Virtual Reality Museum Design

The VR Museum of Science Fiction

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Front cover art: Objekt, 2011; Michal Klimczak (digital image)

Back cover art: KAMERDOLCE sphera, 2019; Michal Klimczak (digital image)

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museumofsciencefiction.org

This white paper serves as a narrative blueprint for the virtual reality Museum of Science Fiction. When completed, the VR Museum in turn will serve as a model for a physical museum once sufficient funding and a location are available.

The Museum of Science Fiction's first VR prototype was built in 2015 with a team from the NASA Goddard Space Flight Center. The project was a demonstration of NASA's heliophysics educational content within the context of a science fiction museum gallery space. The project effectively proved the concept and creatively demonstrated the viability of mixing science educational content within an engaging and interactive virtual science fiction environment. Given the positive market trends and renewed interest in the 2015 prototype, the Museum of Science Fiction is redeveloping the virtual museum for large-scale visitor traffic. This white paper describes the scope of the project in relation to the Museum's mission, how the project is managed, and when the future galleries will be available for visitor enjoyment and education.

Accordingly, this document explores the use of educational and entertainment content within an immersive virtual reality museum. While other forms of alternative reality are also relevant, technologies such as augmented reality (AR) and mixed (or blended reality) will also be discussed as extended reality (XR) experiential design alternatives.

The mission of the Museum of Science Fiction is to cover the history of the genre across the arts and provide a narrative on its relationship to the real world. The Museum shows how science fiction continually inspires individuals, influences cultures, and impacts societies. The goal of the Museum of Science Fiction is to serve as an educational catalyst to expand interest in the science, technology, engineering, art, and math (STEAM) areas, and use technology to educate and entertain.

Most importantly, the VR Museum of Science Fiction will create a center of gravity where art and science are powered by imagination.

- **Center of Gravity** The VR Museum will be a place for people to come together around a shared interest in science fiction. Not only will people be able to visit the VR Museum to learn about science fiction through artifacts, display objects, and archives, but they will also be able to attend and host special virtual events.

- **Art** The VR Museum will be a repository of science fiction depictions throughout the ages, covering centuries of literature, paintings, sculpture, scale models, film, architecture, and music.

What is VR?

Virtual reality is an immersive, simulated experience that can be similar to or completely different from the real world. Applications of virtual reality include entertainment (particularly video games), education (such as medical or military training) and business activities (such as virtual meetings). Other distinct types of VR-style technology include augmented reality and mixed reality, sometimes referred to as extended reality or XR. Currently, standard virtual reality systems use either virtual reality headsets or multi-projected environments to generate realistic images, sounds, and other sensations that simulate a user's physical presence in a virtual environment.

"That's the thing about people who think they hate computers ... What they really hate are lousy programmers."

Larry Niven

- **Science** The VR Museum will show the connections between science fiction and science fact, demonstrating how art can play a role in inspiring scientific investigations and how scientific discovery can inspire art.

- **Imagination** The VR Museum will be a place to celebrate the unique human characteristic of conceiving stories, ideas, and solutions to problems.

VR will push imagination to new frontiers . . .
Before any development started on the updated VR Museum of Science Fiction, the project's objectives were defined, scoped, and roadmapped in a separate requirements document. Some of the key objectives included interactive and immersive educational and entertainment content, accessibility, multiple photo-realistic gallery environments and display objects, ambient binaural sound design, and the capability to have live programming. Perhaps more importantly, we put additional focus on: designing reliable and repeat visitor incentives, validating an appropriate success criteria, and understanding how to monetize visitor traffic without impacting visitor interest and enthusiasm.

BACKGROUND

Although virtual reality has been technically feasible since the late-1960s, the technology only now seems mature enough for widespread adoption. As a consumer electronics product, VR headsets today are easy to use and priced so most people can afford to experiment with the technology. The most significant factors driving current adoption include the following trends:

- Increasing consumer interest as evidenced by rising unit sales
- Affordable hardware pricing
- Commoditization of high performance graphics hardware
- Wireless headsets (without being tethered to a PC)
- Positive media coverage of consumer and commercial applications
- Increasing amount of software and programming choices
- Greater interest/efforts by large technology companies
- Remote work and tele-presence technology options highlighted by COVID-19

Combined, these factors are creating a brighter economic outlook for the technology. The cumulative effect is building momentum for large-scale market growth across many different industry applications and consumer uses. While it is probably true that the technology is still in the "magic lantern" days of its development (to use a historic cinema metaphor), the key point to recognize here is that a sustainable trend appears to have started.

