearth highly optimized and tailored solutions for a myriad of design challenges (Formlabs, 2020).

Historically, architects have consistently pursued innovative design solutions. The advent of computational design tools empowered architects to navigate expansive design possibilities efficiently. Generative design amplifies this by automating the exploration process, granting architects the ability to define design objectives and constraints, and then relying on software to suggest diverse solutions.

In today's rapidly evolving architectural landscape, generative design offers a transformative approach. It not only streamlines the design process but also introduces innovative solutions that might not be immediately evident through traditional methods. As urban spaces become more complex and demands on infrastructure grow, the ability to quickly iterate and optimize designs using AI becomes invaluable (Huang, 2021).

The Importance of Understanding AI Models:

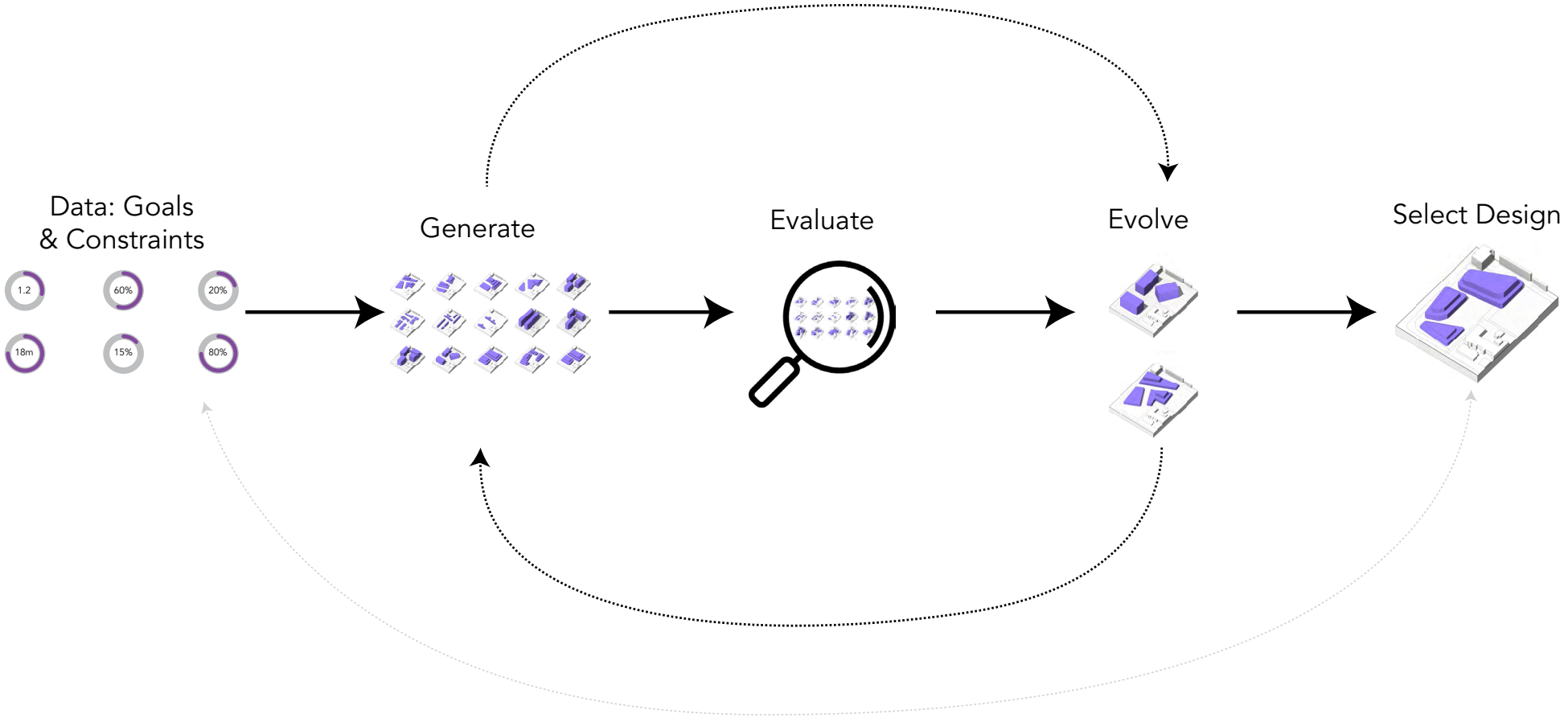
Grasping the intricacies of these AI models demands significant time, rigorous research, and immersive exploration. Such understanding is essential, guiding architects on leveraging data manipulation to achieve desired results via AI.

Informed by extensive literature, hands-on experiments, and available resources, a pivotal decision emerged: GANs deserved a deep dive in this study. This model stands as a beacon for architects, showcasing the potential of a singular model worthy of their time and dedication. Furthermore, this exploration aims to inspire architects to venture into other models, aligning with specific criteria and the unique aspirations of their projects.

The ensuing sections of this chapter will probe into the strengths and limitations of GANs within the architectural domain, equipping architects with a robust foundation to seamlessly weave AI-driven generative techniques into their design processes.

Generative design software

Fig 5.2: *the process of generative design (Author, 2023)*



Models and softwares to be explored

The mind map in figure 5.3 showcases various generative design models, with a particular emphasis on GANs.

My subsequent explorations in this chapter will reveal which softwares, based on research, definitively employ GANs. Some softwares, while not explicitly disclosing their use of GANs, exhibit characteristics and outputs that strongly suggest their reliance on this model. These assumptions are grounded in the tasks and explorations these tools undertake, all of which align with generative design principles. Further details on these tools and their potential use of GANs will be discussed in later subheadings.

Additionally, the diagram highlights potential physics-based simulation models that some of these softwares might employ for site analysis, focusing on wind, solar, and noise studies.

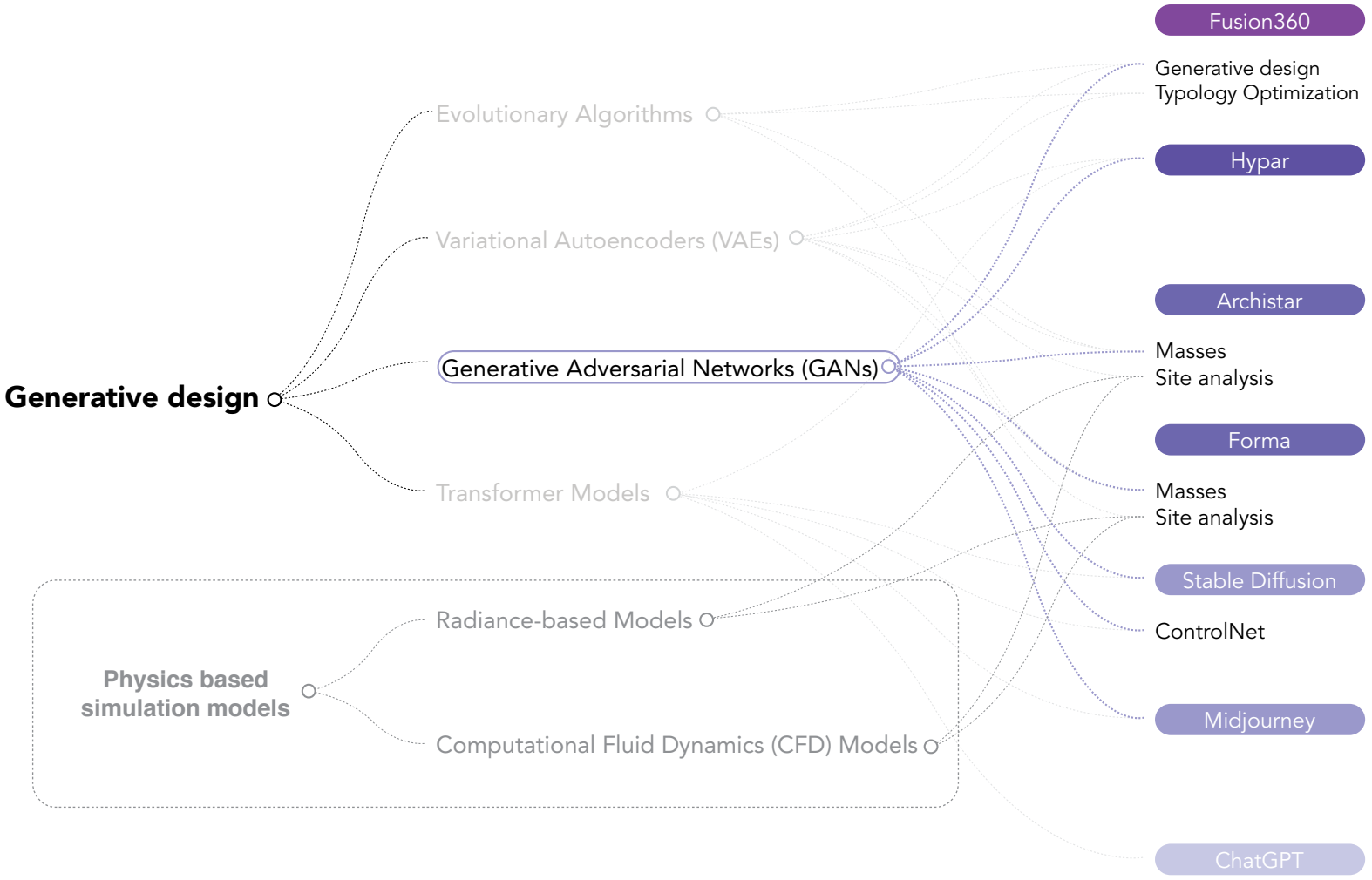


Fig 5.3: *map showing generative design models and physics based models (Author, 2023)*

5.2 What is GANs?

Generative Adversarial Networks (GANs) are AI models renowned for their prowess in generating synthetic images mirroring real ones(Chaillou, 2020). Comprising two main components - a Generator and a Discriminator - the Generator crafts images, while the Discriminator assesses them against a real-image dataset. This feedback loop continually refines the Generator's capability to produce increasingly realistic images (Chaillou, 2020)

In architectural contexts, GANs can be harnessed to generate floor plan designs. Training a GAN with floor plan imagery enables it to design typical building footprints based on a parcel's shape. For instance, the Pix2Pix GAN model, when fed paired images, learns the transformation from one image to its counterpart(Chaillou, 2020)

This statistical methodology offers significant advantages in apartment layout generation. GANs adeptly manage intricate topological challenges and might even surpass or enhance traditional procedural methods. The architectural application of GANs remains an evolving domain, brimming with opportunities for further exploration and advancements. (Chaillou, 2020)

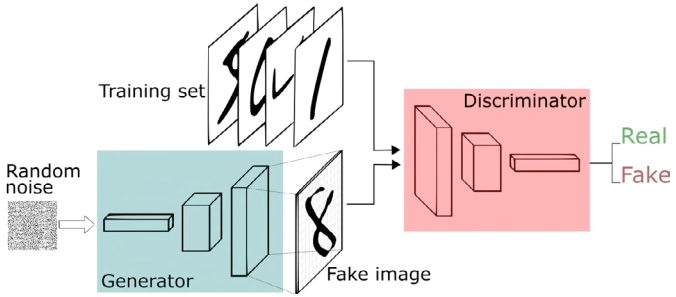


Fig 5.4: *GANs typical model (Silva, 2017)*

Fig 5.5: *How GANs works, simple terms (Unknown, 2023)*

The following diagrams illustrate, in the simplest terms, how GANs works:

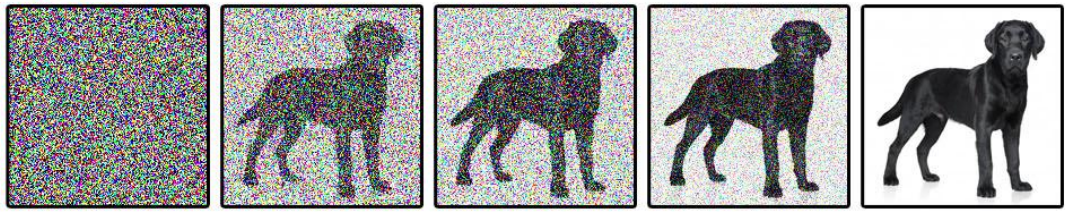
1. We start with a picture of an object, say, a dog. We instruct the computer to gradually turn this picture into noise, remembering each step in the process.



2. Next, we take a picture of actual random noise and instruct the computer to reverse the "dog to noise" algorithm.



3. If we teach the computer about the colour black and then ask it to reverse both the "colour black to noise" and "dog to noise" algorithms simultaneously, the results can be quite interesting.



5.3 Case Study
Stanislas Chaillou's Exploration of GANs in Architectural Design

Introduction:
Stanislas Chaillou, an Architect & Data Scientist at Spacemaker's R&D department, has been at the forefront of integrating AI and architecture. His research has been pivotal in demonstrating the potential of Generative Adversarial Networks (GANs) in the realm of generative design, particularly in crafting floor plans and orchestrating spatial layouts

Methodology:
Chaillou's methodology is rooted in the development of an 'AI bot' capable of creating fully furnished floor plans from a given mass. This bot, through its advanced algorithms, produces multiple iterations, presenting architects with diverse options for further conceptualization. His approach is a three-tiered system:

1. The first bot conceptualizes a mass.
2. The second bot delineates the required program.
3. The third bot furnishes the plan layout.

This process was informed by a vast dataset of diverse plans from across the globe

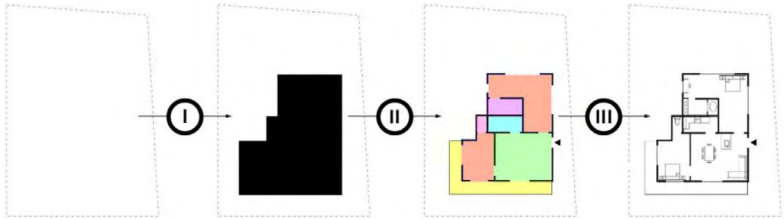


Fig 1.1: *generation of different plans using AI - GANs, (Chaillou, 2019)*

Challenges:
Chaillou acknowledges the inherent bias within AI systems. By adjusting the input data, he was able to generate categorized floor plans based on distinct architectural styles. However, this raises broader questions about the influence and potential manipulation of AI

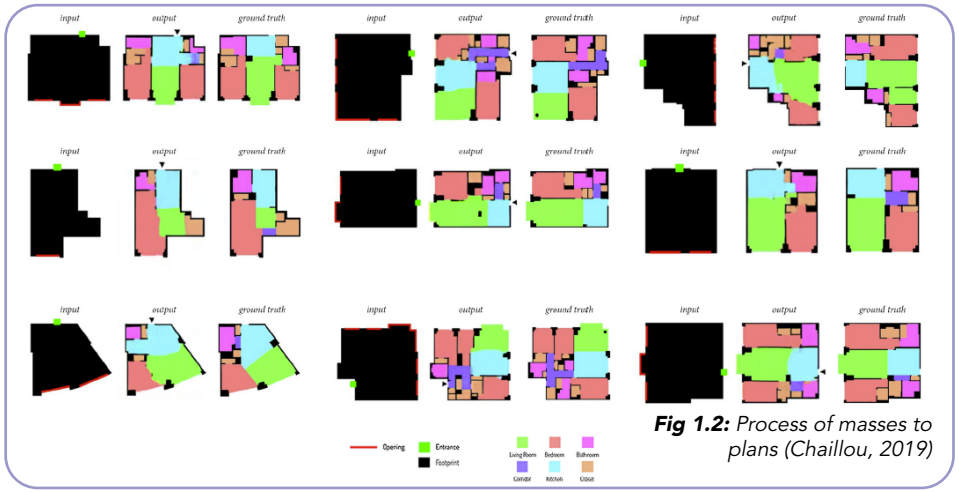


Fig 1.2: *Process of masses to plans (Chaillou, 2019)*

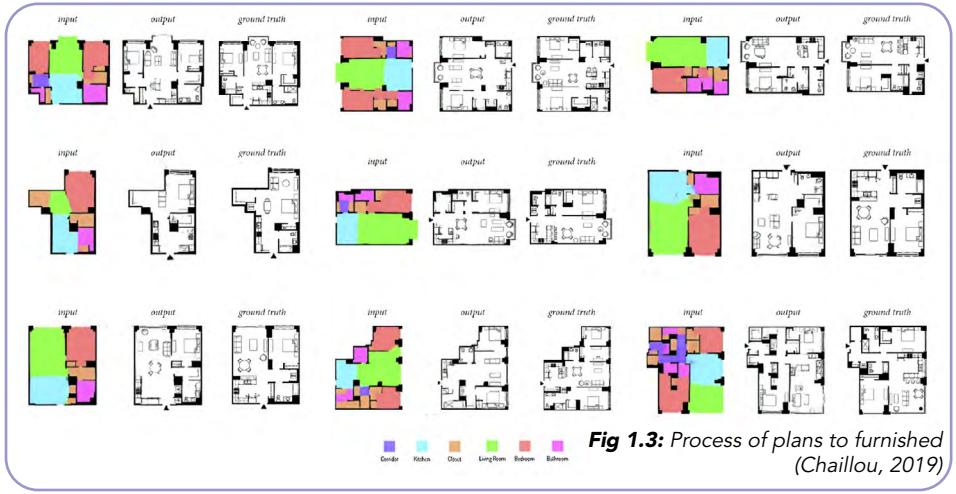
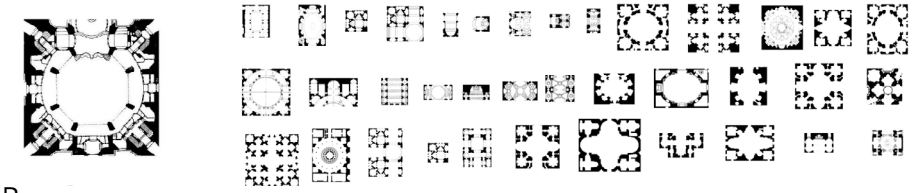
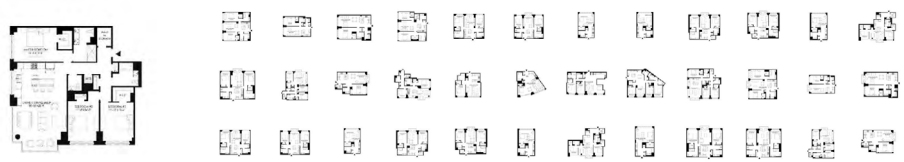


Fig 1.3: *Process of plans to furnished (Chaillou, 2019)*

Results:
By training the AI on specific architectural styles, Chaillou was able to generate floor plans resonating with styles such as Baroque, Victorian Suburban House, Row House, and Manhattan Unit. His results underscore the adaptability of AI in catering to diverse design



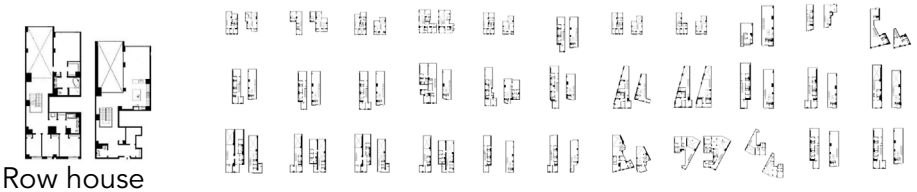
Baroque



Manhattan Unit



Suburban Victorian



Row house

Discussion:
Chaillou believes that the integration of AI in architectural design offers numerous advantages, including the introduction of a novel medium in the architectural profession and the potential to address design blind spots. He emphasizes the need for architects to embrace clarity and simplicity in the design process, viewing AI as a tool to anchor their investigations in a methodologically sound framework

Relevance to Thesis:
Chaillou's exploration serves as a testament to the transformative potential of AI in architectural design. His work offers broader insights into the symbiotic relationship between AI and architecture, underscoring the importance of iterative exploration, the challenges of inherent biases, and the boundless possibilities that emerge when human creativity collaborates with machine intelligence.

Fig 1.4: *generation of different style plans, different influences - GANs, (Chaillou, 2019)*

5.4 Case Study

The Evolution and Implications of Midjourney's AI Image Generators in Architectural Design

In the realm of architectural design, the integration of AI tools has ushered in a new era of possibilities, from automating mundane tasks to generating intricate design concepts. AI image generators, in particular, have become instrumental in visualizing and conceptualizing architectural ideas. As highlighted by Mathew Maganga, 2022 marked a pivotal year in this evolution, with tools like DALL-E and Midjourney emerging as frontrunners. These tools, while groundbreaking, also underscore the inherent biases in AI, especially when tasked with representing diverse cultures, such as African architecture (Maganga, 2022).

Objective of the Study:
This case study seeks to delve into the capabilities and limitations of Midjourney's AI image generator, particularly its representation of "African architecture." The study also aims to understand the potential biases in AI system and their implications for architectural design.

Methodology:
Using Midjourney, a text-to-image generative AI app driven by simple language instructions, a series of prompts were inputted to generate images representing different architectural styles and concepts. The primary prompts used were "African architecture" and "European architecture." The results from these prompts were then analyzed to understand the system's interpretation and representation of these architectural styles



"African Architecture"



"European Architecture"

Fig 2.1: highlighting the potential bias of AI
Midjourney AI images generated using prompt below the image (Author, 2023)



Fig 2.2: Evolution of Midjourney models
Midjourney AI images generated using prompt "African Architecture" (Author, 2023)

Findings:

1. Evolution of Midjourney:

Midjourney has undergone significant refinements over the past year, releasing multiple updated versions of its software. The progression from its earlier versions to the latest showcases a marked improvement in its image generation capabilities, especially its interpretation of "African architecture" as seen in figure 2.2,

2. Challenges with Representation:

The term "African architecture" is inherently complex, given Africa's diverse nations and distinct architectural practices. The history of European colonialism further complicates this representation. Despite its advancements, Midjourney's representation of "African architecture" remains contentious, highlighting potential biases in the system.

3. Bias in Image Generation:

An experiment was conducted using the prompt "decolonized South African city" in figure 2.3. The images generated by Midjourney did not align with vernacular African architecture. This discrepancy underscores the potential biases in the system and highlights the challenges in accurately representing diverse architectural styles.



Fig 2.3: highlighting the potential bias of AI
Midjourney AI images generated using prompt "decolonized South African city" (Author, 2023)

Midjourney Explorations:

The recent release of Midjourney version 5.2 introduced the "zoom-out" feature, allowing users to expand upon an existing image based on textual prompts. This feature offers architects a novel approach to design exploration. By starting with a specific texture or design element, architects can iteratively refine and expand the design using the zoom-out feature. One such application, as demonstrated by Input Design, involves transforming a simple texture into a detailed architectural facade, showcasing the tool's potential in early-stage design ideation.



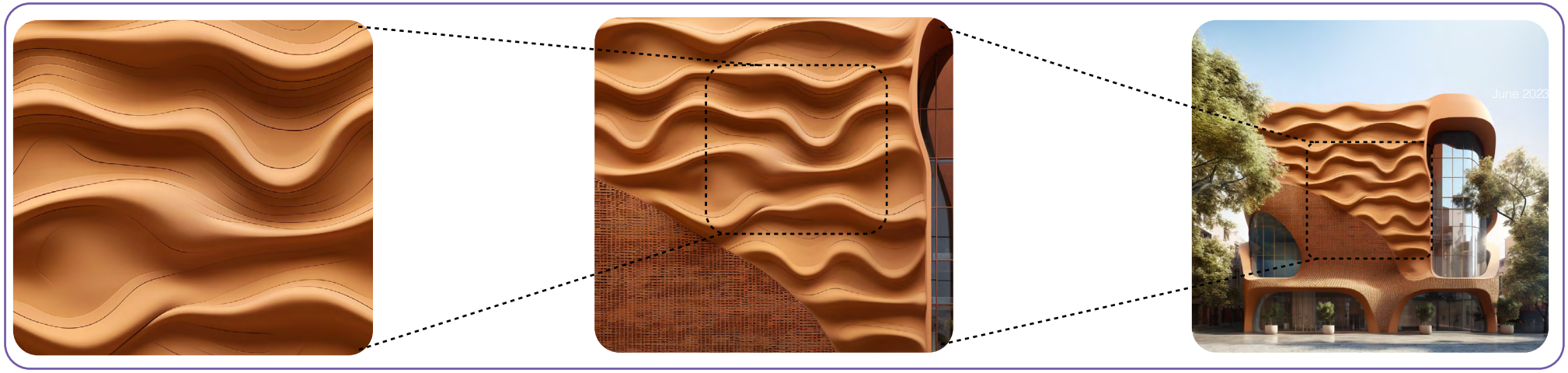


Fig 2.4: Using the "zoom out" feature
All images Midjourney AI images generated using prompt "smooth clay tile" (Author, 2023)

Discussion:
The results from Midjourney highlight the broader challenges with AI image generators. While these systems offer incredible capabilities, they are also shaped by the data they are trained on. The biases in these systems can influence the design process, potentially leading to misrepresentations or oversimplifications of complex architectural concepts. For the architectural community, this underscores the importance of critically evaluating AI-generated outputs and understanding the underlying data and biases that shape these results.

Generative Adversarial Networks (GANs), the underlying technology behind tools like Midjourney, are revolutionizing the architectural design process. The case study of Midjourney underscores the vast potential and challenges of GANs in design exploration. While GANs offer innovative design solutions and rapid iterations, it's imperative for architects to approach these tools with a critical lens, understanding their limitations. As GANs continue to evolve, they will undoubtedly play an even more significant role in shaping the future of architectural design. However, ensuring culturally sensitive and accurate design outputs will remain a paramount responsibility for architects leveraging these AI-driven tools.



Fig 2.5: Using the "zoom out" feature
All images Midjourney AI images generated using prompt "smooth clay tile" (Author, 2023)







5.5 Case Study
Open Source Alternative: Stable diffusion

Stable Diffusion, introduced in 2022, is a powerful deep learning text-to-image model designed primarily for generating detailed images based on text descriptions (Wikipedia, 2022). Beyond this application, it also proves useful in inpainting, outpainting, and image-to-image translations guided by text prompts. Operating as a latent diffusion model, Stable Diffusion falls under the category of deep generative neural networks, much like Generative Adversarial Networks (GANs). The model's publicly available code and weights make it accessible for implementation on most consumer hardware.

Developed by the CompVis group at LMU Munich, Stable Diffusion utilizes the latent diffusion model (LDM) to achieve its impressive capabilities. The concept of diffusion models dates back to 2015 and involves training with the objective of removing successive applications of Gaussian noise from training images. This training process can be likened to a sequence of denoising autoencoders (Wikipedia, 2022). The result is a powerful AI tool that can produce realistic and intricate images from text prompts, revolutionizing the creative process for designers and artists alike.



Fig 3.1: Stable Diffusion, from sketch to render exploration
Process of how using a mass and sketch transforms into a rener (Author, 2023)

Stable diffusion

Stable Diffusion emerges as the preferred choice for personal use, especially for architects seeking a customizable and adaptable AI solution. Unlike closed-source AI models, which are challenging to modify according to specific architectural needs, Stable Diffusion offers an open-source platform that fosters a thriving community. This active community continually creates new extensions and adaptations to cater to various requirements, making Stable Diffusion a flexible and versatile tool for architects. With its deep learning text-to-image generation capabilities, Stable Diffusion enables architects to generate detailed images based on textual prompts.

Compared to other closed-source AI models, Stable Diffusion is an excellent starting point for architects. Its open-source nature leads to continuous improvements and quality enhancements. Combining Stable Diffusion with ControlNet expands creative possibilities through preprocessors that allow personalized image generation. Moreover, it is cost-effective and accessible, running on personal computers with powerful graphics cards.

Stable Diffusion offers a variety of trained image models that are freely available for use. Through extensive experimentation with different models, I discovered the ones that best suit architectural visualization, consistently generating results that closely align with my design ideas when provided with an input prompt. As an architect, my objective is to further explore and refine these models based on the specific type of building or facade I am envisioning. This approach allows me to tailor the AI to my design needs, ultimately leading to more accurate and satisfying outcomes in my architectural projects. With Stable Diffusion's range of image models and the potential to train and customize them, I can achieve a higher level of precision and creativity in my AI-powered design process.

Prompt/Prompt Engineering:

The magic is in the prompts!

Understanding the nuances of AI image generator prompts is paramount for architects and designers leveraging AI tools like Stable Diffusion. Crafting an effective prompt can be the difference between generating a generic image and a design that aligns closely with the architect's vision.

- The Power of the Prompt: As highlighted in the article "Harnessing the Wild Power of AI Image Generation," AI models, especially GANs, have the capability to produce photorealistic images. However, the challenge lies in directing these models to generate controlled images based on specific conditions. The prompt serves as this directive, guiding the AI model in its image generation process.

- Crafting Effective Prompts: An effective prompt is clear, concise, and specific. It should encapsulate the design intent and provide the AI model with enough context to generate an image that aligns with the desired outcome.

- Iterative Refinement: Just as architectural design is an iterative process, crafting the perfect prompt may require multiple attempts. By analyzing the outputs and refining the prompts, architects can hone in on the ideal directive that produces the desired design visualization.

- Conclusion: Mastering prompt engineering is crucial for harnessing the full potential of AI image generators in architectural design. By understanding and effectively utilizing prompts, architects can ensure that AI tools like Stable Diffusion serve as valuable assets in their design toolkit.



Fig 3.2: Bad Prompt
"Parametric Building" (Author, 2023)



Fig 3.3: Good Prompt
"a parametric building in a city environment people walking, by Zaha Hadid, exterior view, sunset, highly Detailed, 4k" (Author, 2023)

how to structure prompts:

1. a parametric building in a city environment people walking, - Subject

2. by Zaha Hadid, - Medium/Style

3. exterior view, - Perspective

4. sunset, - Mood/Vibe

5. highly Detailed, 4k - Magic words

5.5.1 ControlNet:

Mechanics of ControlNet:
ControlNet is a complex system with a specific mechanism of operation that involves two main inputs: a text prompt and an image. The process starts by feeding the text prompt directly into Stable Diffusion. At the same time, the image goes through a series of preprocessing steps to convert it into masks. These masks are essential for guiding the diffusion process.

Once the preprocessing is complete, the masks merge with the Stable Diffusion, along with its text prompt and ControlNet models. The ControlNet plays a crucial role in guiding the diffusion process based on the preprocessed image. This mechanism ensures that the generated output aligns with the given text prompt and is influenced by the characteristics of the input image.

In summary, ControlNet works in conjunction with Stable Diffusion to accept user inputs of a text prompt and an image. It then utilizes the preprocessed image masks to guide the diffusion process, resulting in an output that is influenced by both the text prompt and the characteristics of the input image. This mechanism enables ControlNet to produce coherent and contextually relevant results that align with the user's intentions.

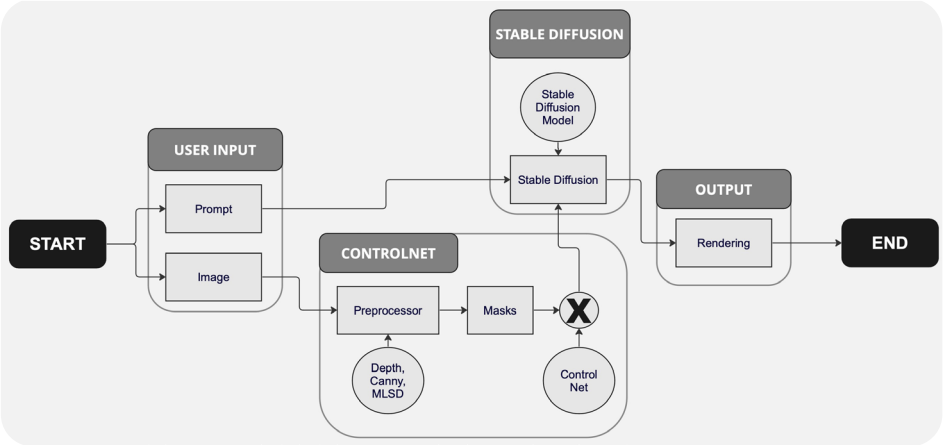


Fig 3.4: ControlNet mechanics
(Author, 2023)

Preprocessors and how they work:

Preprocessors play a crucial role in ControlNet's operation. They are responsible for generating masks that guide the diffusion process and ultimately shape the output images. These masks help ControlNet mimic the shape of the input image, resulting in visually coherent and contextually relevant outputs.

There are five different preprocessors used in this research, each with its unique strengths and limitations. The choice of preprocessor significantly impacts the final outcome. Look at the next page to refrence

1. Canny Edges is a preprocessor that identifies edges in an image by detecting color contrasts. It works well for organic shapes but may produce noisy results when the input is cluttered or messy.

2. Scribble is another preprocessor that draws edges in the style of human scribbles. This allows stable diffusion to be more creative, making it an excellent choice for hand-drawn inputs.

3. Depth Midas creates a depth map of an image, which helps establish depth and composition. While it has its advantages, it may struggle to capture finer details in the image.

4. Normal BAE generates a normal map of the input. Although it may encounter difficulties with complex shapes and flatten backgrounds, it shows potential in certain scenarios involving organic shapes.

5. Segmentation is a preprocessor that segments images, creating masks for each element based on trained categories. It may lack an understanding of depth and detail but proves incredibly useful when users want to specify what they want to generate in specific areas of the image.

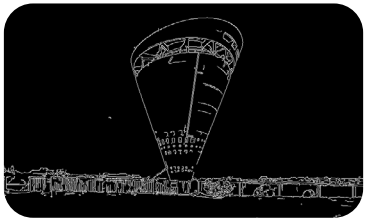
Each preprocessor offers a distinct way to guide the diffusion process. Depending on the design requirements, one may find a particular preprocessor more suitable than others. ControlNet's strength lies in its flexibility, allowing architects to combine different preprocessors to achieve high-quality and controlled results tailored to their specific needs.

1. Stable diffusion:
Prompt “parametric building, city landscape, futuristic, by Zaha Hadid, landscaping, glass, steel, exterior view, 4k, raw image,

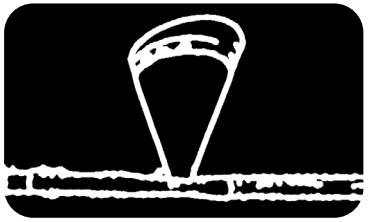


Fig 3.5: Johannesburg Watertower
Used as a base image
(Google, 2014)

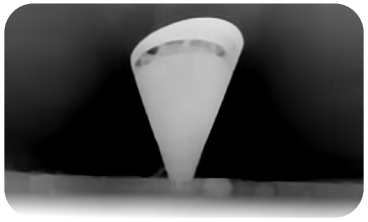
2. ControlNet:
Preprocessors scan image



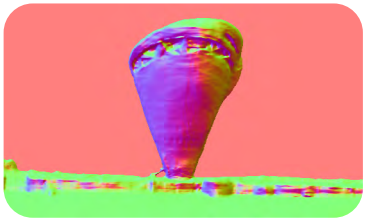
1. Canny Edges



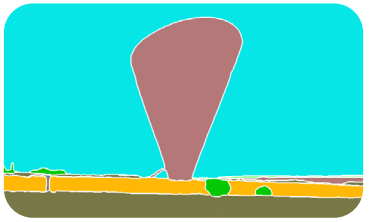
2. Scribble



3. Depth Midas



4. Normal BAE



5. Segmentation

Preprocessors Research Results:



Fig 3.6: *Output images from Stable diffusion + ControlNet (Author, 2023)*

5.6 Case Study
Archistar.ai's Generative Design

Archistar.ai has revolutionized the way property professionals find, assess, and design sites, transforming traditional months-long processes into a matter of minutes.(Archistar, 2023) One of its standout features is the generative design capability, which allows for the rapid generation of building typologies based on specific criteria. The primary objective of this exploration is to demonstrate the power and efficiency of Archistar.ai's generative design feature in producing building masses for various typologies. By doing so, the goal is to understand and create masses for the chosen building typology for an AI innovation center. This exploration was further enriched by experimenting with these typologies on a my chosen site in Newtown, showcasing the platform's adaptability and speed.

Methodology and Results:
Using Archistar.ai, four building masses for each typology were generated, as detailed in figure 4.1. The platform's efficiency was evident in the diverse design solutions produced. The Newtown site experimentation highlighted the platform's adaptability and speed, with some instances also benefiting from Archistar's wind, solar, and shade studies.

Discussion and Relevance to Thesis:
Archistar.ai's platform, with its fusion of generative design and user-friendly drawing tools, offers architects a unique advantage. The platform's adaptability, combined with its generative engine, allows for design at unmatched speeds. The open-source nature of the platform ensures continuous improvements, making it a preferred choice for architects seeking customizable solutions. The exploration of Archistar.ai's generative design feature underscores the growing importance of AI in architectural design. As urban spaces become increasingly complex, tools like Archistar.ai provide architects with the means to navigate these complexities, offering innovative solutions that might not be immediately evident through traditional methods. The goal is to use it for creating masses for the chosen building typology for an AI innovation center.

Challenges and Recommendations:
While Archistar.ai is advantageous, its AI-driven designs require critical evaluation to ensure alignment with real-world contexts. Continuous learning and adaptation are paramount. Engaging with the platform's community can offer insights and best practices. It's essential to remember that AI should enhance, not replace, human creativity in design.

Based on the next 5 pages and its explorations Archistar.ai exemplifies the potential of integrating AI into architectural design. Its generative design feature allows architects to rapidly visualize and iterate designs, but it's crucial to approach with an understanding of the tool's capabilities and limitations.

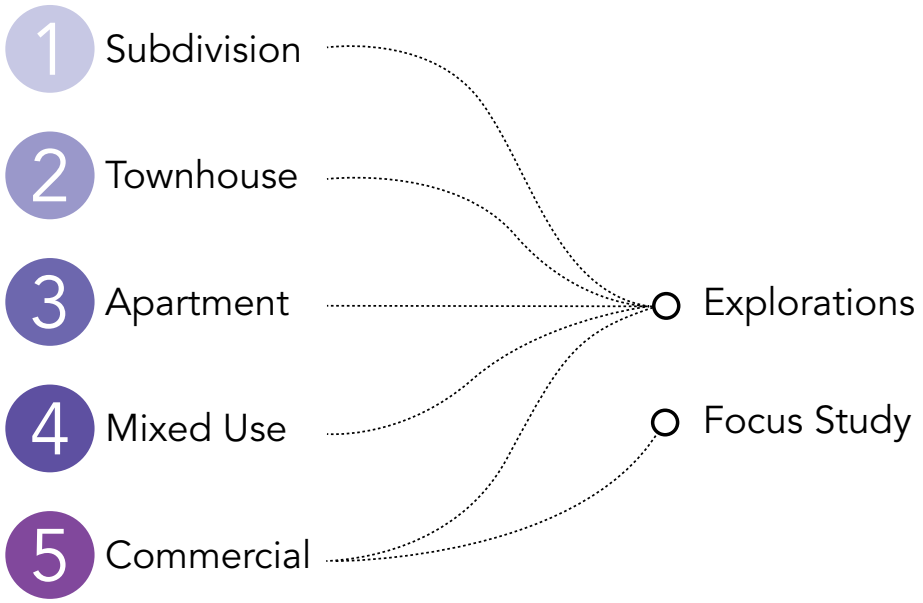


Fig 4.1: *Diagram illustrating different typologies(Author, 2023)*

Subdivision 1

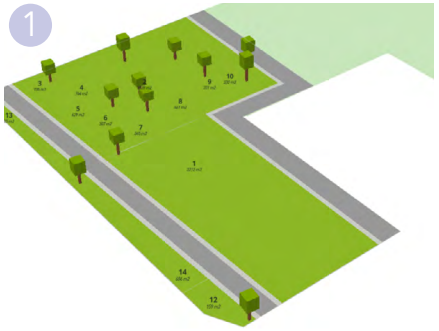
	Area (m^2)	Width (m)	%
Lot A	200	7	60
Lot B	300	10	20
Lot C	200	10	20
Lot D			
Lot E			

Subdivision

Archistar's capability to produce diverse plots with Land Efficiency ranging from 80% to 113% is commendable. This tool pushes the boundaries of efficiency, generating multiple scenarios that a human might only produce in limited variations. However, certain outputs example 1, like a random road placement along an edge, underscore the importance of human judgment in design decisions.

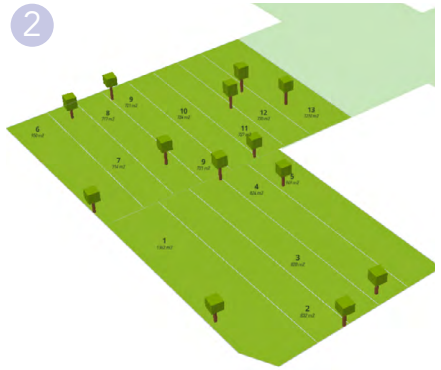
Fig 4.2: *Output masses, Subdivision (Archistar.AI, 2023)*

1



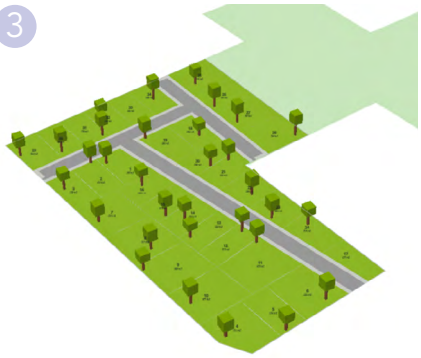
Land Efficiency 113%
Lots 14

2



Land Efficiency 100%
Lots 13

3



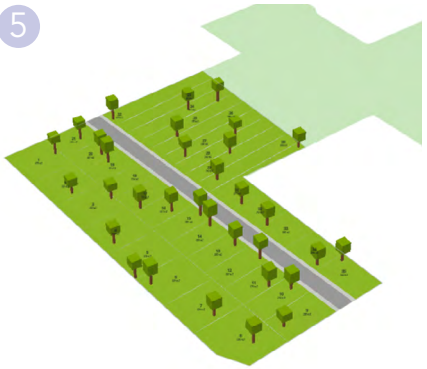
Land Efficiency 80%
Lots 34

4



Land Efficiency 73%
Lots 30

5



Land Efficiency 89%
Lots 35

6



Land Efficiency 70%
Lots 26

Townhouse 2

	Area (m^2)	Width (m)	Building GFA (m^2)	%	Car Park Provision
Lot A	200	7	100	70	1
Lot B	300	10	150	30	2
Lot C					
Lot D					
Lot E					

Townhouse

Archistar's skill is evident in its ability to swiftly generate both subdivided plots and multi-unit townhouses. The simultaneous provision of solar studies and the calculation of garden space percentages for each unit further accentuates its efficiency and depth.

