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VIRTUAL DESIGN:
IMPROVING ARCHITECTURE THROUGH IMMERSIVE CREATION

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ABSTRACT

Mixed reality devices in today's world have only just begun emerging from the origins in the video game and entertainment industry. As these devices advance, their usefulness grows across other aspects of our lives, and can potentially become integrated into daily life. Whether this integration will be seen through headsets, wearable sensory devices, or even implants is hard to tell, but it will assuredly affect how we interact with and experience the spaces we inhabit. Outside of entertainment, the use of mixed reality devices has potential benefits across a myriad of other industries at various scales. This paper explores the potentials of mixed reality devices in a creative sense and how they can influence the design process in architecture and similar design fields. The evolution of mixed reality devices, the cultural perception of the use of them, and various use-based case studies are discussed to determine advantages and disadvantages to the creative process.

INTRODUCTION

The architectural design process began with pencil on paper, which is still a widely revered skill. With the introduction of computers, the process has evolved exponentially from computer aided drafting and realistic digital rendering to BIM (Building Information Modeling) with more information packed into a model than most realize or even utilize. The next evolution of the design process is the use of mixed reality devices in the creative space. These devices pose an opportunity of immersion and visualization in synchronicity with the actual creation and design. This evolution has potential to improve collaboration, reduce design time, and through experiential creation, enhance the overall design.

To understand how the devices can be beneficial, one must first understand how they operate and their beginnings. Mixed reality devices of today originated from research and development beginning in the mid-20th century. Tracking that development helps determine how they can be used and builds the framework of how the devices could be used in the future. Alongside this history of development is a discussion of the perception of mixed reality devices in society through media such as film and literature. This cultural perception may provide a tumultuous path to the integration of such devices to daily use. While much of mixed reality use has risen from entertainment purposes, it has potential to be used in other fields such as education, retail, training, and productivity. The immersion and interaction that mixed reality offers through the engagement of our senses creates beneficial opportunities in processes like design. These devices go beyond just a visual headset and have begun to engage the other senses through peripheral accessories.

In an age of technological renaissance, the rate of innovation poses a challenge to stay current on the latest technologies, but industries must progress with these developments to remain relevant. Can the use of mixed reality devices and accessories enhance the creative process and improve our designs? There may be disadvantages, but this paper seeks to determine if the advantages are worthwhile, and how architectural design can adapt and adopt a new workflow utilizing mixed reality.

HISTORY AND MEDIA

Ideas of experiencing an alternate reality came before the 1960s, but around this time was when Morton Heilig created the first experiential device that could be defined as virtual reality, the Sensorama.

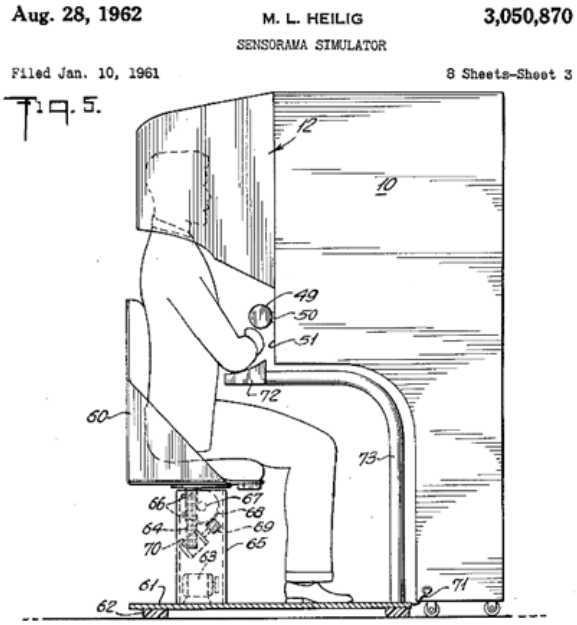

Figure 1: Sensorama patent drawing

The large cabinet was a mechanical device that played through five short films with a multi-sensory experience including visual display, sound, fans, odor generation, and a moving chair.[1] Later that decade, Ivan Sutherland and Bob Sproull created the first HMD known as the Sword of Damocles, as it was a large ceiling mounted rig due to the weight of the device. Though primitive, the Sword of Damocles utilized head tracking and various sub-systems that are precursors of the devices used today.[2]

Through the 70s and 80s virtual systems were largely developed for training and simulation, primarily in medical and military purposes. Work at MIT in Boston created the Aspen Movie Map in 1978, an interactive visual simulation of the streets of Aspen, Colorado.[3] Comparable to today's Google Street View.

Atari founded a VR research lab in 1982, but was quickly dismantled, while Mattel developed the Power Glove to be released in 1989. The power glove was one of the earliest accessories to a virtual experience in the consumer market to be used with Nintendo's NES system.[4]



Figure 2: Power Glove virtual game controller

In the early 90's, another notable accessory was the Virtual Fixtures system developed by the U.S. Air Force's Armstrong Labs. This exoskeleton allowed physical interaction with virtual objects, making it one of the first augmented reality systems developed. The Air Force used this in their simulation testing to train pilots in more realistic flight scenarios.[5] The video game industry began further development in the 90's with the Sega VR headset, the Virtuality arcade system, and Nintendo's Virtual Boy. These early conceptions did not hold the market very long but were necessary milestones to produce the devices we see today.

Along with the development of these devices, society began to imagine what the future could look like in a world where such devices were in common use. This can be seen through film and literature. Example of these include 'Neuromancer' written by William Gibson, 'Until the End of the World' directed by Wim Wenders, 'Ready Player One' written by Ernest Cline, and 'Blade Runner 2049' directed by Denis Villeneuve.

These stories show society using a range of devices that immerse them into virtual worlds or augmentations of the physical world. The portrayed settings are typically dystopian worlds where the use the mixed reality devices solve or at times create issues in the

[1] Heilig M.L. Sensorama Simulator
[2] Sutherland, Ivan E, The Ultimate Display
[3] Naimark, Michael, Aspen Movie Map
[4] Nintendo Power Glove
[5] Rosenburg, L.B. Virtual Fixtures

world. In 'Ready Player One' for example, the world is ravaged by an energy crisis, making transportation difficult and crashing the economy. Society relies on the use of VR devices that connect the world and builds a new system of economy, education, infrastructure, and government. While this solves immediate issues, they are presented with the dilemma that they are ignoring their reality for a virtual world, and letting the situation worsen over time. Other conditions, such as those seen in 'Blade Runner 2049' express worries of overindulgence and distraction from the real world that can be created by a constant infiltration of augmented advertisement and interaction.

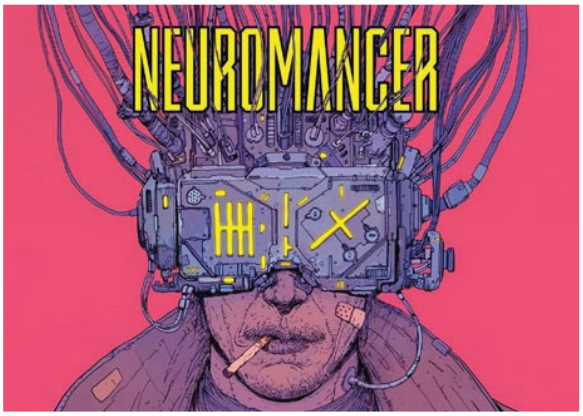

Figure 3: Neuromancer, by William Gibson 1984

The fictional concepts of mixed reality devices have greatly influenced actual designs of products in development. The idea of using mixed reality devices on a wide scale can excite and/or scare many people with the possibilities. This media should not serve as a prediction, but rather a dramatization of issues that may be encountered with the use of mixed reality devices. In understanding this, developers can test and design for potential problems to create beneficial devices.

By 2010 the first prototype of the Oculus Rift HMD was designed. This is one of the leading systems on the market today, now owned by Facebook. At the same time of the development of the Rift, it's main competitor, Valve, was working with HTC in development of the HTC Vive. Both systems focus on the use of an HMD influenced by spatial tracking and a host of sensors along with the use of various accessories such as audio and controllers with force feedback. There has also been increased development in the realm of augmented reality, becoming largely popular with the testing of the Google Glass AR glasses in 2013. AR is still early in development, but companies like Microsoft have released their HoloLens system to content creators as a developer kit before fully releasing on the consumer market. There are now hundreds of companies around the world that are in development of VR/AR related products with new patents and developments being announced regularly.

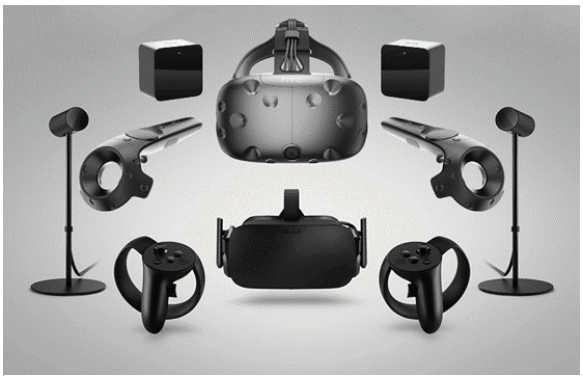

Figure 4: (top) HTC Vive, (bottom) Oculus Rift

SENSORY ENGAGMENT

An important factor of mixed reality devices that can make them successful is the immersion created by the engagement of our senses. The primary focus of current devices is the visual aspect. For an experience to be comfortable, the displays used must mimic realistic vision as much as possible. The resolution of an image is likely the most important aspect to a realistic visual experience. Most available models today are using dual 1080p display but there is a push for 1440p and 4k display to come very soon. The refresh rate of displays used are typically at least 90hz, as this number increases, the perceived image will become smoother, particularly when motion is involved. Another major visual aspect is the field of view, where peripheral vision is incorporated. If the FOV is too narrow a tunnel vision effect will be perceived. The human eye can perceive a nearly 200 degrees of horizontal FOV. As HMDs approach this range of view, the experience can become much more immersive.

Auditory aspects can help to create a better sense of space. This audio needs to be a directional, three-dimensional, sound interface to give the user a better sense of their surroundings. Most headsets use built in audio or headphones with stereo sound, but advancements such as bone induction audio can better create the 'feel' of sound that a stereo headset lacks.

The sense of touch stands to be the next advancement in mixed reality devices though haptic responses and advanced force feedback. This responsive feedback can connect a user with the virtual space which allows your brain to more quickly adapt to interacting with the virtual environment rather than just experiencing it. In addition to feedback from haptic devices, this area of the senses also encompasses the locomotion that one experiences in the virtual space. A fluid motion through a virtual space while the user is standing still can cause what is known as VR sickness, similar to motion sickness. Current solutions to this are a teleportation type of movement, but advances in accessories like omnidirectional treadmills could solve these issues and allow the user to move more freely.

Smell, taste, and temperature sensitivity are some other types of senses that can be incorporated into the virtual environment. While they may not prove to be as important as sight, sound, and touch for effective use of the devices, they can still improve the immersion of the experience if necessary.

USES IN DESIGN

As mixed reality devices advance from the entertainment industry of video games, movies, and experiences, the application of them is starting to become useful in many other industries. In education it is being used in environments such as museums to provide additional information and displays about exhibits and in training for high risk situations such as medical and military scenarios. In retail it is being used by companies like IKEA to allow customers to 'preview' how their furniture will look in their home before they purchase. Mixed reality can be used in navigation and instruction by overlaying information related to a task. In the AEC industry it is widely being used for visualization purposes as well as in construction phases to improve coordination of projects.

While architectural designers are beginning to adopt the technology for purposes such as visualization with clients, it has not moved far from that. In this sense, the use of mixed reality devices has begun to replace the need for rendering and physical model building for client presentation. BIM design stands as the leading technique of construction design. Buildings are being modeled truer to real life situations than ever before. Because of this, it is prime for mixed reality applications, allowing clients and designers alike to understand and experience the designed spaces far before ground has been broken on a project. In the long term, this can affect costs by reducing miscommunication and error, save on time as compared to other visualization techniques, and improve the design by ensuring all parties understand the project before it is built.

Mixed reality is already proving itself to be a powerful visualization tool, but it also has potential to be introduced earlier in the design process. If a designer could be experiencing the design as it is being designed, the process would benefit. Following are some case studies of how mixed reality has been used in the creative process.

Sketch Furniture

Sketch Furniture was a research experiment by Front, a Swedish design studio. Defined as a performance design experiment, the designers of Front free hand sketched furniture in open space using tracking devices. These sketches were recorded with motion capture cameras and translated into three-dimensional models. Through a rapid prototyping manufacturing process, these sketches were then able to be created as real physical pieces of furniture.[6]

[6] Front

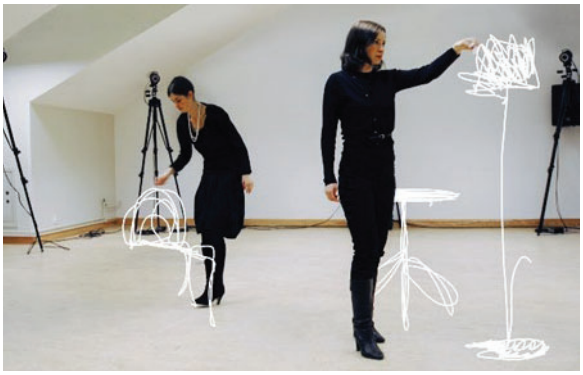

Figure 5: Front designers sketch creations in open space

This experiment was done in 2007, before modern mixed reality devices were being used, but shows how a similar process can be used at conceptual phases of a design process. The disadvantage that the designers have here that can be improved with mixed reality is that they cannot actual see the sketches that they are creating in real time. If they were able to experience their design, it would allow them to create more effectively and possibly avoid failing designs that they could not visualize. The advantage of this process is the rapid iterative design process that Front has developed. The use of free hand sketching to be translated into the digital space and back to the physical can be used to develop initial concept designs.



Figure 7: Sketched designs are created as life size furniture through rapid prototyping

who began research on the project while at Yale's Computer Graphics Group. It is a "software company that is developing a new class of graphical-media-design system that lies between today's 2D digital draw-and-paint systems and 3D computer-aided design systems, combining the ease and fluidity of sketching with expansive 3D capabilities"[7] The creation of an intriguing scene with a digital drawing tool such as a drawing tablet can be transformed into a three-dimensional environment.

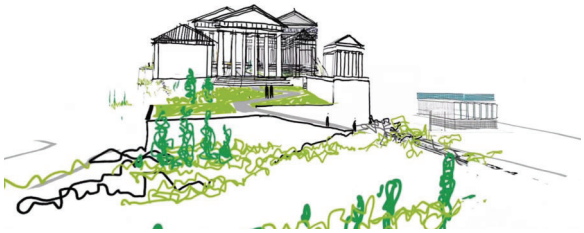

Figure 6: A sketched rendering of the Acropolis using Mental Canvas

Mental Canvas takes the 2D sketches of a designer into the 3D space but could potentially benefit from beginning in that 3D space with the use of mixed reality devices. This, like the Sketch Furniture experiment, shows potential in the early design process, but in a more current platform that is easily translatable to further design software. With the use of Mental Canvas, quick design sketches can be easily understood and communicated in three dimensions.

Gensler

Gensler is a global design firm that is on the forefront of integrating mixed reality devices into their daily workflow. They use mixed reality devices internally in the design process as well as externally for client interaction. They use the devices regularly for internal meetings across offices that they refer to as 'VR Jams'. These meetings involve designers going into a design model using a mixed reality device to be joined by other designers across the country in the same virtual space. These meetings can be used for design discussion, collaboration, and presentation.

[7] Mental Canvas

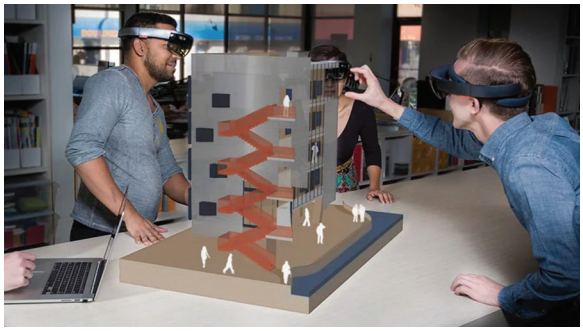

Figure 8: Designers using the Microsoft HoloLens to collaborate on a project

One of Gensler's projects in California was the new headquarters for the microchip maker NVIDIA. The design of this project used VR as a crucial aspect of the design. In an interview Scott DeWoody, Gensler's creative media manager, said "the use of virtual reality was integral to the NVIDIA project and that the firm had 'found a use for it at every spot in the design process.'"[8] The creative leaders at Gensler are major advocates of advancing the use of mixed reality devices in the AEC industry. So much so that they are already recognizing the limitations of virtual reality and looking to the future of the capabilities of augmented reality, using devices like the Microsoft HoloLens in the design process. This is something that is difficult for most to achieve in current conditions as the HoloLens is still in developmental phases and is also at a hefty price tag of $3,000 per headset. Gensler being as large of a firm as they are can certainly afford the research but can also draw the prospects of content developers to test new applications and as a result will help in shaping how those applications are used in the future.

Personal - SHP

As the author, I have personally done some experimentation in the use of mixed reality devices while working at SHP Leading Design. At SHP we have largely used VR for visualization with clients through 360 stereo-panoramic renderings and visualization walkthroughs. In spare time, some of my co-workers and myself have been exploring additional uses and tracking news and developmental releases of programs to try to stay ahead of advancements. Typical programs that have been used are Fuzor and Enscape. These two programs work well with the HTC Vive HMD and communicate directly with Autodesk's Revit, the BIM software that the office uses. While these programs both have production and design capabilities beyond visualization these aspects have not been utilized to their fullest in the office.



Figure 9: Design workflow experiment using Google's Tilt Brush VR application

Additional experimentation has involved the use of simple programs that are more of an artistic style such as Google's Tilt Brush and Blocks. One such experiment with Tilt Brush used a three-dimensional site scan created with information gathered by a drone survey. In this space I was able to quickly produce a conceptual sketch in the site context. This sketch was then able to be exported/converted into a digital format recognizable by our BIM software. While the process was clunky, and the conversion process of the file lost some crucial information, the experiment was a proof of concept that there was a potential workflow between the conceptual virtual space to the precise BIM software for construction detailing. SHP has also been experimenting in AR applications, but has yet to deploy a useable workflow.