PLANNING

The VR exhibit planning interprets science fiction through four themes. The themes explore science fiction's influence on society and allow visitors to walk away with a better understanding of the impact science fiction has on our daily lives. The themes are not distinct and ideas may overlap from one theme to another. The four themes include:

MOSF Mobile App
2015

- **Speculation** Science fiction is speculation. By simply asking "what if?" science fiction has allowed humanity to expand the limits of imagination and explore endless possibilities. Science fiction transports us to other worlds, lets us visit different dimensions, allows us to travel through time, and even to experience alternate realities. Along the way, science fiction encourages us to reflect on our own society by exploring social constructs, from imperialism and colonialism to sensitive societal issues.

- **Exploration** Science fiction is a tool for exploring not only the universe, but humanity as well. It reflects our curiosity and the desire to expand boundaries, to seek new frontiers, both on Earth and beyond. But, science fiction also allows humanity to look inward by holding a mirror to society and exploring what makes us human.

- **Innovation** Science fiction has led to real world innovation. Real-world innovation in turn drives the creative thinking that fuels science fiction.

- **Inspiration** Science fiction uses the extraordinary to inspire people to dream and envision a better world. Many of history's most influential scientists were inspired by science fiction to make the world a better place. And many creators of science fiction use the genre, whether through film or literature, to challenge societal norms to inspire a just and equitable world.

The Museum began the content definition work with writing a curatorial narrative and outlining the main educational objectives. Curatorial content included objects from the Museum of Science Fiction's collection and exhibits from previous Escape Velocity events, for example the 2019 *Technology* exhibition. It also considered current and potential curatorial resources for each exhibition idea: objects, art, and digital assets. This inventory helped inform resource allocation and design specifications.

Integrating the educational objectives with the curatorial narrative was relatively easy and tied together the Museum's overall VR experience. A good example of a STEAM-focused exhibit was the Robots and Computers gallery. In this gallery, visitors learn about "algorithmic bias" and potential programming conflicts in an artificially intelligent quantum computer, the

HAL-9000 from *2001: A Space Odyssey*. To understand more about this real-life problem, visitors are miniaturized to subatomic size (similar to *Fantastic Voyage*, 1966) to explore the inner workings of quantum data processing – which also creates better public understanding necessary to build a new quantum AI-proficient workforce for this century.

Some of the other curatorial ideas under consideration included:

- Allowing visitors to hear commentary from expert docents (curators, artists, modelmakers, conservators, specialists, etc) when they view an object in the virtual gallery to gain context and understand its historical relevance.
- Designing immersive experiences in recreated science fiction settings, ie. the holodeck, Nostromo corridor, Enterprise bridge.
- Exploring physical scale in the VR environment, ie. comparing real structures (a car or Empire State Building) to famous starships.
- Letting visitors to “step into” science fiction art so they can explore and interact with the environment, ie. walking in the desert on Arrakis (*Dune*, 2021) and learning about water reclamation and real-life stillsuit technology.
- Designing the gallery architecture as unique works of science fiction art for exploration and interaction, ie. structures within *Ready Player One* (2018) or *Battlestar Galactica* (2004).

After the curatorial work was completed, much like an ordinary software development project, the next steps involved distilling all of the fantastic ideas down to the feasible and not-so-feasible. This involved writing detailed requirement specifications, coordinating multiple development and quality assurance teams, and using a development process combining waterfall, agile, and “management by milestone” (Agile: make it up as you go along. Waterfall: figure it out before you start. Management by Milestone: it’s done when it’s done). It is useful to validate the idea list with the development team before writing detailed specifications so they can have an early opportunity to provide input on the expected level of difficulty. These estimates are used later to figure out what features and functionality will be in the first release and what will be moved to later releases.