Fig 4.3: *Output masses, house (Archistar.AI, 2023)*







Apartments 3

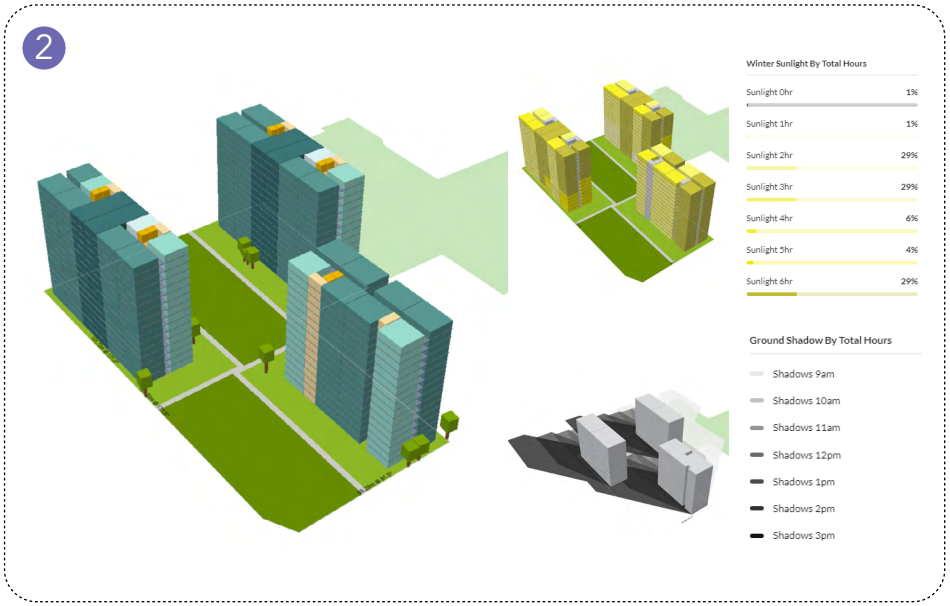
	%	Min Area (m^2)	Min Balc. Area (m^2)	Car Park Provision
Studio	0	35	4	0
1 Bed	20	50	8	1
2 Bed	60	70	10	1
3 Bed	20	90	12	2
4 Bed	0	105	15	2
Visitor Spaces				0.25

Apartments

The variations in building heights and accompanying solar studies are noteworthy. Archistar's capability to highlight building cores, sunlit hours for each apartment, and open areas designated for parks showcases its comprehensive approach to apartment design.

Fig 4.4: *Output masses, Subdivision (Archistar.AI, 2023)*







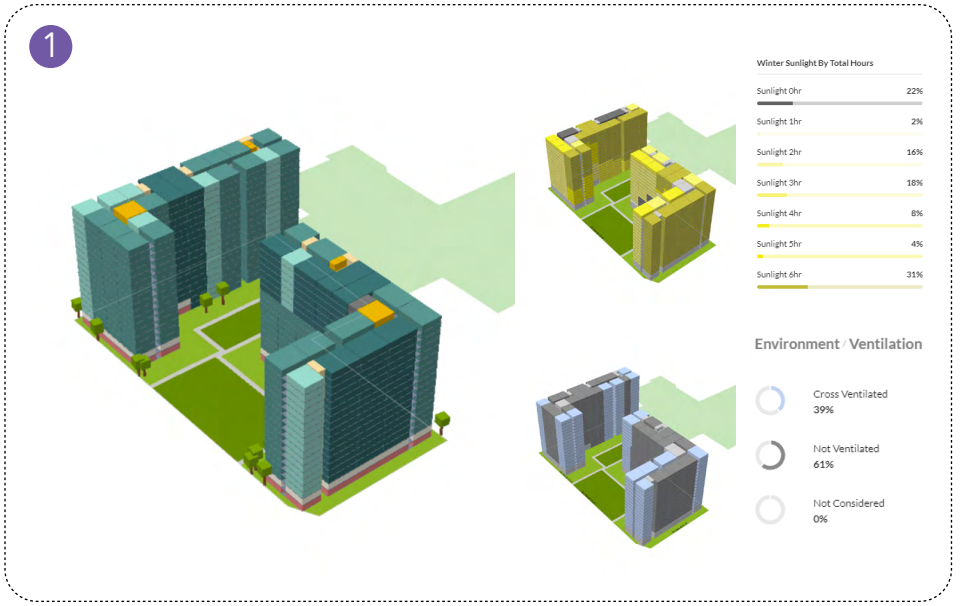
Mixed Use 4

	%	Min Area (m^2)	Min Balc. Area (m^2)	Car Space Rate
Studio	0	35	4	0
1 Bed	20	50	8	1
2 Bed	60	70	10	1
3 Bed	20	90	12	2
4 Bed	0	105	15	2
Visitor Spaces				0.25
Commercial		2000		100
Retail		2000		25
Resi. in Podium		0		
Aboveground Car Park		0		

Mixed Use

The mixed-use analysis is particularly intriguing. Archistar's emphasis on wind ventilation analysis for apartments, ranging from cross ventilation to no ventilation, is a testament to its detailed approach. The tool's ability to highlight ground floor retail space further demonstrates its adaptability to diverse design requirements.

Fig 4.4: *Output masses, Mixed Use (Archistar.AI, 2023)*



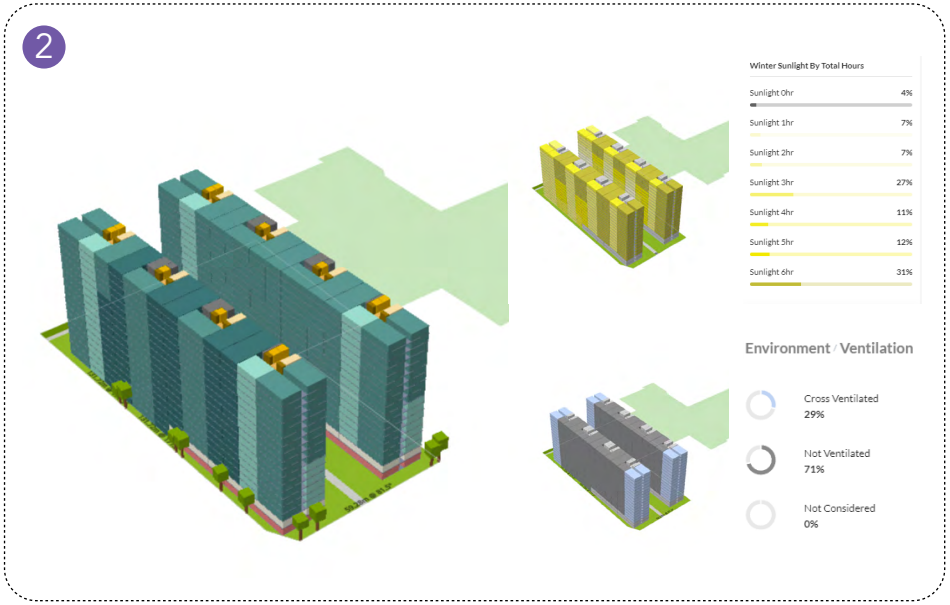




Fig 4.5: *Output masses, Commercial (Archistar.AI, 2023)*

1

Commercial 5



Footprint (ft)	6424m²
Commercial Area (ca)	22 000m²
Retail Area(ra)	3734m²
Coverage (cov)	57%
Gross floor area (gfa)	27 300m²

Commercial

Archistar's approach to commercial spaces is distinctive. While it doesn't incorporate solar or wind studies, possibly emphasizing retail over commercial space efficiency, the tool's outputs offer valuable insights. For instance, in example 1, the form's angular adjustments relative to the site edges suggest its adaptability to optimize for specific environmental factors, such as maximizing northern light exposure.

Given these insights and the tool's capabilities, I've chosen commercial as the primary typology for generating masses for my AI innovation center.

To further enhance my design process, I've begun analyzing these masses using Forma, which will be elaborated upon in the subsequent case study. This preliminary analysis with Forma aims to provide a foundational understanding, guiding my approach to the building's design in later stages.

2

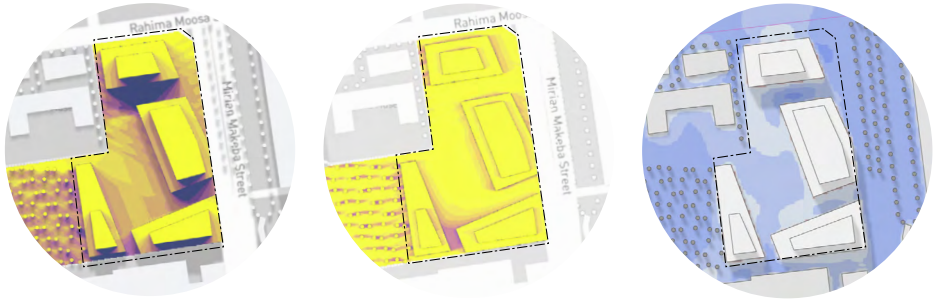
Commercial 5



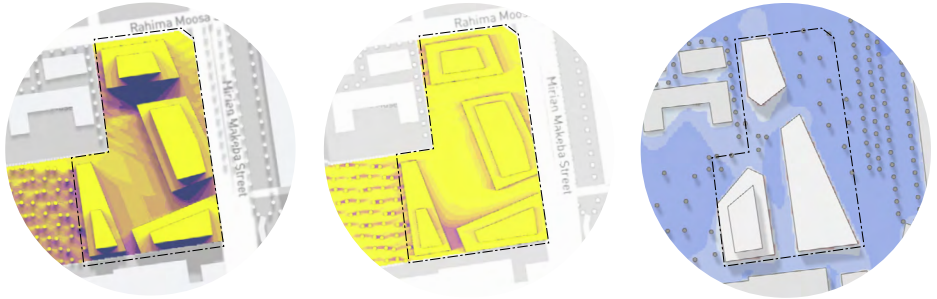
Footprint (ft)	8457m²
Commercial Area (ca)	36 900m²
Retail Area(ra)	6700m²
Coverage (cov)	75%
Gross floor area (gfa)	44 586m²

Fig 1 (Top)
AI Generated Masses - ArchiStarAI

Fig 2 (Bottom page)
Analysis studies - Forma Autodesk



1. Sun



2. Wind - North

5.7 Case Study

Autodesk Forma (Spacemaker): A New Approach to Generative Design in Architecture

Forma (Spacemaker) is an AI-powered platform that operates in the cloud, designed to assist architects and urban designers in generating and assessing design options swiftly. This platform's strength lies in its data-driven approach, analyzing vast datasets to produce optimized design solutions (dezeen staff, 2022).

Data-Driven Approach:
By analyzing data sets, including geographic data, zoning regulations, and environmental conditions, Spacemaker provides a comprehensive view of a project, allowing for designs that consider multiple variables simultaneously (dezeen staff, 2022).

Real-world Application:
Cobe Studio's use of Spacemaker exemplifies its practicality. The platform aids in filtering out unfeasible design concepts by generating multiple massing layouts and then analyzing them for factors like wind, light, and energy use (dezeen staff, 2022).

Generative Design Mass Tool:
Research indicates that while Spacemaker is efficient, its generative design mass tool is more basic compared to platforms like Archistar, due to fewer parameter options. This is visually demonstrated in figure 5.1.

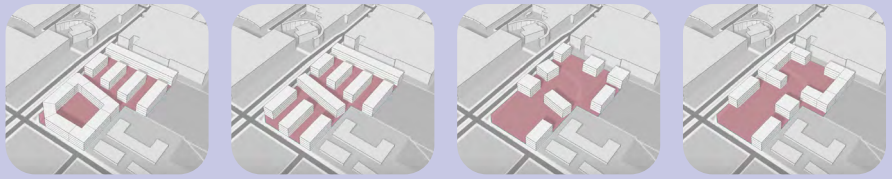


Fig 5.1: Generated masses, Newtown Site
(Forma, 2023)

Personal Application and Conclusion:
Upon exploration, I've discerned that while Archistar excels in creating detailed building masses, Spacemaker shines in site analysis. As showcased in figure 5.2, Spacemaker offers a range of analysis studies, making it a valuable tool for this purpose. My approach, therefore, will be to utilize Archistar for building mass generation and Spacemaker for comprehensive site analysis. This strategy ensures optimal utilization of both platforms, capitalizing on their respective strengths.

Challenges and Recommendations:
While Spacemaker offers valuable insights, it's crucial for architects to critically evaluate its outputs. As with all AI tools, understanding their capabilities and limitations is essential. The key is to use AI to enhance, not replace, the human element in design.

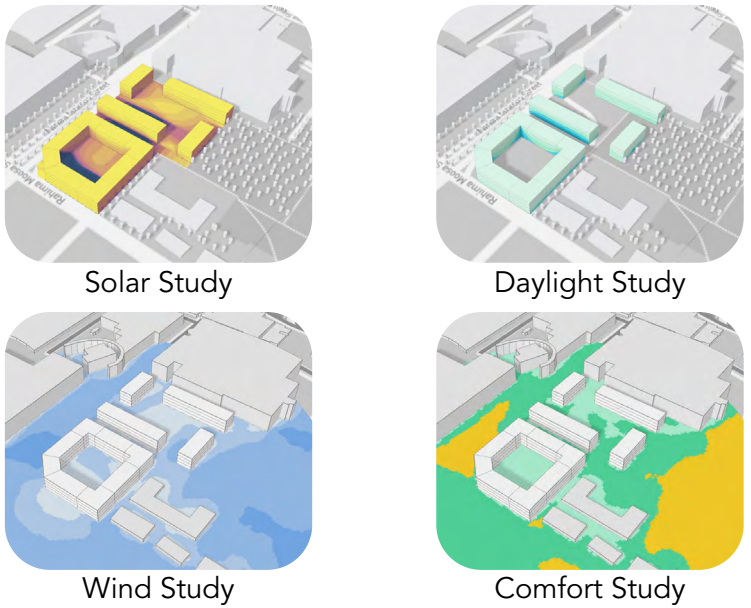


Fig 5.2: Site Analysis done by Forma
(Forma, 2023)

5.8 Case Study
Exploring AI-Generated Floor Plans in Architectural Design

The integration of AI-generated floor plans in architectural design is transformative. Tools like PlanFinder AI, released in 2023, and Hypar are reshaping the design process through automated optimization, offering architects a new avenue for conceptualizing floor plans and room layouts.

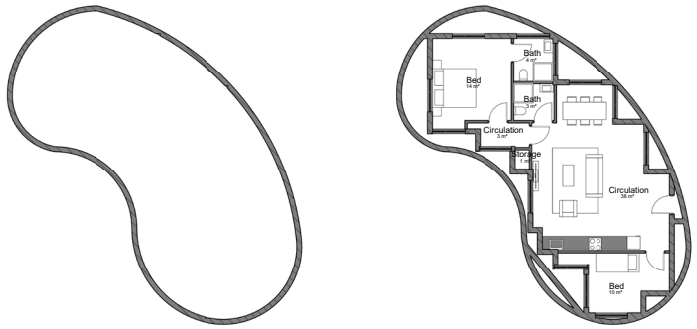
Benefits:
AI floor plan generators, with their capability for rapid experimentation and iteration, are revolutionizing the traditional design workflow. The flexibility in design options, real-time adjustments, and the integration of machine learning, are driving architectural innovation forward, embracing the technological advancements of our era.

Practical Application with PlanFinder AI:
To assess the capabilities of PlanFinder AI, I experimented by inputting organic shapes, pushing the tool's boundaries beyond its comfort zone of traditional block plan layouts. The results, as depicted in figure 6.1, are intriguing. While some layouts might not be optimal, they demonstrate the tool's potential and adaptability. It's fascinating to observe how the tool interprets organic forms, often converting them into straight walls to produce a viable plan.

Evolution and the Future:
PlanFinder AI, being a recent introduction in 2023, is in its nascent stages. However, its continuous learning and daily improvements, as stated on their website, are promising. Reflecting on the evolution of platforms like Midjourney in just a year gives us a glimpse of the potential trajectory for tools like PlanFinder AI. These rapid progressions align with the rules of singularity discussed in chapter 2, suggesting that the growth and expansion of such software are exponential.

Highlighting Hypar:
Hypar emerges as a notable tool in this landscape. Beyond mere floor plan generation, its holistic approach to design could be invaluable for projects like the AI innovation center.

The integration of AI in architectural design, especially in floor plan generation, signifies a pivotal shift in architectural practices. The current trajectory, combined with the exponential growth observed in platforms like PlanFinder AI, suggests a future where AI tools will be central to architectural innovation.



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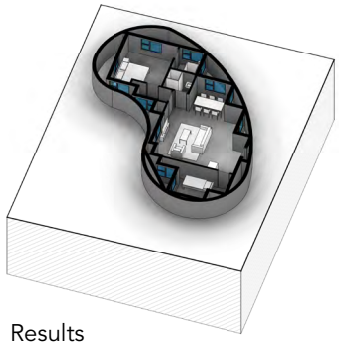
Results



Results

Fig 6.1:
Floor plan generator, Results derived from the programme 'Planfinder' (Author, 2023)

5.9 Case Study
Optimizing Architectural Design: Fusion 360 and Topology Optimization

Typology Optimization

Studying typology optimization in the context of an architecture thesis on AI in the design process is highly relevant. Typology optimization aligns with the growing trend of computational generative design strategies in architecture. This approach offers a powerful tool for creating elegant organic forms by determining voids in continuum structures. Not only does it enhance aesthetic possibilities, but it also ensures a performance-based design, aiming to find the most efficient structural form under defined conditions and volume constraints. However, it's essential to acknowledge potential challenges or limitations of TO to provide a balanced view.

Fusion 360: Experimentation

Upon researching, I found Fusion 360, a software suitable for my building design. Mastering Fusion 360's capabilities for TO presented a steep learning curve, demanding significant time and effort. However, the potential it offers and the results I've achieved make the endeavor worthwhile.

This software enables me to run simulations to test various aspects of my design. For instance, in my initial exploration with the software, depicted in Figure A, I simulated a traditional steel bracket. By indicating that the blue arrow represents a load in Newtons and the green circles as fixed supports, the simulation demonstrates the forces' flow through the bracket in an optimized manner. Such optimization not only conserves material, promoting sustainability, but also introduces an aesthetic appeal.

Traditional buildings often incur costs on structural aspects, later adding materials and facades for design enhancement. Using this method, I can innovatively approach structure and aesthetics, resulting in cost

Figure A

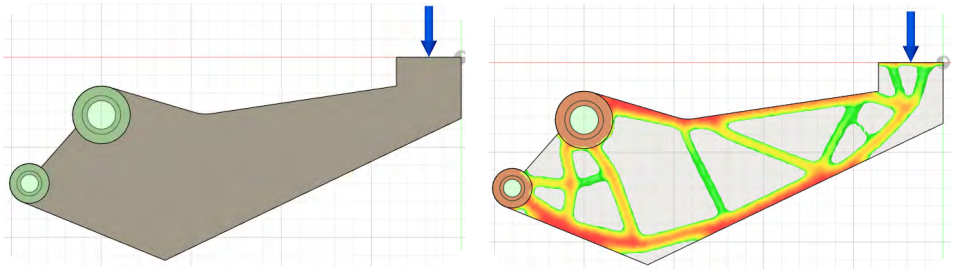
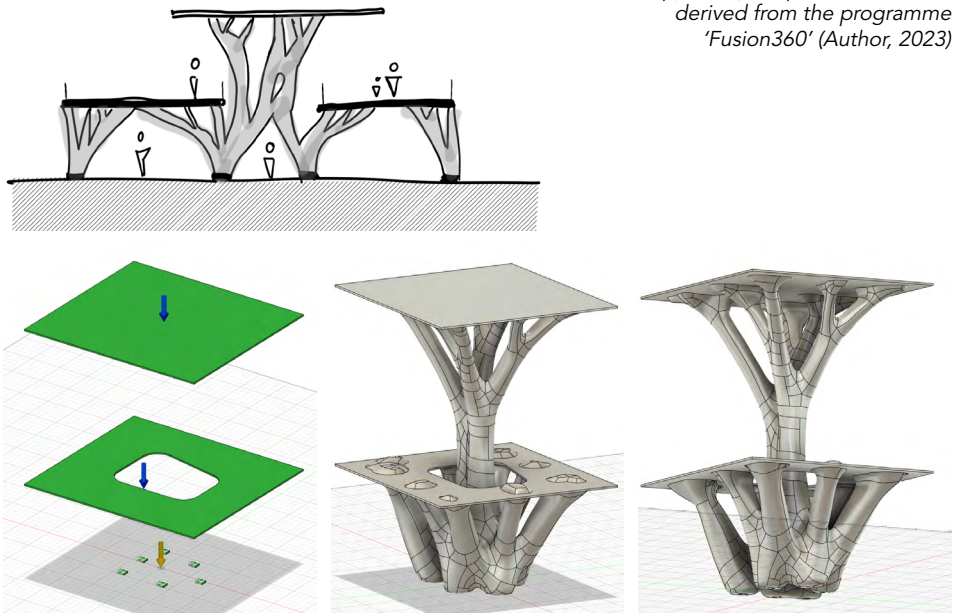


Fig 7.1:
First exploration, Results derived from the programme 'Fusion 360'(Author, 2023)

Figure B

Fig 7.2:
Canopy Design exploration. Results derived from the programme 'Fusion360' (Author, 2023)



and sustainability benefits. I intend to delve deeper into this simulation approach for my innovation center design.

In my subsequent experiments, Figures B and C illustrate my growing proficiency with the software. Figure B showcases how I might design canopies around my innovation center, drawing inspiration from the construction methods seen in the Qatar National Convention Centre (QNCC) precedent. Figure C, a smaller-scale exploration, envisions the potential use of TO for features like staircases or bookshelf brackets. The practicality and construction methodologies for these designs will be discussed in the "Design Development" chapter.

Figure C

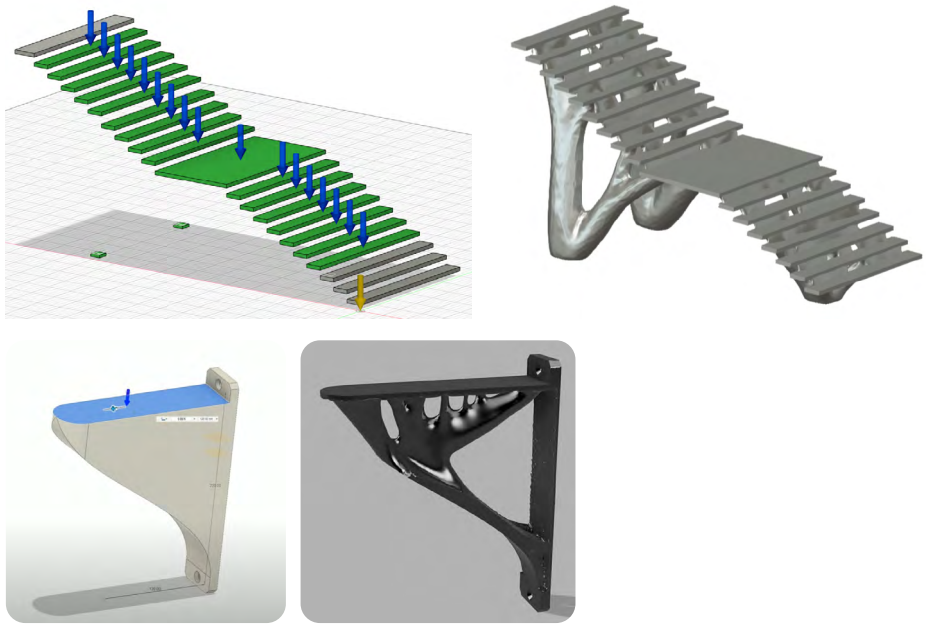


Fig 7.3:
Bracket + Stairs Design exploration. Results derived from the programme 'Fusion360' (Author, 2023)

Precedent: Qatar National Convention Centre (QNCC)

Topology Optimization (TO) has been making waves in the architectural realm, enabling architects to pioneer innovative solutions across various scales. Central to TO is its ability to birth unconventional structural typologies, which stand out not just for their aesthetic appeal but also for their sustainable approach, given the efficient material usage.

A prime example of TO's prowess is seen in the Qatar National Convention Centre (QNCC). This edifice is particularly noteworthy as it represents the zenith of TO application in architectural design, boasting the title of the largest structure ever crafted using TO tools. As noted by Januszkiewicz in 2013, this structure remains unparalleled in its scale achieved through TO tools. The incorporation of TO, with its foundation in engineering computational methods, into architectural practices heralds a fresh design thinking paradigm. It marries performance evaluation with generative parameters, providing architects with the arsenal to challenge and redefine traditional design boundaries, paving the way for structures that are both sustainable and avant-garde.



Fig 7.4:
Qatar National Convention Centre (Unknown, 2013)

5.10 Research Conclusion:

The fifth chapter of the research delves deep into the transformative role of AI tools in the architectural design process. The chapter's exploration is comprehensive, touching upon various facets of AI's integration into architecture, from generative design to the application of Generative Adversarial Networks (GANs). Here's a synthesized conclusion based on the chapter's content:

1. Generative Design Paradigm Shift: Generative design, powered by AI, has ushered in a new era in architectural design. Unlike traditional methods that are rooted in a designer's expertise, generative design begins with design goals, allowing AI to shape the model. This approach not only streamlines the design process but also introduces innovative solutions that might not be immediately evident through traditional methods.

2. Prominence of GANs: Among various AI models, GANs have emerged as a significant player. Their ability to produce creative outputs, typically associated with human creativity, has made them a favorite in the arts and design sectors. In architectural contexts, GANs can be harnessed for tasks like generating floor plan designs, showcasing their versatility.

3. Case Studies Insights:

- Stanislas Chaillou's Exploration: Demonstrates the potential of GANs in architectural design, particularly in crafting floor plans and orchestrating spatial layouts.
- Midjourney's AI Image Generators: Highlights the challenges and biases inherent in AI image generators, emphasizing the need for critical evaluation.
- Stable Diffusion: Offers an open-source platform for text-to-image generation, making it a flexible and versatile tool for architects.
- Archistar.ai: Exemplifies the potential of integrating AI into architectural design, especially in terms of rapid visualization and iteration.
- Forma (Spacemaker): Demonstrates the power of a data-driven approach in architectural design, providing comprehensive insights for projects.
- PlanFinder AI & Hypar: Signify a pivotal shift in architectural practices, with AI playing a central role in floor plan generation.
- Fusion 360 and Topology Optimization: Introduces a novel approach to design, merging structure and aesthetics, resulting in cost and sustainability benefits.



4. The Power of Prompts: Crafting effective prompts is crucial for harnessing the full potential of AI image generators in architectural design. An effective prompt should be clear, concise, and specific, guiding the AI model to produce the desired outcome.

5. Challenges and Recommendations: While AI tools offer transformative potential, it's essential to approach them with a critical lens. Understanding their capabilities and limitations is crucial. AI should be viewed as a tool to enhance, not replace, the human element in design.

6. Future Outlook: The rapid evolution of AI tools, combined with the exponential growth observed in platforms like PlanFinder AI, suggests a future where AI will play an even more significant role in shaping architectural design. However, ensuring culturally sensitive and accurate design outputs will remain a paramount responsibility for architects leveraging these AI-driven tools.

In conclusion, the integration of AI tools in architectural design is not just a trend but a paradigm shift. These tools, with their ability to rapidly iterate, optimize, and introduce innovative solutions, are revolutionizing the architectural landscape. However, as with all tools, they come with their set of challenges. It's up to the architectural community to harness their potential responsibly, ensuring that the designs they produce are not only innovative but also culturally sensitive and contextually relevant.



Fig 6.1:
All images Midjourney AI images generated using prompt "innovation center programme analysis diagram architecture" (Author, 2023)

06

PRECEDENT STUDIES

EXPLORING INNOVATION SPACES AND THEIR DESIGN

In the digital age, technology, particularly Artificial Intelligence (AI), has emerged as a transformative force, redefining the paradigms of learning, collaboration, and architectural design. As architects grapple with the integration of these technological advancements, the challenge lies in ensuring that innovation spaces not only harness the power of technology but also remain rooted in human-centric principles. These spaces, pivotal in the modern economy, serve as mirrors reflecting cultural, demographic, and economic shifts (Wagner & Watch, 2017).

With the rise of innovation hubs and centres, multiple challenges emerge:

Incorporating the latest technologies, how can architects ensure that these spaces are contributing to creativity?

Neglecting the human-centric aspect of innovation presents a potential risk. How do we address this?



prompt "workspace innovation space interior"(Author, 2023), Midjourney



prompt "restaurant innovation space interior"(Author, 2023), Midjourney



prompt "library innovation space interior"(Author, 2023), Midjourney



prompt "laboratory innovation space interior"(Author, 2023), Midjourney



prompt "wood workshop innovation space interior"(Author, 2023), Midjourney

This chapter endeavors to answer these questions through a multi-faceted approach:

1. Innovation Spaces and Architectural Design: Drawing insights from Wagner & Watch's "The New Design of Work," we explore the evolution and design priorities of innovation spaces, emphasizing the balance between aesthetics, functionality, and human interaction.

2. Real-world Application - Wits University's Tshimologong Precinct: A case study approach delves into the operational successes and challenges of a real-world innovation hub, offering tangible insights into the integration of technology and space.

3. Insights from an Anonymous Innovation Precinct: Through interviews with representatives of a leading innovation precinct in South Africa, we gain a deeper understanding of the challenges and opportunities of designing innovation spaces in the age of AI and digital transformation. This section provides a unique perspective on the practicalities of integrating AI into architectural and programmatic frameworks.

4. AI's Transformative Influence on Innovation Spaces: This section underscores the profound impact of AI on various sectors, from restaurants and libraries to universities. By examining specific examples, we highlight the architectural implications of AI, emphasizing the need for spaces to evolve in response to AI-driven operational changes.

Purpose:

This chapter seeks to illuminate the significance of innovation spaces in the contemporary architectural landscape. By examining their evolution, design principles, and the interplay between their physical layout and the activities they host, we aim to provide a comprehensive understanding of how these spaces can be designed to foster optimal collaboration and innovation in an AI-driven world.

Fig 6.2:
AI image generated, prompt as showen from Author, (Midjourney, 2023)

6.1 The Evolution of Innovation Spaces

Historical Context:

A transformation has occurred in traditional workspaces once regimented by cubicles and solitary offices. The modern era marked by various discipline convergence and the need for spontaneous interactions has led to the emergence of collaborative hubs termed as innovation spaces (Wagner & Watch, 2017).

The Shift in Design Priorities:

Aesthetics are still considered important but functionality flexibility and the promotion of interactions top the priority list in designing innovation spaces. According to Wagner & Watch (2017), focus has moved away from individual desktops; instead highlighting shared regions transparent architecture features along with environments merging job relaxation and social exchanges.

Programming's Role in Innovation Spaces

The Link between Design and Programming:
Just one aspect of the success of an innovation space is its physical design. Programming with events trainings and meetups plays a crucial role by bringing the space to life fostering interactions and ensuring promotion of innovation as intended Wagner & Watch 2017 says. Through interviews of an existing Innovation center discussed later, we cover and highlight this aspect in the same chapter.

The Anatomy of Innovation Spaces

The Building's Bones:
In her illustration "bones of the building", Julie Wagner underscored how significant a building's layout like shape, size and height is to regulate ease and frequency of direct human interaction. It implies that physical

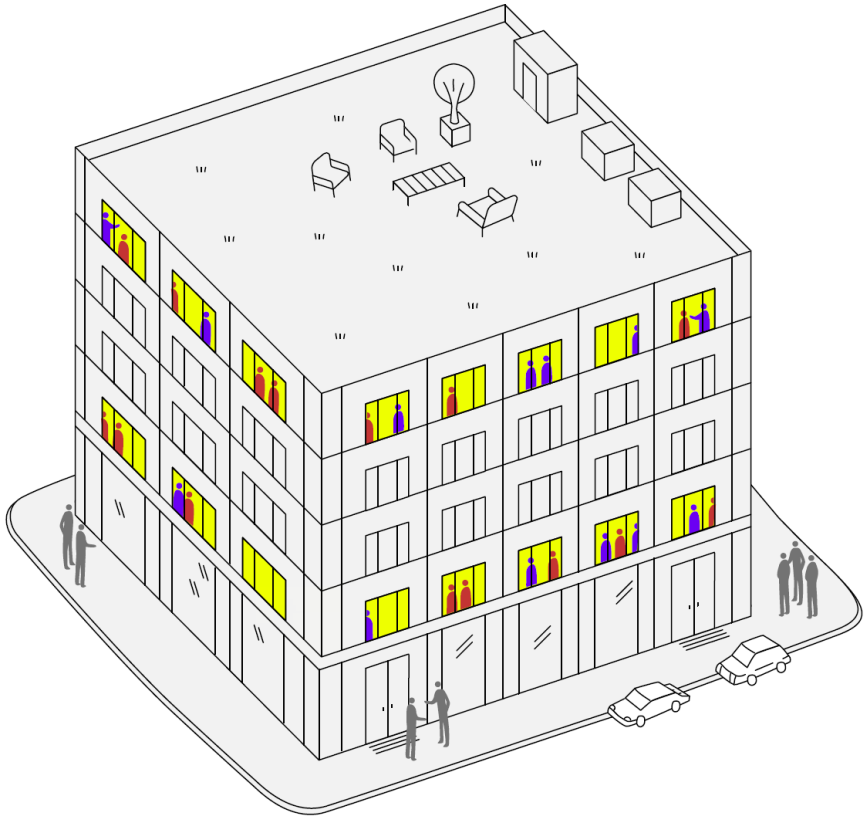


Fig 6.3:
Workers on different floors will simply not bump into each other as compared to workers on the same floor (J.Wagner, 2023)

boundaries incorporated inside buildings could promote or obstruct unexpected conversations vital for innovative ideas.

Vertical vs. Horizontal Spaces:
Wagner discusses research that shows vertical separation in buildings can impact interaction more than horizontal separation. To promote spontaneous encounters Wagner & Watch recommended single-story or same-floor configurations in their 2017 study.

The Atrium:
An atrium can effectively reduce barriers between floors as a strategy. The visuals between spaces are clearer when you remove part of the floor section which is usually the core. Interactions across different floors can be promoted by a well-designed atrium acting as a leveller. Per Wagner & Watch (2017), crucial factors for the success of an atrium as a connector are the design specifics namely its noise levels and uses.

Internal Staircases:
Historically grand staircases once relegated to the peripheries of buildings are now being revived and positioned centrally. When staircases are designed to be wide and aesthetically appealing they become interaction hubs that facilitate encounters while individuals move from one floor to another as stated by Wagner & Watch (2017).

Corridors:
We can design corridors strategically to encourage serendipitous encounters. In some innovation spaces, corridors are designed to lead towards the central area thus promoting interaction among people passing through. Corridors can be designed to minimize noise in certain zones or they can evolve into unstructured gathering places as stated by Wagner & Watch in 2017.

Thoroughly exploring the physical aspects of innovation spaces reveals that these design elements are more than just trends and have proven their success at fostering innovation and collaboration. I intend to incorporate these insightful findings into my innovation center design. Using this foundation we should now focus on delving deeper into understanding how these spaces foster collaboration and what strategies can maximize their potential.

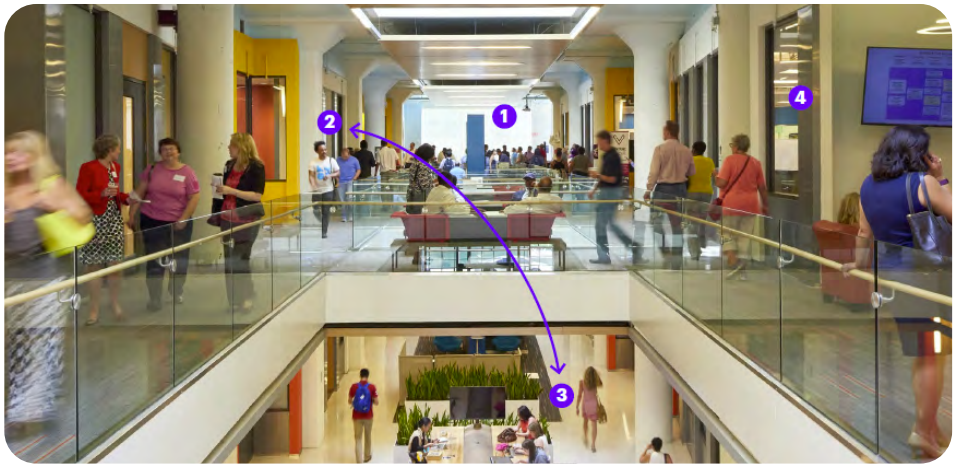


Fig 6.4:
This atrium creates new connections between two floors @4240 in St. Louis. (1) Natural light can reach lower floors; (2&3) Workers and visitors on different floors are much more connected to each other; (4) Open spaces allocated for quiet work should not be located near an atrium. Photo credit: Romondo Davis. (J.Wagner, 2017)

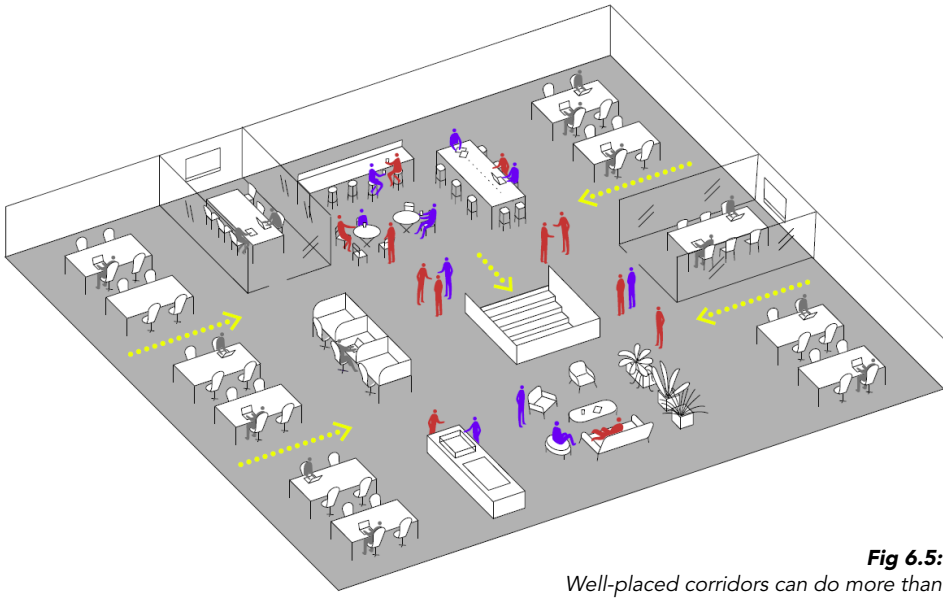


Fig 6.5:
Well-placed corridors can do more than help circulate people they can help facilitate unexpected encounters. (J.Wagner, 2017)

6.1.1 Dynamics of Collaborative Work Settings

Team Mixing Through Design:

In fostering collaboration and interdisciplinary interactions, the spatial strategies employed in innovation spaces bear great importance. Either facilitating or hindering seamless integration of diverse disciplines could be a result of these spaces' design causing enhanced communication and collaboration.
Example: Wagner & Watch noted in 2017 that Stanford's Clark Center gives importance to spatial design because it fast-tracks collaborations between diverse fields like biology engineering and computer science.

Techniques to Facilitate Mixing and Collaboration:

Seating Charts: To foster interactions, some managers put together researchers from a wide range of specializations strategically.
Neighborhoods or Pods: Researchers in certain workspaces are organized into specific zones where they share equipment and supplies which promotes conversation.
Open Work-Floor Settings: By removing physical barriers in places such as advanced manufacturing incubators and maker spaces we can encourage spontaneous interactions and collaborations.
Reconfigurable Areas: Spaces such as the Clark Center at Stanford aim to be regularly adaptable accommodating diverse departmental group formations.

Embracing Flexibility in Design:

Innovation processes need flexibility in space design due to continuous change. We need to consider every part of the space such as movable walls and adaptable furniture for this.

The Role of Wheels: Emphasis on mobility and adaptability highlights the resurgence of wheels in the 21st century especially in incubators and co-working spaces. Using furniture and equipment on wheels one can quickly reconfigure settings according to immediate needs.

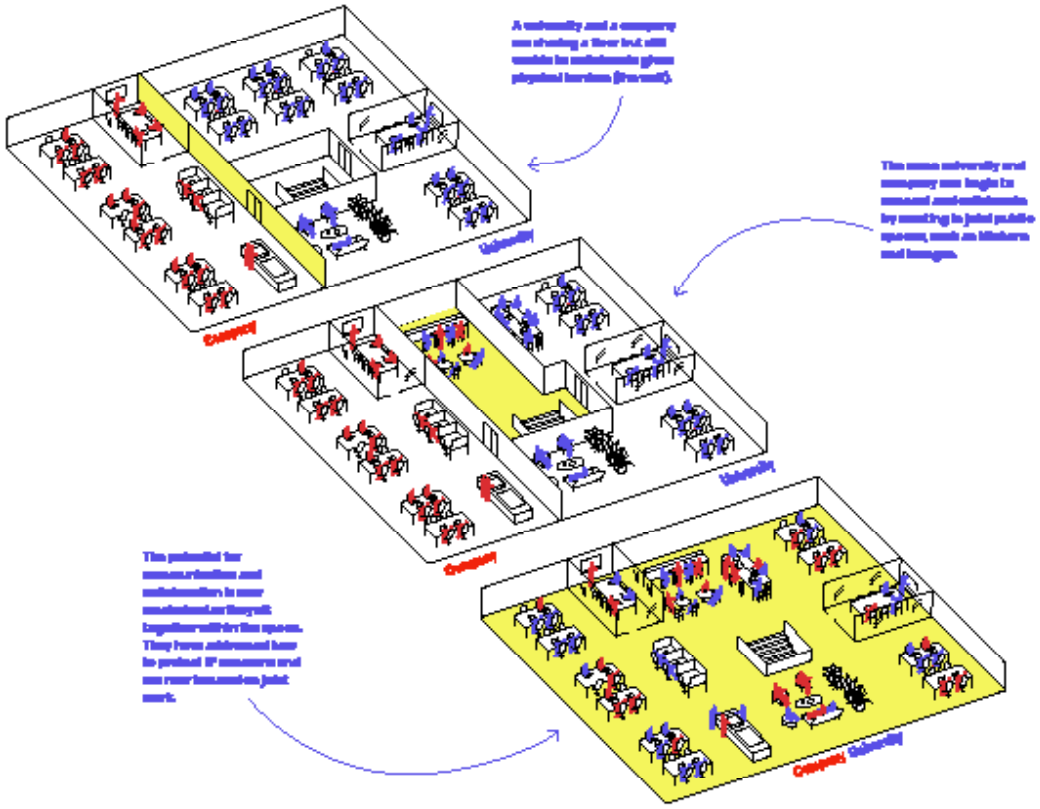


Fig 6.6:
illustration of successful spaces based on what one would want to achieve and how to approach it. by (J.Wagner, 2017)

Spatial strategies such as those used by Stanford's Clark Center deeply impact interdisciplinary collaboration according to the study. Key takeaways emphasize on the significance of flexible seating arrangements that enhance interactions along with the development of 'neighborhoods' fostering organic conversations and adjustable work settings valuing openness. Design elements like wheels for mobility and the capacity to freely alter spaces underscores the importance of flexibility in innovation centers. Moving forward with the innovation center's design these insights will guide me in creating a current and future-ready space.