SHP is driven to stay at the cutting edge of technology but does not have a research group other than interested employees dedicated to exploring the capability of mixed reality use in the field. As a result, it is slower to adapt to the processes as opposed to a firm such as Gensler. SHP is also reliant on usable applications becoming available to consumers and relevant to the current workflow of projects.

[8] Pacheco, Antonio

CONCLUSION

It is crucial for the architectural industry to stay on the forefront of advancing technologies. The use of mixed reality devices in the design process can provide substantial benefits to workflow and design quality. Mixed reality devices have the capability to create an immersive design experience that engages our senses in a way that current processes cannot achieve. If properly adapted, the use of such devices could revolutionize the design process

The intention of future research is to conduct experimental research. A collection of experiments will be conducted to explore the advantages and disadvantages of mixed reality in design. If resources allow, this will involve a range of AR and VR devices, compatible applications and various design software.

WORKS CITED

Adcock, Matt. 2018. *It's Time to Get Ready for Augmented Reality.* January 11. Accessed March 25, 2018. theconversation.com/its-time-to-get-ready-for-augmented-reality-89760.

ATOM, Sitewide. n.d. *IEEEVR 2018.* Accessed March 25, 2018. www.ieeevr.org/2018/.

Bellias, Matt. 2016. *How Augmented Reality Is Transforming Building Management.* November 1. Accessed February 23, 2018. www.ibm.com/blogs/internet-of-things/augmented-reality-and-building-managment/.

Chang, Lulu. 2018. *Ikea Place, the AR App from the Furniture Giant.* March 20. Accessed March 25, 2018. www.digitaltrends.com/home/ikea-place-ar/.

Cline, Ernest. 2018. *Ready Player One.* New York: Broadway Books.

Cumming, Ed. 2014. *William Gibson and Neuromancer: the Man Who Saw Tomorrow.* July 28. Accessed March 19, 2018. www.theguardian.com/books/2014/jul/28/william-gibson-neuromancer-cyberpunk-books.

Entertainment, Abrams Gentile. n.d. *Powerglove.* www.ageinc.com/tech/index.html.

Eric E Sabelman, Roger Lam. 2015. *The Real-Life Dangers of Augmented Reality.* June 23. Accessed February 23, 2018. spectrum.ieee.org/consumer-electronics/portable-devices/the-reallife-dangers-of-augmented-reality.

Fink, Charlie. 2017. *VR Training Next Generation of Workers.* October 30. Accessed April 2, 2018. www.forbes.com/sites/charliefink/2017/10/30/vr-training-next-generation-of-workers/#352abeef64f5.

Front. n.d. *Sketch Furniture.* www.frontdesign.se/sketch-furniture-performance-design-news.

Gesincourt, Florian de. 2015. *Ready Player One.* Accessed April 9, 2018. www.artstation.com/artwork/bg49G.

Gibson, William. 2017. *Neuromancer.* Gollancz.

Hanke, John. 2017. *Did We Just Glimpse the Future of Augmented Reality.* September 13. Accessed February 23, 2018. www.rollingstone.com/glixel/features/did-we-just-glimpse-the-future-of-augmented-reality-w502780.

Heilig, M.L. 1962. Sensorama Simulator. August 28.

James Wu, P.N. Rao Rajesh. 2017. *How Close Are We to Elon Musk's Brain-Computer Interface?* April 12. Accessed February 23, 2018. www.cnn.com/2017/04/12/health/brain-computer-interface-partner/index.html.

Kirkland, Allegra. 2015. *The Terrifying 'Smart' City of the Future.* March 1. Accessed February 23, 2018. www.alternet.org/civil-liberties/terrifying-smart-city-future.

Leap, Magic. n.d. *Magic in the Magic.* Accessed March 15, 2018. www.magicleap.com.

Limer, Eric. 2018. *How Microsoft's HoloLens Works Its Holographic Magic.* February 15. Accessed March 15, 2018. www.popularmechanics.com/technology/gadgets/a15324/how-microsofts-hololens-works/.

n.d. *Mental Canvas.* www.mentalcanvas.com.

Mise, Kevin. 2017. *Big AR: The Future of Augmented Reality.* August 9. Accessed February 23, 2018.

hackernoon.com/big-ar-the-future-of-augmented-reality-c91c267b3d9f.

Naimark, Michael. 1978. *Aspen Moviemap.* www.naimark.net/projects/aspen.html .

Nunez, Michael. 2015. *How It Works: The Oculus Rift.* March 10. Accessed March 15, 2018. www.popsci.com/oculus-rift-how-it-works#page-2.

Pacheco, Antonio. 2018. *VR Was Essential to Gensler's Design of NVIDIA's New Headquarters.* April 18. archpaper.com/2017/04/gensler-nvidia-new-headquarters/#gallery-0-slide-0.

Peppiatt, Dom. 2016. *Here's Exactly How The HTC VIVE Works.* January 1. Accessed March 15, 2018. www.gadgetdaily.xyz/heres-exactly-how-the-htc-vive-works/.

Pradanos, Inaki. 2017. "Viewpoint: A Critical View on Smart Cities and AI." *Journal of Artificial Intelligence Research.*

Qualcomm. 2016. *Smart Cities: Smart Buildings.* July 19. Accessed February 23, 2018. www.qualcomm.com/videos/smart-cities-smart-buildings.

Rosenburg, L.B. 1992. "The Use of Virtual Fixtures As Perceptual Overlays to Enhance Operator Performance in Remote Environments." *USAF Armstrong Laboratory.*

Stevens, Philip. 2017. *How Gensler is Using Microsoft HoloLens to Develop Its Projects.* June 23. www.designboom.com/architecture/gensler-microsoft-hololens-virtual-mixed-reality-06-25-2017/.

Sutherland, Ivan E. 1965. "The Ultimate Display." *Proceddings of IFIP 65.*

SXSW. n.d. *CR/AR SXSW Conference & Festivals.* Accessed March 23, 2018. www.sxsw.com/conference/vr-ar/.

Thompson, Janna. 2018. *Why Virtual eality Cannot MAtch the Real Thing.* March 13. Accessed March 24, 2018. theconversation.com/why-virtual-reality-cannot-match-the-real-thing-92035.

2017. *Blade Runner 2049.* Directed by Denis Villeneuve.

VRDC@GDC. n.d. *VR & AR Conference @ GDC.* Accessed March 23, 2018. www.gdconf.com/vrdc/.

1991. *Until the End of the World.* Directed by Wim Wenders.

ADDENDUM TO:

Virtual Design: Improving Architecture Through Immersive Creation

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RESEARCH

Following the completion of the initial writing, I began to conduct research concerning my theories. I investigated the history of extended reality devices from entertainment and medical to military uses, and to the potential capabilities of the future of such devices. This led me to building a list of available devices that could support my intentions as well as the software involved. This culminated in a decision to acquire an HTC Vive virtual reality system due to its high fidelity performance and previous experience that I had with the device. After obtaining the headset, I was able to trial over two dozen applications that had a degree of creation or visualization that would be relevant to architectural design.

Many of these programs proved to be difficult to use or did not communicate well with other design programs. This communication proved important as I never intended for virtual design to completely replace the design workflow, but rather as a new tool to add to the existing toolkit to improve the process.

The application testing led to the decision to rely on the use of TiltBrush for virtual sketching/concept design and Enscape for visualization/materiality. Both programs were able to communicate well with Autodesk's Revit (BIM design software), as well as offer additional unique features that brought them to the top of the stack.

As a test of this workflow, I completed a quick design study that I called the Cliff House. For this study I obtained a 3-dimensional model of a cliff face in Australia. A place that I would likely never be able to visit. I was able to import this model into TiltBrush, formulate a conceptual design, pass the concept over to Revit and develop the project using Enscape. This study served as a successful 'proof of concept' of the general workflow I planned to use.

PRECEDENTS

Prior to moving towards final design, a precedent exploration was undertaken to understand the primary goals to be achieved that show the advantages of the use of extended reality in design. This involved aspects of collaboration in design, relationship to site/environmental conditions, and spatial interaction.

DESIGN

After discussion of goals and direction, the decision was made to make Miami's Alumni Hall a full case study for the final design. This was beneficial as an existing condition to ground the virtual work and was easily accessible as reference.

Looking into site conditions and needs of the university, the building would become a 'Center for Innovation'. An interdisciplinary, collaborative workspace, where all the departments of the university could share technology and information. To support this, part of the existing building is converted into classrooms and offices, while most of the addition is dedicated to technology driven workshop type spaces. Another major aspect of this design would build on Miami's efforts to support the growing field of E-sports

(competitive video gaming). This takes the form of an arena/theater space that, while flexible to different types of performances, has an E-sports focus in its' design.

These programmatic elements are gathered around the southern side of the building towards the street, splitting about the north south axis to maintain the existing major façade. To not be too obtrusive, a large portion of the building is placed below grade, allowing the building to mesh with the landscape and allow flow of students through and around the building.

The initial concept development of the design was created using TiltBrush. Initially, the existing condition was modeled from record drawings and a version of the model was able to be imported into TiltBrush. This allowed for a reference in the virtual space that could then be sketched in and around. The sketching sessions lasted between 30 minutes to 2 hours. While sketching the concepts, the spatial interaction in the 3D virtual realm allowed for greater understanding of the volumetric space as it was being created.

These sketches were able to be exported from TiltBrush, and imported into Revit, where the project was further developed in a traditional BIM environment. Once the project was developed enough to again consider spatial conditions as well as materials, it was launched in Enscape to gain a fully rendered virtual experience. This proved to be far more influential than a 2D still as seen in typical render practices. This allowed me to better understand the spaces I had created as well as quickly realize and correct mistakes that had been made.

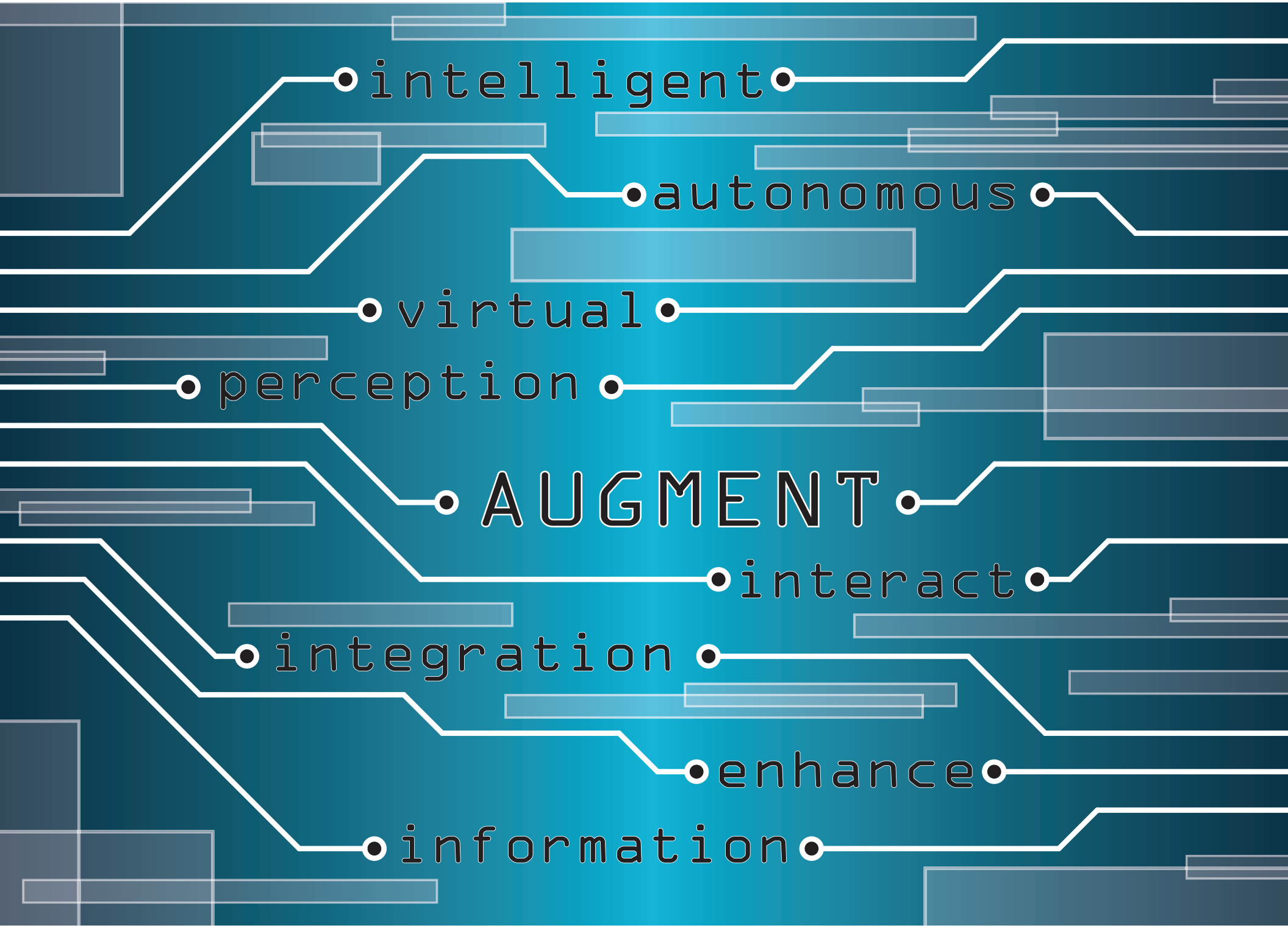
This process was repeated in multiple iterations to develop the project effectively, as any design would be. Upon realizing conditions in a developed stage, I was able to export a 3-dimensional model and again place it in to TiltBrush for conceptual sketching. This worked well as large scale massing concepts, as well as one-to-one scale interior development and spatial organization in later stages.

FINAL THOUGHTS

Is it possible to use extended reality tools to aid the development of architectural design? Absolutely, but it is not easy, nor completely effective. The major difficulty lies in what is commercially available and compatible with current design workflows. Outside of developing hardware and software (namely software) with the express purpose of architectural design, it is challenging to develop designs that are not overburdened by an unoptimized process.

During the final review of the project, the notion arose that spatial understanding while designing a space (while it is being drawn) is somewhat of a prerequisite skill of a good designer. While I do not disagree with this sentiment, my research endeavored to explore the benefits of virtual design as well as the downfalls. Using new advanced tools will not make a bad designer a good one, but rather I see it as a potential improvement to the process.

I believe the development of extended reality products needs significant improvement before it could possibly be a mainstream solution in the architectural realm, but I hold hope that it is an inevitability. As I move back into the architectural field at a professional capacity, I plan to pursue discussions with software engineers and influential connections with the intention to develop an extended reality product that could be a seamless and impactful solution to improve the design process.


intelligent
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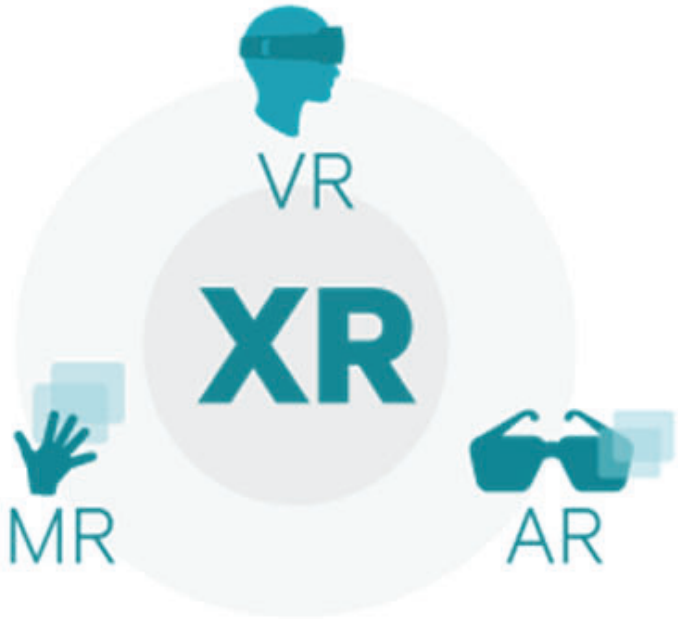
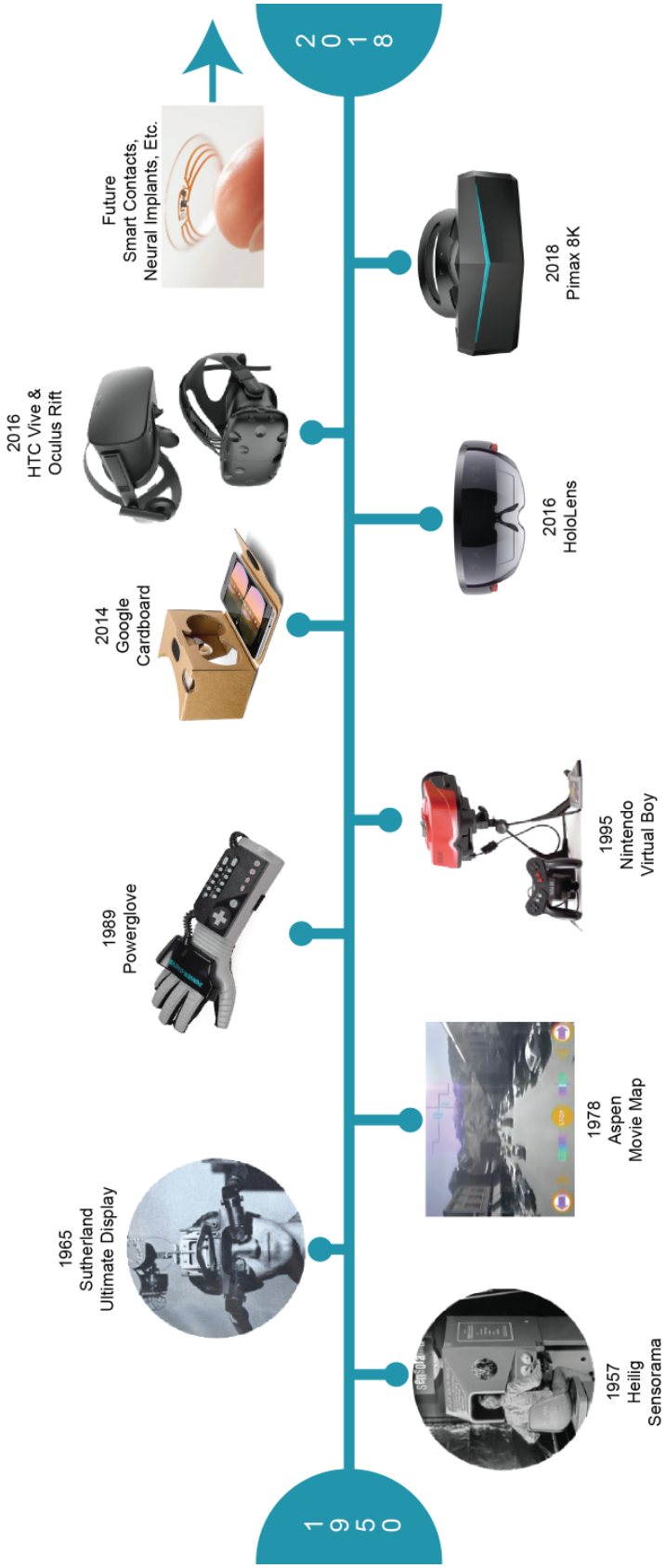
STATEMENT

Utilizing Extended Reality in the architectural design process allows for a freedom of creativity as well as a grasp of advancing technology. Through experiential design, we can improve with rapid iteration, collaboration, and spatial understanding to ultimately create greater value in the design process.