Starting with the first of seven gallery spaces, an example of a basic requirement could read as follows:

> “The large interior entrance space will have a scale of 100 feet by 100 feet and a ceiling height of 50 feet. The photo-realistic appearance of the space will use photogrammetric images of a large empty warehouse or shuttlecraft hangar bay. Lighting for the space will be provided from skylights and overhead industrial light sources. The binaural sound design will use an endless loop sound file providing appropriate effects and ambient low level music.”

A requirements description of a display object within the exhibit could read as:

> "A poster hangs on the wall of the virtual space from the 1902 film, "*A Trip to the Moon*." Visitors can examine the poster and click the wall label to read additional text explaining what it is. Accompanying the caption, there are clickable symbols that can start a scene from the movie and a short clip of a film historian explaining its historical significance."

An interactive gallery space requirements description could read as:

> "A visitor enters a large 100-foot square space where robots from multiple science fiction films, television, and literature are on display, slowly moving around the room. These include Maria (*Metropolis*), Robbie (*Forbidden Planet*), Nomad (*Star Trek*), B9 (*Lost in Space*), a Cylon (*Battlestar Galactica*), HAL 9000 (*2001: A Space Odyssey*), Gort (*The Day the Earth Stood Still*), AMEE (Red Planet), R2-D2 and C-3PO (*Star Wars*). In this space, the robots can be visually compared in size, appearance, and gait. When approached, they greet the visitor and information is presented about each character, discussing similarities and differences, how the original prop/character was constructed, and the cultural significance of each robot."

