Neon Horizon

TNM091 - Media Production for Immersive Environments

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August 6, 2022

Abstract

The relevance of immersive media is greater than ever and on the rise. The goal of this project is to produce an immersive video with as high production value as possible. The final result as well as the report will show what three people during a relatively short period of time can muster. Which is, with a lot of problem solving and research, a show worthy product with reasonable flaws.

1 Introduction

This project delved into a small scale production of an immersive video using the dome display format. By producing a video in this format, it brought forward interesting and unique challenges. The goal of the video is a musical journey following a car that is escaping from a bank heist. The stylistic theme is of a nighttime city filled with neon lights while the car is driving towards the horizon. The project has involved different aspects such as visual effects, audio and the art of combining these two in order to create immersive media. The targeted dome display is the dome located at the *Visualiseringcenter C* in Norrköping.

2 Technical solutions

2.1 The Dome

For this project, the end product is aimed to run on the immersive media called a Dome. A Dome is built up with a half sphere screen which is projected with several projectors which images is stitched together seamlessly by a software, resulting in a half spherical image that surrounds the audience. The specific Dome which will be supported for this particular project is run by 6 projectors which supports both mono and stereo formats. The audio for the Dome is built with 8 speakers in the format 7.1, which includes two front speakers, two back speakers, two side speakers, one center and one sub-woofer. With this audio format, the effect of 360 sound can be achieved.

2.2 Software

2.2.1 Maya 2016

The backbone software for the project has been the software *Maya 2016*. The reason for this was mainly for the straightforward *UI* that exists within Maya that allowed for fast progression, along with its built in renderer that supports high fidelity scenes. The idea was also to render the video offline, which was also suited best for Maya.

2.2.2 Domemaster3D

Another benefit of using Maya was the plugin *Domemaster3D* which supports the dome display. The plugin is configurable and different settings were able to be set in order to match the targeted dome configuration. These were the slight *head tilt*, which is needed for the cameras to show images correctly, the *camera separation*, which controls the combination of mono and stereo as well and the *FOV* (Field of View), which controls how much of the world that is observable. The latter two goes hand in hand and should be scaled equally for a visually correct representation when for example making the world appear larger by scaling them down. The plugin also contributed towards why an older version of Maya was chosen, as its compatibility with Maya only went so far as 2016.

2.2.3 Backburner

To make the rendering more efficient and save lots of time, it was planned to use a *Backburner*, which is a so called *render farm* that uses several computers to divide the render in several jobs and simultaneously render small parts of the render, which was also included in a optional course moment for rendering dome stereo images. This process does not need the computers to open different kinds of interfaces that in other case would drain the efficiency of the rendering, making the rendering even faster.

2.2.4 Amateras

Along with the previously mentioned software another helpful tool for dome-production has been the software *Amateras* which allows for spherical projection mapping. This made it possible to get a preview of how it roughly would look on the dome display. Of course the effect would still be far from how it actually would be perceived and felt, but as the access to the dome was limited it at least provided some direct feedback.

2.2.5 Photoshop

An image editing software was required for the creation of the skylight texture. Photoshop was used for this matter due to it's broad documentation and helpful tutorials for the means required in this project.

2.2.6 Audio Software

When it comes to the audio production a whole cluster of software has been tested, but in the end the only software that was actually used for final production was *Audacity*. It allowed for easy and fast manipulation of sound channels which made it possible to match the sound format in the dome, hence creating 360 sound. The audio software used before this was a bundle of *JACK*, *JACK-Rack* and *BrahmaVolver*. These three when used in conjunction allowed for a lot of control when mixing the sounds but came at the cost of a poor UI and very little documentation.

2.3 Recording of sound

Initially sounds were captured using a *Brahma-in-Zoom* microphone, which the sound was played up from a cellphone.

3 The Scene

3.1 The Neon City

In order to have an immersive video, the backdrop and scenery in the shots have to be believable. To achieve this visual effect, a scene was created emulating a city during nighttime. The city is supposed to also look like it existed on another planet or dimension, straying a bit from reality but still having the same core layout as a typical city that we are used to. The stylistic theme of the city is simple, neon lights on buildings as far as the eye can see. For inspiration and references scenery such as the streets of Miami at night was used as it had similar style of what was wanted to be achieved in our scene.

As the scene was created in Maya, the scene had to be created from the ground up with our own produced assets. The assets were models that were also modelled within Maya and could easily be duplicated and transformed cleverly to create a large scale city, without creating hundreds of unique models. In this project a total of 15 models were used in the city, with varying levels of detail based on proximity to which the object was going to be to the camera. The desired neon effect had to look appealing and realistic as it is the main component of what makes the city stand out, but at the same time not strain on the light complexity too much. After a few version of neon light prototypes the one used in the final version was a glow material using a built in global illumination technique in Maya. This came to be the best mix between render time and visual quality for a neon effect.