XR TIMELINE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1989
Powerglove
1995
Nintendo
Virtual Boy
2014
Google
Cardboard
2016
HTC Vive &
Oculus Rift
2016
HoloLens
2018
Pimax 8K
Future
Smart Contacts,
Neural Implants, Etc.
2018

XR Design Tools Current Access: On-Hand | Available | Unavailable | Not Released

Devices					Specs			
VR (smartphone)			**Cost**	**Hardware Req.**	**FOV**	**Resolution**	**Positional Tracking**	**Control**
Homido Mini Glasses			$0.99	Smartphone	85°	Phone*	No	No
Cardboard			$5	Smartphone	90°	Phone*	No	No
Daydream			$50	Smartphone**	100°	Phone*	No	single controller
Gear VR			$50	Smartphone**	100°	Phone*	No	single controller
Oculus GO			$200	Stand-Alone	110°	2x1280x1440	No	single controller
VR (HMD)								
Vive Focus			$600	Stand-Alone	110°	2x1440x1600	Yes (inside out)	single controller
HTC Vive			$500	VR-Ready PC	110°	2x1080x1200	Yes	dual controller
HTC Vive Pro			$800+ hardware	VR-Ready PC			Yes	dual controller
Oculus Rift			$400	VR-Ready PC	110°	2x1080x1200	Yes	dual controller
Windows Mixed Reality			$350-$500	VR-Ready PC	95-110°	2x1440x1440	Yes (inside out)	dual controller
PS VR			$200	Playstation 4	100°	2x960x1080	Yes	Playstation controller
Pimax 8K			$600	VR-Ready PC + Vive Tracking	200°	2x3840x2160	Yes	dual controller
StarVR/IMAX			Unknown	Unknown	210°	5120x1440	Yes	Unknown
AR								
HoloLens			$3,000	Stand-Alone	90-110°	1268x720	Yes (inside out)	Gesture tracking
Magic Leap One			$1,000?	Lightpack	100°?	?	Yes (inside out)	single controller
Google Glass			$1,500	Stand-Alone	N/A	640x360	No	Touch control
Meta			$1,500	VR-Ready PC	90°	2560x1440	Yes (inside out)	Gesture tracking

* Spec dependent on phone used with device
** Limited range of phone compatibility

XR Design Tools

Current Access: On-Hand | Available | Unavailable | Not Released

Applications		Cost	Device Tier	Visualization	Drawing	Sculpting	Component	Multi-User	3D Import/Export	Viveport sub	Notes
360° Panoramic Renders		$0	VR (smartphone)	X					N/A		no content creation
360° Video		$0	VR (smartphone)	X					N/A		no content creation
Google Cardboard apps		$0-20	VR (smartphone)	X					N/A		
Google Daydream apps		$0-20	VR (smartphone)	X					N/A		
Cyber Paint		$4	VR (smartphone)		X				No		2D drawing
Paint VR		$5	VR (smartphone)		X				No		3D drawing
WebVR		$0	VR (smartphone)	X					No		very accessible browser based viewing tool
Unreal Engine 4		$0	VR (HMD)	X		X	X		FBX,OBJ		physics, materials, high quality - steep learning curve
IrisVR		$50/month	VR (HMD)	X				X	SKP,RVT,3dm,FBX		Game Design engine
Fuzor		$200/month	VR (HMD) & AR	X			X	X	RVT,PLN		Primarily Viz and planning with collaboration
Enscape		$45/month	VR (HMD)	X			X	X	SKP,RVT,3dm		side by side connection with Revit - primarily Viz
Massit		$0	VR (HMD)			X			OBJ		Experimental, no support - live material rendering
PaintLab		$0	VR (HMD)		X				No		3D painting
TiltBrush		$20	VR (HMD)		X				FBX,OBJ	X	3D drawing
Blocks		$0	VR (HMD)			X			OBJ, FBX		simple low poly massing
Quill		$30	VR (HMD) - Oculus only		X	X			FBX	-	3D drawing and animation
Gravity Sketch		$30 - EDU ?	VR (HMD)		X	X			OBJ,FBX,Rhino	-	precision drawing/surface modeling
Shape Lab		$0	VR (HMD)			X			No	X	free sculpting / ZBrush style creation
Medium		$30	VR (HMD) - Oculus only			X		X	OBJ,FBX	-	3D drawing and animation
Immerse Creator		$20	VR (HMD)			X	X	X	FBX	-	Early Access
MasterpieceVR		$30	VR (HMD)		X	X		X	OBJ,FBX,STL	-	3D painting/sculpting/animation
MakeVR		$5-20	VR (HMD) - Vive only			X			OBJ,STL	X	snap/booleon/sweep tools
AnimVR		$30	VR (HMD)		X				OBJ,FBX	-	Animation focus
MindeskVR (for Rhino 5)		$200/month	VR (HMD)		X	X			OBJ,3dm,DWG		Rhino 5 plugin - limited VR tools
Max Interactive (3DS Max)		$190 - EDU $0	VR (HMD)	X					FBX		Autodesk
Revit Live		$345/month	VR (HMD)	X					RVT		Autodesk
Forge		per use credits	VR (HMD) & AR								Autodesk - development tool

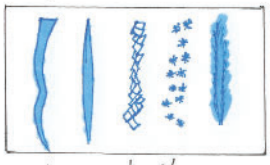
major AR apps under development and not consumer ready

Tilt Brush

Workflow 1

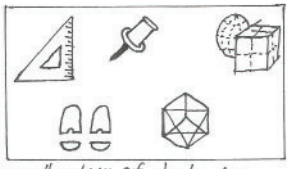
Import
- OBJ
redo

Brush Library



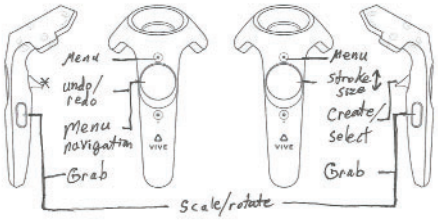
- Extensive brush and effects options
- Easy to use sketch tools

Tools



- collection of tools for various tasks
ie. Straight edge, Pin objects Primitive guides, teleport, link to Poly components.

Export
- FBX
- OBJ



Pros: - Fun and easy sketching
- extensive brush library
- Full color spectrum

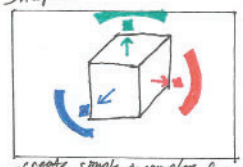
Cons: - lacks precision
- scaling issues ("man" to "elephant" - no metric)

Unreal Engine 4

Workflow 1

Import
- OBJ
- FBX

Shapes



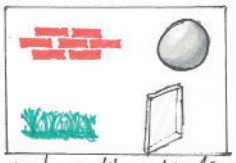
- create simple & complex forms

Assets



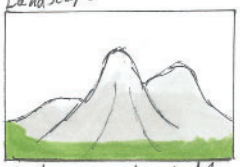
- dynamic asset library

Materials



- render quality materials

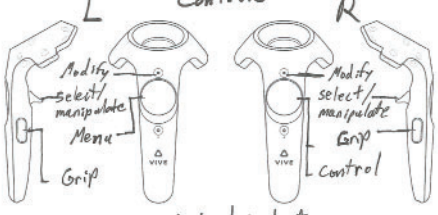
Landscape



- landscape creation + editing

Export
- FBX
- STL
- OBJ

Controls*



* Controls dependant on use

Pros: - Very powerful object + environment creation & manipulation
- Asset library can be expended
- High quality render
- 6 DOF on objects

Cons: - Extremely complex and difficult to learn
- Import/Export is difficult

Enscape

Workflow 1

Import
- DWG
- DXF
(Revit)

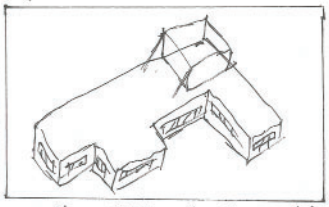
- Have to convert File to DXF or DWG to import to Revit

Live - Link



- direct link with Revit shows immediate changes made
- Ideal for working side by side
- Excellent Render/material quality

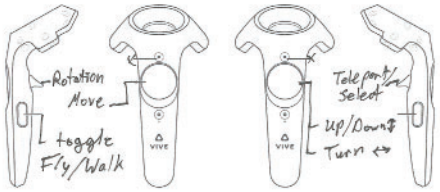
Fly mode vs. Walk mode



- User movement is versatile with a gravity bound walk mode and a Fly mode, unobstructed by objects in the space.