Meta Quest 2 HMD

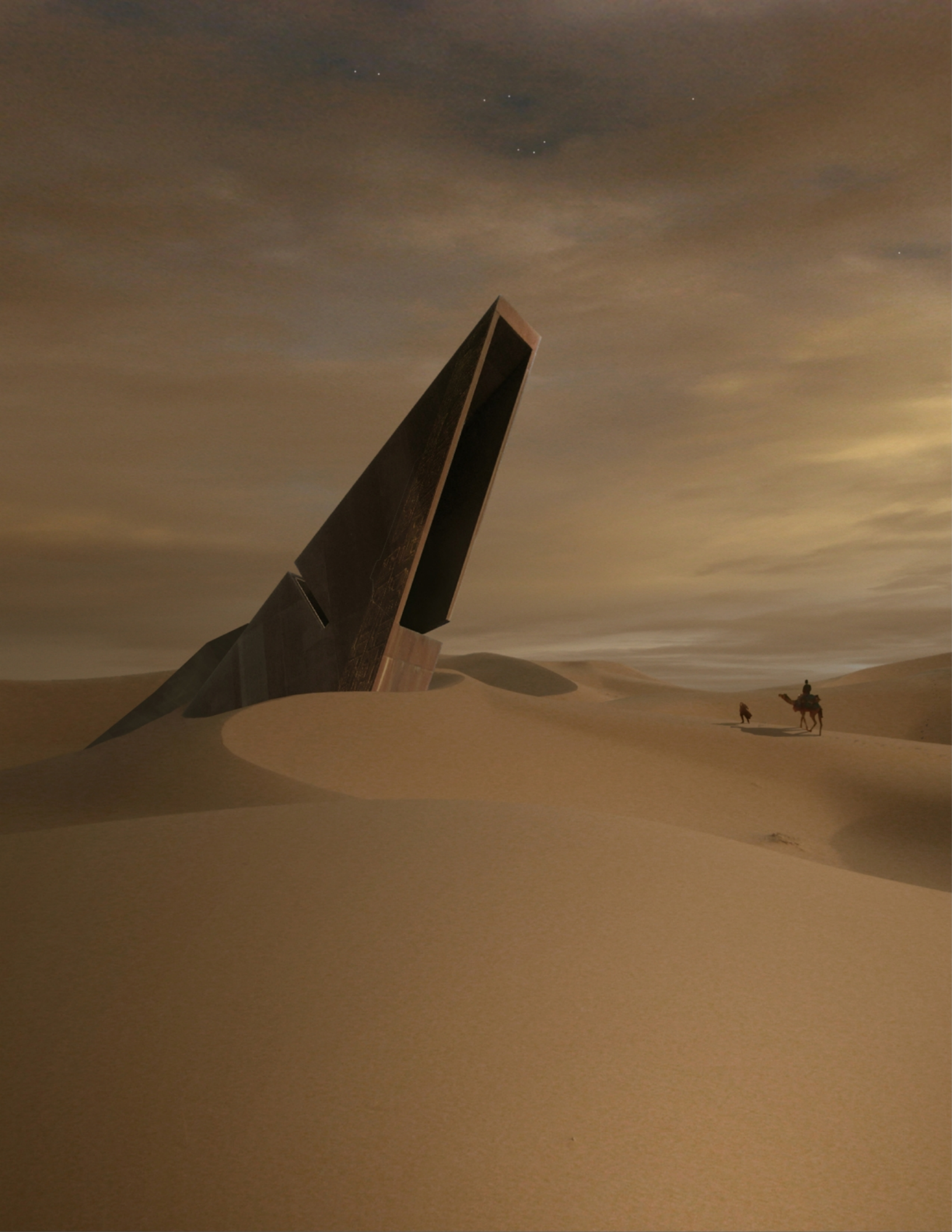
EQUIPMENT AND ACCESS

Architects have been using VR for a number of years to present clients with 3D virtual models. Many 3D modeling tools, such as Blender, 3DSMax, Maya, and SketchUp Pro, allow users to export their models to rendering engines, such as Unity 3D. The rendering engine then allows users to map high-resolution textures onto 3D elements, and translates those to a format that can be viewed in a VR headset.

Once a VR environment is built, there are a few different ways to access the space. Most involve a physical device where a person can view an app or video. Some devices, such as Google Cardboard, are simple and relatively inexpensive, while others, such as those sold by Oculus, HTC, and Sony, are more sophisticated and expensive.

Google Cardboard consists of a simple cardboard box that can be purchased from Google's website for under $10. Users download the Cardboard app from the Play Store onto their smartphones, which they then slip into the Cardboard box, run the app, and view it through VR lenses in the box.

With the advent of 6G mobile internet technology and 100 gigabit/sec connectivity, it is very possible that using a smartphone in a visor (like Cardboard and paired with hand controllers) will introduce VR and holographic imaging to FaceTime phone calls.



The advantage of making a Google Cardboard app for the Play Store is that it could reach a much wider audience than apps that run on other, more expensive devices. Anyone with a smartphone can inexpensively access VR this way. The Cardboard box is not proprietary to Google and can be customized by any museum, which also provides a nice branding opportunity for their gift shop. The drawback to Cardboard, however, is that users are limited in how they interact with the VR environment. Unlike other devices, which track the user's movement and are paired with hand controllers for interacting and navigating in the VR environment, Google Cardboard is limited to viewing video and images. This interaction, in comparison to the more immersive experience offered by other devices, can feel static and may not be very interesting to encourage repeat visits.

MOSF Mobile App
2022

For mobile visitors, the 2022 mobile app upgrade includes Google Cardboard for access to the VR Museum of Science Fiction

Other VR devices, such as the Oculus Rift, Oculus Quest 2 and HTC VIVE, as well as Playstation VR, offer much more interactive and immersive experiences. These devices work in a similar way to Google Cardboard, consisting of a headset with VR lenses. However, instead of relying on the user's smartphone to run the VR software, the headset contains the necessary hardware. The app is typically purchased from the device store and downloaded onto the device. The device is also paired with hand controllers that allow the user to interact with virtual objects and navigate within the virtual space. The result is a much more immersive and satisfying experience for visitors.

Since the Museum of Science Fiction is creating an immersive experience for large-scale audiences, the goal of this VR project is to produce a photo-realistic experience for the widest possible audience, and available on Steam platform and the Oculus store. To reach the widest possible audience and accomplish the Museum's educational objectives, the app is designed to be family-friendly and suitable for all ages. The Museum also tries to ensure that the app is accessible to people with disabilities. This includes closed captioning for users with hearing disabilities. More information on accessibility can be found on the Library of Congress website. The Museum is also considering use of a video and an interactive mini app that runs on the MoSF website for users that do not have access to VR. This video will be made available on the Google Play store and run on a customized MoSF Google Cardboard purchased from the Museum's gift shop. When available, this video will be posted on the Museum's social media sites as a trailer to build visitor excitement and awareness.