6.2 Precedent Study: Tshimologong Precinct

Located in the heart of Braamfontein, Johannesburg, the Tshimologong Precinct emerges as a symbol of digital innovation and creativity. Established through a collaborative effort between the University of the Witwatersrand and various partners, its strategic positioning amidst businesses and student residences makes it a vibrant hub for technological advancement and entrepreneurial spirit (tshimologong.joburg, 2021).

Significance & Offerings:
Deriving its name from Setswana, "Tshimologong" translates to "New Beginnings". This encapsulates the precinct's overarching mission: to serve as an incubator for startups and to spearhead African digital innovation through synergies between academia, corporate entities, and governmental bodies (studyinternational.com, 2016). By drawing inspiration from global digital hubs, the precinct aspires to create a unique African footprint in a domain traditionally overshadowed by giants like Silicon Valley.

Facilities within the precinct are diverse and tailored to foster innovation. From coworking spaces equipped with high-speed internet to computer labs, meeting rooms, workshops, and a café, the precinct offers an environment conducive to knowledge exchange, networking, and collaborative ideation (Moodley, 2015).

Events & Collaborations:
A hallmark of the Tshimologong Precinct is its dynamic event calendar, designed to dismantle barriers for emerging African tech businesses and entrepreneurs. With events such as Hack.Jozi, collaborations with Microsoft's AppFactory, IBM's Living Lab, and various gaming incubators, the precinct is committed to nurturing talent and promoting digital skill sets (Moodley, 2015; ITWeb, 2022).

However, the Fak'ugesi African Digital Innovation Festival stands out as the precinct's flagship event. Rooted in the confluence of technology, art, and African culture, this festival serves as a platform to amplify African narratives, stories, and innovations, positioning the continent as a leader in global digital creativity (Manaleng, 2022).



Fig 6.7:
External and Internal photographs of the Tshimologong Precinct

Relevance to the AI Innovation Center:
The success and approach of the Tshimologong Precinct provide invaluable insights for the design and operational strategy of the proposed AI Innovation Center. The precinct's emphasis on collaboration, community engagement, and fostering a conducive environment for innovation can be mirrored and enhanced upon in the AI Center's design. Furthermore, the precinct's partnerships and collaborations with tech giants and academic institutions can serve as a blueprint for potential funding and support avenues for the AI Innovation Center. The integration of art, culture, and technology, as showcased by the Fak'ugesi Festival, underscores the importance of a holistic approach, which the AI Innovation Center can adopt, ensuring that technological advancements are deeply rooted in cultural and societal contexts.

6.3 Insights from an Anonymous Innovation Precinct: Adapting to the AI Era

From the interviews conducted with representatives of a leading innovation precinct in South Africa, several key insights emerged regarding the design and functionality of innovation spaces in the age of AI and digital transformation.

The precinct, while boasting a comprehensive infrastructure, has identified areas for improvement, particularly in fostering collaboration and networking. The representative noted, "While the space, by itself, is technically sufficient – the layout could be improved to encourage networking and collaboration, securely store resources, avoid sound pollution/interference, and heighten its visibility." (Interview A, 2023)

The precinct's approach to integrating AI and technology underscores the potential of AI in streamlining processes and enhancing user experience. The representative shared, "Staff have undergone informal training on how to use AI platforms like ChatGPT. Many entrepreneurs in the co-working space and Makerspace use AI platforms or develop AI models, as well as other emerging technologies like blockchain." (Interview A, 2023)



Fig 6.9: *AI image generated, prompt "Collaborative workspace with AI enhancements" from Interviewee, by Author (Midjourney, 2023)*



Fig 6.8: *AI image generated, prompt "Innovation Precinct integrating AI technologies" from Interviewee, by Author (Midjourney, 2023)*

Furthermore, the frequency and variety of events held at the precinct emphasize the need for versatile spaces. The representative stated, "There is usually about one or two events per week. Often these are simply hosted at our premises and not organised by [the precinct]. Of those that are organised by [the precinct], there are about 20-30 per year (incl virtually)." (Interview A, 2023)

Feedback from the precinct also highlighted the potential of AI in the design and functionality of innovation spaces. The representative suggested, "I think the easiest thing to implement which will have the most measurable impact would be to incorporate AI/IoT into venue bookings, tour bookings, user access and identification." (Interview A, 2023)

By analyzing the experiences and insights shared by the representative of this anonymous innovation precinct, the design of the AI Innovation Centre can be informed, refined, and optimized to address the unique challenges and opportunities of integrating AI into architectural and programmatic frameworks.

6.4 AI's Role in Modern Innovation Spaces

The rapid evolution of Artificial Intelligence (AI) is reshaping the landscape of various sectors, including the architectural design and functionality of innovation spaces. As AI continues to permeate different areas of our lives, its integration into innovation spaces can lead to enhanced efficiency, improved user experiences, and the creation of more adaptable environments.

Relevance to Architectural Design:
The transformative power of AI is not just about automating tasks or enhancing user experiences; it's about reimagining the very spaces we inhabit. The architectural implications of AI are profound, influencing design considerations, spatial configurations, and user interactions within these spaces. This section delves into specific examples that highlight these architectural implications.

A. AI in Restaurants: Sweetgreen's Robotic Infinite Kitchen and More

Sweetgreen's Robotic Infinite Kitchen is a testament to how AI can revolutionize the restaurant industry. This innovative approach not only streamlines operations but also redefines the spatial layout and user journey within the restaurant. The integration of robotics and AI demands a rethinking of kitchen design, customer interaction zones, and seating arrangements.

Proposal for AI Innovation Center: Incorporate a prototype restaurant where the hospitality sector can experiment with AI-driven systems. This will serve as a testing ground for businesses and offer a glimpse into the future of dining for visitors. Such a space can demonstrate how architectural design needs to evolve in response to AI-driven operational changes.



Fig 6.10: Sweetgreen's robotic Infinite Kitchen
(Sweetgreen,2023)

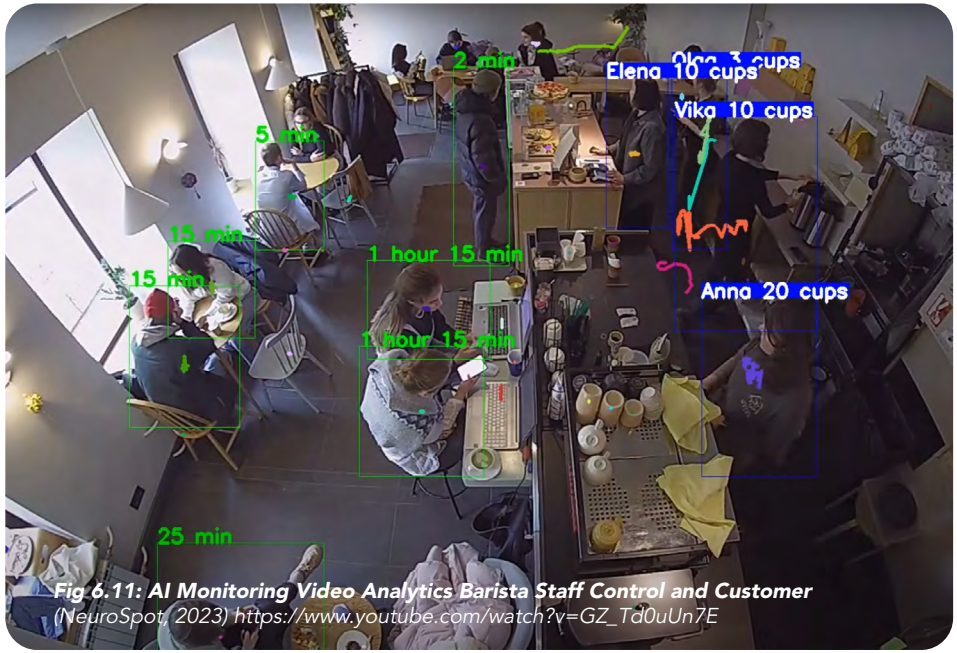
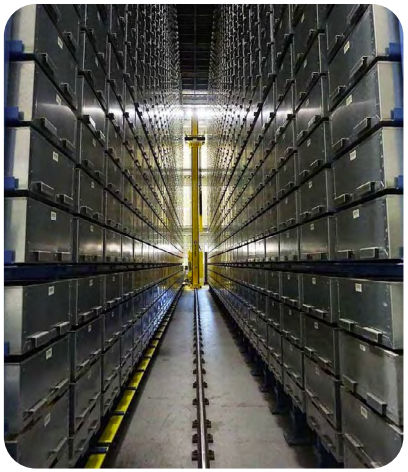
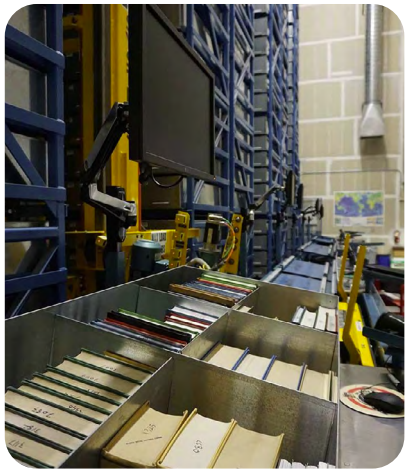


Fig 6.11: AI Monitoring Video Analytics Barista Staff Control and Customer
(NeuroSpot, 2023) https://www.youtube.com/watch?v=GZ_Td0uUn7E

Fig 6.12: Automated Storage and Retrieval System







B. AI in Libraries: Automated Storage and Retrieval Systems (ASRS)

Libraries like the University of Chicago's Mansueto Library have adopted ASRS, showcasing a radical shift in how libraries are spatially configured. Instead of vast open shelves, books are stored efficiently in compact spaces, retrieved by robots upon request. This not only saves space but also allows for more versatile use of the available area, transforming the traditional library experience.

Proposal for AI Innovation Center: Integrate an ASRS-driven library, highlighting innovative typologies for library design. Such a system would be a visual testament to the blend of tradition (books) and modernity (AI), emphasizing the architectural adaptability required in the AI era.

C. AI in Universities

Universities are leveraging AI for personalized learning, administrative tasks, and research. This shift has implications for classroom design, research labs, and common areas. For instance, AI-driven personalized learning might demand more modular and adaptable learning spaces, while AI in research could necessitate specialized labs.

Proposal for AI Innovation Center: Collaborate with institutions like Wits University to establish spaces where AI-driven educational research and experiments can be conducted. The architectural design of such spaces would need to be flexible, accommodating a range of AI-driven activities from personalized learning sessions to large-scale data analyses.

The intersection of AI and architectural design presents both challenges and opportunities. As we've explored, AI's influence on restaurants, libraries, and universities necessitates a reimagining of spatial configurations, user interactions, and design priorities. The AI Innovation Center stands as a beacon for this architectural evolution, demonstrating how spaces can adapt to technological advancements while still prioritizing human-centric design. As the broader thesis suggests, the architectural implications of AI are profound, and the AI Innovation Center serves as a tangible manifestation of this future-forward vision.



Fig 7.1:
Site plan of Newtown (Author, 2023)

07

GROUND ZERO

NEWTOWN DESIGN PRINCIPLES

As a testament to urban regeneration and cultural evolution, Newtown serves vibrantly in the heart of Johannesburg. Being historically rich and strategically positioned near Wits University made this area a hub of cultural and commercial activity. Each striving to rejuvenate its landscape and increase Newtown's socio-cultural importance over the decades has been a goal of numerous urban planning projects. Despite its illustrious past, ripe for transformation is the currently underutilized space that Newtown's context reveals. The selected site of the Innovation Centre offers a golden opportunity to drive urban regeneration. Not only does the AI Innovation Centre have potential backing from entities like Sci-Bono and inherent proximity to academic institutions, it's also poised for breathing new life into Newtown. Intellectual growth along with economic progress could be catalysed by this institution as well which also supports seeding a thriving culture of innovation.

7.1 Regional and Local Context

Fig 7.2:
Macro Context (Author, 2023)

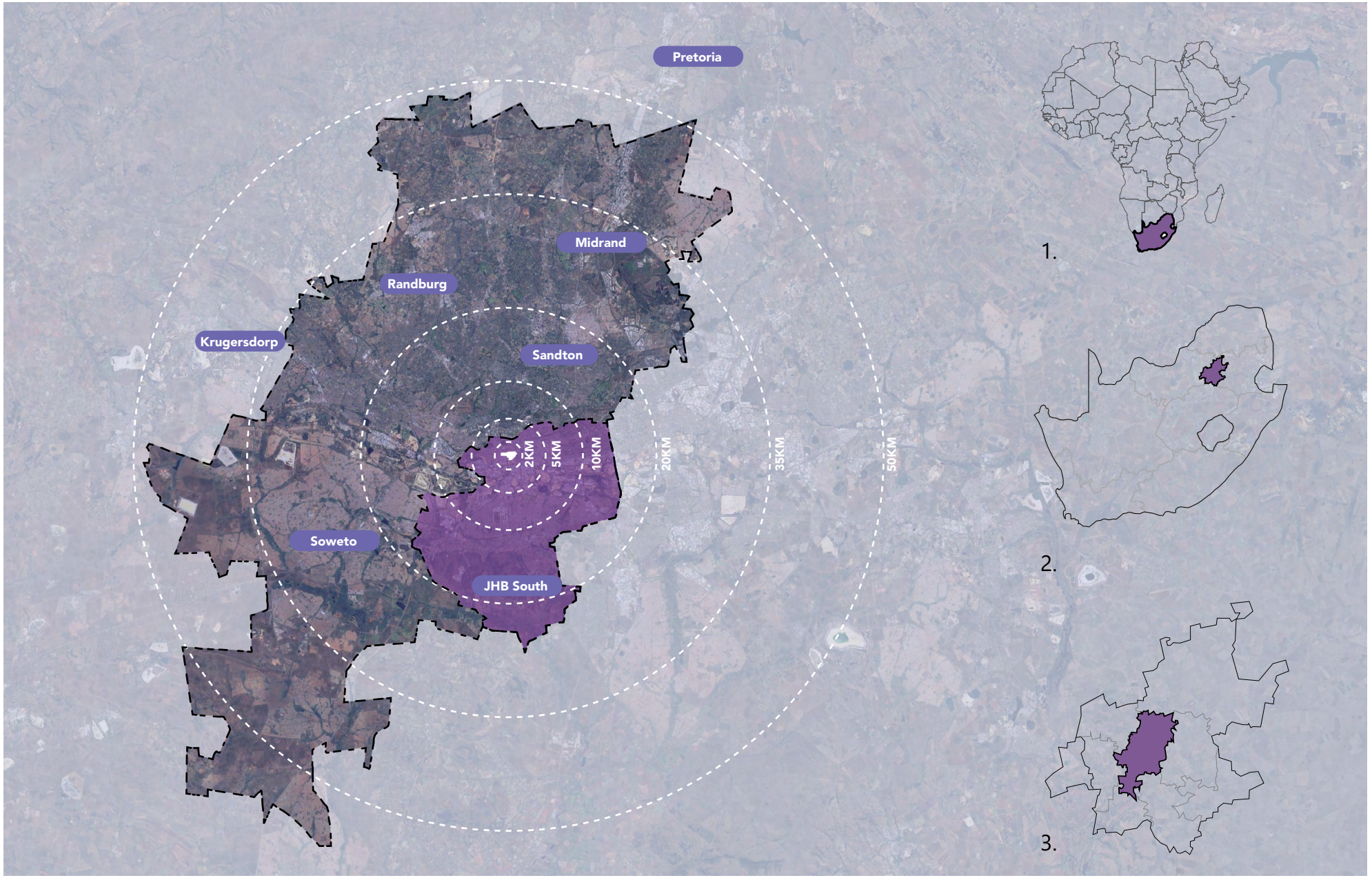
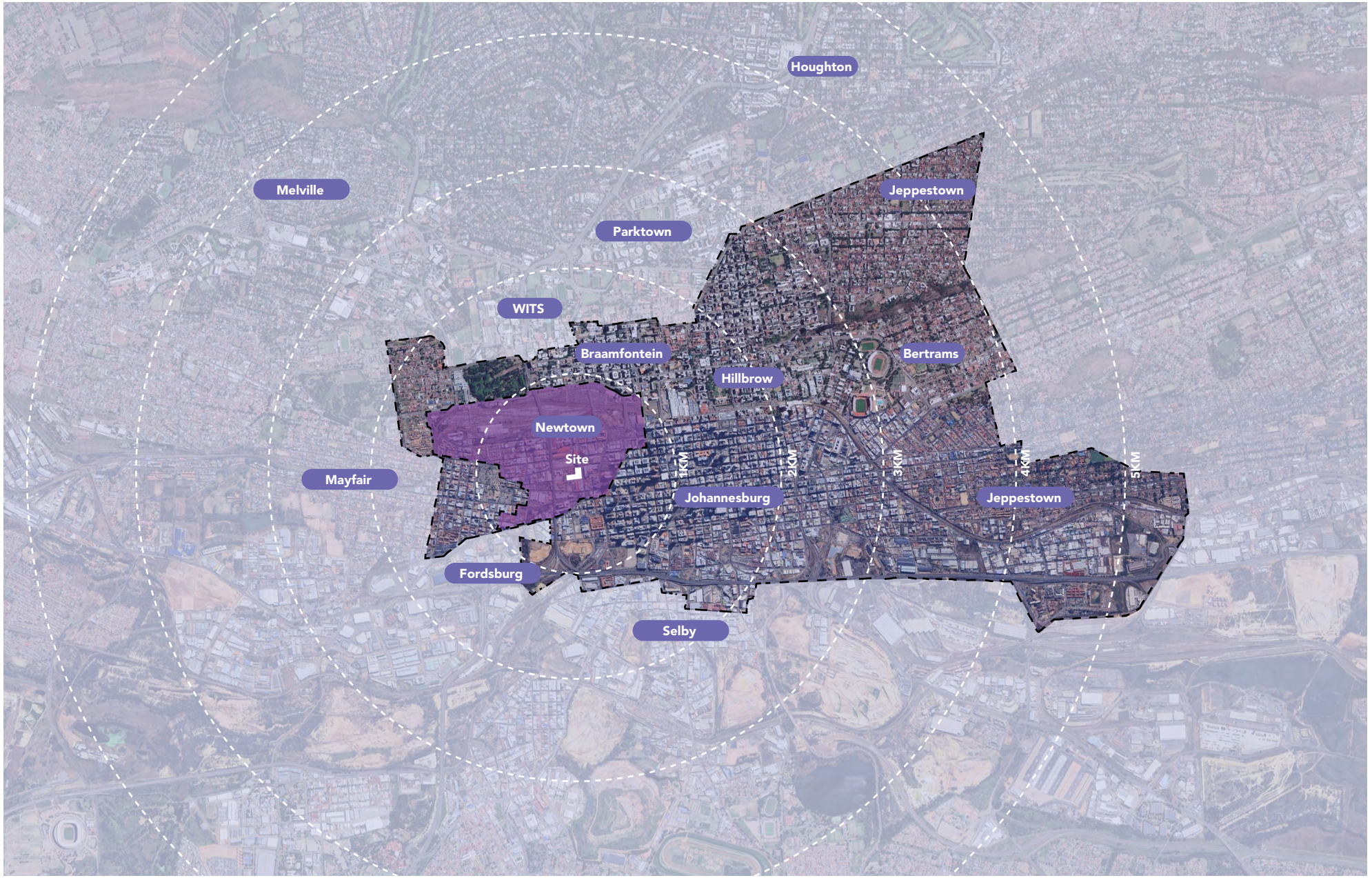


Fig 7.3:
Inner-City Context (Author, 2023)



7.2 Newtown's Evolution: A Snapshot

Drawing from findings by Lemon Pebble Architects (2018), several key urban planning projects have shaped Newtown's trajectory:

- Newtown Urban Design Framework, 1999:

GAPP Architects and Urban Designers for City of Johannesburg and National Department of Trade and Industry

Highlighting the revitalization of existing urban fabric first then progressing with creating quality public spaces to concluding with establishing an environmentally friendly atmosphere geared towards arts and cultural activities is what this framework's details entail.

- Newtown Cultural Precinct Urban Design Plan, 2001:

GAPP Architects and Urban Designers for City of Johannesburg

With the aim of promoting mixed-use environments and residential opportunities, a more detailed plan focuses on integrating key activities in Newtown while also forging connections to nearby territories.

- Newtown North Urban Design Framework, 2005:

Urban Solutions Architects and Urban Designers/GAPP Architects and Urban Designers for Johannesburg Development Agency and Propnet

This plan aimed at creating a distinct identity for the precinct and establishing linkages with the greater inner city by proposing mixtures of land use and public space interventions.

- Newtown Development Framework Review, 2015 (Draft):

GAPP Architects and Urban Designers for Johannesburg Property Company

This framework aimed at re-integrating the cultural district of Newtown and was more focussed towards developing properties on municipally owned parts of the land in Newtown.

Additionally enhancing our understanding are smaller precinct specific plans. Examples can include projects like: The Inception of an Urban design plan specifically concentrated on Brickfield's residential neighbourhood dated back from 2003, a separate one focused at central place located next to mu chosen site from the same year along with few others including market theatre development & Pim street urban framework both laid down during 2005 ending it up with re-establishing structure for Africa Museum space within Newtown. These all contributed significantly towards adding more detailed & comprehensive layers to Newtown's history of urban regeneration.

Cycles of revitalization followed by periods of stagnation have been experienced in Newtown despite these numerous interventions. Although bringing a wave of development and promise initially, each project's momentum eventually waned over time leading to periods of stagnation or decline.

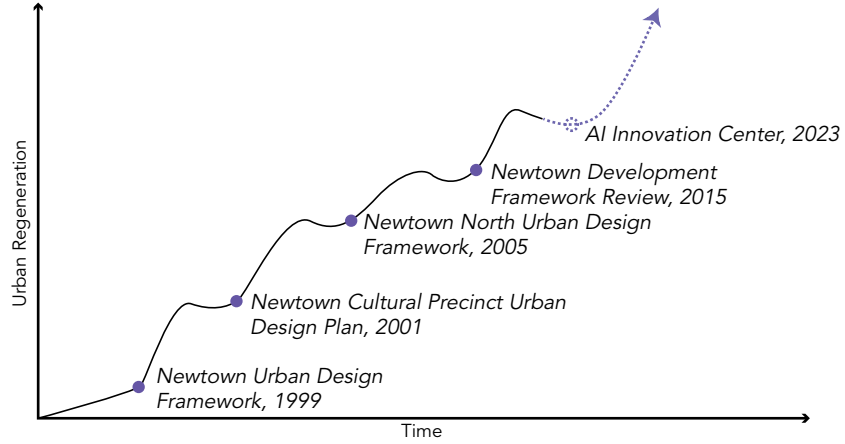


Fig 7.4: *Line graph showing Newtowns Urban Regeneration projects of the years (Author, 2023)*

In this context, it is that the proposal for an AI Innovation Centre in Newtown emerges. The introduction of the AI Innovation Centre provides an opportune time for strategy as it coincides with when the precinct finds itself at an important intersection waiting for its subsequent transformation. Propelling Newtown into a future full of possibilities; this centre could serve as enormous groundwork for an era of growth & innovation. It builds on previously established parameters hence promoting sustainable city revival.

Origins:
In the late 1880s, Brickfields emerged, known for brick manufacturing, housing diverse unskilled laborers. By 1896, these residents were displaced for a new railway (Newtown.co.za, n.d.).

The Rebirth as Newtown:
Following the removals and subsequent demolition of the Brickfields slums, the Johannesburg town council embarked on an ambitious project. They envisioned a new district, which they christened "Newtown" (Newtown.co.za, n.d.). This new district was marked by the construction of a grand market building, touted as the largest of its time. Additionally, a power station was erected, complete with electric workshops, a turbine hall, and residential quarters for workers. This transformation positioned Newtown as a pivotal agricultural trading and industrial hub. Many of the structures from this era have been preserved and repurposed for modern-day tourism and commercial activities (Newtown.co.za, n.d.).

Cultural Revival in the 1970s:
The 1970s saw the market evolve into the Market Theatre, Johannesburg's pioneering non-racial theater. The Africana museum was established, and Mary Fitzgerald Square became a flea market hotspot. This era solidified Newtown's cultural identity (Newtown.co.za, n.d.).

Challenges of the 1990s:
Despite its cultural prominence, Newtown faced decline in the 1990s due to management issues, dwindling businesses, and infrastructural challenges (City of Joburg and Johannesburg Development Agency, 2019).

Looking Ahead:
Today, there's a renewed focus on revitalizing Newtown. Efforts are underway to reinvigorate its cultural status and restore its vibrancy, ensuring that Newtown's rich history continues to inspire future generations.

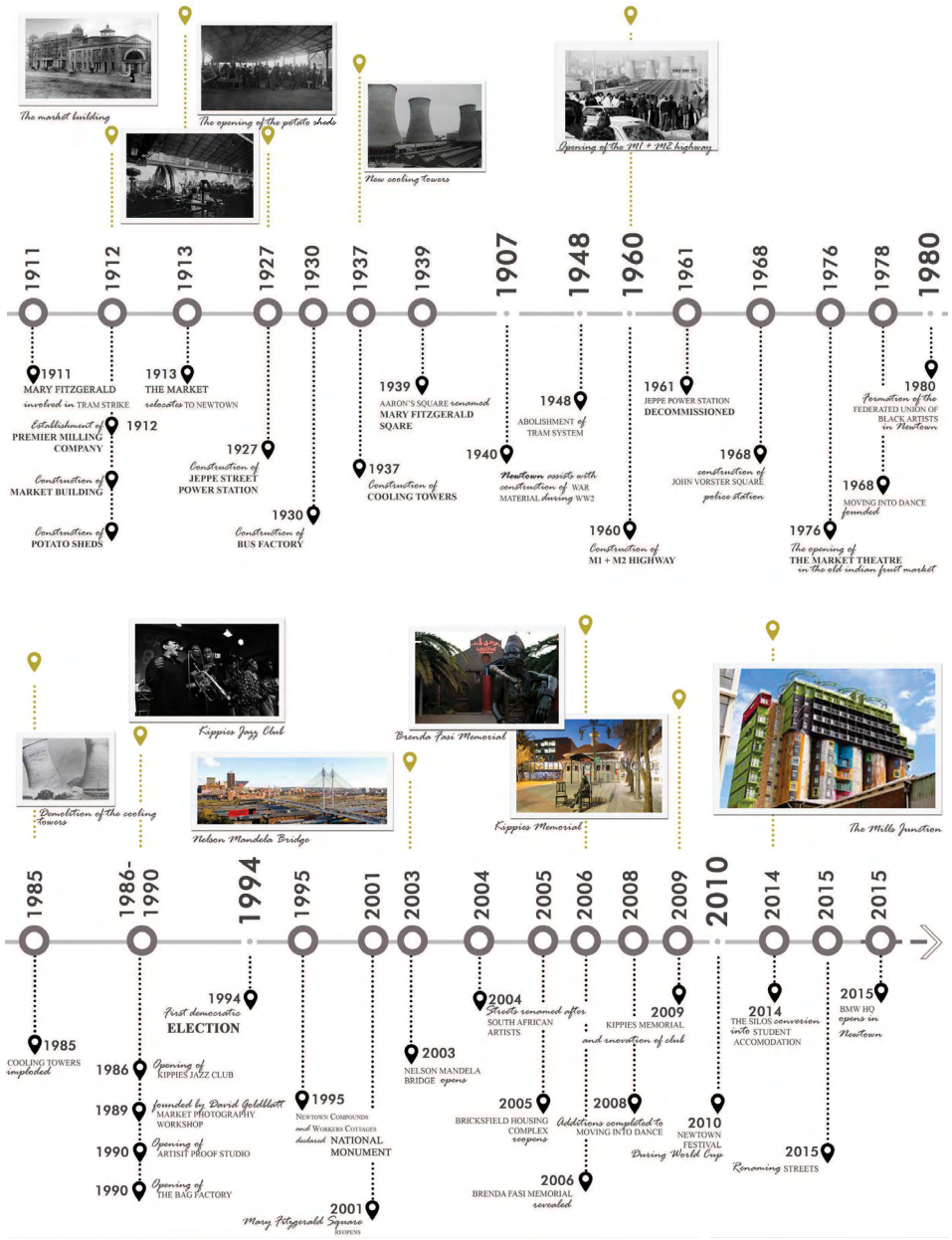


Fig 7.5: *Timeline of Newtown (Lemon Pebble Architects, 2018)*

7.4 Macro Site Analysis

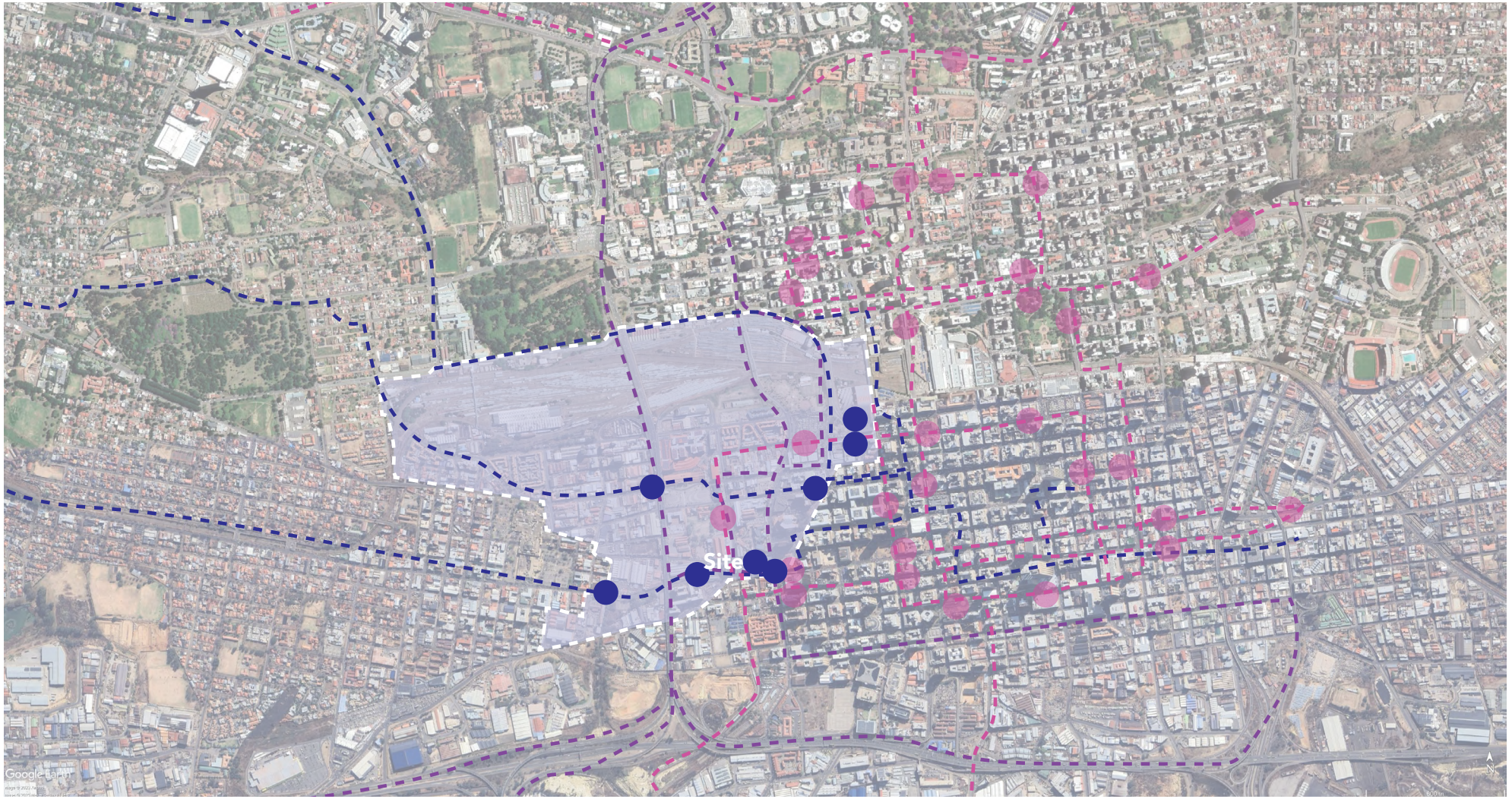


Fig 7.6:
bus networks and infrastructure
Author, 2023)



Social hotspot areas

Primary Pedestrian movement

Fig 7.6.1:
pedestrian movement and hotspots
(Author, 2023)

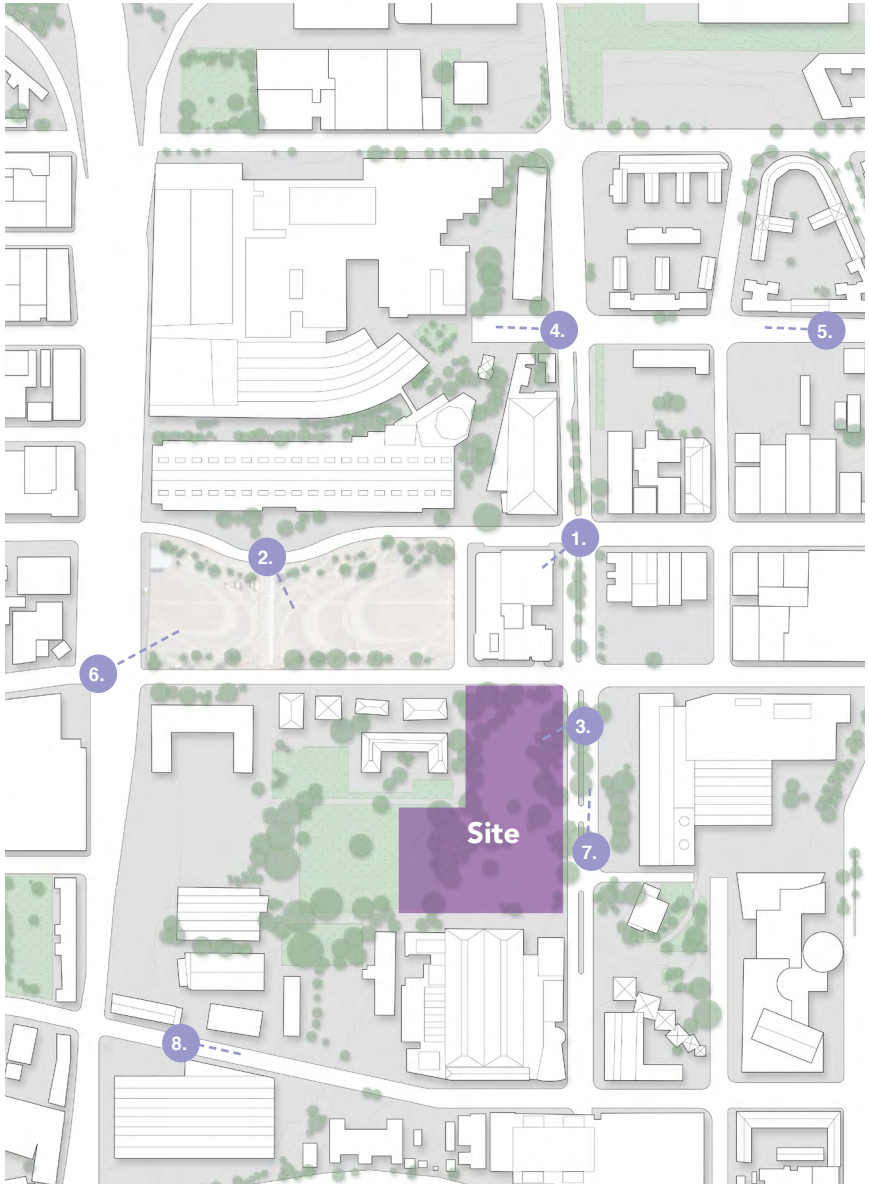












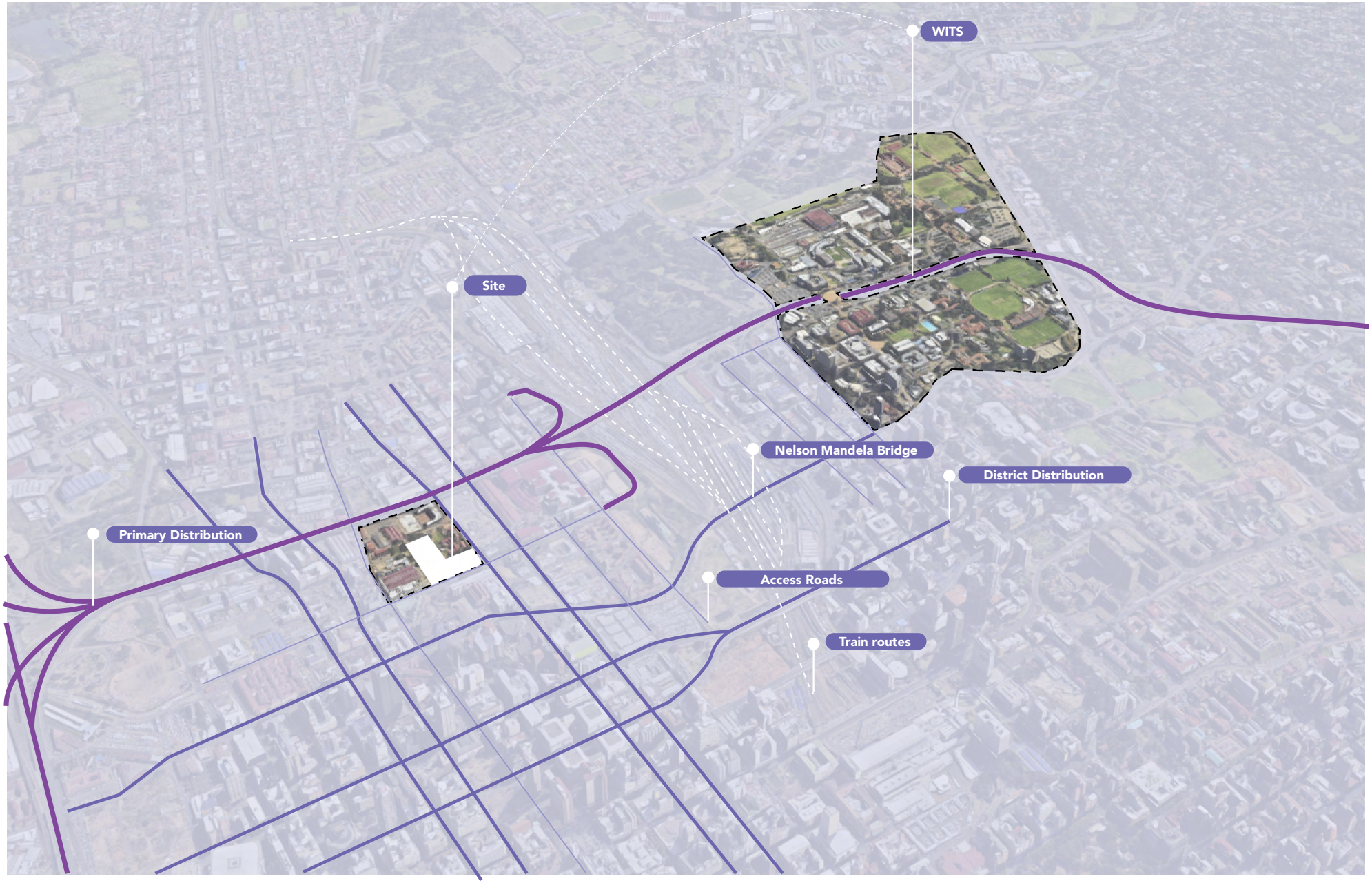






Fig 7.6.2:
Socio-cultural spaces (Author, 2023)
Images (Google, 2023)

Fig 7.7: *Site in relation to WITS, Road networks (Author, 2023)*



Site plan + Cultural Connections

1. Discovery Sci-bono center
2. Market Photo Workshop
3. Family Court
4. Workers Musuem
5. Turbine Hall
6. Mary Fitzgerald Square
7. Market Theatre Afrika cultural center & Museum Africa.
8. Residential housing