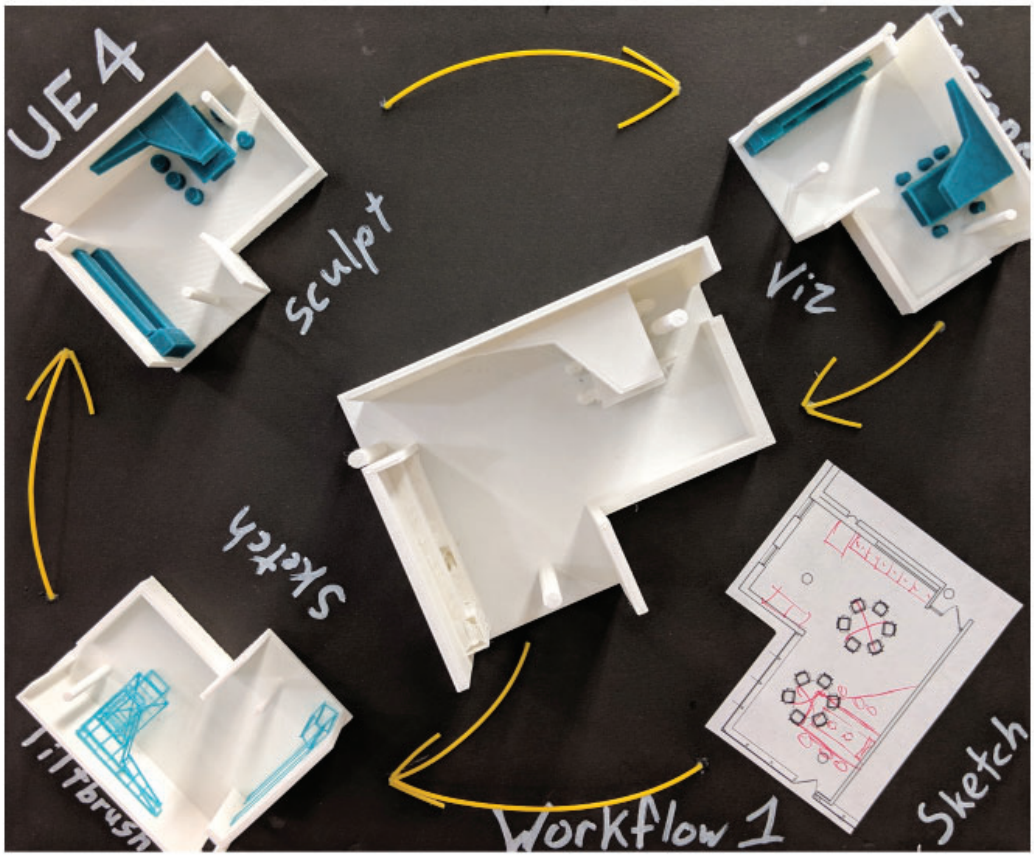
Export
- OBJ
- FBX

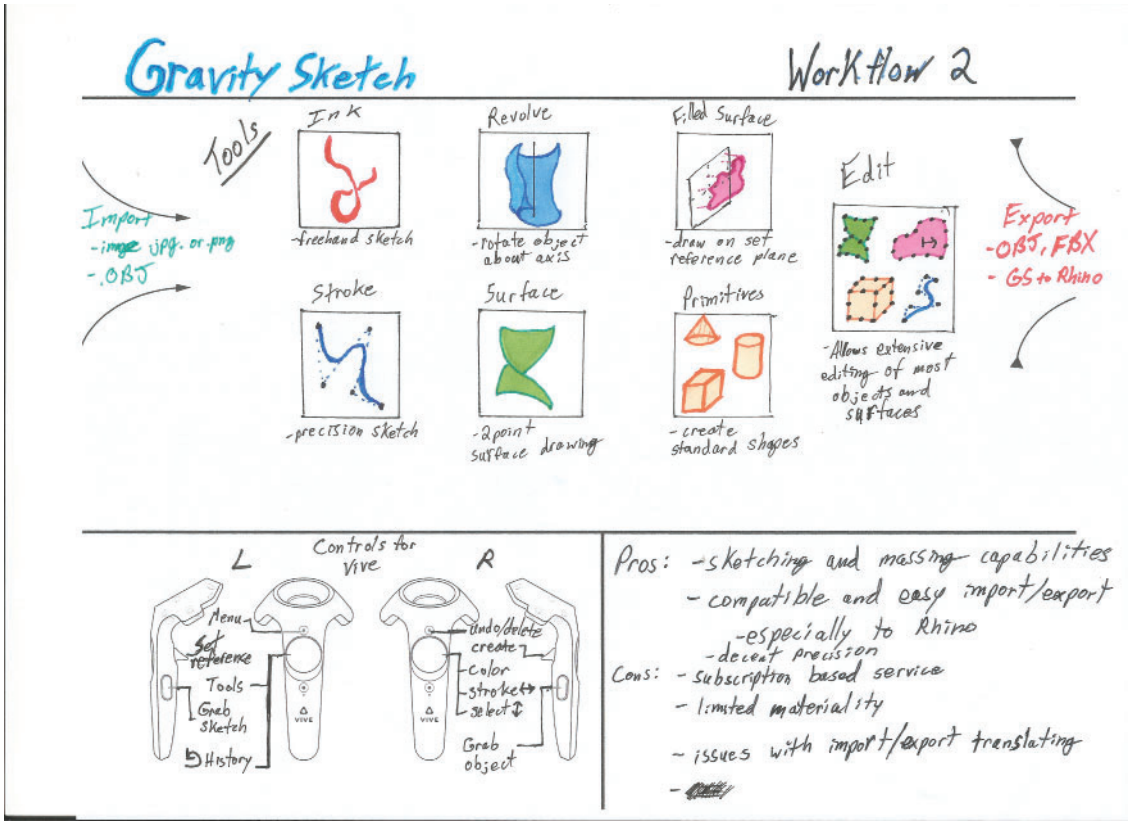
- OBJ export w/ plug in

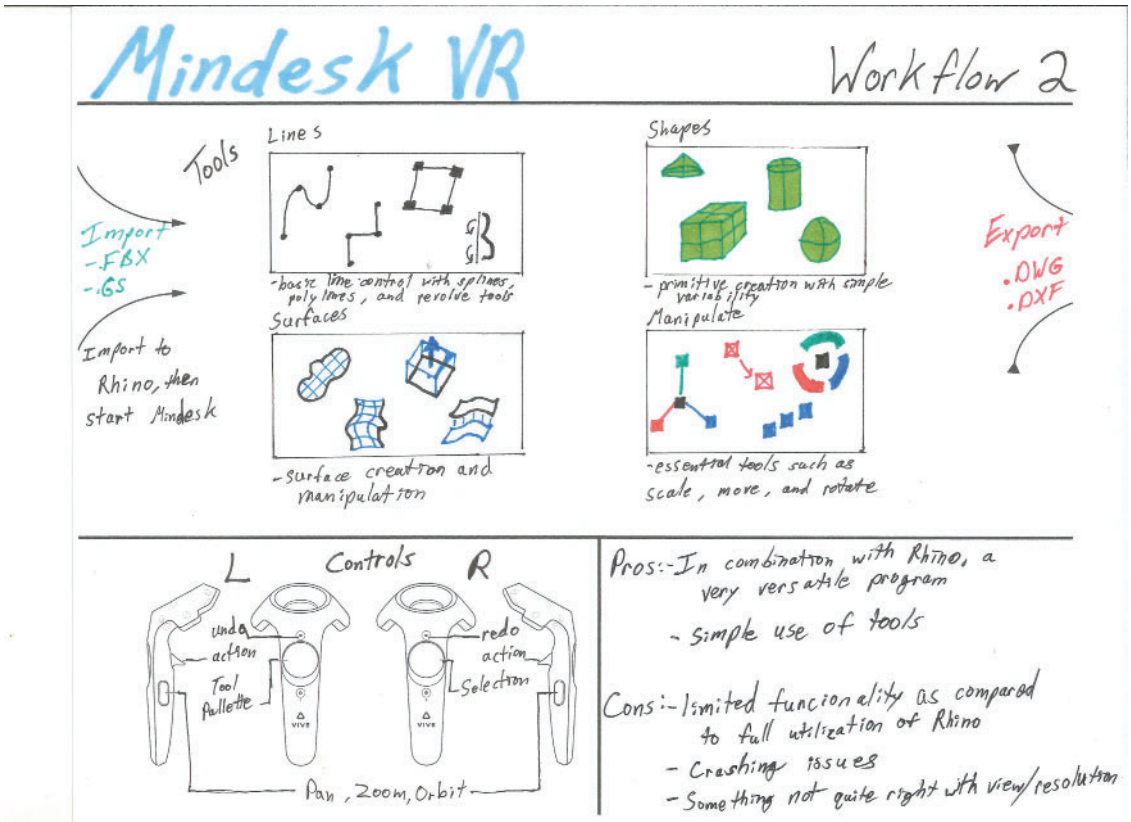


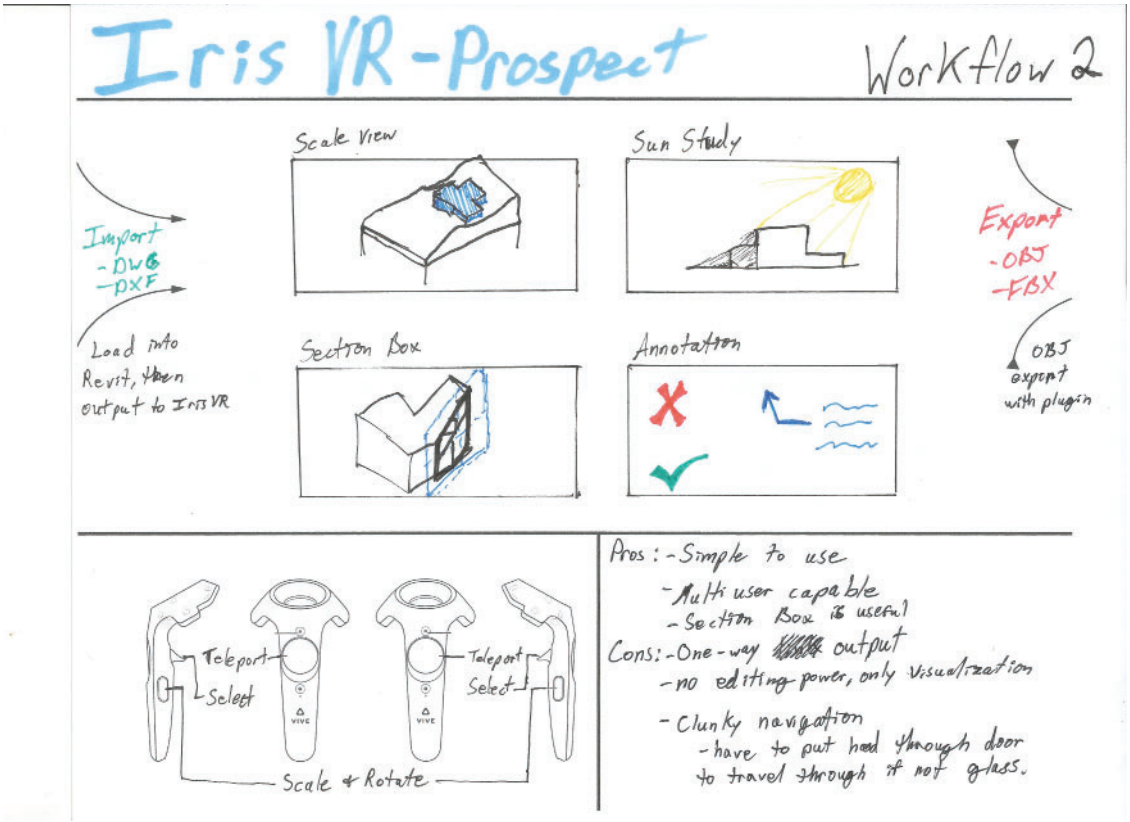
Pros: - Works excellently with Revit
- Live link shows immediate high quality edits in Revit
- Multi-user capable

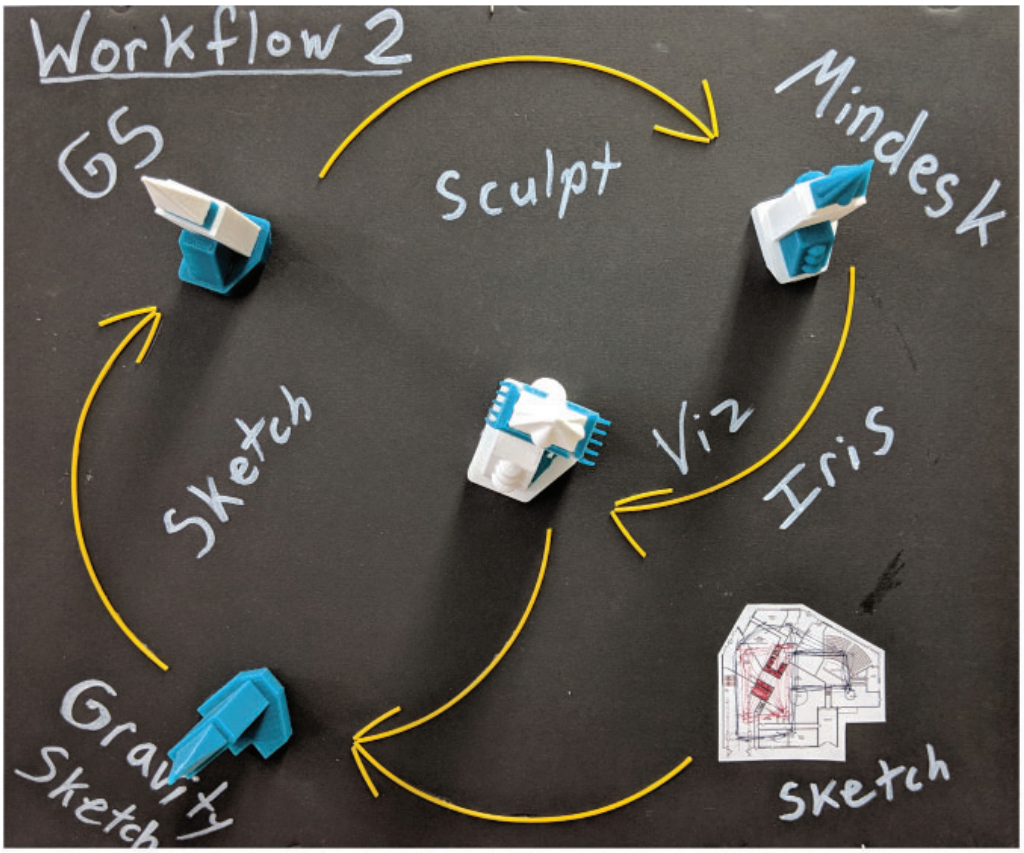
Cons: - Issues importing into Revit
- materials lost
- No editing capabilities in VR
- heavy graphics demand

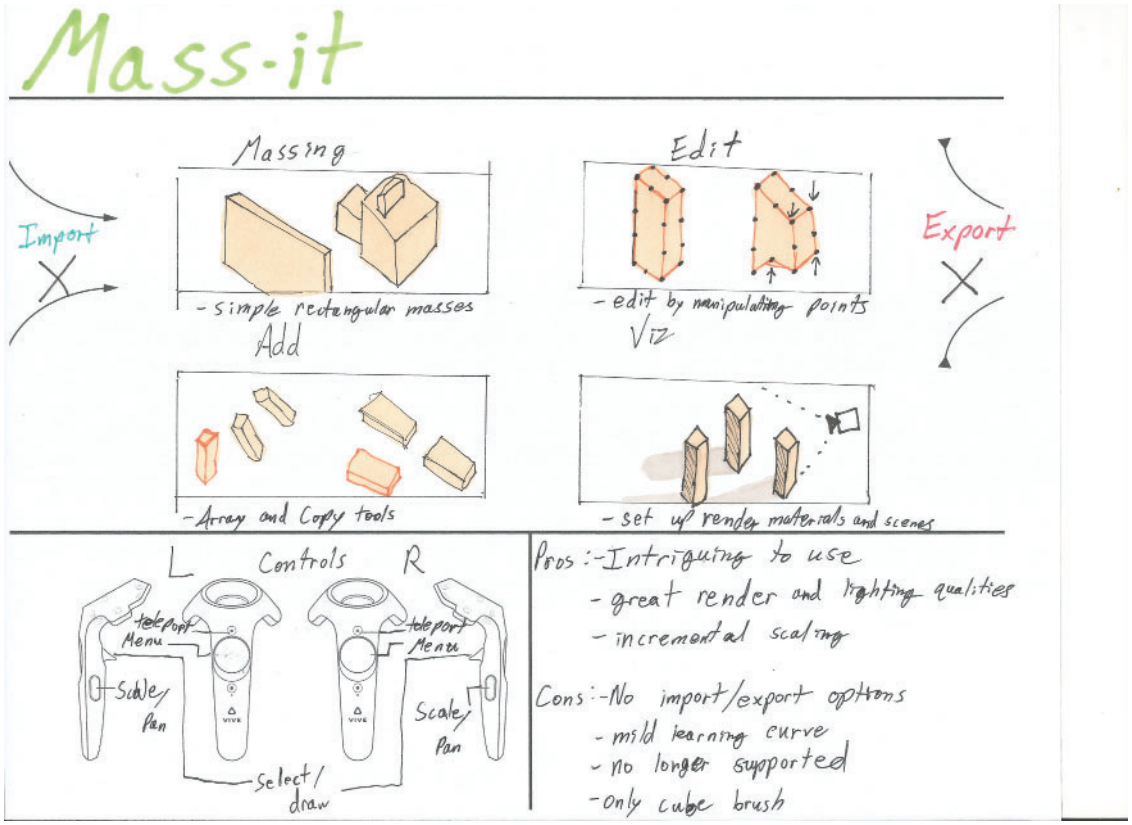


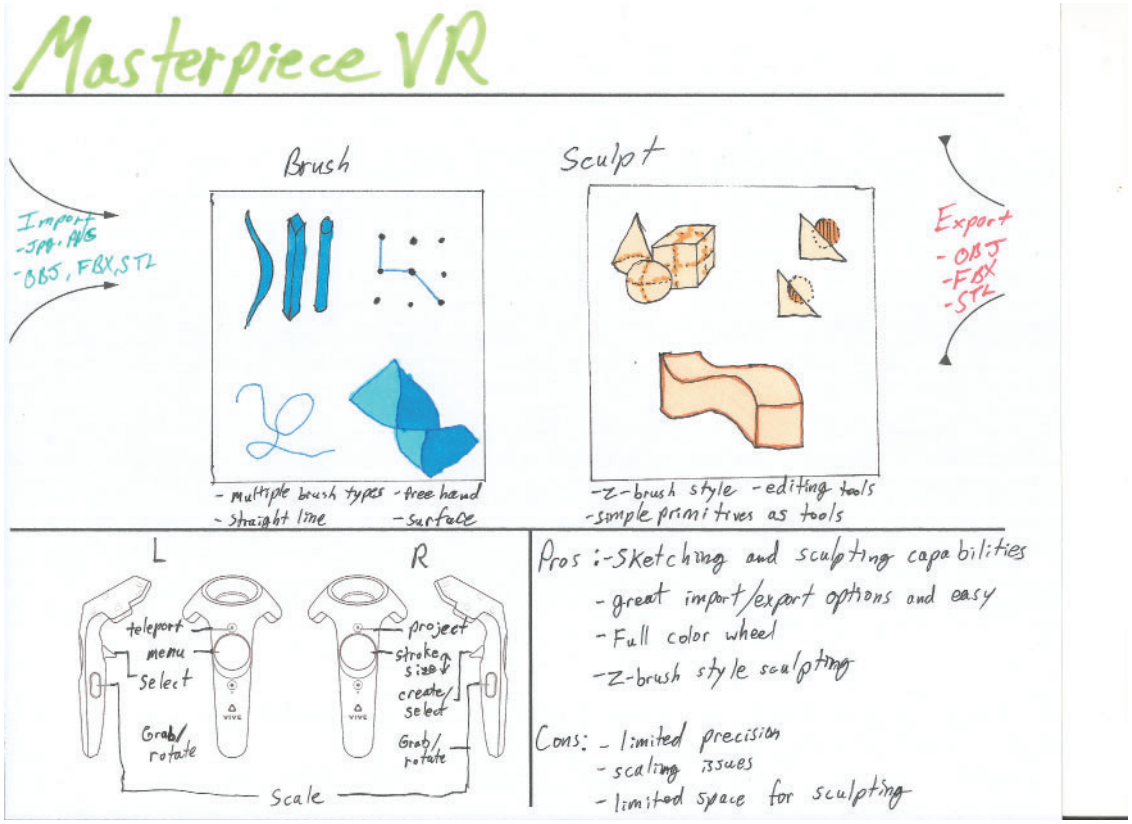

Gravity Sketch
Workflow 2
Tools
Import
-image .jpg. or .png
-.OBJ
Ink
-freehand sketch
Revolve
-rotate object about axis
Filled Surface
-draw on set reference plane
Edit
-Allows extensive editing of most objects and surfaces
Export
-OBJ, FBX
- GS to Rhino
Stroke
-precision sketch
Surface
-2 point surface drawing
Primitives
-create standard shapes
L
Controls for Vive
R
Menu
Set reference
Tools
Grab Sketch
History
Undo/delete
create
color
stroke
select
Grab object
Pros: -sketching and massing capabilities
- compatible and easy import/export
-especially to Rhino
-decent precision
Cons: - subscription based service
- limited materiality
- issues with import/export translating
-


Mindesk VR
Workflow 2
Tools
Import
-.FBX
-.GS
Import to Rhino, then start Mindesk
Lines
-basic line control with splines, polylines, and revolve tools
Surfaces
-surface creation and manipulation
Shapes
- primitive creation with simple variability
Manipulate
-essential tools such as scale, move, and rotate
Export
.DWG
.DXF
L
Controls
R
Undo action
Tool Palette
redo action
Selection
Pan, Zoom, Orbit
Pros:-In combination with Rhino, a very versatile program
- simple use of tools
Cons:-limited functionality as compared to full utilization of Rhino
- Crashing issues
- Something not quite right with view/resolution

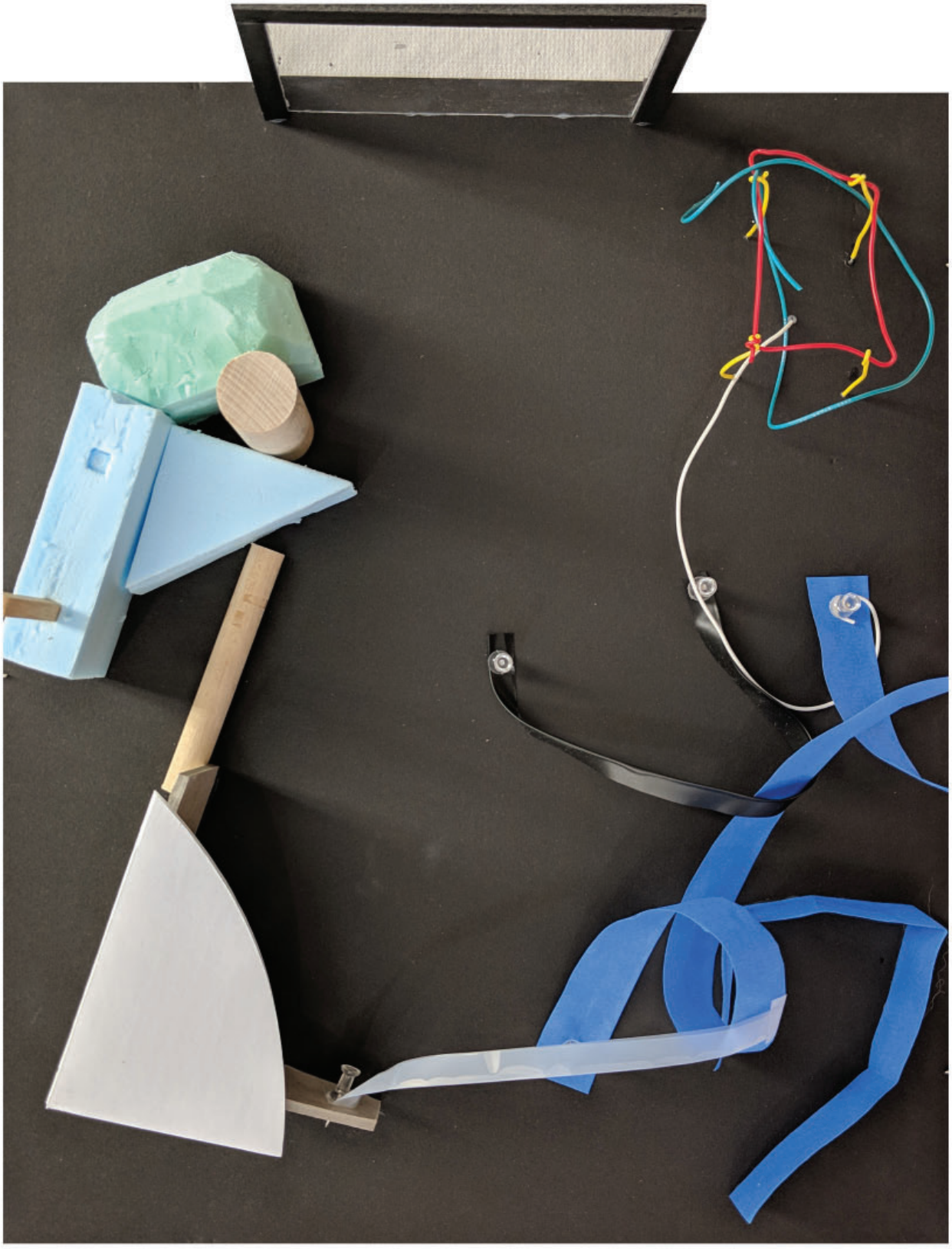

Iris VR - Prospect
Workflow 2
Scale view
Sun Study
Import
- DWG
- DXF
Load into Revit, then output to Iris VR
Export
- OBJ
- FBX
OBJ export with plugin
Section Box
Annotation
Teleport
Select
Teleport
Select
Scale & Rotate
Pros: - Simple to use
- Multi user capable
- Section Box is useful
Cons: - One-way output
- no editing power, only visualization
- Clunky navigation
- have to put head through door to travel through if not glass.