3.2 The Neon Plains

In the same way as the city, the more open barren landscape outside the city is constructed using mountains and big rocks in the outskirt. The idea is that the plains is a scenery shift from the city that makes the video more progressive and interesting.

3.3 The Portal

The car in the scene is driving towards a portal which will take it out of the neon world. The portal was made by creating a triangle shaped curve and connecting a particle system, set to emit particles from the curve. A radial field was added which makes the particle move to a set point creating a decent portal effect. A turbulence field was also added to make the particles move a bit chaotic, making the portal look more alive. The particle type was set to "MultiStreak" which makes the particles look like lines. It med it easier to fill the triangle with a lesser amount of particles. The closing of the portal was animated by keying its scale in one axis.

3.4 Sky-Dome

Apart from the physical models within the scene, having an overcasting light emitting from the sky above adds to the immersion. The goal was as mentioned earlier to have a hint of an otherworldly vibe in the scene, making the sky a perfect subject to be creative and add to this theme. The idea for the texture of the skylight was to visualize a planet which was in the midst of space, very close to a magenta colored nebula that is the main source of natural nightlight. By having the nebula act corresponding to what a moon would be at nighttime on earth, it creates an interesting aspect of which the light is not white or blue tinted that we are used to, but rather magenta tinted light rays are emitted from the sky. In the start, the IBl was fixed and limited in size, which when the camera translated in a direction, it was clear to see that the IBL was moving to, breaking the illusion of the scene being on a planet in a huge universe. Therefore, the IBL was keyed to be fixated with the cameras translation, which made the distance to the IBL the same for each frame.

4 Method

4.1 Rendering

Unfortunately, the backburner render farm did not support rendering from the Domemaster3D stereo camera. In order to be able to render in time, the render was started manually. This was possible by getting access to login at several computers with the same account at a time and manually set the frame sequence and start the renders. If the computers didn't receive information within 12 hours, the user was logged out and the render was aborted. To make this function, a render table was created to attain structure and understanding between the project members which can be sen in Figure 1. With this table the project members was able to check each computers work status, frame range, start and end time of the render, last user, the last time they used the computer and if there are some important notes to share. This table was frequently updated and new copies were made to be able to log and review the previous render jobs.

4.2 Final Gather

To achieve a neon effect in the scene, the first method that was used was a post VFX method. The post effect applied a glow effect on and around the surfaces after the ray tracing. However, the test renders showed that the color, brightness and bloom effect acted different when varying angles, distances and number of such materials being observed in the frame. As no connection or pattern could be found, this method was abandoned. Instead, another method of simulating global illumination was applied, namely *final gather*. Final gather is a fast and easy way of achieving good global illumination results. It may not be a physical accurate method, however that's not the goal. With final gather, it is possible to produce soft shadows and add slow indirect illumination changes such as light that rounds a corner before the light source is revealed and such. To achieve the neon effect on a surface, a *light surface* was applied to the material, which added a glow to the material. There is one thing to bear in mind though, the material does not create a glow in it self. The light is in fact bouncing on other surfaces with the final gather and does not emit light itself. This means that if no other geometry for the light to bounce of, no effect will be achieved from this method. [1]

4.3 Image-Based Lighting

The skylight emitted from the sky-dome, wrapping around the scene, was produced by a technique called IBL (Image-Based Lighting). A image based lighting is a spherical image which uses the lighting information in a environment map to illuminate a scene by projecting the map onto the scene. [2]

To get most out of the image that is to be emitted light from, an image that consists of a wide range of colour levels is needed. One such is a so called HDRI. A HDRI (High Dynamic Range Image) is an image that includes both colours and brightness values of a scene, which creates a wide dynamic range. The reason that a HDRI is used for IBL is that low dynamic images, such as JPG or PNG files, only range from 0-255 in luminance values, which in most cases does not offer the level of detail that is needed for a 3D environment for realistic results. [3]

4.4 7.1 Dome Sound

In order for the movie to be fully utilizing the dome features, the sound had to sound immersive.