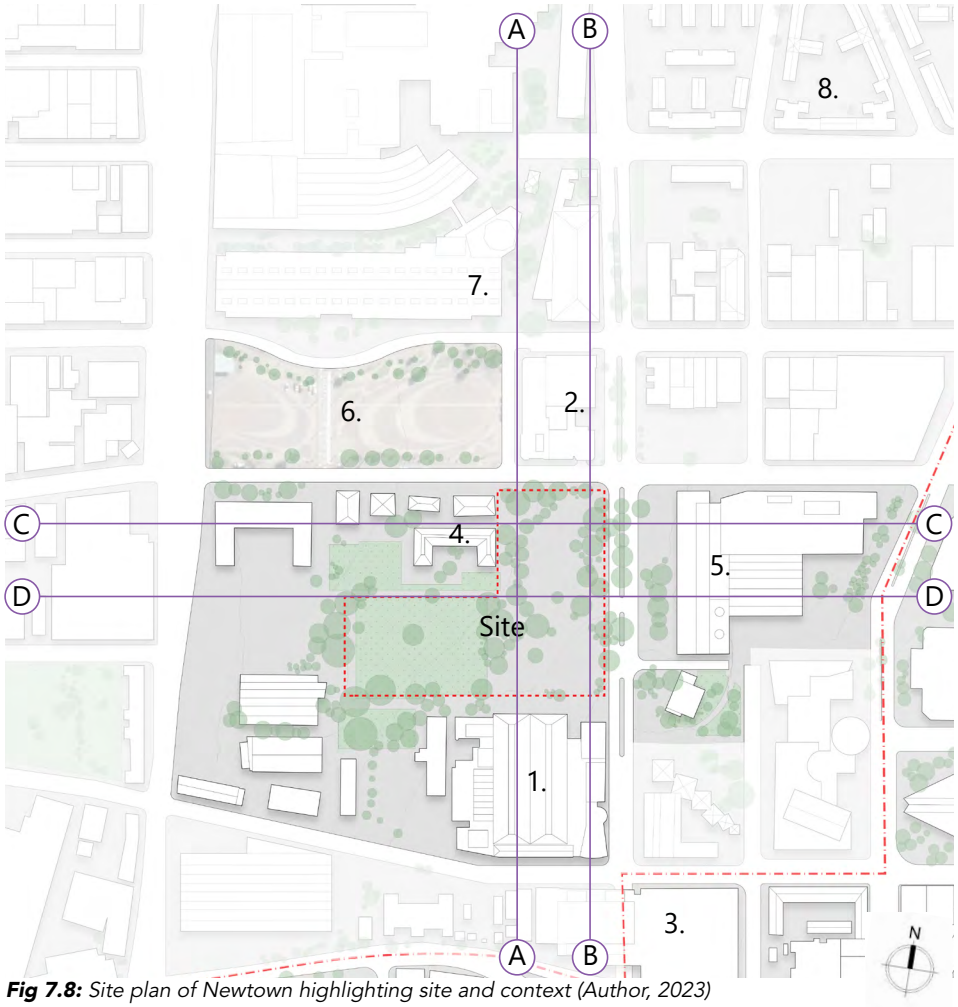
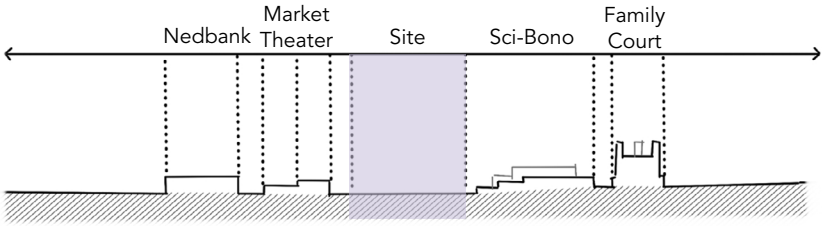


Fig 7.8: *Site plan of Newtown highlighting site and context (Author, 2023)*



Section A-A
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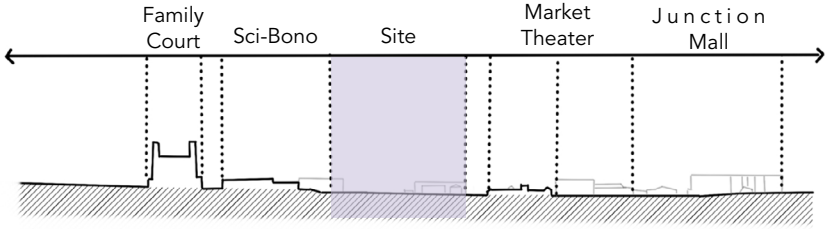

Section B-B
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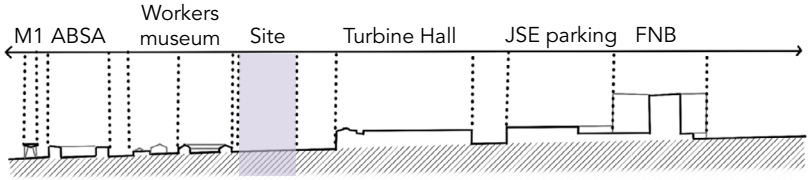

Section C-C
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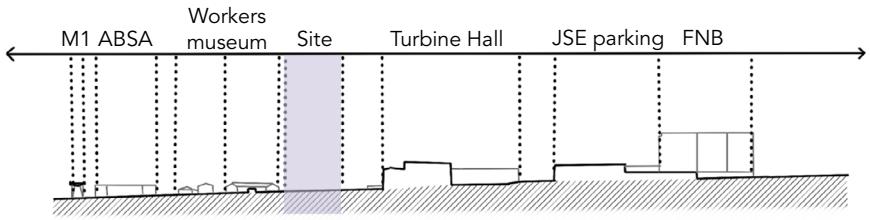


Section D-D
Scale 1:5000

Fig 7.9: *Urban section through site (Author, 2023)*

Primary redevelopment (Urban Corridor)

Public Environment structure
Pedestrian Routes and Urban Space

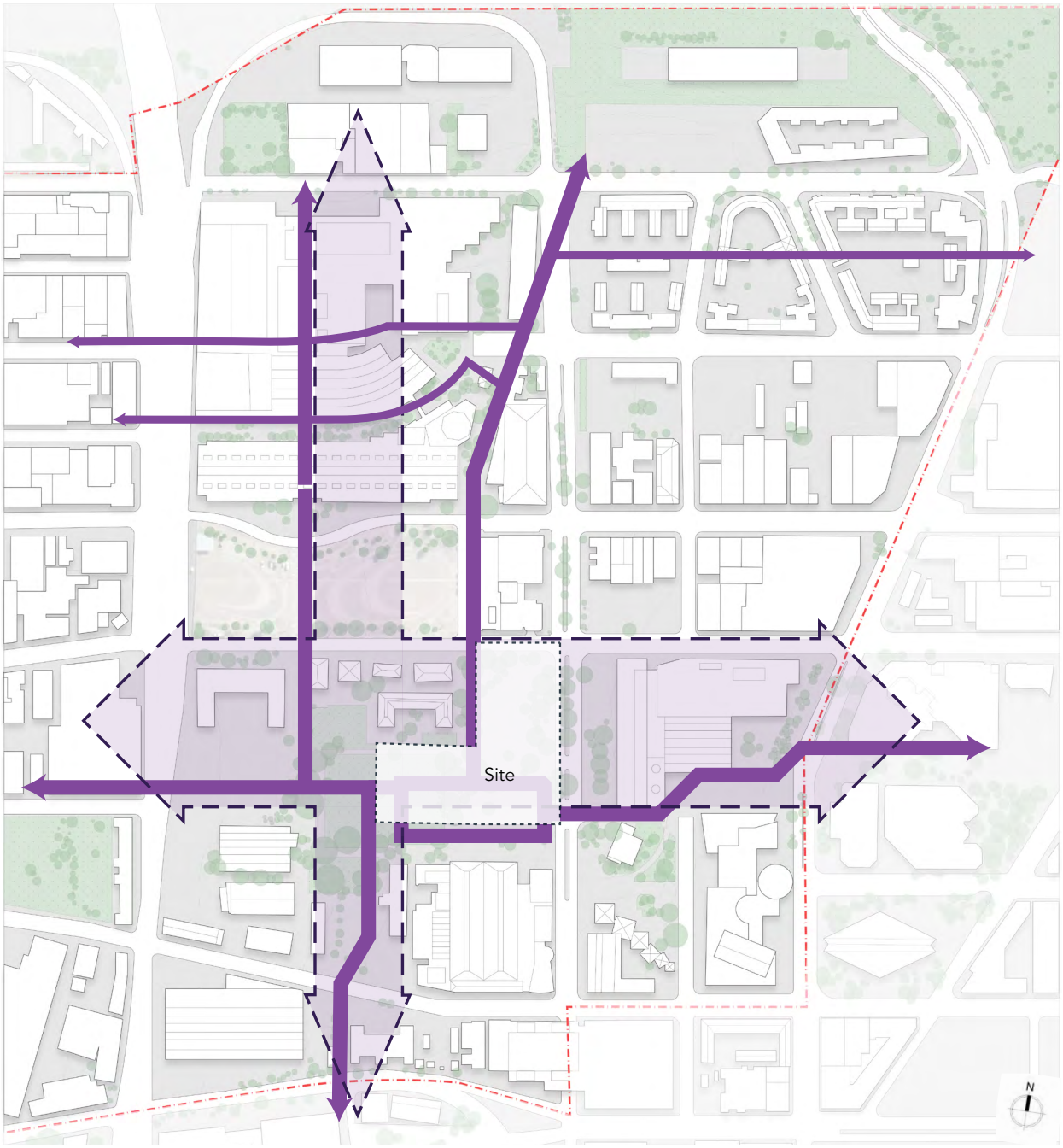


Fig 7.10:
Newtown precinct plan concept [drawn by Author], 2003 GAPP ARCHITECTS & URBAN DESIGNERS

Site and Newtown History



Fig 7.12: *Aerial view of power precinct 1956 looking east (Source: Museum Africa)*

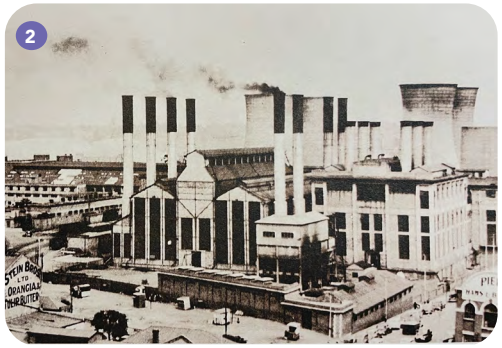


Fig 7.13: Jeppe Street Power Station 1940s (Source: JHB One Hundred Years)



Fig 7.14: Jeppe Street Power Station 1930 looking west (Source: Museum Africa)

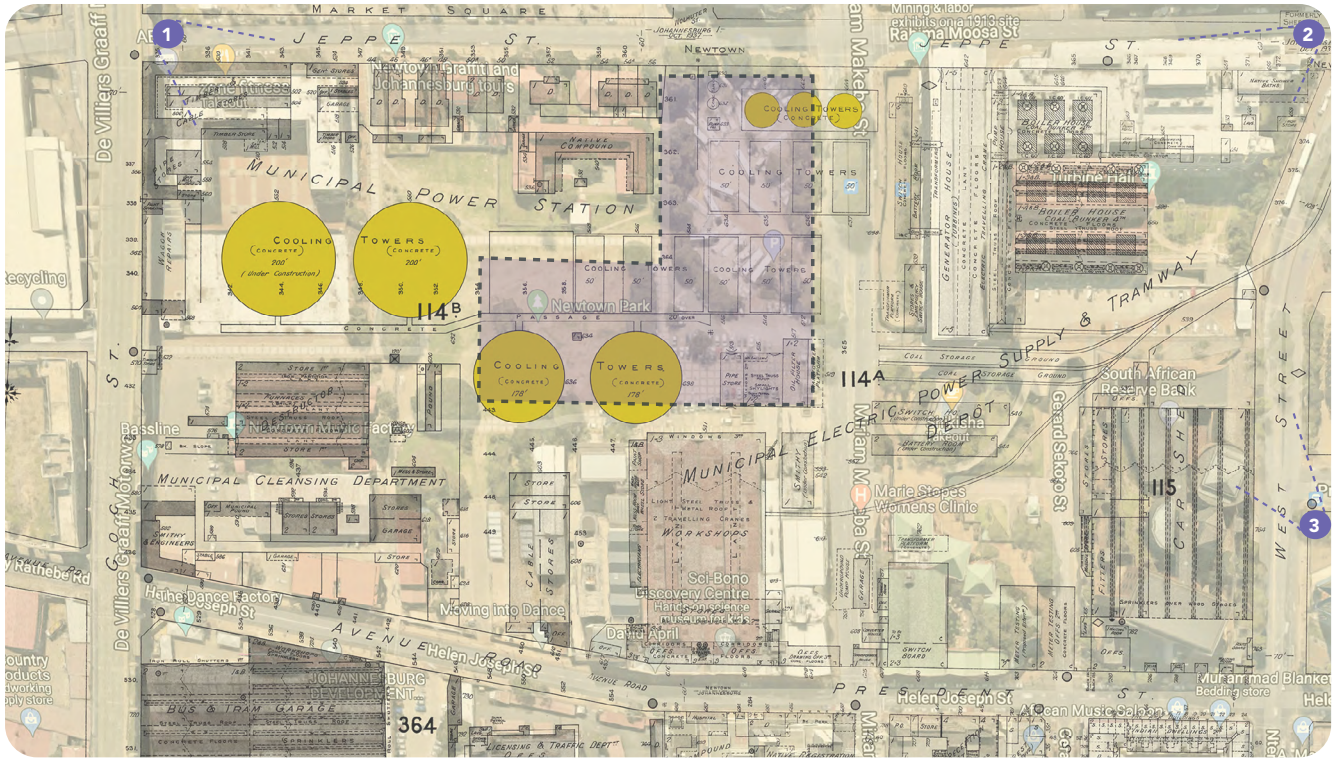


Fig 7.16: *existing extension plans for the plant, 1937. Overlayed with google earth.*



Fig 7.15: Historical fabric of Newtown then (1940)

Council owned land (eased areas and others)

Private ownership (including financial instatutions)

Outline of Newtown Study for cultural precinct study

1. Discovery Sci-bono center
2. Music dance factory
3. Craft center
4. Workers library
5. Turbine Hall
6. Mary Fitzgerald Square
7. Market Theatre Afrika cultural center & Museum Africa.
8. Residential housing

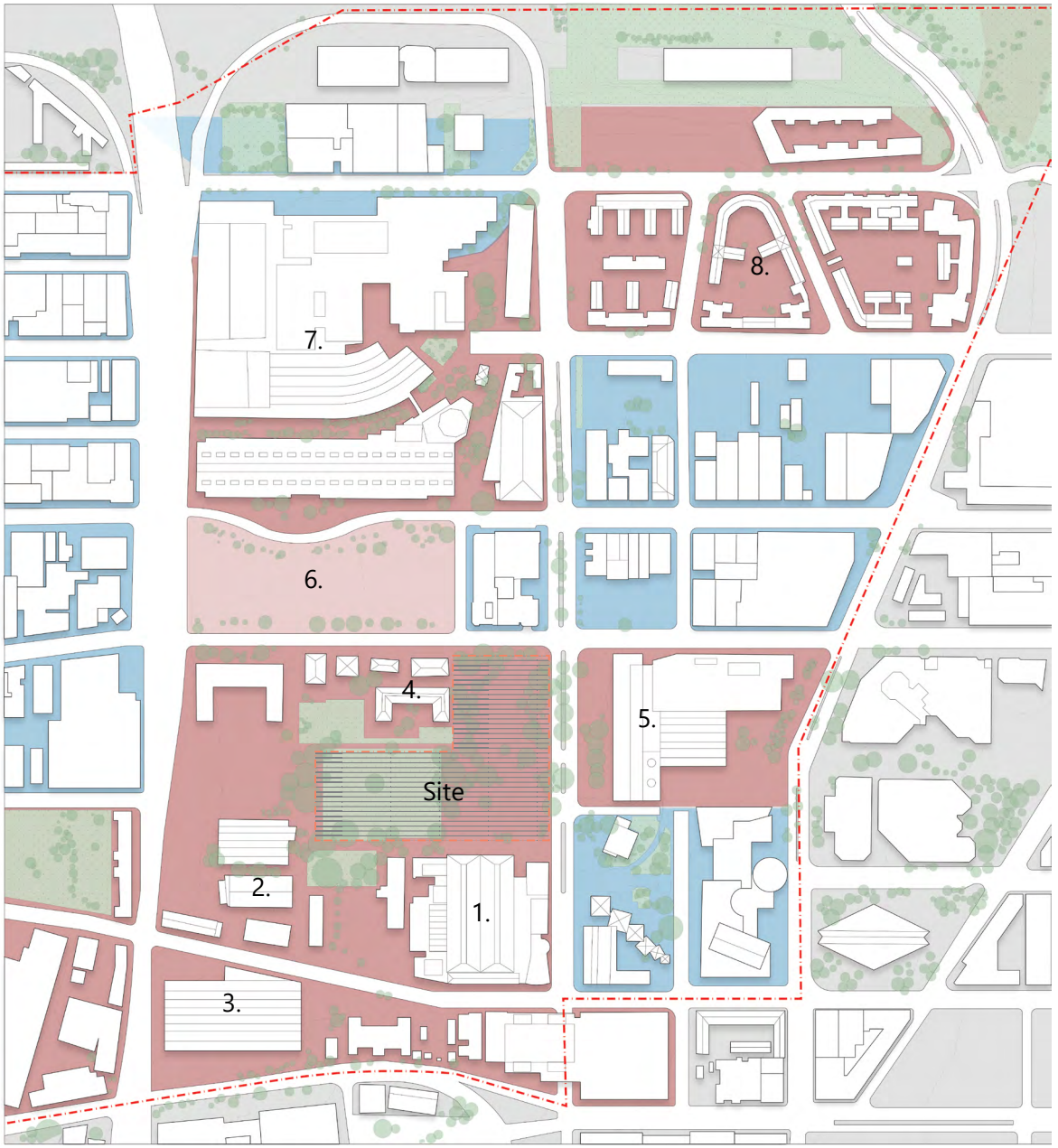


Fig 7.18:
Map showing ownership of land (Author, 2023)



Fig 7.19:
Interdependent Sub-zone, according to precinct plan (Author, 2023)

7.5 Site Analysis

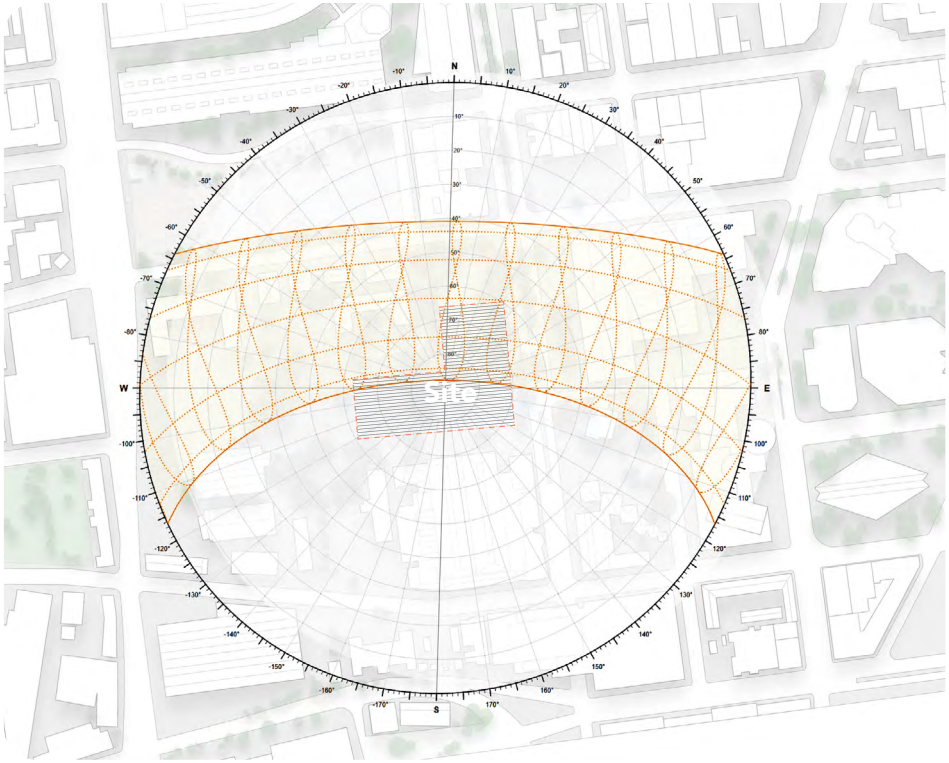


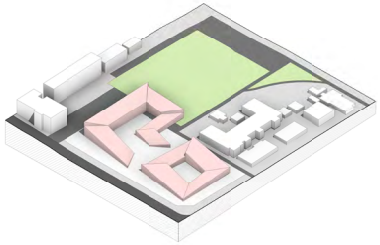
Fig 7.20:
Solar Study mapping (Author, 2023)

Solar study

The 2D sun path diagram superimposed over the site shows that the area receives most of its natural daylight from the north. The shaded yellow band represents the suns movement throughout the year with the top of the band showing the suns positions during the winter months and the bottom band during the summer months. When looking at the two extremes, we see that during the summer months overhangs will be vital to prevent unwanted heat but during the winter months, the sun's altitude will allow for sunlight and heat to reach into the building.

Sun - Low North + High South

For an early design method focused on building blocks, creating two separate masses with courtyards and different heights can enhance sunlight penetration into the building. By strategically positioning the South side of the building at a higher elevation and the North side at a lower elevation, the design enables better utilization of northern sunlight.



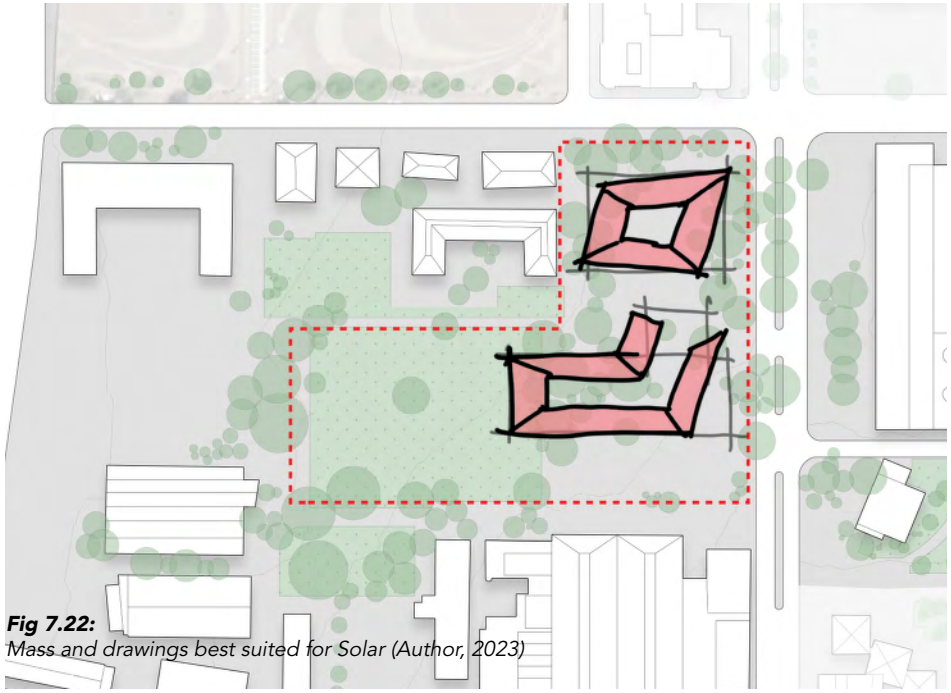
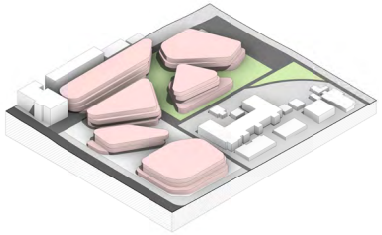


Fig 7.22:
Mass and drawings best suited for Solar (Author, 2023)

Movement

Upon mapping the existing movement on the site and in the park, potential areas for program activation can be identified. Additionally, this approach ensures the preservation of existing movement patterns throughout the site, promoting a sense of continuity and respect for established flows.



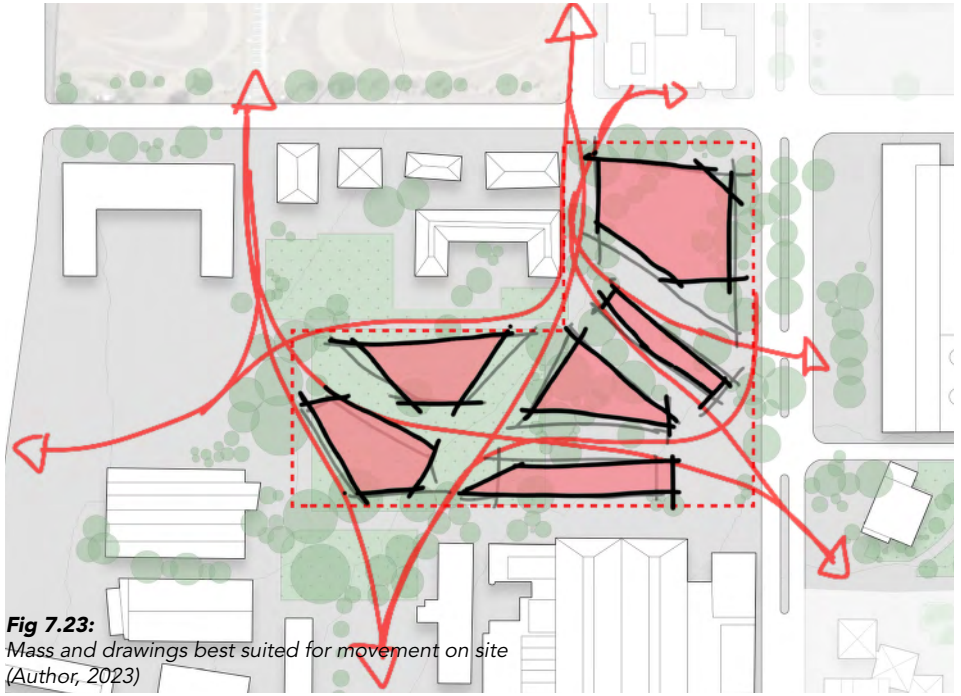
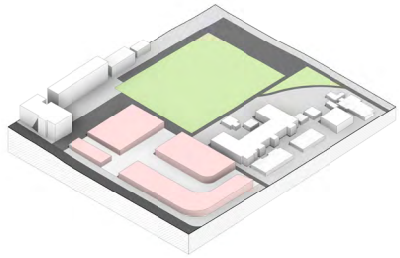


Fig 7.23:
Mass and drawings best suited for movement on site (Author, 2023)

Street Edges & Courtyard

By designing a mass that emphasizes engagement with the street edge and incorporates courtyards based on anticipated movement through the site, we can identify key factors to integrate into the overall design. This approach allows for a better understanding of how the building can interact with its surroundings and provides valuable insights for shaping the overall design concept.



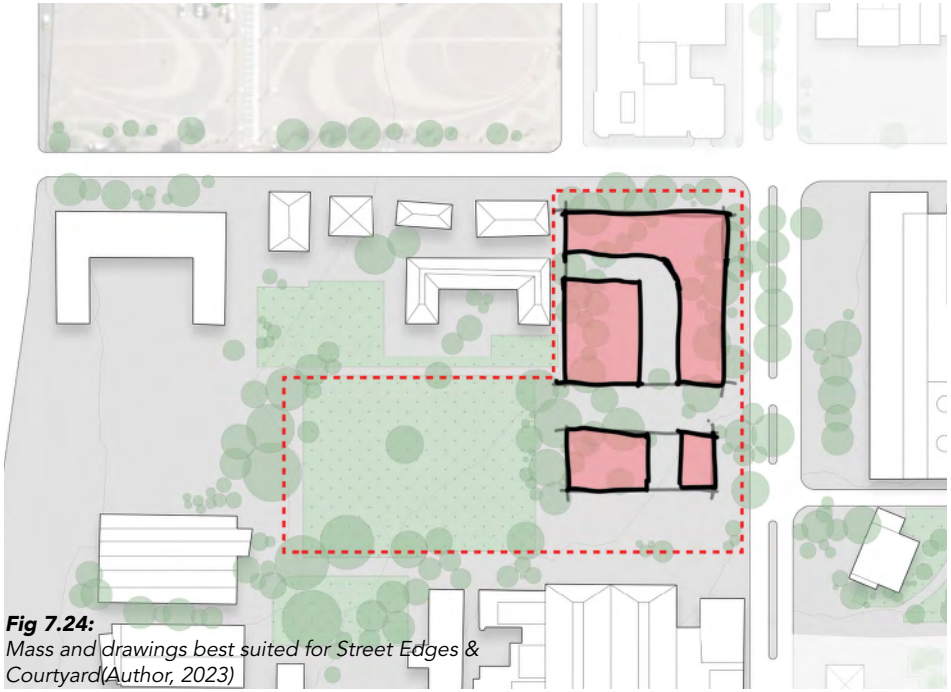
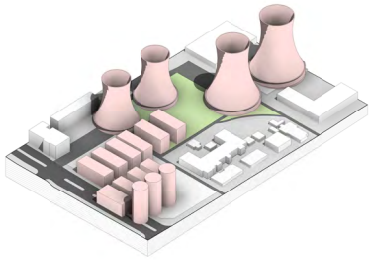


Fig 7.24:
Mass and drawings best suited for Street Edges & Courtyard(Author, 2023)

Historical Footprint

By examining and mapping the historical footprint, we can gain insights into how it can be integrated into the building design or landscaping. This process allows us to understand the potential opportunities for incorporating historical elements, whether through architectural features or within the surrounding landscape.



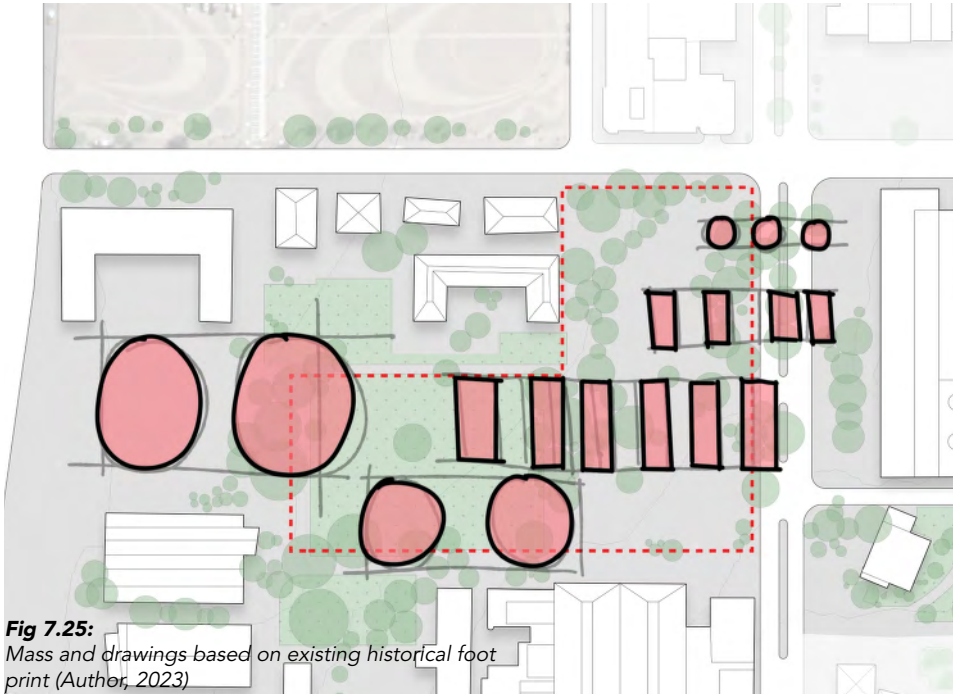


Fig 7.25:
Mass and drawings based on existing historical foot print (Author, 2023)



Fig 8.1:
All images Midjourney AI images generated using prompt "Parametric Architecture design by Zaha Hadid" (Author, 2023)

08

THE PROJECT

FEASIBILITY AND PROGRAMME

8.1 Viability

Executive Summary

The proposed AI Innovation Centre in Newtown, Johannesburg, aims to establish a pioneering hub for artificial intelligence research, development, and commercialisation. Drawing inspiration from the Wits Innovation Centre (WIC) and Tshimologong Precinct, the AI Innovation Centre seeks to create an environment that fosters interdisciplinary collaboration, nurtures talent, and accelerates the translation of AI academic research into practical, commercially viable outcomes.

Located in a region that has undergoing significant revitalisation over the years as outlined in chapter 7, the Centre is strategically positioned to become a key player in the emerging tech and

innovation landscape of Johannesburg. The Newtown area, known for its vibrant arts and culture scene, offers an accessible and central location, ideal for attracting a diverse range of individuals - students, researchers, entrepreneurs, and industry professionals alike.

Funding for the project is expected to be multifaceted. The Department of Science and Innovation (DSI) recently awarded Wits University R8-million in seed funding to implement Phase 1 of the South African Quantum Technology Initiative (SA QuTI), (Campbell, 2021). This initiative complements the AI Innovation Center's activities and might provide a template for developing similar funding strategies. Furthermore, the team plans to engage with the same group that funds the Sci-Bono Center for potential contributions which explored into more depth later in the chapter.

Fig 8.2:
WITS logo

Client Brief

The main client for the proposed AI Innovation Centre in Newtown is the University of the Witwatersrand (Wits). As a leading research institution, Wits could greatly benefit from the establishment of this AI-focused center, as it will not only augment their research capabilities but also strengthen their educational offerings and industry collaborations. This initiative could also position Wits as a pioneer in AI innovation in South Africa and beyond. Secondary clients would include AI start-ups, established tech companies, and government agencies interested in AI advancement. These entities stand to benefit from the research, development, and commercialization opportunities the Centre would provide, as well as the potential for collaboration and partnership. Refer to figure 8.3 showcasing the structure of the AI innovation center with WITS and funding partners

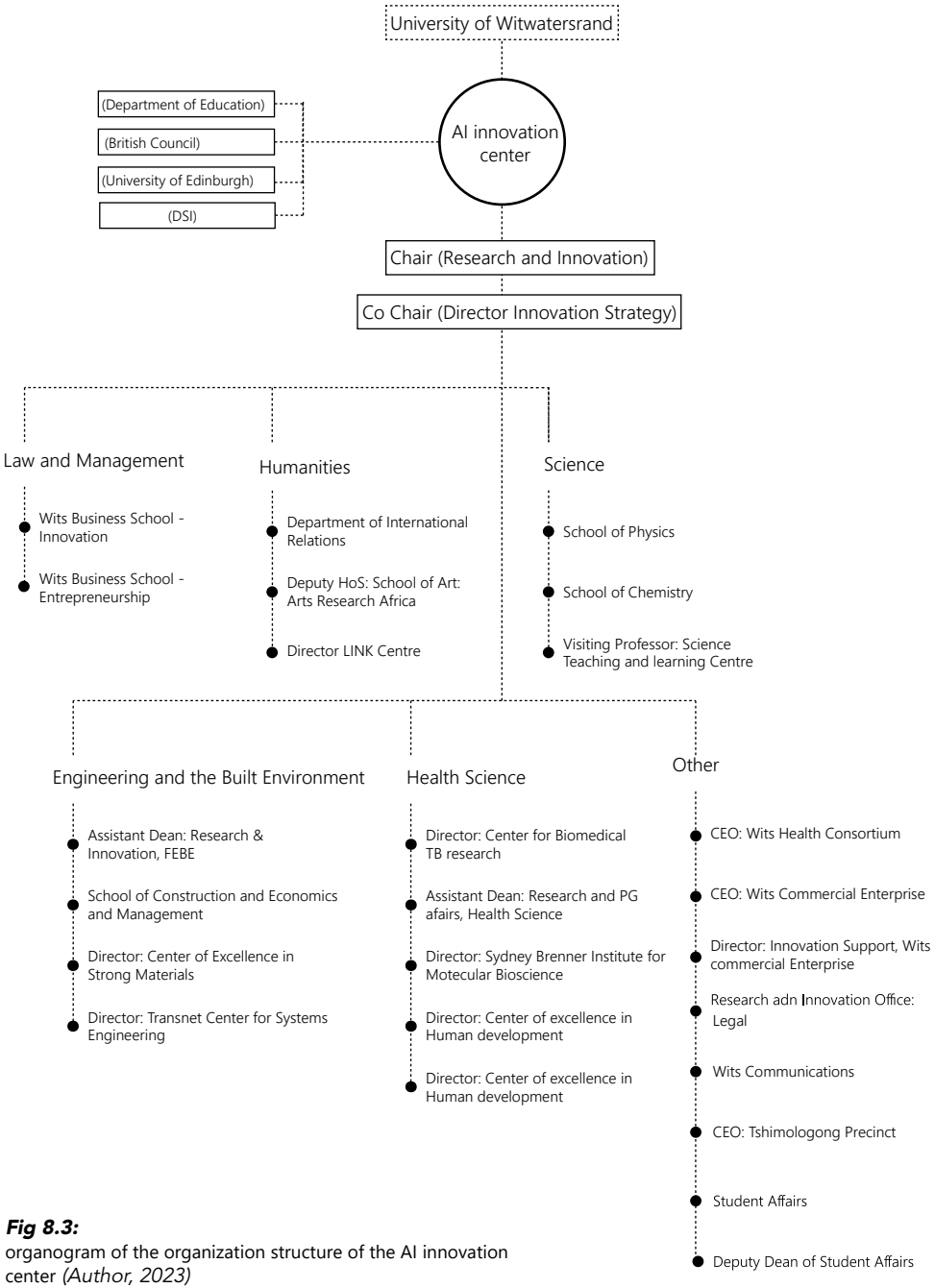


Fig 8.3:
organogram of the organization structure of the AI innovation center *(Author, 2023)*

Funding:

University of Witwatersrand: As the primary stakeholder, the University will provide substantial funding for the center, which will be instrumental in enriching the university's research and innovation ecosystem, providing opportunities for commercialisation of academic work and offering hands-on learning experiences for students

Department of Science and Innovation (DSI): The DSI's recent award of R8-million in seed funding to Wits for the South African Quantum Technology Initiative (SA QuTI) demonstrates their commitment to supporting advanced technology initiatives. This initiative aligns closely with the AI Innovation Center's objectives and can contribute towards funding support.

Gauteng Department of Education: The AI Innovation Center plans to approach the Gauteng Department of Education, which funds the Sci-Bono Center, (located next to the site) to explore potential financial contributions. The Gauteng Department of Education's support would validate the center's educational and scientific objectives and provide a strong foundation for its success.

Partnerships with Other Organizations: The center aims to forge strategic partnerships with other organizations such as the British Council and the University of Edinburgh, both of whom have partnered with the WIC already. These organizations could provide funding, as well as collaborative opportunities for research and innovation

Financial Considerations:

Costs:
Based on the latest construction cost guide provided by Aecom in Appendix B, I have estimated the total building cost. As detailed in Appendix A, the projected construction cost is approximately R133,999,839.95, inclusive of VAT and application costs as seen in Annexure F
Land Costs:
Estimated price of land R1,800 000,00. The proposed site for the AI Innovation Center currently belongs to the city of Johannesburg. The project will necessitate a change in the site's ownership, which I plan to achieve through a purchase by the client. This acquisition process will rely on provisions within Section 14(2) of the Municipal Finance Management Act of 2003 (MFMA).
Professional Fees:
The professional fees for consultants have been roughly estimated at 12% (Daskalakos, C.2023) of the total project cost. These fees encompass a wide range of services that will be necessary for the successful execution of the project.

Income
Membership Fees:
Similar to Wits Innovation Centre (WIC), the AI Innovation Center could implement a membership-based model. This would provide consistent income from individuals or organizations who wish to be a part of the innovative environment and utilize the resources provided by the center. A rough estimate is based on research there can be up too 200 members a month at R2000 x 200 = R400 000
Corporate Partnerships:
The center could develop partnerships with corporations that are interested in artificial intelligence research and development. These corporations might sponsor specific projects, fund research grants, or even rent space in the center for their own innovation teams. refer to annexure A for rough estimate of potential sub income per month based on leasible area, income of R1 107 397.20
Event Hosting and Space Rental:
The AI Innovation Center could generate revenue by hosting AI-related events such as conferences, workshops, and seminars. In addition, it could rent out space to external parties for their own events. refer to Appendix A
Government Grants and Funding:
Just as the South African Quantum Technology Initiative (SA QuTI) received funding from the Department of Science and Innovation (DSI), the AI Innovation Center could apply for similar grants and funding from various government departments.

Technology, Sustainability, Materiality

New Technology:
3D printing and steel cladding/framing are emerging technologies under consideration for the AI Innovation Centre project. While the implementation of such technologies in a developing country context might appear financially challenging, a comprehensive understanding of the current landscape suggests that these innovative methodologies could hold significant promise for the future of construction.

Africa's high unemployment rate and the consequent low labour costs, coupled with the cheap availability of traditional construction resources, often make manual labour more cost-effective compared to high-tech implementation. This scenario suggests that a shift towards new technologies could potentially lead to job losses in traditional construction roles.

However, a deeper exploration reveals that the implementation of these advanced technologies may offer opportunities for upskilling local labour. The nature of these new technologies necessitates a higher level of precision, thereby creating the need for more skilled professionals in the process and opening up avenues for training and skills development. A comparative analysis of traditional labour versus high-tech implementation in terms of job numbers and skills requirements would provide a clearer understanding of the potential trade-offs and benefits.

Sustainability:
Sustainable construction methods have witnessed a steady increase over the past two decades. However, this growth has coincided with a decrease in the availability of skilled contractors and tradesmen, thereby creating a scarcity of needed expertise for such advanced projects.

While the scarcity of skilled professionals poses a challenge, the project's focus on sustainability provides an opportunity to value the development of these skills highly. The incorporation of sustainable design principles might initially come with higher costs and require a pool of skilled professionals, but it holds significant long-term benefits. These include energy efficiency, reduced environmental impact, and potential cost savings over the lifespan of the building. A comprehensive cost-benefit analysis of traditional versus sustainable construction methods would help underline the advantages and future potential of the latter.

Materiality:
The cost and availability of materials are critical considerations in any construction project. Global shortages, for example, led to a dramatic increase in the cost of steel between 2020 and 2022. The AI Innovation Centre project, with its exploration of new construction methodologies such as 3D printing and steel cladding/framing, must take these potential material cost fluctuations into account.

Understanding the cost difference between traditional and alternative materials is essential. While traditional materials like cement and bricks might be cheaper, alternative materials used in advanced technologies could offer advantages such as durability, sustainability, and improved aesthetic appeal.