Workflow 2
GS
Sculpt
Mindesk
Sketch
Viz
Iris
Gravity Sketch
Sketch


Mass-it
Massing
Edit
Import
Export
- simple rectangular masses
- edit by manipulating points
Add
Viz
- Array and Copy tools
- set up render materials and scenes
L
Controls
R
teleport Menu
Scale/ Pan
Select/ draw
Pros :- Intriguing to use
- great render and lighting qualities
- incremental scaling
Cons :- No import/export options
- mild learning curve
- no longer supported
- only cube brush


Masterpiece VR
Brush
Sculpt
Import
-JPG, PNG
-OBJ, FBX, STL
Export
- OBJ
- FBX
- STL
- multiple brush types - free hand
- straight line - surface
- Z-brush style - editing tools
- simple primitives as tools
L
R
teleport menu
Select
Grab/ rotate
project
stroke size
create/ select
Grab/ rotate
Scale
Pros :- Sketching and sculpting capabilities
- great import/export options and easy
- Full color wheel
- Z-brush style sculpting
Cons: - limited precision
- scaling issues
- limited space for sculpting

CONCEPT COLLAGE

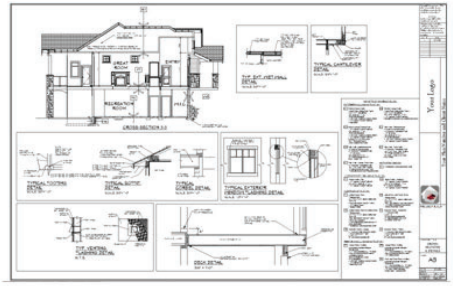


DESIGN PROCESS

PAST



DRAWING



DOCUMENTS

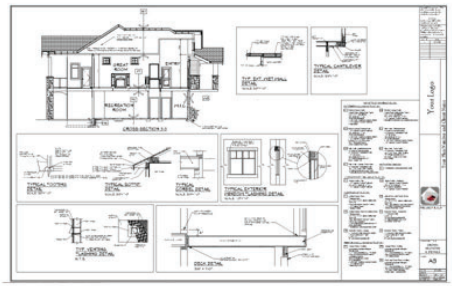
CURRENT



DRAWING



CAD/BIM MODELING



DOCUMENTS

DESIGN PROCESS

PROPOSED



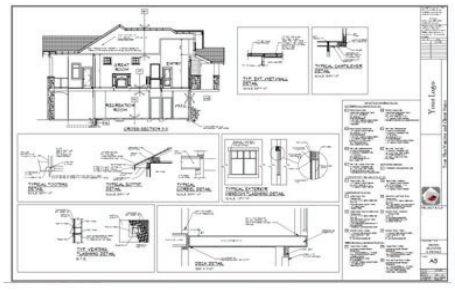
DRAWING



VIRTUAL DESIGN

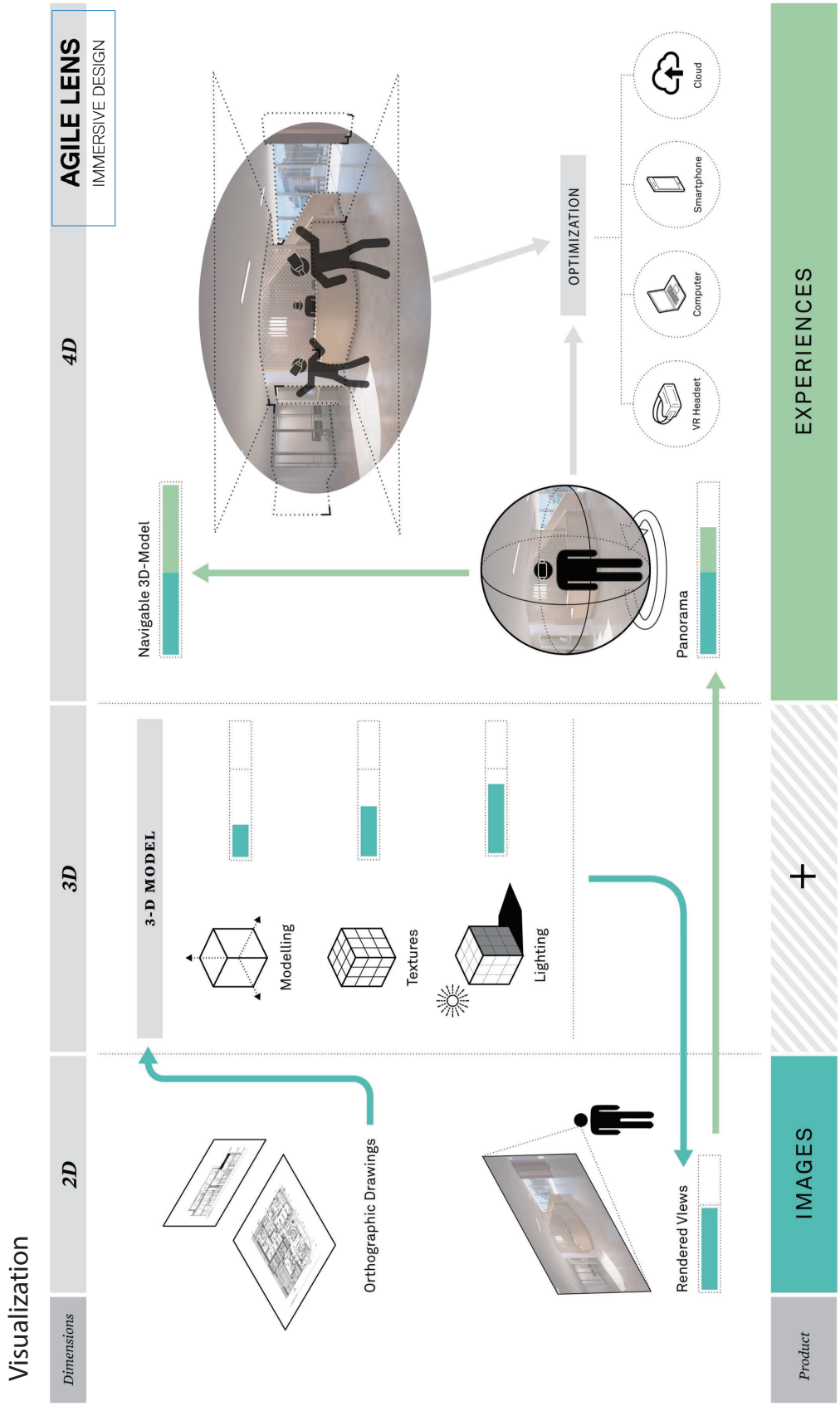


CAD/BIM MODELING



DOCUMENTS

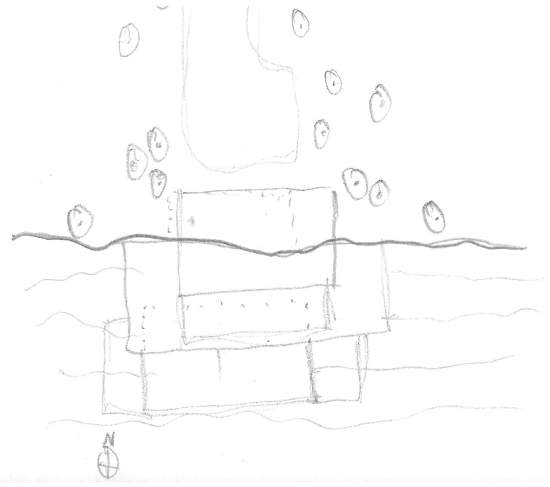
VISUALIZATION FLOW



DESIGN STUDY



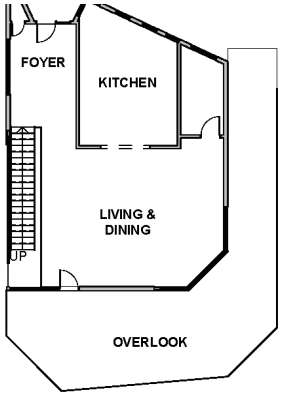


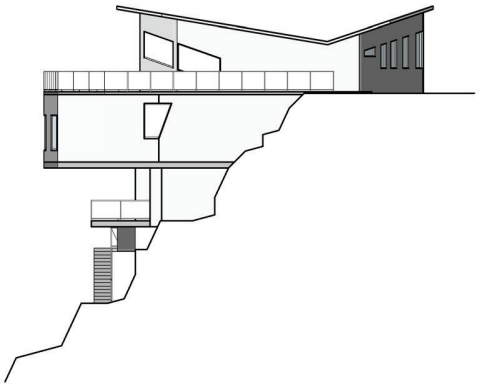








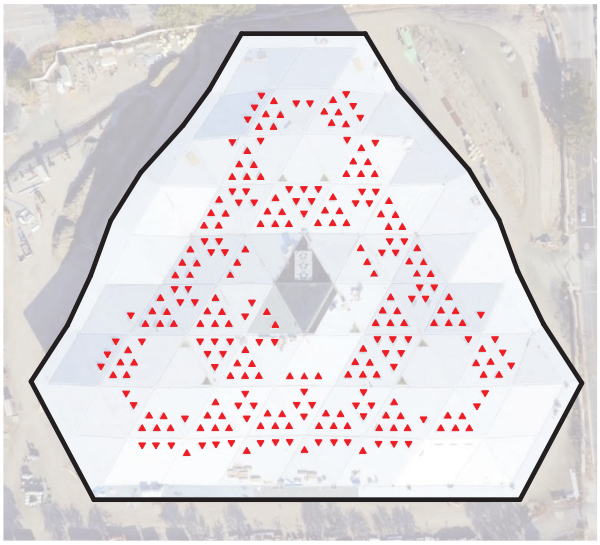


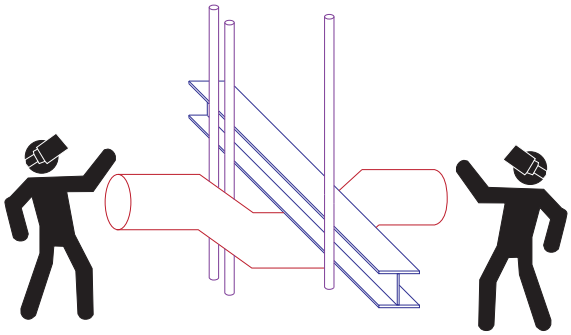


PRECEDENTS

COLLABORATION - NVIDIA HQ







NVIDIA is a leading American technology company focusing on graphics processing. Construction of their new headquarters in Santa Clara California was completed in late 2107. It is a two story, 500,000 square foot triangular building with an ungulating roof that accomodates over 2,500 employees. Triangular forms are used throughout the building which NVIDIA claims is "the fundamental building block of computer graphics."

The building was developed using NVIDIA's own iray, an advanced physics based rendering and lighting simulation software. Gensler's intention was to maximize, not the quantity of light, but the quality of light. Integration of the iray system into a virtual reality workflow allowed designers to make the appropriate decisions to meet this goal. VR systems were also used to improve interior layouts and in collaboration with construction teams for coordination.

SITE RELATIONSHIP - PROJECT MOSUL







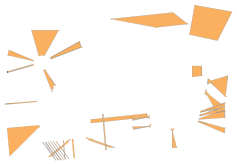
Project Mosul is an initiative by REKREI to crowdsource images from where ever possible that help to recreate lost or destroyed artifacts and buildings. Through photogrammatry technology they are able to use photos and videos to digitally formulate 3D representations of objects such as ancient statues. Their goal is to virtually preserve cultural heritage and history.

While REKREI now is reconstructing various enviroments around the world, their initial focus was based around the destruction in Mosul, Iraq. In association with The Economist, they've recreated the devestated Cultural Museum of Mosul and many of the precious antiquities inside as a virtual representation that can now be toured by anyone in the world.

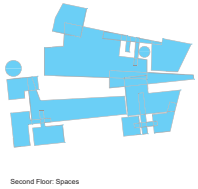
Techniques such as this could be used in association with extended reality applications to design in respect to site specific conditions that are either no longer existant or not readily accessible.

SPATIAL INTERACTION - COURTYARD HOUSE

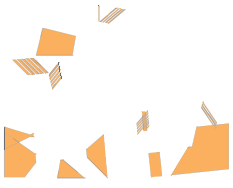




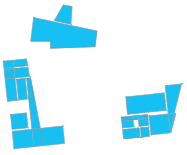
Second Floor: Views



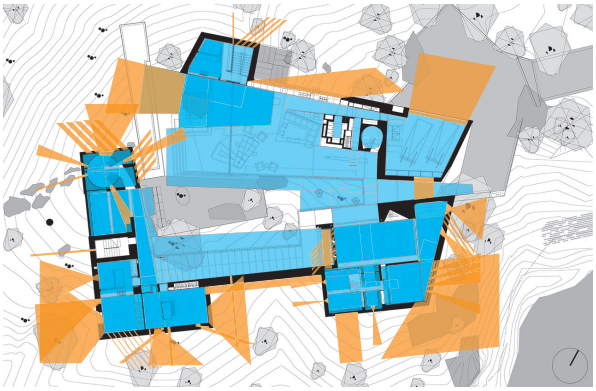
Second Floor: Spaces



Ground Floor: Views



Ground Floor: Spaces



The Courtyard House by Wendell Burnette is a rammed earth, steel clad home in Scottsdale, Ari zona. the 7,200 square foot home is built around an open central courtyard with an emphasis on views to the surrounding desert and mountanous landscape.

This project was completed in 2014, and had no ties to virtual reality. Though it's intensive control of spatial and visual aspects shows opportunities where the use of VR design could be greatly beneficial. Improved spatial understanding of confined versus open spaces could be improved. Additionally, with full virtual site context, views could be more precisely defined by actually experiencing the views outside of a plan or setion drawing.



Higgins Hall, Pratt Institute



Knowlton School of Architecture



Medina Haram Piazza



Mecanoo Library Delft



New World Symphony



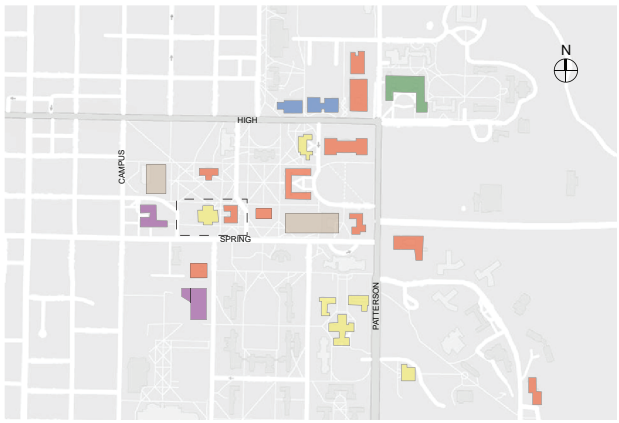
Esports Stadium Arlington

DESIGN

SITE CONDITIONS

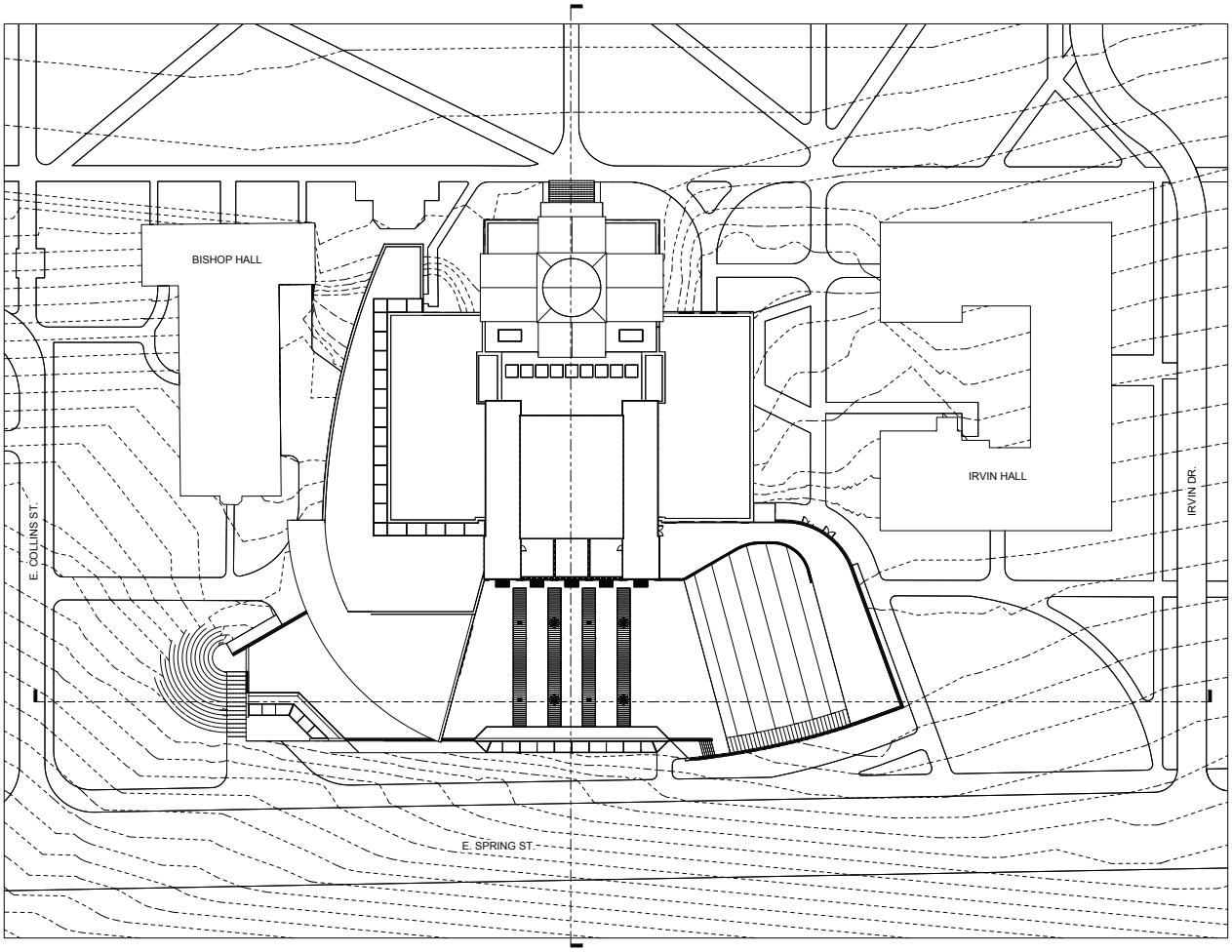


Alumni Hall was originally built as a Carnegie library, completed in 1910 at a cost of $80,000. it has since undergone several renovations, primarily in 1924 (east wing), 1952 (west wing), and 1997 (south addition).
Although Alumni Hall certainly holds historical significance, it is not registered as a protected historic building by Oxford or the National Register.