CURRENT (10/1 Early morning)									
Computer	Status	Current work description	Frames	Start time	End time	Left/right (Stereo)	Name of user	Last in use	Notes
K3407-301	Available	Idle	2417-2453	07:40	14:01	Stereo	Anton	07:40	
K3407-302	Available	Idle	2454-2490	06:13	12:44	Stereo	William	06:13	
K3407-303	Available	Idle	2491-2527	06:15	12:54	Stereo	William	06:15	
K3407-304	SocketError	Idle	2528-2564			Stereo	Anton	07:43	Fick också socketerror
K3407-305	Available	Idle	2565-2601	06:19	12:22	Stereo	William	06:20	
K3407-306	Available	Idle	2602-2638	06:22	12:14	Stereo	William	06:24	
K3407-307	Available	Idle	2639-2675	06:27	12:20	Stereo	William	06:27	
K3407-308	Available	Idle	2676-2712	06:29	12:37	Stereo	William	06:29	
K3407-309	Available	Idle	2713-2749	06:30	12:41	Stereo	William	06:31	
K3407-310	Reserved	Idle	-	-	-	-	William	10:15	
K3407-311	SocketError	Idle	2750-2786			Stereo	Anton	07:45	Fick också socketerror
K3407-312	Unavailable	✗	✗	✗	✗	✗	✗		
K3407-313	Available	Rendering	2787-2823	06:35	~14:30?	Stereo	William	06:37	
K3407-314	SocketError	Idle	2824-2850			Stereo	Anton	07:51	Fick också socketerror
K3407-315	Available	Idle	2373-2416	22:59	06:31	Stereo	William	06:00	
K3407-316	SocketError	Idle				Stereo	Anton	07:58	Fick också socketerror
K3407-317	Reserved	Working	-	-	-	Stereo	Viktor	Ongoing	
K3407-318	SocketError	Idle				Stereo	Anton	08:00	Fick också socketerror
Important notes:									

Figure 1: Table to structure the render procedure for the project.

As explained previously the dome has 8 channels, whereof one channel called the LFE channel is the sub-woofer. These channels could be used to make directed sounds, making what is seen on the screen appear more alive with a sound that is coming from that direction.

In this project there were a lot of sounds that did not utilize the directed sounds, because it simply didn't fit. Examples of this was the music and the police sirens which were all equally played through the 7 speakers, with this being intended. However other sounds that were directed were effects that seemed more fitting, such as the neon flickering in the intro only being played from the front, as that is were the sign is located. The passing car that flew by to the left in high speed, and the bank alarm that was being dispersed from within the bank.

To make the sound come from the wanted direction, with regards to what angle that sound-emitting object is seen on the screen, it was important that the animation of the camera movement was done first. When the animated sequence was done the audio mixing was done through lowering or increasing the respective channel that corresponds to the certain direction. For example when creating the bank alarm the first 2-3 seconds is a straight shot where the bank is present from the front, therefore only front speakers plays the audio on high volume, while all other speakers plays the audio at a very low volume. Once the camera starts to pan and move the other speakers would be increased and the front ones reduced and so forth. This methodology was applied to all directed sounds.

4.5 Dome Tests

4.5.1 Visual adjustments

Through early testing in the dome, it was clear that having tall and slender skyscrapers close to the camera would result in unwanted bending effects. By moving and making sure the skyscrapers was not as close to the camera this effect would mostly be avoided.

When building the scene, the units were set to centimeters instead of meters. This was due to Maya's way of rendering the scene in the preview window not being able to render it properly if the scene was 1:1 scale in meters. By changing it to centimeters it did however come with the effect that the Domemaster3D camera's separation would be miss-configured as it was based in meters. The effect became as if the human eyes were separated by 6.5 meters which was fixed by dividing the separation by one hundred.

An unwanted nauseating effect that came from rapid or to quick movements had to be avoided in order for the video to be enjoyable. Some of the earliest test gave an idea of how fast or how slow it needed to be for panning movements.

4.5.2 3D Sound

Testing of sound in the dome was crucial for making the sound be perceived in 3D space. All early test showed that the first sound mixings were not playbacked as intended. However some problems lied within the dome software and not in the mixing of the audio files.

4.6 Gamma Correction

Due to the dark nature of the scene and the capacity of the color reproduction of the projectors. The final images had to be gamma corrected to make certain details visible in the dome. For this the software ImageMagick was used, which can easily run through image sequences and adjust them. It took about 1-2 seconds to adjust a 4k image.

5 Results

The final movie frames and earlier iterations can be seen in the images presented below. In Figure 2 the whole scene can be seen from a bird eye view.

In figure 3 a few of the created models is seen, with varying levels of model complexity based on their proximity to the camera.

The gamma correction before and after is what is displayed in figure 4. The gamma value was increased with 1.3 (30 percent) in order for details to be more clearly seen and not be covered in darkness.

The early neon effect created through post VFX and the new and improved global illumination method Final Gather can be seen up close in Figure 5.