Local Skills:
The AI Innovation Centre project presents an opportunity to upskill local labour to meet the demands of new technologies and sustainable design principles. This approach would not only address the project's skills needs but also contribute to resolving the broader issue of unemployment in the region. A quantification of the potential jobs created, the nature of these jobs in terms of skills required, and the opportunities for upskilling could

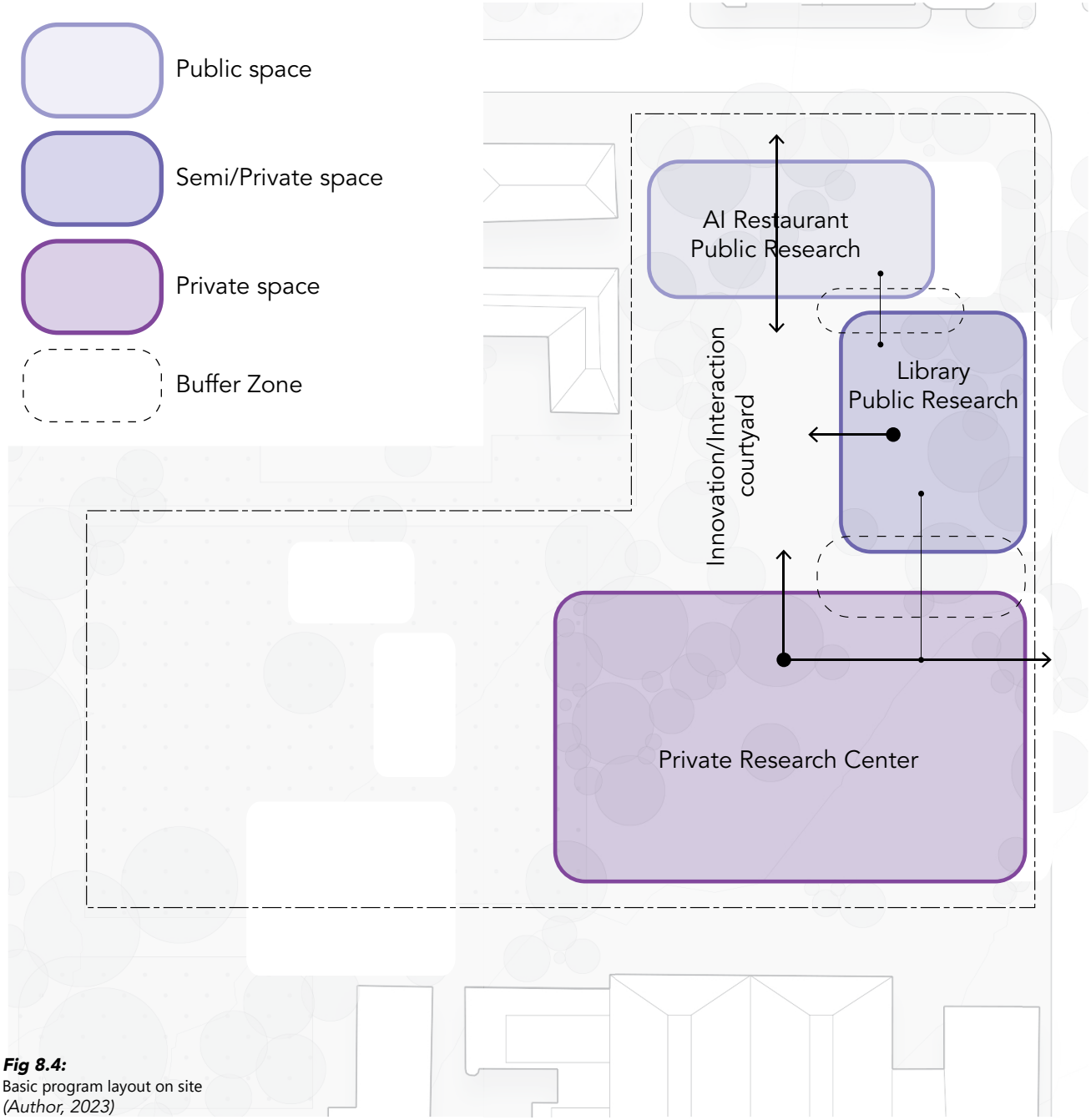


Fig 8.4:
Basic program layout on site
(Author, 2023)

8.2 Programme

WITS AI innovation center			
Description	**No. off**	**Approx.**	**Approx Area**
Public Reception/Foyer			
Foyer and entrance lobby	1	70	70
Private courtyards	1	100	100
Exhibtion spaces	1	750	750
Innovation Support - work station	1	40	40
Storage Space reception	1	40	40
Open/Loan Innovation area			
Open work spaces	1	500	500
Informal meeting areas + lounges	1	250	250
Study/research cubicles	70	4	280
on line literature (50 PCs)	1	150	150
Teaching / Lecturing			
Public lecture venue - 150 seats	1	500	500
Research Labs	1	1500	1500
Teaching/Multipurpose venue - 2 x 40 seate	4	250	1000
Open area for reception linked to lecture hal	70	4	280
Public Toilets to SANS spec - per floor	1	150	150
Administration			
Administrative Offices	1	150	150
Administrative Offices (Director)	1	30	30
Staff break and storage rooms	1	150	150
Committee room	1	30	30
Staff Toilets	2	20	40
Restaurant			
Restaurant for 60 users	1	180	180
Outdoor terrace area	1	125	125
Kitchen	1	100	100
Public toilets	1	30	30
General services			
Server room	1	20	20
Storage per floor	4	20	80
Delivery area	1	20	20
Refuse room 1	1	20	20
Refuse room 2	1	20	20
Visitors toilets	2	30	60
Visitors toilets (disabled)	3	3	9
Total Area			6674

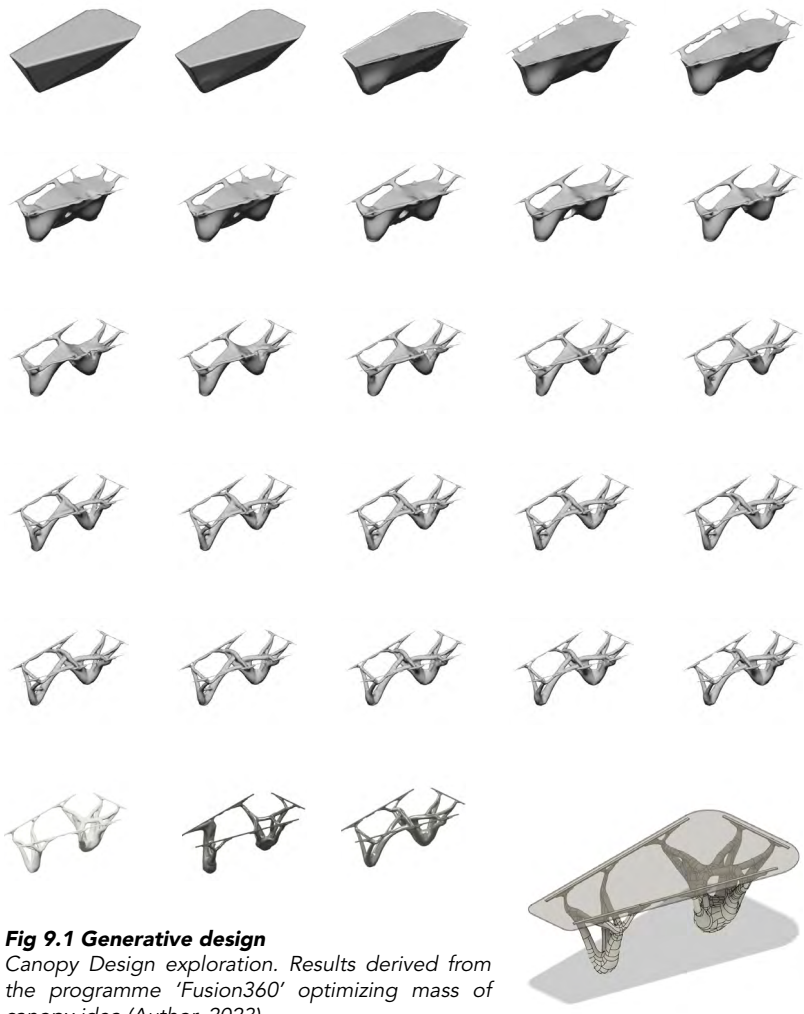


Fig 9.1 Generative design
Canopy Design exploration. Results derived from the programme 'Fusion360' optimizing mass of canopy idea (Author, 2023)

09

THE PROJECT

DESIGN DEVELOPMENT

9.1 Innovative Design Experiments: Navigating the AI Landscape in Architecture

The design development phase has been a revelation. As I delved deeper into the intricacies of AI, I was constantly reminded of an anecdote from my early days as an architecture student. I had once spent hours trying to perfect a model, only to realize that a simple tweak in perspective changed everything. This year felt similar, but on a much grander scale. With every new AI tool I explored, I was challenged to rethink traditional architectural paradigms.

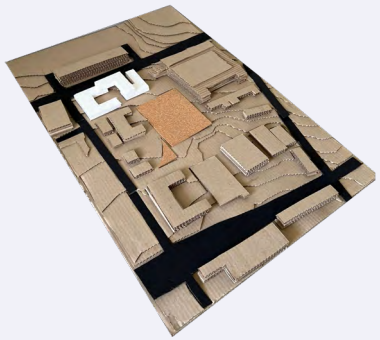
Unlike the foundational phase, where I was gathering tools and knowledge, the design development phase was about application. I had to constantly remind myself of the end goal: the AI Innovation Centre in Newtown. This tangible project became my anchor, ensuring that my explorations, no matter how abstract, always had

a real-world application.

One of the most enlightening moments came when I revisited charrettes. Traditionally, charrettes were about rapid model-making, a flurry of creativity under time constraints. But with tools like "Stable Diffusion" (as detailed in Chapter 5), I realized that charrettes could be reimagined. What if architects could harness AI to generate multiple design iterations in a fraction of the time?

However, it's essential to note that the depth of my design development at this stage might seem different from traditional theses. Due to the unique structure and approach of my thesis, my design development won't be as advanced as one might expect. While many of my peers have been able to integrate their findings into their designs throughout the year, my journey has been more about exploration and evaluation. A significant portion of my experiments and findings from this year might not directly contribute to my final design. But they have been instrumental in shaping my understanding and approach.

As I transition to the next phase, the insights from these explorations will be invaluable. In my final research paper 2, with the building design underway, I anticipate a more robust and comprehensive design development. This foundation, built on a year of exploration, will guide me as I embark on the actual design of the AI Innovation Centre. With a clear understanding of my chosen tools and methodologies, I'm poised to redefine architectural design, blending tradition with innovation.



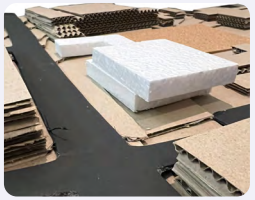


Fig 9.2: Site model 1:500
(Author, 2023)

9.2 Charrettes Modelling: A New Approach

The term "Charrette" carries with it a rich historical tapestry, originating from the 19th-century architecture students at Paris's École des Beaux Arts. In contemporary times, it has evolved to signify a collaborative approach in architecture, seamlessly blending intensive work sessions with public engagement (National Charrette Institute, 2020). My ambition was to challenge and redefine this age-old charrette methodology. Rather than adhering to the time-honored practice of swift model-making, I aspired to revolutionize the process, targeting both speed and a breadth of design ideas. My deep dive into "Stable Diffusion," as elaborated in Chapter 5, became the linchpin of this transformation.

Using Stable Diffusion, I introduced a novel approach to charrettes. While many peers focused on design and materiality, I showcased alternative methods.

For a glimpse of the journey with Stable Diffusion, refer to Appendix C + D at the report's end. It captures my iterative process to perfect the outcomes for the charrettes. Note that it is a small insight into the process.

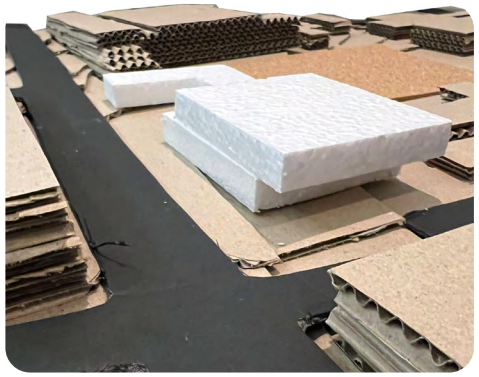
I'll outline how I utilized Stable Diffusion in three ways:

1. 3D Mass Explorations
2. 3D Mass + Sketch Explorations
3. 3D Explorations via Digital Modeling

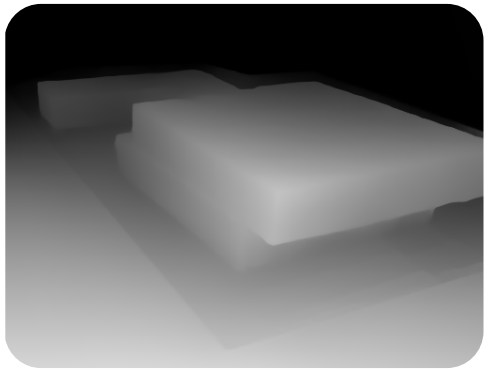
This period was particularly exhilarating for me. My research into Stable Diffusion and ControlNet revealed its predominant use for transforming sketches into visual renders based on text prompts. I hypothesized that this could be extended to 3D masses and digital 3D models crafted in Revit. By April 2023, I had not only validated this hypothesis but also showcased its feasibility. This revelation was groundbreaking at that juncture, primarily because I couldn't identify any prevalent use of this technique for converting 3D models into renders using AI. Fast forward to the present, and numerous apps and software have integrated this capability, underscoring the rapid evolution of architectural tools.

3D mass Explorations

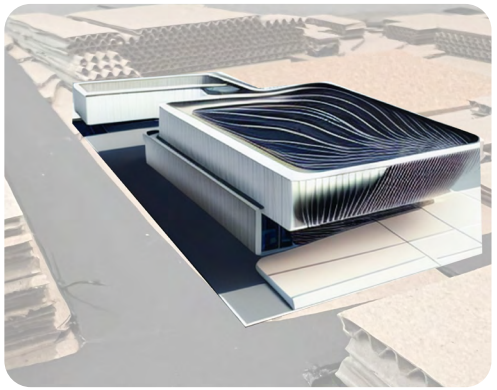
Fig 9.3: Charrettes Process
3D mass Explorations (Author, 2023)



Original 3D mass on the site model - at this stage of research on AI I noticed a trend where designers were turning sketches into renders with Stable diffusion. My idea was to see if creating a 3D model could achieve the same?

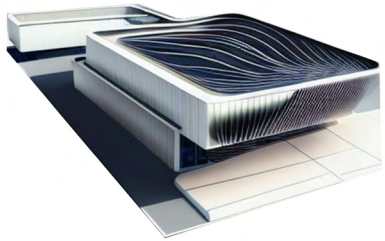


Controlnet creating a depthmap of the 3D mass. Stable diffusion

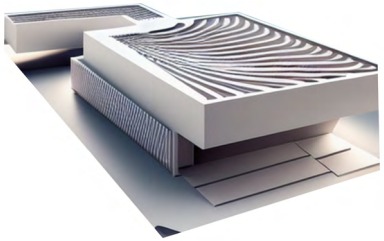


Result

Material Explorations



prompt "Exterior view, parametric design, modern, organic roof, steel and glass primary materials" by Author.



prompt "Exterior view, parametric design, modern, organic roof, steel and glass primary materials" by Author.



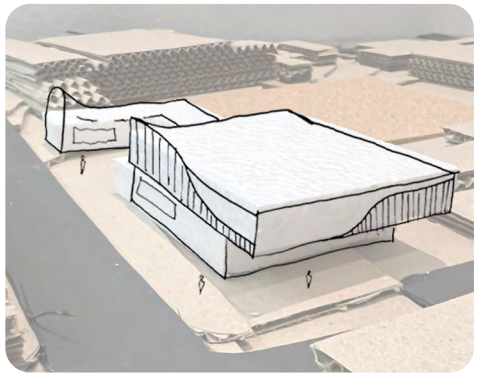
prompt "Exterior view, parametric design, modern, organic roof, concrete and glass primary materials" by Author.



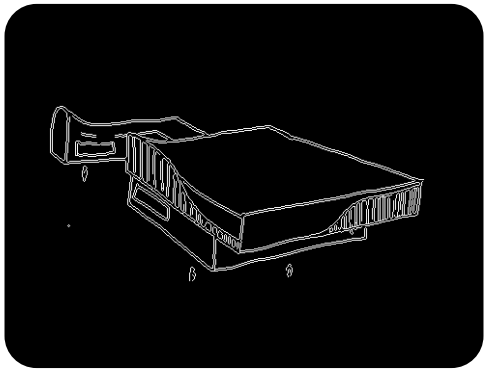
prompt "Exterior view, parametric design, modern, organic roof, timber and glass primary materials" by Author.

3D mass + Sketch Explorations

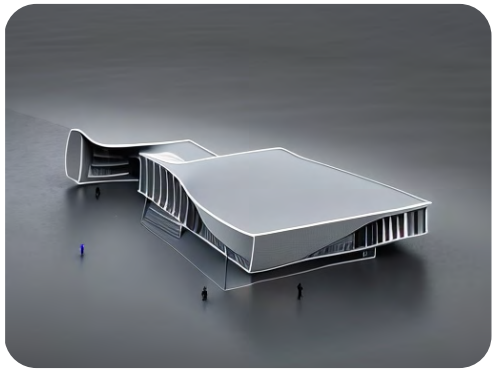
Fig 9.4: Charrettes Process
3D mass + Sketches Explorations (Author, 2023)



Once I had realized what was possible, I then pushed the limits by seeing what could happen if I combine the two by overlaying a sketch with the 3D mass.

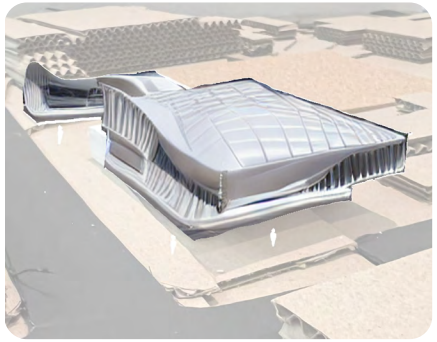


Controlnet creating a depthmap of the 3D mass. Stable diffusion

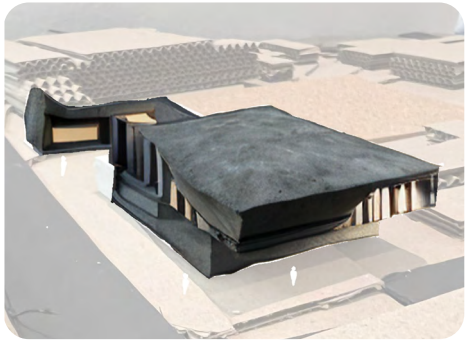


Result

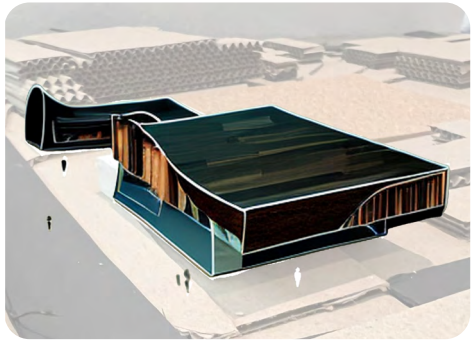
Material Explorations



prompt "Exterior view, parametric design, modern, organic roof, steel and glass primary materials" by Author.



propmt "Exterior view, parametric design, modern, organic roof, concrete and glass primary materials" by Author.

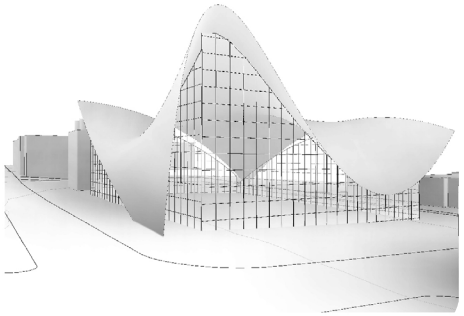


propmt "Exterior view, parametric design, modern, organic roof, timber and glass primary materials" by Author.

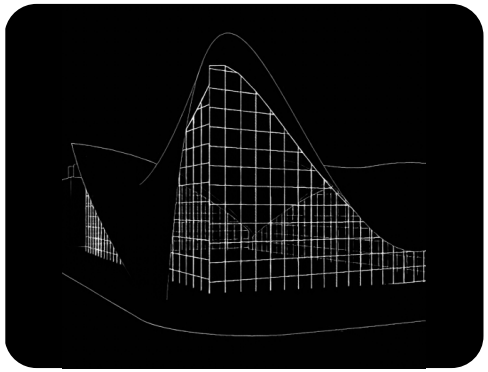
This is when I noticed how I started getting more realistic images due to ControlNet having more information to work from

3D explorations through digital modeling

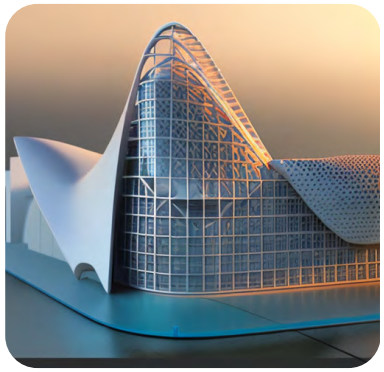
Fig 9.5: Charrettes Process
3D explorations through digital modelling (Author, 2023)



Once I had realized what was possible, I then pushed the limits by seeing what could happen if I could quickly create a mass on Revit



Controlnet creating a depthmap of the 3D mass. Stable diffusion



Result

Material Explorations



propmt "Exterior view, parametric design, modern, organic roof, steel and glass primary materials" by Author.



propmt "Exterior view, parametric design, modern, organic roof, concrete and glass primary materials" by Author.



propmt "Exterior view, parametric design, modern, organic roof, timber and glass primary materials" by Author.

9.3 Informed mass vs AI generated mass

At this stage of design development, I have two methods of approach in designing masses and doing analysis. First approach being informed mass design – designs that I have designed based on my experience and the context within the site. Second approach is providing data, based on constraints based on research, to an AI mass generator tool. The goal here is to compare and understand which designed/generated masses align with my goal as the designer and from my analysis make an informed decision on the generated mass going forward.

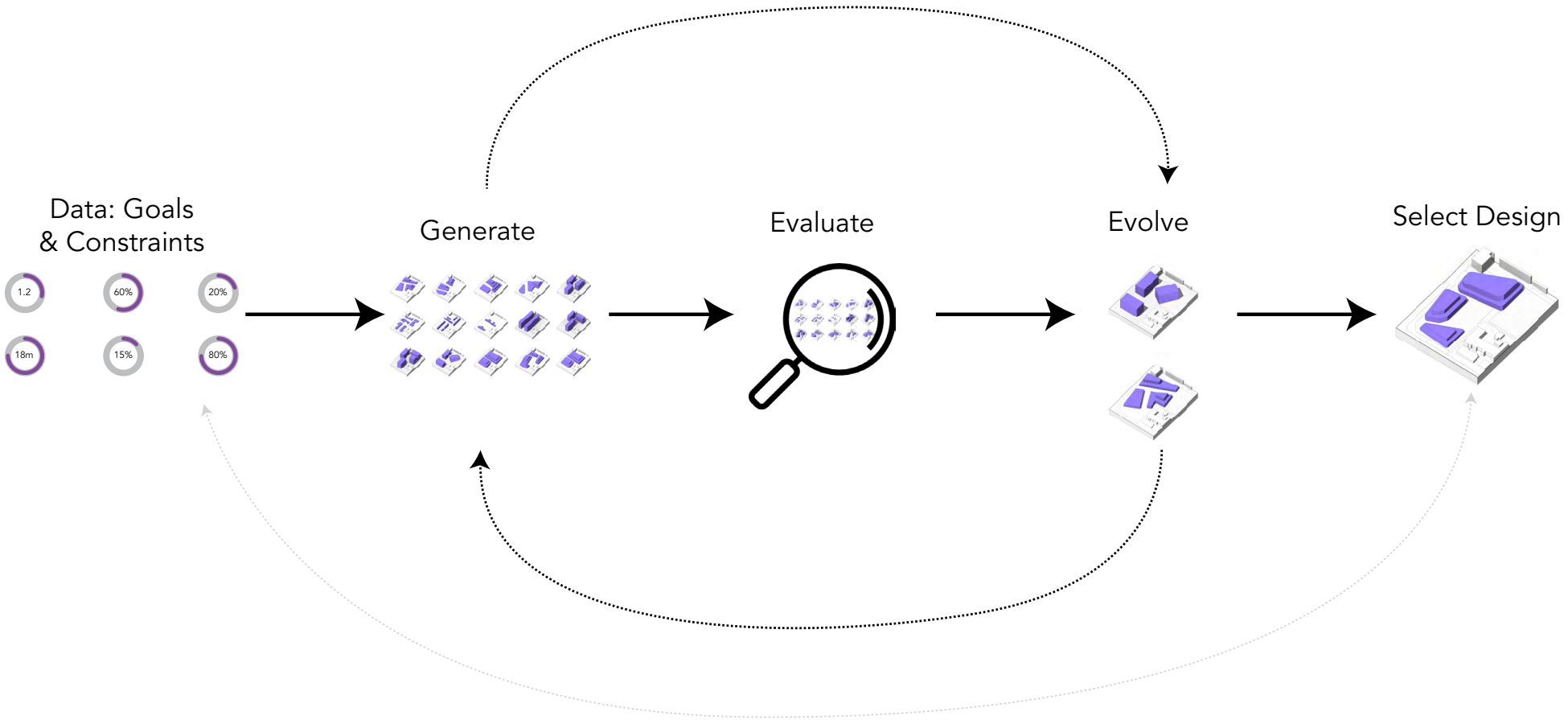
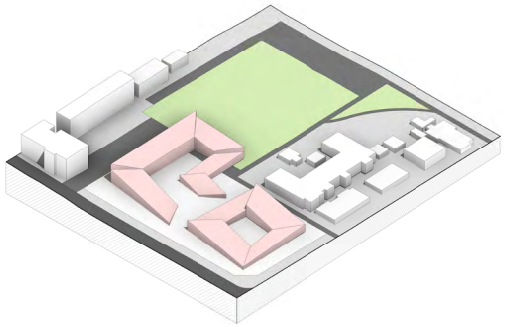
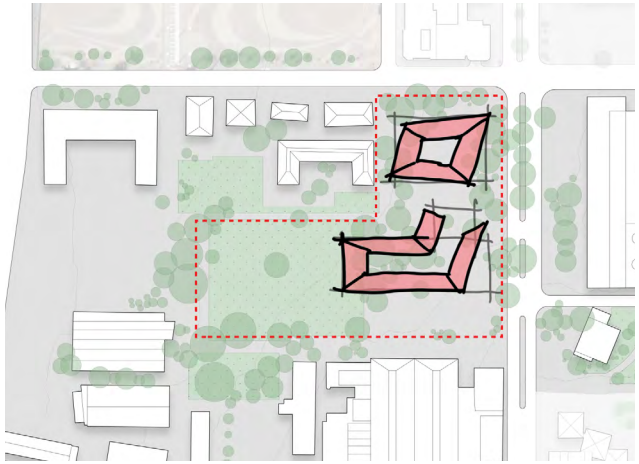


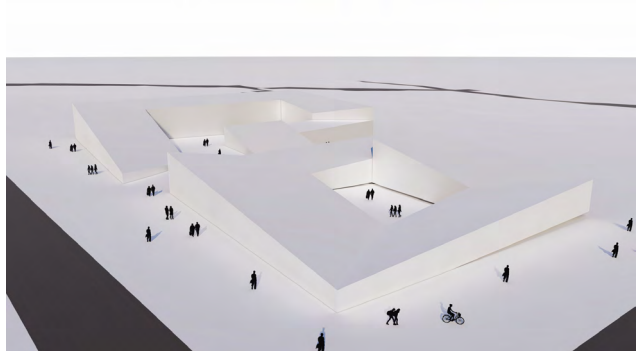
Fig 9.6: Charrettes Process
Creating masses based on site analysis, Sun Masses (Author, 2023)

Informed mass - Sun - Low North + High South

For an early design method focused on building blocks, creating two separate masses with courtyards and different heights can enhance sunlight penetration into the building. By strategically positioning the South side of the building at a higher elevation and the North side at a lower elevation, the design enables better utilization of northern sunlight.













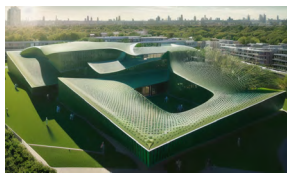


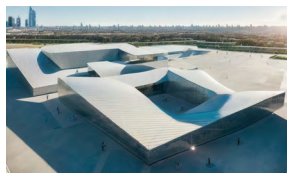






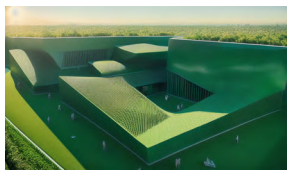








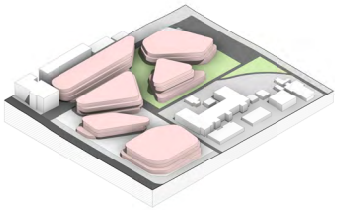


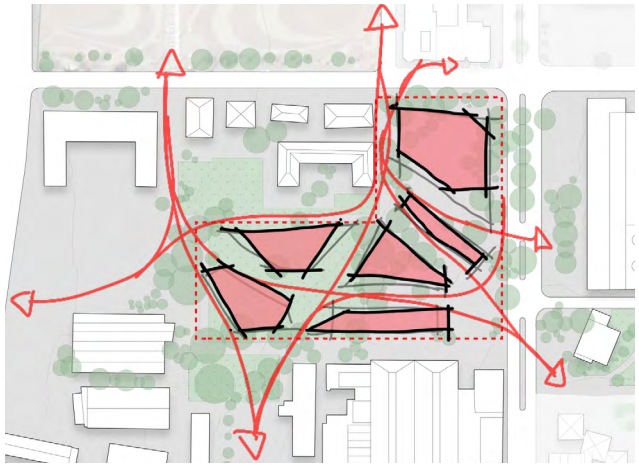


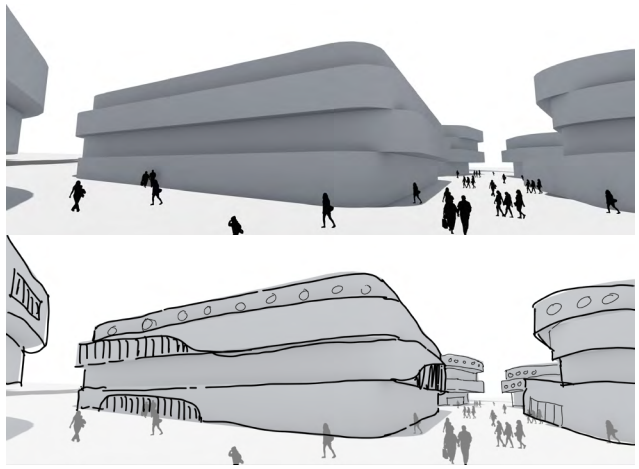
Informed mass - Movement

Upon mapping the existing movement on the site and in the park, potential areas for program activation can be identified. Additionally, this approach ensures the preservation of existing movement patterns throughout the site, promoting a sense of continuity and respect for established flows.

Fig 9.7: Charrettes Process
Creating masses based on site analysis, Movement Masses (Author, 2023)

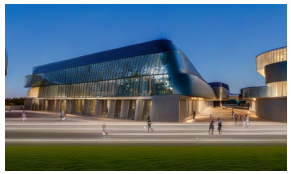




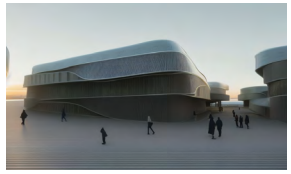










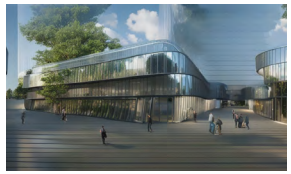














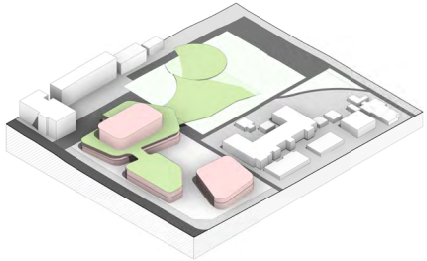


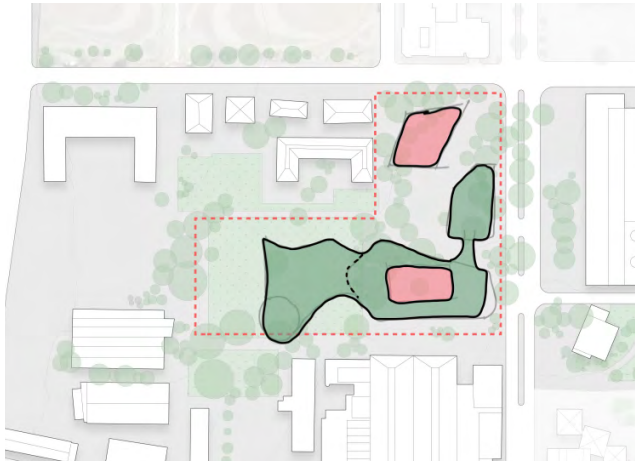


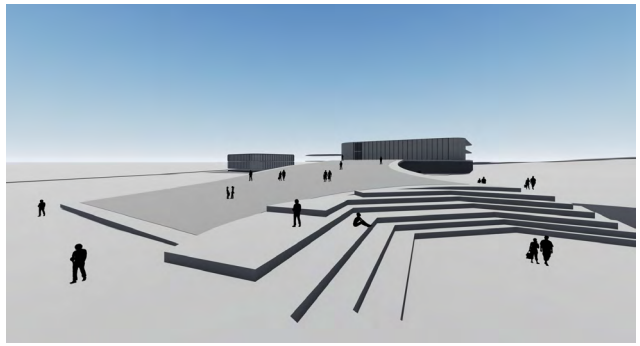
Informed mass - Green Roof design

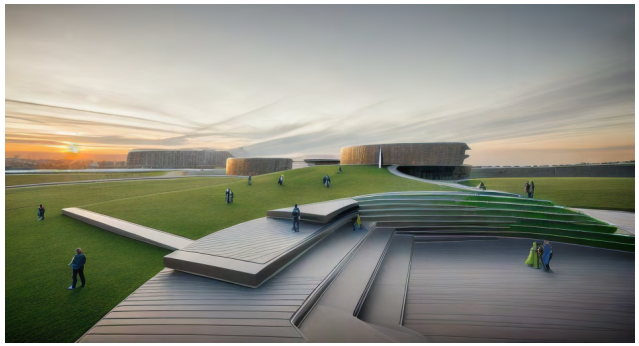
The design goal is to seamlessly integrate the park with the building, achieved by incorporating landscape elements into the structure's roof. This approach ensures that the building actively engages with the park, creating a harmonious connection between the two.

Fig 9.8: Charrettes Process
Creating masses based on site analysis, Engaging with the park Masses (Author, 2023)

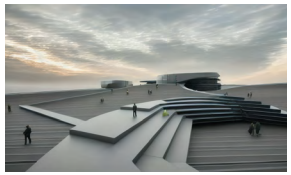


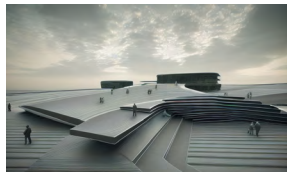


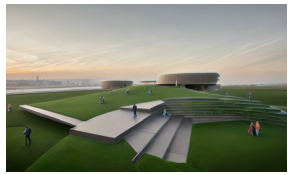


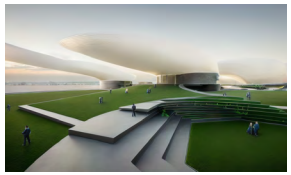


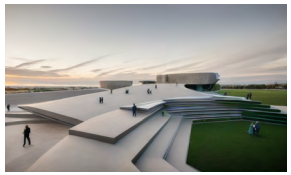


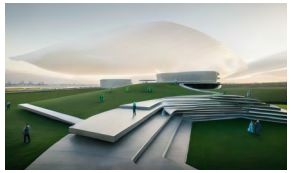


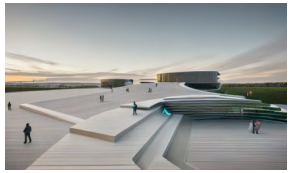


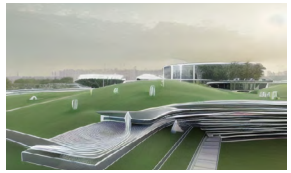


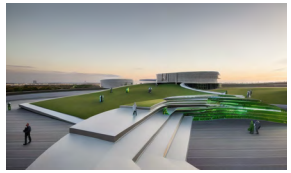


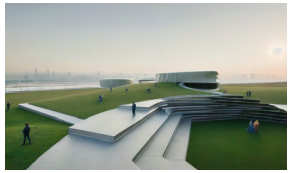








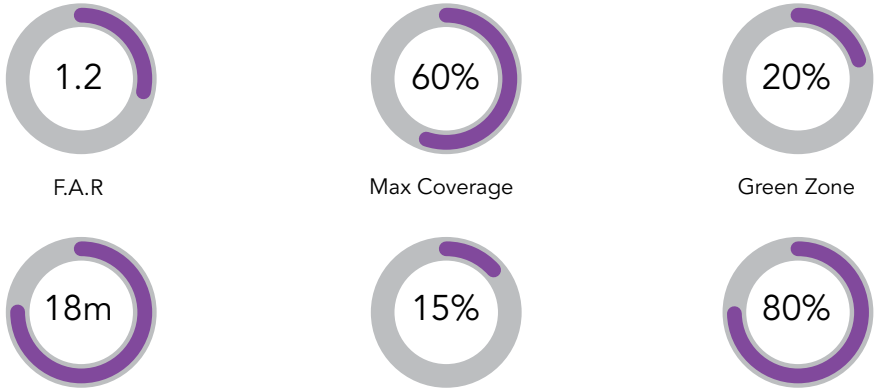




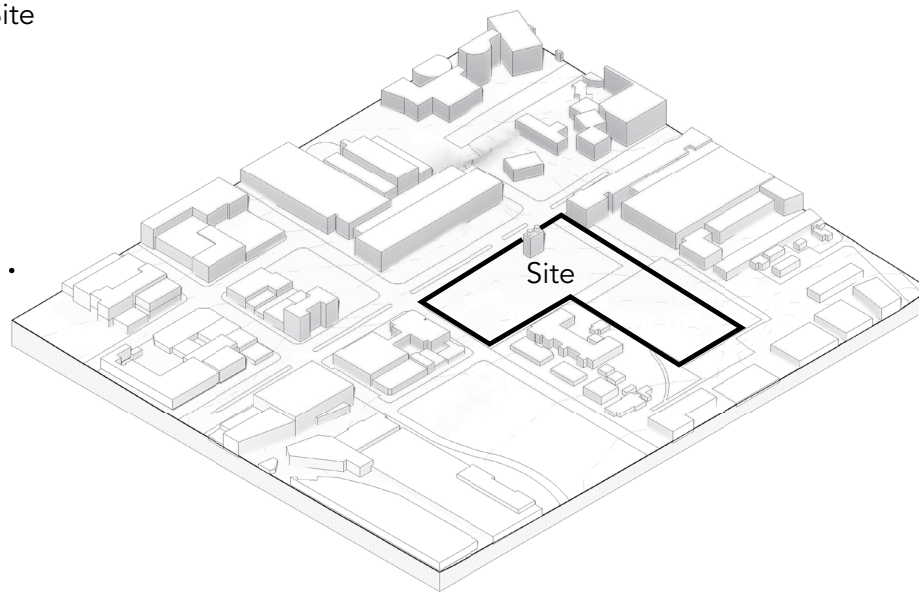


AI Mass Generator:

Constraints



Site

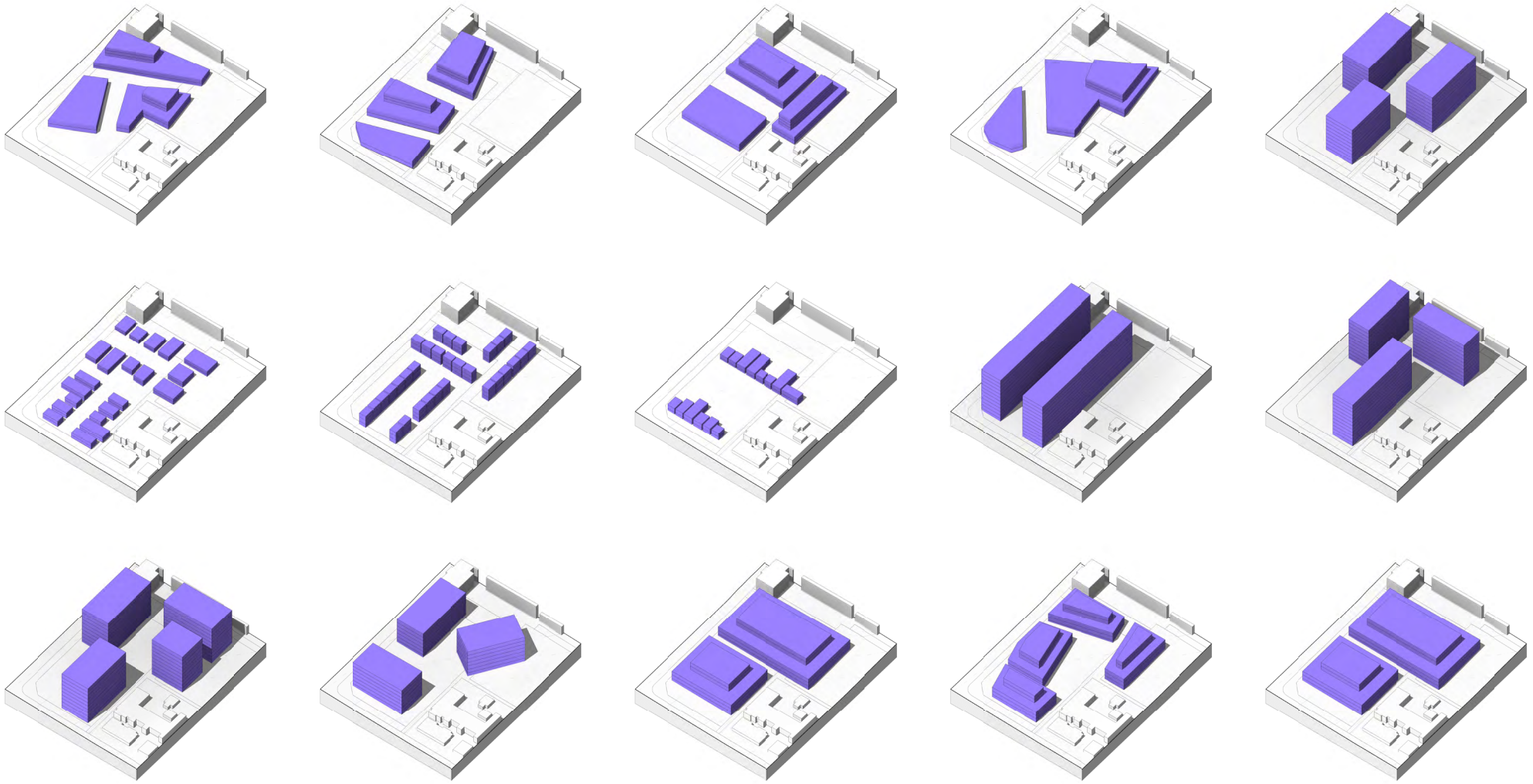


Harnessing the potential of AI Mass Generator, I have unlocked the ability to generate an array of design possibilities at an unprecedented speed up to a total of 100 masses were generated and from that 5 masses that aligned with my design intent + goals was chosen to evaluate. This tool allows me to explore various spatial configurations, test design iterations, and refine our design process efficiently based off of parameters I have provided. As seen in the examples below located on Site.