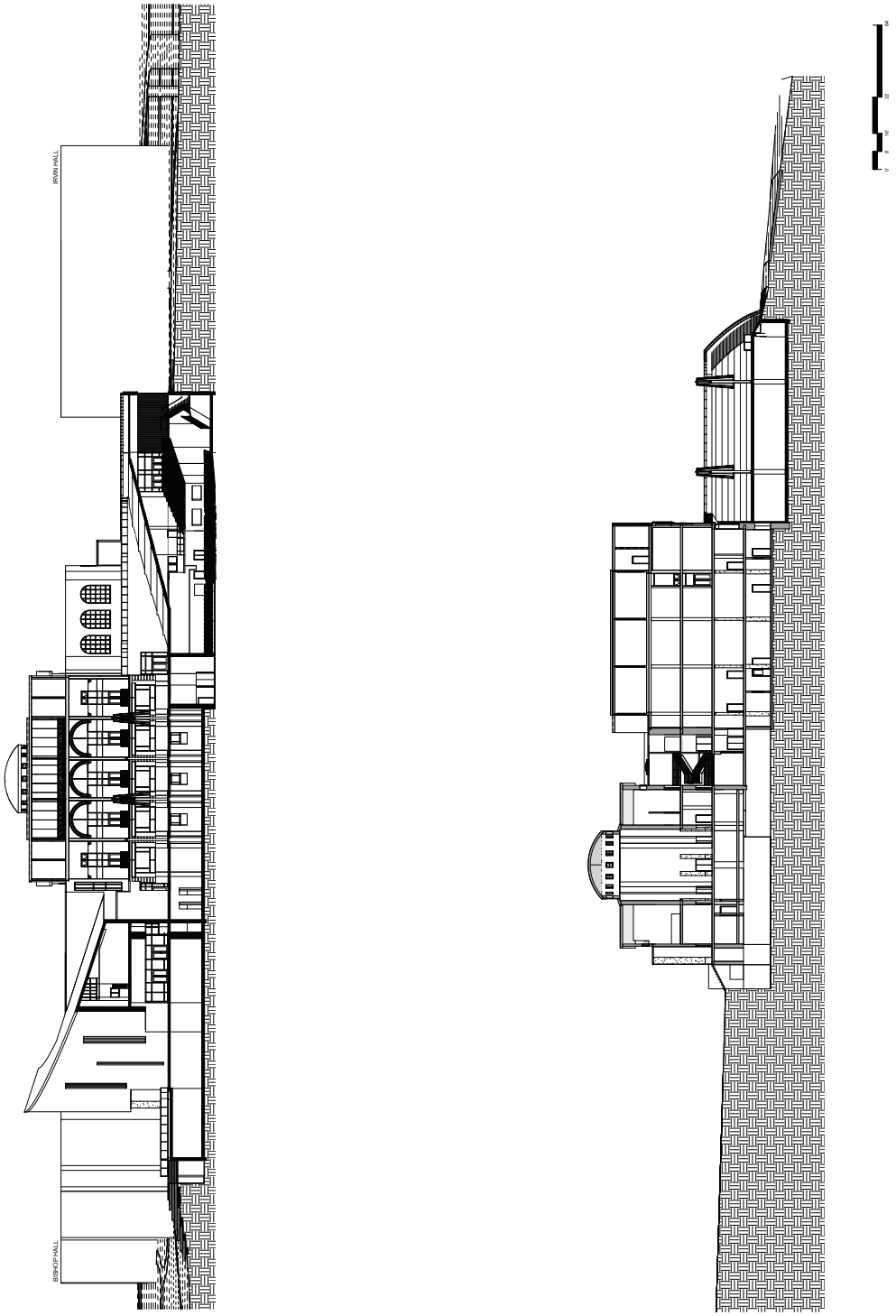


ACEDEMIC DEPARTMENT SITE DISTRIBUTION

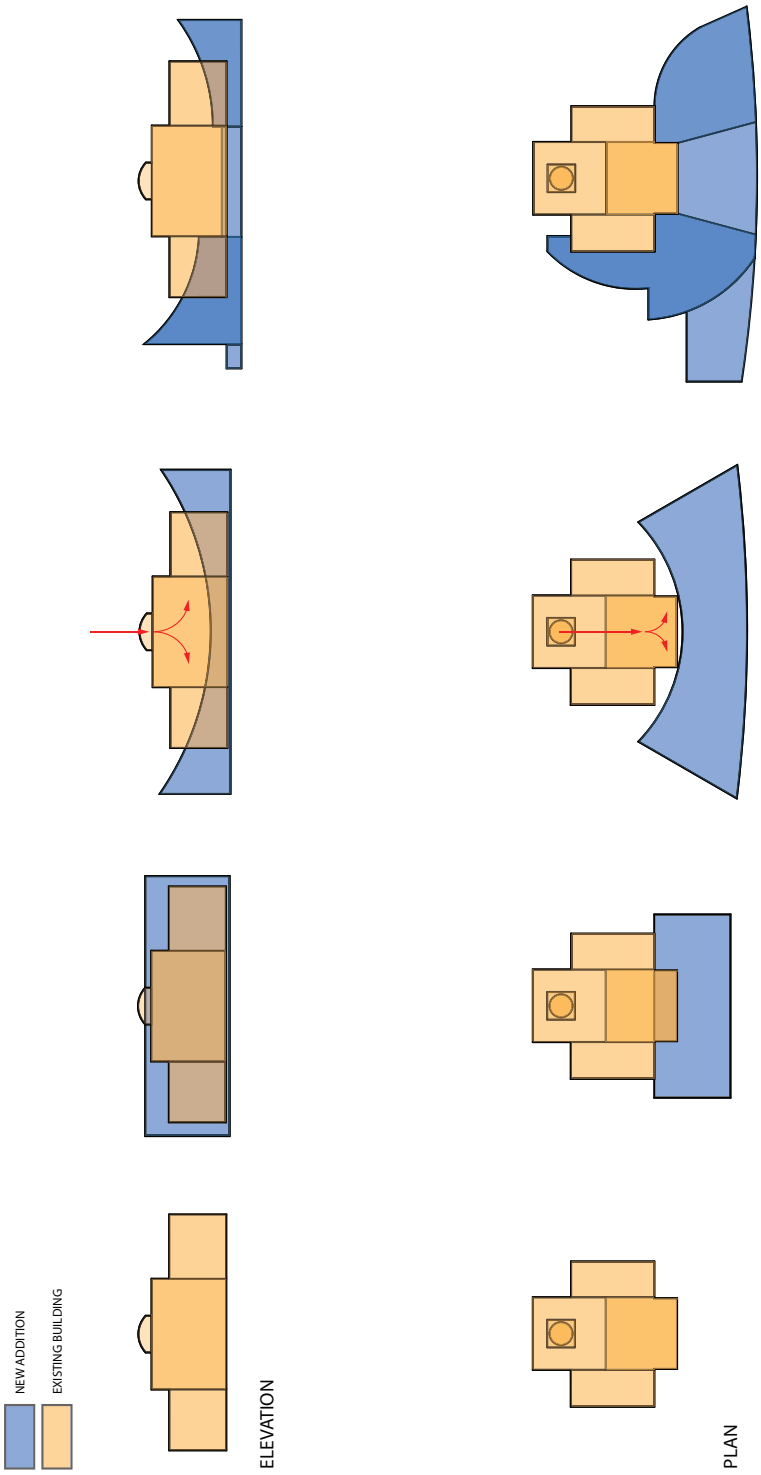
- CAS: College of Arts and Sciences
- FSB: Farmer School of Business
- CCA: College of Creative Arts
- EHS: Education, Health, Society
- CEC: College of Engineering and Computing