An overview of these methods when used in a small part of the city and their difference can be seen in figure 6. Note however that the camera positions are not equal and therefore the comparison is not fully fair.

The scene quality of the image seen in Figure 7 is what the original vision entailed, with all lights enabled.

For the last scene in the movie, a 360 degree real world image was used as the skydome, along with a plane that is textured with snowcovered grass. A frame from the movie for this scene can be seen in figure 8.

The rendering time of the images varied a ton throughout the many iterations of the scene. The early renders resulted before Final Gather was used and lights were emitted from the streets and cars could be finished in times under 10 minutes. Once Final Gather and lights were emitted from objects the rendering time landed somewhere around 7-8 hours per frame, for an 8K image. Rendering in 4K with the same settings resulted in around 2 hours per frame. Once the lights were turned off the render time landed around 20 minutes on average per frame. Figure 9 shows a table of which how the render times varied based on the main factors described earlier.

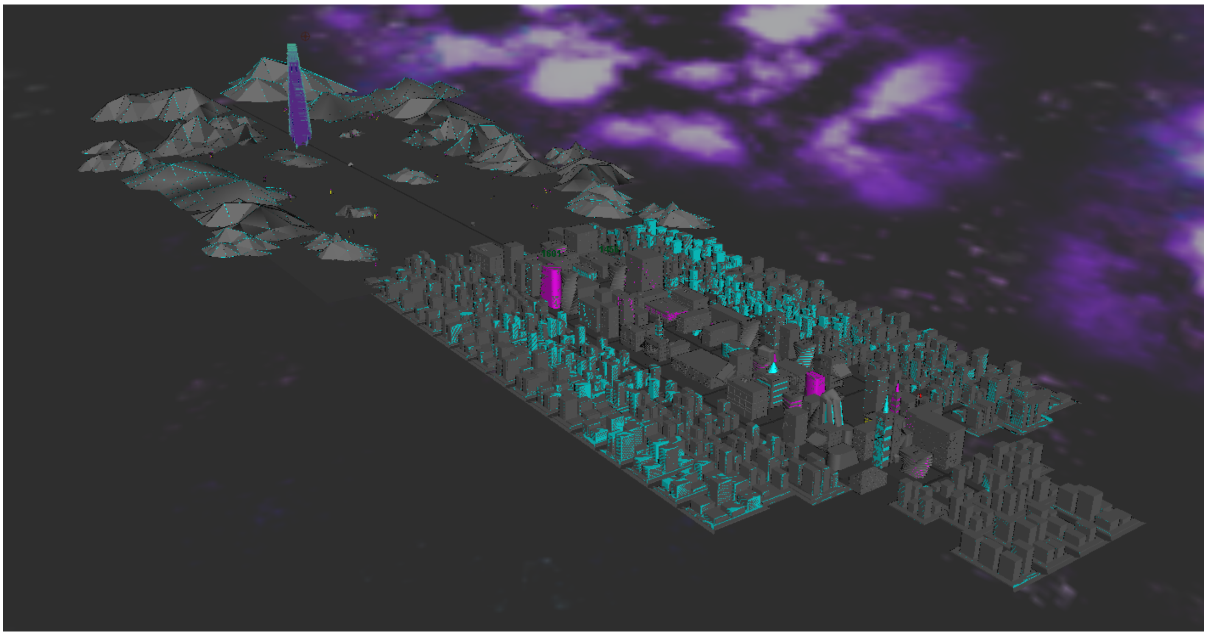


Figure 2: An overview of the scene

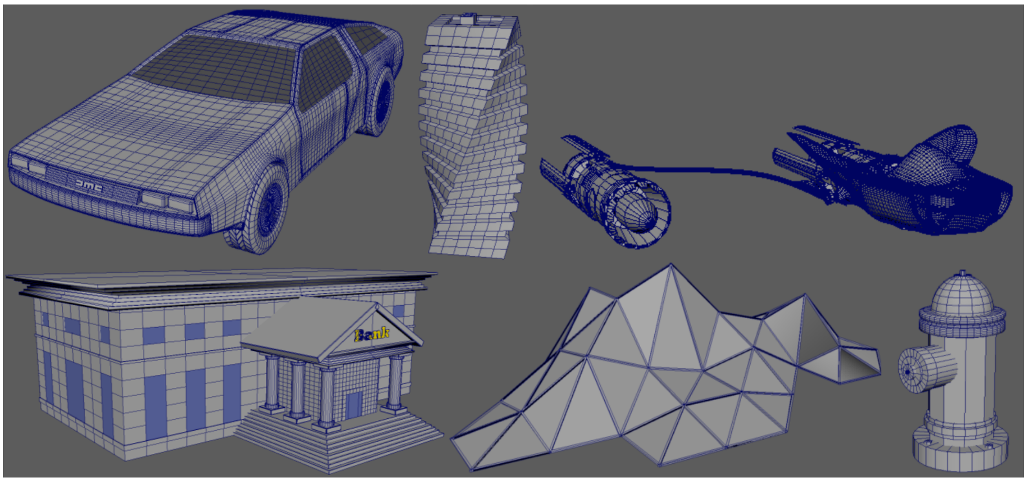


Figure 3: Some of the models used in the scene

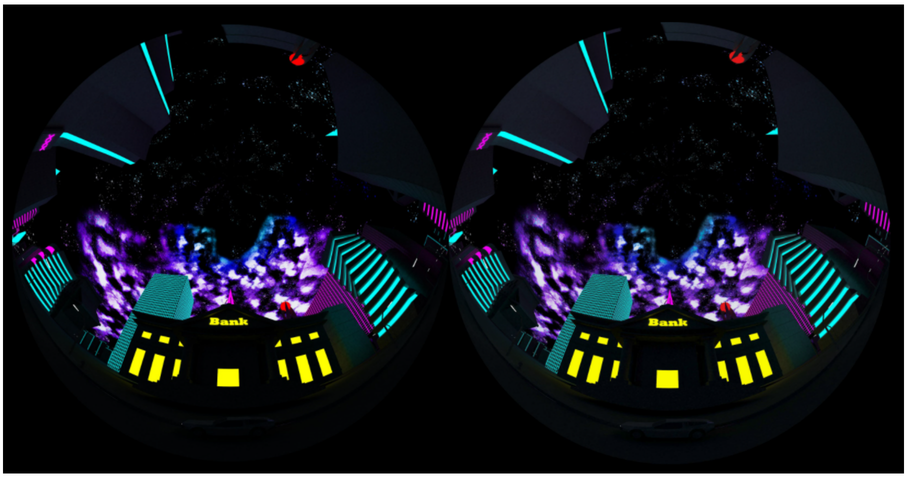
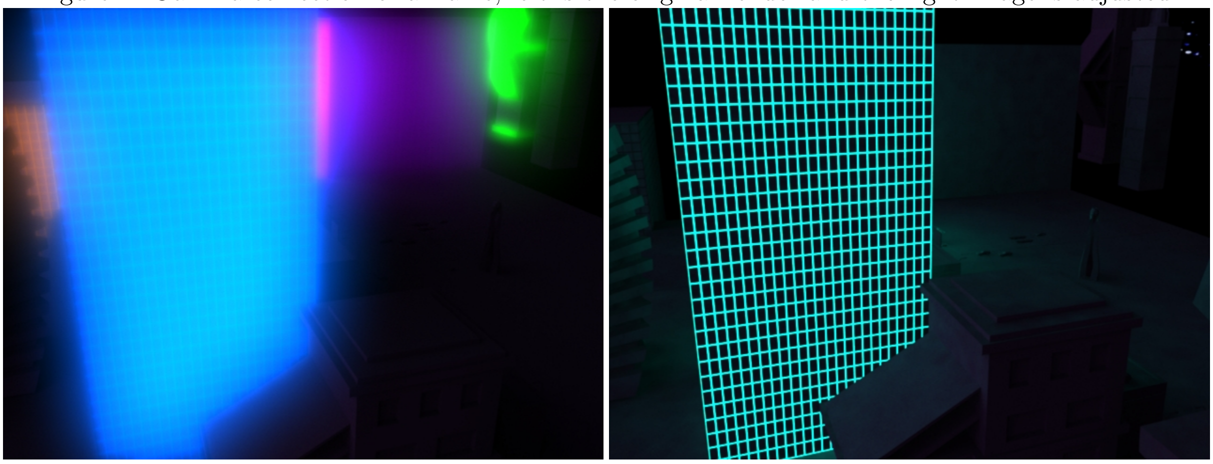
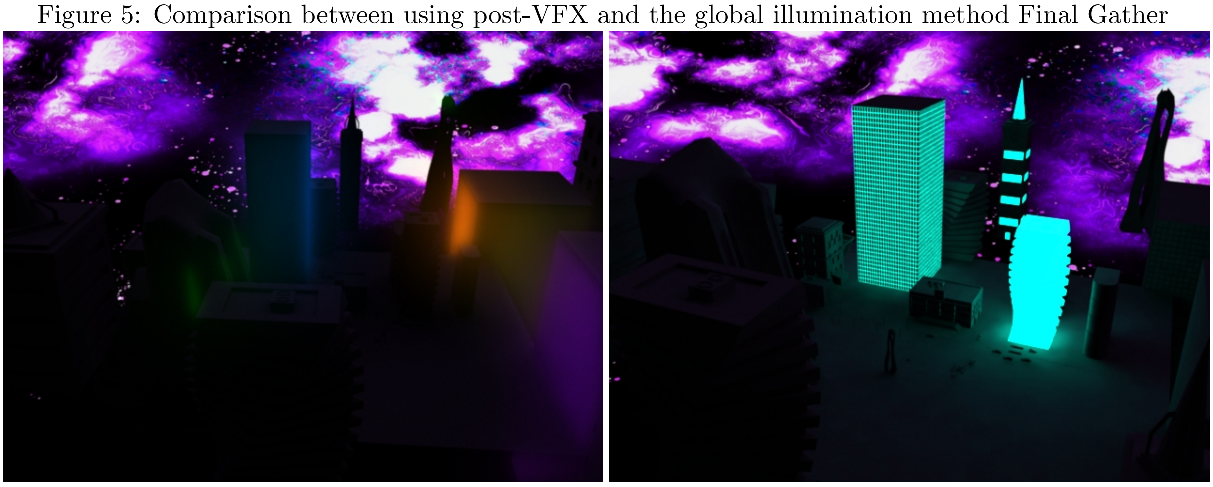