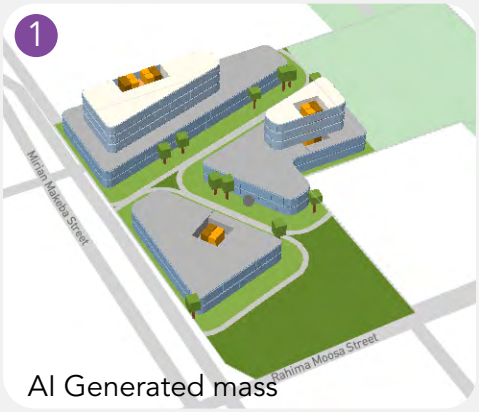
Programme / Area needed for AI innovation center

Description	***Proposed***	***Allowed***	***Complies***
Area of Site (m^2)	n/a	6252 m^2	n/a
F.A.R	1.1	4	Yes
Coverage	60%	100%	Yes
Use Zone	**Business 1**: Shops, Place of Instruction, Institutions, public + private parking, residential	Business 1 + Industrial 1 + Proposed new Roads and widenings + Public Space	Yes
Parking Requirements	155 as per Annexure A	119	no
Height Zone	2 stories	H2 – Permits 7 story	Yes
Building Lines	3m between al buildings and 1.5m Along street edges	3m between al buildings and 1.5m Along street edges	Yes

Handful of the various generated masses on site in Newtown, based on different programmes



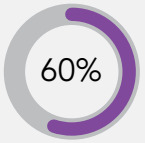
Commercial 1



AI Generated mass



F.A.R



Max Coverage



Green Zone



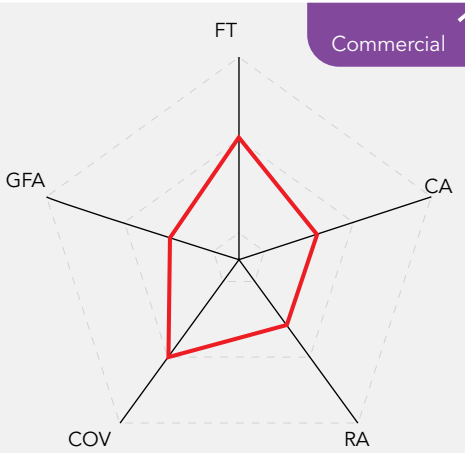
Building Heights



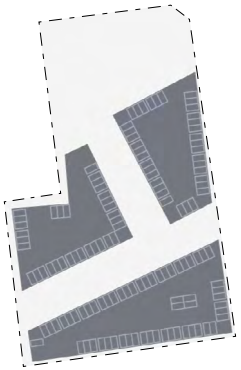
Communal Space



Commercial Area



Footprint (ft)	5195m²
Commercial Area (ca)	11 193m²
Retail Area(ra)	2000m²
Coverage (cov)	46%
Gross floor area (gfa)	13 193m²



Parking - 120 bays

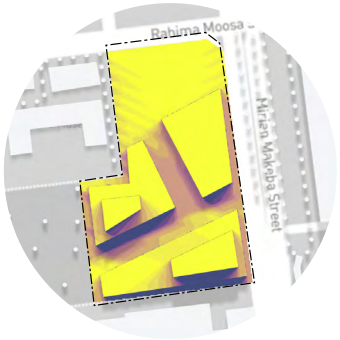


4.

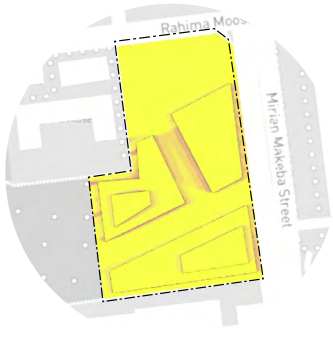
Fig 1 (Top Left)
AI Generated Masses - ArchiStarAI

Fig 2 (Bottom page)
Analysis studies - Forma Autodesk

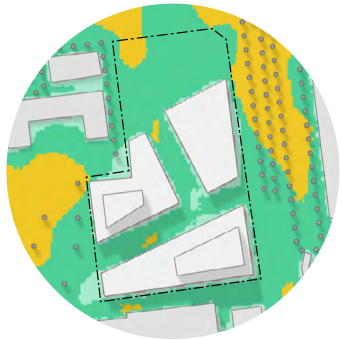
Fig 3 (Top page)
Graphs - By Author



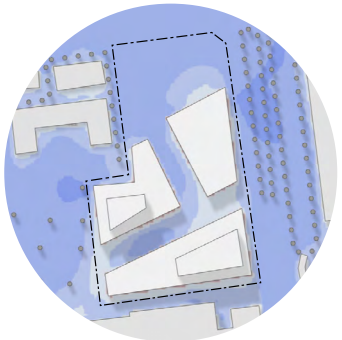
1.a winter solstice



1.b summer solstice



2.



3.

1. Sun

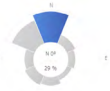


2. Comfort



3. Wind - North





4. Daylight potential - SE view

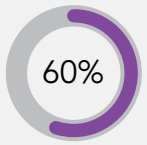


Commercial 2

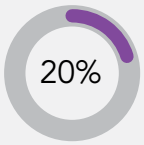




F.A.R



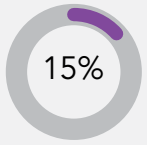
Max Coverage



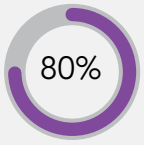
Green Zone



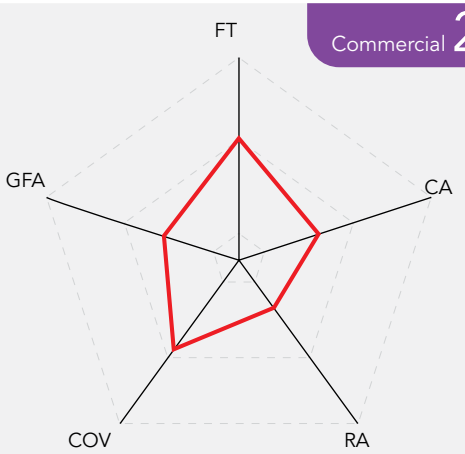
Building Heights



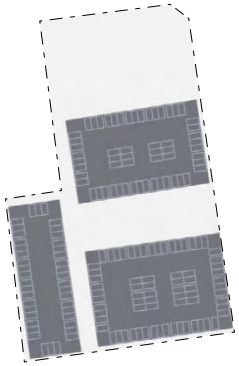
Communal Space



Commercial Area



Footprint (ft)	4976m²
Commercial Area (ca)	11 295m²
Retail Area(ra)	1894m²
Coverage (cov)	44%
Gross floor area (gfa)	14 023m²


Parking - 172 bays

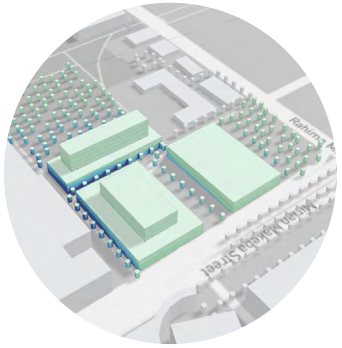
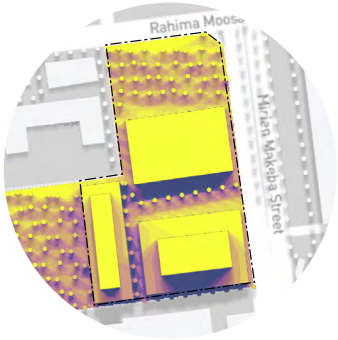

4.

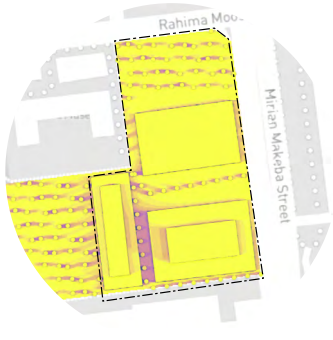
Fig 1 (Top Left)
AI Generated Masses - ArchiStarAI

Fig 2 (Bottom page)
Analysis studies - Forma Autodesk

Fig 3 (Top page)
Graphs - By Author

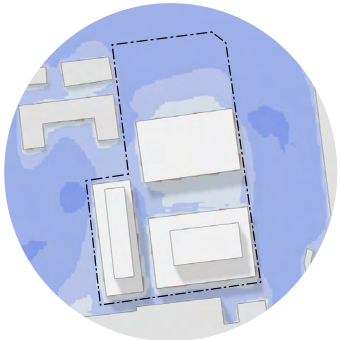


1.a winter solstice

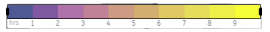


1.b summer solstice


2.


3.

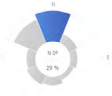
1. Sun



2. Comfort



3. Wind - North





4. Daylight potential - SE view



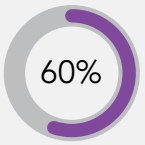
Commercial 3



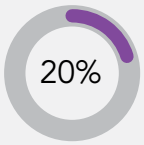
AI Generated mass



F.A.R



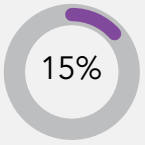
Max Coverage



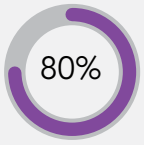
Green Zone



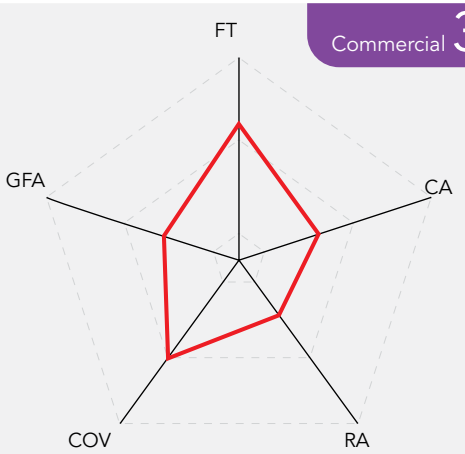
Building Heights



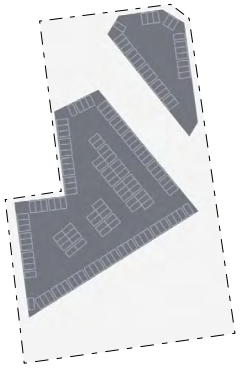
Communal Space



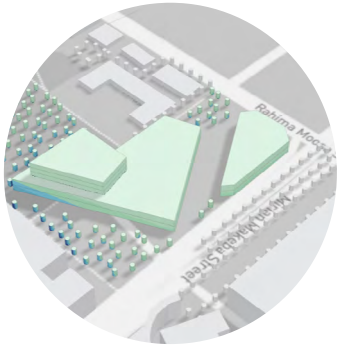
Commercial Area



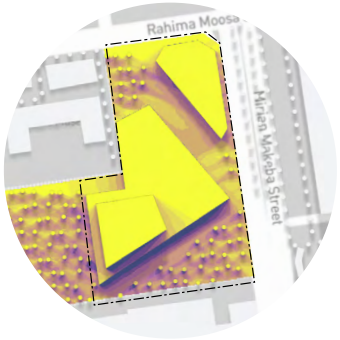
Footprint (ft)	5782m²
Commercial Area (ca)	11 340m²
Retail Area(ra)	2249m²
Coverage (cov)	51%
Gross floor area (gfa)	13 953m²



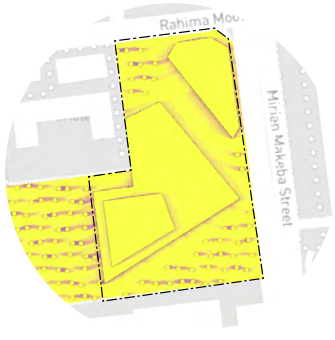
Parking - 147 bays



4.



1.a winter solstice



1.b summer solstice



2.



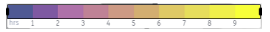
3.

Fig 1 (Top Left)
AI Generated Masses - ArchiStarAI

Fig 2 (Bottom page)
Analysis studies - Forma Autodesk

Fig 3 (Top page)
Graphs - By Author

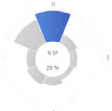
1. Sun



2. Comfort



3. Wind - North

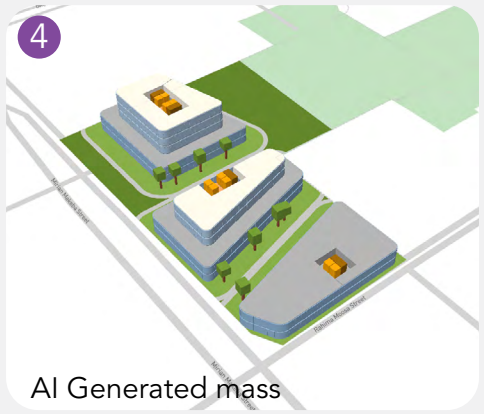




4. Daylight potential - SE view



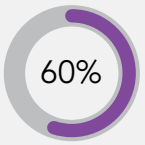
Commercial 4



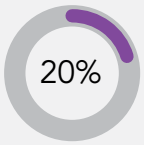
AI Generated mass



F.A.R



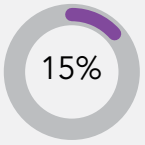
Max Coverage



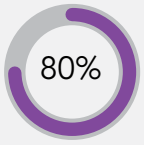
Green Zone



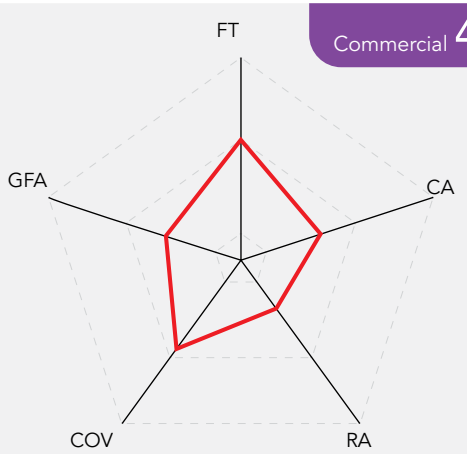
Building Heights



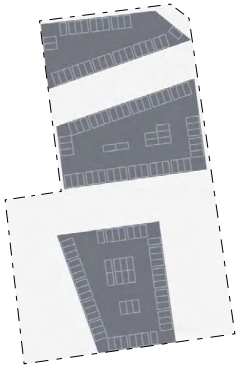
Communal Space



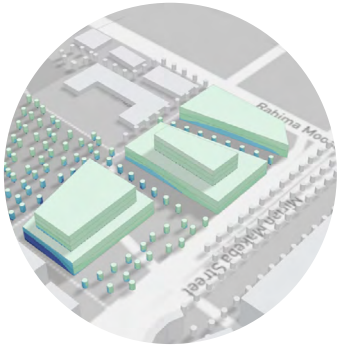
Commercial Area



Footprint (ft)	4960m²
Commercial Area (ca)	11 158m²
Retail Area(ra)	1894m²
Coverage (cov)	44%
Gross floor area (gfa)	13 838m²



Parking - 135 bays

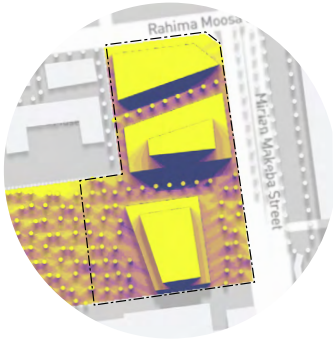


4.

Fig 1 (Top Left)
AI Generated Masses - ArchiStarAI

Fig 2 (Bottom page)
Analysis studies - Forma Autodesk

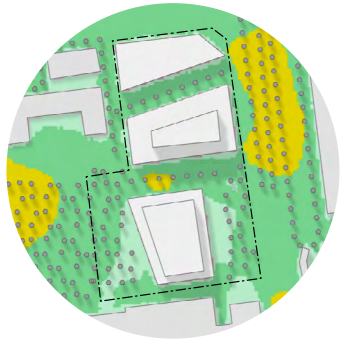
Fig 3 (Top page)
Graphs - By Author



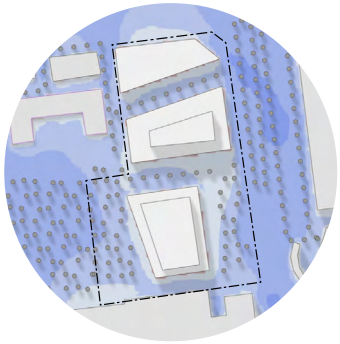
1.a winter solstice



1.b summer solstice

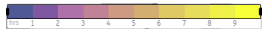


2.



3.

1. Sun

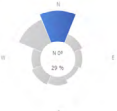


2. Comfort



3. Wind - North





4. Daylight potential - SE view



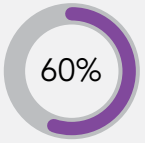
Commercial 5



AI Generated mass



F.A.R



Max Coverage



Green Zone



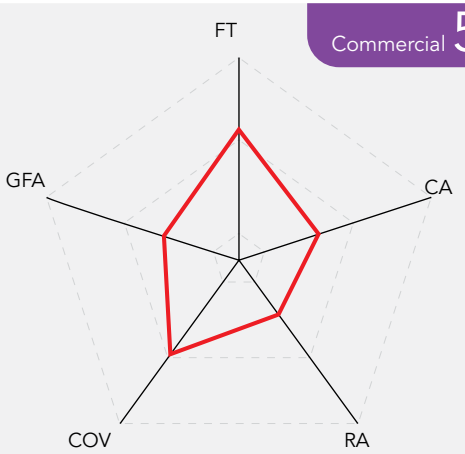
Building Heights



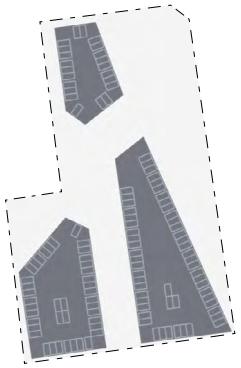
Communal Space



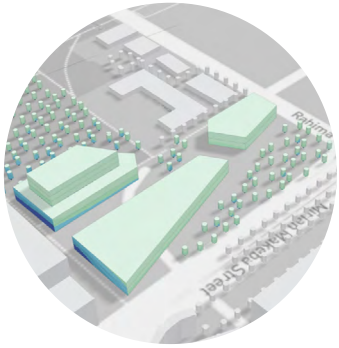
Commercial Area



Footprint (ft)	5482m²
Commercial Area (ca)	11 015m²
Retail Area(ra)	2096m²
Coverage (cov)	48%
Gross floor area (gfa)	13 660m²



Parking - 119 bays

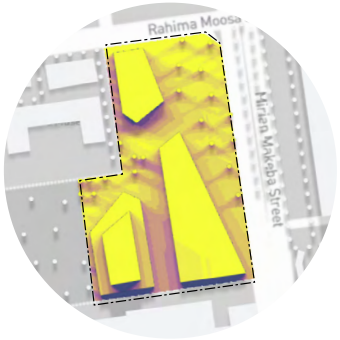


4.

Fig 1 (Top Left)
AI Generated Masses - ArchiStarAI

Fig 2 (Bottom page)
Analysis studies - Forma Autodesk

Fig 3 (Top page)
Graphs - By Author



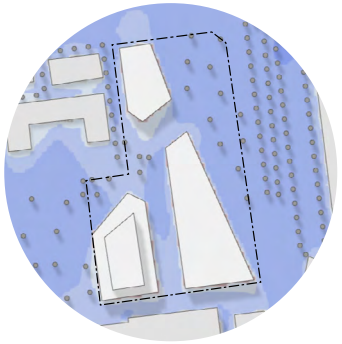
1.a winter solstice



1.b summer solstice

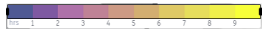


2.



3.

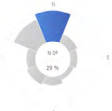
1. Sun



2. Comfort



3. Wind - North

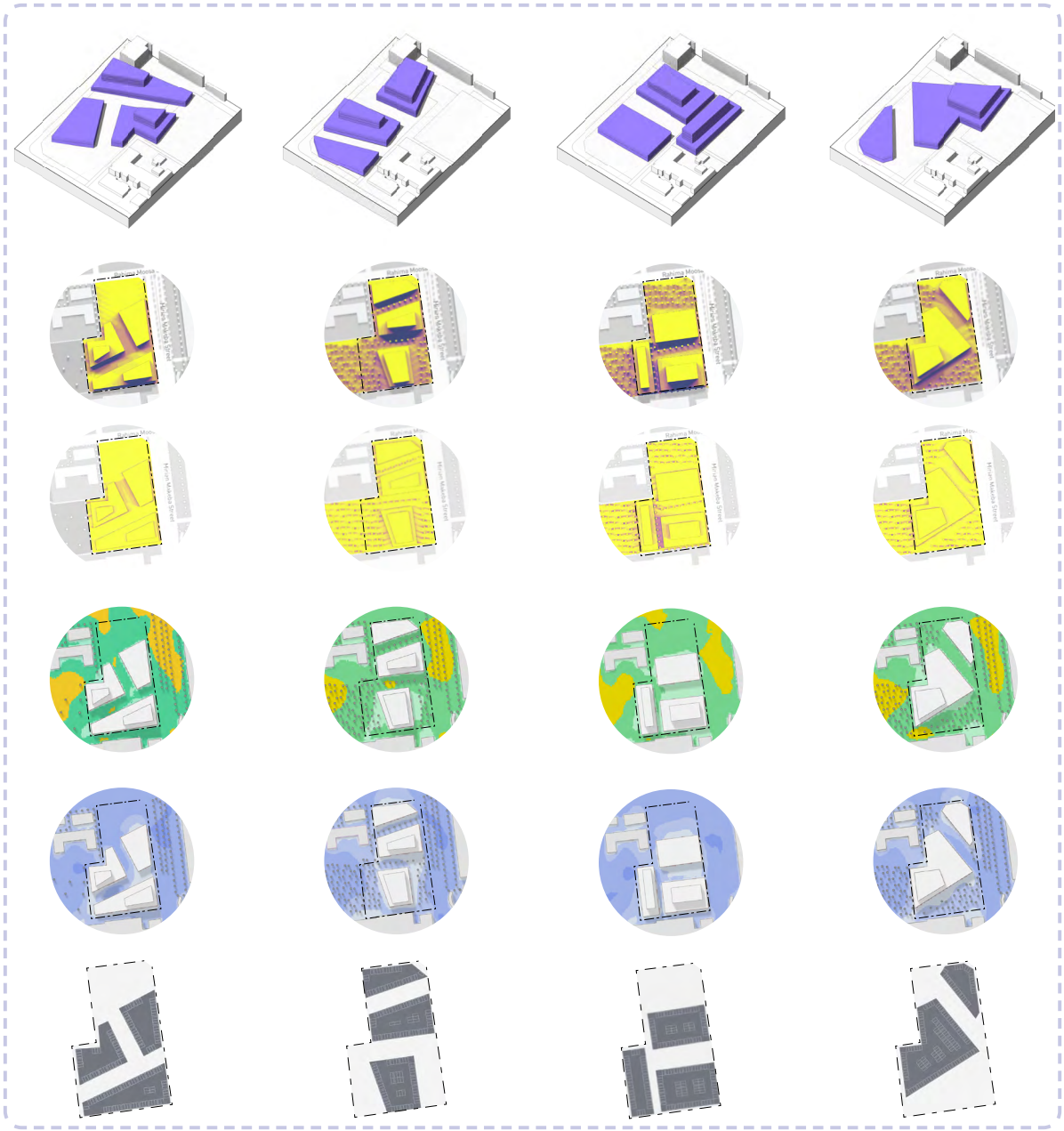




4. Daylight potential - SE view



Output - Chosen generated masses



Masses Analysed

Winter Solstice

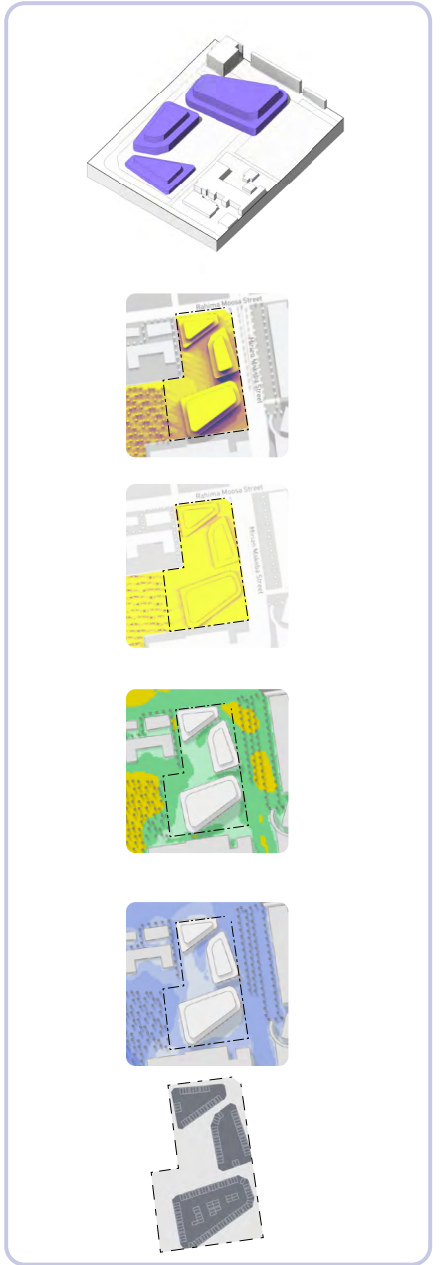
Summer Solstice

Comfort

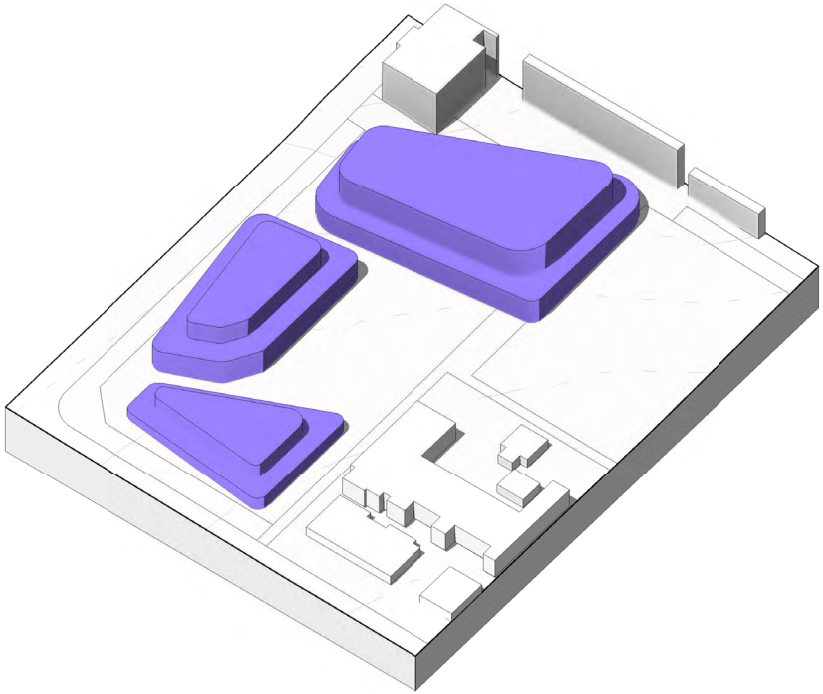
Wind

Parking Layouts

Resolved/Designed Mass

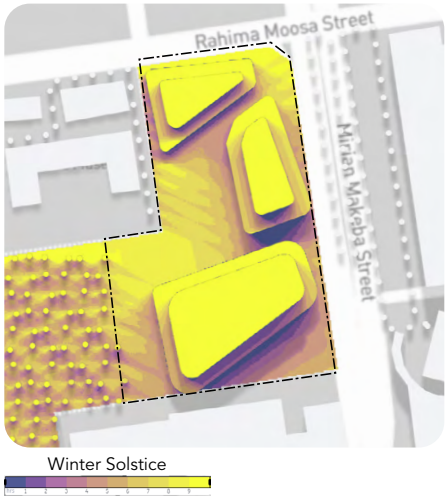


Resolved/Designed Mass



Once I analysed generated masses and designed masses. I looked at which masses aligned with my goal and vision for the building mass. I made these informed decisions based on research and experience. The above mass was designed based on a few factors. Looking at my informed masses – “Sun - Low North + High South” and “Movement” it aligns with some major principles such as creating taller/higher building mass on south side of the site allowing the shorter masses on northside of the site to receive more sunlight and the above mass also aligning’s with existing movement on site.

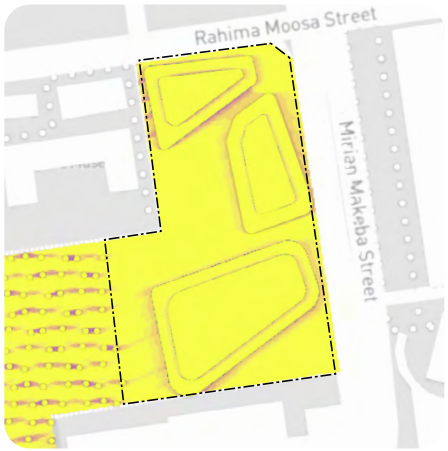
Looking at wind and sun analysis studies, I picked up that a courtyard is very successful in the west side of the site connecting to the park. As it allows adequate sunlight and maximum comfortability bystanders as the courtyard is protected by its surrounding buildings.



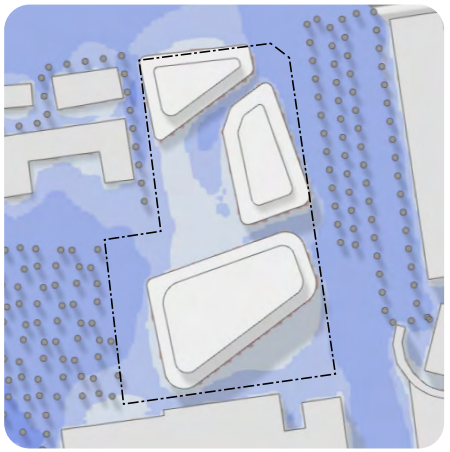
Winter Solstice



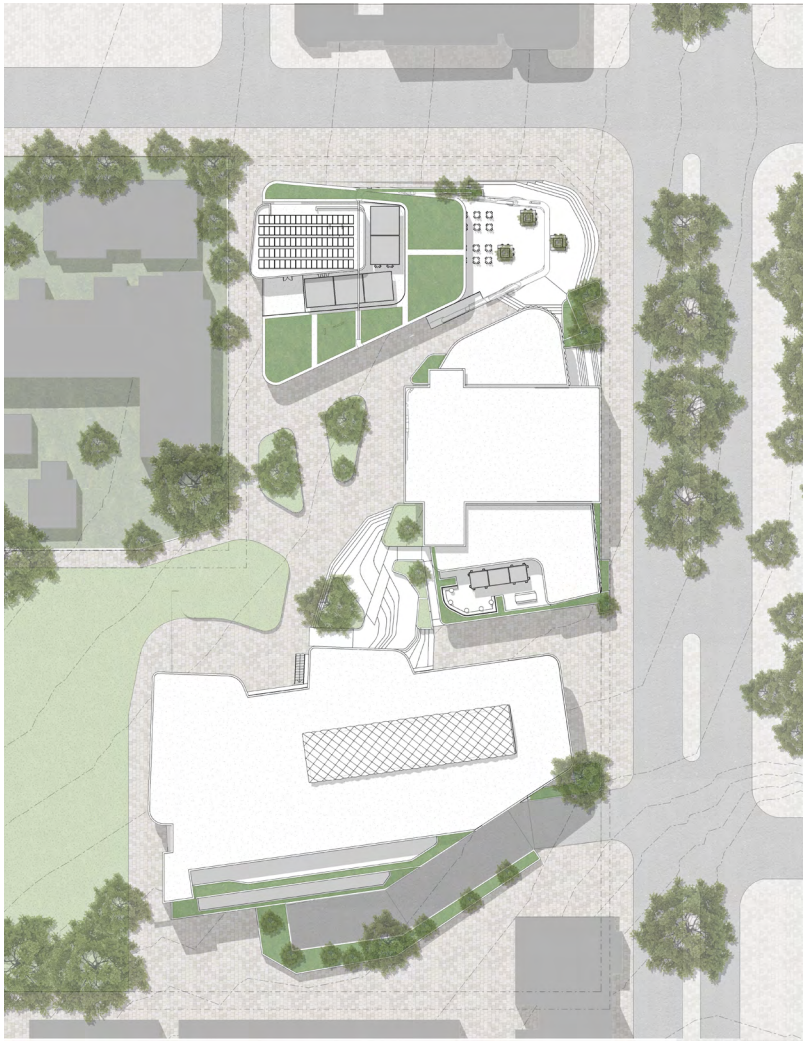
Comfort



Summer Solstice



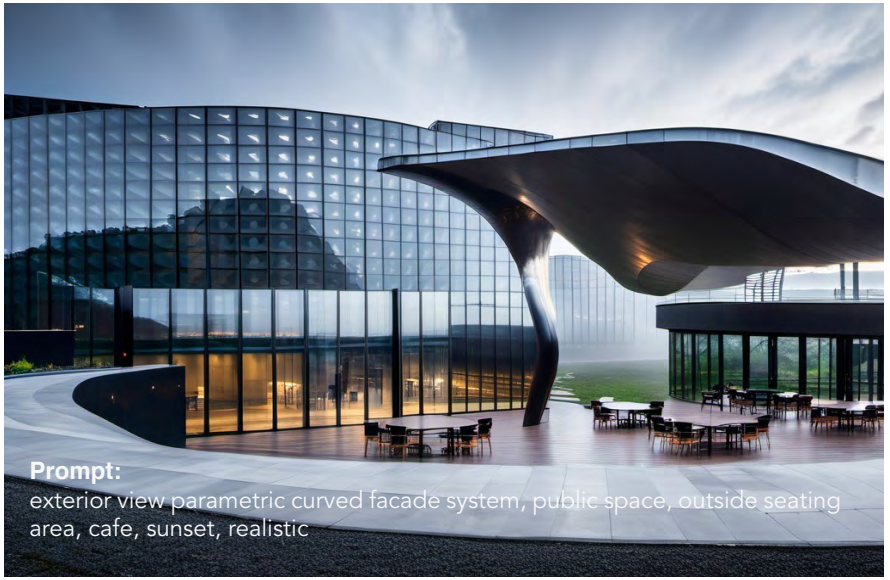
Wind

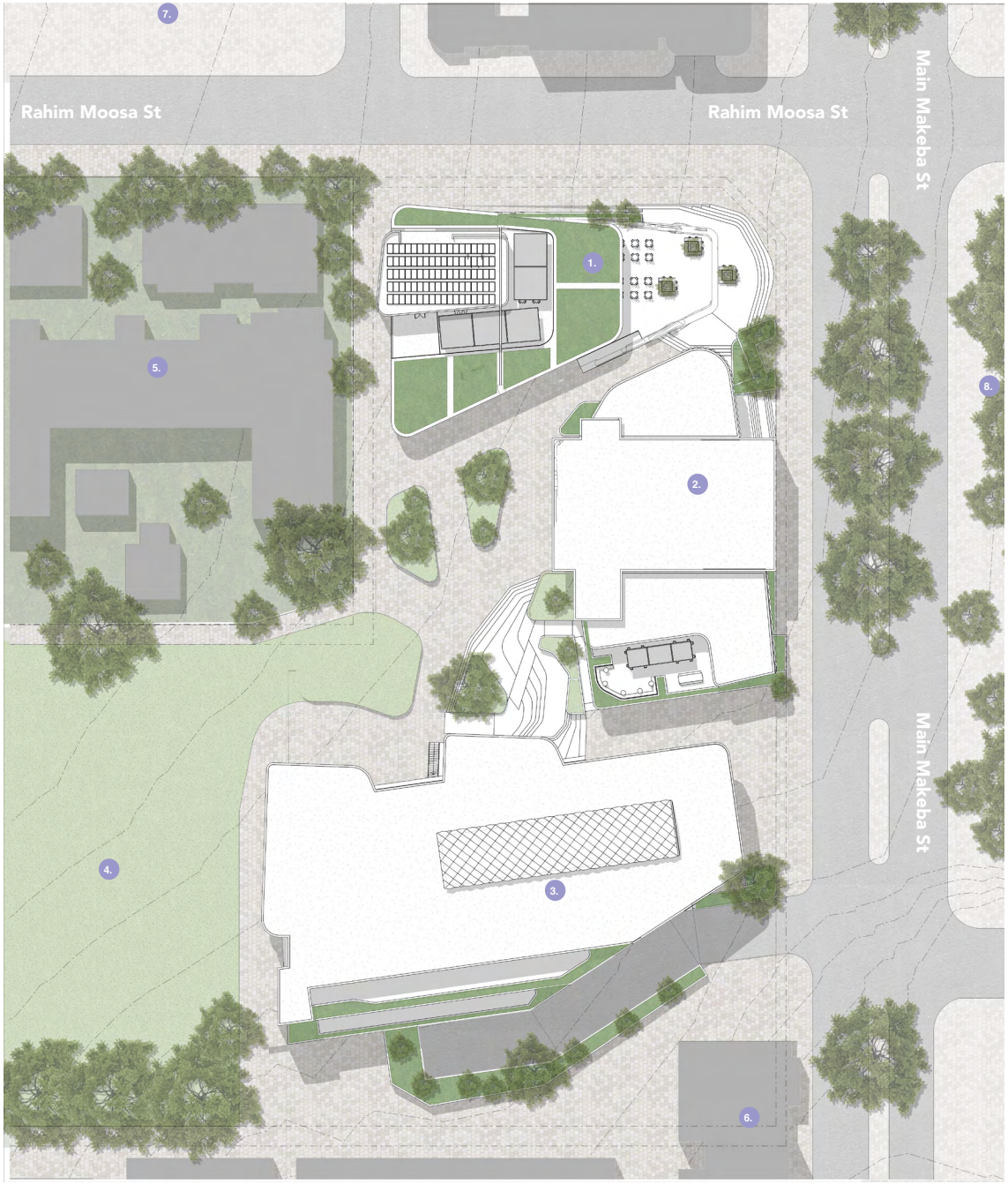


10

THE PROJECT

FINAL DESIGN



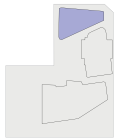


Site Plan

1. Innovation Restaurant - Public
2. Innovation Library - Semi Public
3. Innovation Center - Private
4. Park
5. Workers Musuem
6. Discovery Sci-bono center
7. Mary Fitzgerald Square
8. Turbine Hall

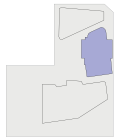


Ground Floor Plan



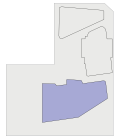
Innovation
Restaurant Public

1. Vegetable garden
2. Seating Area
3. Waiting/Viewing Area
4. Vegetable prep room
5. Outside work Area
6. Circulation



Innovation Library
Semi Public

1. Automated Storage and Retrieval System
2. Reception
3. Ablutions
4. Entrance
5. Lift
6. CAD Labs
7. Hot desks/ Work rooms
8. Fire escape

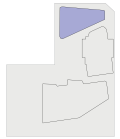


Innovation Centre
Private

1. Auditorium
2. Entrances
3. Atrium Staircase
4. Reception
5. Lifts
6. Fire Escapes
7. Show rooms / Exhibition Spaces
8. Outside collaboration Space
9. Ablutions
10. Cafe linked to main Restaurant
11. Hot desks / Work rooms
12. Interior Collaboration Spaces
13. BOH entrance
14. Ramp to basement