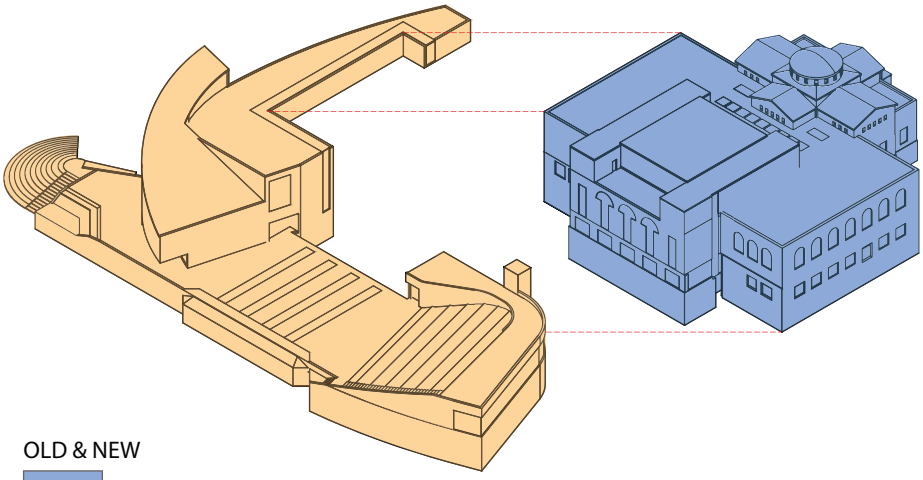
SITE SECTIONS



PARTI DIAGRAM



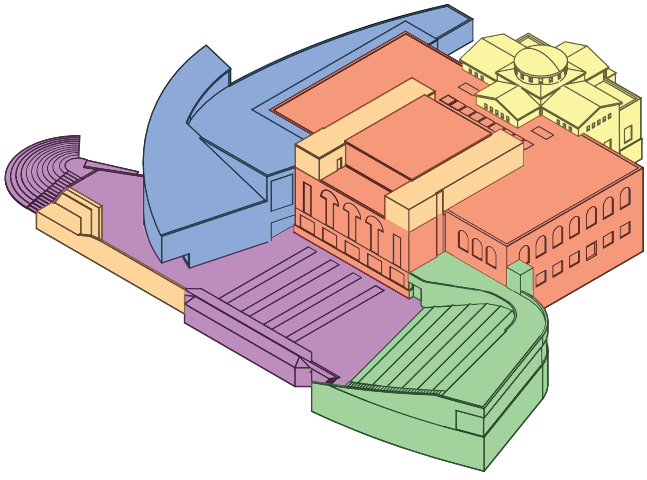
MASSING DIAGRAMS



OLD & NEW

EXISTING BUILDING

NEW ADDITION



PROGRAM

WORKSHOPS

PLAZA

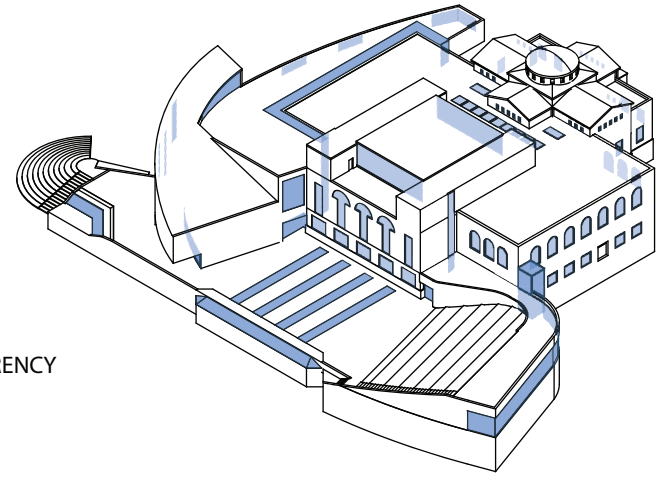
OFFICES

ARENA

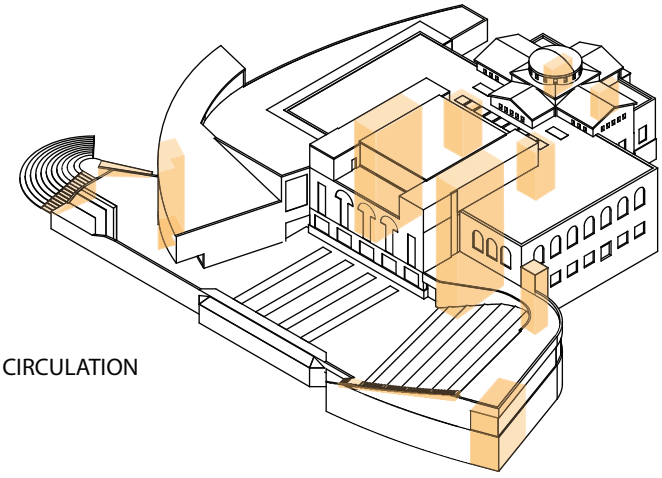
CLASSROOMS

BUILDING SERVICES

MASSING DIAGRAMS

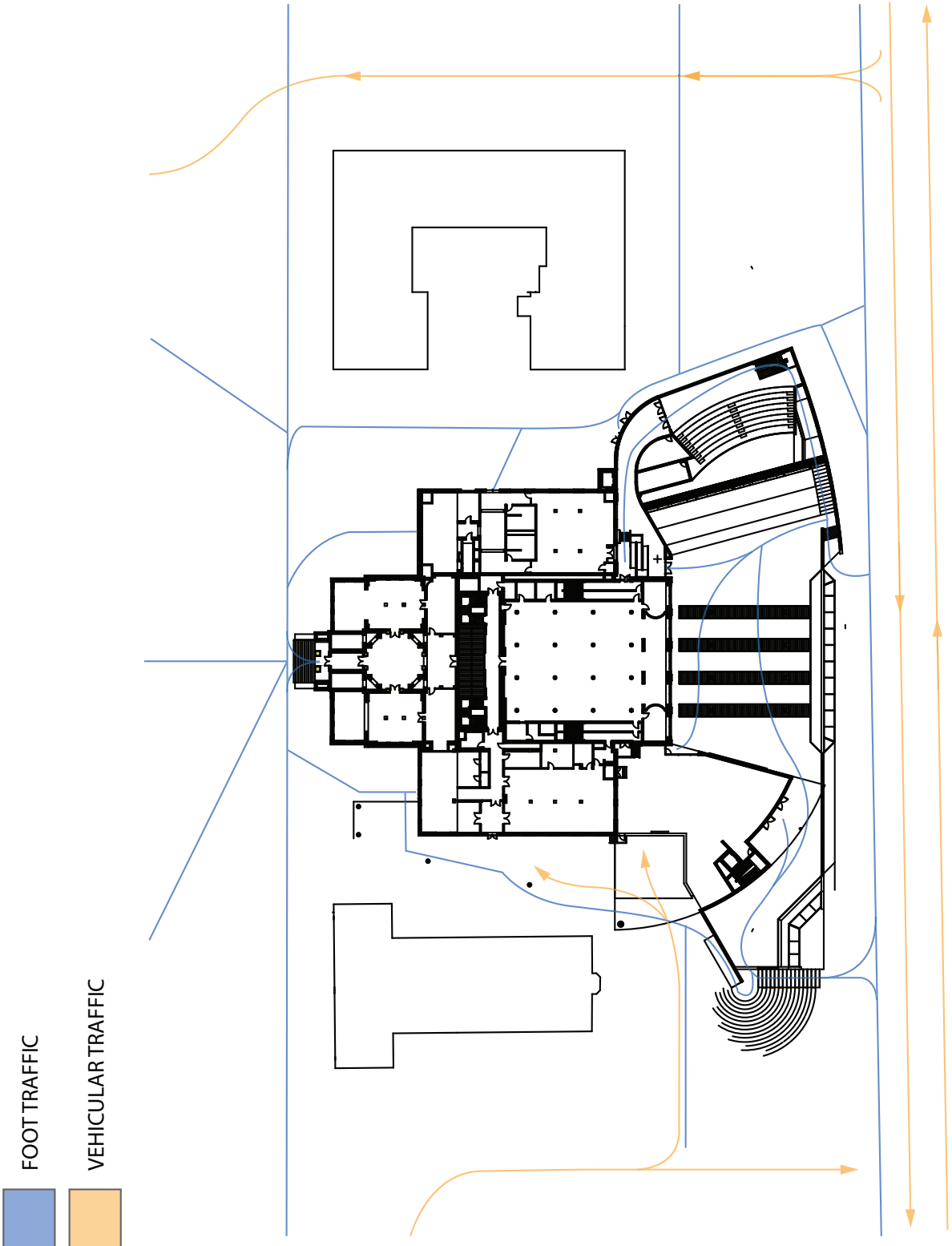


TRANSPARENCY

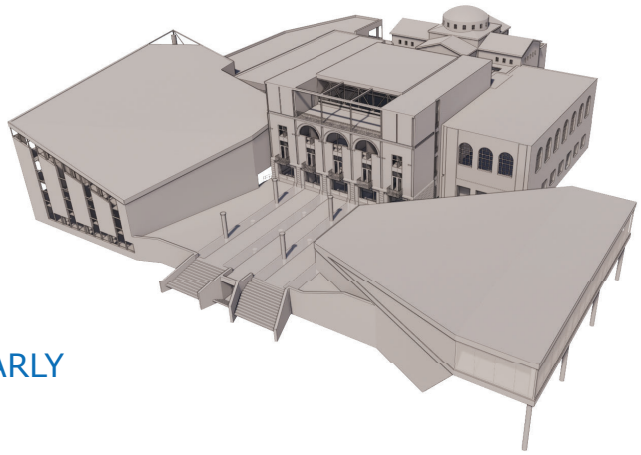


VERTICAL CIRCULATION

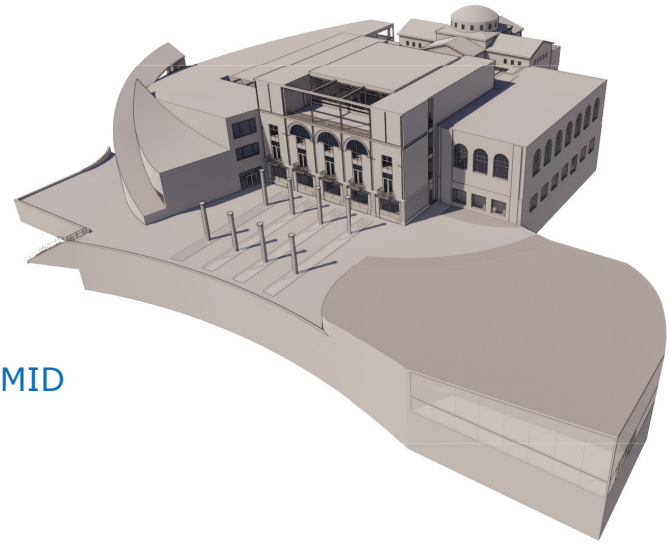
SITE CIRCULATION



FORMAL PROGRESSION



EARLY



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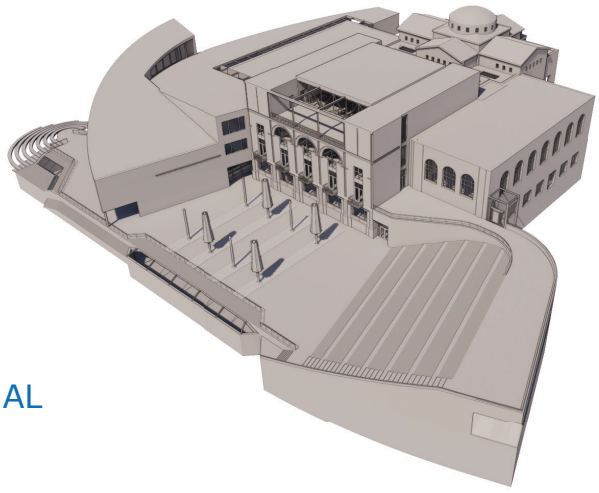
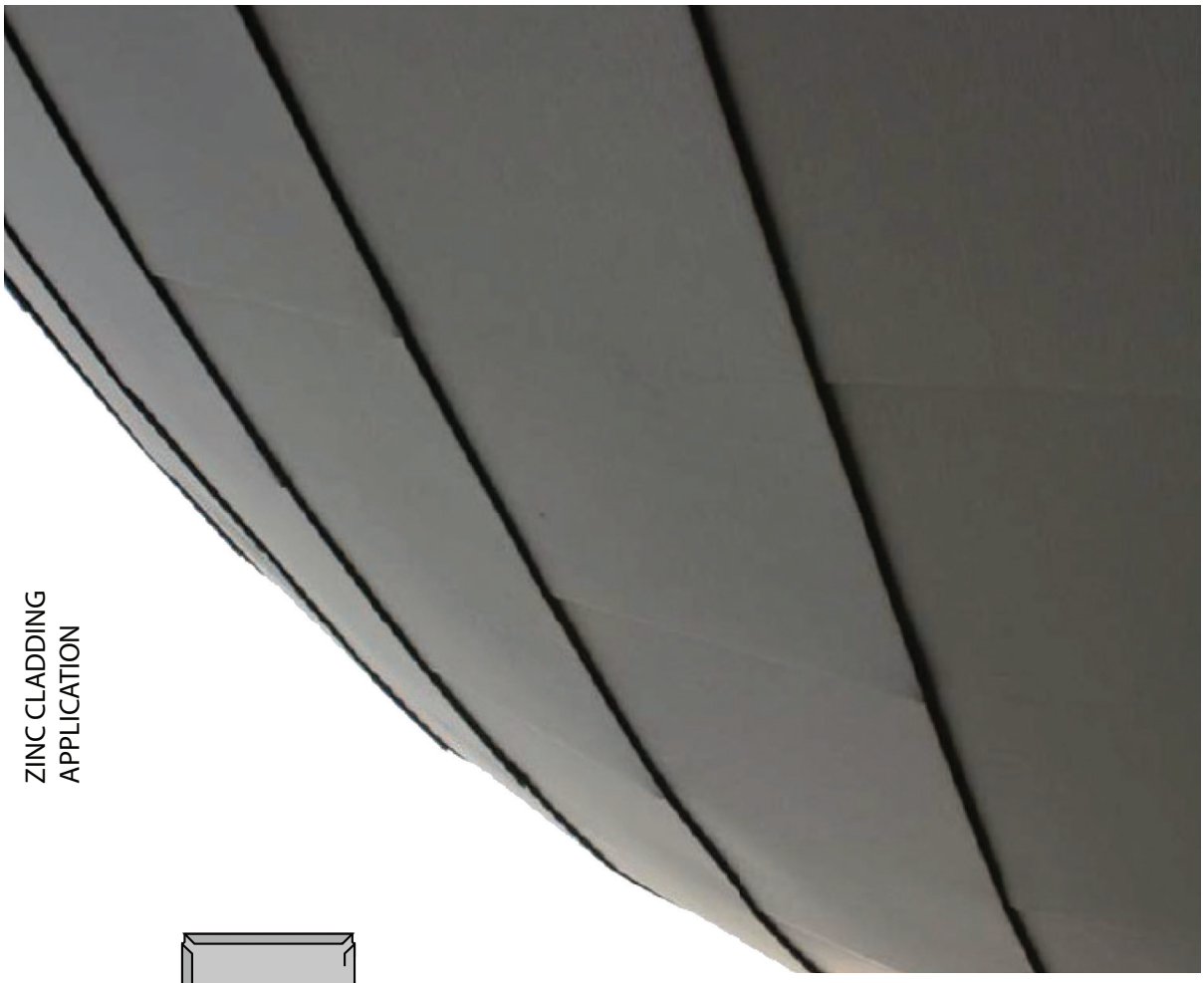
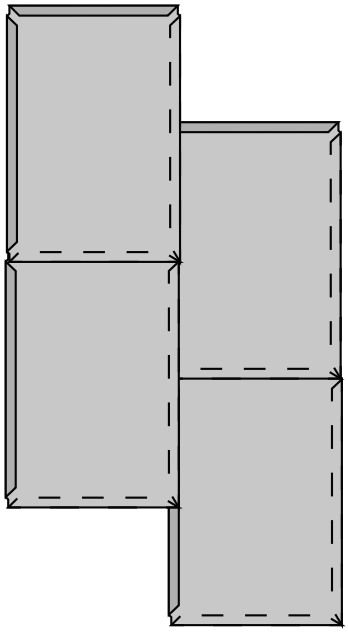