Figure 4: Gamma correction of a frame, left is the original render and the right image is adjusted



(a) Post-VFX (b) Global illumination with Final Gather

Figure 5: Comparison between using post-VFX and the global illumination method Final Gather



(a) Post-VFX overview with lower illumination (b) Overview of the Final Gather method

Figure 6: Comparison between using post-VFX and the global illumination method Final Gather on a far distance.

Figure 7: Rendered frame of a section of the city with all lights enabled

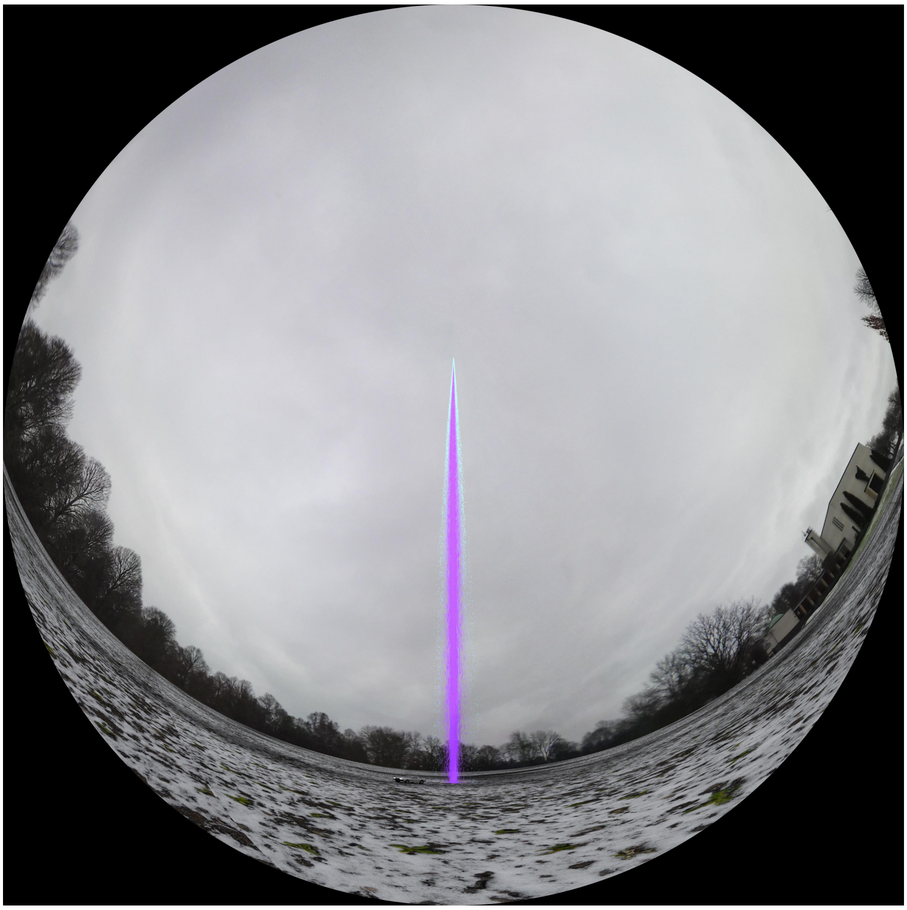


Figure 8: A frame from the earth scene

Time	4K	8K	postVFX	Final Gather	Lights ON
~10 Min	Yes	No	Yes	No	No
~2 Hours	Yes	No	No	Yes	Yes
~8 Hours	No	Yes	No	Yes	Yes
~20 min	Yes	No	No	Yes	No