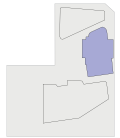


First Floor Plan



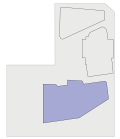
Innovation
Restaurant Public

1. Vegetable garden
2. Seating Area
3. Vegetable prep room
4. Solar panels



Innovation Library
Semi Public

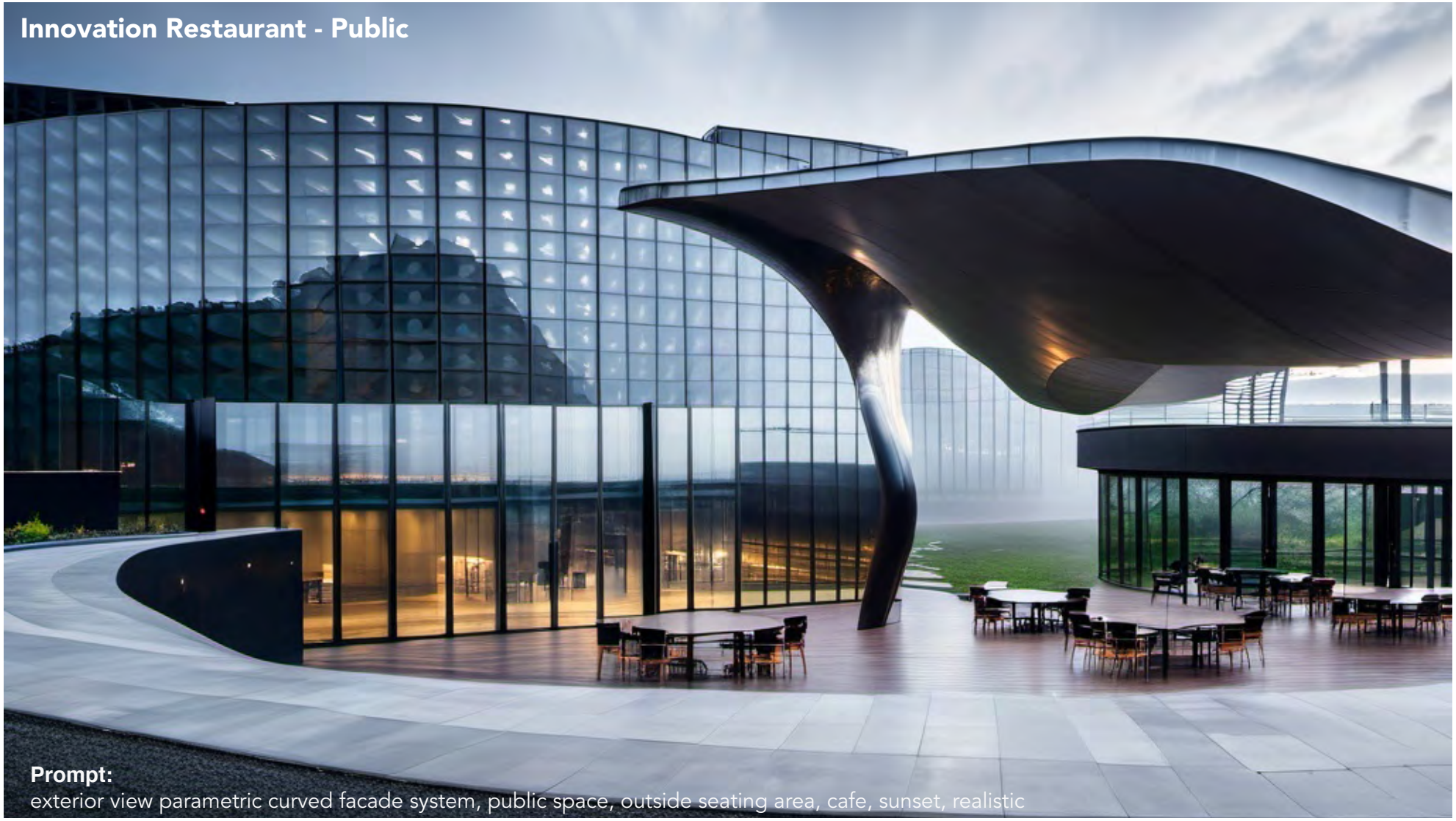
1. ASRS
2. Reception
3. Ablutions
4. Lecture room 50 seats
5. Fire escape
6. Lift
7. Outside collaboration Space
8. Hot desks / Work rooms



Innovation Centre
Private

1. Innovation collaboration space
2. Atrium Staircase
3. Hot desks / Work rooms
4. Lecture room 20 seats
5. Lifts
6. Fire Escapes
7. Show rooms / Exhibition Spaces
8. Outside collaboration Space
9. Ablutions
10. Interior Collaboration Spaces

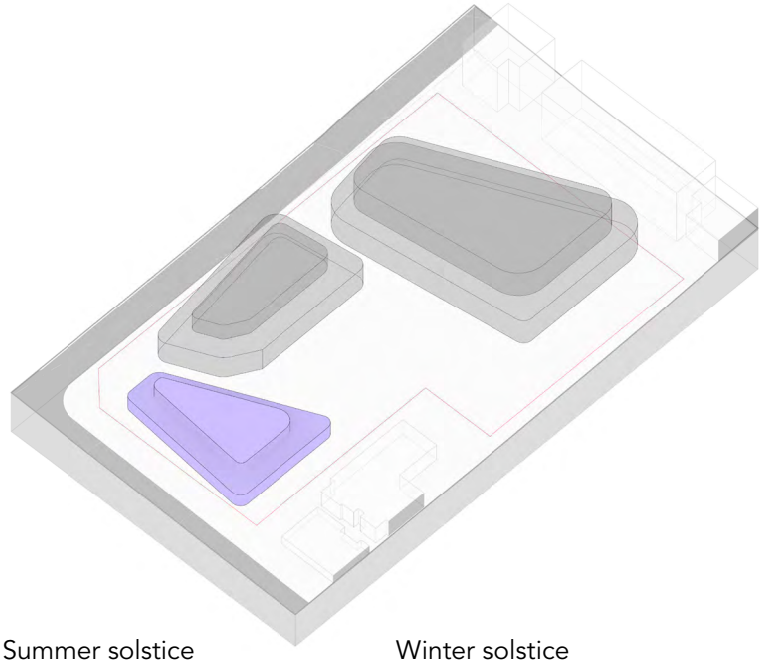
Innovation Restaurant - Public



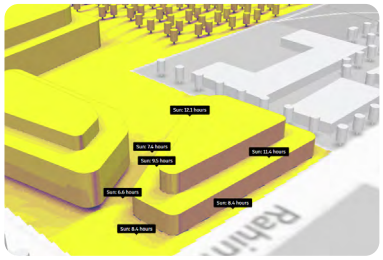
Prompt:
exterior view parametric curved facade system, public space, outside seating area, cafe, sunset, realistic

Innovation Restaurant - Public

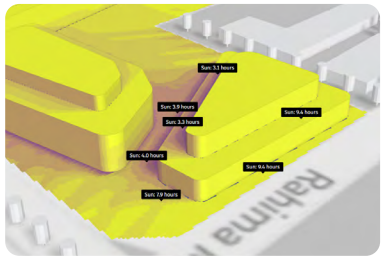
Chosen Mass



Summer solstice

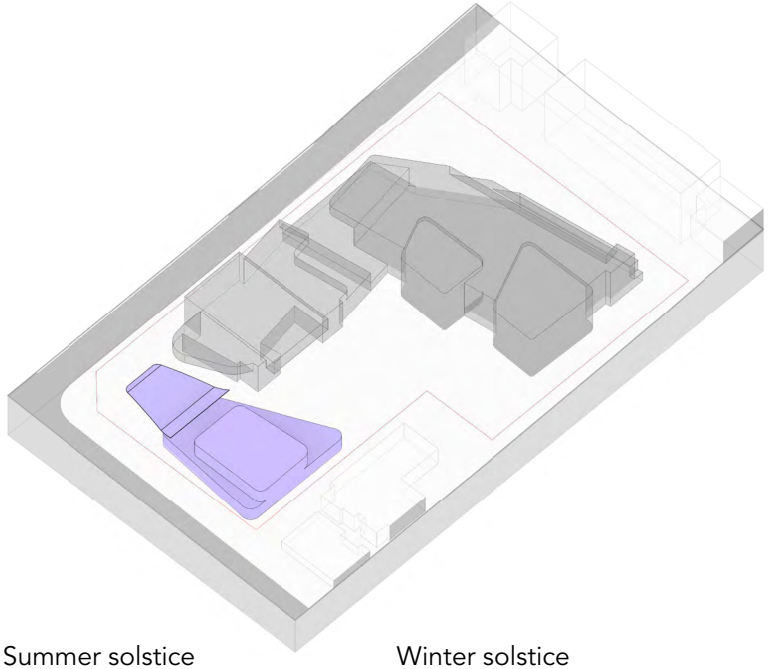


Winter solstice

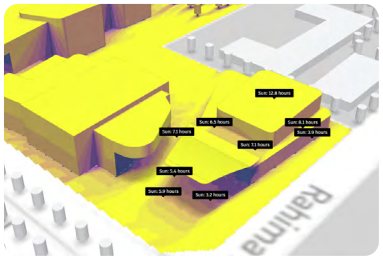


After exploring the mass area and understanding what programme is needed, I was able to analyse how much sunlight the mass received during the winter solstice and summer solstice to assist in the design approach.

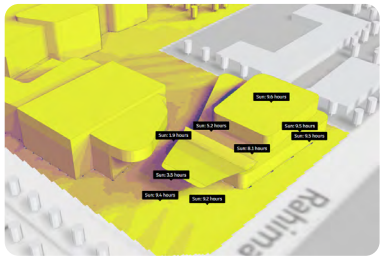
Designed Mass



Summer solstice



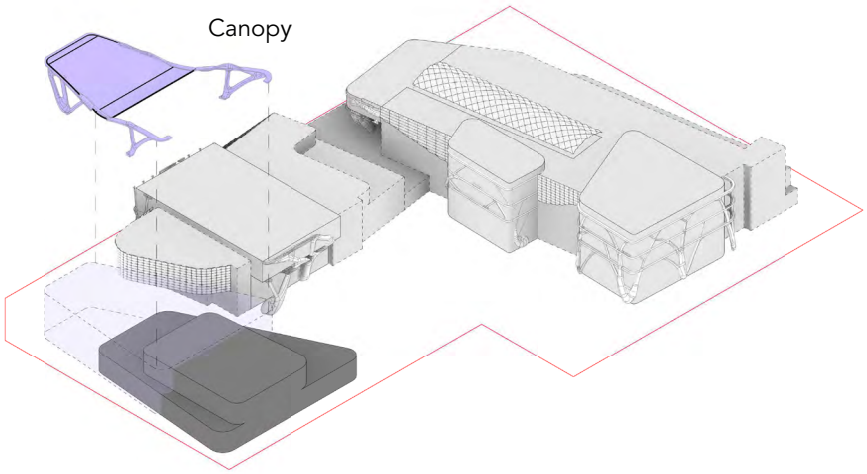
Winter solstice



The goal for this mass was to create a canopy that engaged with the public and created shading for public interface areas and vegetation. By analysing how many hours of sunlight the roof areas and public area received I was able to adjust the mass as needed. For example, vegetation required for the programme needs 6-7 hours of sunlight.

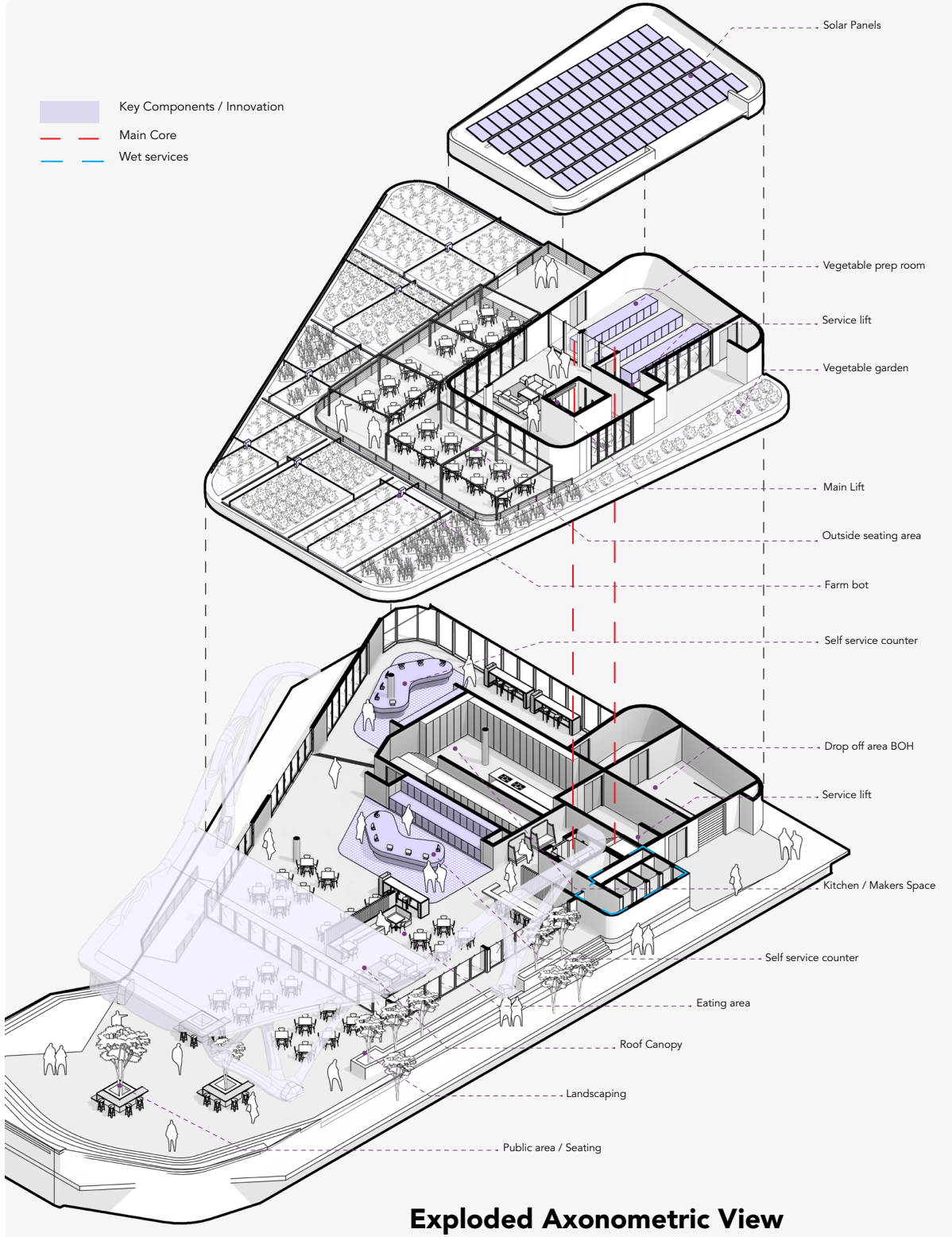
Innovation Restaurant - Public

Typology Optimization



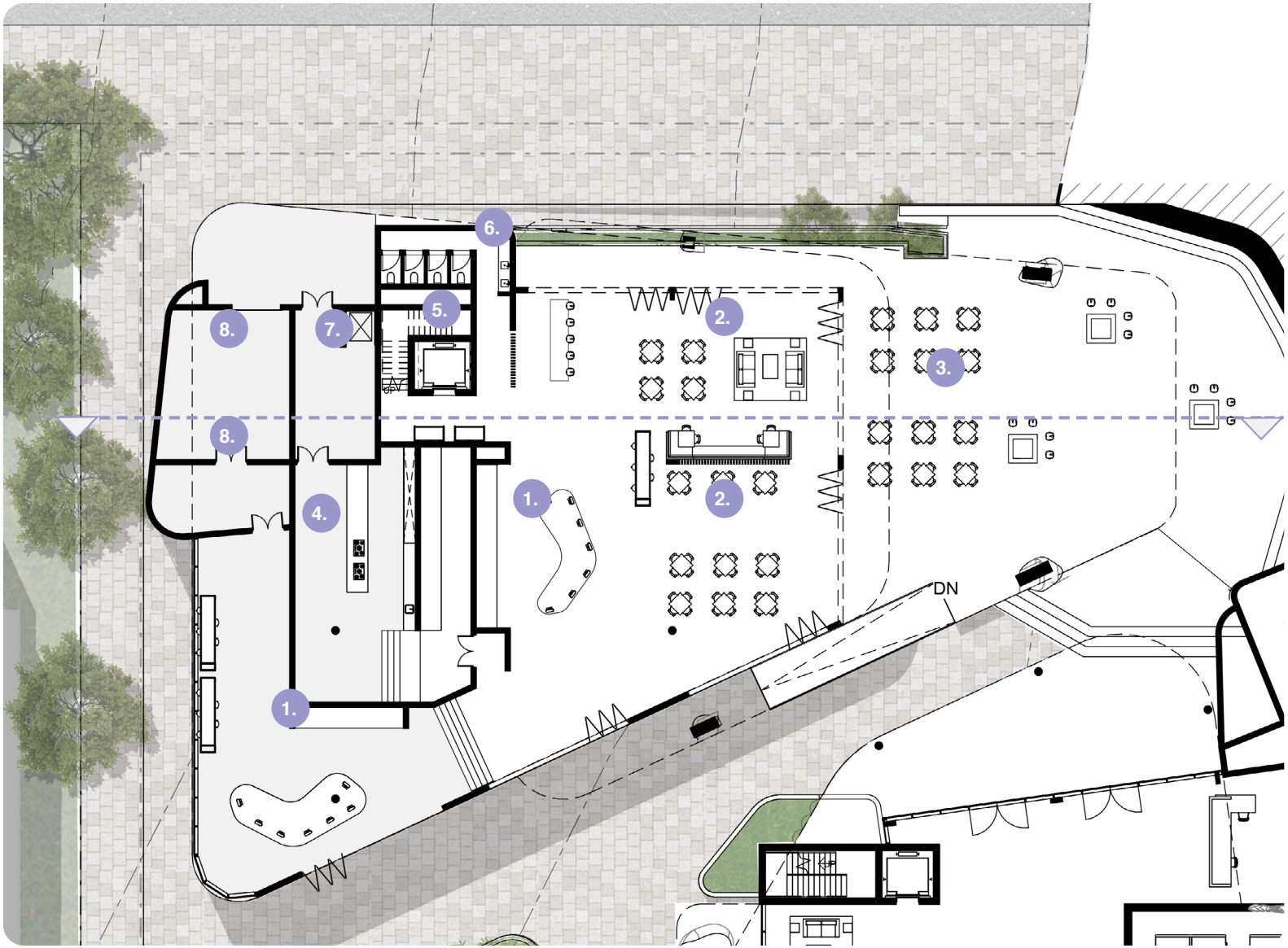
The programme for this building is a restaurant that acts as a testing ground for the hospitality sector to come and experiment with innovative ideas and methods that can improve and assist local restaurants. By having grounds for vegetation allows for systems such as “farmbot” to test how it can water, fertilize and plant seeds as seen on the drawings.

The canopy acts as a statement that engages with the public leading them into the building whilst provides shading for the vegetation. I used Typology Optimization to assist in emphasizing this.



Exploded Axonometric View

Innovation Restaurant - Public

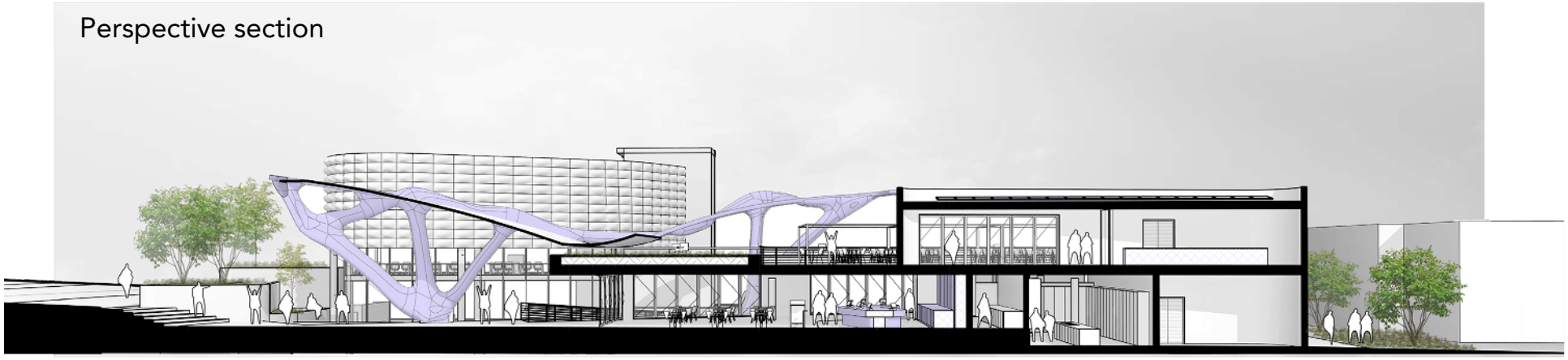


1. Self service counter
2. Private seating area
3. Public seating area
4. Kitchen / makers space
5. Circulation
6. Ablutions
7. Service room + Lift
8. BOH storage
9. Waiting / Viewing Area
10. Outside seating Area
11. Outside work Area
12. Vegetable prep room
13. Farmbot and Vegetable garden

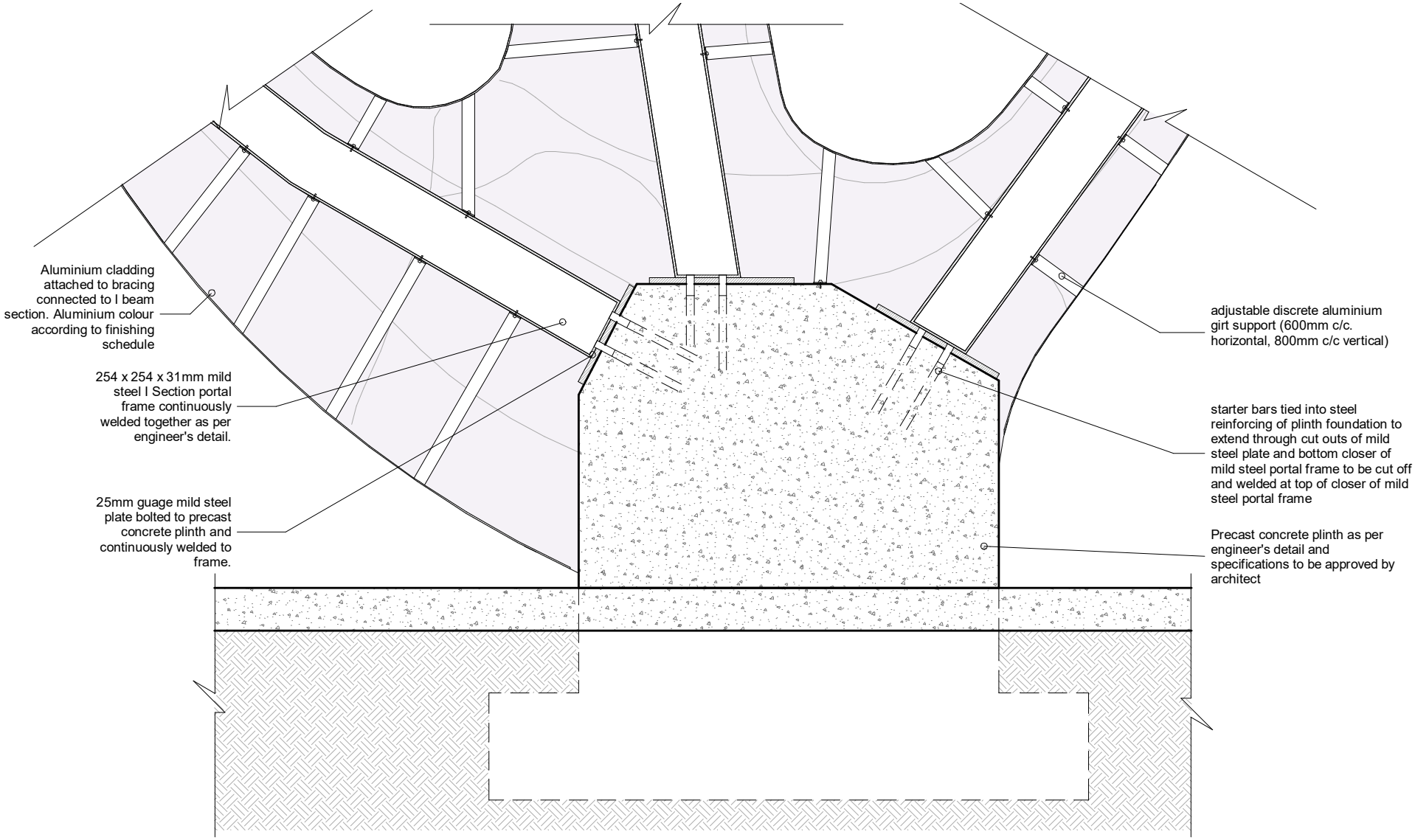
Ground Floor



Innovation Restaurant - Public

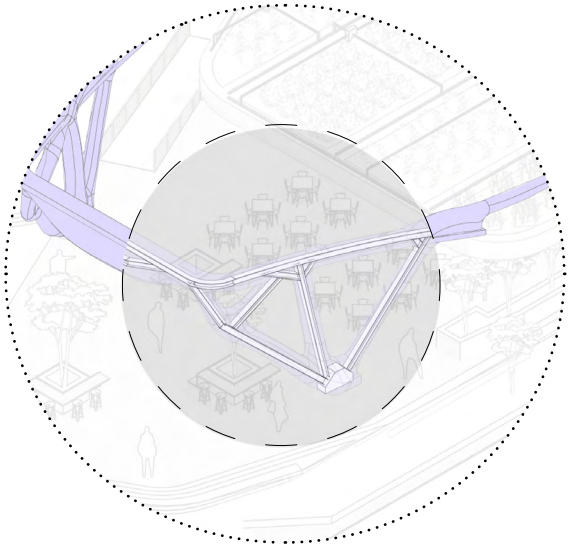




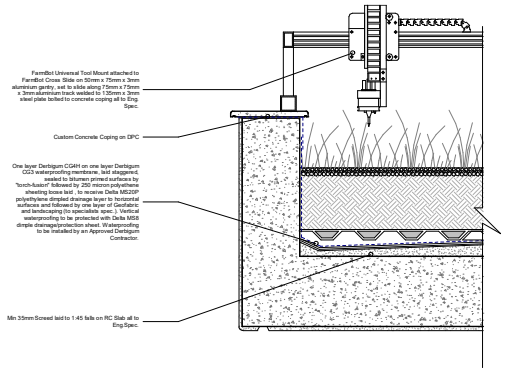


Detail Foundation - Canopy

Innovation Restaurant - Public Technical design



Aluminium Cladding wrapped around steel frame structure connected to a concrete plinth



Detail Farmbot

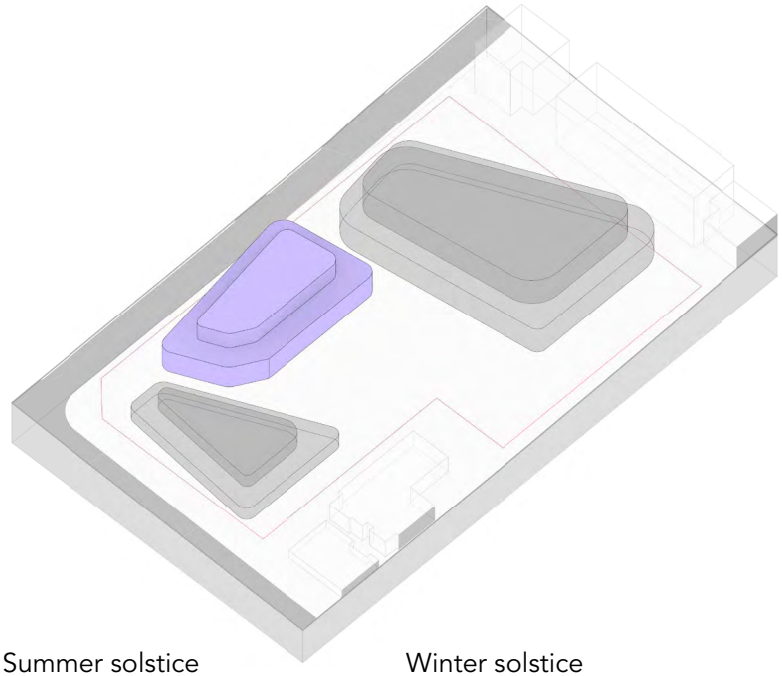


Prompt:
table with touch screens where people order food and behind the table is a conveyor belt with food and robotic arms system making the food

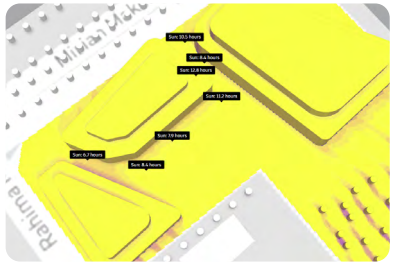

Innovation Library - Semi Public
Prompt:
exterior view parametric curved facade system, public space, white finishes, steel and glass materials

Innovation Library - Semi Public

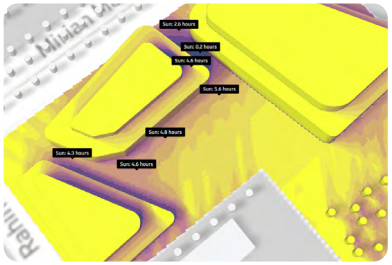
Chosen Mass



Summer solstice

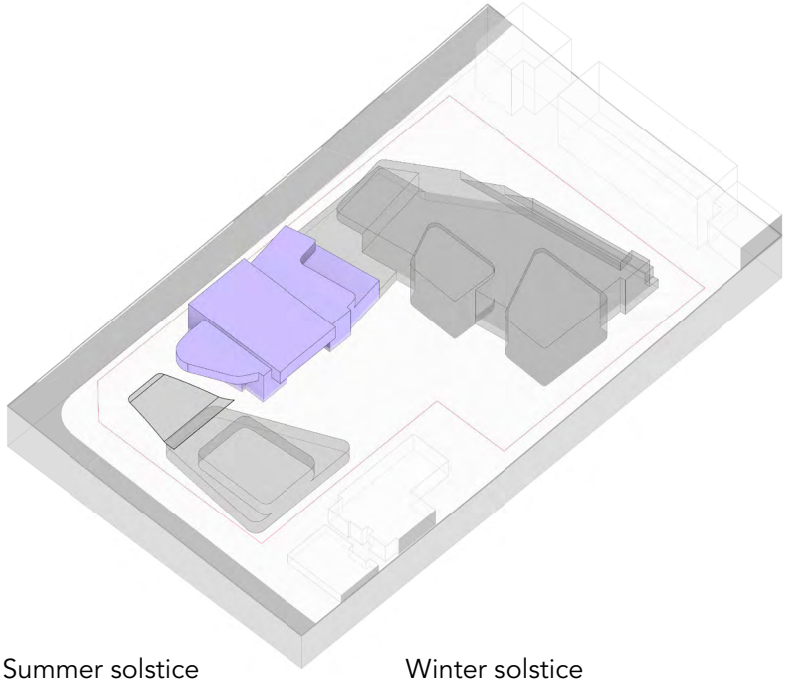


Winter solstice

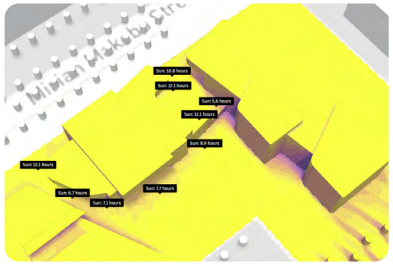


After exploring the mass area and understanding what programme is needed, I was able to analyse how much sunlight the mass received during the winter solstice and summer solstice to assist in the design approach.

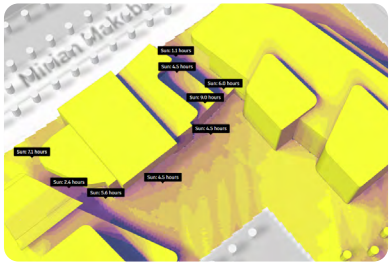
Designed Mass



Summer solstice



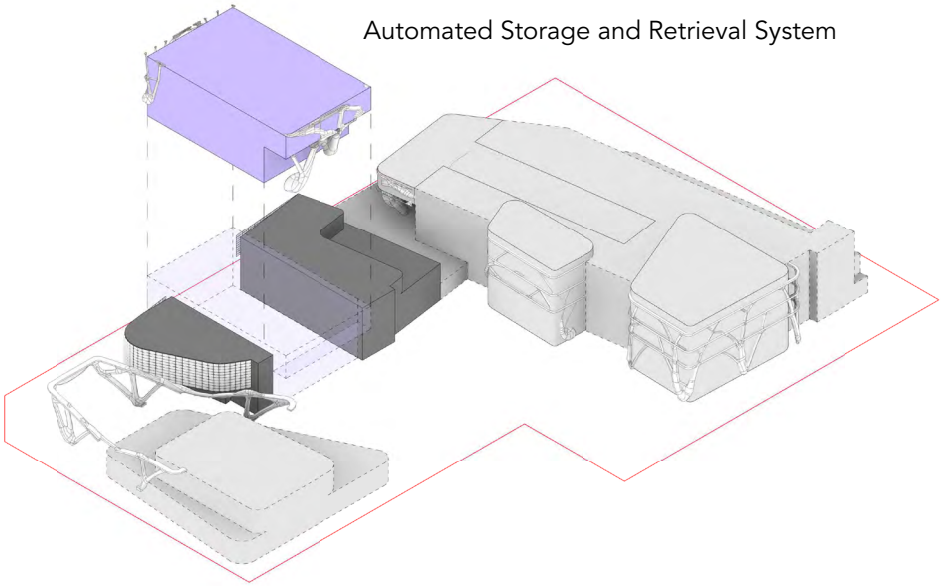
Winter solstice



Analysing the designed mass suited to the programme, I determined how much harsh sunlight the north façade received and how little sunlight the south side of the mass received. This assisted me in understanding that a façade system is needed on the north for sunlight and also stepping the building back on the south side allows more sunlight to enter.

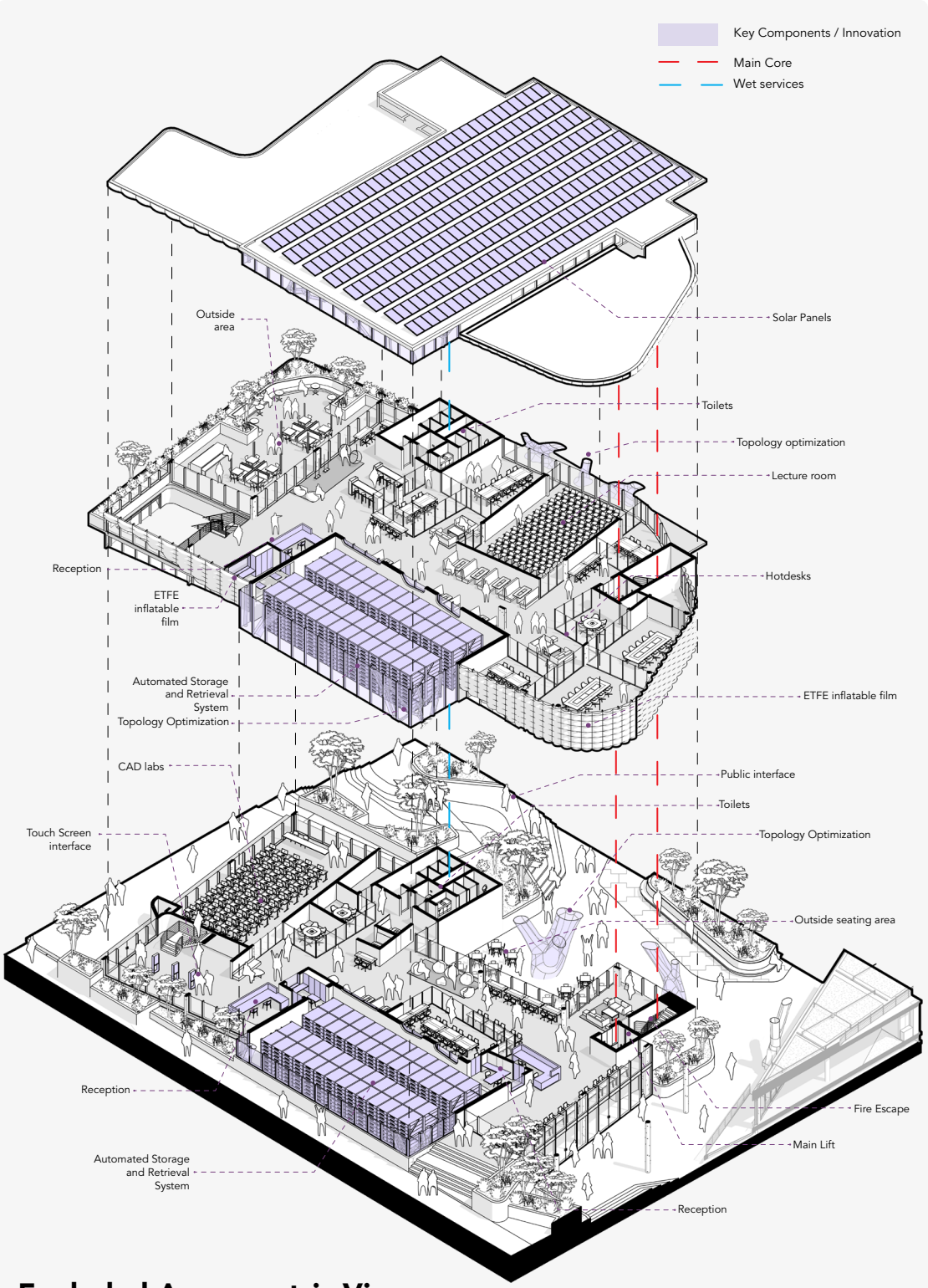
Innovation Library - Semi Public

Typology Optimization



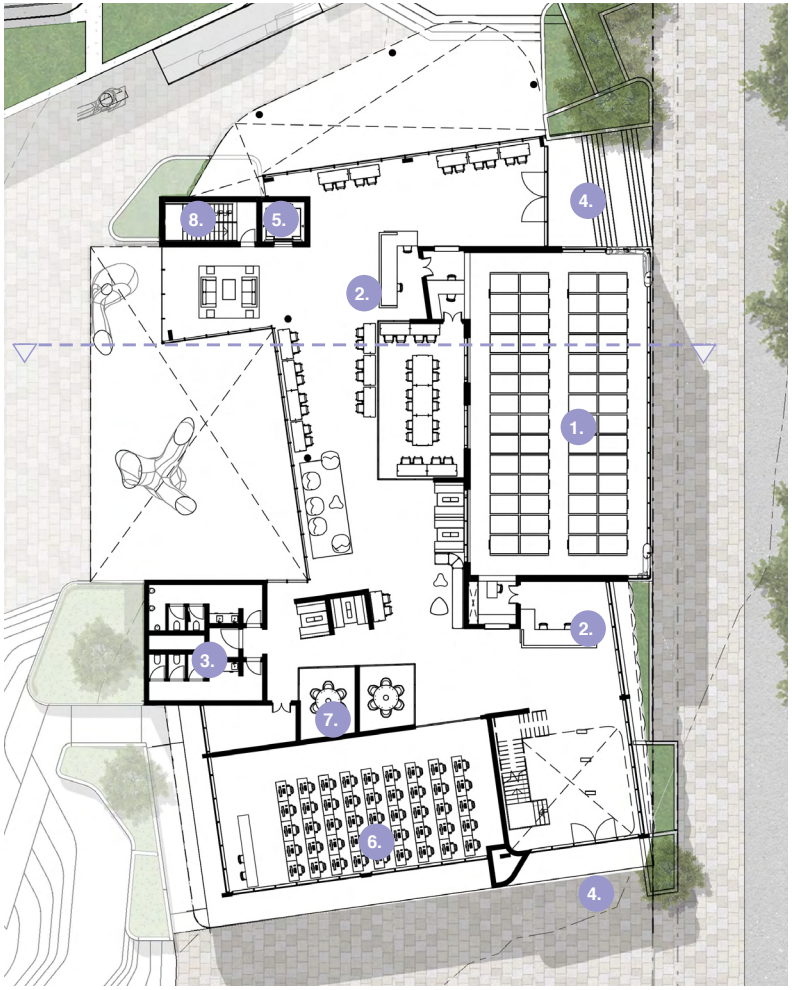
The programme for this building is a library that fosters and promotes innovation. This library does this by using Automated Storage and Retrieval System. A system that stores all data, books and archive work in one place. Allowing users to request data and have it delivered to them in minutes.

The goal is to let the libraries users and the public engage with Automated Storage and Retrieval System. This has been achieved through highlighting the system on the facades of the building through Typology Optimization.