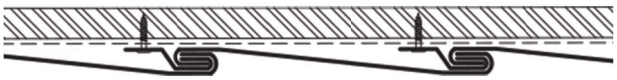
FINAL



ZINC CLADDING APPLICATION

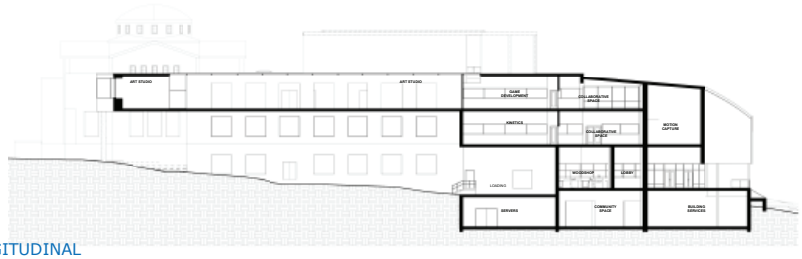


ZINC CLADDING FIELD CONDITION

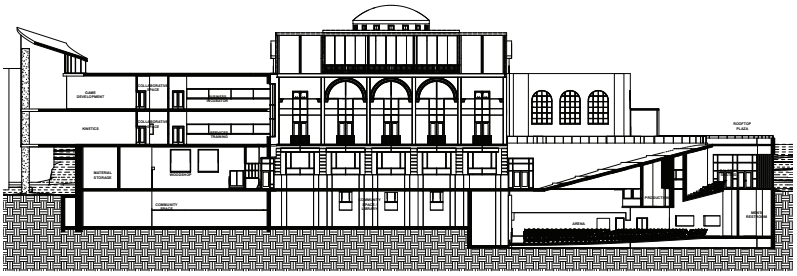


ZINC CLADDING SECTION DETAIL

SECTION & ELEVATION



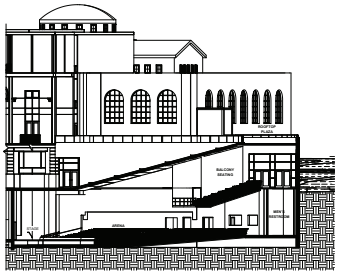
BUILDING SECTION - LONGITUDINAL



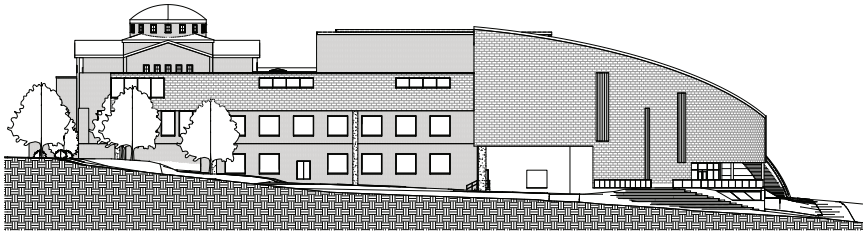
BUILDING SECTION - LATITUDINAL



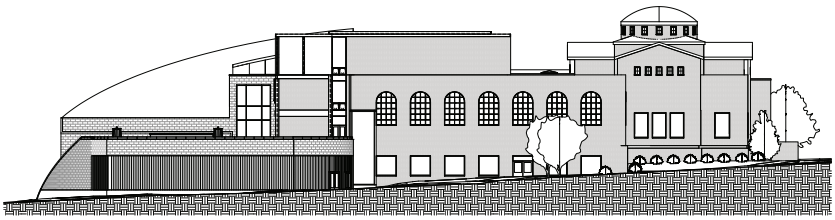
NORTH ELEVATION - PARTIAL



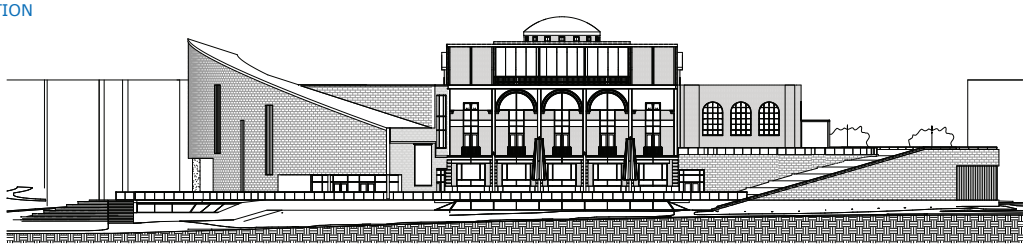
BUILDING SECTION - ARENA



WEST ELEVATION



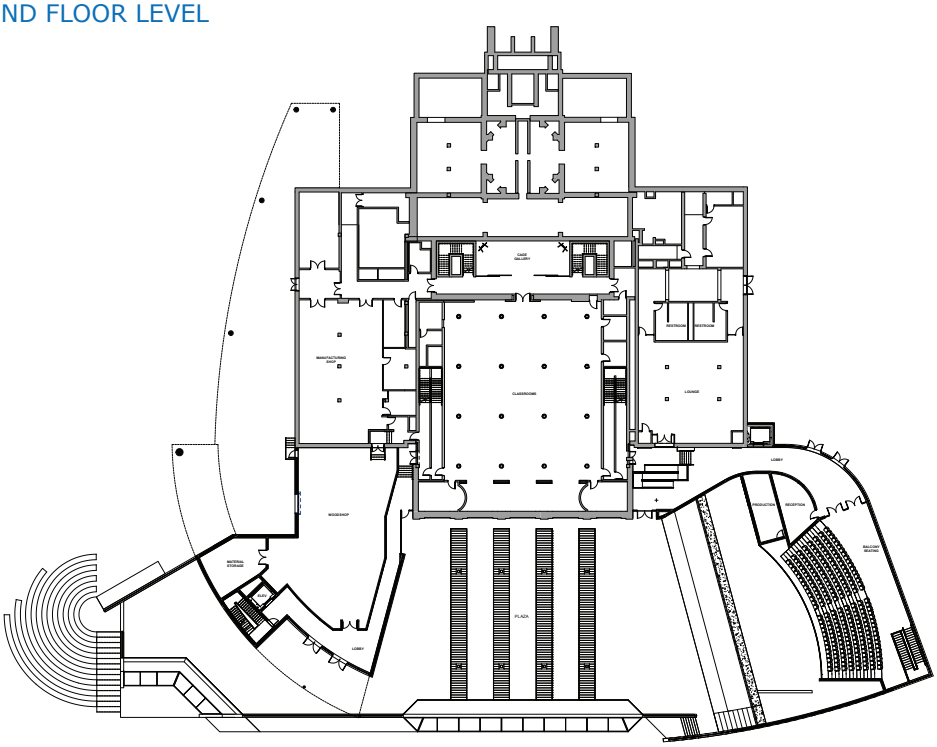
EAST ELEVATION



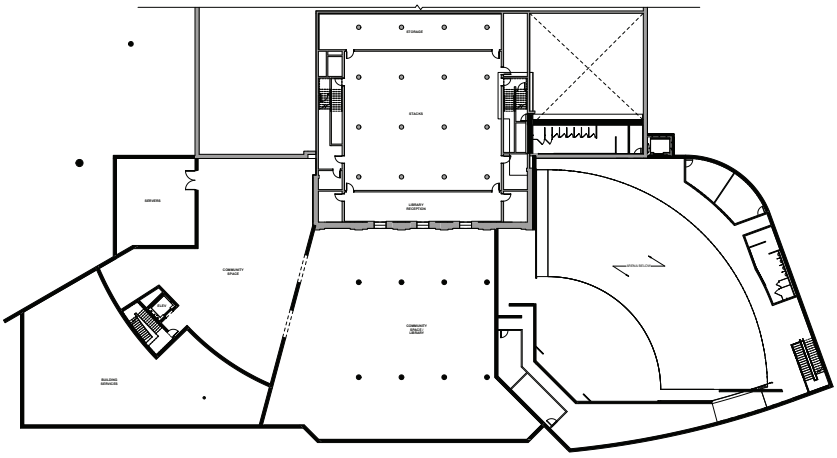
SOUTH ELEVATION

FLOOR PLANS

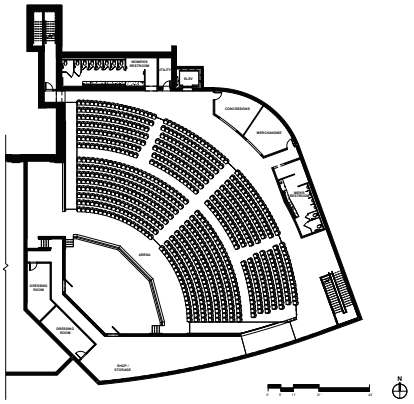
PLAZA/GROUND FLOOR LEVEL



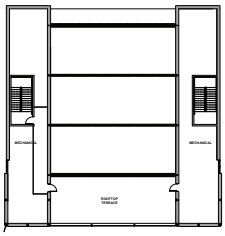
BASEMENT FLOOR



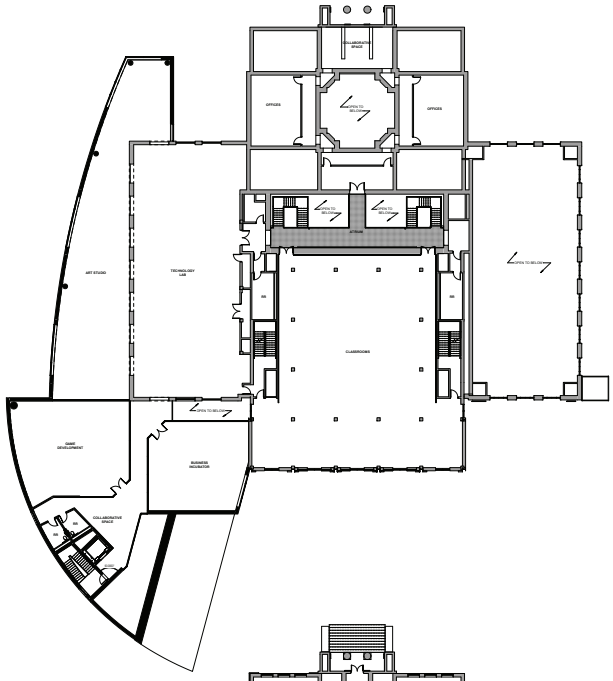
ARENA LOWER FLOOR



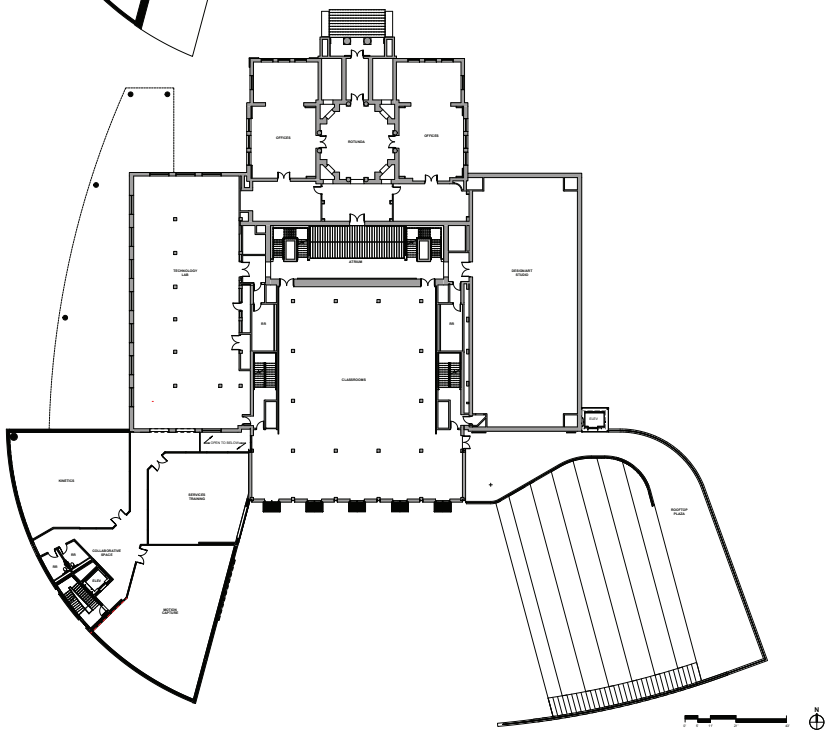
THIRD FLOOR

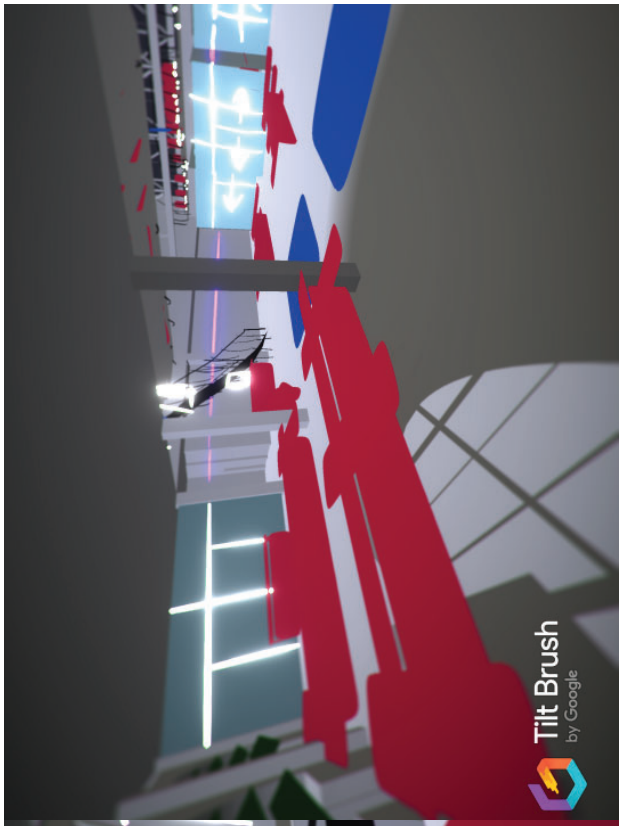


SECOND FLOOR



FIRST FLOOR

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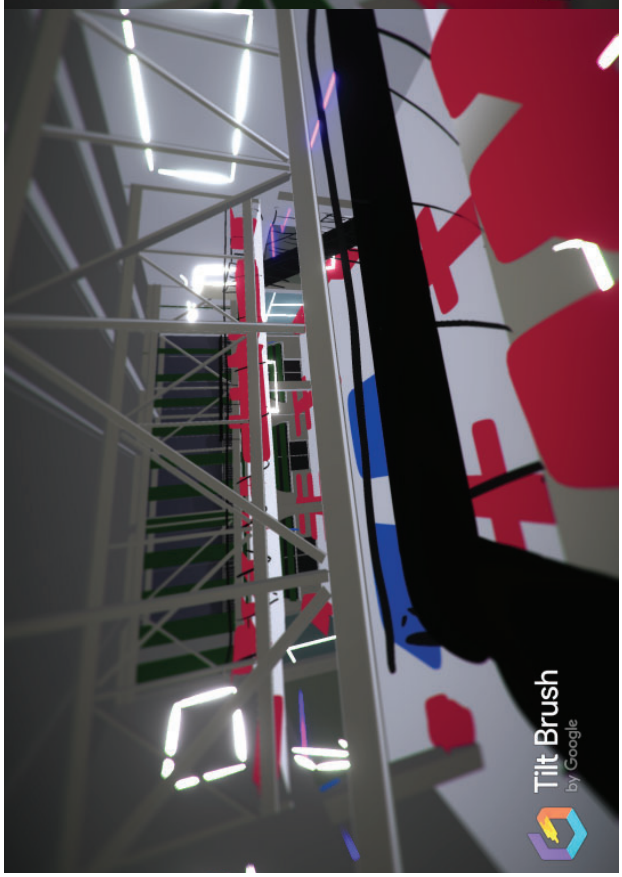
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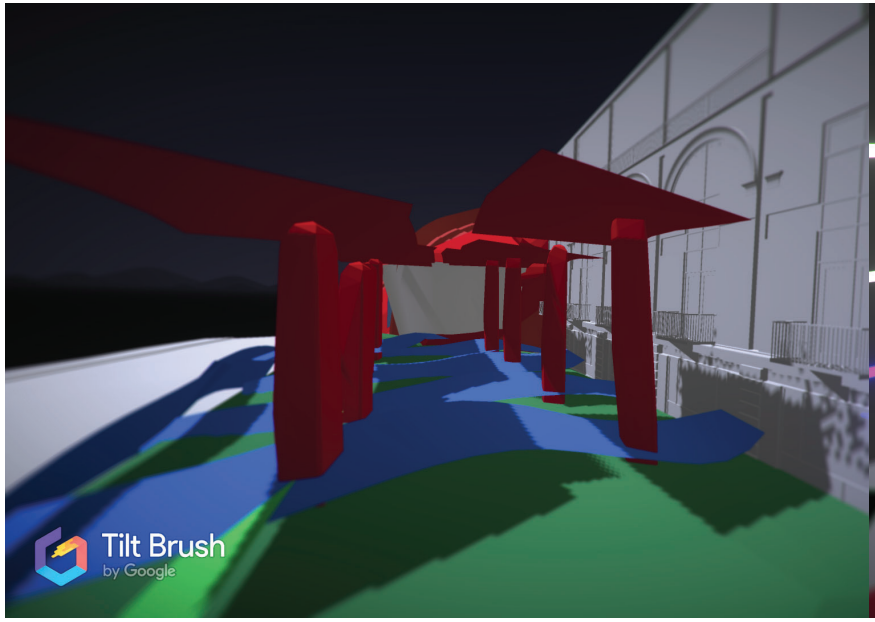
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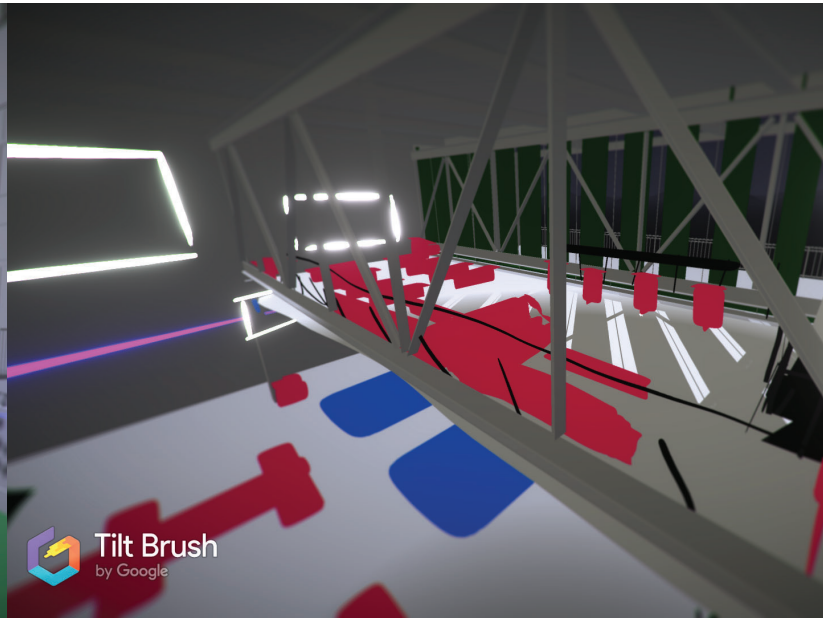
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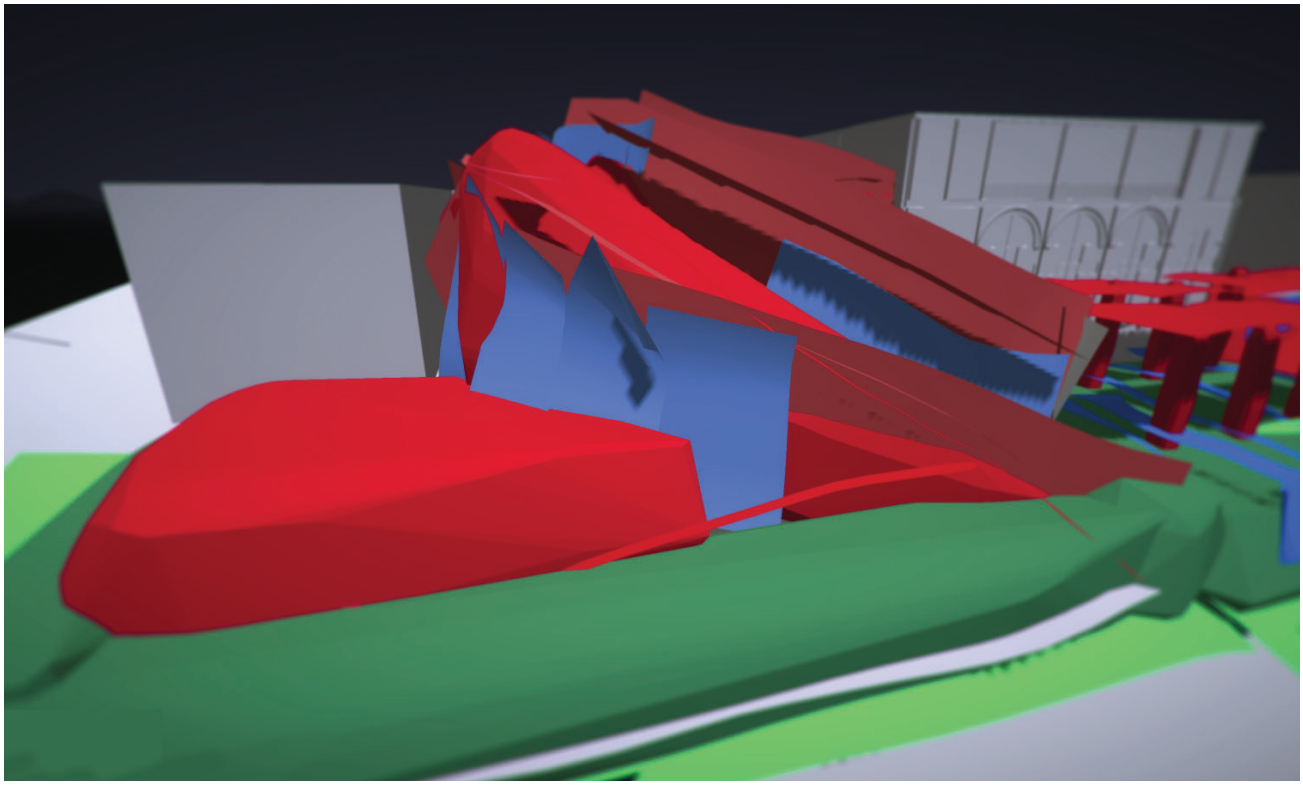



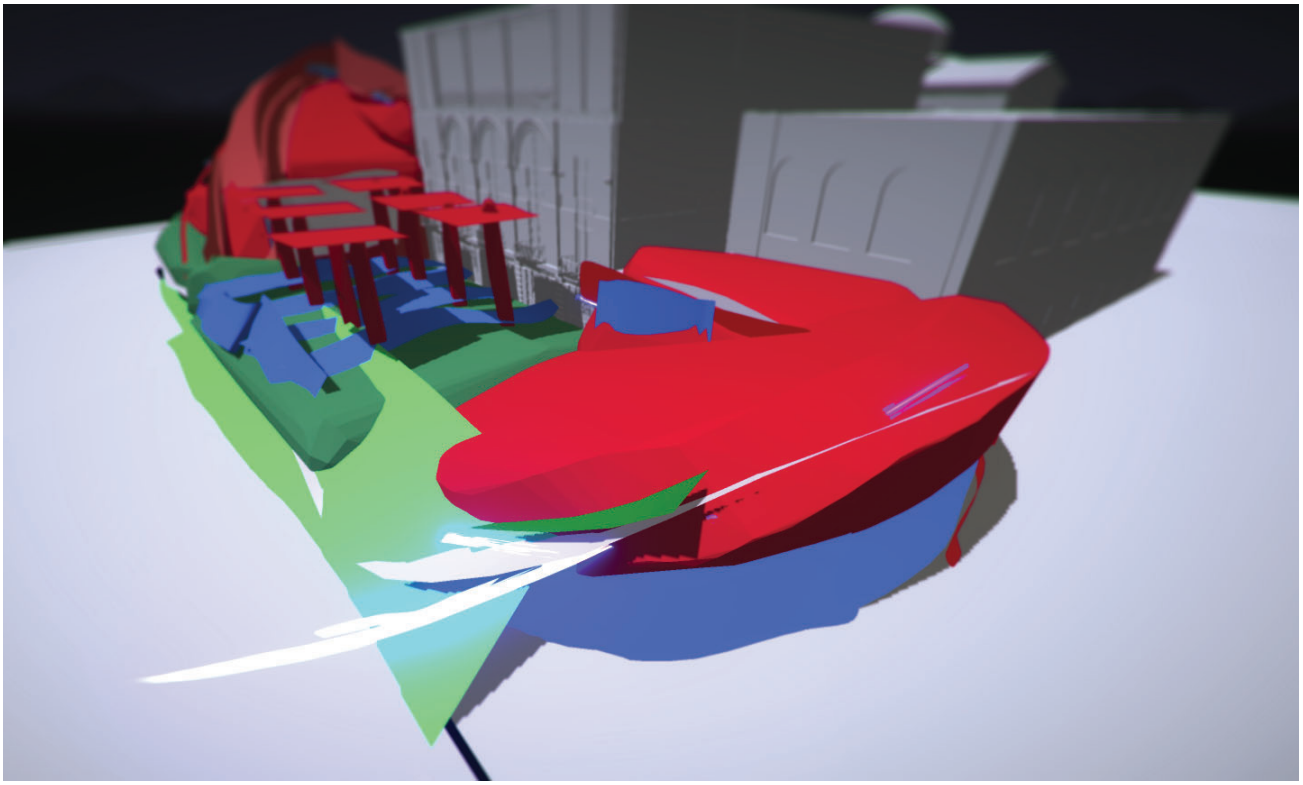

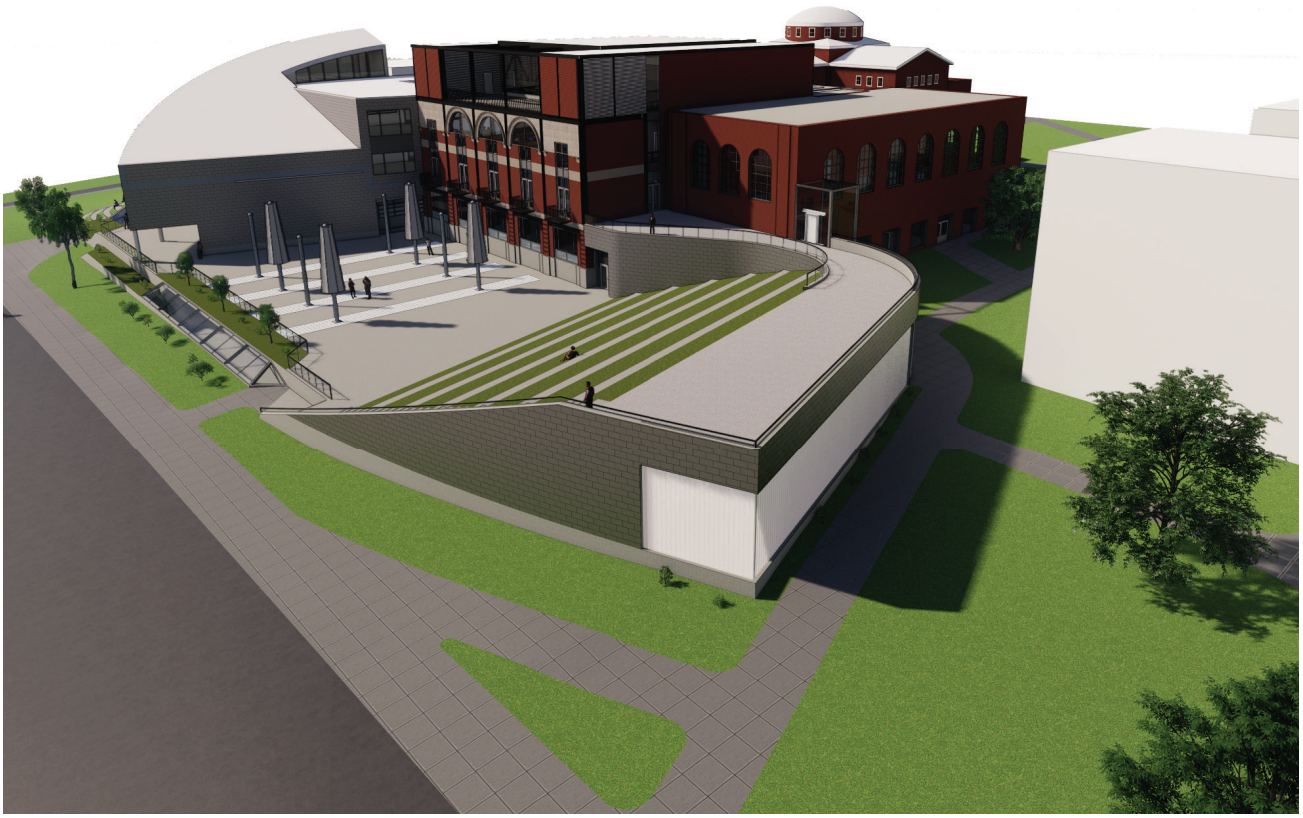

I sincerely thank all those that have helped me along the way to achieving my goals.