Figure 9: Render time based on different factors

6 Discussion

As the Dome is a rather rare immersive media there are very limited amount of resources and support for development of Dome material. As we wanted to develop a offline rendered video, the chosen software for the production was set to Maya, which we all was more or less familiar and comfortable with. Then there was only one option for Dome production, namely the Domemaster3D, which we had been familiarized with through the course. There was one slight problem however, the Domemaster3D was only supported for the 2016 version of Maya. This was problematic for different kinds of reasons, the first being that no older versions than Maya 2018 was accessible for download on private computers, forcing us to work mainly on the university computers. This itself caused several other problems like accessibility, which was both limited by other students as well as the active pandemic, leaving us with no other option than accessing the computers via remote network connection. The remote connection was handy but unfortunately suffered from delay and unresponsiveness from time to time.

The portal ended up causing a lot of issues, due to the fact that it would originally not render using the domestereo camera. This was discovered rather late since many test renders were done using a regular camera in Maya to quick get a look on the outcome. But, after a lot of error searching and on the verge of coming up with another solution the problems were discovered. The type of particle chosen did not appear on the dome renders and the reason for that remains unknown. But by switching to another type of particle made it appear on the rendering. A problem that followed was that the portal would get rendered some times. This required some searching and was solved by caching all calculations for the whole sequence before rendering the images.

Another problem with having to use Maya 2016 and not newer versions like Maya 2020, which was currently the newest version, was all the missing functionality and resolved problems included in the newer versions. This had a great affect on the project as several frequent problems and crashes could have been avoided as well as time saving and unique functions for modelling and rendering could have been used.

When working with offline rendering, the render time is of high importance and is something that is always a struggle in all kinds of projects. For an image sequence of higher quality and several light sources, the render time can take from a few minutes to several days or more depending on the detail of the scene, lights, and so on, and therefore has to be planned and accounted for from the very start. This was something the group was well aware of and worked on throughout the project. Frequent low-res test renders was performed after almost each new implementation and setting that could affect the render time to study it's effect and estimate if it was reasonable or not. However, in several occasions, we could not resolve what the cause of the large and varying render time was caused by. It was discovered late that the largest factor of the render time was caused mainly by the area lights in the scene as they were heavy to compute and needed many calculations.

As the main focus of the project was the neon lights and is set in the night, the scene depended on the emitting light-sources, which became a huge problem. This was mostly fixed by replacing the area-lights with less heavy light sources such as spotlights and point lights as well as decrease the amount of light-sources as much as possible while still achieving an aesthetically appealing result. Another method to lower the render time was to limit the amount of render-able objects and light sources in the scene for each render sequence to only the observable ones for each frame. By doing so, the hidden objects as well as the areas of the scene outside the observable area, such as behind the camera, could be unaccounted for which resulted in a faster rendering. This however had to be done manually and carefully prepared which was a bit of a struggle and time consuming which easily could have been avoided by functions included in later versions of Maya.

To make the rendering more efficient we planned to use Backburner, as mentioned before. However, as Domemaster3D is a user made plugin and is not complete and fully optimised to cover all functionality as wanted. It turned out that Domemaster3D cameras was not supported when sending jobs with Backburner, making this functionality unusable. This was something we unfortunately also discovered rather late, which could have been discovered much earlier if it would have been tested before. The problem was that it took long to be able to even send ordinary jobs to the render farm, which was resolved when it was most needed, but as turned out to be unsuccessfully anyway. If this functionality would have been accessible and functional from the beginning, it would have made the production much faster and easier. It would have enabled us to drastically lower the frequent test renders and to gather image sequences and more high resolution images for the limited tests in the Dome area to get a clearer visual of how it looks and what worked and not and so on.

Another drawback regarding the Backburner was that, for it to be able to make use of the network rendering, the project had to be located on a network file path and not a local file location. This means that the program runs much slower and sometimes can encounter problems like crashing or delays and such as it relies on the internet connection and workload on the server and so on. So as it even turned out that Backburner didn't work with dome cameras, it also made the workflow much slower.

Because of the long render time and lack of access and functionality of the render-farms, we could not gather the materials we wanted to try out, or our new implementations, settings and such. Each time we had to limit the materials to low resolutions, simplified scenes and images instead of video sequences. Gladly, we could at least use Amateras to get some kind of assumption of how it looked on a sphere when we didn't have access to the Dome, but it was far from enough to make conclusions or get a perspective on how it would look in the Dome.