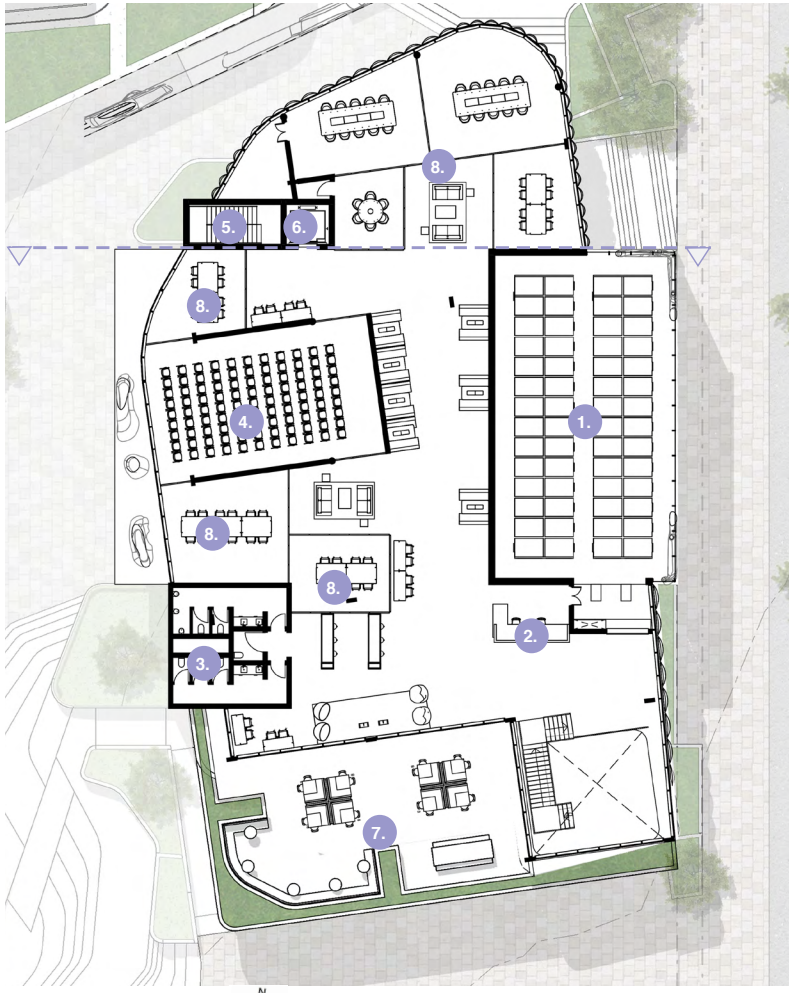
Exploded Axonometric View

Innovation Library - Semi Public



Ground Floor

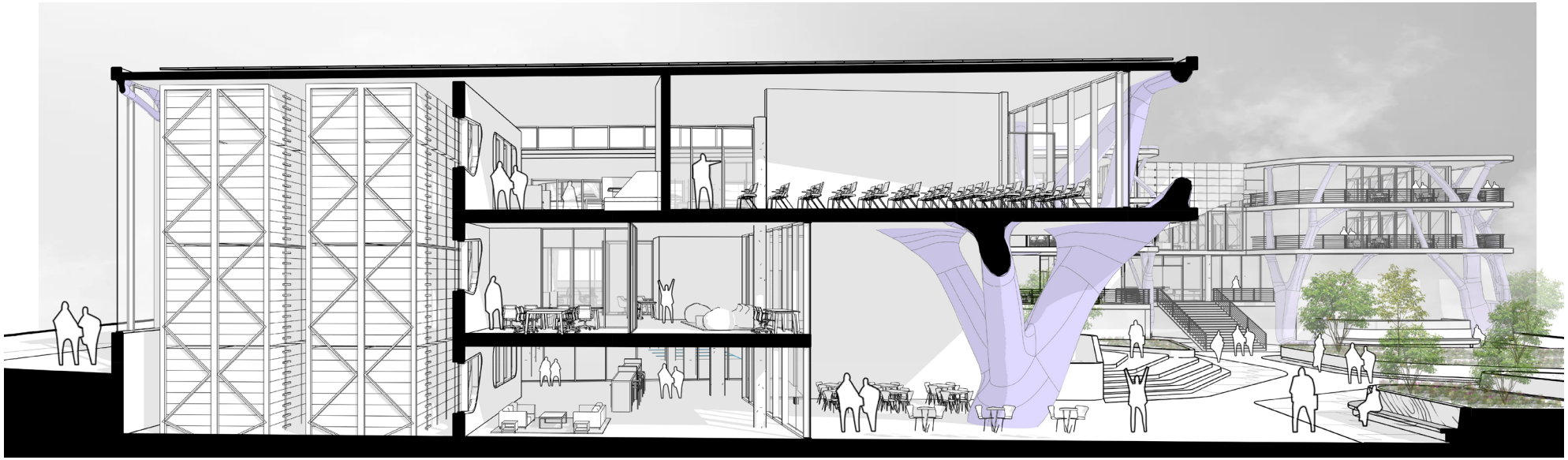
1. Automated Storage and Retrieval System
2. Reception
3. Ablutions
4. Entrance
5. Lift
6. CAD Labs
7. Hot desks/ Work rooms
8. Fire escape



First Floor

1. Automated Storage and Retrieval System
2. Reception
3. Ablutions
4. Lecture room 50 seats
5. Fire escape
6. Lift
7. Outside collaboration Space
8. Hot desks / Work rooms

Innovation Library - Semi Public

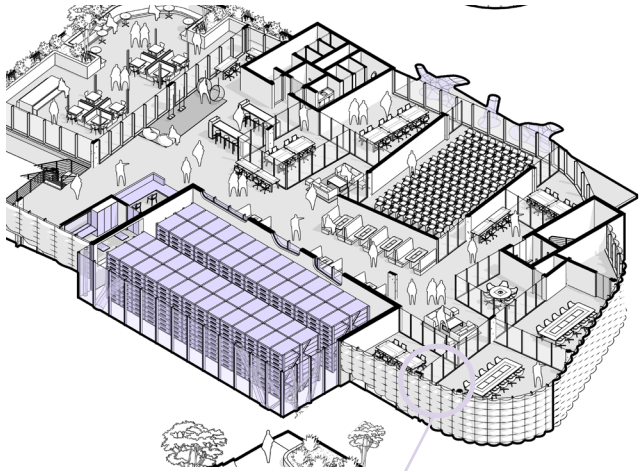


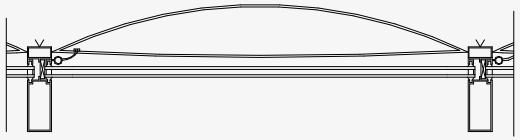
Perspective section



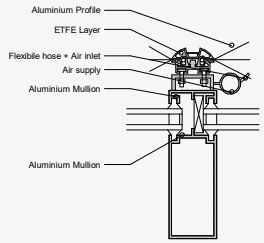
East Elevation

Innovation Library - Semi Public Technical design





Detail ETFE

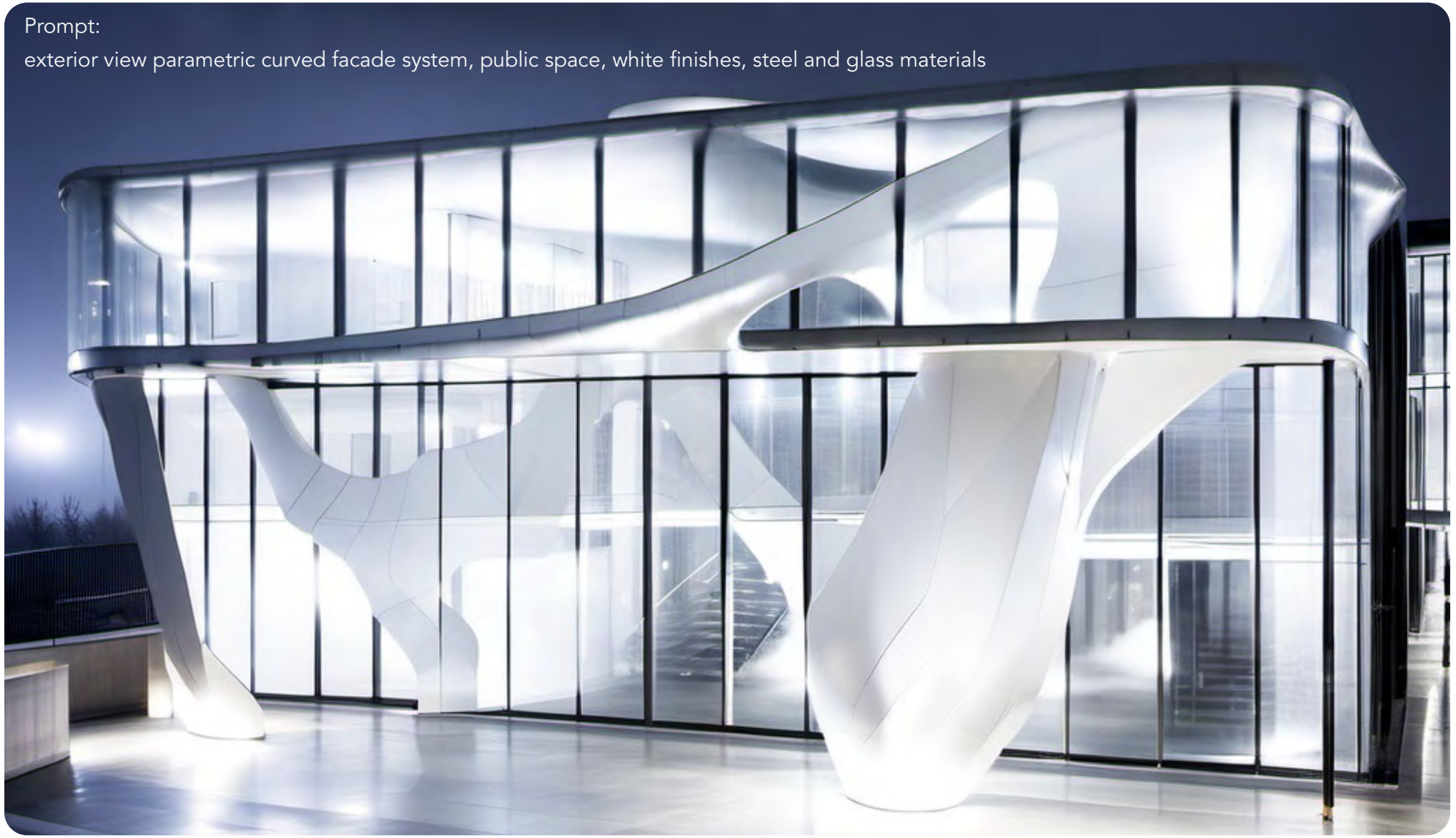


Detail ETFE



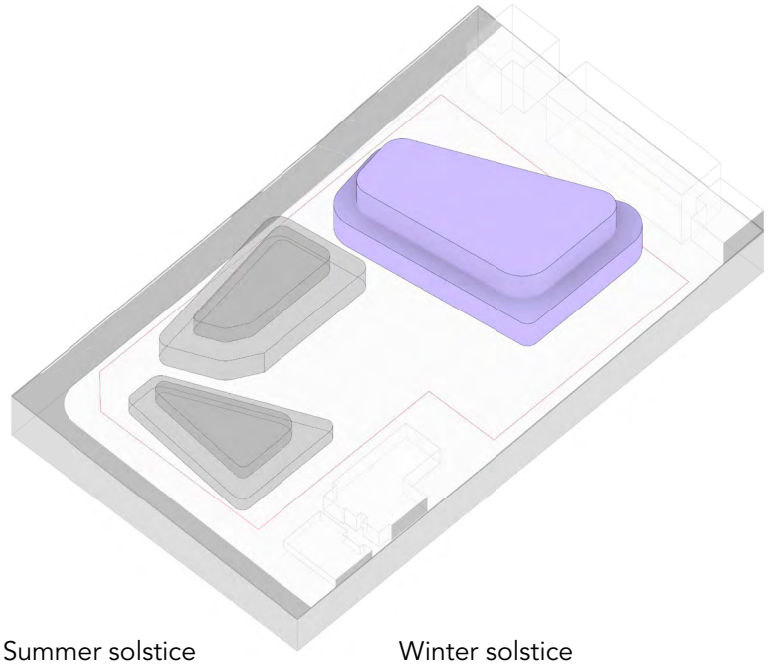
Prompt:
Automated Storage and Retrieval System behind glazing whilst people look at it and getting books

Innovation Centre - Private

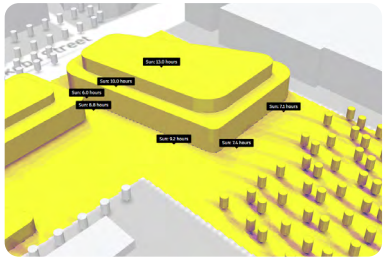


Innovation Centre - Private

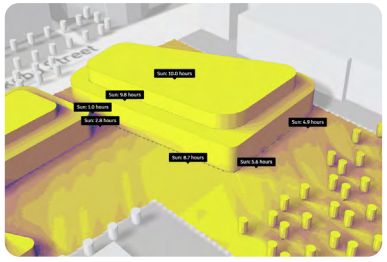
Chosen Mass



Summer solstice

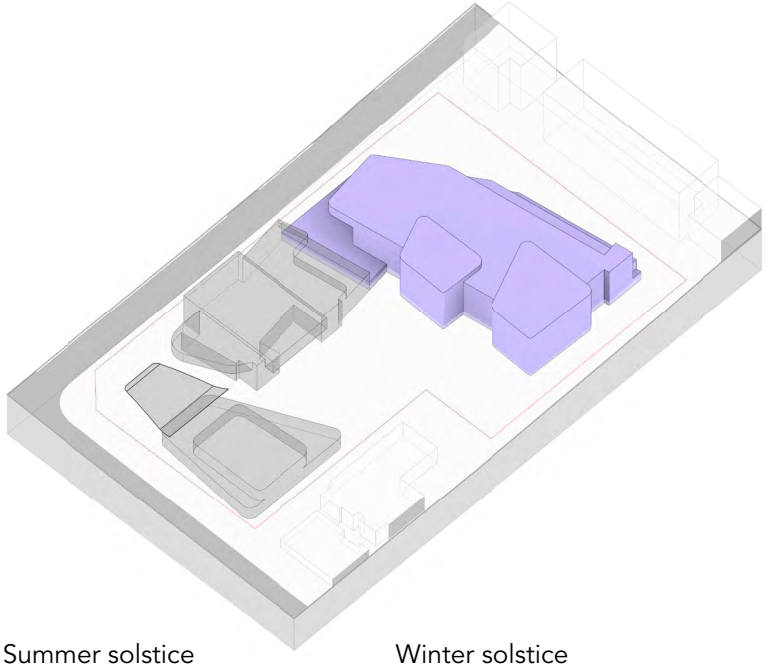


Winter solstice

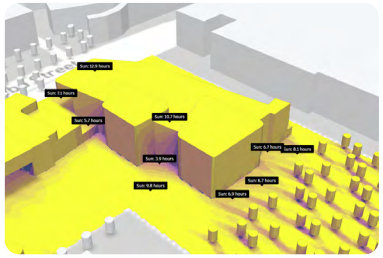


After exploring the mass area and understanding what programme is needed, I was able to analyse how much sunlight the mass received during the winter solstice and summer solstice to assist in the design approach.

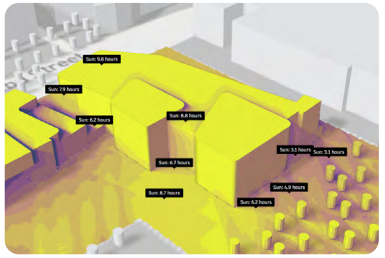
Designed Mass



Summer solstice



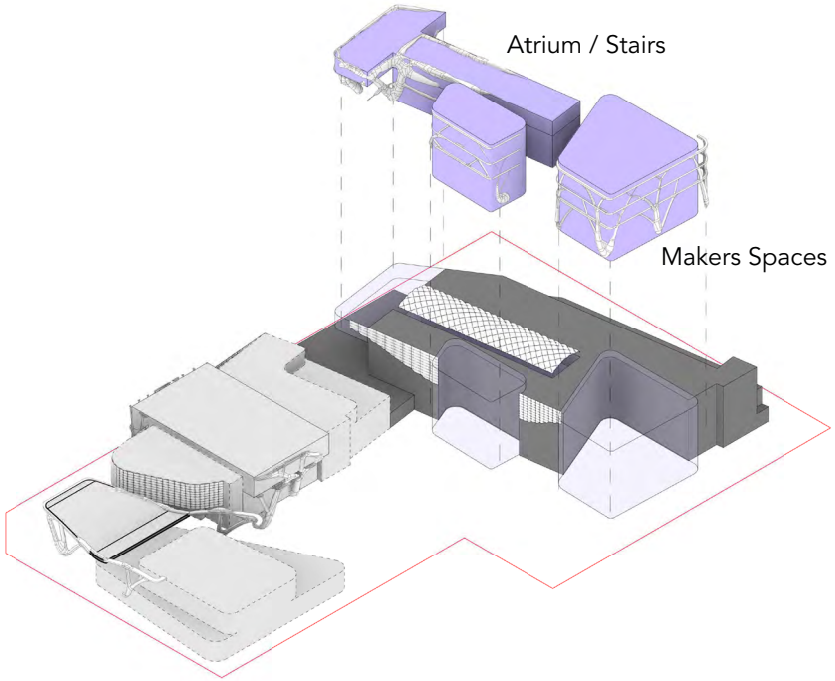
Winter solstice



Analysing the designed mass suited to the programme, I determined how much harsh sunlight the north façade received and how little sunlight the south side of the mass received. This assisted me in understanding that a façade system is needed on the north for sunlight and also stepping the building back on the south side allows more sunlight to enter.

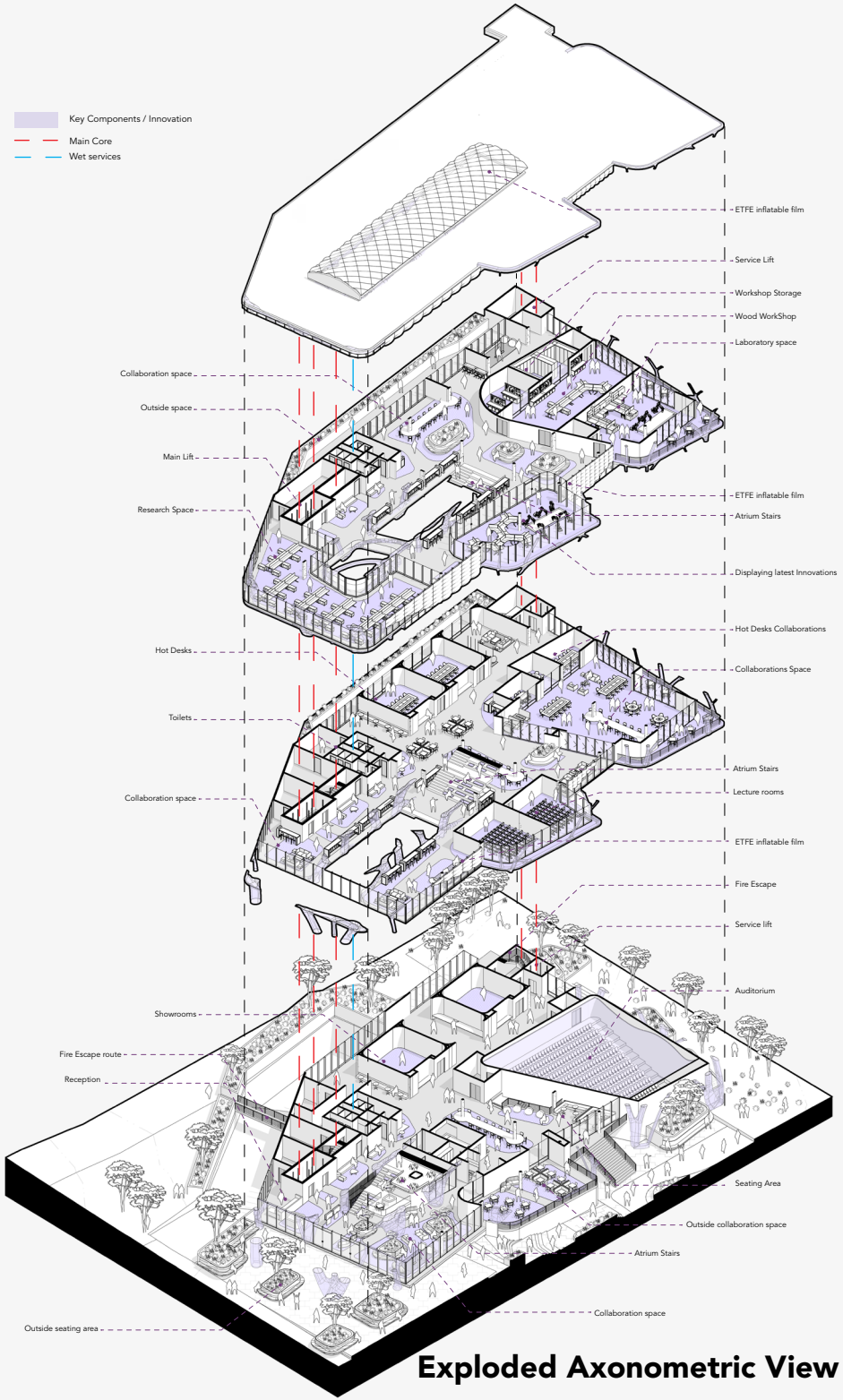
Innovation Centre - Private

Typology Optimization



The programme for this building is the AI the innovation center itself, being completely private to the university and its users. Key factors to influence its users to engage and create innovative ideas using AI.

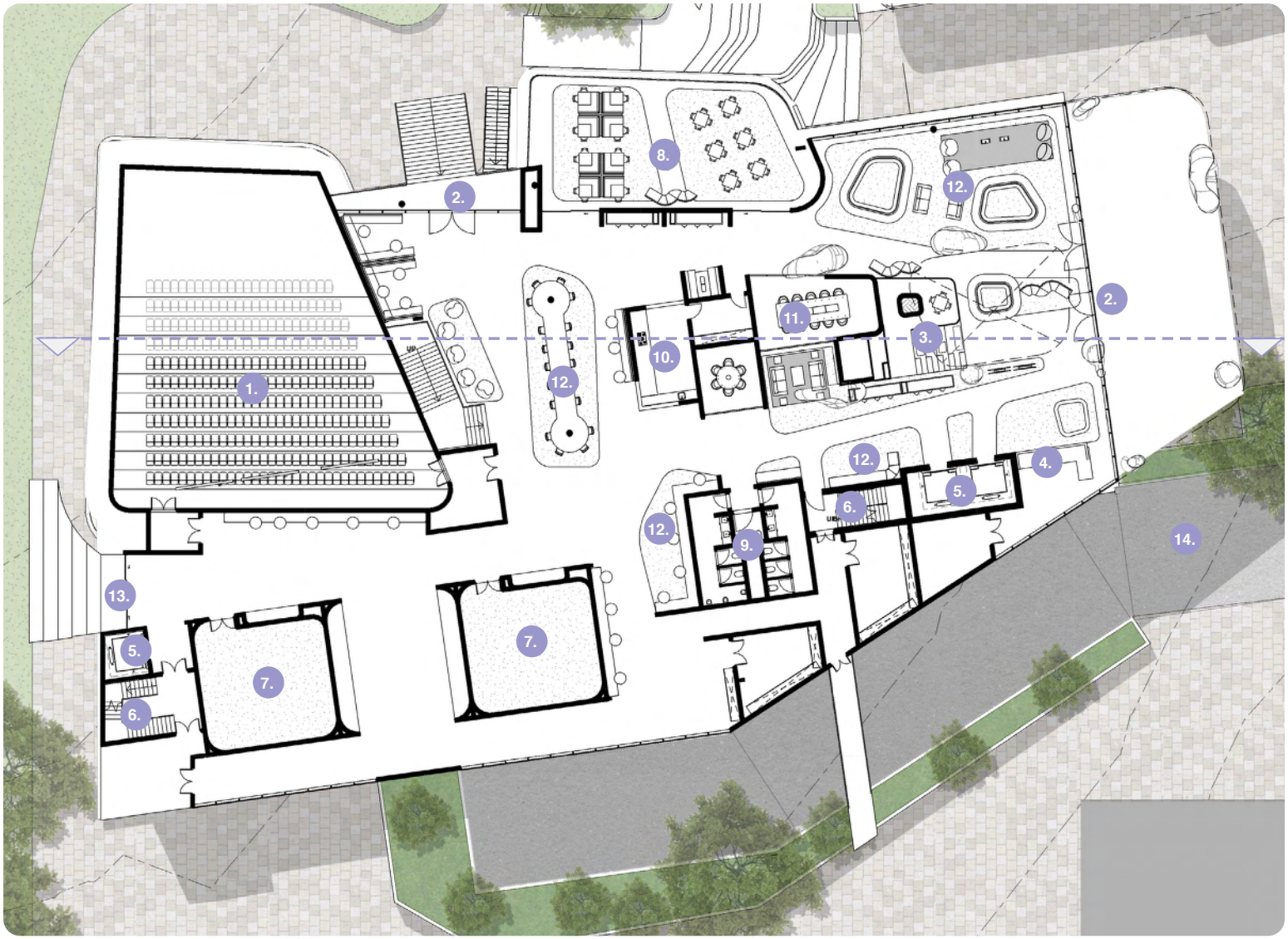
Key areas needed is makers spaces and atrium that assists in connecting all the spaces. This was achieved in highlighting the spaces using Typology Optimization.



Exploded Axonometric View

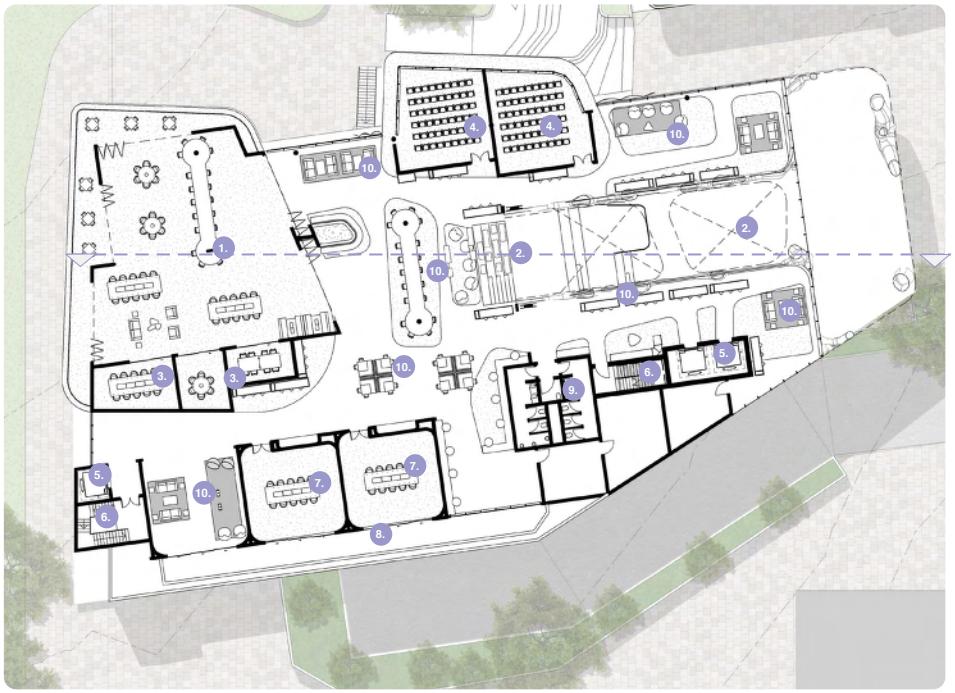
Innovation Centre - Private

1. Auditorium
2. Entrances
3. Atrium Staircase
4. Reception
5. Lifts
6. Fire Escapes
7. Show rooms / Exhibition Spaces
8. Outside collaboration Space
9. Ablutions
10. Cafe linked to main Restaurant
11. Hot desks / Work rooms
12. Interior Collaboration Spaces
13. BOH entrance
14. Ramp to basement



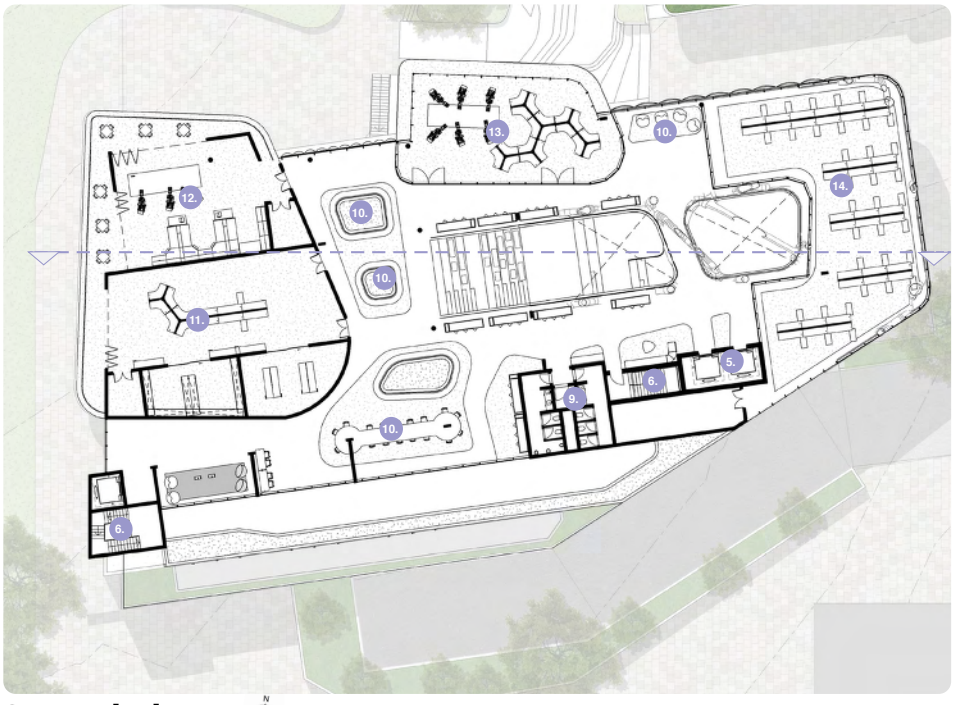
Ground Floor

Innovation Centre - Private



First Floor

1. Innovation collaboration space
2. Atrium Staircase
3. Hot desks / Work rooms
4. Lecture room 20 seats
5. Lifts
6. Fire Escapes
7. Show rooms / Exhibition Spaces
8. Outside collaboration Space
9. Ablutions
10. Interior Collaboration Spaces
11. Wood WorkShop
12. Laboratory space
13. Displaying latest Innovations
14. Research Space



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13. Displaying latest Innovations
14. Research Space

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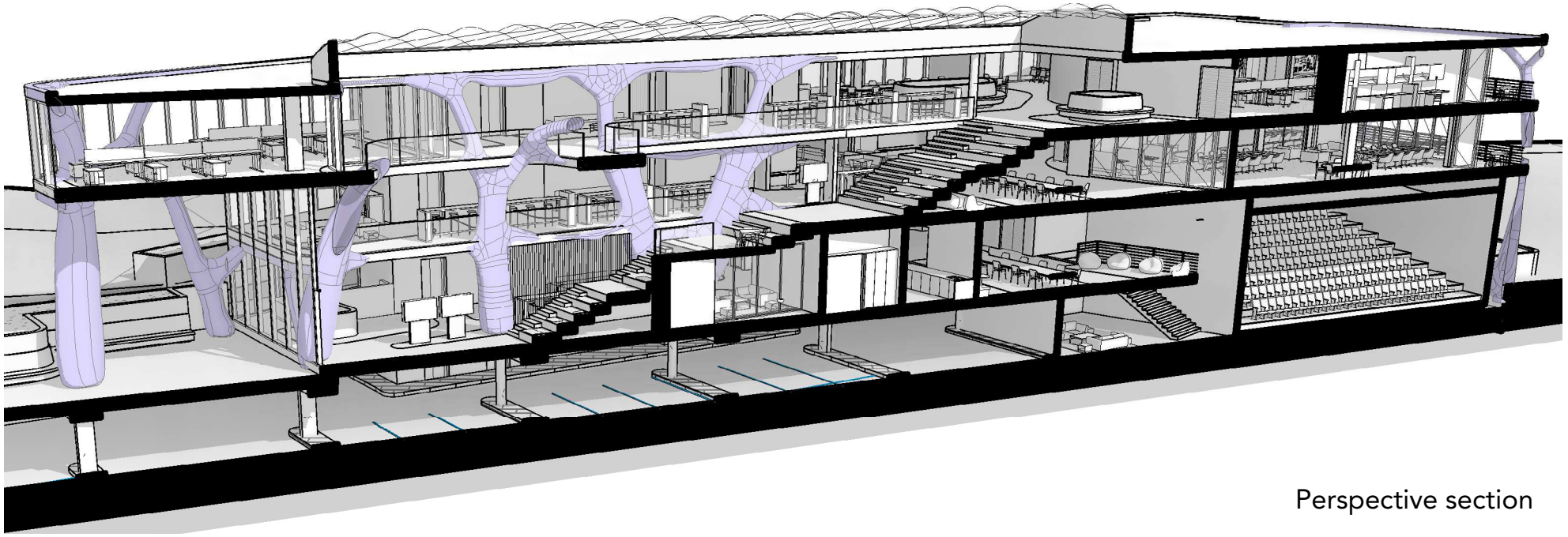


Perspective section



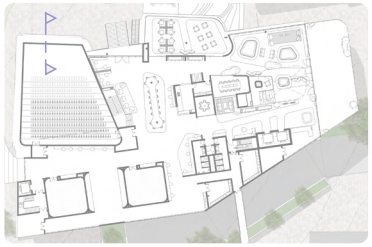
West Elevation

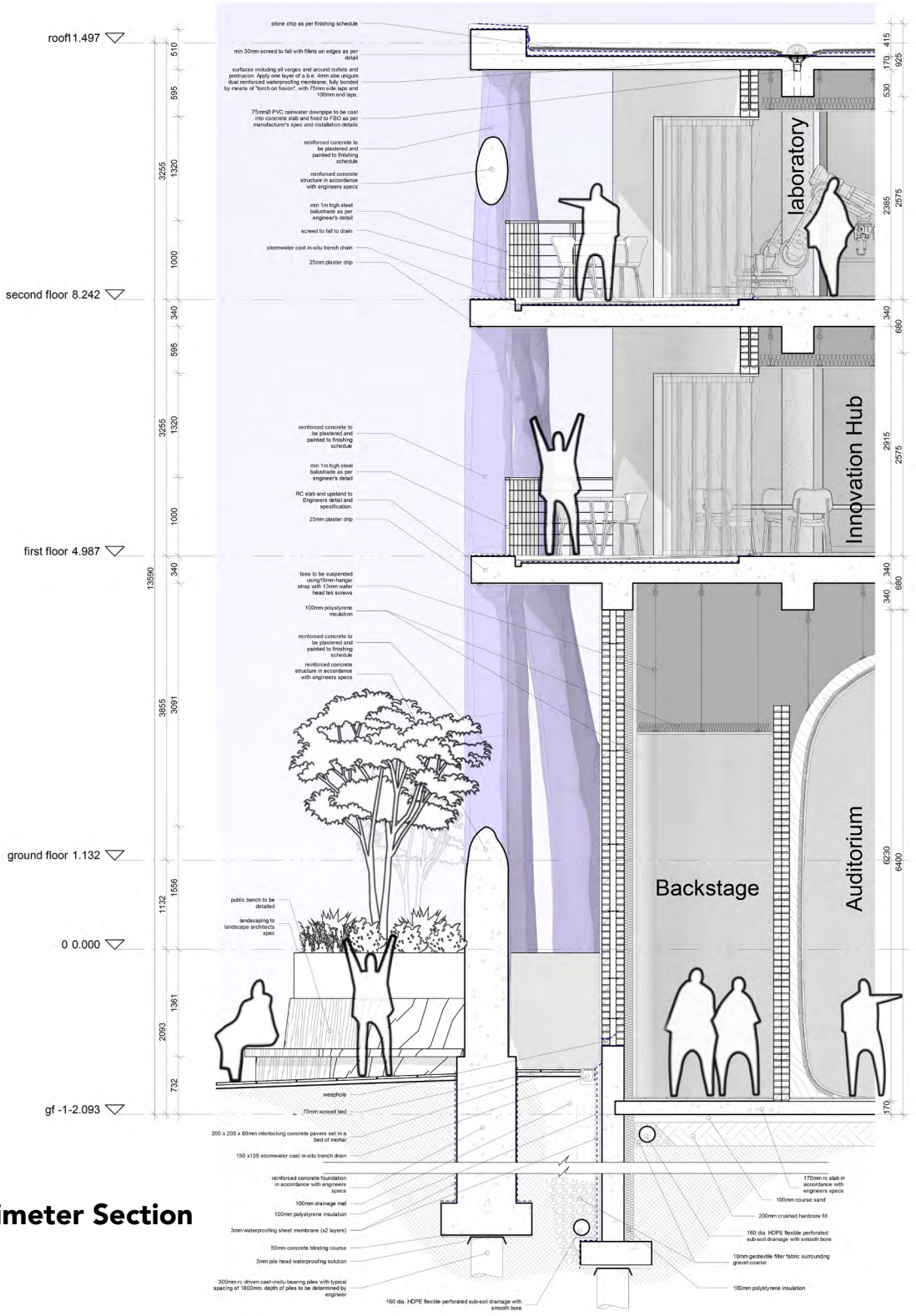
Innovation Centre - Private Technical design



Basement - parking







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List of Appendices

Appendix A - Construction Costs

1: Restaurant			
Gross Floor Area	Leasible Areas	Service Areas	Parking (6/100m2)
435	348	87	20.88
		Parking Surface	0
		Parking Structure	21

Building Construction Costs			
Gross Building	Parking Surface	Parking Structured	Construction Costs
R 5,220,000.00		R 96,048.00	R 5,316,048.00

Income		
Retail	R 195,750.00	
Parking Surface		R800/month
Parking Structured	R 16,704.00	R800/month
TOTAL	R 212,454.00	

2: Public Reception/Foyer			
Gross Floor Area	Leasible Areas	Service Areas	Parking (4/100m2)
1000	800	200	32
		Parking Surface	0
		Parking Structure	32

Building Construction Costs			
Gross Building	Parking Surface	Parking Structured	Construction Costs
R 18,000,000.00		R 147,200.00	R 18,147,200.00

Income		
Retail	R 150,000.00	
Parking Surface		R800/month
Parking Structured	R 25,600.00	R800/month
TOTAL	R 175,600.00	

3: Teaching lecturing			
Gross Floor Area	Leasible Areas	Service Areas	Parking (0.4/100m2)
1170	936	234	3.744
		Parking Surface	0
		Parking Structure	4

Building Construction Costs			
Gross Building	Parking Surface	Parking Structured	Construction Costs
R 40,950,000.00		R 17,222.40	R 40,967,222.40

Income		
Retail	R 175,500.00	
Parking Surface		R800/month
Parking Structured	R 2,995.20	R800/month
TOTAL	R 178,495.20	

4: Open Innovtaion Area + Research Labs			
Gross Floor Area	Leasible Areas	Service Areas	Parking (4/100m2)
2680	2144	536	85.76
		Parking Surface	0
		Parking Structure	86

Building Construction Costs			
Gross Building	Parking Surface	Parking Structured	Construction Costs
R 48,240,000.00		R 394,496.00	R 48,634,496.00

Income		
Retail	R 402,000.00	
Parking Surface		R800/month
Parking Structured	R 68,608.00	R800/month
TOTAL	R 470,608.00	

Administration			
Gross Floor Area	Leasible Areas	Service Areas	Parking (4/100m2)
400	320	80	12.8
		Parking Surface	0
		Parking Structure	13

Building Construction Costs			
Gross Building	Parking Surface	Parking Structured	Construction Costs
R 4,800,000.00		R 58,880.00	R 4,858,880.00

Income		
Retail	R 60,000.00	
Parking Surface		R800/month
Parking Structured	R 10,240.00	R800/month
TOTAL	R 70,240.00	

Total Parking Structured	155	Total Structure Costs	R 117,923,846.40	R 1,107,397.20 INCOME SUB TOTAL

Appendix B

Rates per SQM

Construction Rates	
Description	R/SQM
Office Spaces	R15,000.00
Restaurant	R12,000.00
Gallery/exhibition	R18,000.00
Conference rooms	R35,000.00
open work spaces	R12,000.00

parking Requirements

Parking requirements as per City of Johannesburg Land Use Scheme of 2018	
Description	Parking Requirments / 100sqm
Office Spaces	4
Restaurant	6
Gallery/exhibition	4
University Spaces	0.4
open work spaces	3

Profesional Fees Calculation

Profesional Fees Calculation (as per notice 122)	
Description	Amount
Profesional Fees %	12%
total construction costs	R117,923,846.23
total	R14,150,861.55

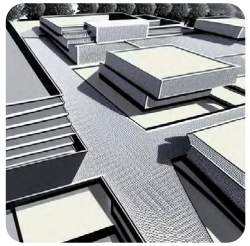
Council Submission Fee

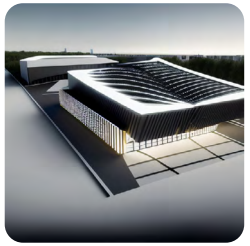
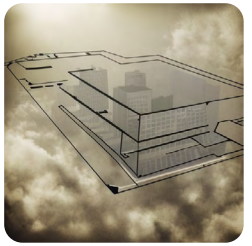
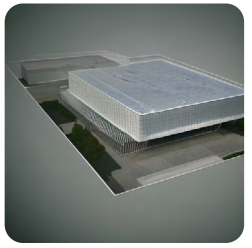
Council Submission fee	
First 1000 SQM at R21/SQM	R21,000.00
Second 1000 SQM at R20/SQM	R20,000.00
Remaining above 2000 SQM at R18/SQM	R84,132.00
total	R125,132.00

Total Cost of project

Total Cost of project	
Description	Amount
Land costs	R1,800,000.00
total construction costs	R117,923,846.40
Professional Fees	R14,150,861.55
Council Submission	R125,132.00
Total Cost of project	R133,999,839.95

Appendix C

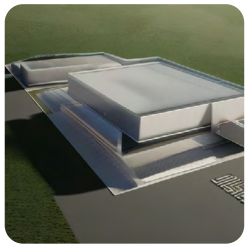




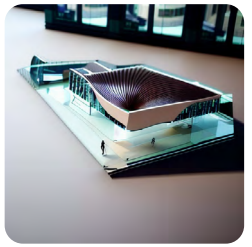
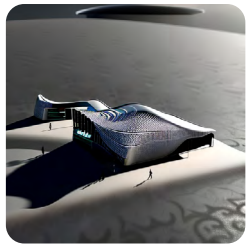


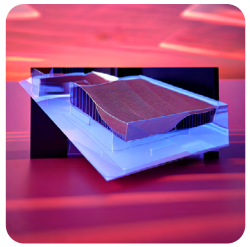




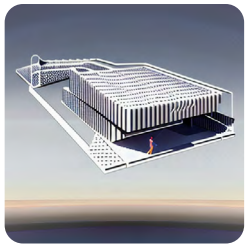




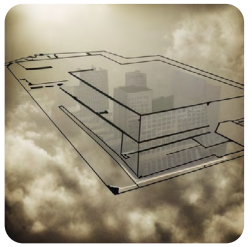










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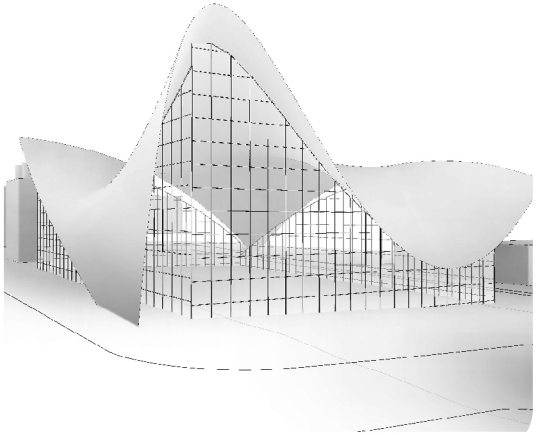

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG

SCHOOL OF ARCHITECTURE PLANNING

24 May 2023

Faculty of Engineering and the Built Environment:

Ethics clearance letter:

Dear Liam Wilson

Student number (1711485), this letter confirms that your ethics application has been cleared. Your clearance/protocol number: SOAP022/04/2023

Yours sincerely

Lerato Nkosi

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