Currently, there is growing enthusiasm in the museum community to offer some type of VR experience. These experiences fall into three categories: the exhibit-based experience, the standalone experience, and the museum proxy. The exhibit-based experience offers museum visitors a more immersive way to experience a traditional museum exhibit. One example is London's V&A "Curious Alice," an exhibition that explores the Lewis Carroll classic novel, *Alice in Wonderland*. Museum visitors put on VR headsets and are transported to various worlds where they are able to interact with

"Science is magic that works."

Kurt Vonnegut
Cat's Cradle

characters from the novel. By offering a more immersive and uniquely interactive way to experience what would otherwise be an ordinary and static exhibit, the museum enhances the visitor's experience through the use of VR technology.

Another approach is the standalone experience. An example of this approach is *The Night Cafe: A VR Tribute to Van Gogh* on the Oculus. Not tied to any particular physical museum or exhibition, this VR app lets visitors take an imaginary and immersive journey into the artist's works from where ever they are. The third way for visitors to experience VR is the museum proxy. Here, rather than enhancing a museum experience, VR is a substitute for a physical museum. This type of experience gained popularity when Google introduced the Online Museum Project in 2011, and eventually started offering immersive 360 videos, which could be viewed on Google Cardboard. This type of experience lets visitors explore museums that would otherwise be unavailable to them.

The Museum of Science Fiction is uniquely positioned to create a novel VR experience – one that combines all three experience types, and takes advantage of a novel concept in virtual reality – the shared VR experience. As the world emerges from pandemic lockdowns and quarantines, the Museum is planning to offer a new type of museum – a hybrid of real and virtual space, with VR experiences that occur within a physical museum space. The physical space will be a simple, large room or outdoor space where museum visitors gather, put on VR headsets, and interact with one another in a virtual environment.

MEASURING SUCCESS

> "Imagination is everything. It is the preview of life's coming attractions."
>
> Albert Einstein

To monitor the project's success, we identified both qualitative and quantitative measures to track the VR Museum's performance. These measures focus on the following categories:

Mission Alignment

a. Does the VR experience align with the MOSF mission?
b. Is the VR experience educational and does it promote STEAM learning objectives?

1. Visitor Traffic and Engagement
    a. Number of app downloads
    b. App Store ratings
    c. Social Media/Media exposure
    d. Number of visitors
    e. Time spent in the Museum
    f. Most popular galleries or exhibits
    g. Measureable interaction with educational content
    h. Measureable interaction with entertainment content
2. Financial Contribution
    a. Advertising revenue
    b. Corporate sponsorship revenue
    c. Donations
    d. Initial app purchase revenue
    e. Subsequent in-app purchase revenue
        i. Admission to special programs and live events
        ii. Virtual meeting space or other venue rentals
        iii. Ecommerce and gift shop sales

ECONOMIC MODELS

There are currently three revenue models for monetizing apps in the Oculus store: the paid app, the subscription, and the freemium. The paid app model offers the app for a one time fee – the most common way to monetize an app. The advantage of this model is that it gives the developer guaranteed income based on downloads. The drawback however, is that the initial cost of the app, especially if high, may discourage downloads.

The subscription model allows users to install and use the app free of charge for a limited time period, after which the user converts to a monthly subscription. The advantage is a steady revenue stream. However, subscribers may become unhappy with the monthly fee and uninstall the app.

The freemium model provides users free access to download and use the app. Users are later offered optional in-app purchases for premium content or additional functionality. The advantage with this model is that users are much more likely to install the app if it is free, and like with the subscription, it has the potential to generate a steady revenue stream if add-on premium content

is regularly offered. Users are also less likely to uninstall the app than with a subscription because they can choose to pay for specific content and don't feel forced into paying for something they might not want. This revenue model is probably the most suitable for the Museum and may also provide options for special live program ticketing and admission.

Oculus Rift HMD

Another revenue contribution area is venue rentals of virtual meeting spaces within the Museum's VR environment. For geographically distributed teams, imagine having a meeting in the Briefing Room of the Starship Enterprise! In addition, the Museum's VR experience presents sponsorship or partnership opportunities, as well as the potential to raise additional revenue through advertisers. It could also be presented to potential donors as a way to raise interest in a future, physical location for the Museum of Science Fiction

DETACHED FROM REALITY . . .