As the render farm was no longer an option and instead had to start and distribute the render jobs manually, it occurred some problems along the way. The first problem was that the rendering it self took longer as with the render farms, the programs which is used to start the render manually had to run in the background, taking up power for the rendering. It also took a bit of extra time to log in and start up the programs on each computer for each render, which also was limited as a user could start a maximum of 10 render jobs. Another factor is the human error, because no matter how meticulous we human are, mistakes happen. As the procedure had to be made several times over and over, it leaves a room of possible mistakes and struggles. At several occasions, the renders could not start because of an error called SocketError, which was not discovered what it was caused by, making the render unable to start. There was also some other problems about having to log in within 12 hours, which weren't aware of in the beginning and therefore caused the rendering to shut down a couple of times.

Another struggle was to achieve a neon effect that was both efficient and aesthetically appealing. The first method with the post VFX was a really cheap solution which may have looked appealing in some cases but turned out to be unstable and unreliable. Both the color, brightness and bloom acted different when varying angles, distances and number of such materials being observed in the frame. Compared to the post VFX method, final gather resulted in a much more realistic and reliable result but came with a great cost of much heavier calculations, especially regarding the light sources. Regarding that the method for the neon surfaces didn't emit light itself wasn't much of a problem as the neon surfaces in the scene was a part of other objects and structures.

The sound production in the project has been problematic from the start, mainly from using JACK and JACK-Rack as when problems arise little to no help could be found through online searching. The sounds that were mixed using JACK ended up sounding non-correct and the 3D sound effect in the dome was not achieved. As these problems seemed very time consuming to fix and understand, a decision was made to completely scrap the usage of JACK, JACK-Rack and use another more streamlined audio mixing software like Audacity. This made it much easier to work with the sound as well as finding proper documentation and tutorials when problems appeared.

Unfortunately a significant amount of time were used remaking sounds that were created in Audacity. This came from the test that took place in the dome where the audio sounded stereo-like, even when mixed as 8 channels. It was believed that the error came from some mistake when mixing the sound, therefore certain tweaks were made in hopes of solving the unknown problem but to no avail. Later in the project it was discovered that the issue did not stem from mixing of the sound, but was a temporary error in the dome software when the sound was played.

Another aspect of the sound in the project is the recording of sounds, or in this case lack thereof.

The original plan was to record a handful of sound effects to use in the video. But due to all the other unforeseen factors and problems with rendering the audio aspect was pushed back, leaving with very little time for extra work. This motivated the idea behind recording already existing sounds found online through a speaker, causing the quality of the recordings to be very low. Mixing these sounds and listening to them it was clear that the quality was borderline acceptable at best and a decision was made to leave out the recording of sounds and just use existing recordings found online directly. This proved to not be as good as hoped either, but was still an improvement and saved on time.

One of the most unforeseen problem was to do with the audio and visual syncing. Not only did it require the animated sequence to be done first so that the audio could be synced to it, putting a limit to how much time could be spent on it, but it also took many iterations and tweaks to get it to be satisfactory. Later changes to the audio itself also forced the whole soundtrack to be revisited and adjusted for the changed audio effects, making it a huge time sink.

6.1 Alternative Solutions

Towards the end stage of the project when the planned render farm Backburner proved to be unusable, alternatives were looked at. This was more of a desperate attempt of getting a way of efficiently rendering frames before the new year shift. Unfortunately these alternative render farms that did have support for the Domemaster3D plugin did not come cheap, even with student discounts. If however one of the render farms would have proven to be in a somewhat reasonable price range, the rendering process could have been started earlier giving more room for adjustments and refinements that would have without a doubt bumped up the quality of the production more in line with our original vision.

One way that could have significantly improved the quality of the final video were if audio had been captured using real sounds in a soundproofed or at least somewhat padded room. This would remove some of the artifacts and crackling sounds that are present in the sound used in this project. However as the main sound effects involves vehicle sounds it would most likely be proven to be very tricky to get access to those sound sources within a room.

An interesting approach that could have improved rendering time vastly would of been if there would have been a way to simplify the light sources so that the render time could be lowered drastically. Through the testing, as mentioned before, the street lights definitely contributed the most to the increase in render time. This could have been seen as a liberty of creativity of the fact it is taking place in another world, where street lights are not a standard used. However the lights did add a visually appealing effect when the car drove down the street and would of been a compromise in terms of visual effect and reality.

References

[1] Autodesk. Final gather, 2016.

[2] CryENGINE. Image based lighting, 2013.

[3] Maxim S. Image based lighting, 2016.