Perhaps the best way to conclude this white paper is with a walk-through of the completed first phase.

Emphasis on fascinating educational content, financial viability (the means to pay for itself and provide a funding source), and building repeat visitor traffic are among the most important design considerations. Weaving these design considerations into an effective and compelling visitor experience is the ultimate goal – and very similar to that of any physical museum.

The required UI / UX features and functionality for the first phase include a range of items: testing access to educational content; donation, guest book, and suggestion box functions; expandable signage and labels; embedded video content; testing photo-realistic renderings of animated models, lighting and environment; binaural sound design; and visitor movement controls.

Let's begin. Starting with just a proof of concept entrance hall and single exhibition gallery, this first phase will build awareness and interest in the overall project. Visitors experiencing this "beta" phase need to understand that the Museum is "under construction" to avoid feeling disappointed by the limited scope. A virtual suggestion box, where visitors can leave comments and ideas will help crowdsource the project and make it more of a community effort.

After downloading and installing the app, visitors find themselves awed and delighted, standing in a cavernous entrance hall where a Type-9 shuttlecraft is sitting opposite to an X-Wing Fighter. There are no barriers here. Visitors can get as close as they like.

Ivan Sutherland, 1966
Inventor of the first head-mounted display at MIT

The photo-realistic space is built using a photogrammetric process where dozens of high resolution 360-degree images are joined together using special image processing software. Google Earth VR is a good example of using photogrammetric images to create photo-realistic 3D environments. The same process is used to create a 3D model of C-3PO who greets you near the X-Wing.

Over to the right, you see a stargate (with moving vertical water) and a holodeck arch where other visitors are passing through on their way to other galleries. Being able to mix VR technology, narrative storylines from film, television, and literature, and creative, spectacular exhibition presentation is essential to creating the best possible visitor experience. The main objective is to engage and immerse visitors, convey curatorial messaging, and possibly getting them to act on it in some meaningful way.

In addition to the familiar "teleport" jumping, visitors can also hover above the exhibits. Complete freedom of movement in any direction provides visitors with total visibility of the space and to see areas that might not otherwise be visible from the floor.

The gallery sound design adds even more fascination to such an incredible environment. Sound design adds an important element to an immersive experience. This is because our hearing is so much more sensitive than our vision. To put it in perspective, if we could see as well as we hear, we would be able to see a 25 watt light bulb from 3 miles away. The gallery sound design uses binaural sound recordings. This method of recording uses two microphones to create a 3-dimensional stereo effect for the listener – it simulates actually being in the room where the sound is being created. Binaural sound design is like the secret sauce of exhibit design.

As visitors get more excited about joining the VR Museum community, they can sign the guestbook at the information desk so they can get updates about new gallery openings and special program announcements. A donation box is also nearby for visitors to support the MoSF mission.

From the main entrance hall, next to the holodeck arch, a dimly lit corridor recreated from the Nostromo (*Alien*, 1979) connects to the Computers and Robots gallery. AMEE (*Red Planet*, 2000) is there to meet you and seems to be functioning normally for the moment. In this sense, robots and computers was an easy choice for the first gallery for several reasons:

- Practical quantum computers will likely become operational in the 5 to 10 years.
- AI will converge with quantum computing during this time.
- Development of advanced [and autonomous] robotics will accelerate from using AI and quantum computing tools.
- Workforce education will be required to understand how to manage developments in AI, quantum computing, and advanced robotics.

- It is necessary for the general public to understand how these civilization-changing technologies will impact societies, economies, the geo-political structure between world governments.

C-3PO *Star Wars*, 1977

To educate visitors about this coming super-watershed, two main curatorial messages are highlighted: optimism about using AI and quantum computing tools to solve humanity's biggest problems, and a warning about unintended consequences – what could go wrong without proper foresight. Sometimes, in order to make sense of reality, it helps to step back from it – remember the line from *WarGames*, "Shall we play a game?" Computers and robots don't always behave in predictable ways. R2-D2 had an underlying mission to find Obi-Wan Kenobi and the HAL-9000 had such a massive programming conflict, the only possible solution for it to complete its mission was to kill the crew. Westworld (1973) was another example of computers and robots going completely awry.

Beyond the first phase, when fully completed, the VR Museum will include six other galleries: Creators, Time Travel, Lifeforms, Other Worlds, Vehicles, and Technology – each with its own distinct sound design. Live programming for multi-visitor, shared spaces and outside areas will also be available for visitor exploration and enjoyment.

The VR Museum will be able to welcome class trips from any country in the world, 24 hours a day, any day of the week with amazing educational science content from NASA and the Johns Hopkins Applied Physics Lab. Students will go on treasure hunts, answer trivia questions, and solve riddles – where winners earn points to unlock privileges, access new features, and gain special functionality.

And if all of this is not enough, visitors will be able to present themselves as photo-realistic avatars (in costume if they like). Selfies and group photos will certainly add to social splash, along with live events and films festivals. Eventually, even an ecommerce gift shop will open so visitors can order Museum of Science branded products to enjoy at home.

The VR Museum of Science Fiction in its final form will give us an opportunity to animate all of our years of planning. The VR Museum will also be used as a conceptual model for a future physical Museum of Science Fiction.

WEB 3.0

The Internet began with browsing the Worldwide Web and then ecommerce changed the way consumers bought goods and services. Web 2.0 enabled a completely mobile and wireless internet. Web 3.0 promises to interconnect all types of devices with a standardized interface – the internet of things or IoT. These interconnected devices will eventually share an enormous amount of sensory data. Matter, a new standardized interface protocol, is eliminating the interoperability problems that has, until recently, made adoption and integration difficult – if not impossible. Web 3.0 interoperability is now coming into place with the backing of large technology companies. Along with Web 3.0 IoT, is the prospect of the virtual internet. Similarly, augmented reality and virtual reality, collectively known as extended reality (XR), will benefit from common technology standards adopted by industry participants. If Web 3.0 is to include an XR-enabled internet, our imaginations will have a new sandbox to play in.

ADDENDUM: AR/VR MARKET PROJECTIONS

Although VR/AR technologies are not yet considered to be in the mainstream, recent trends are suggesting sustainability over the next 36 months. A few indicators supporting these forecasts include the following statistics:

- 37% of businesses think AR/VR and other immersive technologies will become mainstream in 2 to 5 years, 25% within 2 years, 17% in the next 5-8 years, 15% in less than 2 years, and 6% in 8-10 years (Perkins Coie, 2020).
- COVID-19 helped accelerate the compounded annual growth rate of AR/VR to 38.1% and 27.9%, respectively (Yahoo Finance, 2020).
- In 2020, the combined AR/VR markets were worth $12 billion with an impressive annual growth rate of 54%, resulting in a projected valuation of $72.8 billion by 2024 (IDC, 2020).
- The global shipments of AR/VR headset shipments in 2020 amounted to 5.5 million units, 9.6 million for 2021, and 43.5 million by 2025 (Statista, 2022).

For much of its history, virtual and augmented reality struggled to overcome a range of adoption challenges. Among the factors hindering VR adoption, the main problems involved, limited content offerings (27%), poor user experience (19%), business and consumer reluctance (19%), regulation and legal risks (12%), the cost to consumers (11%), and financing and investment (9%). (Perkins Coie, 2020).

Prior to Facebook announcing its commitment to the "metaverse" and changing its name to Meta Platforms, the biggest concerns for investors in VR startup companies included the lack of an established market for the technology (46%), untested technology (38%), slow business adoption (38%), slow consumer adoption (32%), and lack of trusted teams and technologies to invest in (13%) (Perkins Coie, 2020).

At this point, historic investor concerns and consumer adoption challenges are now being allayed in meaningful ways, increasing the rate of user trials and acceptance. Although the technologies are still mainly viewed for entertainment or games, industry use cases are rapidly being developed for retail, ecommerce, **nongaming entertainment**, employee development, manufacturing, and medical training.

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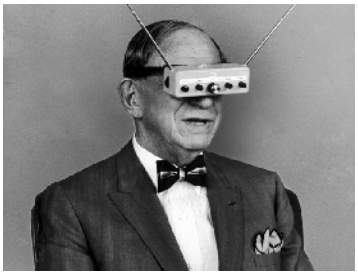

Hugo Gernsback, 1963
Teleyeglasses